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ENVIRONMENTAL SCIENCES DIVISION

SOILS, SURFICIAL GEOLOGY, AND GEOMORPHOLOGY OF THE BEAR CREEK VALLEY LOW-LEVEL WASTE DISPOSAL DEVELOPMENT AND DEMONSTRATION PROGRAM SITE

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NUCLEAR AND CHEMICAL WASTE PROGRAMS
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ABSTRACT

LIETZKE, D. A., S. Y. LEE, and R. E. LAMBERT. 1988. Soils, surficial geology, and geomorphology of the Bear Creek Valley Low-Level Waste Disposal Development and Demonstration Program site. ORNL/TM-10573. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 159 pp.

An intensive soil survey was conducted on the proposed Low-Level Waste Disposal Development and Demonstration Program site (LLWDDD) in Bear Creek Valley. Soils on the site were related to the underlying residuum and to the surficial colluvium and alluvium. Within any particular geologic formation, soils were subdivided based mostly on the degree of weathering, as reflected by saprolite weathering and morphologic features of the soils. Degree of weathering was related both to slope shape and gradient and to the joint-fracture system. Exceptions were in the Rome Formation, where soils were primarily related to the particular geologic materials, and in both colluvium and alluvium, where soils were related more to the degree of soil development and to the texture and source of the soil parent materials. Erosion classes were also used to make further subdivisions of any particular soil. Deep pits were dug in each of the major Conasauga Group formations (Pumpkin Valley, Rogersville, Maryville, and Nolichucky) for soil and saprolite characterization. Because of the widespread presence of alluvium and colluvium, which are potential sources of fill and final cover material, pits and trenches were dug to characterize the properties of these soils and to try to understand the past geomorphic history of the site.

Two transects were made at angles to the geologic strike to determine both geologic and soil variability. These data (presented in Appendixes B and C) should help modelers achieve a better understanding of geologic and soil variability on the site. The soil map and other interpretive materials have been digitized to allow flexibility in use.

The results of the soil survey investigation indicated that the deeply weathered Pumpkin Valley residuum has good potential for the construction of tumuli or other types of belowground or aboveground

burial of prepackaged compacted waste. The associated Pumpkin Valley colluvium has good potential for use as fill and cover materials. Drainage networks are well defined and entrenched in this part of the Conasauga, thus allowing for the greatest thickness of soil between the waste and groundwater. Rutledge residuum is exposed at several locations, but most areas of the Rutledge Formation are buried by colluvium. The colluvium-filled trace of the Rutledge Formation provides additional filtration of surface or subsurface contaminated water. The colluvium of both the highly weathered Pumpkin Valley and Rutledge saprolites has a higher cation exchange capacity plus higher levels of free iron and manganese (which are crucial for vadose zone water filtration) than any of the other Conasauga formations on the site. The Maryville Formation has the next highest potential because of its relatively high elevation and distance from groundwater. The Maryville Formation on this site has many of the same problems that are present in Oak Ridge National Laboratory's Solid Waste Storage Area 6. The only advantage of the Nolichucky Formation is its relatively level topography, which will lessen the costs of tumuli site preparation. Problems with the Nolichucky are (1) shallow depth to water, (2) shallow depth to relatively unweathered saprolite with low cation exchange capacity, and (3) nearness to the Maynardville Formation. Rock outcrops and shallow depth to rock in the Maynardville areas provide a potential short circuit in the natural ability of the soil-regolith mantle to filter and purify vadose water before it reaches saturated zones at depth.

The best potential use of the LLWDDD site for waste disposal is a well-designed combination of burial methods, including trenches and tumuli, where compacted and packaged waste is carefully emplaced. A well-designed plan for control of erosion and diversion of water from each waste trench or tumulus is also crucial for maximizing use of this site.

1. INTRODUCTION AND OBJECTIVES

The Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) site is located on the Oak Ridge Reservation (ORR) at the intersection of Tennessee Route 95 and Bear Creek Road in Bear Creek Valley. The site extends east along Bear Creek Road to Gum Hollow Branch Road, north along Gum Hollow Road to Pine Ridge, then west along the crest of Pine Ridge to Route 95, and south along Route 95 to its intersection with Bear Creek Road (Fig. 1).

The climate at the site is generally characterized by mild winters, long springs and falls, and warm and humid summers. The total annual precipitation, based on a 20-year record, is 1.36 m (53.5 in.), and the mean annual air temperature is 14.4°C. Mean annual soil temperature at a depth of 50 cm is 15 to 16°C, with cooler and moister soils on northeast and east aspects and warmer and drier soils on southerly and westerly facing slopes. Aspect affects both evapotranspiration and forest vegetation distribution in the absence of managed forests.

Current land use is forest, with managed pine plantations, old field succession woods, and regrowth of forest previously classified as high grade. No old growth timber is on the site. The only open areas are (1) the maintained power-line and telephone-line rights-of-way, (2) partially overgrown access roads to pine plantations, and (3) roads cut for drilling operations.

The major objectives of this project were (1) to map the surficial soils on the site, (2) to evaluate landform stability, (3) to determine present and past erosion occurrence and evaluate potential erosion and drainage problems, and (4) to develop interpretive materials for planning.

1.1 METHODS FOR MAPPING SOILS

Individual soils and map units were established within a hierarchical framework. For each soil, highest priority was given to soil morphology, which is related to and largely controlled by geology

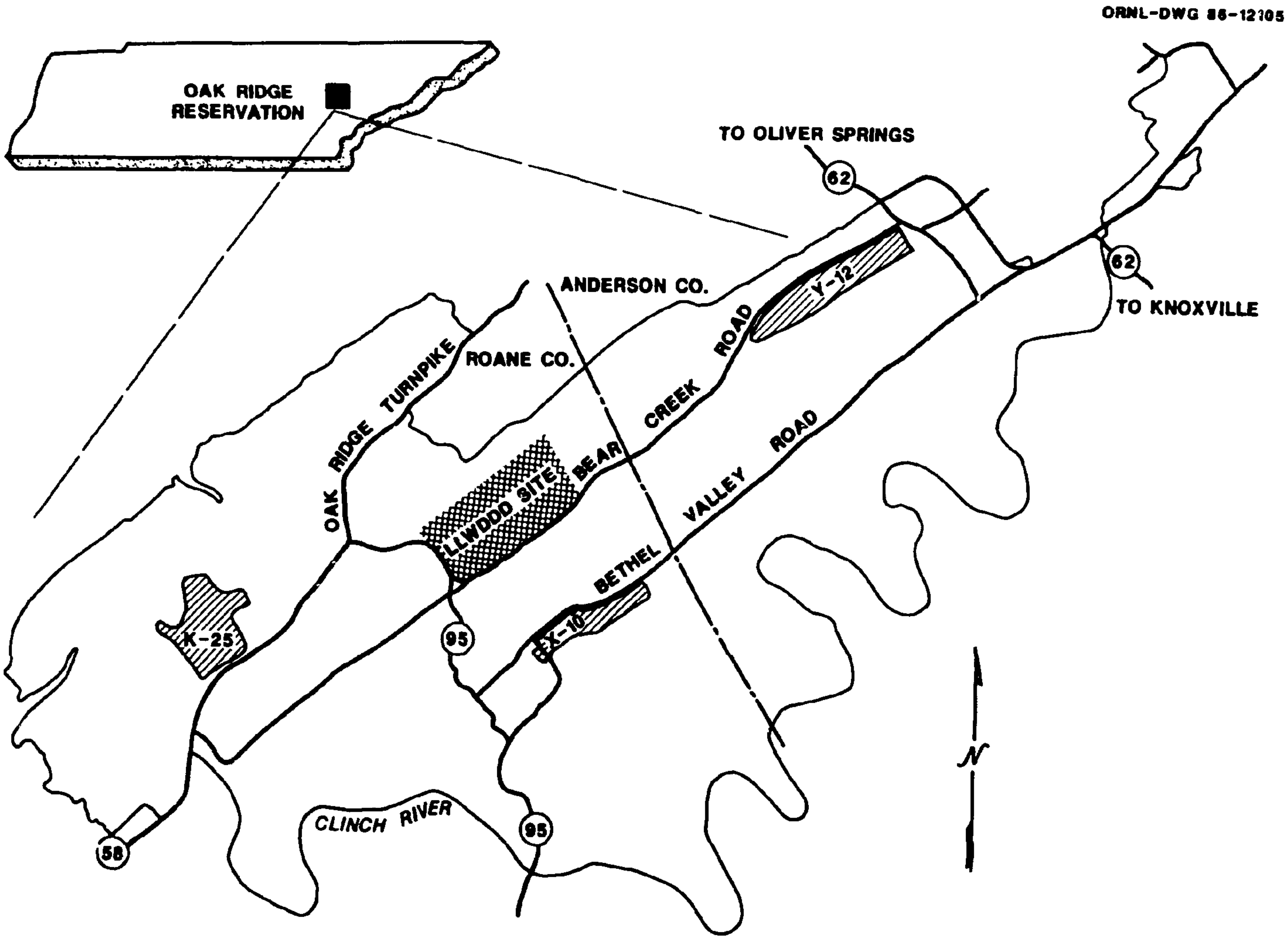


Fig. 1. Location of the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) site on the Oak Ridge Reservation.

(parent materials), hydrology, and geomorphic processes, all of which define the soil system. To establish mapping units, each soil was subdivided according to landform configuration and slope gradient, wetness, and by erosion class. During mapping, soil observations were made to a depth of 1.5 m or to a paralithic contact (which precluded deeper observations) if shallower. Deeper observations were made in pits that were at least 3.0-m deep or to backhoe-refusal depth if less than 3.0 m. All major soils were described and sampled according to the methodology of the Soil Survey Manual (Soil Survey Staff 1984). All major soils were described from exposures in small, hand-dug pits.

2. MODELS OF SOIL GENESIS AND THE WEATHERING OF ROCK TO FORM SAPROLITE

2.1 GENERAL MODELS

The genesis and formation of soils are highly complex and only partially understood because of the large number of variables involved and their complicated interactions. Models of soil genesis are formulated to evaluate the more important variables contributing to the processes that result in the formation of soil from hard unoxidized parent rock. Smeck et al. (1983) compared several models of soil genesis. Three of the models studied seem to have applicability to the humid Southeast and to the LLWDDD site: Jenny's (1941) State Factor Analysis, Simonson's (1959) Generalized Process, and Huggett's (1975) Soil-Landscape.

Jenny was the first to describe a plausible system that could explain the formation of soils and their distribution on landscapes. Jenny's five factors of soil formation are (1) climate, (2) biota, (3) topography, (4) parent material, and (5) time. The first three factors contribute energy to the genesis of soils, but the climatic and biotic factors are probably the most important in the humid Southeast. Energy from the biotic and climatic factors, plus the potential and kinetic energy from the topographic factor, acts on rock to form parent material. Energy subsequently transforms parent material into a genetic soil, one having distinctive soil horizonation and referred to as the soil solum. Time is a required factor because processes and rates of processes change with time.

Simonson's Generalized Process Model was one of the first to evaluate soil genesis from a systems basis. Simonson's model involved the accumulation of parent material and the processes of (1) additions, (2) losses, (3) translocations, and (4) transformations, all of which change parent material into soil. Simonson used Jenny's state factors to define the external and internal conditions of his model. These conditions define the combination of the four processes listed above that would be most active in the genesis of a given soil and the probable genetic pathways.

Huggett's Soil-Landscape Model defined the practical boundaries of a dynamic open system of soil modeling. Huggett proposed using the soil-landscape system as a basis for a three-dimensional model, where the watershed or drainage basin was the minimum area that should be studied and evaluated. Huggett defined the boundaries of his open system model by drainage divides, land surface, and the soil-rock weathering front at the base of the soil profile.

Soil genesis at any one place is defined by a subset of the total set of state factors. A narrowly defined subset of these state factors identifies and drives a specific subset of the generalized soil-forming processes, which, in turn, defines a specific soil-forming process that produces a soil with distinctive horizonation, chemical and biochemical properties, and clay-mineral distributions. General processes of soil formation vary from place to place in a watershed, even with uniform parent materials, because of lateral movements of water and earth materials and the interactions of climate, topographic aspect, and biota.

2.2 SOIL GENESIS FROM PARENT ROCK ON THE LLWDDD SITE

Current relationships between landforms and soils on the LLWDDD site are influenced by the geohydrology of the underlying rock and the surface water flow pathways produced by geomorphic processes of the past that shaped today's landforms. Figure 2 illustrates the geologic stratigraphic column and the soil-saprolite-rock column on the LLWDDD site.

On a given geologic formation, as the slope gradient steepens or the convexity increases, there is more overland runoff and less infiltration. Overland runoff carries soil particles from the surface, which is considered a loss in Simonson's model. The lack of geomorphic stability slows the formation of the Bw subsoil horizon and prevents formation of Bt subsoil horizons (Soil Survey Staff 1984). Infiltration, however, produces an increased rate of subsurface chemical weathering and also an increase in surface stability. This results in the ongoing formation and thickening of pedogenic soil horizons as well as the continued deep weathering of underlying saprolite and bedrock.

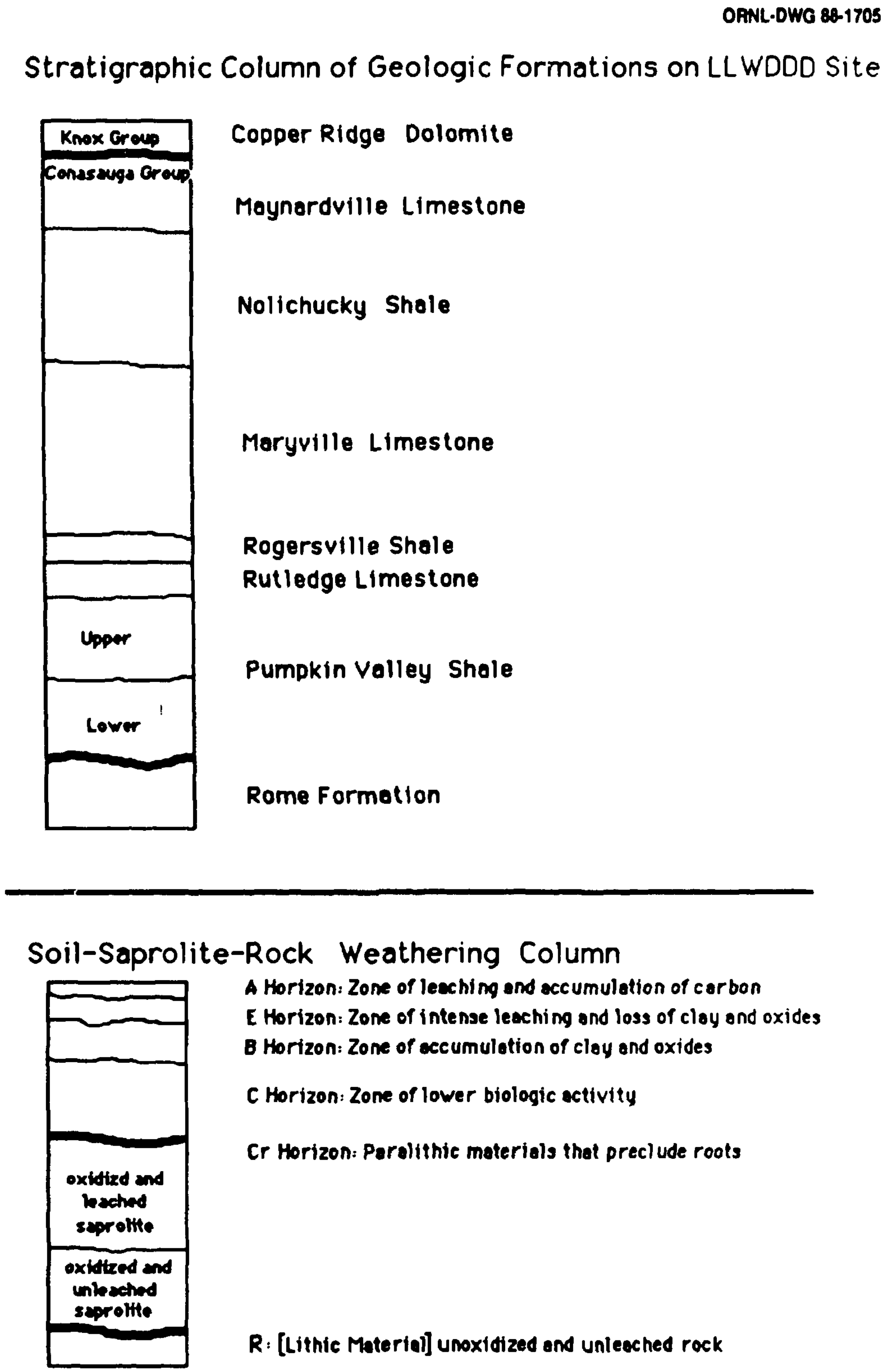


Fig. 2. Stratigraphic column of geologic formations on the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) site and soil-saprolite-rock weathering column.

The relationship between the depth to unoxidized and unleached bedrock and the rate of soil formation is less certain because more recent geomorphic periods of instability have resulted in the removal of the upper soil horizons, especially on steeper slopes, while deep oxidization and leaching have continued. Therefore, weakly developed soils on steep slopes can have thick and highly weathered saprolite beneath.

In Fig. 3, the sandstone-siltstone sequence in lower Pumpkin Valley appears to weather differently than the upper shale-siltstone sequence. The higher sandstone content allows for a more uniform downward movement of water and a more uniform weathering front. The uppermost pedogenic soil horizons in the No. 20 to No. 23 soil weathering sequence of the soil solum form parallel to the landform surface. Lower horizons, however, tend to form parallel to the rock strike and dip; such parallel formation is more noticeable in the less weathered No. 24D soils. The reorientation of lower pedogenic horizons is due to differential subsurface water flow pathways. This differential water flow can result when harder impermeable shale saprolite interbeds with softer and more permeable sandstone and siltstone saprolite. Zones in the leached saprolite that have increased water flow also have higher rates of weathering and form soil horizons earlier than do less weathered areas. It is not uncommon, when making a vertical cut in a soil profile, to find a Cr horizon (paralithic materials) above a Bt horizon, which is a highly illogical pedogenic soil horizonation sequence. But, when water flow pathways are oriented to the strike and dip in the lower soil solum, soil horizons would form first in more weathered saprolite zones.

Weathering processes and movement of water (as overland flow or as subsurface throughflow or lateral flow) are affected by landform morphology. Figure 4 illustrates the effects of geologic formations of the Conasauga Group and landform morphology on rock weathering, saprolite thickness, and the sequence and thickness of horizons in the soil solum.

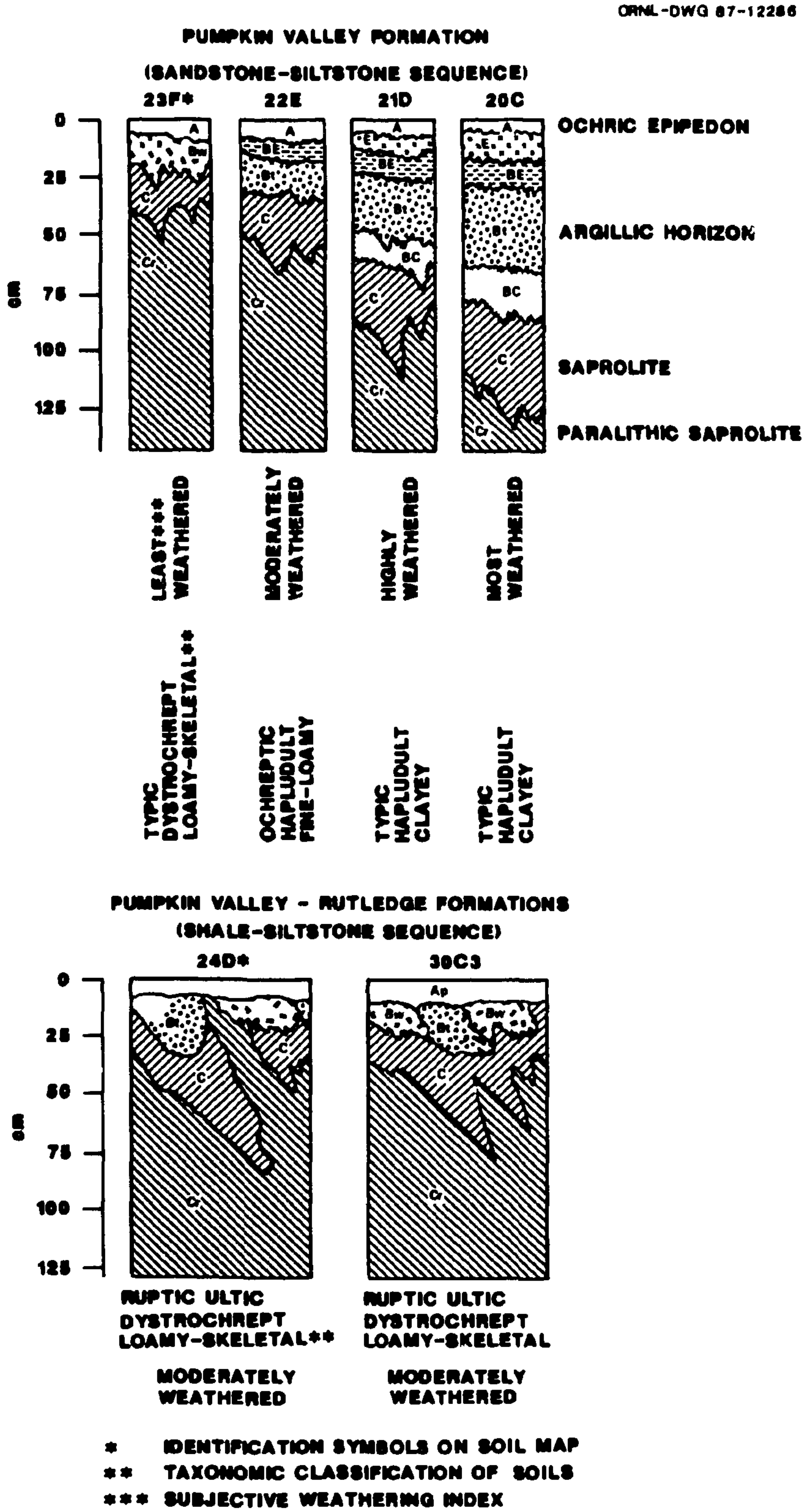


Fig. 3. Weathering sequences of the Pumpkin Valley Formation and the Pumpkin Valley-Rutledge Formations.

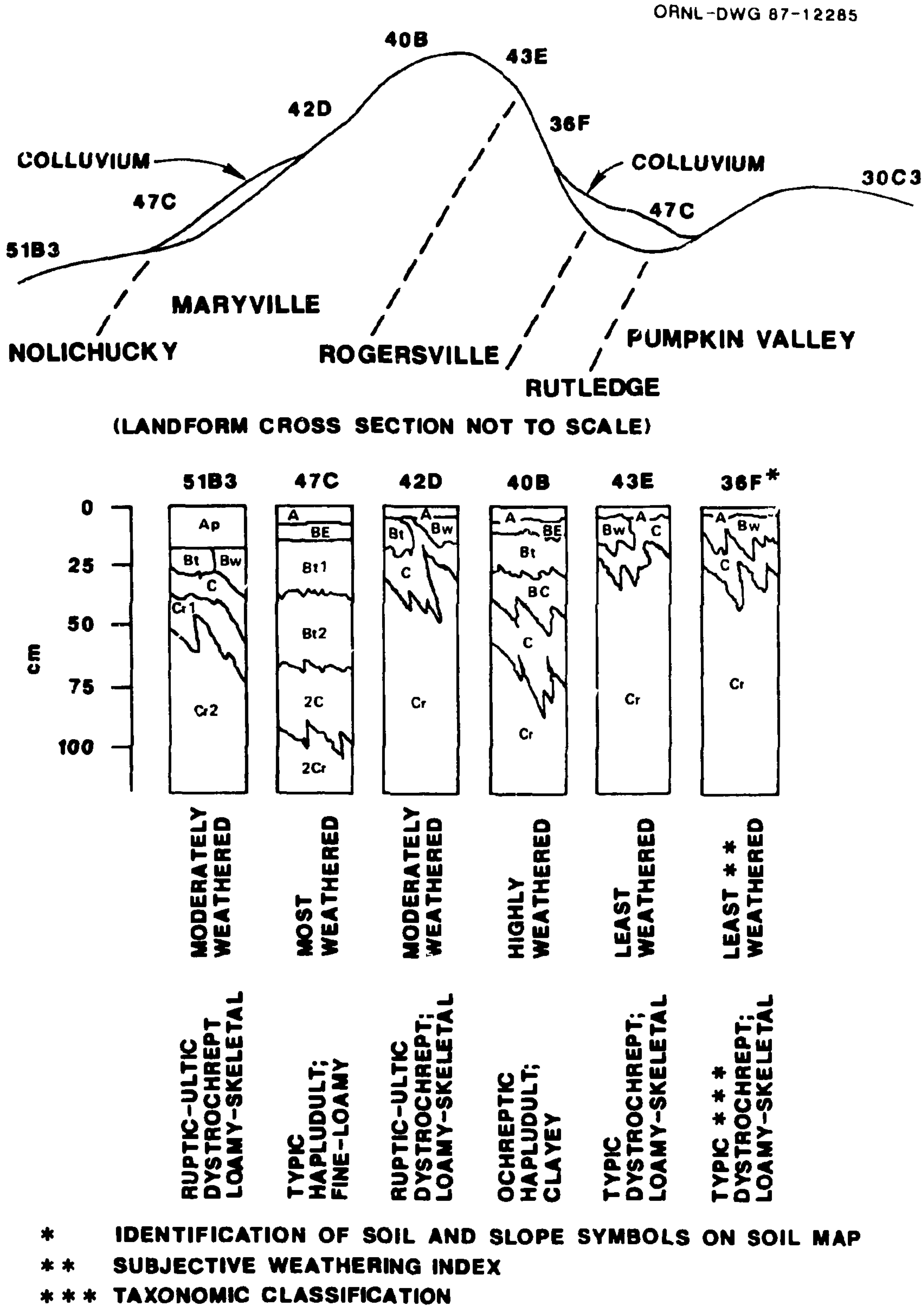


Fig. 4. Weathering and landform relationships on the Conasauga Group.

Soils representing a moderate stage of weathering and soil formation (Fig. 4) have the most complex sequence of pedogenic soil horizons and water flow pathways through the underlying saprolite and into the bedrock beneath. Soils representing a highly weathered stage have had sufficient geomorphic stability to form upper pedogenic horizons that are oriented parallel to the surface. However, with increasing depth, lower and less weathered soil horizons are oriented to the underlying geologic strike and dip and have highly irregular lower boundaries.

Soil-forming processes, including shrinking and swelling of clay minerals and biologic perturbations, are responsible for the destruction of geologic rock structure in the C horizon and the subsequent formation of pedogenic soil structure. Upper soil horizons (A, E, and B) have the best expression of pedogenic soil structure; transitional BC and CB horizons have evidence of both pedogenic soil structure and remnant-rock-oriented strike and dip. Biologic activity, and either translocated clay particles or neo-formed clay minerals in C horizons, start the pedogenic process of destroying rock structure.

Higher bulk density in underlying Cr materials (leached saprolite) precludes root penetration and proliferation; smaller pores and cracks preclude most clay particles except in water flow zones where the fracture and joint spacing provides higher permeability. Higher-permeability areas weather faster and deeper into both the unleached saprolite and the rock beneath. Tree roots and other biotic activity can extend deeply into the saprolite along these water flow zones. The higher bulk density at the boundary of the C horizon and the leached saprolite (identified by the symbol Cr and sometimes referred to as paralithic materials) generally stops the hydraulic penetration of coring tubes (including shelby tubes). Bulk density continues to increase with depth in the leached saprolite zone. However, at some depth bulk density becomes high enough to preclude the penetration of a split-spoon coring device. This depth appears to coincide with the transition from leached saprolite to unleached saprolite; however, additional study and analysis is needed to confirm these observations. In the unleached saprolite-bedrock transition zone, where there is an oxidizing gradient, the decrease in weathering finally precludes the use of augering equipment having cutting bits that resemble steel "fingers." Below this depth, rotary drills are required to bore into unoxidized and unleached rock.

What must be stressed in planning waste burial activities at the LLWDDD site is the gradational, extremely variable nature of weathering processes and irregular thicknesses of the soil solum and leached saprolite in the Pumpkin Valley, Rogersville, Maryville, and Nolichucky Formations of the Conasauga Group.

The Maynardville Limestone has a different mode of weathering, in contrast to the other formations. Limestones, especially those of very high purity, have very low internal permeability. These limestones tend to weather from the outside inward because water flows over joint and fracture surfaces rather than through (more or less) the rock as it does in sandstone, siltstone, and shales of the other Conasauga members. Not all carbonate rocks, however, weather in this manner. Rock having a lower calcium carbonate content tends to be slightly more permeable; water can move through such rock, dissolving soluble components and subsequently forming saprolite. The weathering of carbonate rocks tends to produce pinnacles, ledges, and solution cavities. Most rainfall infiltrates and percolates downward as throughflow. The transition between bedrock and the high-clay-content soil in the Maynardville Limestone tends to be narrow, on the order of a few centimeters to decimeters, depending on the calcium carbonate content and the kinds of impurities. Saprolite does not form in the Maynardville Limestone except in the upper and lower transition zones, and the soil solum rests on hard rock. Because of the type of weathering that occurs in carbonate rocks, solution cavities, channels, and caves form in limestone and are eventually filled with translocated or neo-formed clay, or soil flows into surface depressions caused by the collapse of underlying cave or solution channel roofs. Pinnacles and ledges, either attached or detached, are a common feature of carbonate rock weathering. Weathering processes of carbonate rock are sufficiently different so that they are termed "karstification."

3. SURFICIAL GEOLOGY

The LLWDDD site is bounded on the south by Bear Creek, which flows in the Maynardville Formation of the Conasauga Group, and on the north by Pine Ridge and the uppermost Rome Formation that is exposed in the area. McMaster (1963) mapped the general locations of the major geologic groups on the site, but not the location of each formation within a group. With the exception of the Maynardville Formation, there were very few outcrops of hard rock. Therefore, the characteristics of oxidized and weathered rock leached of its calcium carbonate, defined here as saprolite, were used to identify each geologic formation.

Soil mapping, utilizing a topographic phase map (Fig. 5a), located the saprolite of each geologic formation where it is exposed at the surface. Substantial areas were covered by alluvium and colluvium. The largest area of the site is underlain by the Conasauga Group. This group is represented on the ground surface by residuums of the Pumpkin Valley, Rutledge, Rogersville, Maryville, Nolichucky, and Maynardville Formations (Fig. 5b). The Rutledge Formation, which occurs between the Pumpkin Valley and Rogersville Formations, is a generally linear depression in which streams flow or which has largely been filled with colluvium derived from the Rome and Pumpkin Valley Formations. However, several exposures of Rutledge residuum have been identified. The Conasauga Group occurs in narrow, steeply thrusted and intricately folded and faulted bands that average 0.8-km thick. Each formation has some surface exposure. Transition zones between each formation also occupy the surface area. Some transition zones are rather narrow, <7- to 15-m wide, and some are 15- to >30-m wide.

The Rome Formation in the LLWDDD site occupies the upper third of the south side of Pine Ridge. A bench landform high on the side of the ridge marks the boundary between the Pumpkin Valley and Rome. The bench is formed by the presence of a thick, grayish white to yellow brown sandstone that contains abundant feldspars. This bench is

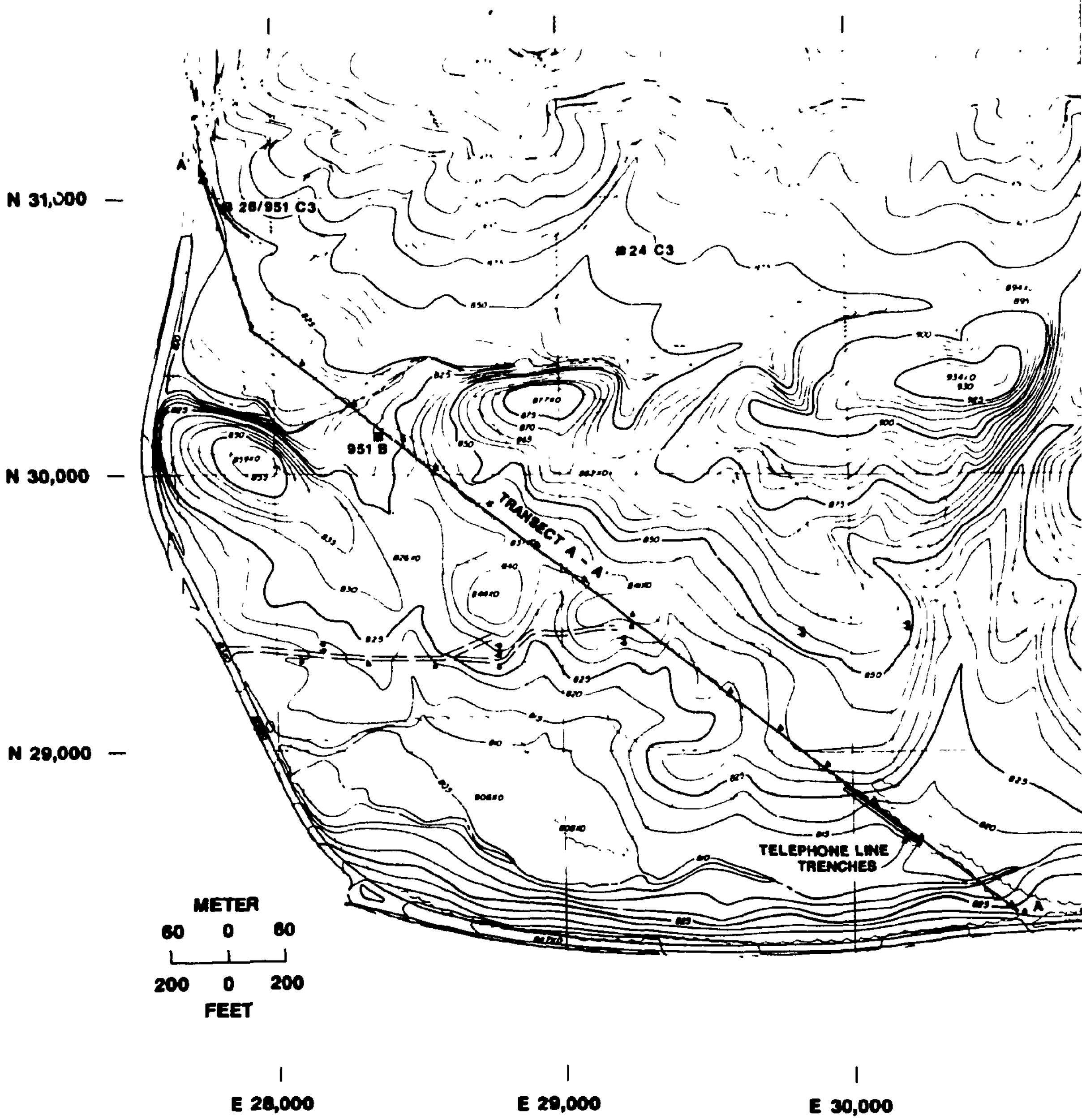
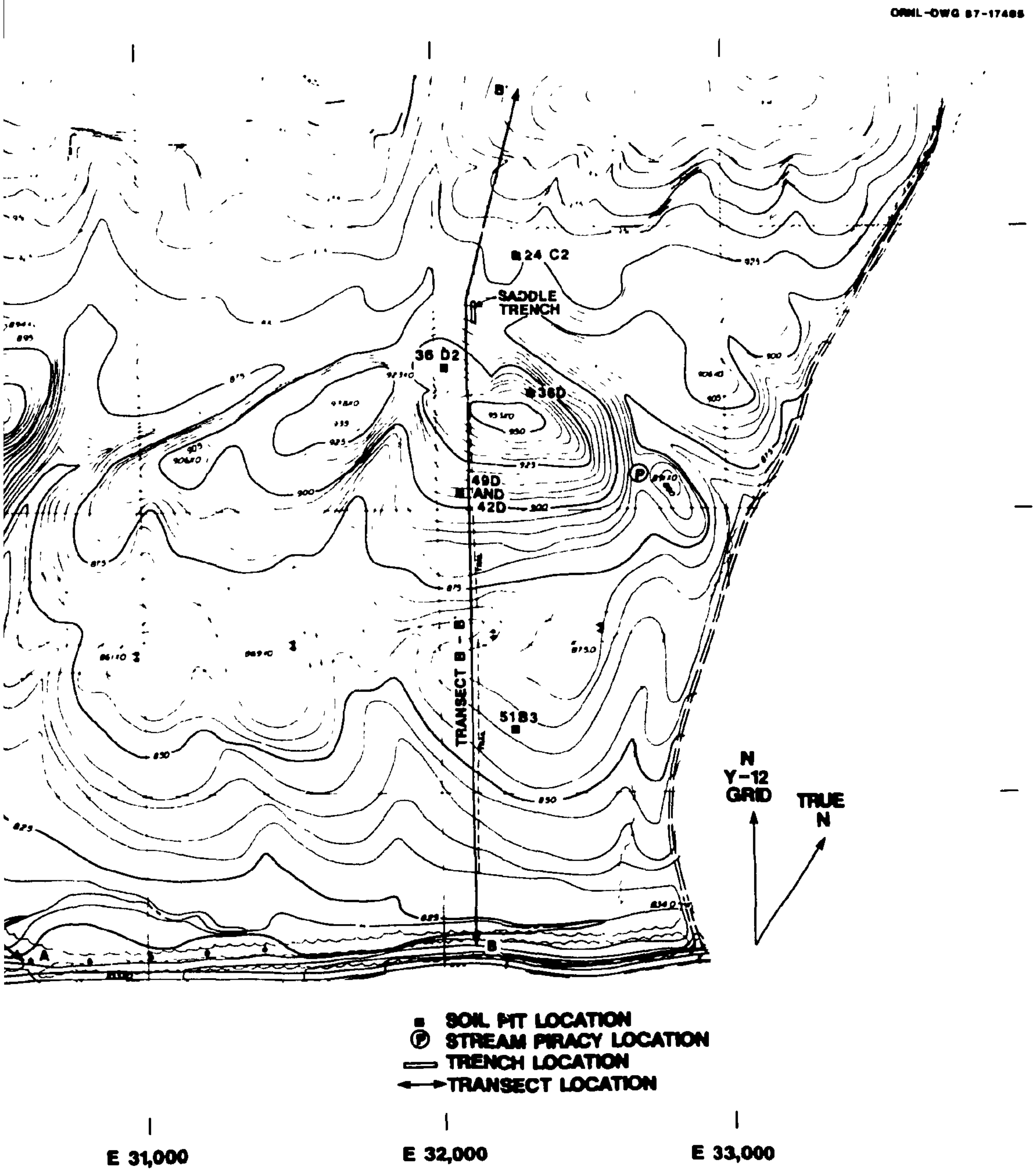


Fig. 5a. Topograph



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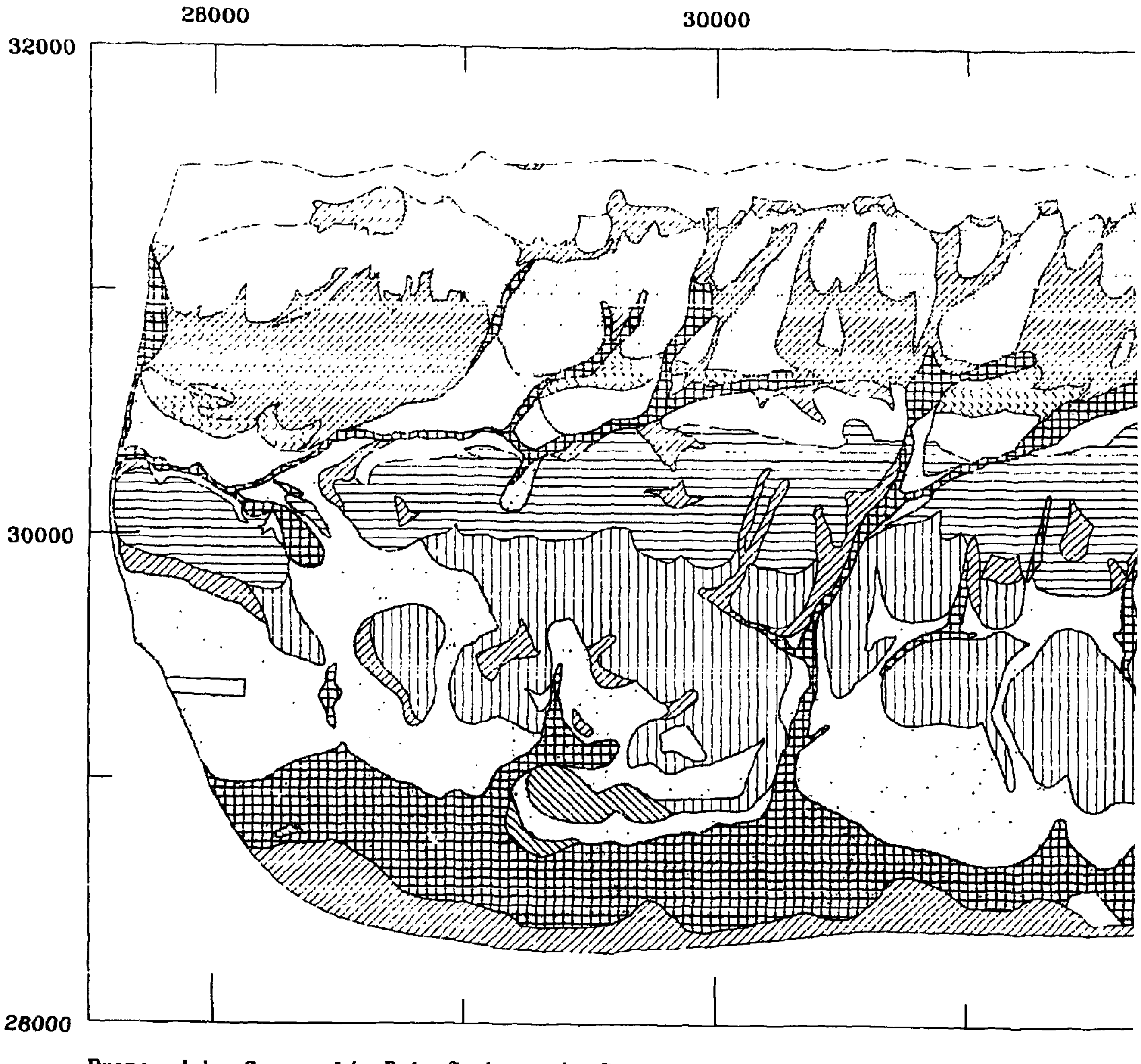

Prepared by Geographic Data Systems, in Cooperation with the Environmental Sciences Division, ORNL

Fig. 5b. Surficial geology map. (R-M-N

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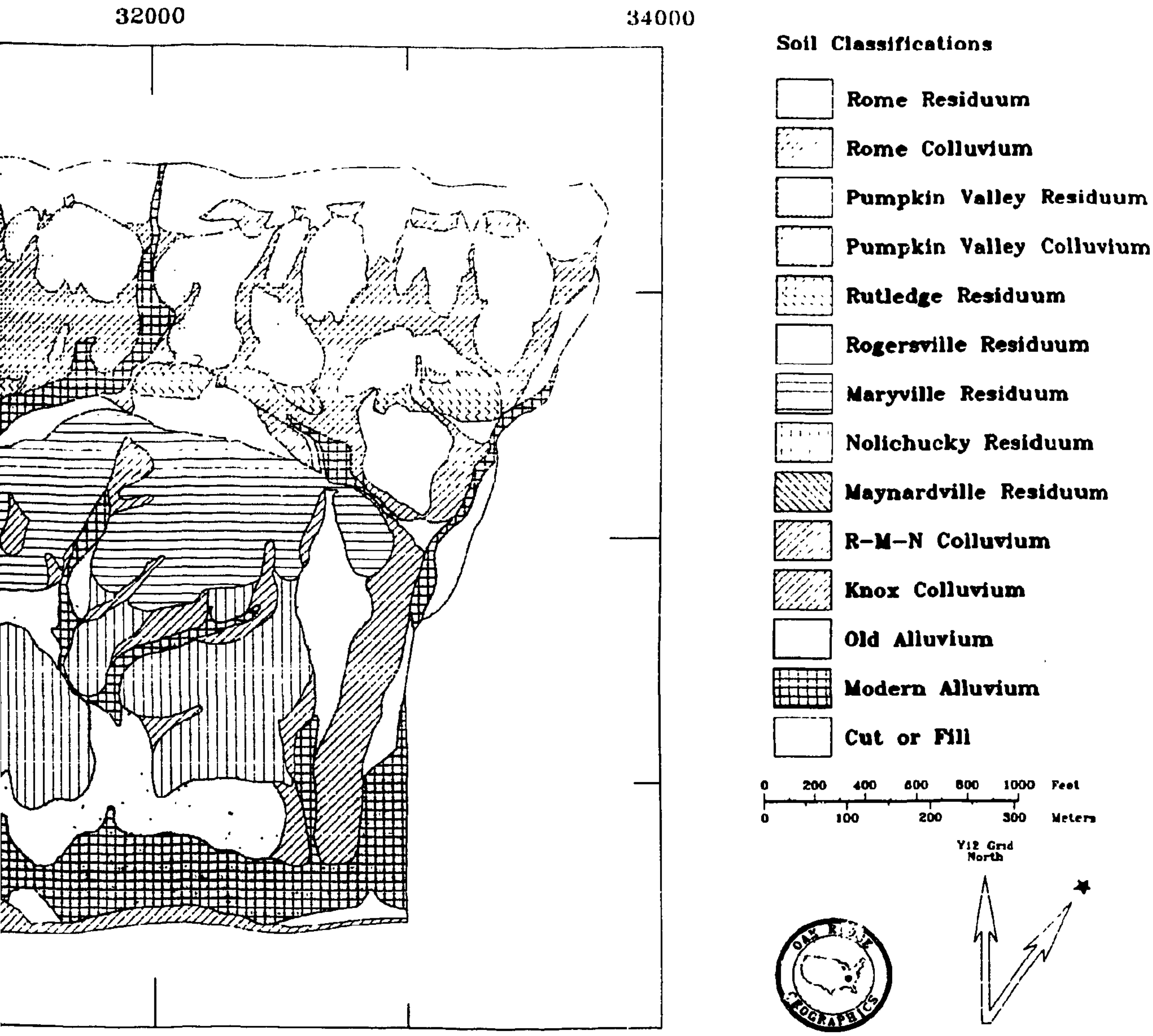

(R-M-N = Rogersville-Maryville-Nolichucky.)

usually covered with colluvium. Most drainageways on the south side of Pine Ridge have cut headward through the Pumpkin Valley until they have impinged on this uppermost Rome Sandstone unit. Some of the deeper drainageways contain springs, and others have only wet-weather seepage areas. Rome Formation saprolite on the south side of Pine Ridge is identified by the presence of a calcium-carbonate-cemented medium-grained feldspathic sandstone unit. This unit has been leached free of calcium carbonate and has been oxidized to a yellowish red color. Just below the sandstone unit is a unit composed of fissile maroon and greenish gray shale. This fissile unit occurs either on the highest knobs of the ridge or on the north side. One unit occurs on the south side where a drainageway has eroded through the resistant sandstone unit, exposing the member very low on the slope. But, where the fissile unit occurs on sideslopes and in saddles, it is usually covered by colluvium, containing large quantities of hard, gray siliceous sandstone gravels and cobbles, which is part of a hard sandstone unit (cemented by silica) that holds up the ridge.

The Pumpkin Valley Formation in the LLWDDD site has at least two recognizable members that weather to form distinctive soils. The upper member, which is composed of interbedded claystone and siltstone with abundant strata of very fine grained glauconitic sandstone, has low permeability. The saprolite has a distinctive purple violet tint, which, along with the dark green of the glauconite, makes it easily recognizable. The lower Pumpkin Valley is dominated by still more permeable siltstone and very fine grained glauconitic sandstone. This saprolite can be identified by its higher sand content and colorful appearance, with colors ranging from red, violet, yellow, and brown to shades of green. The transition zone between the Pumpkin Valley and Rutledge Formations is mostly covered by alluvium and colluvium. The Rutledge Formation is identified by a low-glauconite, higher-lime-content claystone and siltstone saprolite that is exposed in four areas on the LLWDDD site. Rutledge saprolite can be identified by its yellow brown to olive hue and by brown iron oxide coatings on fragments. Black manganese coatings are minimal. The hardwood forest growing on Rutledge residuum is dominated by white oak. The Rutledge Formation gradually merges with the lower Rogersville Formation.

The surface transition zone between the Maryville and Rogersville Formations is usually <15-m wide. It is marked by the increased presence of greenish, bluish, and pinkish claystone and siltstone strata in contrast to the olive and yellow brown hues of the Rutledge Formation. Also present in the uppermost Rutledge Formation and throughout the Rogersville Formation are fine-grained glauconitic siltstone strata. The Rogersville Formation is typically <30-m thick and is exposed only on steep, obsequent northeast-facing slopes. However, there are three locations on the site where the Rogersville Formation is considerably thicker. This increased thickness evidently is caused by local faulting, which thrusts slices of the Rogersville Formation over other slices of the Rogersville Formation, or else there are areas where the Rogersville Formation is thicker. On stable landforms, the soil that forms in Rogersville saprolite has a yellow brown to yellowish red clayey subsoil. Glauconite strata are abundant throughout the Rogersville Formation. Rogersville saprolite is relatively permeable.

The broad transition between the lower Maryville Formation and the upper Rogersville Formation is marked by an increase in the calcium carbonate content in the lowermost Maryville and increasing amounts of olive-hued saprolite. This transition zone is from 15-m to >30-m wide. The Maryville Formation on this site consists of (1) calcareous siltstones and claystones and (2) argillaceous limestone. Thin strata of very fine grained calcareous sandstone also occur throughout the formation. Glauconitic strata are common in the lowermost part of the formation, but decrease in the upper sections. Maryville saprolite is high in silt content, moderately high in clay content, and contains permeable, very fine grained sandstone strata. It also has a relatively high content of iron and manganese oxide, reflected by thick, bright red or dark red iron oxide coatings in the upper saprolite and thick, black manganese oxide coatings below the zone of iron oxide coatings. Maryville saprolite is easily recognized by its oxidized color. Unoxidized and unleached rock has a dark gray color, but as oxidation and hydrolysis proceed, rock is transformed into oxidized and unleached saprolite and acquires a dark olive color

(5Y hue). With continued weathering and nearness to the surface, the leached saprolite color changes to a light olive brown (2.5Y hue); in the lower soil solum, very soft saprolite fragments can have a yellowish brown (10YR hue) color. The soils that form in the uppermost saprolite on stable landforms generally have a red or yellowish red subsoil enriched in translocated clay. The Maryville soils on the LLWDDD site have morphologic characteristics similar to those in Solid Waste Storage Area 6 (SWSA-6) (Lietzke and Lee 1986). Chemical and mineralogical analyses now under way will help determine whether the Maryville and Nolichucky soils and saprolites in SWSA-6 are similar to the soils on this site. The transition zone between the Maryville and Nolichucky Formations is marked by a decrease in calcium carbonate and an increase in brownish-colored saprolite.

The saprolite of the Nolichucky Formation is predominantly claystone, but contains lenses and strata of siltstone and very fine grained sandstone throughout. In the uppermost part, it also contains some lenses and strata of argillaceous limestone that have weathered to a sticky clay saprolite. The Nolichucky Formation is usually characterized as having a relatively low calcium carbonate content, especially when compared with the Maryville Formation below and the Maynardville Limestone above. The Nolichucky Formation can be readily recognized at the surface by the mostly brownish color of the saprolite. The brown oxidized color of the saprolite is derived from the darker brown of the unoxidized rock beneath. Because of the low carbonate content and the highly jointed and fractured nature of this formation, water has been able to percolate downward, allowing oxidation and hydrolysis reactions to proceed to a considerable depth. The resultant chemically weathered and very acid materials form a thick saprolite, which maintains a rather high bulk density and has a relatively low permeability. Tree roots are evidently not able to penetrate along planes, joints, and fractures in the leached saprolite zone to reach calcium in the unleached saprolite below. The Nolichucky Formation, when compared with the Maryville Formation, has a relatively lower iron content, based on iron coatings on joint and fracture faces in the saprolite. However, the manganese content is quite high. The soil that forms in the Nolichucky saprolite on stable landforms has a yellow brown to strong brown clay-enriched subsoil.

The uppermost part of the Nolichucky Formation is a clay-rich or argillaceous limestone, with interbeds of claystone in the transition zone where the Nolichucky merges with the lowermost Maynardville Formation. The weathering of these rocks has produced a very thick saprolite, high in silt and clay, and very sticky. In many places, however, there seems to be a rather abrupt transition from the claystones of the Nolichucky to the limestones of the Maynardville. Most areas of the transition zone are covered by old alluvium.

Most of the Maynardville Formation consists of high-carbonate-content limestone that weathers to residuum, which contains clay and silt residue but little iron. This limestone occurs mostly in the floodplain and the current low terraces of Bear Creek. When these rocks weather, very little saprolite forms. Soils that form in the residuum are shallow and overlie hard rock; rock outcrops are common. However, most of the Maynardville Limestone is covered by Bear Creek alluvium.

At the LLWDDD site, the transition between the Maynardville Limestone and the Copper Ridge Formation of the Knox Group is a low-chert-content dolomite or dolomitic limestone that contains abundant impurities of silt and clay-sized particles and iron oxides. The rock in this transition zone weathers to form a moderately thick saprolite (of low-chert and high-silt content plus clay) in which a red clayey soil has formed. With the exception of some outcrops of rock between Bear Creek Road and Bear Creek, as well as some immediately above the road, this transition zone is covered by thin to thick Knox colluvium or by Modern- to Pleistocene-aged alluvium.

4. GEOMORPHOLOGY

4.1 TERMINOLOGY

The terminology used to describe landforms and geologic materials is shown in Fig. 6. This terminology is used throughout the sections on geomorphology and the descriptions of soil mapping units that follow. Common terms used to describe a hill are summit or crest, shoulder or summit shoulder, sideslope, footslope, and toeslope. Crests and sideslopes generally have convex shapes and usually are defined as erosion surfaces, where soil particles are detached and transported to depositional environments. Sideslopes are sometimes referred to as (1) dip slopes, where the rock dip is roughly parallel to the landform slope or (2) obsequent slopes, where the rock dips into the slope. Hydrology differs considerably on these two kinds of sideslopes. Footslopes are areas where slope shapes change from convex to concave. Footslopes are either erosional or depositional, depending on the gradient of the slope and the convexity or concavity of the landform. Toeslopes have concave slope shapes and are mostly depositional environments in their natural state, where under the influence of gravity, water-saturated sediments are transported and deposited downslope as colluvium. However, past agricultural activities tended to make even these landforms erode. Major depositional environments on the LLWDDD site are terraces and floodplains. In these environments, sediments transported by running water are deposited as alluvium, which can be identified by its stratification.

Bedrock (Fig. 2) is defined as unleached and unoxidized rock, and the weathered zones above (which have not been transported) are termed saprolite (in-place, isovolumetric weathering of bedrock). Depth to bedrock on the LLWDDD site is highly irregular because of the joint and fracture network and the channelized flow of water at depth.

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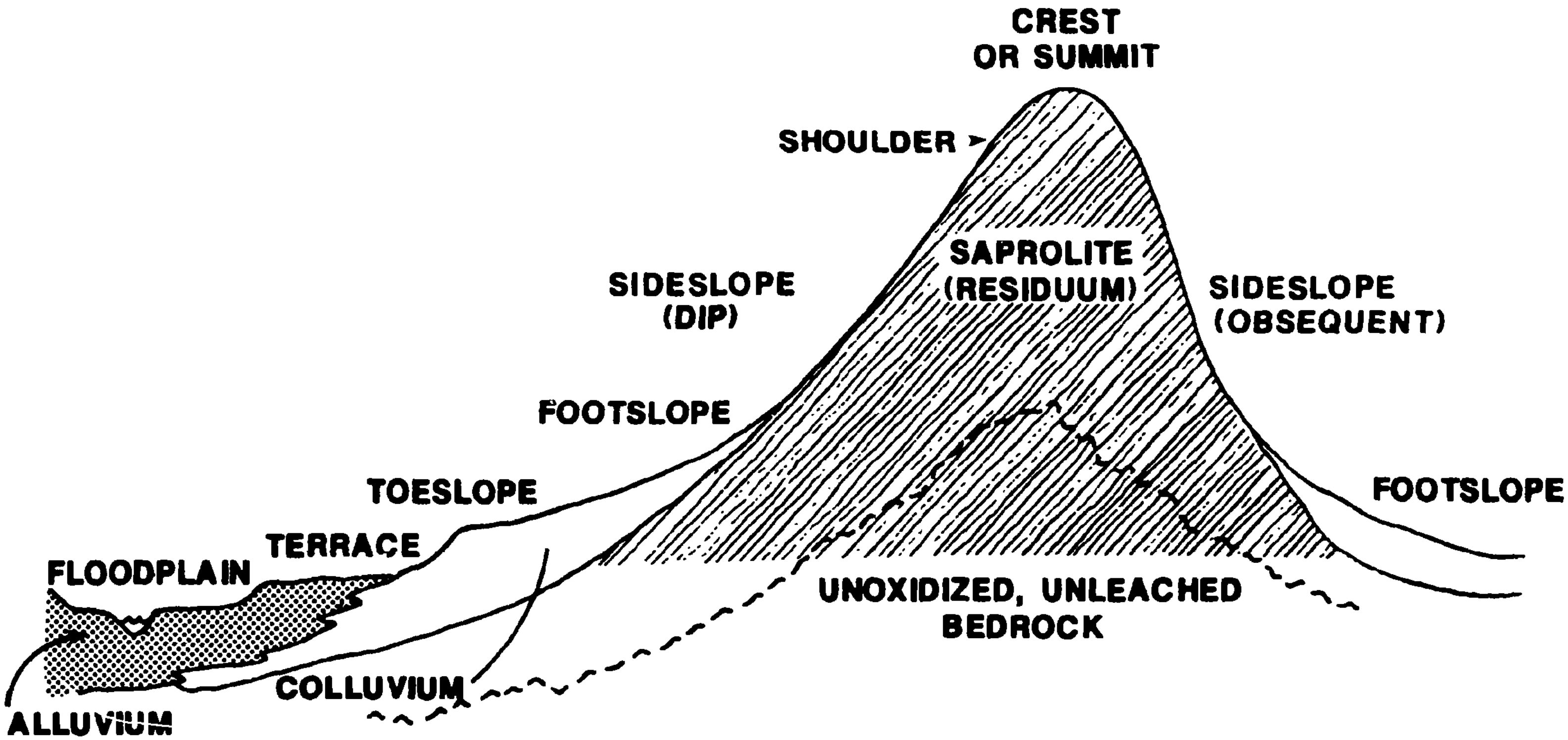

Fig. 6. Geomorphic terms used in describing landforms.

4.2 GEOMORPHIC HISTORY

The geomorphic history of the LLWDDD site is long and complicated. Only a simplified history, starting with current conditions and extending back through the Holocene and the Pleistocene Epochs, is attempted. The Modern age of the Holocene Epoch is defined for the purposes of this report, as beginning ~300 years ago when the activities of European settlers resulted in large-scale deforestation, the beginning of agricultural activities, and the onset of anthropogenic-accelerated erosion. The Holocene Epoch covers a time span starting at the end of the Pleistocene (~12,000 years ago) and includes the Modern age. In the Southeast, the Holocene is often thought to have been a benign period with little climate fluctuation. However, Holocene climate changes have produced periods of geomorphic instability, the results of which are reflected in the burial of Paleo-Indian habitations on low river terraces by fresh sediments. There is no evidence, however, of Paleo-Indian influence on the soils of this particular site. During the Pleistocene Epoch, which covers a period of at least 2 million years, important climatic fluctuations occurred in the Southeast.

4.2.1 Modern Geomorphic Period

In humid environments, the dominant modern geomorphic processes are those of denudation (the wearing away of topographic highs) and either the filling of low areas or the transport of sediment away from the local watershed system. These processes are driven by rainfall and the force of gravity. Soil particles are detached by raindrops or overland flow and then transported downslope to a depositional site or into a stream. This natural process will be a slow one whenever there is a vegetative cover on, and a tree canopy above, the soil surface. Deforestation and primitive agricultural management practices strip the vegetative cover off the land, leaving bare soil exposed to the full force of raindrop impact and runoff. Agricultural fields rapidly erode by sheet and rill erosion and related transport processes. In areas where water coalesces, gullies form and start their headwardly cutting activity into steeper landforms.

Within the LLWDDD site, about half the area was open land, according to the 1941 U.S. Geological Survey (USGS) topographic map of the area (Fig. 7). The open land was on the more gentle slopes; the steeper areas of Maryville, Rogersville, and Pumpkin Valley, and most of the Rome soils were evidently not cultivated. Today, areas in agricultural land use in the late 1930s can be readily identified (1) by the present forest vegetation and (2) by the effects of plowing and erosion on soil morphology. Some steeper land areas, once cultivated or pastured, probably had been allowed to revert back to forest much earlier. Areas of hardwood forest without pines or cedars indicate a forest without much past disturbance, except for periodic logging activity. The soils in these areas show little evidence of past erosion. A hardwood forest with Virginia pines and cedars indicates that the land was once logged and cleared or partially cleared, probably pastured, or periodically burned before reverting to forest prior to the Atomic Energy Commission (AEC) takeover in 1941-1942. The soils in these areas show some effects of past erosion, but the areas have been revegetated long enough so that the soils are regenerating their natural forest soil morphology and horizonation.

Areas on the site that were used for growing agricultural crops in 1941 are mostly severely to very severely eroded. The abandonment of open lands after the AEC takeover produced serious erosion and numerous gullies before old field succession covered the land with vegetation and, finally, trees. These areas can be identified by the presence of numerous gullies that are no longer active as well as a forest of Virginia pine, cedars, and oaks. Many open hillside fields were eventually reforested with pine trees that were planted for short-term rotation, a destructive and sediment-producing land-use practice that continues today. The bulldozing of logging slash on slopes of already severely eroded and shallow soils can strip off additional soil after each clear-cut, thereby reducing the rooting thickness of these already thin soils and increasing the frequency and amount of surface runoff.

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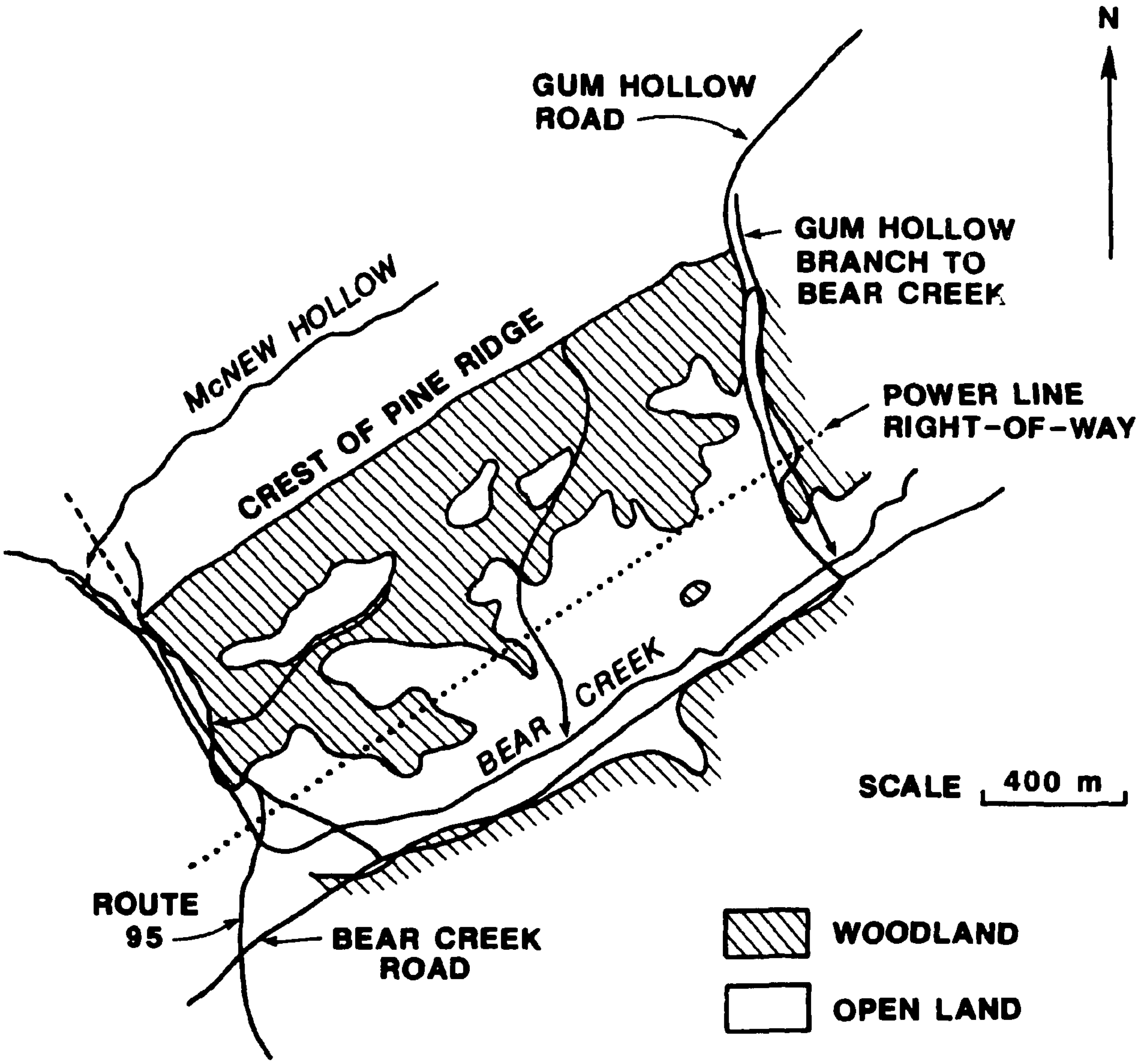

Fig. 7. Pre-Atomic Energy Commission (AEC) land use on the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) site.

There are many places where the soil has been stripped down to fairly hard and coherent saprolite, which has very low levels of plant nutrients and water-retention capacity. These areas can be identified by very sparse pines and partial to no groundcover and are now extremely eroded and will continue to erode. Each succeeding removal of slash and nutrient-rich topsoil in a short-term pine rotation reduces the productivity and depth of the soil. These extremely eroded soils should be put back into a long-term pine rotation or allowed to revert back to hardwoods if soil regeneration is to occur. Past soil erosion has significantly changed the hydrology of the LLWDDD site. Shallow soils and severely eroded soils produce more overland runoff and less infiltration. Other evidence that Modern age erosion has occurred is revealed in drainageways and in the Bear Creek floodplain where 50 to 100 cm or more of Modern sediment (mostly topsoil, derived from agriculture and forest mismanagement) has covered older soils. Modern geomorphic processes of erosion and sedimentation have produced significant changes in some of the surficial soils on the site. They have altered some landforms greatly while at the same time changing other landforms very little.

The presence of Modern and older, multiaged colluvium on sideslopes and footslopes in the uplands indicates that there have been past cycles of accelerated geologic erosion (the Holccene and late Pleistocene) (Figs. 8a and 8b). Colluvium consists of soil particles and rock fragments that have been transported downslope under the influence of gravity, usually as a saturated mass. Colluvial deposits are readily identified by the lack of geologically oriented strike and dip (rock structure). The rock fragments in colluvium are mostly disoriented (with the exception of large, flat fragments, which are often oriented parallel to the slope). Colluvium from the Pumpkin Valley, Rogersville, Maryville, and Nolichucky Formations (Pumpkin Valley colluvium and R-M-N colluvium in Fig. 5b) has a higher rock fragment content, along with other morphologic features, which readily distinguishes it from residuum or alluvium. The reworking and sorting

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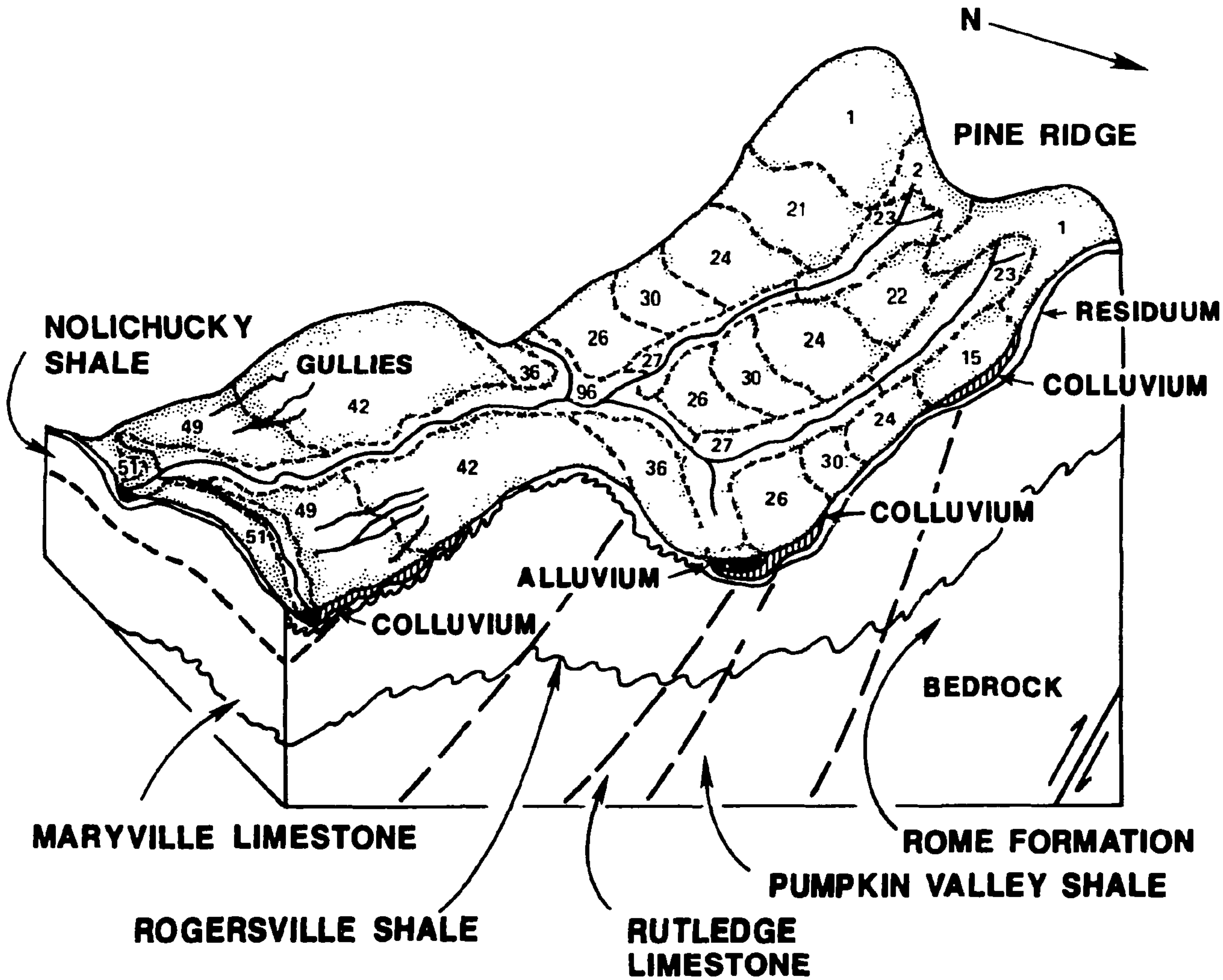

Fig. 8a. Diagram showing the generalized relationship between geology and soils on the Nolichucky to Rome Formations.

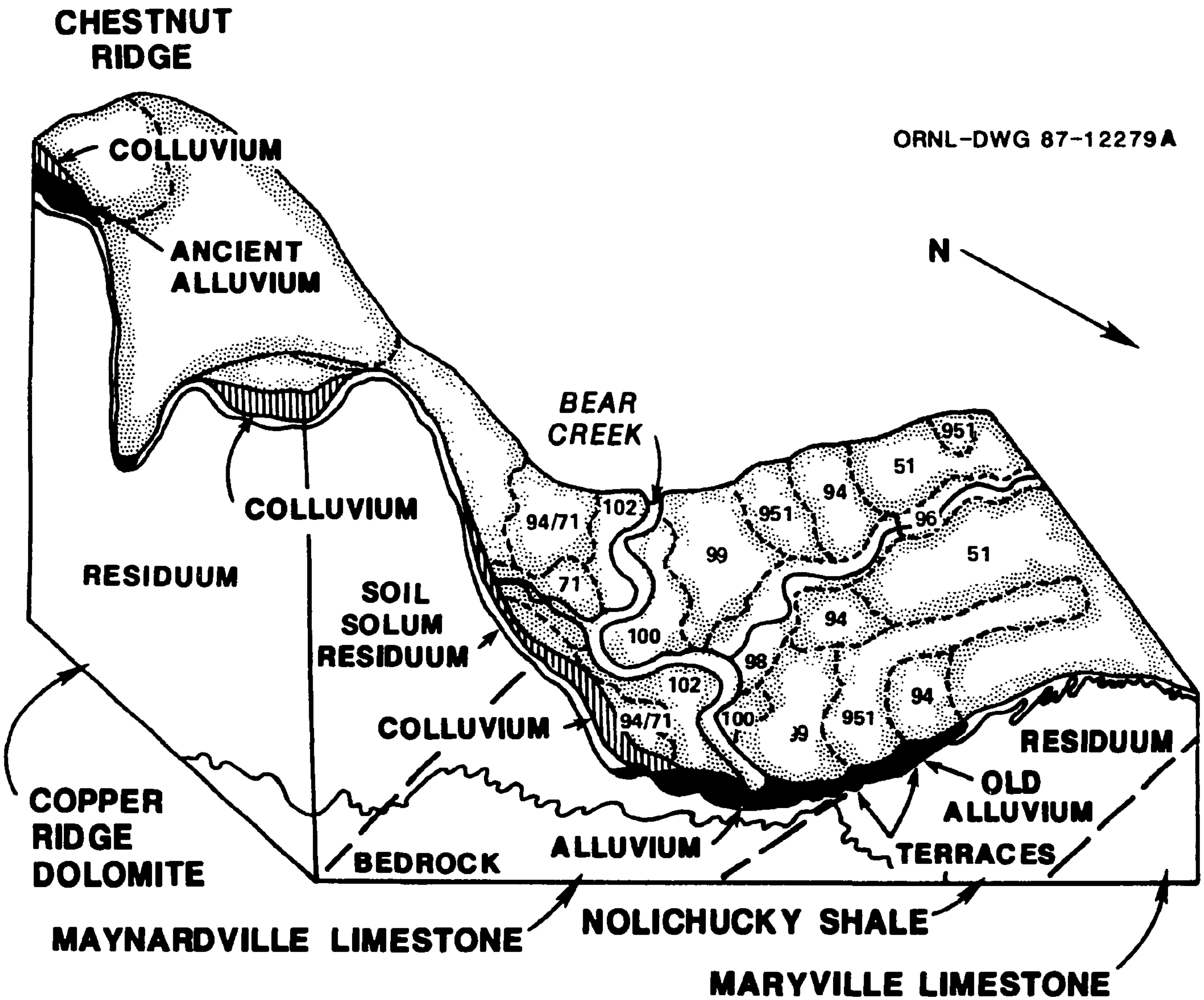

Fig. 8b. Diagram showing the generalized relationship between geology and soils on Chestnut Ridge to the Nolichucky contact.

of low toeslope colluvium by lateral stream cutting produces a deposit with characteristics of both colluvium and alluvium. The youngest colluvium on the site is of Modern age. It often occurs as fan deposits at the outlets of young gullies; it usually has a high content of relatively fresh rock fragments and very little expression of soil horizonation. The largest areas of young colluvium and alluvium are identified as Modern Alluvium in Fig. 5b. This soil material, in which soil horizons have not yet formed, has a very fresh appearance. It covers older soils and occurs as fans at the outlets of gullies and drainageways and at the base of cultivated slopes throughout the site.

4.2.2 Holocene Geomorphic Period

The next significant alteration of soils and landforms took place between ~4000 and 2800 years ago, a period of time in the Holocene defined as the neoglacial. Holocene-aged colluvium and alluvium are identified on the LLWDDD surficial geology map as Rome Colluvium, Pumpkin Valley Colluvium, and R-M-N Colluvium (Fig. 5b). Colluvium of Holocene age occurs (1) in doubly concave landform segments that occupy footslope and toeslope positions at the base of slopes, (2) as fans at the outlets of headwardly eroding drainageways, (3) on sideslopes in doubly concave elongated landform segments, and (4) in saddles between subdrainage basins on the site. Many of the colluvial landforms that were intensively used for agricultural activities were severely to extremely eroded with shallow to deep gullies common. However, the youngest Modern colluvium is preserved mostly in wooded areas or at the base of slopes where it was not cultivated. Holocene colluvium can overlie (1) in-place saprolite, (2) the remnants of older, truncated colluvial soils of earlier Holocene or Pleistocene age, or (3) the truncated remnants of residual soils. The largest acreage of colluvium exposed at the surface is of Holocene and late Pleistocene age.

Because erosional geomorphic processes are dominant at the LLWDDD site, the occurrence of older early Holocene and Pleistocene colluvium (and its associated older upland residual soils) is sporadic. The Maryville soil sampling pit (Fig. D-2) cuts through an old-colluvium-filled gully or drainageway. This colluvium, probably early to middle Pleistocene in age, has a bright red, high-clay-content subsoil as opposed to the yellow brown to yellow red subsoil of late Pleistocene and Holocene colluvial soils with a lower clay content. Topographic inversion has transformed most areas of early Pleistocene colluvial concave landforms into convex erosional landforms (Fig. 9). Not all areas of old colluvium were mapped, because the occurrence of this colluvium was difficult to predict and a lack of ground control made it difficult to map these very small areas. On-site evaluations are needed to locate these old colluvial soils, since they have very good ability to transmit water laterally. (The Maryville pit, which intercepted an old-colluvium-filled gully, was one of the few deep pits that consistently collected water after a short rain event.) The higher-sand-content member of the lower Pumpkin Valley Formation, with its higher permeability, was more stable during the Pleistocene and Holocene Epochs, so both the older colluvial soils and their related upland residual soils have been preserved at the surface. However, most of the oldest colluvium has been buried by younger colluvium. The early Holocene to late Pleistocene colluvium derived from the Pumpkin Valley and Rome Formations still occurs on footslope landforms, but the oldest Pleistocene-aged colluvium from the Pumpkin Valley Formation, which has also undergone topographic inversion, occurs on hillside and hilltop erosional landforms.

4.2.3 Pleistocene Geomorphic Processes

The climate shifts of the Pleistocene produced significant changes not only in the types of geomorphic processes that were active on the site, but also in the rates and intensities of these processes. Upland soils on the LLWDDD site underwent several cycles of denudation during the Pleistocene Epoch, generally corresponding to the times of maximum glaciation. Some areas of soils, especially those on steeper slopes, were periodically stripped down to hard rock or to hard saprolite, while other less geomorphically sensitive areas were hardly affected. The latest major episode of this activity probably occurred during the Wisconsinan, a period of several thousand years that ended ~12,000 years

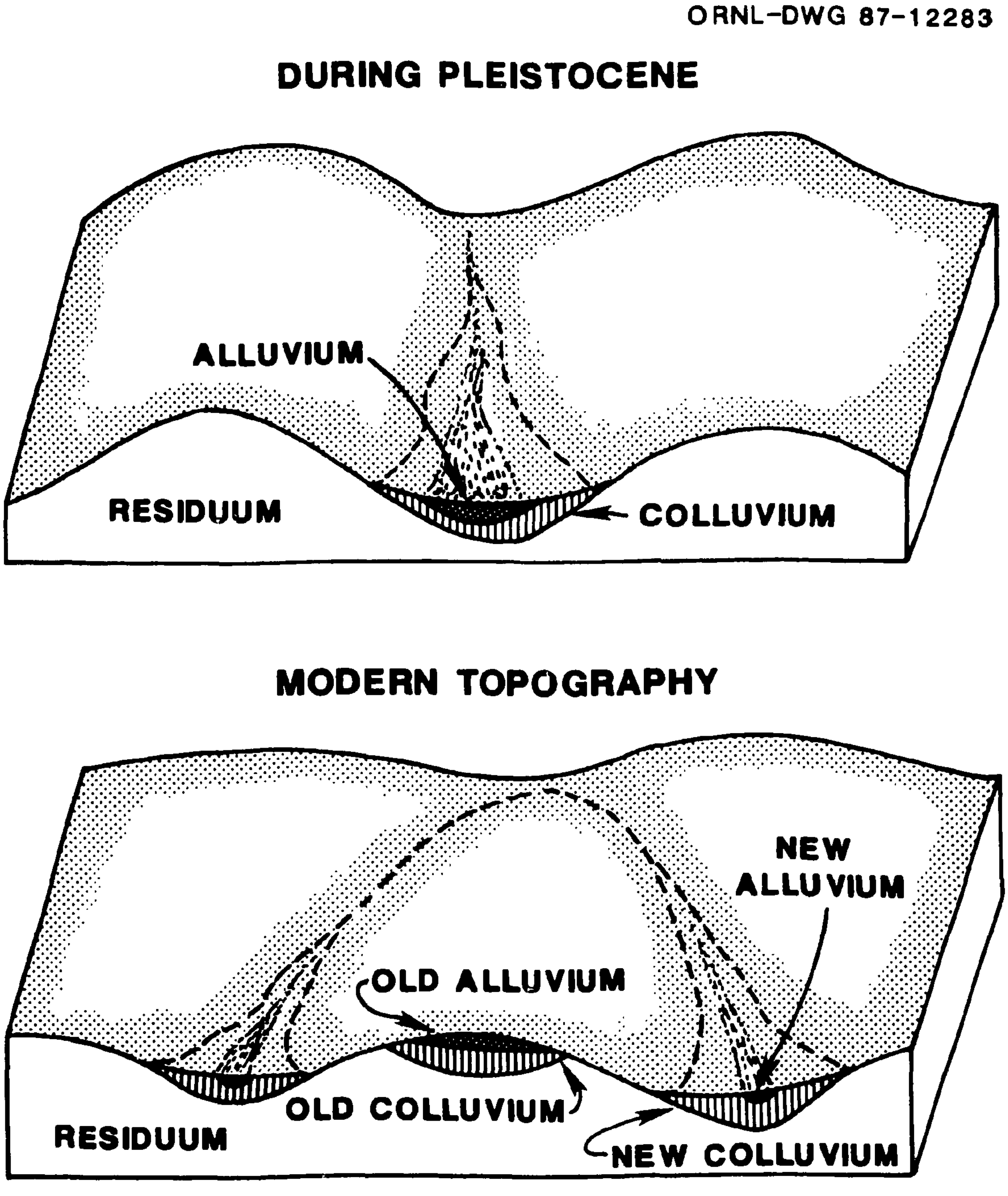

Fig. 9. Topographic inversion expressed on Pumpkin Valley residuum.

ago. The longest period of unstable soil conditions in the Wisconsinan occurred between 18,000 and 25,000 years ago when glaciers extended to their maximum. Numerous freeze-thaw cycles along with periods of deep soil freezing and spring thawing from the surface downward, which produce highly saturated soils, destabilized many upland soils. Large volumes of soil flowed downslope as mud and debris flows, filling topographic lows and choking stream valleys and river channels. Bear Creek apparently aggraded its floodplain, and the channel probably assumed a braided stream morphology when sediment production exceeded the sediment transport capacity of the stream. The Clinch River may also have been unable to transport the increased sediment and may have aggraded its channel, producing a widening floodplain with a braided stream and damming Poplar Creek and other Oak Ridge Reservation (ORR) tributaries.

The highest occurrence of alluvium on the site (identified as Old Alluvium in Fig. 5b) occurs at elevations of from 270 to 295 m, and is preserved only in nearly level saddle landform segments (Figs. 8a and 8b) or is buried beneath younger colluvium. The age of this highest alluvium is not known with certainty, nor is it certain if this highest alluvium is related in age to the much wider extent of old alluvium occurring at ~254 to 257 m. The alluvium mapped in SWSA-6 (No. 52 soil) also occurs at an elevation of from 254 to 257 m (Lietzke and Lee 1986). Laboratory and mineral-weathering analyses will be required to determine the time relationship between these two alluvial materials. Most areas of soils identified as old alluvium have similar morphology, except that the higher-elevation areas usually have some coarse fragments in the upper soil and the lower-elevation soils do not. The alluvium at higher elevations may grade down to the larger extent of alluvium at the lower elevation as a result of stream transport of sediment. When the Bear Creek floodplain in the LLWDDD site became choked with sediment, the stream was forced into other pathways through lower areas of the site (Fig. 5a). The evidence for this is the chert gravels and other stream-rounded gravels that overlie the residuum in these areas.

During the Pleistocene Epoch, at least three "stream piracy" events occurred within the site. (Stream piracy is defined in t' Dictionary of Geological Terms by the American Geological Institute as "the diversion of the upper part of a stream by the headward growth of another stream.") One important location is identified by the symbol "P" in Fig. 5a. Prior to the piracy, large amounts of sediment were deposited in an alluvial or deltaic fan that extends to the present-day Bear Creek floodplain. This deltaic fan is identified by the symbol No. 471 on the soil survey map (see Fig. A-1). After the piracy, stream sediments were diverted easterly to the stream's present channel, identified by the authors as "Gum Hollow Branch," which defines the eastern boundary of the site.

At the cessation of Wisconsinan glaciation, climatic changes produced upland soil stability, allowing streams to channelize, form meanders, and gradually remove accumulated sediments. As the Clinch River and one of its tributaries, Poplar Creek, started to carry out sediments faster than they were brought in, a terrace system was formed. The Clinch River continued its downcutting until the Tennessee Valley Authority's Melton Hill Dam and Watts Bar Dam were constructed. Bear Creek gradually reverted to its former floodplain. Continued removal of alluvium by downcutting and meandering formed the present-day Bear Creek floodplain, with its system of tributaries and low terraces. Remnants of higher and older terraces are preserved above the Holocene-aged low terraces. Some were exposed in Transects A-A' and B-B' (Fig. 5a). Bear Creek reached local base level at the LLWDDD site in the Pine Ridge water gap when hard sandstones of the Rome Formation were encountered. Bear Creek continues to downcut its channel through the hard sandstones of Pine Ridge and through the water gap farther downstream, located at the eastern tip of McKinney Ridge.

Bear Creek flows across the Rome Formation and all of the Conasauga Group, except the Maynardville Limestone where the stream turns a sharp angle and flows parallel to the strike of the limestone. The current Bear Creek channel is situated close to the southern edge of the floodplain, where it has been undercutting the rock sidewalls.

There are several places along Bear Creek where high-chert-content colluvial fans have forced the channel away from the south side. Chert from these fans, identified as Knox Colluvium in Fig. 5b, has been spread downstream over most of the floodplain, forming a cherty layer directly on hard rock or covering and thus preserving the remnants of an older alluvial or residual soil.

The geomorphic events and processes that took place during the Wisconsinan period of glaciation were but repetitions of similar events that took place during the Illinoian and Nebraskan glacial periods of middle and early Pleistocene time. Remnants of old terraces from these earlier Pleistocene events are preserved on the Chestnut Ridge area of the ORR, but apparently none are preserved on the LLWDDD site.

5. MAPPING UNIT DESCRIPTIONS*

5.1 ROME FORMATION

The Rome Formation consists of a wide variety of lithologies, including (1) a siliceous sandstone member, (2) a feldspathic very fine grained sandstone member, (3) a fissile maroon and gray shale member, (4) a maroon sandstone member, and (5) a pinkish-color iron-cemented micaceous-sandstone member, which are on the crest and south side of Pine Ridge on the LLWDDD site. These soils are defined by their morphology and the properties of the leached saprolite. The feldspathic fine-grained sandstone member is extensive enough in the Rome Formation so that weathering groups have been established. The No. 1 soil has a high sand content and also has an argillic horizon if there is a sufficient increase of clay in the B horizon. The No. 1 soils are on the south side of Pine Ridge and on the thick sandstone bed that marks the boundary between the Rome Formation and the Pumpkin Valley Formation. The No. 7 and No. 8 soils, formed in a fine-grained feldspathic sandstone with higher feldspar content, have well-defined and expressed argillic horizons, which the No. 1 soils generally lack. Depth to hard saprolite is usually more than 100 cm in the No. 7 soils and between 50 and 80 cm in the No. 8 soils.

5.1.1 Rome Residuum

1E, -F. The soils in these map units classify as Typic Hapludults;† sandy or coarse-loamy, mixed, thermic; and Typic Udipsamments; mixed, thermic. They formed in the saprolite residuum of fine-grained yellowish feldspathic sandstone, which is assumed to have been cemented by calcium carbonate. This observation is based on the kinds of tree species growing on these soils, trees that require

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*Refer to the soil map (Fig. A-1 in Appendix A) for locations of all delineations that comprise each map unit.

†For an explanation of taxonomic terms, see Appendix A.

moderate amounts of calcium, such as white oak and flowering dogwood. Most areas of these soils occur on the south side of Pine Ridge on linear and convex sideslopes between the summit knobs and the first bench landform. Rainfall infiltrates rapidly and percolates downward through the joint and fracture system. There is little evidence of overland flow from these soils. These soils form a weathering sequence with the No. 7 and No. 8 soils. They are the least developed member of this sequence.

4E. The soils in this map unit classify as Typic and Ochreptic Hapludults; coarse-loamy, mixed or siliceous, thermic. They formed in yellowish brown, yellowish red, and whitish fine- and medium-grained sandstone saprolite with fragments of hard, white or reddish sandstone littering the surface. These soils occupy the crested knobs and shoulder areas of Pine Ridge. One sandstone unit is a yellow red medium sand. Also included are bands of a hard maroon sandstone interbedded with a maroon and gray fissile shale (No. 3 soils that are too small in extent to map) and feldspathic fine-grained sandstones of the No. 1 to No. 8 weathering sequence. Vegetation on these soils is mostly oaks, hickories, and pines, which tolerate droughty and acid soils. Rainfall infiltrates easily, and there is little evidence of overland runoff. Water seems to readily percolate downward through the joint and fracture system, and the upper soil is well oxidized throughout. (Note: This map unit is "undifferentiated" because of the great variety of parent materials and soils. This map unit occupies a specific landform: the central ridge and the upper-ridge shoulders, sideslopes, and saddles of Pine Ridge.)

7C, -D, -E. The soils in these map units classify as Typic or Ochreptic Hapludults; fine-loamy, mixed, thermic. Depth to paralithic materials or the Cr horizon is usually >100 cm. The saprolite is a light yellowish brown. The Bt horizon has 10YR or 7.5YR hues, a texture of loam or clay loam, and a strong grade of subangular blocky structure. Thicker Bt horizons tend to have higher clay content. Most areas of these soils occupy the summits and upper sideslopes of Pine Ridge and secondary ridges north of Pine Ridge. Included on steeper slopes are areas where the depth to the Cr horizon is less and the soil horizons above are less strongly developed (No. 8 soils of the Bear Creek soil survey, for example). Because of the good subsoil structure, rainfall infiltrates rapidly and readily percolates downward through the joint and fracture system beneath.

5.1.2 Rome Colluvium

15D, -E. The soils in these map units classify as Typic Hapludults; fine-loamy, mixed, thermic. These soils formed in colluvium >50-cm thick but often 100- to 200-cm thick. These soils occupy bench landforms high on the south side of Pine Ridge at the contact between the Rome Formation and the Pumpkin Valley Formation of the Conasauga Group. These soils have a well-expressed morphology, with a well-defined loamy very fine sand E horizon and a 7.5YR-hue loam or clay loam Bt horizon. Coarse fragments range from few to common and consist of hard sandstone. The bench collects soil materials which gradually move downslope from higher residual soils and which are already weathered. Consequently, once stability is reached, soil development can occur quite rapidly. These soils, because of their depth and particle-size distribution, have the capacity to store considerable water and then release it gradually into lower horizons and the joint-fracture system of the underlying rock, thus contributing to the summer base flow of streams. As a result of their water-storage capability, these soils generate little overland runoff. These and other colluvial soils on the LLWDDD site are hydrologically important.

5.2 CONASAUGA GROUP

5.2.1 Pumpkin Valley Formation

The No. 21, No. 22, and No. 23 soils form a weathering sequence on the lower member of this formation, which contains a high content of interbedded glauconitic fine-grained sandstone and siltstone. The degree of weathering and amount of soil development is dependent on whether water tends to run off or to infiltrate. Infiltration in these soils and their associated landforms is dependent not only on the slope gradient but also on the width and convexity of the sideslope and on the underlying rock's joint and fracture network. Even though slope classes overlap for these soils, the landform width and convexity are different. Most areas of the No. 21 soils on E slopes are generally on 25 to 35% slopes; most of the No. 22 soils on E slopes have slopes of 35 to 45%. The No. 22 soils also occur on lower-gradient landforms where interfluves are narrower and more convex. Most areas of the No. 23 soils are on >45% slopes. If the areas are on less steep slopes, then the landform, usually a spur ridge, is narrow and highly convex.

5.2.1.1 Pumpkin Valley Residuum

21D, -E. The soils in these map units classify as Typic Hapludults; clayey, mixed, thermic. These soils formed in interbedded glauconitic sandstone and siltstone saprolite of the lower Pumpkin Valley Formation and occur on broad convex landforms on the lower southern slopes of Pine Ridge. The argillic horizon has a strong structure, hues of 2.5YR to 7.5YR, and a texture of clay loam to clay. Depth to the Cr horizon is from 50 to 100 cm, but some areas are deeper than 100 cm. These soils evidently formed in rock that was initially low in calcium carbonate, since the tree species that grow on these soils can tolerate acidic infertile soils and are evidently unable to tap into any calcium carbonate at depth. Very few white oak or dogwood trees grow on any of the Pumpkin Valley soils. Water readily infiltrates these soils and flows downward through the Bt horizon. However, the upper part of the Cr horizon saprolite is plugged by clay. During heavy or prolonged rainfall, water perches in the lower subsoil, producing a variable reducing environment. Once water perches and the soil above becomes saturated, there is subsurface lateral flow in the E horizon at its contact with the Bt horizon below. These soils have produced colluvial soil material in the past whenever the upper A and E horizons of the soil become so overly saturated that stability is lost.

22D, -E. The soils in these map units classify as Typic or Ochreptic Hapludults; clayey or fine-loamy, mixed, thermic. These soils formed in interbedded glauconitic sandstone-siltstone saprolite of the lower Pumpkin Valley Formation, where they occupy narrower, steeper, or more convex landforms on the lower slopes of Pine Ridge. The argillic horizon has a strong structure and 5YR to 10YR hues. Depth to the Cr horizon is generally <50 cm. Areas of these soils on F slopes have a generally (1) shallower depth to paralithic materials, which impedes both root penetration and proliferation, and (2) less downward water movement and more overland and subsurface lateral flow. Vegetation on these soils consists of mixed hardwoods with very few white oak and dogwood, an indication of low calcium carbonate content in deeper saprolite layers. These soils generate more overland flow because of the greater convexity of the landform. However, there is less clay plugging of the uppermost saprolite zone below the level where paralithic materials occur.

23F. The soils in this map unit classify as Typic Dystrochrepts; loamy-skeletal, mixed (glauconitic), thermic. These soils formed in glauconitic sandstone-siltstone saprolite of the lower Pumpkin Valley Formation. They occupy steep sideslopes of drainageways cutting headwardly into and through the Pumpkin Valley Formation on the south side of Pine Ridge. Overland runoff on these steep slopes has removed soil from the surface almost as fast as the underlying rock has weathered to soil. These soils have a very high erosion potential in their natural forested state. Clearing would increase the erosion hazard as well as the rate of downslope movement of soil material by gravity, as creep or solifluction in a moist state or as mud or debris flows in a saturated state. Vegetation on these soils is rather sparse on southerly aspects and somewhat better on northerly aspects. Vegetation suffers drought stress cycles during most of the summer because of the limited volume of soil above paralithic materials, a condition which impedes root penetration and proliferation. During the summer heat and drought of 1986, there was premature leaf drop from trees growing on these soils. These soils are hydrologically important because they generate rapid overland or near-surface lateral flow during storm events.

24B2, -C2, -D, -D2, -D3. The soils in these map units classify as Ruptic Ultic Dystrochrepts; clayey (Bt argillic horizon) and loamy-skeletal (cambic horizon), mixed, thermic. These soils formed in "violet" shale-siltstone-very fine grained sandstone saprolite of the upper Pumpkin Valley Formation, which contains abundant glauconite. Some areas that were cultivated in the past are now severely eroded. If they are maintained in short-term pine rotation, recent bulldozing activities to clear slash have increased the erosion problem. The time that elapses between the clearing of the land and the time the trees become large enough or the time weedy ground cover finally closes over the soil surface causes these soils to have a very high erosion potential. Many of these soils are eroded to very severely eroded, and the areas have lost most of their soil, so the Cr horizons are close to the surface. Where paralithic materials are exposed on the surface, there are sparse trees, poor tree growth, and very little ground cover; the soil surface is left nearly bare and subject to constant erosion. Most areas of these soils on C and D slopes were cultivated in the past. Only a few small areas on steeper D slopes were not cultivated; these currently support a mixed stand of hardwoods. Because of past erosion, these soils have lost most of their capacity to retain rainfall. Consequently, they probably now generate more overland or near-surface lateral flow; little water percolates downward into deeper saprolite layers. Two pits were located in areas of these soils for characterization purposes. Descriptions and photographs are presented in Figs. D-5 and D-6 in Appendix D.

5.2.1.2 Pumpkin Valley Colluvium

The following sequence of No. 25, No. 26, and No. 27 soils constitutes a time and lithosequence. The No. 25 soils are the oldest and formed primarily in Pumpkin Valley colluvium. The No. 25 landforms have undergone topographic inversion, so most areas of the No. 25 soils occupy topographically high landform positions that are now erosional rather than depositional landforms. The younger No. 26 soils still occupy recognizable footslope and toeslope depositional landforms, although younger drainageways are already starting to incise some of these landforms. This activity represents the beginning of a new cycle of topographic inversion. The No. 26 soils formed on a mixture of Pumpkin Valley and Rome colluvial materials, but the harder, coarse fragments are dominated by Pumpkin Valley materials and occupy the largest extent of the Pumpkin Valley colluvial units. The youngest No. 27 soils were formed in colluvium dominated by Rome-derived coarse fragments. Most areas of these soils blanket the No. 26 soils. They also occupy young fan landforms of drainageways that have been actively cutting into the Rome. The No. 27 soils probably have a thin, younger layer of recent sediment eroded from agricultural areas or from clear-cut areas in forests, but based on soil morphology and degree of horizonation, the bulk of the soil was probably transported and deposited during the neoglacial period (~2800 to 4000 years ago). The youngest age of the No. 26 soils is probably late Wisconsinan (~18,000 to 25,000 years ago). There seems to be a large hiatus between the No. 26 and No. 25 soils, based on soil morphology, and more importantly, on topographic inversion. The youngest age of the No. 25 soils is assumed to be middle or early Pleistocene (~1 to 2 million years ago.)

25B2. The soils in this map unit classify as Typic Hapludults; clayey, mixed, thermic. They are the oldest of the Pumpkin Valley colluvial units. Most areas of these soils are on broader uplands underlain by the No. 20 or No. 21 soils and are not related to present colluvial landforms. These soils have a Bt horizon with the reddest hue (2.5YR) and highest clay content of any Pumpkin Valley colluvial soils; they are probably some of the oldest soils on the LLWDDD site. These soils contain mostly Pumpkin Valley fragments, but have some Rome sandstone gravels. It is presumed that this old colluvium was deposited before headward-eroding drainageways reached the Rome sandstones. Subsequent topographic inversion has placed most areas of these soils on what are now erosion surfaces. Some areas of No. 25 soils have been covered by younger sideslope colluvium of the No. 26 soils and are preserved. These soils are important in that they tend to generate very little overland runoff. Most rainfall enters the soil and continues downward where it contributes to summer base flow in streams.

<u>26B, -C, -C2, -D, -E</u>. The soils in these map units classify as Typic Hapludults; clayey or fine-loamy, mixed, thermic. These soils formed in older colluvium, usually with two or more discontinuities. Depositional landforms are still recognizable as doubly concave footslopes, but many have been incised by drainageways or partially covered by No. 27 soils. These soils have Bt horizons, with 10YR and 7.5YR hues, and a texture of loam or clay loam. They have one or two discontinuities where No. 26 colluvium overlies a truncated No. 25 soil or a truncated residual soil. Discontinuities in soils produce conditions for temporary water perching, and more importantly, for lateral subsurface transmission of water. Most areas of these soils were in cultivation at the time of the AEC takeover and are currently maintained in pine plantations. The apparent reason for the lack of severe erosion compared with similar Nolichucky landforms, for example, is that these soils generate very little overland runoff. Their depth, good structure, and porosity do not produce saturated conditions near the surface, except in severe events, which allows most rainfall to infiltrate. These soils contribute to stream base flow during periods of low rainfall.

<u>27B, -C, -D, -D2, -E</u>. The soils in these map units classify as Typic Hapludults; fine-loamy or loamy-skeletal, mixed, thermic. These soils formed in the youngest of the Pumpkin Valley colluvial units. The uppermost colluvium contains abundant Rome fragments. These soils occur on typical toeslope landforms and, if sufficiently thick, contain several discontinuities. Some lower areas are covered with Modern alluvial No. 98 soils. The underlying paleosol is No. 26 soil. Most

areas of these soils are not severely eroded, because they have favorable properties that allow for good internal throughflow transmission of water. These soils tend to move water laterally because of rock-fragment orientation generally parallel to the slope. These soils have a high coarse-fragment content in the uppermost soil horizons; the underlying No. 26 paleosol typically has a lower coarse-fragment content. These soils also have a Bt horizon in 10YR to 7.5YR hues and have gravelly to very gravelly loam textures.

26/951C3. The soils in this map unit classify as Typic Hapludults; fine-loamy, mixed, thermic. The No. 26 soil profile is underlain by No. 951 alluvium, which is underlain by No. 24 Pumpkin Valley glauconitic siltstone and sandstone saprolite. The extent of this soil is not known, because its occurrence cannot be predicted with any certainty. The identified delineations on the soil survey map have scientific interest in the geomorphic analysis of the area. For example, a pit that was dug for a delineation (see Fig. D-8 in Appendix D) exposed all three parent materials. Samples were then collected for characterization and comparison with similar soils that had not been buried.

5.2.2 Rutledge Formation

The Rutledge Formation in the LLWDDD site consists of (1) shale and siltstone with a of relatively high calcium carbonate content and (2) limestone beds. Most of the Rutledge Formation with high limestone content has been covered by alluvium and colluvium. However, there are four areas on the LLWDDD site where the Rutledge Formation is dominated by siltstone and shale. These less permeable areas were more resistant to erosion or saprolite collapse and are exposed at the surface.

5.2.2.1 Rutledge Residuum

30B2, -B3, -C2, -C3, -D3. The soils in these map units classify as Ruptic Ultic Dystrochrepts; clayey (Bt argillic horizon) and loamy-skeletal (cambic horizon), mixed, thermic. These soils formed in yellowish-, grayish-, reddish- and olive-hued shale-siltstone low-glauconite saprolite, weathered from calcareous rocks of the

Rutledge Formation on the site. These soils occur between the No. 24 soils and the Rogersville Formation. The saprolite under these soils has variable permeability, depending on whether the saprolite is claystone or a siltstone. Water tends to perch in the upper part of the paralithic materials and extends up into the lower subsoil, where drainage mottling is evidence of a fluctuating water table. Nearly all areas of these soils are moderately to severely eroded, not only from past agricultural activities but also from more recent forest management practices. Some smaller areas are very severely eroded and can be identified by very sparse ground cover and bare soil surface. Most areas of these soils are now in pine plantations. These soils are hydrologically important because they rapidly generate high overland flow during storm events. Bare soil areas also generate high amounts of sediment during storms.

5.2.3 Rogersville Formation

The No. 35, No. 36, and No. 37 soils form a weathering sequence on the Rogersville Formation, with No. 35 soils having the least development and No. 37 soils the most. The No. 35 and No. 36 soils occupy most of the surface; No. 37 soils are very limited in extent due to a lack of stable surfaces and low-gradient slopes.

5.2.3.1 Rogersville Residuum

35E, -F. The soils in these map units classify as Typic Dystrochrepts; loamy-skeletal, mixed, thermic, shallow. These soils occur almost exclusively on steep north and northeast aspects below Maryville ridgetops. The saprolite beneath the soil solum ranges from gray to pinkish-color siltstone and claystone and commonly contains glauconitic strata. These soils, because of the steep slopes on which they occur, generate overland flow that removes surface soil material almost as fast as the underlying rock weathers to form soil. Thus, these soils are kept in a near steady state of youthfulness. Most areas of these soils have been logged. Some areas were pastured, but little accelerated erosion from past activities was observed. Current vegetation consists of hardwoods.

36B, -D, -D3 -E, -E3, -F. The soils in these map units classify as Ruptic Ultic Dystrochrepts; fine-loamy or clayey (argillic horizon) and loamy-skeletal (cambic horizon), mixed, thermic. These soils comprise the largest areal extent of the Rogersville Formation. They occur on summits and sideslope landforms. Severely eroded areas have lost most or all of their diagnostic features, and their morphology is either Typic Dystrochrepts (No. 35 soils) or very shallow Udorthents. These soils, depending on past and current land use, have hardwood vegetation in undisturbed areas--a mixture of hardwoods, Virginia pine and cedars of old field successional areas, or planted pine trees. Because of the shallow soil solum, these soils do not have much water-retaining capacity, so overland flow or near-surface lateral flow is common, especially on dip slopes. The rougher rock surface of obsequent slopes allows for longer water residence time and, therefore, more water enters the saprolite and moves downdip along planar surfaces and through joints and fractures. Two pits (Figs. D-3 and D-4) were located in these soils for characterization purposes.

37B2, -B3. The soils in these map units classify as Typic Hapludults; clayey, mixed, thermic. These soils formed in steeply dipping Rogersville shales and siltstones. They have a continuous Bt horizon of variable thickness. The Bt horizon has a yellow brown to strong brown color of 10YR and 7.5YR hues, in contrast to the 5YR and 2.5YR hues of Maryville Bt horizons. Depth to the Cr horizon is also highly variable, ranging from <50 to >100 cm. These soils, of limited extent, occur only on gently sloping upland summits that were cultivated in the past. Present-day vegetation is mixed hardwoods, pine, and cedar, which is typical of old field plant succession.

5.2.4 Maryville Formation

The No. 40, No. 42, and No. 43 soils form a weathering sequence on the Maryville Formation. The No. 40 soils occupy gently sloping and stable landforms, are the most weathered, and have a deeper solum that has stronger horizonation and a continuous clayey Bt horizon of a 2.5YR hue. The No. 42 soils occur on steeper slopes or on landforms with more convexity. These soils have been periodically stripped of their upper soil horizons so that, along a trench sidewall, the Bt horizon is interrupted by either a cambic Bw horizon or by a C or Cr horizon of saprolite materials. They are considered to be moderately weathered. The No. 43 soils occur on the steepest and most convex landforms. They have no Bt horizon except in a few deep pockets. Soil solum thickness is usually <50 cm, but may be as little as 10 cm. They are considered to be the least weathered. The Maryville Formation contains more calcium carbonate than the Pumpkin Valley, Rogersville, or Nolichucky Formations. As a result, hardwood tree growth appears to be better, of higher density and, most importantly, the trees are white oak and tulip poplar with an understory of flowering dogwood, which indicates that oak and poplar tree roots are in contact with calcium even though the soil solum (below the A horizon) and the upper leached saprolite zone are extremely acid and leached.

5.2.4.1 Maryville Residuum

40B. The soils in this map unit classify as Typic Hapludults; clayey, mixed, thermic. These soils formed in strongly weathered Maryville saprolite. The soils have a Bt horizon with a 2.5YR hue; the underlying upper saprolite horizons are tightly plugged by clay. These soils occur on broad, upland summits with little convexity and on gentle, lower sideslopes in areas of steeper topography. Most areas of these soils were not cultivated because of their small extent or inaccessibility. Some areas that were cultivated are now severely eroded and have morphological characteristics similar to the No. 42 soils (except for the presence of 2.5YR clay, which plugs voids in the upper saprolite). The saprolite under these soils is more weathered and softer than that under the adjacent No. 42 and No. 43 soils. Clay, iron, and manganese are being translocated downward in these soils. Some clay at depth is probably neo-formed from solution. Limestone strata in the deeper unleached saprolite zone are filled in with manganese, and either neo-formed or translocated clay (as calcium carbonate) is removed so that collapse does not occur. In fact, the addition of swelling clay tends to increase the original volume. It is not unusual to find good pedogenic structure and tree roots deep in the soil in these particular more weathered zones that are bracketed by less weathered, unleached saprolite. These soils, because of the greater solum thickness, tend to retain more water, so there is less overland runoff generated by most storm events. However, clay plugging in the upper saprolite reduces permeability so that water perches during prolonged storms and during the winter wet season. It is during these wet periods that the soil becomes saturated, subsequently generating overland or near-surface lateral flow of water.

42B, -B3, -C, -C3, -D, -D3. The soils in these map units classify as Ruptic Ultic Dystrochrepts; clayey (Bt argillic horizon) and loamy-skeletal (Bw cambic horizon), mixed, thermic. These soils occur on narrow summits and on upper and middle sideslopes with considerable convexity. They are the soils of largest extent that are underlain by the Maryville Formation. They formed in moderately weathered saprolite of the Maryville Formation and have an intermittent clayey Bt horizon that has 2.5YR to 5YR hues. Siltstone and claystone fragments in the solum and upper saprolite have hues ranging from 10YR to 2.5YR. Depth to paralithic (Cr horizon) materials is highly variable, ranging from <10 to >100 cm over short distances. Areas of these soils that were not cultivated support good stands of northern hardwoods, including white oak and its understory of flowering dogwood as well as some white pine. This observation is surprising, given the relatively shallow solum depth and surface acidity. However, deep-rooted trees have pumped nutrients to the surface where they are recycled by the forest vegetation. Where these soils have been cultivated in the past without any, or with minimal additions of, lime and fertilizer, erosion has stripped off this higher-pH and nutrient-rich surface A horizon, thereby greatly impoverishing the soil. Based on observations made during mapping, these eroded soils apparently do not support the tree species at the same density as do uneroded soils. Both severely and very severely eroded areas of these soils are mostly in short-term pine rotation and have ongoing erosion problems. Continued pine rotation will deplete near-surface plant nutrients to the extent that weedy ground cover will not adequately cover the soil, thus increasing the rate of soil erosion. In addition, short-term pine rotation does not allow for a deep penetration of roots to tap calcium supplies, and large pine tap roots cannot easily penetrate paralithic saprolite. Both severely eroded and smaller areas of very severely eroded soils have lost most of the solum; the soils in these areas have morphologic properties similar to No. 43 soils, with the exception of reddish clay flows in the saprolite that were translocated from a Bt horizon. Figure D-2 in Appendix D shows this soil.

43D, -D3, and -E, -F. The soils in these map units classify as Typic Dystrochrepts; loamy-skeletal, mixed, thermic. These soils occur (1) on steep sideslopes of drainageways that are cutting headwardly through the Conasauga Group or (2) on highly convex shoulders and sideslopes of spur ridges with lower slope gradient. Most E and F slope areas are located on northeast and east aspects on obsequent slopes. These soils have a thin solum, usually <50-cm thick, above paralithic materials. The saprolite directly beneath the solum usually has 2.5Y to 5Y hues, or, if more weathered, has 2.5Y to 10YR hues. Because of the shallow solum, these soils do not retain much rainfall. As a result, they generate considerable overland or near-surface lateral flow during many storm events. Overland flow has removed soil particles from the surface almost as fast as soil is formed by the weathering of the underlying rock. Consequently, these soils are kept in a near steady state of youthfulness. Vegetation on these soils consists of oaks and hickories. Poison ivy also grows very well in most areas of these soils due to a more open canopy and a higher nutrient status.

5.2.5 Nolichucky Formation

The Nolichucky Formation can be readily identified by the oxidized brown or pinkish brown color of the claystone and siltstone saprolite. In contrast to the adjacent more permeable Maryville Formation, geomorphic processes of erosion and denudation do not result in the formation of high hills and steep slopes in the less permeable Nolichucky Formation. The lower permeability of this formation may have allowed for higher overland runoff and consequently for more equal denudation over the entire landform; and, perhaps, past freeze-thaw cycles were more effective in reducing hilltop elevations. Part of the answer may also lie in the observation that many areas of the Nolichucky Formation were periodically covered by alluvium during the Pleistocene. The presence of alluvium and the occasional rounded river slick on these broad landforms and in saddle divides, where evidence of past geomorphic activity has been preserved, provides evidence of past stream erosion and deposition. Landform configuration and saprolite color were the primary distinguishing characteristics used to locate the surface boundary zone between the Maryville and Nolichucky Formations.

The following No. 50, No. 51 and No. 52 soils form a weathering and drainage sequence on this site.

5.2.5.1 Nolichucky Residuum

50B, -B3. The soils in these map units classify as Ruptic Aquultic Dystrochrepts; clayey (Bt argillic horizon) and loamy-skeletal (Bw cambic horizon), mixed, thermic. These soils are on lower sideslopes where overland and subsurface lateral waterflow from higher areas keeps the lower part of the soil wet during winter and spring. The upper part of the Cr horizon is usually plugged by gray clay. These soils are limited in extent because they are usually covered by colluvium, except at the base of long slopes where colluvial materials have been deposited farther upslope.

51B2, -B3, -C3, -D3. The soils in these map units classify as Ruptic Ultic Dystrochrepts; clayey (Bt argillic horizon) and loamy-skeletal (Bw cambic horizon), mixed, thermic. These soils occupy summits and upper, middle, and lower sideslopes. Because of their favorable topography, they were probably once intensively cultivated. Most areas, even on gentle slopes, were severely eroded. Because of the past erosion, many borings of these soils have the morphologic characteristics of Typic Dystrochrepts, but the underlying saprolite contains abundant clay flows that have been translocated from a Bt horizon. These soils have an intermittent clay-enriched subsoil horizon with colors of 10YR and 7.5YR hues. Present forestry management practices have continued to cause soil erosion. The current vegetation consists mostly of pine plantations or poor scrubby hardwoods. White oak, with its flowering dogwood understory, is a rare occurrence on these soils. Because of the lower calcium carbonate content of the unleached saprolite, along with the very acidic solum and leached saprolite, deep tree roots evidently do not contact much calcium; thus, the current hardwood vegetation is tolerant of both the low-nutrient and extremely acidic conditions in the upper several feet of soil and saprolite. Due to the relatively impermeable nature of the saprolite, these soils generate high amounts of either overland water flow or near-surface lateral flow during most storm events. The upper soil layers become saturated readily and tend to move down gentle slopes quite readily because of their high silt and clay content. The soils in these map units occupy the largest acreage in the area underlain by the Nolichucky Formation. A soil pit for characterization is located in these soils. [A description and photograph of the soil profile (Fig. D-1) are provided in Appendix D.]

52B2, -B3. The soils in these map units classify as Typic Hapludults; clayey, mixed, thermic. These soils occur on gentle slopes throughout the Nolichucky Formation, but are most common in the upper portion of the Nolichucky Formation, which contains a higher proportion of saprolite weathered from argillaceous limestone. These soils have a reddish yellow, clayey Bt horizon. The leached saprolite beneath is soft, highly weathered, and plugged by clay in the upper part. Many areas of these soils were, at one time, covered by No. 951 alluvium, which has been exhumed. A thin smear of alluvium, <50-cm thick, remains in some places below elevations <257 m. Nearly all areas of these soils were cultivated and were severely eroded. Most areas are currently used for pine plantations.

5.2.6 Maynardville Formation

The Maynardville Formation on the LLWDDD site has three members, two of which have surface exposure. The lower member has intermittent surface expression; it consists of argillaceous limestone interbedded with clay shale and may be considered the boundary zone between the Nolichucky Formation and the Maynardville Formation. Distinctive soils, of limited and sporadic distribution, formed in this member. The middle member consists of high-calcium-carbonate-content limestone whose residue contains some smectite, vermiculite, and manganese oxides, but very little iron oxide. Most soils of this member are buried under Bear Creek alluvium and low-terrace soils. The upper member is evidently a transitional zone of limestone, dolomitic limestone, and dolomite that interbeds with the lower Knox Group's Copper Ridge Formation, and may be considered the gradational boundary zone between these two formations. This member has a high iron content, but very little chert. It weathers to form a red clayey soil, even though rock outcrops are common. No soils of this member are exposed on the LLWDDD site because they are buried by colluvium and alluvium derived from surficial Knox soils.

5.2.6.1 Maynardville Residuum

55B3, -C3. The soils in these map units are classified as Typic Hapludults; clayey, mixed, thermic. These soils occur in the transition zone between the Nolichucky and Maynardville Formations and in the upper Maynardville Formation. They weathered from argillaceous limestone and calcareous claystone. The soils are deeply weathered and are >1.5 m to hard rock. The hues of the very sticky clay Bt horizon range from 5YR to 7.5YR. Most areas of these soils were once covered by streams and No. 951 alluvium. Subsequent erosion has removed most of the evidence of the past burial and present exhumation. [See the interpretation of the telephone line trenches (Fig. B-4) in Appendix B and Transect A-A' (Fig. C-1) in Appendix C for an explanation of the geomorphic history of these and adjacent Nolichucky soils.] Because of the favorable topography and the initial characteristics of the uneroded soil, these soils were all cultivated and became severely eroded prior to the AEC takeover. The present vegetation consists of planted pines. Erosion continues under current forest management practices, which includes the windrowing of slash. Most areas of these soils have clayey subsoil exposed at the surface; severely eroded places are devoid of vegetation and small gullies are forming. Water cannot easily infiltrate the clayey surface layers of these soils; consequently, they generate high amounts of overland runoff and sediment. These soils are included in the Maynardville Formation because they have characteristics that are typical of soils that form in limestone saprolite rather than in the shale and siltstone saprolites of the Nolichucky Formation.

56B. The soils in this map unit classify as Typic Hapludalfs; fine, mixed or montmorillonitic, thermic. These soils formed in thin residuum of high-carbonate-content limestone. The Bt horizon has a 10YR hue, a high clay content, and is very sticky due to the vermiculite and smectite it contains. Depth to limestone is from 50 to 100 cm, but outcrops are abundant. These soils were more deeply covered by alluvium in the past, but most alluvium has been removed by the erosional processes of Bear Creek and its Holocene meander system. Most areas of these soils were too rocky to cultivate, but they were probably pastured. Current vegetation consists of cane and scattered hardwoods, including tulip poplar and walnut.

5.2.7 Rogersville-Maryville-Nolichucky (R-M-N) Colluvium

The soils that formed in colluvial materials which washed and rolled downslope from the Rogersville, Maryville, and Nolichucky Formations have similar morphologic characteristics, including shale and siltstone fragments and high silt content. Therefore, they were grouped together when the LLWDDD site was mapped. Most of the colluvial soils on the site could be identified according to the origin of the parent material. The Rome and Pumpkin Valley colluvial soils have different assemblages of rock fragments and a high content of very fine sand. Colluvium from the Rome Formation and the Pumpkin Valley

Formation was intercepted by drainageways in the Rutledge topographic low and did not extend onto and through the Rogersville, Maryville, and Nolichucky Formations (with one exception: the No.471 deltaic fan or fan terrace, which contains fragments and soil from the Rome and Pumpkin Valley soils and saprolites).

47B, -C, -C3, -D, -E. The soils in these map units classify as Typic Hapludults; fine-loamy, mixed, thermic. These soils are on toeslopes and fan terraces. They usually have one or more lithologic discontinuities, but there is little evidence of perched water at lithologic contacts unless the truncated remains of a clayey, argillic horizon in the buried paleosol are present. Erosion during the Pleistocene Epoch evidently stripped off most of the preexisting soil before deposition of this colluvium began. These soils are roughly equivalent to the Pumpkin Valley No. 26 colluvial soils in degree of soil development in the upper profile. Below the lithologic-time discontinuity, there is either an older colluvium or the truncated remains of a residual soil. These soils are most common on the Maryville Formation, but they also occur on the Rogersville Formation and the Nolichucky Formation. Most areas of these soils occur in first-order drainageways and the the sideslopes of these drainageways. Many areas have been partially covered by recent colluvium and local slope-wash alluvium produced by the cultivation of adjacent higher landforms. Included in mapping are small and scattered areas of a younger colluvium similar in age to the Pumpkin Valley No. 27 colluvial soils but only ~50-cm thick. The Rogersville Formation and the upper Conasauga Group evidently did not generate as much colluvium as the higher and more dissected Pumpkin Valley and Rome Formations during the neoglacial episode. Most areas of these soils were cultivated in the past, and most are now in pine plantations. Because these soils have favorable physical properties, including relatively low clay content and good porosity, they have not been severely eroded in the past. These soils have properties that permit infiltration and retention of rainfall, much of which percolates downward or flows laterally and contributes to stream base flow.

471B2, -C, -C2, -C3, -D, -D2. The soils in these map units classify as Typic Hapludults; fine-loamy, mixed, thermic. These soils formed in paleo-Gum Hollow colluvial-alluvial fan materials that contain Rome and Conasauga fragments. They have gravelly textures and are similar to the No. 47 soils in subsoil color and texture, yet have more strongly developed horizonation. These soils are roughly equivalent in age to the Pumpkin Valley No. 25 colluvial soils and are also equivalent in age to the No. 49 soils described later in this section. The source stream watershed that delivered the sediments was cut off by stream piracy, which indicates an early to middle Pleistocene age for these soils. Because of the favorable soil properties and topography, most areas of these soils were intensively cultivated in the past and were moderately to severely eroded. Most of these areas are now maintained in pine plantations. Because these soils are deep and porous, they retain most rainfall, which flows downward as throughflow or as shallow subsurface lateral flow.

47/951B. The soils in this map unit classify as Typic Hapludults; fine-loamy, mixed, thermic. These soils formed in No. 47 colluvium over No. 951 Pleistocene alluvium over Nolichucky saprolite. These soils occur adjacent to No. 951 soils in footslope and toeslope landforms, where the alluvium was buried by colluvium. Not all possible areas of these soils have been identified because of the difficulty of locating them in dense pine thickets and because they occur mostly in small, narrow strips around larger areas of Nolichucky soils below elevations of ~257 m. Larger areas that were identified were located on the soil map primarily for geomorphology studies, in the hope of determining the geologic erosion rates.

48D. The soils in this map unit classify as Typic Fragiudults; fine-loamy, mixed, thermic. These soils (of very limited extent) formed in colluvium similar to that of the No. 47 soils, but the underlying paleosol is commonly a clayey, truncated residual soil that perches water. A fragipan has formed in the lower part of the youngest colluvium. In contrast, the No. 47 soils generally lie on weathered paralithic materials and do not perch water.

<u>49B, -B3, -C</u>. The soils in these map units classify as Typic Hapludults; clayey, mixed, thermic. These soils formed in the oldest R-M-N colluvium, primarily derived from surficial soils and saprolite of the Maryville and Rogersville Formations. They are now on convex landforms (in contrast to No. 47 soils, which are on concave landforms), and most have undergone topographic inversion or are now perched high above present drainageways. These soils seem to be related to, but are younger in degree of development than, the Pumpkin Valley No. 25 colluvial soils. They seem to be about the same age as the No. 471 soils in terms of landform location, but are older than the No. 951 soils in terms of landform relationships. The No. 49 landforms were probably concave landforms when the No. 471 fan terrace was being deposited. Many small areas of these soils occur on sideslopes in units of Rogersville No. 36 and Maryville No. 42 soils, where their presence cannot be located or predicted by observable landform features. The Maryville sampling pit dissected an old drainageway filled by the No. 49 soil (Fig. D-2 in Appendix D). These old-colluvium-filled drainageways now deliver considerable water downslope, since the Maryville pit fills with water after each heavy rain and water can be seen seeping from the colluvium-residuum contact. The extent of these soils is small, but they are important for what they can reveal of the past geomorphic history of the area and should prove useful in determining the long-term rates of geologic erosion.

5.3 KNOX GROUP

No residual soils from the Knox Group occur on the LLWDDD site, but Knox colluvium and Knox-influenced alluvium occur on the south side of Bear Creek.

5.3.1 <u>Knox Colluvium</u>

<u>71B, -C, -D, -E</u>. The soils in these map units classify as Typic Hapludults or Paleudults; fine-loamy or loamy-skeletal, siliceous, thermic. These soils occur (1) on low colluvial-alluvial fan terrace deposits of streams and (2) on intermittent drainageways that head into the Knox Group. They have a dark surface soil and a reddish cherty

clay-loam argillic horizon beneath. Still lower is the Maynardville residuum. These fan terrace deposits are probably of middle or late Wisconsinan age (~25,000 years ago). The fan deposits have effectively prevented Bear Creek from migrating downdip along the strike, but the creek has impinged on the toe of these fans and has redistributed chert fragments downstream. The Knox alluvium identified as No. 102 contains chert fragments throughout the soil. It is located mostly on the south side of Bear Creek, except where the creek has been channelized. The Modern alluvium, identified as No. 98 or No. 100, contains only chert fragments in the lowermost part of the soil, usually just above rock or the remnants of a truncated paleosol. The Knox colluvial No. 71 soils have the appearance of being much older than ~25,000 years because they formed in highly preweathered soil materials that came from the surface and uppermost horizons of very old Knox residual and colluvial soils. These soils have a good capacity for retaining water for slow release to stream base flow. Water (in springs and seeps) wells up through these soils to the surface; therefore, these soils have an effect on water quality. Most areas of these soils were extensively cultivated in the past because of their favorable physical properties, including water retention and lower-clay-content subsoil even though they contain large quantities of chert fragments.

711D. The soils in this map unit classify as Typic Hapludults and Paleudults; fine-loamy and loamy-skeletal, siliceous, thermic. These soils occur at the base of long slopes where E horizon soil material and loess have washed off the higher-elevation Knox soils and gradually accumulated. These soils have a thick albic E horizon and a pale brown or light yellowish brown Bt horizon beneath. The upper soil horizons usually have a very high silt content, derived from both the direct accumulation of loess and from loess washed downslope onto these footslope landforms. Fragic properties may occur at the contact with an underlying paleosol, which is either an older, very cherty colluvial soil or a clayey soil that formed in Maynardville residuum. These soils occur only in narrow strips between drainageways and are very limited in extent.

5.4 ALLUVIUM

5.4.1 Old Alluvium

94B, -B2, -B3, -C. The soils in these map units classify as Typic Hapludults; fine-loamy, mixed, thermic. These soils formed in alluvium. They occupy locations on two landforms that are separated by elevation and age but have similar morphology. These soils are commonly associated with the No. 49 soils on higher parts of the landscape and are described as "old" No. 94. Some areas also occur on lower parts of the landscape, are underlain by the Maynardville Formation, and are referred to as "young" No. 94. Morphologically, they are very similar, but they might have significant chemical differences; these soils can be separated later should conditions warrant. During the early stages of soil formation, there were periods of fluctuating water tables, which brought about the formation of segregated iron and manganese compounds and their subsequent transformation into hard nodules. These soils are now well drained and highly oxidized due to continued downcutting of Bear Creek and its tributaries on the site. Small, hard manganese and iron nodules are required for positive identification. The Bt horizon has either a 7.5YR or 5YR hue and either a loam or clay loam texture. Where the No. 94 soils occur over the underlying Maynardville Limestone, there has been better drainage and oxidation; the alluvial soil has the redder hues. Thus, these soils at a lower elevation over limestone have a morphology similar to higher-elevation soils occurring on shale, even though they are of younger age. Differential rates of soil development seem to have resulted in soils of different absolute age having similar relative ages, based on their morphological characteristics. Soils in these map units have properties that permit rapid infiltration of water and downward throughflow. The high water-holding capacity of these soils allows for slow release to stream base flow and for plant growth. Most areas of these soils were cultivated in the past and exhibit varying degrees of erosion. Most of them are now maintained in pine plantations. These soils are mapped only on the Conasauga Group and contain only fragments from the Rome Formation and the Conasauga Group. [A similar soil (No. 941) is mapped over the Knox Group, but it contains abundant chert fragments.]

94/71D. The soils in this map unit classify as Typic Hapludults and Typic Paleudults; fine-loamy, mixed or siliceous, thermic. These soils occur on the southside footslopes of Bear Creek and are underlain by the Maynardville Formation. The old alluvium No. 94 soils are the remnants of an older alluvial terrace that has been partially covered by younger cherty Knox colluvium or has been mostly washed away, exposing cherty colluvial No. 71 soils beneath. These soils are very small in extent, but they are important for our understanding of the past geomorphic history of the area.

95B. The soils in this map unit classify as Typic Hapludults; fine-loamy, mixed, thermic. These soils occur on low terraces of tributary drainageways, mostly in the areas of the Rome Formation and Pumpkin Valley Formation soils. They have a high content of very fine sand throughout the profile and have a yellowish brown Bt horizon and a loam or light clay loam texture. They generally contain very few to no coarse fragments. These soils are similar in morphology to the upper part of the No. 951 alluvium soils, but they occur in defined drainageway terrace landforms, where they are connected to the R-M-N No. 47 colluvial soils and to the Pumpkin Valley No. 27 colluvial soils and their landforms. They do not have segregated iron-manganese modules and are much younger than the No. 951 soils. They are probably of Holocene neoglacial age. (The No. 8 soil of SWSA-7 has similar landform location and morphology.)

951A, -B, -B2, -C, -C2,-C3, -D. The soils in these map units classify as Typic or Aquic Hapludults; fine-loamy, mixed, thermic. These soils formed in alluvium and surficial loess and have a very high content of fine and very fine sand. A paleosol, also formed in alluvium, with slightly higher clay content and less loess, usually occurs within a depth of 100 cm, but there are few or no fragic properties at the discontinuity. Some areas have a fragipan. Fragipan areas are found where the alluvium is underlain directly by a clayey residual soil and are identified by the No. 952 symbol in areas large enough to map. These soils reflect a time when Bear Creek and Poplar Creek were probably dammed by rapidly aggrading Clinch River terraces and represent a backwater deposition. One or more old Bear Creek channels have been identified in the LLWDDD site by the presence of chert fragments and well-rounded gravels (Fig. 5a). Because of the gentle topography, loess and dust also settled and were preserved. There are three major sources of alluvium: Bear Creek, Gum Hollow Branch, and the drainageway (located just west of Gum Hollow), which nearly cut through Pine Ridge. Lesser sources include the drainageways that collect runoff and sediment from the portion of Pine Ridge that lies between Gum Hollow and Route 95. These soils typically have a 2.5Y hue in the upper Bt horizon. The upper solum has a high silt and very fine sand content. The lower Bt, which has a better structure than does the upper Bt, seems to be slightly older and mostly of alluvial origin. This horizon and the transition horizons beneath it become more mottled with increasing depth. Small, hard manganese nodules are a common feature in the upper soil, and large manganese or iron concentrations are commonly found in the lower Bt horizon. Most areas of these soils lie directly on 2C or 2Cr horizons of Pumpkin Valley, Rogersville, Maryville, and Nolichucky saprolites. Areas of these soils that are on 0 to 3% slopes are mostly Aquic Hapludults; areas on higher landform segments and those landform segments with more convexity are mostly moderately well drained Typic Hapludults. These soils occupy a significant acreage in the soil survey area. They were mapped whenever the thickness of alluvium exceeded 50 cm. Nearly all areas of these soils were cultivated in the past. The amount of past erosion depended on management practices and slope gradient. Nearly all areas of these soils are now in pine plantations. These soils have significant engineering problems: they cannot be compacted, and they have a very low weight-bearing capacity. Figure D-7 shows a representative profile of the No. 951 soils.

Note: Areas of No. 951 soils and very similar alluvial parent materials occur in the Bear Creek, Grassy Creek, McNew Hollow, Hot Yard Hollow, Raccoon Creek, and the White Oak Creek watersheds. Areas of No. 951 soils also occur in the Poplar Creek watershed at similar elevations.

952B. The soils in this map unit classify as Typic and Aquic Fragiudults; fine-silty, mixed or siliceous, thermic. These soils occupy toeslope positions between residual soils of the Nolichucky and Maryville Formations and deeper alluvium of the No.951 soils. These soils have a fragipan that occurs at a depth ranging from 80 to 125 cm below the soil surface. Below the fragipan is a buried soil with a clayey argillic horizon that perches water. These soils are minor in extent, but they are significant for geomorphic studies in that a buried paleosol is preserved beneath younger surficial sediments.

5.4.2 Modern Alluvium

5.4.2.1 Rome and Pumpkin Valley Alluvium

96B. The soils in this map unit classify as Typic and Aquic Udifluvents; coarse-loamy, mixed, thermic. Where these soils occur along drainageways, they are highly stratified. Most of the sand fraction is very fine sand. Where they occur at the base of cultivated slopes, these soils consist primarily of topsoil that has washed off higher slopes. Most areas of these soils in drainageways have a well-defined channel and are well drained or moderately well drained as a result. Most of the upper 100 cm of these soils consists of sediments eroded by the initial deforestation, subsequent agricultural use, and today's forestry land uses. Most areas of these soils are underlain by a paleosol. Depth to this old soil is generally >50 cm. These soils are frequently flooded for short periods whenever storms produce upland overland flow. Present-day vegetation is mostly hardwoods.

97A, -B. The soils in these map unit classify as Typic and Aeric Fluvaquents; coarse or fine-loamy, mixed, thermic. These soils are on nearly level and very gently sloping floodplains of drainageways that have their source in the Rome Formation and the Pumpkin Valley Formation. Most of the sand fraction is very fine sand. Slopes are mostly <2% but can be as much as 12% below springs. Most areas of these soils contain springs or seepage zones, keeping them wet. A lack of defined channels allows water to flow very slowly across the area, which also keeps the soils wet. These soils usually contain large amounts of manganese brought either by upwelling groundwater or carried in and deposited by lateral flow from higher colluvial and residual soils. Most areas of these soils support hardwood vegetation and a ground cover of plants that tolerate prolonged wetness.

5.4.2.2 Maryville and Nolichucky Alluvium

98A, -B. The soils in these map units classify as Typic and Aquic Udifluvents; coarse or fine-silty, mixed, thermic. These soils have a much higher silt content than either the Rome or Pumpkin Valley alluvial soils. They are in narrow drainageways in larger areas of Rogersville, Maryville, and Nolichucky soils. These well-drained and moderately well drained soils are undifferentiated with respect to degree of wetness. Most areas of these soils have a well-defined and entrenched channel. The largest areas of these soils occur on the floodplain and low terraces of Bear Creek. Nearly all areas of these soils have a buried soil at a depth between 50 and 100 cm. Narrow areas of these soils were probably never cultivated and currently support hardwood trees, but larger areas adjacent to Bear Creek were cultivated and now support cane, walnut, planted pines, and other species associated with old field succession.

99. The soils in this map unit classify as Typic and Aeric Fluvaquents; fine or coarse-silty, mixed, thermic. These somewhat poorly drained and poorly drained soils occur in nearly level drainageways within areas of Rogersville, Maryville, and Nolichucky soils that contribute high-silt-content sediments to these drainageways. Most areas of these soils have a buried soil at a depth

between 50 and 100 cm. Most areas of these soils either contain springs or seepage zones or have no defined channel and thus remain wet most of the year. Present vegetation consists of hardwoods with a ground cover of water-tolerant plants.

100A. The soils in this map unit classify as Typic and Aquic Udifluvents; coarse or fine-loamy, mixed, thermic. These soils are moderately well drained to somewhat poorly drained; they formed in a thin veneer of Modern alluvium <50-cm thick over a wet soil (Typic Ochraqualf; fine, mixed or montmorillonitic, thermic) derived from the Maynardville Limestone. Most areas of these soils occur within the present-day floodplain of Bear Creek before the creek turns northerly and cuts through Pine Ridge. In some areas, remnants of an old, cherty paleosol commonly occur just above the bedrock, especially close to the lowermost floodplain.

101A. The soils in this map unit classify as Aeric Ochraqualfs; fine-silty, mixed, thermic. These soils formed in alluvium of the same age as the No. 951 alluvial soils, but they have a surficial capping of loess overlain by younger Modern alluvium that is <50-cm thick. These somewhat poorly drained soils occupy the nearly level abandoned paleo-floodplain and wider channels of Bear Creek. Present-day vegetation is a dense stand of hardwoods and abundant ground cover of poison ivy.

5.4.2.3 Knox Group Alluvium

102B. The soils in this map unit classify as Typic and Aquic Udifluvents; fine-loamy or loamy-skeletal, siliceous, thermic. These well-drained and moderately well drained soils formed in alluvium which contains a high proportion of fine earth sediment and chert fragments derived from Knox residual and colluvial soils. All areas of these soils occur on the south side of the present Bear Creek channel or the trace of the channel before recent dredging and channel straightening. They also contain Conasauga and Rome sediments, and may have mixed mineralogy where they occur in the Bear Creek floodplain. (Note: No. 102 soil is mostly mapped in drainageways in the Knox Group soils as a complex, shown as No. 102/69.)

6. INTERPRETATIONS

The ability to predict the response of soil to a change in land use or management is an important consideration in any land use planning activity. Most predictions are based on past observations and are related (1) to the physical characteristics of the landform, (2) to external forces that have influenced soil formation, and (3) to the physical, chemical, mineralogical, and hydrological properties of the soil. The U.S. Department of Agriculture's Soil Conservation Service developed the National Soils Handbook (Soils Survey Staff 1983) to assist soil scientists in providing reasonable estimates of future soil behavior and in evaluating the soil resource data base for environmental impact assessments. The depth of soil observation for predicting soil behavior in the National Soils Handbook is confined to ~2.0 m, or to lithic (R) or paralithic (Cr) materials if they occur at a shallower depth.

6.1 DRAINAGE

Several drainage classes are referred to in the descriptions of the mapping units. Definitions of these classes are based on the frequency and duration of periods when the soil is not saturated (Soil Survey Staff 1983). Well-drained soils are those soils for which there is no morphologic or field-measured evidence of saturation within a depth of ~1.0 m. The presence of drainage mottles in a soil is evidence of periods of saturation and biological reduction processes. Mottles in the soil are of three basic types. The first type is color variation due to inherited parent material colors. Mottles of this type are most often found in the lower subsoil-saprolite transition zone where there has been incomplete destruction of the parent material by soil-forming processes. Peds may have formed and may be coated by clay particles, but the interiors still have the color pattern inherited from the saprolite parent material. Many saprolites, especially in the Conasauga Group soils, have variegated colors with Pumpkin Valley saprolite being the most colorful. The second type of nondrainage mottles occurs in the upper soil solum where an E horizon is migrating downward into the upper Bt horizon. In this migration, clay and iron oxides are differentially stripped, leaving a mottled appearance in the transition zone.

The third type of mottles is the kind induced by chemical and biochemical oxidation-reduction processes. Drainage mottles come in all shades, but the most important for evaluating soil saturation and anoxic conditions (required for reduction and mobilization of manganese and iron compounds) are those mottles having a chroma of 3 or less. Drainage mottles with a chroma of 2 or less indicate soil zones stripped free of manganese and iron compounds, the result of intense but localized reducing conditions. Drainage-induced mottles of higher chroma are due to the differential movement of subsoil water, which results in oxidized and reduced zones, and to the differential flow of manganese and iron plasma from reducing zones with 3 or less chroma mottles to oxidizing zones with 4 or higher chroma mottles. Manganese oxides that coat ped or fragment faces generally indicate the presence of a restricted-permeability zone in the subsoil or a substratum whose chemical environment is capable of oxidizing reduced manganese ions. Many well-drained soils from the Knox Group have an oxidizing environment for several meters. Conversely, many Conasauga soils that are underlain by relatively impermeable shale have an oxidizing environment only in the uppermost 50 to 100 cm. Below this depth, they exhibit increasing morphologic evidence of restricted water movement or water stagnation, where biologic activity reduces the partial pressure of oxygen to very low levels, bringing about anaerobic respiration. The best-drained part of most Conasauga soils occur only in the soil solum (the upper 50 cm) where most plant roots proliferate. Moderately well drained soils are those for which there is morphologic or field-measured evidence of a perched or fluctuating groundwater table that comes to within 50 cm of the soil surface. If the water table in such a soil is perched, the soil below the restricted-permeability zone will have brighter and more oxidized colors. However, if a true groundwater table is present, the soil will become increasingly grayer with depth, until gray becomes the dominant color.

Somewhat poorly drained soils have a water table that is close to the surface for considerable periods. Drainage mottles with a chroma of 2 or less occur commonly just beneath the A horizon. In the LLWDDD site, these soils are in drainageways or in areas where run-on from higher slopes keeps the soils in a wet condition for longer periods of time.

Poorly drained soils are wet at, or very close to, the surface for a considerable part of the year. They are dominated by colors with chroma of 2 and 3. If water is upwelling, there are black manganese oxide compounds in the upper soil, a common condition where springs and wet weather seeps occur in the LLWDDD site. If water is moving downward, then the zone of manganese oxide accumulation is below the zone in which reddish and yellowish iron oxide compounds accumulate.

Periods of saturation and the production of drainage mottles can be induced in a soil by more than one means. The net effect, however, is a soil that receives more water than it can transmit downward or laterally. Soils with rapid permeability can be poorly drained if the amount of water entering the soil is greater than the rate of water transmission through the soil. This commonly occurs at the base of slopes where considerable run-on water produces saturated conditions or where water wells up in springs and seepage areas. Other soils are poorly drained because of the soil's inability to transmit water downward or laterally. For example, soils with a high clay content and with minimal soil structure can be poorly drained.

The interpretation of saturated flow zones in saprolites is more difficult. As water moves downward through a soil, it becomes increasingly channelized. Water flow is mostly uniform in the A horizon because of the granular nature of the soil structure. The upper subsoil has peds that are mostly equal in size, but in the lower subsoi' the occurrence of prismatic soil structure starts the process of funneling water into definite flow zones. Tree roots also have an effect on subsurface water flow pathways. In the lower solum and upper saprolite, the funneling continues so that water flows in defined zones, which can be identified by the occurrence of clay flows. Zones of saturated and unsaturated flow in saprolite can be identified by morphologic evidence as well as by visual observation when pits are opened during wet periods.

Soil drainage can change through changes in land-use practices. The removal of trees, especially conifers, results in soils becoming wetter. The change in land use from forestry to agriculture also produces a change in soil drainage due to the increase in surface runoff that usually accompanies agriculture. On upper slopes, some soils are drier because of increased runoff; on lower slopes, there is increased wetness due to run-on from higher slopes. Toeslopes and drainageways fill with sediments or become eroded and gullied. The proposed change in land use from forestry to waste disposal at the LLWDDD site will significantly change the present hydrologic regime.

Both surface and subsurface drainage will be required on the LLWDDD site. The total potential number of tumuli should be used to determine the area of the site that will have minimal rainfall infiltration or retention capacity. This will affect the size of surface drainage ditches, permanent stormwater-retention basins, temporary sediment basins, and other engineering practices to retain sediments and to control removal of surface water from the site. Large areas with little or no water retention on the LLWDDD site will result in increased wetness of soils on lower sideslopes, footslopes, and toeslopes. Subsurface drainage systems may be necessary to keep water tables from rising too high during wet periods under tumuli that are situated in lower areas. The current natural drainage system appears to be more or less in balance with the present hydrologic regime and forest vegetation. This natural drainage system should be studied and modified as needed to handle increased runoff and subsurface wetness. (Areas on the LLWDDD site that are now wet and poorly drained or are subject to flooding are shown in Fig. 10.)

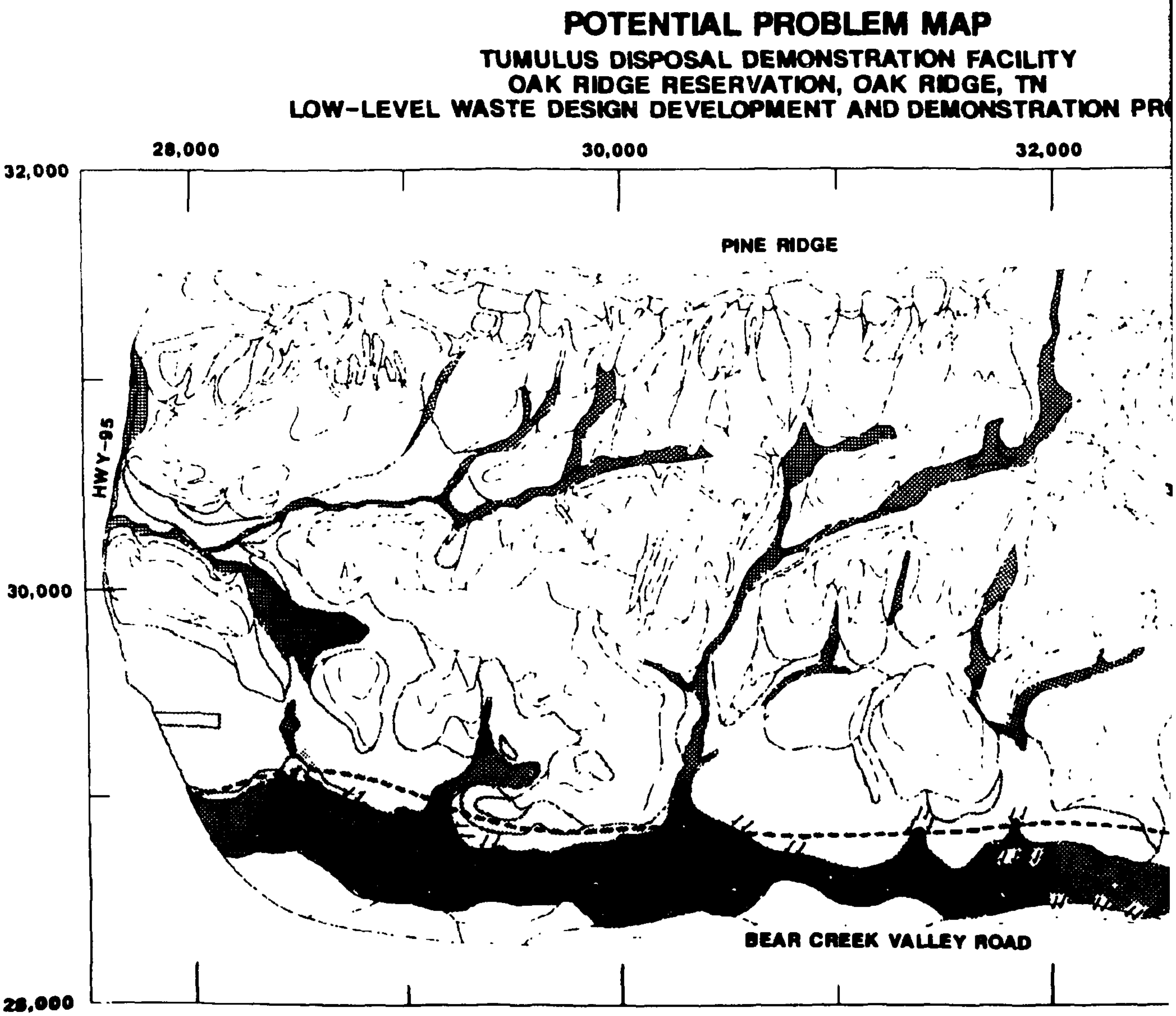

Fig. 10. Map showing potential problem areas on the Low-Level Waste Disposal

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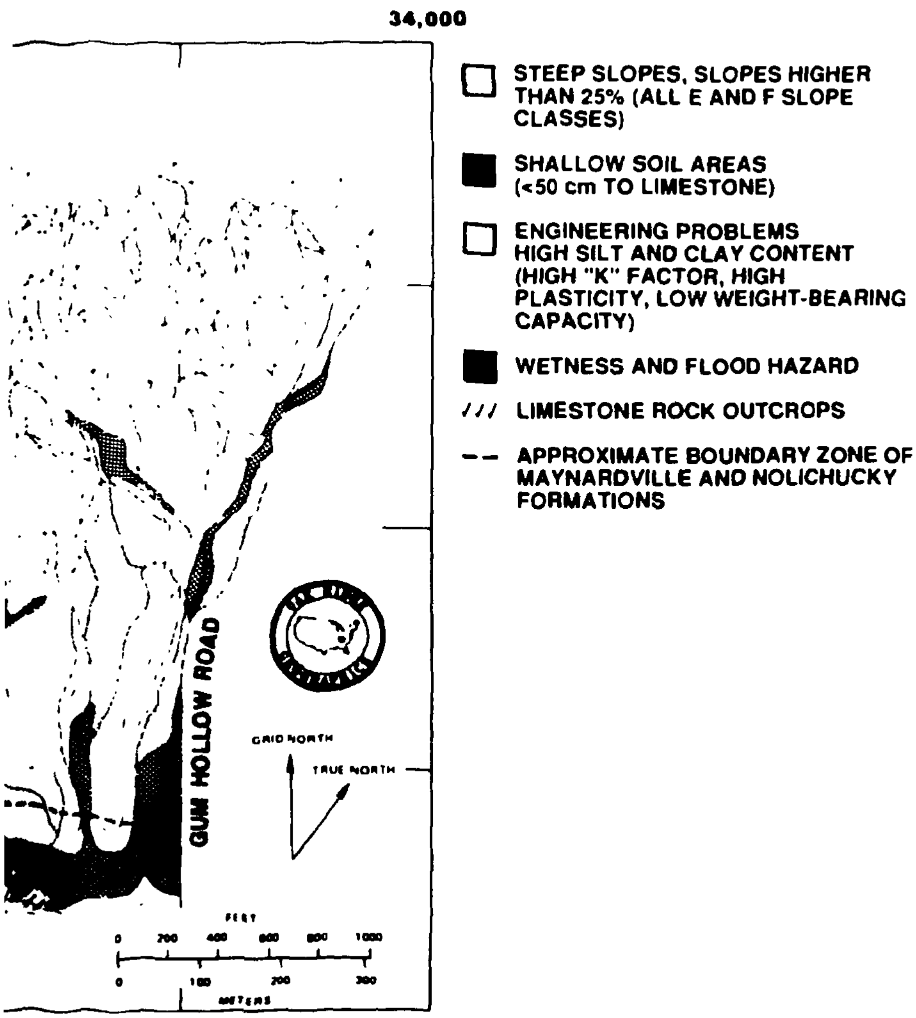
N PROGRAM



posal Development and Demonstration Program site.

6.2 EROSION

Erosion is of two types: geologic erosion and anthropogenic erosion. Geologic erosion is a natural process in which a steady-state soil-climate system punctuated by periods of accelerated denudation when there is a significant change in the regional climate. These climatic changes can affect the rate of ongoing geomorphic processes or induce new geomorphic processes in areas of geomorphically sensitive soils, while other geomorphically insensitive soils are not affected or are minimally affected. A change in the watershed stream base level that induces an episode of instability can also accelerate geologic erosion.

Anthropogenic erosion is caused by changes in land use and improper land management. This type of erosion can accelerate the rate of geologic erosion or induce a significant change in geologic erosion of a watershed system that is in a quasi steady state under forest vegetation.

Anthropogenic-accelerated erosion can be evaluated in a given watershed by observing the effects of differential erosion in areas of agriculture, intensive forestry, and other land uses where the natural vegetation was disturbed and then comparing these areas with those that are more or less in a "natural" state or that have experienced minimal anthropogenic influence.

Three classes of past erosion (Fig. 11) have been recognized on the LLWDDD site. Most areas in which no erosion or only slight erosion has taken place are currently in hardwood forest, with the only activity being past logging, burning, and some cattle pasturing.

Some hardwood areas do not seem to have had much disturbance except for periodic harvesting of the best timber. The soil morphology in these areas of minimal disturbance was compared with that in other areas on similar landforms and slope gradients to determine how much of the soil had been lost by erosion induced or accelerated by humans. Areas that are moderately eroded have lost much of the original A horizon, with its wealth of plant nutrients, and part of the E horizon beneath it. These moderately eroded areas still have a relict Ap

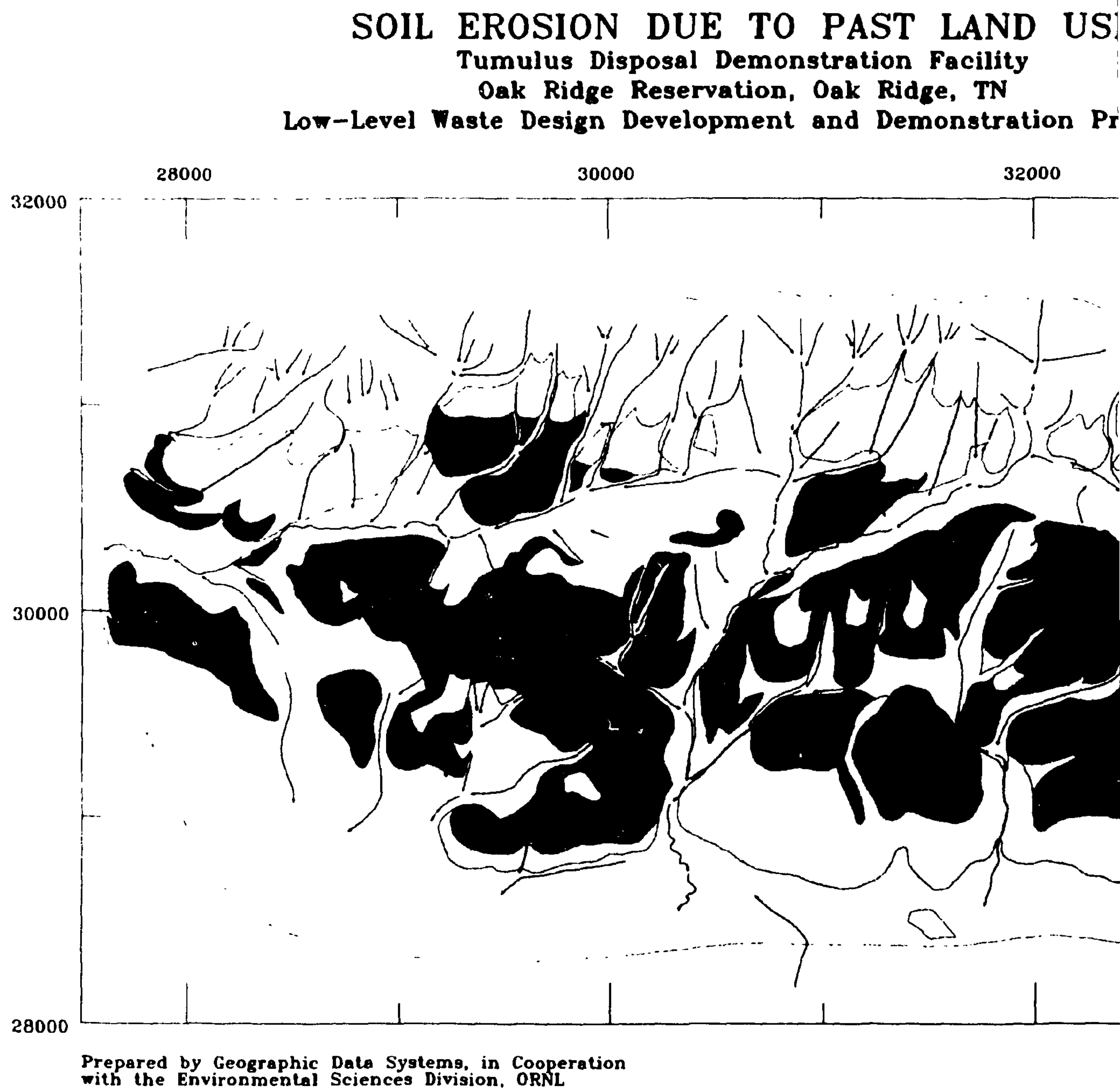


Fig. 11. Soil erosion due to past land use

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USE

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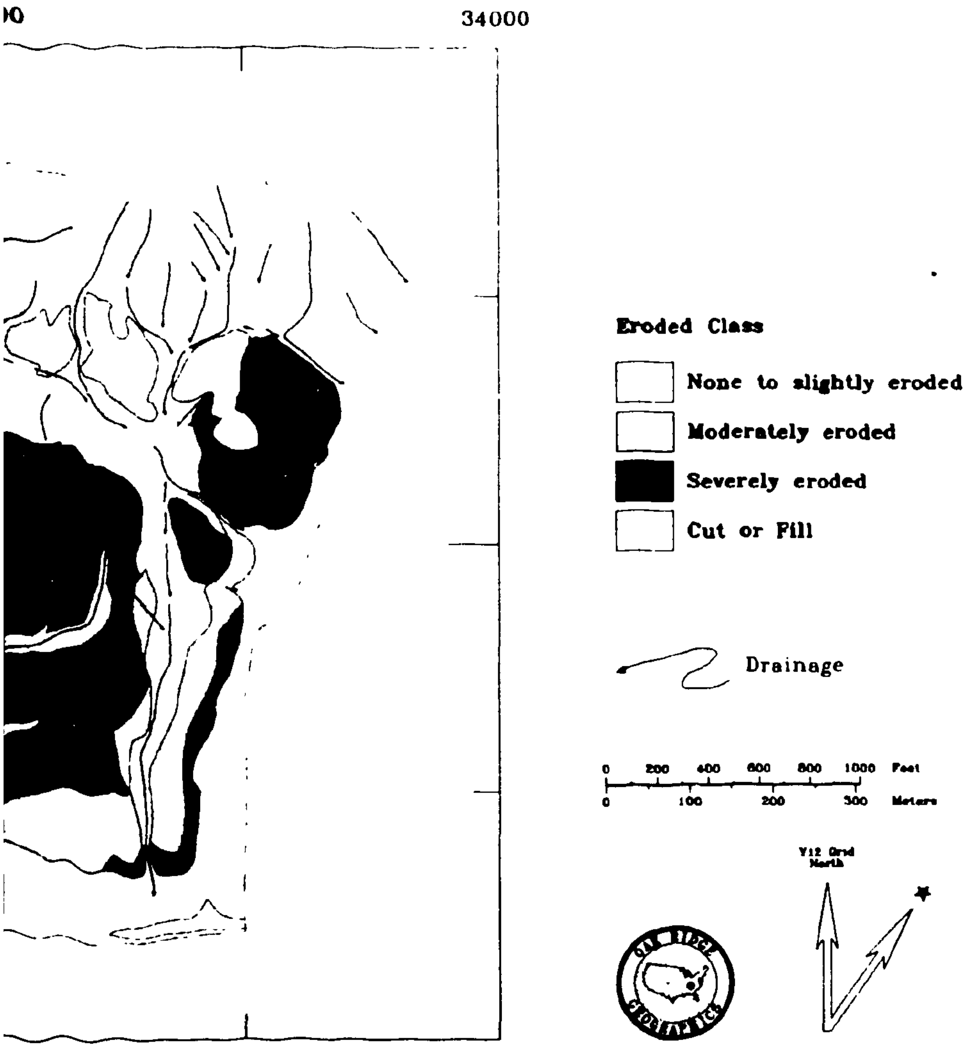


d use.

(plowed) horizon even though a new A horizon is forming in the upper few centimeters of the old Ap horizon. Severely eroded hillsides have lost about half of the original soil solum thickness on the LLWDDD site. Clayey subsoil materials are now exposed at the surface or comprise the greater proportion of the relict Ap horizon. Other soils with thin sola have lost most of their upper diagnostic horizons, and some soils with originally thin sola have been stripped nearly to paralithic materials. Some very severely eroded areas have been included in larger areas of severely eroded soils. These areas can be identified in the woods by the common to abundant occurrence of small gullies.

Erosion affects the hydrologic properties of soils in at least two major ways: (1) the rate and duration of overland flow increases as erosion becomes more severe and (2) the volume of soil that can retain water decreases to a point where even storm events of low intensity and duration result in overland flow.

6.3 EROSION POTENTIAL

The erosion potential of a site can be estimated by the use of the Universal Soil Loss Equation (USLE) (USDA Staff 1978). The USLE can be used to design conservation practices and procedures to minimize accelerated soil loss on the LLWDDD site. Potential erosion hazards can be evaluated for larger tracts of land by evaluating slope gradient, length of slope, amount of very fine sand and silt in the upper soil, and the thickness of soil that can retain rainfall before the onset of overland runoff.

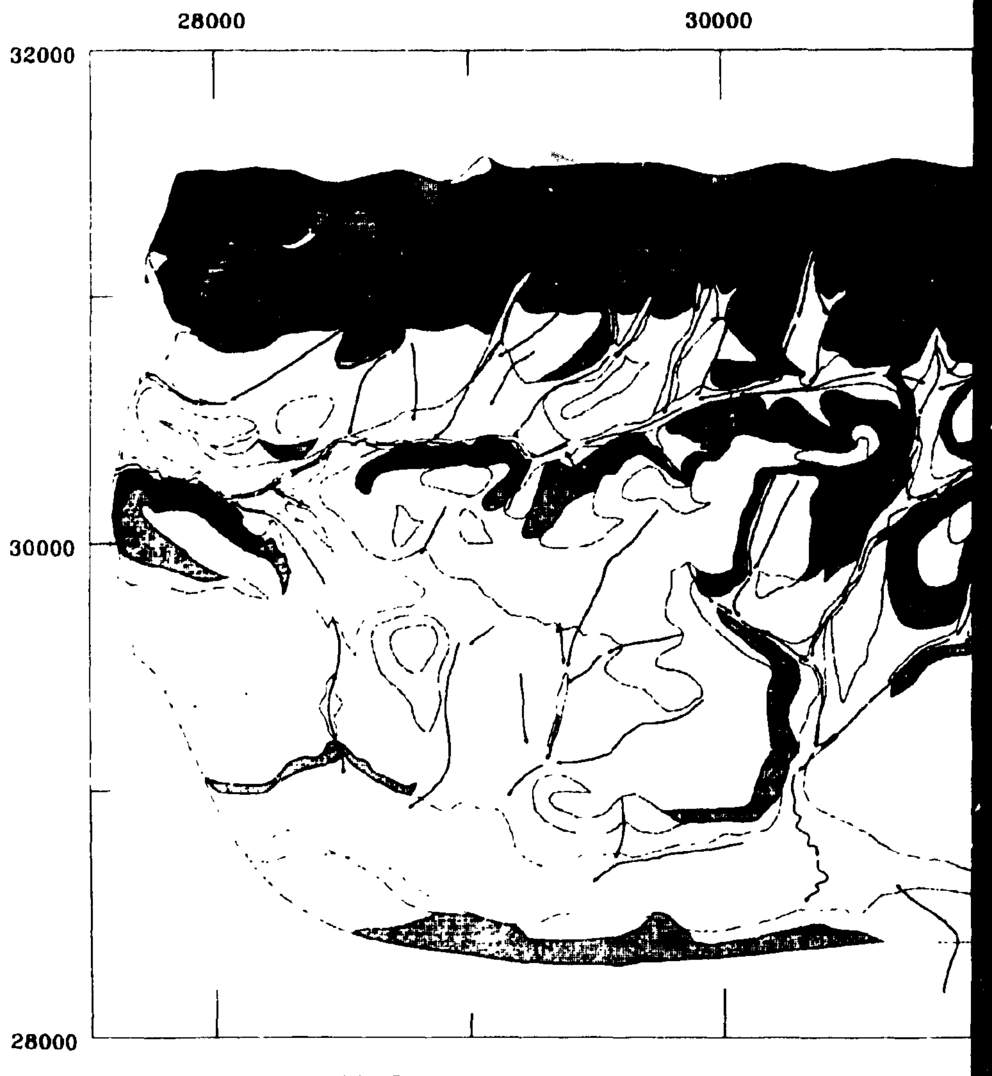
A soil erodibility factor [K] estimates the probability that a soil particle can be detached from the surface and transported downslope by rainfall (Soil Survey Staff 1983). The [K] factor can be estimated by using a nomograph that relates the [K] factor to five soil properties: (1) percentage of silt plus very fine sand, (2) percentage of sand >0.10 mm, (3) organic matter content of the soil layer that is exposed to rainfall, (4) soil structure, and (5) limiting permeability (USDA Staff 1978). Rock fragments affect the [K] factor by providing an armoring effect. Rock fragments have an important effect on [K] values on the LLWDDD site. Based on data from each of the pits that were sampled, [K] factors have been generated for the soil solum and leached saprolite of each major soil on the LLWDDD site (Table 1). Disturbed whole soil [K] values are highly dependent on the amount of saprolite manipulation and the resultant amount of stable aggregation and permeability, but they should be useable in predicting soil loss from tumuli soil cover before it is protected by vegetation.

There are four areas on the LLWDDD site that have very high erosion potential: (1) land with slopes >25% (see Fig. 12), (2) all areas that were severely or very severely eroded in the past, (3) shallow soils underlain by hard rock, and (4) soils that have high silt plus clay content. Most soils on the site have some potential for accelerated erosion if they are disturbed and left unprotected. The only exceptions are nearly level areas on flood plains and low toeslopes where sediments accumulate.

Land with low erosion potential has (1) slopes <5%, (2) permeable deep soils (>2.0 m to paralithic materials), and (3) permeable soils with loamy textures. Land with moderate erosion potential has slopes as high as 25% if the soils are loamy and >1.0-m deep to paralithic materials, or 12% if the soils are >50-cm but <100-cm thick. Land with moderate erosion potential was also moderately eroded in the past, even on slopes <5%. For example, the No. 951 soils have a moderate erosion potential, even on slopes that are <5%, because of their high content of very fine sand and silt. Engineering design and practices can reduce erosion potential (1) by reducing the length of slopes, (2) by periodically removing overland flow in defined channels on hillsides, and (3) by quickly revegetating disturbed areas by either temporary seeding or permanent vegetative practices.

SOIL SLOPE C

Tumulus Disposal Demons
Oak Ridge Reservation, C
Low-Level Waste Design Development a



Prepared by Geographic Data Systems, in Cooperation with the Environmental Sciences Division, ORNL

Fig. 12.

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CLASS
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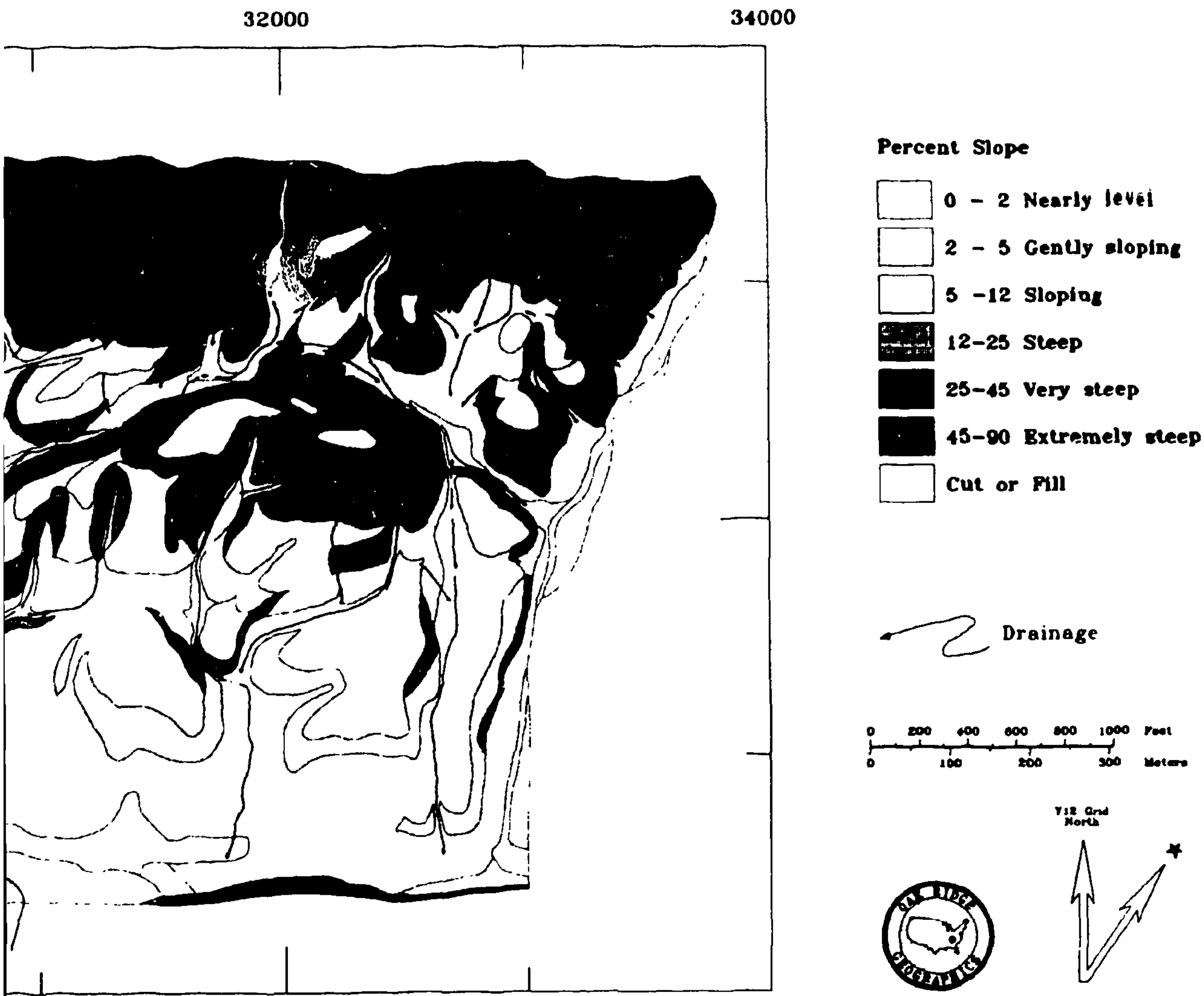
Oak Ridge, TN
and Demonstration Program



2. Soil slope classes.

Table 1. Range of estimated [K] values for major soils on the Low-Level Waste Disposal Development and Demonstration Program site[a]

Geology and Soil No.	In-place fine earth	In-place whole soil	Disturbed whole soil[b]
Nolichucky residuum			
Soil No. 51			
Solum	0.26-0.34	0.24-0.31	0.28-0.34
Saprolite	0.41-0.49	0.03-0.04	0.01-0.03
Maryville residuum			
Soil No. 42			
Solum	0.19-0.28	0.10-0.12	0.13-0.18
Saprolite	0.30-0.36	0.02-0.03	0.01-0.05
Rogersville residuum			
Soil No. 36			
Solum	0.07-0.34	0.07-0.19	0.06-0.17
Saprolite	0.26-0.33	0.03-0.23	0.01-0.04
Pumpkin Valley residuum			
Soil No. 24			
Solum	0.26-0.44	0.16-0.20	0.17-0.24
Saprolite	0.30-0.44	0.03-0.23	0.01-0.17
R-M-N[c] colluvium			
Soil No. 49			
Solum	0.19-0.26	0.12-0.23	0.20-0.28
Pumpkin Valley colluvium			
Soil No. 26			
Solum	0.32-0.42	0.21-0.39	0.21-0.28
Old alluvium			
Soil No. 951			
Solum	0.36-0.52	0.36-0.52	0.38-0.56

[a]Data from J. T. Ammons and R. E. Lambert, University of Tennessee, 1987.

[b]Estimated range of [K] values for bare soil between disturbance and 1 year afterward.

[c]R-M-N = Rogersville-Maryville-Nolichucky.

6.4 POTENTIAL SOURCES OF SOIL FOR FINAL COVER

The LLWDDD site contains very small areas of deep soils from which to obtain the large amounts of cover materials that will be required in the construction of tumuli. High-clay-content soil from the Copper Ridge Formation will probably be used to construct the tumuli. This Copper Ridge fill can be modified by lime and fertilizer to provide a seed bed for temporary plant cover during construction. However, this soil does not have the properties necessary to ensure a final low-maintenance vegetative cover that will persist. The best source of soil materials suitable for final cover on the LLWDDD site are the soils in the No. 25, No. 26, and No. 27 map units. These soils have good physical properties, are not extremely erodible, and have a good water-retention capacity. They have a high whole-soil cation exchange capacity, but they are very acid and would require additions of lime and fertilizer. The next best source of final cover would be the soils in the No. 951 map units. These soils, however, have a high content of very fine sand and silt, which results in a very high erosion potential between the time of placement on tumuli and the time of 100% vegetative cover. The No. 951 soils are not deep; they average about 1.0- to 2.0-m deep over shales. However, they are plentiful. Large volumes will be excavated for site grading during construction of sediment-retention basins and tumuli. These soils have high water-retention and cation exchange capacity. They are also acid and will require additions of lime and fertilizer in order to quickly establish vegetative cover. Other nearby areas having potential cover or fill materials are McNew Hollow and Hot Yard Hollow. Both of these hollows contain a large quantity of colluvium (No. 15, No. 16, and No. 17 soils) that has good compaction properties and also is suitable for growing a vegetative cover.

Research is needed to determine the best types of temporary and permanent vegetative cover for disturbed areas and the type of long-term maintenance that will be required to prevent unwanted vegetation from invading, or conversely, to prevent the gradual disappearance of vegetation and the onset of accelerated erosion.

6.5 ROCK OUTCROPS AND DEPTH TO LIMESTONE

Rock outcrops were observed along the boundary between the Nolichucky Formation and the Maynardville Formation. They are indicated by "VV" marks on Fig. 10. Only one limestone outcrop was observed in the Nolichucky Formaton. It is located in the power-line right-of-way and is indicated by a "V" mark. Depth to limestone is highly variable in the area occupied by the Maynardville Formation. Modern and old alluvium covers most of this formation, but rock is not far below the surface. Bear Creek flows on Maynardville Limestone for most of its length in the LLWDDD site. The Maynardville Formation has special problems resulting from solution channels and cavities that allow for direct or nearly direct movement of surface water to groundwater. This rapid movement of water provides minimal filtration and purification by natural biochemical and chemical processes in the soil.

6.6 INFILTRATION CHARACTERISTICS OF SURFICIAL SOILS

Locating soils with high infiltration rates and deep percolation, soils that tend to generate lateral flow, and soils that generate high amounts of overland flow is important in modeling and perhaps in understanding the geohydrology of the LLWDDD site. The upper part of Pine Ridge, where most rainfall infiltrates, has some of the characteristics of a sponge. The lower sections of Pine Ridge and the Pumpkin valley area look something like funnels lying on their sides, with the top of the funnel upslope collecting the surface runoff and subsurface lateral water flow. Most of the "funnels" release water into the colluvium-filled trace of the Rutledge Limestone. Here, water either percolates downward or is transmitted laterally on or near the surface, appearing as channelized flow or as springs or seeps of the major east- to west-flowing drainageway located in the trace of the Rutledge Formation. Lateral piping of water below the surface is common in sloping floodplain soils where tree roots and animal burrows evidently started the pipes.

Only at four locations was the Rogersville-Maryville and Nolichucky breached by drainageways that extended into Pumpkin Valley and Rome catchment areas. Two of these locations define the east and west boundaries of the site. The third drainageway lost its head that once extended into the Pumpkin Valley and Rome areas through stream piracy. Only one drainageway has managed to cut through and capture drainage from three major "funnels" in the Rome and Pumpkin Valley Formations.

Soil characteristics that contribute to high infiltration are (1) a moderate to strong grade of granular structure in the A horizon, (2) a moderate to high organic carbon content in the A horizon, (3) a high porosity, including many tubular pores formed by soil biota, (4) surface soil textures of sandy loam, loam, and silt loam, and (5) good subsoil permeability that allows for infiltrated rainfall to move readily downward without saturating the soil surface.

Areas of soils with high infiltration and rapid, deep percolation are shown in Fig. 13. These soils have (1) loamy fine sand to very fine sandy loam surface textures and (2) loamy very fine sand to very fine sandy loam subsoils. The underlying leached saprolite has been highly fractured and is permeable. Most areas of these soils are on steep slopes. However, the forest vegetation plus the ground litter and surface organic layers markedly enhance the already high infiltration capability.

Soils having a low to moderate infiltration capacity tend to generate more overland runoff. Some of the soils in this group are on convex sideslopes with slopes >45%. Most of these particular soils have all the requirements for high filtration, but because they are situated on very steep slopes, surface runoff or near-surface lateral flow is favored. Most areas of these very steep soils on Pine Ridge (Rome soils) have a good ability to promote downward movement of throughflow. Areas of Conasauga soils on very steep slopes, however, tend to generate more overland flow because the subsoil and saprolite are less permeable than those of Rome soils. Most of the soils in the group are not situated on very steep slopes, but have several characteristics that prevent high infiltration. If a soil in this group initially has a high rate of infiltration, it soon becomes

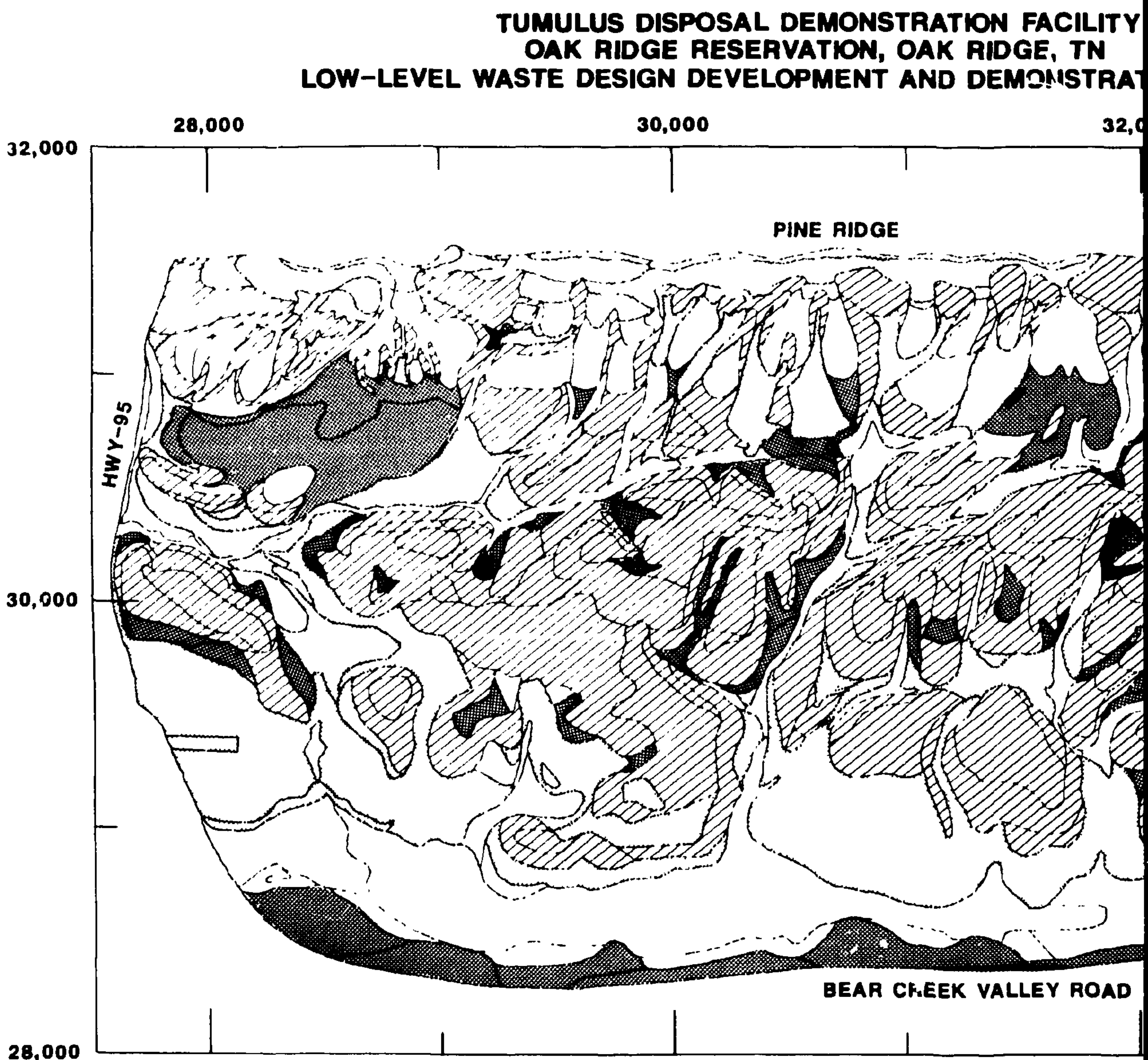


Fig. 13. Infiltration characteristics of soils on the Low-Level

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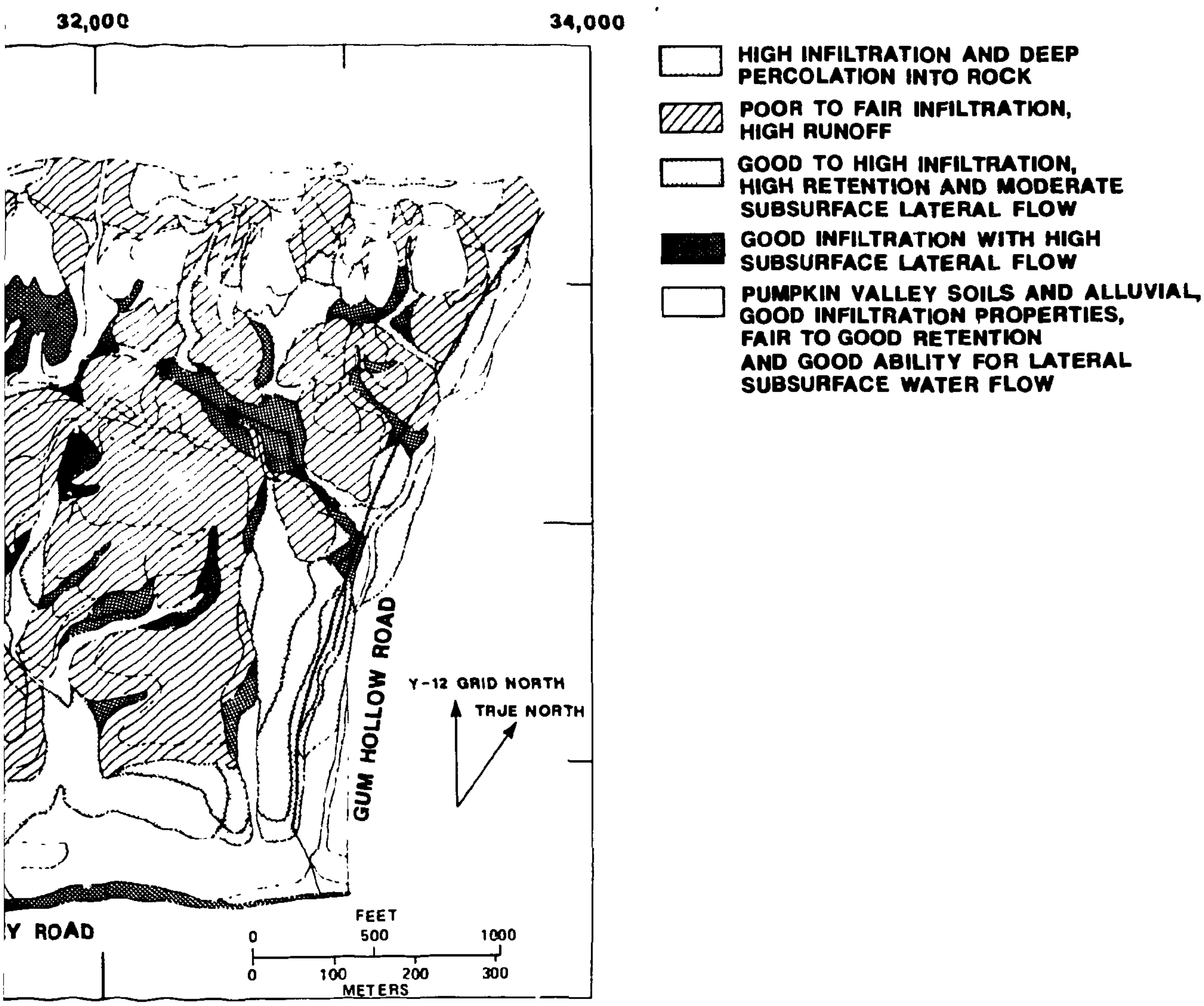

w-Level Waste Disposal Development and Demonstration Program site.

saturated due to a shallow solum or to slow permeability in the solum and leached saprolite. Many soils with very low to moderate infiltration were badly eroded. These soils usually have lower organic carbon content in the surface horizons, poorer structure or higher clay content, and a thinner solum than similar, but uneroded, soils. Other soils on the LLWDDD site have moderate to high infiltration, high water-retention capacity, and a moderate ability to transmit water as lateral flow. Most of these soils formed in Pumpkin Valley colluvium (No. 27 soils) and alluvium (No. 951 soils). Stratification and lithologic discontinuities tend to produce perched water zones in the soil. Most of these soils have surface textures of very fine sandy loam and loam and silt loam and subsoil textures of loam, very fine sandy loam, clay loam, and silty clay loam. They also tend to have good soil structure. Soils with moderate infiltration, moderate retention, and high subsurface lateral flow formed in colluvium. Lithologic discontinuities and coarse-fragment orientation tend to create conditions for perched water tables and subsequent rapid lateral flow downslope.

Other soils on the LLWDDD site have a combination of generally favorable infiltration, moderate subsoil and saprolite permeability, and the capability to generate lateral water flow just beneath the soil surface in E horizons (Pumpkin Valley residual soils) or along stratifications, in the case of most Modern alluvial soils. Soils with very low infiltration are mostly very severely eroded. These soils have exposed clayey surface layers or saprolite is exposed at the surface.

7. SUMMARY

A major objective of the LLWDDD soil survey was to identify the surface soil solum, its morphologic characteristics, and its relationship to the underlying residuum. An attempt was made to relate the morphologic characteristics of the highly weathered, leached, and oxidized saprolite to the geologic character of the unoxidized and unleached bedrock beneath. Depth to bedrock is highly variable, given the joint and fracture system, the varying permeability of each stratum, and the channelized water flow zones where weathering can extend deeply into bedrock. The thickness of each soil solum and the number, sequence, and thickness of pedogenic horizons (e.g., A, E, Bt, and B horizons) were related to the geomorphic stability of the landform or landform segment that a particular soil occupied. Depth of weathering (e.g., the leached and oxidized zone between the C horizon and bedrock is more often related to a longer period of geologic weathering than to the time of soil horizon formation). Widespread geomorphic events in the Pleistocene and Holocene Epochs periodically destabilized land surfaces, resulting in episodic events that removed most to all of the existing soil down to coherent weathered saprolite or hard rock. Widespread colluvium of differing ages is evidence of past periods of geomorphic instability.

The relationship of soils to landforms is also evidence of the important role of geomorphic processes in shaping the present landscape. Water and its pathways of overland and subsurface flow have had an important effect on the present rates of deep rock weathering and near-surface soil formation. Stream piracy has occurred at one location (and perhaps at two or more additional locations) on the site. Rates of geologic erosion need to be estimated as accurately as possible. Accelerated erosion due to present and past agricultural activities and forest management practices was evaluated during the soil survey. It is estimated that between 30 and 60 cm of soil has been removed from areas of severely eroded land, identified in the soil identification legend (see Section 5) by the symbol "3" following the slope letter designation. Gullied areas, which are very common on colluvial toeslopes, are very severely eroded and have probably lost 60 cm of soil. Thus, potential erosion and the means of controlling erosion are important considerations (1) in planning site preparation, (2) during site use, and (3) after closure.

To prevent the LLWDDD site from returning to natural hardwood forest after closure, long-term maintenance of shallow-rooted vegetation will be required. This type of maintenance would require that natural plant succession be arrested at an early stage. This result could be achieved by maintaining soil pH and fertility levels suitable for shallow-rooted grasses and shrubs. A thick grass sod will greatly slow the invasion of woody plants, such as blackberry briars, honeysuckle, and tree seedlings, which shade grass and force its demise. In addition, periodic mowing or use of herbicides would be required to keep woody plants from invading grass areas.

The soil survey of the LLWDDD site identified the location and extent of each major kind of soil and the underlying geologic formation. This information provides a basis for locating roads, waste burial areas, local fill and cover materials, and potential problem areas that must be considered in more intensive planning for maximum site utilization.

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APPENDIX A

SOIL MAPPING AND CLASSIFICATION

APPENDIX A

SOIL MAPPING AND CLASSIFICATION

Each soil has a distinctive subset of morphologic properties that can include color, horizonation, thickness and sequence of horizons, structure, and texture. Some related properties are measured in the laboratory. Important diagnostic properties which soils have in common and which were produced by a subset of soil-forming processes (i.e., soil genesis) are used to define conceptual classes for the purposes of classifying and mapping soils (Smith 1983).

A.1 MAP UNIT CONCEPTS

Map units are defined by soil morphology, landform configuration, slope class, and degree of past erosion. Individual delineations represent the real world and consist of landform segments that are similar in terms of geology, soil morphology, and landform configuration. The total delineations of one kind comprise the map unit. Individual delineations are slightly different in one or more respects than are all other delineations that comprise a map unit, but the delineations that comprise one map unit are more alike than those that comprise another map unit.

The landform configurations are as follows:

1. doubly convex upland summits
2. doubly convex upper and mid-sideslopes
3. convex/plano mid- and lower sideslopes
4. concave/convex/plano lower sideslopes
5. doubly concave footslopes
6. drainageways

Slope classes are as follows:

A	0 to 2%	nearly level
B	2 to 5%	gently sloping
C	5 to 12%	sloping
D	12 to 25%	steep
E	25 to 45%	very steep
F	45 to 90%	extremely steep

Erosion classes are as follows [see the Soil Survey Staff's (1984) revised Soil Survey Manual, Chapter 4, for definitions]:

1. none to slight
2. moderate
3. severe
4. very severe (numerous gullies)

Other symbols used in soil mapping are as follows:
Drainageway: ——> · —— · —— >
Highly disturbed areas: fill or cut

A.2 SOIL LEGEND

Symbols that convey information are used to identify the various types of soil on the soil map (see Table A-1 and Fig. A-1). Each identified soil has been and classified according to the principles and criteria given in Soil Taxonomy (Soil Survey Staff 1975). In addition, the properties of the underlying geologic formations were utilized as one criterion in identification of residual soils. Colluvium of different geologic origins and ages and alluvium of different geologic origins and ages, and degrees of wetness were additional criteria used to identify and separate colluvial and alluvial soils.

Each soil in the legend is identified by a one-, two-, or three-digit number that is related to (1) the underlying geologic formation, (2) the geomorphic process (colluviation or alluviation), or (3) time. Within any geologic formation, soils are subdivided based on their degree of weathering and time of formation. Colluvial and alluvial soils are subdivided based on degree of soil formation, age of constituent materials, physical properties, and wetness. Each identification symbol also contains a letter that refers to the slope gradient perpendicular to the contour. A number symbol without a letter has an "A" slope of <2% and no erosion. Many identification symbols also contain an additional number after the letter; this number refers to the degree of past erosion when compared with the least eroded soil in the survey area.

In the legend, residual soils are listed primarily according to the geologic formation, which defines, for the most part, the parent materials of each soil. Colluvial soils from each major geologic group or formation also have a commonality of parent material properties. Alluvial soils, which are defined by (1) shallow depth to stratification or evidence of past stratification, (2) parent material properties, (3) degree of wetness, and (4) landform location, tend to occur over more than one geologic formation, since geomorphic processes of alluvial transport and sedimentation mix materials. Soils of first- and second-order streams generally reflect their parentage; soils in higher-order stream segments have a more diverse parentage. For example, the main Bear Creek floodplain soils are a mixture of Rome, Conasauga, and Knox geologic materials, but the first- and second-order tributaries contain sediments derived from the soils of one or, at most, two geologic formations.

A.3 SOIL CLASSIFICATION

In the United States, a hierarchical system of soil classification evolved to its current state with the development of Soil Taxonomy (Soil Survey Staff 1975) and the more recent amendments, which are a reflection of advancing knowledge of soils and their genesis. Soil taxonomy is based primarily on the properties of soils near the surface, properties that are the most direct result of a soil-forming process, but some properties of deeper soils (at or near a depth of

Table A-1. Classification of soils on the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) site

	Taxonomic classification	Parent materials
1.	Typic Hapludults; sandy and coarse-loamy, mixed, thermic	Rome feldspathic sandstone residuum
4.	Typic Dystrochrepts; loamy-skeletal, siliceous, thermic	Rome sandstone along the crest of Pine Ridge
7.	Typic Hapludults; clayey, mixed, thermic residuum	Rome feldspathic sandstone
15.	Typic Hapludults; fine-loamy, mixed, thermic	Rome colluvium
21.	Typic Hapludults; clayey, mixed, thermic	Pumpkin Valley residuum
22.	Ochreptic Hapludults; clayey, mixed, thermic	Pumpkin Valley residuum
23.	Typic Dystrochrepts; loamy-skeletal, mixed, thermic	Pumpkin Valley residuum
24.	Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic	Pumpkin Valley residuum
25.	Typic Hapludults; clayey, mixed, thermic	Pumpkin Valley colluvium
26.	Typic Hapludults; fine-loamy, mixed, thermic	Pumpkin Valley colluvium
26-951.	Typic Hapludults; fine-loamy, mixed, thermic	Pumpkin Valley colluvium overlying old alluvium
27.	Typic Hapludults; loamy-skeletal, mixed, thermic	Pumpkin Valley colluvium
35.	Typic Dystrochrepts; loamy-skeletal, mixed, thermic	Rogersville residuum
36.	Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic	Rogersville residuum
30.	Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed thermic	Rutledge residuum
37.	Typic Hapludults; clayey, mixed, thermic	Rogersville residuum
40.	Typic Hapludults; clayey, mixed, thermic	Maryville residuum
42.	Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic	Maryville residuum
43.	Typic Dystrochrepts; loamy-skeletal, mixed, thermic	Maryville residuum
50.	Ruptic Aquultic Dystrochrepts; loamy-skeletal, mixed, thermic	Nolichucky residuum
51.	Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic	Nolichucky residuum
52.	Typic Hapludults; clayey, mixed, thermic	Nolichucky residuum
55.	Typic Hapludults; clayey, mixed, thermic	Maynardville residuum
56.	Typic Hapludalfs; fine, mixed, thermic	Maynardville residuum
47.	Typic Hapludults; fine-loamy, mixed, thermic	Conasauga colluvium
47-951.	Typic Hapludults; fine-loamy, mixed, thermic	Conasauga colluvium overlying old alluvium
48.	Typic Fragiudults; fine-loamy, mixed, thermic	Conasauga colluvium
49.	Typic Hapludults; clayey, mixed, thermic	Conasauga colluvium
71.	Typic Hapludults; fine-loamy, siliceous, thermic	Knox colluvium
94.	Typic Hapludults, fine-loamy, mixed, thermic	Old alluvium
94-71.	Typic Hapludults; fine-loamy, mixed, thermic	Old alluvium overlying Knox colluvium
95.	Typic Hapludults; fine-loamy, mixed, thermic	Old alluvium
96.	Typic and Aquic Udifluvents; coarse-loamy, mixed, thermic	Modern alluvium in areas of Rome and Pumpkin Valley residuum
97.	Typic and Aeric Fluvaquents; fine-loamy, mixed, thermic	Modern alluvium in areas of Rome and Pumpkin Valley residuum
98.	Typic and Aquic Udifluvents; coarse-silty, mixed, thermic	Modern alluvium in areas of Rogersville, Maryville, and Nolichucky residuum
99.	Typic and Aeric Fluvaquents; fine-silty, mixed, thermic	Modern alluvium in areas of Rogersville, Maryville, and Nolichucky residuum
100.	Typic and Aquic Udifluvents; coarse- and fine-loamy, mixed, thermic	Modern alluvium in Bear Creek
101.	Aeric Ochraqualfs; fine-silty, mixed, thermic	Old alluvium
102.	Typic and Aquic Udifluvents; fine-loamy, siliceous, thermic	Modern alluvium from Knox residuum and colluvium
471.	Typic Hapludults; fine-loamy, mixed, thermic	Conasauga colluvium and alluvium
951.	Typic Hapludults; fine-silty, mixed, thermic	Old alluvium
952.	Typic and Aquic Fragiudults; fine-silty, mixed, thermic	Old alluvium

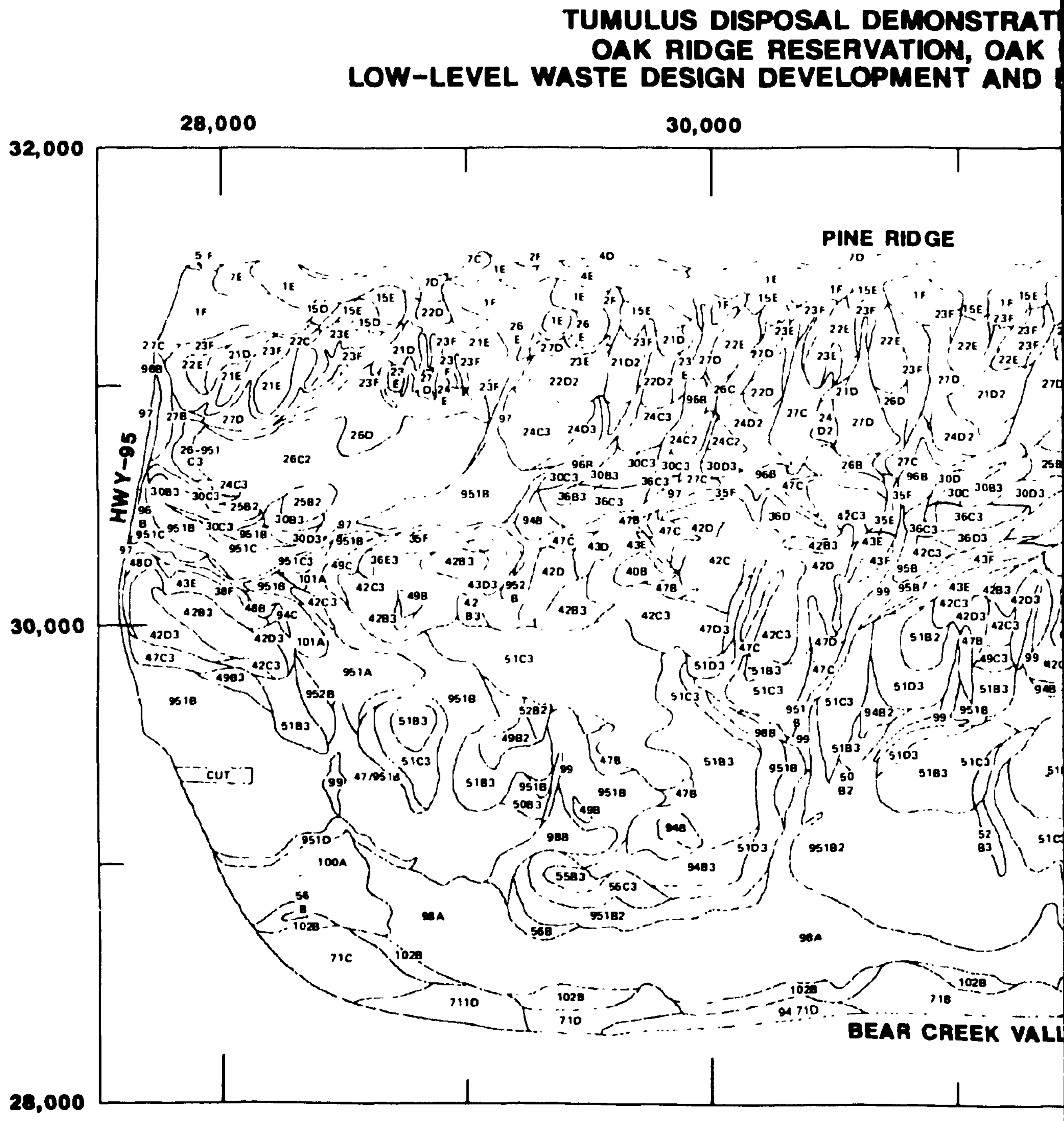

Fig. A-1. Soil survey map.

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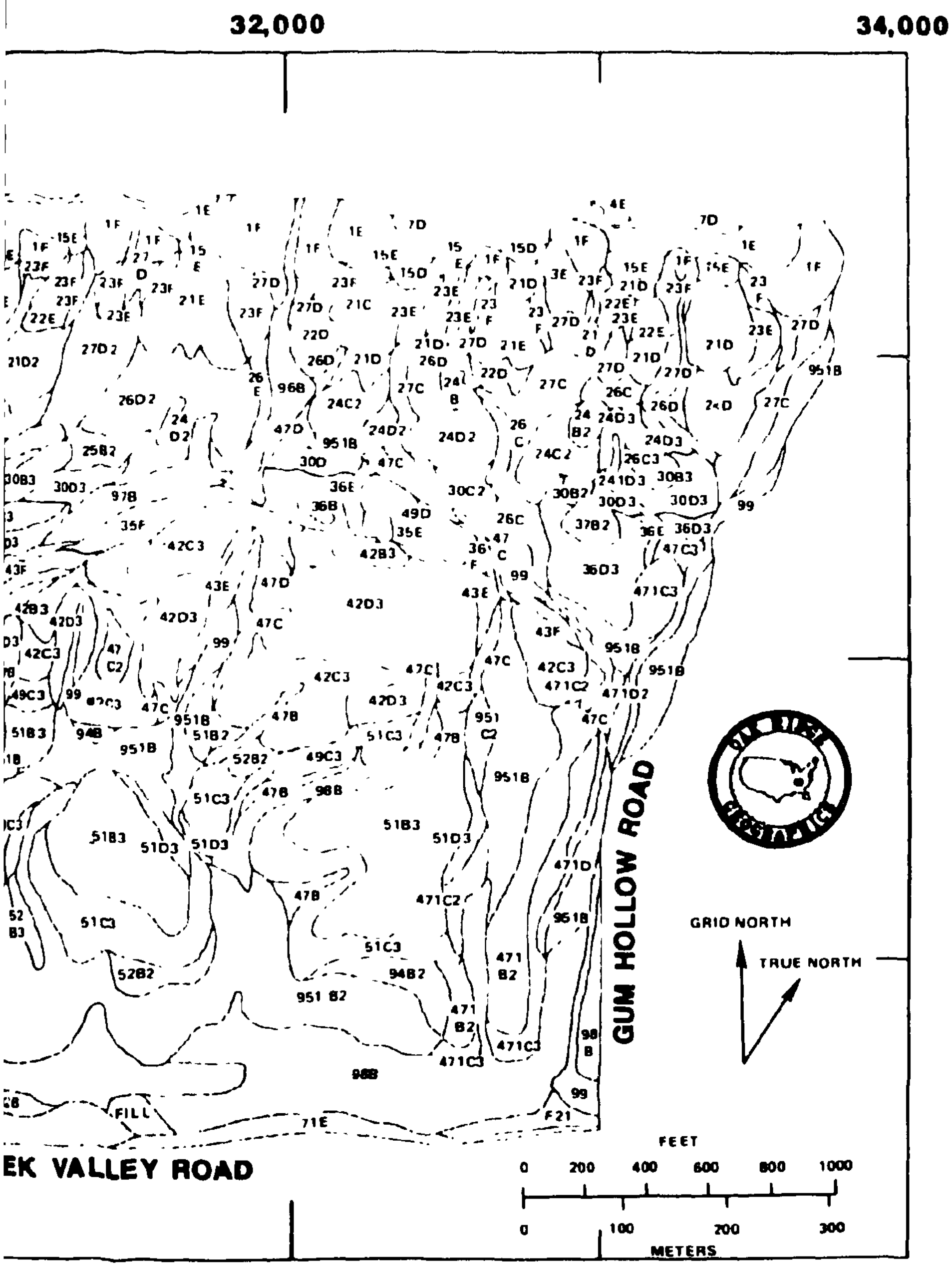

vey map.

2.0 m) are used to define one or more high-level categories of the classification system. The highest category in soil taxonomy is the Order. There are currently ten orders and a provisional eleventh. Four of the ten orders are located on the LLWDDD site. Among the orders represented on the LLWDDD site are the Entisols, which are very young soils of floodplains. Soils in this order reveal very little evidence of their genesis. They are usually stratified close to the surface and lack any pedogenic development of horizons. Most Entisols have a thin A horizon and some accumulation of organic carbon overlying a stratified C horizon. Surface A horizons formed only after abandonment of the open fields; subsequent revegetation greatly reduced the sediment deposition in floodplains and low terraces. Entisols on the LLWDDD site range from well drained to poorly drained. Next is the order of Inceptisols. These are young soils, mostly on steep slopes, that have minimal soil horizonation, but insufficient time has elapsed since the inception of soil formation for distinctive horizonation to have occurred. Inceptisols have an A, Bw, and C horizon sequence. Most Inceptisols are underlain by leached saprolite, which is designated by the symbol Cr and defines the upper boundary of paralithic materials. Most Inceptisols on the LLWDDD site will evolve with time into two other soil orders that have more distinctive and contrasting horizonation: the Alfisols and Ultisols. Soils classified as Alfisols have a clay-enriched subsoil Bt horizon (argillic horizon) and 35% base saturation at a depth of from 1.8 to 2.0 m. Soils classified as Ultisols also have a clay-enriched subsoil Bt horizon (argillic horizon), but they are more highly weathered, with 35% base saturation at a depth of from 1.8 to 2.0 m below the surface. All of the soils in a particular order must have at least one or more common properties that are the result of a common genetic pathway.

Each order has one or more suborders. The Suborder separates soils that have more properties in common. Two suborders of the order of Entisols are present on the site: (1) Fluvents, well-drained and moderately well drained soils of floodplains that have fine stratification throughout the upper soil and (2) Aquents, wet stratified soils of floodplains and seepage areas. The order of the Inceptisols is represented by one suborder on the site: this is the order of Ochrepts. Soils classified as Ochrepts are well drained, have a light-colored surface layer (ochric epipedon), and have a subsoil horizon (cambic horizon) with minimal but significant evidence of a soil-forming process under way. The orders of Alfisols and Ultisols are each represented by two suborders: (1) Aqualfs and Aquults, which are wet soils that have a light-colored surface layer (ochric epipedon) and a clay-enriched subsoil horizon (argillic horizon) and (2) Udalfs and Udults, which are well-drained soils that have both an ochric epipedon and an oxidized subsoil argillic horizon, respectively.

The category below the Suborder is the Great Group; each suborder has one or more great groups, with the soils in each great group having more commonality of properties. (The Great Groups are listed in Table A-2.) Each great group has one or more subgroups. (Subgroups on the LLWDDD site are also listed in Table A-1.) Each subgroup has one or more families. Each category above the Family is conceptual. The Family category is represented by real physical and chemical properties from a prescribed depth and thickness of soil. On the LLWDDD site, mineralogy classes are similar for most soils (mixed); particle-size classes are the most variable and are the only ones shown in Table A-2.

The Soil Series is the lowest category in soil taxonomy. Each soil series is defined mostly by observable soil features. Some of the soils on the LLWDDD site would fit into an existing soil series if only the upper soil above a depth of 2.0 m [or to paralithic materials (Cr horizon) if shallower] were classified. However, when deeper soil layers into which trees root seeking water and nutrients (below a depth of 2.0 m or between paralithic materials and hard rock) are classified, very few of them fit into an existing soil series. Each soil series is represented by a one-, two-, or three-digit number (see Table A-1).

Table A-2. Categories of soil taxonomy on the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) site

Order	Suborder	Great Group	Subgroup	Family
Entisols	Aquents	Fluvaquents	Typic Fluvaquents Aeric Fluvaquents	Fine or coarse-silty, or fine-loamy
	Fluvents	Udifluvents	Typic Udifluvents Aquic Udifluvents	Fine or coarse-silty, fine-loamy or loamy-skeletal
Inceptisols	Ochrepts	Dystrochrepts	Typic Dystrochrepts Ruptic Ultic-Dystrochrepts	Loamy-skeletal or fine-loamy
Alfisols	Aqualfs	Ochraqualfs	Typic Ochraqualfs Aeric Ochraqualfs	Fine or fine-loamy
	Udalfs	Hapludalfs	Typic Hapludalfs Ultic Hapludalfs	Fine or fine-loamy
Ultisols	Aquults	Ochraquults	Typic Ochraquults Aeric Ochraquults	Fine-loamy or clayey
	Udults	Hapludults	Typic Hapludults Ochreptic Hapludults	Fine-loamy or clayey

APPENDIX B

SADDLE AND TELEPHONE LINE TRENCHES: INTERPRETATIONS AND SOIL DESCRIPTIONS

APPENDIX B

SADDLE AND TELEPHONE LINE TRENCHES: INTERPRETATIONS AND SOIL DESCRIPTIONS

B.1 INTERPRETATION OF THE SADDLE TRENCH

The saddle is located along Transect B-B' (see Fig. 5a and Fig. C-2) ~606 m from Bear Creek. In this saddle, diagrammatically illustrated in Fig. B-1, the Rutledge Formation and Pumpkin Valley Formation join in a topographic low produced by headwardly eroding drainageways located in the trace of the Rutledge Limestone on either side. During periods of stability, a thick soil would have formed on this original toeslope landform and the underlying saprolite would be deeply weathered. Based on evidence in the trench (Fig. B-1), the old residual soil was stripped off down to hard coherent saprolite, with the strata of harder saprolite being more resistant to erosion than the softer strata. The soil numbers in Figs. B-1 and B-2 are tentative and are placed on stratigraphic units according to the soil morphology of similar colluvial and residual soils adjacent to this trench. Colluvium (No. 25A, older than No. 25 colluvium) filled in the drainageway created by the stripping, and a soil formed during the stable period that followed. The No. 25A soil formed in an environment with a fluctuating or perched water table, as evidenced by the mottled zone in the lower part. The No. 25A colluvial soil was mostly stripped off during another erosion episode, leaving only two small areas that were preserved by higher areas of bedrock. After stripping, the gully was filled with No. 25 colluvium, the oldest of the Pumpkin Valley colluvial soils still present that have not been completely buried or destroyed by mass wastage. A stable period followed and a soil formed in this colluvium. Another period of instability occurred, which then stripped part of the No. 25 soil from the saddle. The gully was filled with No. 26 colluvium, the most extensive of the Pumpkin Valley colluviums. The mottled zone in the underlying No. 25 paleosol probably formed during the development of the No. 26 soil, which formed

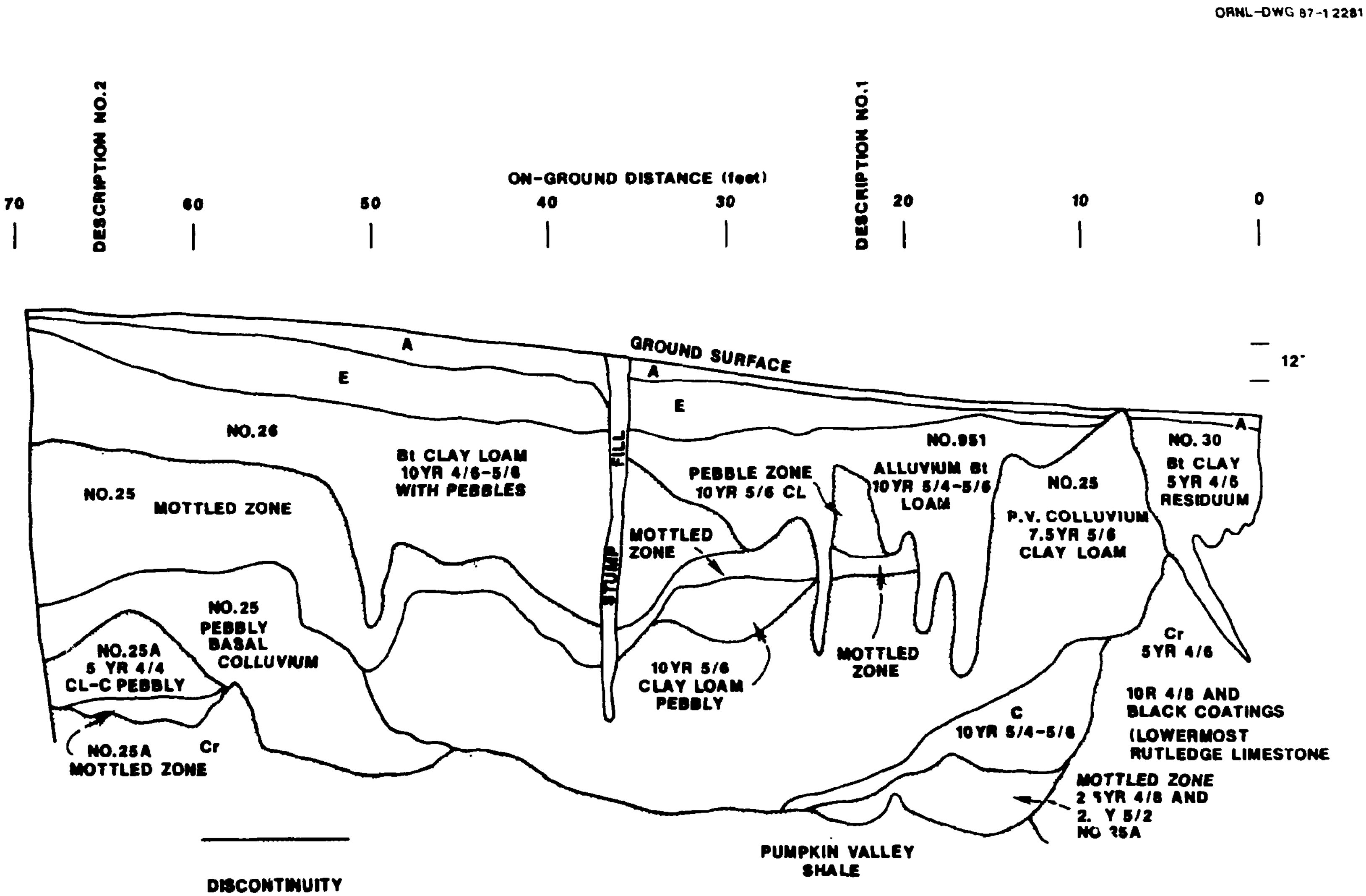

Fig. B-1. Saddle trench cross section. (C = clay; CL - clay loam; CL-C = clay loam-clay; P.V. = Pumpkin Valley; 1 ft = 0.3048 m.)

in a moderately wet environment, given the 10YR hue in the Bt horizon compared with the more normal 7.5YR and 5YR hues in Bt horizons in higher landforms nearby. Another erosional episode partially removed the No. 26 soil. This time, the resultant gully was backfilled by the No. 951 alluvium deposit. (The identity of the alluvium in this trench was based on a few pebbles and rock fragments in the material.) The environment during deposition of the alluvium was wet enough for crayfish to construct burrows through and into the underlying No. 25 paleosol. These burrows are identified at the 4.8-m, 5.7-m, and 7.5-m marks on the diagram (Fig. B-1). These old burrows have smooth sidewalls in contrast to stump fills which have irregular sidewalls. (See Figs. B-2 and B-3 for details.)

The residual soil, No. 30, at the far south end of the trench has formed a reddish yellow clayey Bt horizon. Surface erosion from past agricultural activities probably stripped off the upper E horizon and the transition horizons down to the Bt horizon, which is now directly beneath the A horizon.

It is very evident that there have been fluctuating periods of stability and instability for a considerable period of time. These stable and unstable periods are most likely climatically controlled and are related to the climate perturbations of the Pleistocene age. Thus far, no dateable carbon materials or buried A horizons have been located (with the exception of Trench No. 4 of the Telephone Line Trenches). The sequence of events in the Saddle Trench predate the erosional-depositional events that are preserved in Telephone Line Trenches Nos. 1 to 4. (See Fig. 5a in Section 3 and Fig. C-1 in Appendix C for location.)

YP 5184

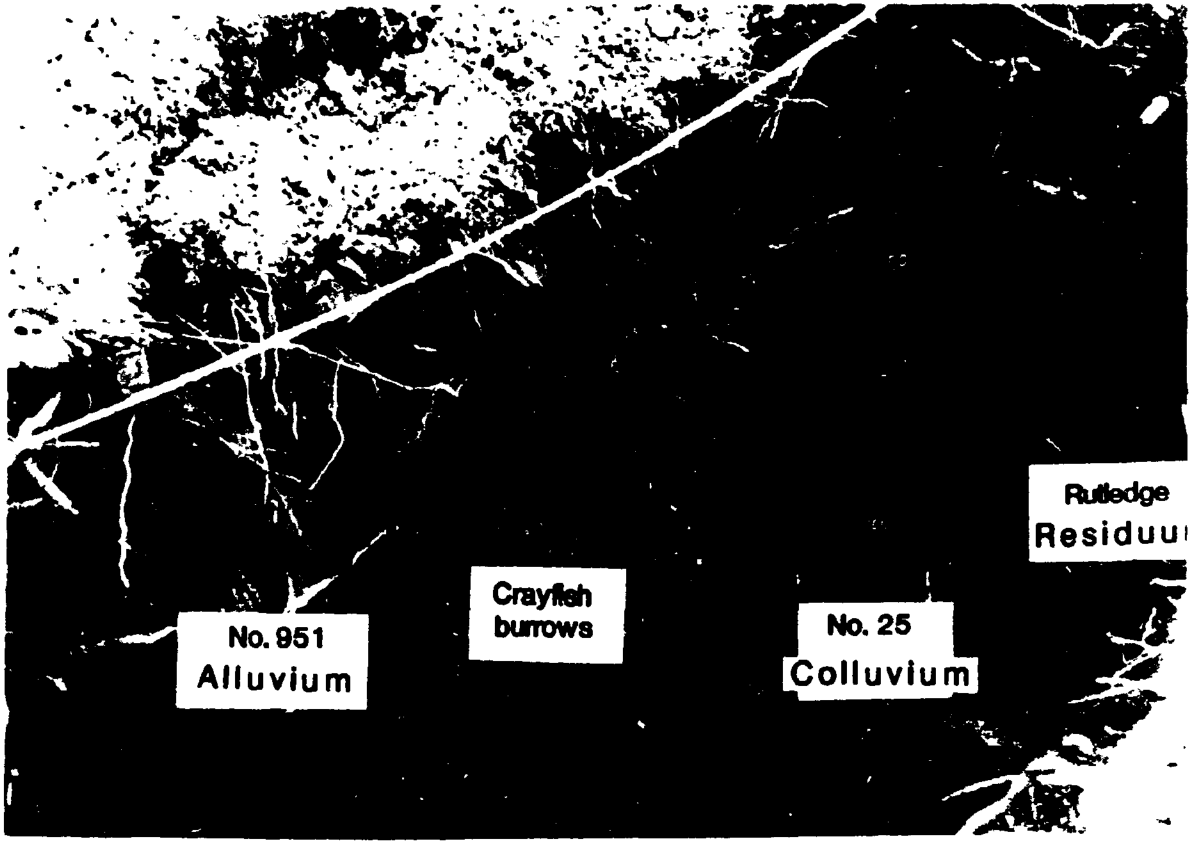

Fig. B-2. View of crayfish burrows in No. 951 soil and into the underlying No. 25 soil.

YP 4413

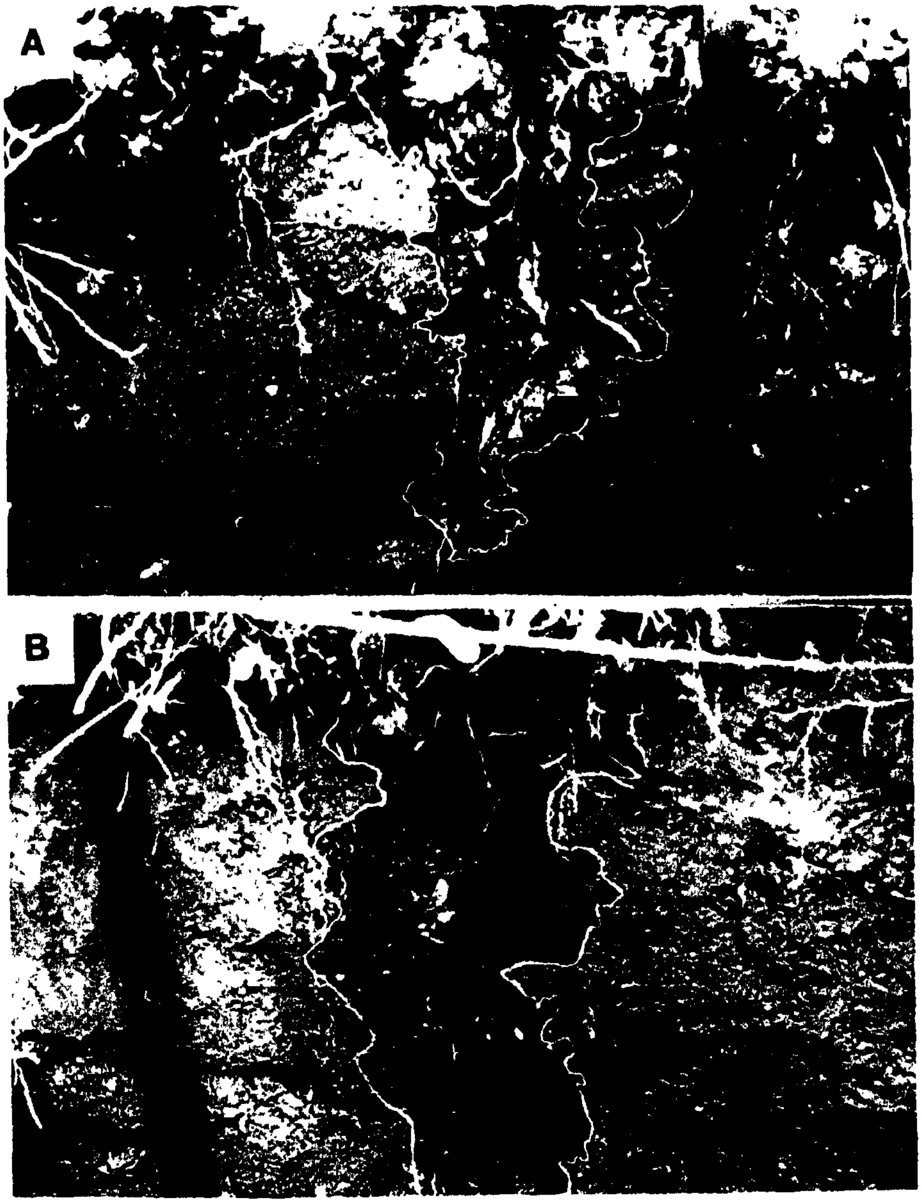

Fig. B-3. In-place stump and stump filling. (Note the irregular shape of stump fill in contrast to the crayfish burrows in Fig. B-2).

B.1.1 Descriptions of soils from Saddle Trench in the LLWDDD site

Saddle Description No. 1

Location: About 6.3 m north of the south end of the trench.
Parent Materials: Thin old alluvium over old colluvium over Rutledge residuum.
Classification: Typic Hapludults; fine-loamy, mixed, thermic.

O: 2-0 cm; partially decomposed organic leaves and litter.

A: 0-2 cm; dark brown (10YR 4/3) very fine sandy loam; moderate fine granular structure; very friable; many fine and medium roots; 1-2% pebbles; pH 6.0; abrupt wavy boundary.

E: 2-32 cm; yellowish brown (10YR 5/4) very fine sandy loam; weak fine granular structure; very friable; common medium roots; 1-2% pebbles; pH 6.2; clear wavy boundary.

Bt1: 132-52 cm; yellowish brown (10YR 5/8) loam; weak fine subangular blocky structure; very friable; 1-2% pebbles; thin discontinuous yellowish brown (10YR 5/6) clay films on ped faces; many pores; pH 5.5; gradual wavy boundary. (Base of alluvium.)

2Bt2: 52-100 cm; strong brown (7.5YR 5/6) gravelly clay loam; moderate fine subangular blocky structure; friable; few fine roots; 15-20% subrounded pebbles; few fine roots; common pores; pH 5.0; gradual wavy boundary.

2Bt2: 100-125 cm; strong brown (7.5YR 5/6) gravelly clay loam with common medium distinct light olive brown (2.5Y 5/4) mottles; moderate medium subangular blocky structure; firm; few medium roots; 15-20% pebbles; common pores; continuous strong brown (7.5YR 5/6) clay films on ped faces and also covering mottles; pH 5.0; gradual wavy boundary.

2Bt3: 125-162 cm; red (2.5YR 4/8) ped interiors and yellowish brown (10YR 5/6) ped exteriors; gravelly loam; weak coarse prismatic parting to moderate medium subangular blocky structure; firm; thick strong brown (7.5YR 5/6) clay films on primary ped faces; few medium roots common pores; pH 5.0; abrupt wavy boundary. (Base of first colluvium.)

3C1: 162-180 cm; highly mottled red (2.5YR 4/8) and light brownish gray (2.5Y 6/2) loam; massive, no rock structure; no roots; very soft, highly weathered pebbles; pH 4.5; abrupt wavy boundary. (Base of oldest colluvium.)

4C2: 180-204 cm; bedded red (2.5YR 4/8), gray, and violet saprolite weathered from Rutledge shale member; massive; very soft; clear irregular wavy boundary.

4Cr: 204-225 cm; highly weathered leached saprolite from Rutledge shale member.

Note: Vertical streaks associated with prismatic structure start in the lower part of the 2Bt2 horizon and extend through the 2Bt3 horizon.

Saddle Description No. 2

Location: About 4.2 m south of the north end of the trench.
Parent Materials: Old alluvium over Pumpkin Valley colluvium over Pumpkin Valley residuum.
Classification: Typic Hapludults; fine-loamy, mixed, thermic.

O: 2-0 cm; partially decomposed organic matter.

A: 0-2 cm; brown (10YR 4/3) very fine sandy loam; weak fine granular blocky structure; very friable; many fine and medium roots; many tubular pores; 5% pebbles; clear wavy boundary.

E: 2-26 cm; yellowish brown (10YR 5/4) very fine sandy loam; weak fine granular structure; very friable; common fine and medium roots and pores; 5% pebbles; gradual wavy boundary.

Bt1: 26-55 cm; yellowish brown (10YR 5/8) loam; weak fine subangular blocky structure; very friable; few fine and medium roots and pores; 10% pebbles; clear wavy boundary. (This horizon is a mixture of alluvium and colluvium and marks the lower extent of alluvium.)

2Bt2: 55-76 cm; yellowish brown (10YR 5/6) loam; moderate fine and medium subangular blocky structure; friable; few roots; many pores; 10-15% pebbles; thin discontinuous dark yellowish brown (10YR 4/4) clay films on ped faces; clear wavy boundary.

2Bt3: 76-92 cm; strong brown (7.5YR 5/6) gravelly clay loam; moderate medium subangular blocky structure; friable; few fine roots; many pores; 15-20% pebbles; vertical flow zones start at the top of this horizon; clear wavy boundary.

2Bt4: 92-115 cm; brown (7.5YR 4/4) gravelly clay loam; weak medium subangular blocky structure; friable; few fine roots; common pores; 15-35% pebbles; clear wavy boundary. (Base of younger colluvium.)

3Bt5: 115-148 cm; reddish brown (5YR 4/4) clay loam; weak coarse subangular blocky structure; firm; few fine roots; common pores; 5-10% soft sandstone pebbles; continuous brown (7.5YR 4/4) clay films on ped faces; gradual wavy boundary.

3Bt6: 148-180 cm; yellowish red (5YR 5/6) clay loam-clay; weak coarse subangular blocky structure; firm; few fine roots; common pores; 5% pebbles; many medium yellowish brown (10YR 5/4) mottles covered by yellowish brown (10YR 4/4) clay films; abrupt wavy boundary. (Base of older colluvium.)

4C: 180-196 cm; soft Pumpkin Valley leached saprolite with red and gray faces; crushes to shaly, silty clay loam; few fine roots and root mats in lower part.

4Cr: 196 cm; weathered and leached saprolite from Pumpkin Valley Shale.

B.2 INTERPRETATION OF TELEPHONE LINE TRENCHES

The series of trenches described in this section are located along Transect A-A' about 76 m north of Bear Creek. (See Fig. 5a and Fig. C-1 for location.) The trenches are diagrammatically shown in Fig. B-4. They reveal a complicated late Pleistocene, Holocene, and Modern geomorphic history of the area. The highest elevation in the LLWDDD area for which there is general distribution of alluvium is ~250 to 260 m Thus, the entire slope was, or should have been, covered with No. 951 alluvium one or more times. Trench No. 1 (the uppermost trench) has a thin smear of alluvium, but the reddish color, which is indicative of increasing age in an oxidizing environment, and the silty clay loam texture indicate that it is older than the yellowish and lower-clay-content No. 951 alluvium which would have covered it. This older alluvium represents alluvial deposition, soil formation, and denudation that took place before the geomorphic events that produced the No. 951 alluvium. The lowermost corner of Trench No. 1 has a sequence of alluvium over colluvium over residuum, Profile T-1. This colluvium is traced downslope through Trench No. 2, where it is sandwiched between two alluviums and underlain by a paleosol that formed in residuum. In Trench No. 3, residuum comes to the surface, the result of more recent erosion. The colluvium that first appears in Trench No. 1 is exposed at the surface in this trench. The alluvium and colluvium from Trenches Nos. 1 to 3 are probably the result of periodic climate-related episodes of the Pleistocene Epoch that resulted

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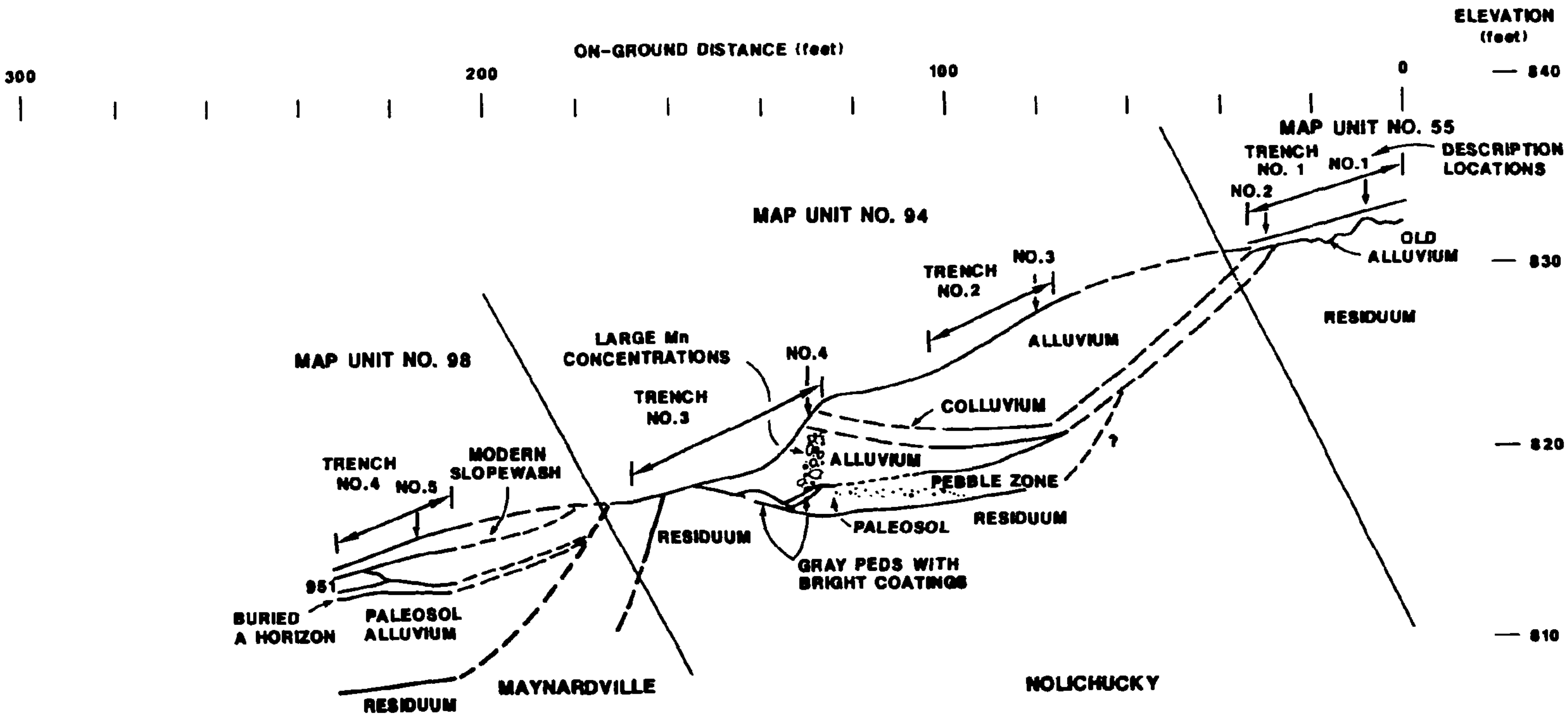


Fig. B-4. Trench transect parallel to telephone line. (1 ft - 0.3048 m.)

in periods of stability and instability. Bear Creek Valley was filled by a mixture of alluvium derived from the local Rome Formation and Conasauga Formation along with some windblown loess. Chert fragments are very rare in the No. 951 alluvium and in the alluviums and colluviums of Trenches Nos. 1 to 3, indicating that the Knox soils were mostly stable during these climatic episodes. During the Holocene, Bear Creek gradually removed the accumulated sediments that had plugged the valley by downward cutting and lateral meander shifts. Downcutting continued until the hard rock of the Maynardville Formation was encountered. A layer of chert commonly lies on top of the rock contact, whereas the sediments above are mostly chert-free. Trench No. 4 contains the record of the late Holocene. The uppermost sediments are the result of the initial land-clearing activities and accelerated erosion due to agricultural and forestry practices. Below these surficial sediments, there is a thick layer of gradually accumulated topsoil, the result of gradual downward geologic transport of hillslope surface soil. Beneath this layer is a complete, untruncated paleosol, which is assumed to have formed in sediments deposited after Bear Creek ceased downcutting in the Holocene Epoch and started accreting sediments. Beneath the paleosol, there is clayey residuum weathered from the Maynardville Limestone, Profile T-5.

B.2.1 <u>Descriptions of Soils from Telephone Line Trenches</u>

<u>Profile T-1 from Trench No. 1 (Uppermost End of Trench)</u>

Parent Materials: Thin alluvium over interbedded shale and limestone of the lower Nolichucky Formation.
Classification: Typic Paleudults; clayey, mixed, thermic. Or Ultic Hapludalfs; fine, mixed, thermic.
Soil: No. 55.

A1: 0-4 cm; dark brown (10YR 4/3) silt loam; moderate fine granular structure; friable; clear wavy boundary.

Ap: 4-12 cm; dark yellowish brown (10YR 4/6) clay loam with shale fragments; moderate fine subangular blocky structure; firm; 12 to 15% shale fragments; common fine roots; many tubular pores; pH 6.2; clear wavy boundary.

Bt1: 12-30 cm; strong brown (7.5YR 5/6) silty clay loam; strong moderate subangular blocky structure; friable; continuous yellowish brown (10YR 5/6) clay films on ped faces; common small, hard manganese nodules; <5% fragments of Rome origin; few fine roots; many interstitial and tubular pores; pH 6.5; clear wavy boundary. (Mixture of old alluvium and residuum.)

Bt2: 30-59 cm; strong brown (7.5YR 5/6) silty clay-clay; moderate medium prismatic parting to strong fine angular blocky structure; firm; continuous strong brown clay films on prism faces and on many angular ped faces; no manganese nodules or rock fragments; few fine roots; many interstitial and tubular pores; pH 6.0; gradual wavy boundary.

Bt3: 59-107 cm; yellowish brown (10YR 5/6) clay-silty clay; moderate coarse prismatic parting to moderate fine and medium angular blocky structure; firm; few fine distinct light yellowish brown (2.5Y 4/6) mottles in prism interiors and few fine prominent red (2.5YR 4/8) mottles on ped exteriors; thin to thick continuous strong brown (7.5YR 5/6) clay films on prism faces; no fragments; few fine roots; common interstitial and tubular pores; pH 5.5; gradual wavy boundary.

Bt4: 107-157 cm; yellowish brown (10YR 5/6) clay-silty clay; weak medium prismatic parting to moderate fine angular blocky structure; firm; moderate medium distinct light olive brown (2.5Y 5/6) mottles in prism interiors and common fine prominent light brownish gray (2.5Y 6/2) mottles in the lower part; continuous strong brown (7.5YR 5/6) clay film on prism faces and common fine red (2.5YR 4/8) iron stains and streaks on angular ped faces; no fragments; few fine roots; common interstitial pores; pH 5.5; clear wavy boundary.

Bt5: 157-198 cm; yellowish brown (10YR 5/6) silty clay; weak coarse prismatic parting to moderate fine angular blocky structure; firm; many medium distinct light olive brown (2.5Y 5/6) and common fine prominent light brownish gray (2.5Y 6/2) mottles in prism interiors; black manganese films and red iron films on some interior angular peds; strong brown (7.5YR 5/6) clay films on prism exteriors and root channels; no fragments; common interstitial pores; pH 5.5; clear wavy boundary.

BC: 198-276 cm; yellowish brown (10YR 5/6) silty clay-silty clay loam; weak coarse prismatic parting to moderate fine angular blocky structure; very firm; many medium prominent light brownish gray (2.5Y 6/2) mottles throughout prisms; common manganese films on angular peds; common discontinuous strong brown (7.5YR 5/6) clay films on prism faces; some peds have saprolite interiors; no fragments or roots; pH 5.5; gradual wavy boundary.

CB: 276-298 cm; mottled strong brown (7.5YR 5/8) and yellowish brown (10YR 5/6) silty clay loam-silty clay; firm; many prominent light gray (10YR 7/1) mottles; many manganese zones. (Augered.)

C: 298-335 cm; light olive brown (2.5Y 5/6) and yellowish brown (10YR 5/6) silty clay loam; light gray (10YR 7/1) in flow zones; many black manganese zones; some strong brown clay flows in flow zones. (Augered.)

Profile T-2 from Trench No. 1

Parent Materials: Old alluvium over old colluvium over residuum.
Classification: Typic Hapludults; clayey, mixed, thermic. Or Ultic [illegible]ludalfs; fine, mixed, thermic.
S[illegible] Transition zone from soil No. 55 to soil No. 94.

Ap: 0-15 cm; dark brown (7.5YR 4/4) shaly clay loam; moderate medium and coarse granular structure; friable; 15-20% shale fragments; many fine roots; many tubular pores; abrupt wavy boundary.

Bt1: 15-27 cm; yellowish red (5YR 4/6) silty clay loam; moderate fine subangular blocky structure; friable; 10-15% fragments of shale and Rome sandstone; many hard manganese nodules 1-2 mm in diameter; few fine roots; many interstitial and tubular pores; clear wavy boundary.

Bt2: 27-47 cm; yellowish red (5YR 4/6) silty clay loam; moderate medium subangular blocky structure; friable; thin, discontinuous reddish brown (5YR 4/4) clay films on ped surfaces; many large 1- to 2-cm-diam manganese nodules; 10-15% Rome sandstone fragments; few fine roots; many interstitial and tubular pores; clear wavy boundary. (Base of alluvium.)

2Bt3: 47-77 cm; yellowish red (5YR 4/6) clay; moderate medium subangular blocky structure; friable; continuous reddish brown (5YR 4/4) clay films on ped faces; many soft shale and sandstone fragments and ~10-15% hard fragments; few fine roots; common interstitial and tubular pores; abrupt wavy boundary. (Colluvium.)

3Bt4: 77-84 cm; yellowish red (5YR 4/6) silty clay; moderate fine subangular and angular blocky structure; firm and sticky; continuous yellowish red clay films on ped surfaces; no fragments; few fine roots; common interstitial and tubular pores; clear wavy boundary.

3BC: 84-100 cm; yellowish red (5YR 4/6) silty clay; weak medium prismatic parting to moderate fine angular blocky structure; firm and sticky; continuous yellowish red clay films on prism exteriors; many angular peds have strong brown (7.5YR 5/8) saprolite interiors; few fine roots; no fragments; common interstitial and tubular pores. (Residuum.)

Profile T-3 from Trench No. 2

Parent materials: Alluvium over colluvium over older alluvium over residuum.
Classification: Ultic or Typic Hapludalfs; fine-loamy, mixed, thermic.
Soil: No. 94 map unit.

Ap: 0-18 cm; dark brown (7.5YR 3/4) loam-silt loam; moderate medium granular structure; friable; 10-15% fresh shale fragments; many fine roots; many tubular pores; pH 6.3; clear wavy boundary.

A: 18-36 cm; dark brown (7.5YR 3/4) loam; moderate medium granular structure; friable; no shale fragments but 5-10% sandstone fragments; many fine roots; many tubular pores; pH 6.5; clear wavy boundary.

AB: 36-70 cm; dark reddish brown (5YR 3/4) loam; moderate fine subangular blocky structure; friable; 5-10% sandstone gravels; common hard manganese nodules; common fine roots; many tubular and interstitial pores; pH 6.8; gradual wavy boundary.

Bt1: 70-92 cm; mixed blotches of reddish brown (5YR 4/4) and strong brown (7.5YR 4/6) silty clay loam; moderate medium subangular blocky structure; friable; thin, continuous dark reddish brown (5YR 3/4) clay films on ped surfaces; many manganese nodules 2.0 mm to 1.0 cm in diameter; 10-15% sandstone and shale fragments; few fine roots; many interstitial and tubular pores; pH 6.5; gradual wavy boundary.

Bt2: 92-158 cm; blotchy yellowish red (5YR 4/6) and dark reddish brown (5YR 3/4) gravelly silty clay loam; moderate medium subangular blocky structure; friable; continuous dark reddish brown clay flows on ped surfaces; many hard manganese nodules; 15-20% sandstone and shale fragments; few fine roots; many interstitial and tubular pores; pH 6.0; clear wavy boundary. (Base of alluvium.)

2Bt3: 158-199 cm; yellowish red (5YR 4/6) very shaly clay; moderate fine subangular blocky structure; friable; clay plugged with yellowish red and red clay and red (2.5YR 4/8) iron-clay in the lower part; 35-50% shale and sandstone fragments from the Pumpkin Valley Formation and Rome Formation; few fine roots; common interstitial and tubular pores; pH 6.0; abrupt wavy boundary. (Base of colluvium.)

3Bt4: 199-315 cm; strong brown (7.5YR 5/6) silty clay-silty clay loam; moderate medium subangular blocky structure; firm; yellowish red (5YR 5/6) clay films on ped surfaces; manganese specks throughout; lag gravel deposit at 290-315 cm, no fragments above; no roots; common interstitial and tubular pores; pH 6.0; abrupt wavy boundary. (Base of older alluvium.)

4Bt5: 315-363 cm; mottled yellowish brown (10YR 5/6) and strong brown (7.5YR 5/4) silty clay-clay; firm; many manganese coatings and zones plugged with yellowish red clay; pH 6.0 at 363 cm. (Auger boring into residuum.)

<u>Profile T-4 from Trench No. 3</u>

Parent Materials: Old colluvium over old alluvium over Maynardville Limestone residuum.
Classification: Ultic or Typic Hapludalfs; fine-loamy, mixed, thermic.
Soil: Inclusion in No. 94.

Ap: 0-15 cm; dark yellowish brown (10YR 3/4) loam; moderate medium granular structure; friable; many fine and medium roots; 10-15% shale and sandstone fragments; many tubular pores; abrupt wavy boundary.

Bt1: 15-50 cm; yellowish red (5YR 4/6) gravelly clay loam-clay; moderate medium subangular blocky structure; friable; continuous reddish brown (5YR 4/4) clay films on ped surfaces; few manganese nodules; 15% hard and 25-35% soft shale and sandstone fragments; common fine and medium roots; many interstitial and tubular pores; clear wavy boundary. (Base of colluvium.)

2Bt2: 50-100 cm; light olive brown (2.5Y 5/6) silty clay loam; moderate medium subangular blocky structure; firm; continuous yellowish red (5YR 4/6) clay films on ped surfaces; many large 2- to 10-mm-diam manganese nodules; 5-10% sandstone fragments; few fine roots; many interstitial and tubular pores; gradual wavy boundary. (Alluvium.)

2Btg: 100-151 cm; mottled light olive brown (2.5Y 5/6) and olive gray (2.5Y 5/2) silty clay loam; weak, coarse prismatic parting to moderate medium subangular blocky structure; firm; continuous strong brown (7.5YR 4/6) clay films on prism faces; discontinuous red (2.5YR 4/8) iron coatings on subangular peds; 5-10% fragments; few fine roots; common interstitial pores; gradual wavy boundary.

2BC: 151-220 cm; yellowish brown (10YR 5/6) very gravelly clay loam; massive; firm; discontinuous strong brown (7.5YR 4/6) clay plugs; many large manganese-plugged zones; gray water flow zones; 35-50% fragments; few fine roots; abrupt wavy boundary. (Lag gravel at base of alluvium.) (Auger boring.)

3Bt: 220-275 cm; yellowish brown (10YR 5/6) silty clay-clay; massive; very firm; manganese, clay, and red iron zones; no fragments. (Auger boring into residuum.)

3BC: 275-340 cm; strong brown (7.5YR 5/8) silty clay-clay saprolite; massive; very firm. (Maynardville Limestone residuum.)

Profile T-5 from Trench No.4

Parent Materials: Modern overwash over alluvium over old alluvium over Maynardville Limestone residuum.
Classification: Typic Udifluvents; fine-loamy, mixed, thermic.
Soil: No. 98 map unit.

A: 0-40 cm; dark yellowish brown (10YR 4/6) loam-silt loam; weak fine granular structure; friable; many fine and medium roots; many tubular pores; pH 6.3; abrupt wavy boundary. (Overwash.)

Ab: 40-60 cm; dark reddish brown (5YR 3/2) gravelly loam; moderate fine granular structure; very friable; 15-20% shale and sandstone fragments; common medium roots; many tubular pores; pH 6.5; diffuse wavy boundary.

ACb: 60-96 cm; dark reddish brown (5YR 3/3) light clay loam; moderate fine granular structure; very friable; <5% shale and sandstone fragments; common medium and fine roots; many tubular pores; pH 7.0; gradual wavy boundary.

Bwb: 96-124 cm; dark brown (7.5YR 3/4) light clay loam; moderate coarse subangular blocky structure; friable; 10-15% shale and sandstone fragments; few fine roots; pH 7.2; clear wavy boundary. (Base of alluvium.)

2A'b: 124-183 cm; dark brown (10YR 3/3) silty clay loam; moderate fine and medium subangular blocky structure; very firm; very dark gray (10YR 3/1) coatings on ped surfaces; 10-15% shale and sandstone fragments; few fine roots; common interstitial and tubular pores; pH 7.5; clear wavy boundary.

2Btgb: 183-260 cm; light olive brown (2.5Y 5/6) silty clay loam-silty clay; moderate medium subangular blocky structure; very firm; continuous dark grayish brown (10YR 4/2) coatings on ped surfaces and interior mottles in peds; 10-15% shale and sandstone fragments; few fine roots; few interstitial pores; pH 7.5. (Base of older alluvium.)

3Btg: 260-300 cm; light olive brown (2.5Y 5/6) heavy, sticky clay with many fine distinct dark grayish brown (2.5Y 4/2) mottles and flow zones. (Augered.)

3R: 300 cm; hard gray Maynardville Limestone.

APPENDIX C

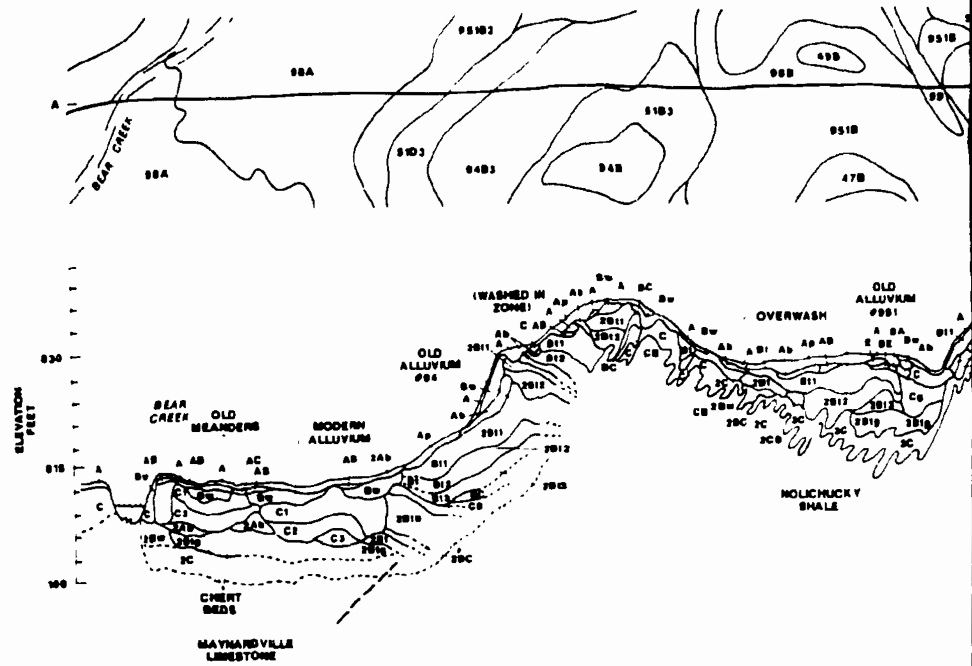
TRANSECTS A-A' and B-B'

APPENDIX C

TRANSECTS A-A' and B-B'

Two soil transects were completed on the LLWDDD site, located in Bear Creek Valley, Roane County, Tennessee. Transect A-A' (Figs. 5a and C-1) was located parallel to a telephone line running east to west, cutting diagonally across the northeast-to-southwest-running valley. This transect intercepted old alluvium that lies on truncated residual soils or on highly weathered saprolites of the Nolichucky, Maryville, Rogersville, Rutledge and Pumpkin Valley Formations. The transect length is ~1000 m on-the-ground. It originates at Bear Creek ~800 m northeast of the intersection of Bear Creek Valley Road and Tennessee Highway 95 (latitude: 35°56'20" N, longitude: 84°20'5" W) and runs to just southeast of the Pine Ridge water gap through which Bear Creek drains at Tennessee Highway 95 (latitude: 35°56'30" N, longitude: 84°20'35" W). All geologic formations of the Cambrian-aged Conasauga Group were encountered. The elevation along Transect A-A' ranged from 242 to 254 m above sea level. Most of the vegetation in the area consisted of transplanted pine, some red maple in low-lying areas, and scattered areas of upland oaks and hickories.

Transect B-B' (Figs. 5a and C-2) was located ~800 m northeast of Transect A-A'. It also originates at Bear Creek (latitude: 35°56'25" N, longitude: 84°19'35" W) and runs northwest, perpendicular to strike, until it reaches the crest of Pine Ridge (latitude: 35°57'5" N, longitude: 84°19'49" W). Transect B-B' follows a drilling road for much of its 788-m length. This transect traverses all of the formations of the Conasauga Group as well as the upper sandstone members of the Cambrian Rome Formation. Elevation varies from 248 m above sea level at Bear Creek to 306 m on Pine Ridge. Transect B-B' exposed residual and colluvial soils, as well as the effects of past erosion. Vegetation varied from transplanted pines on the lower quarter of the transect to maples, oaks, and hickories, with intermixed pines, elsewhere.



BEAR CREEK
98A
OVERWASH
OLD ALLUVIUM
(WASHED IN ZONE)
BEAR CREEK
OLD MEANDERS
MODERN ALLUVIUM
ELEVATION FEET
NOLICHUCKY SHALE
CHERT BEDS
MAYNARDVILLE LIMESTONE

Fig

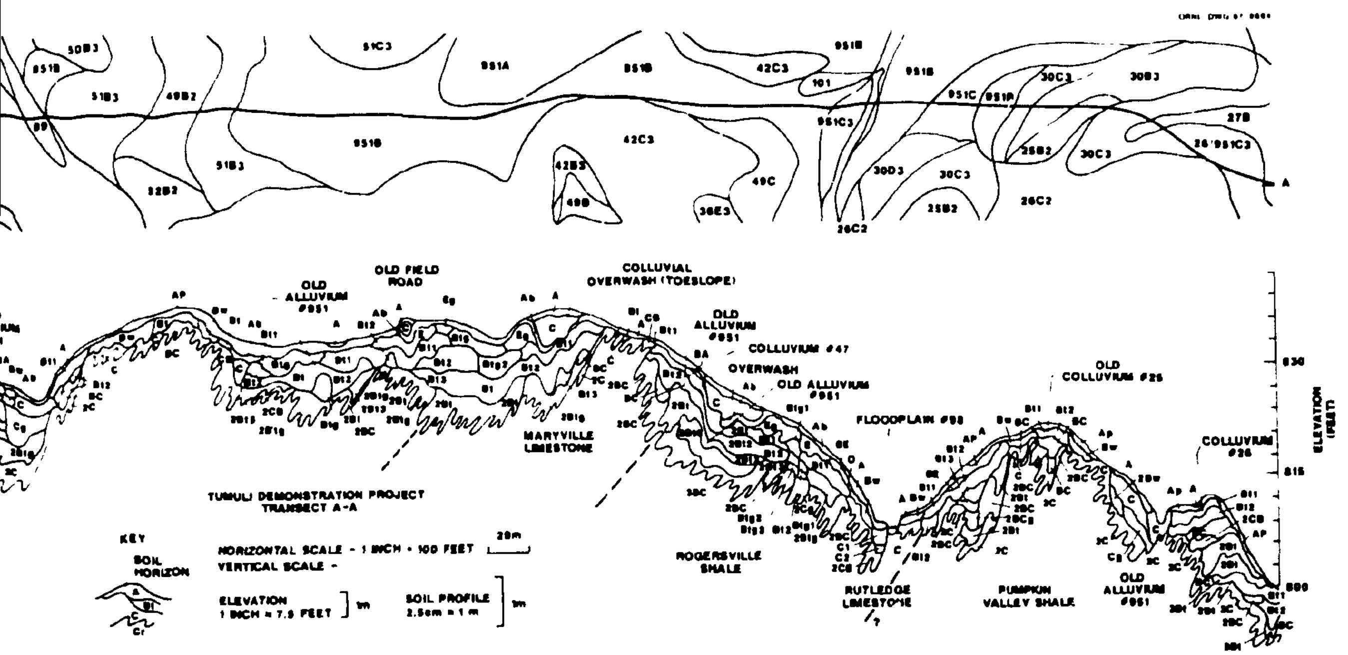


Fig. C-1. Transect A-A'.

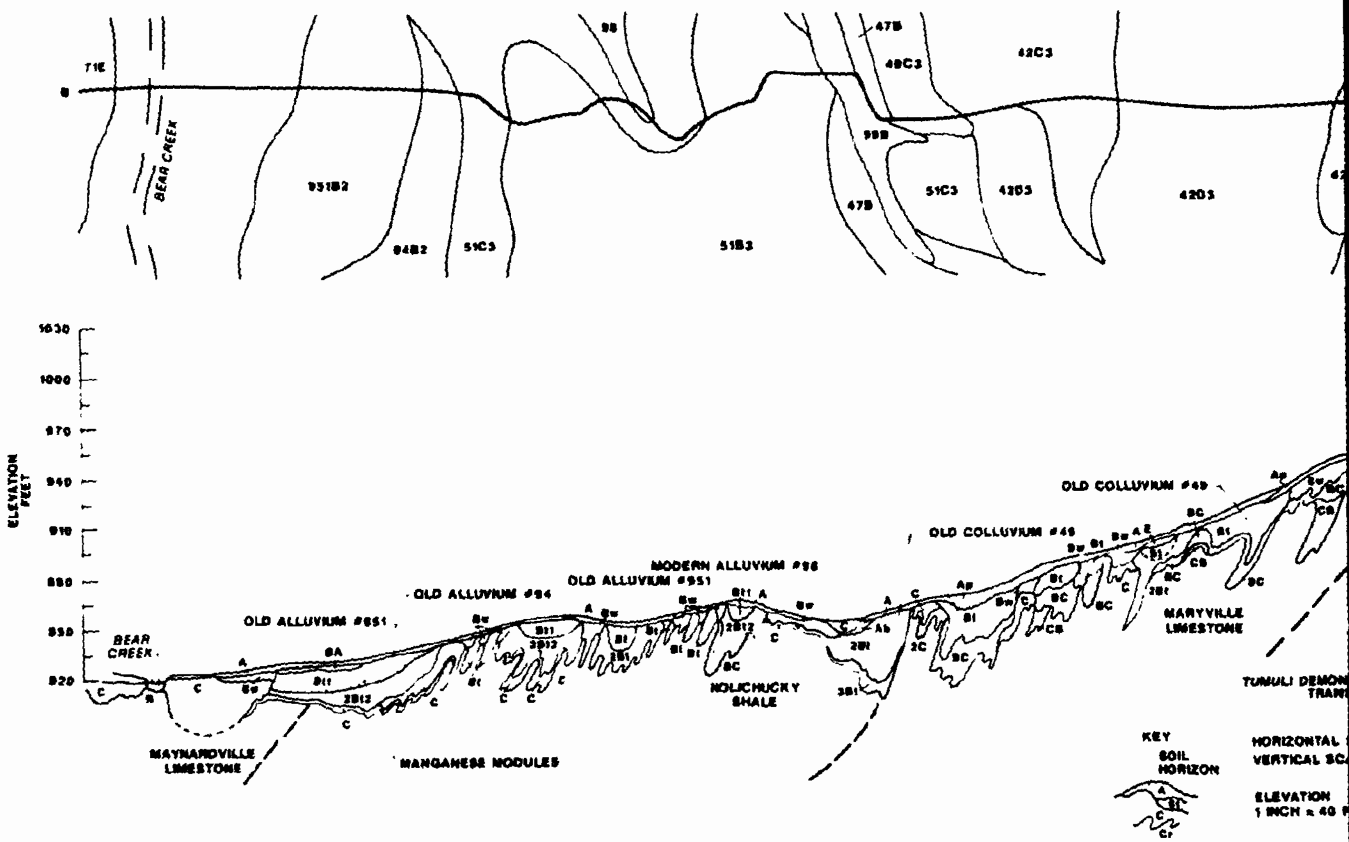
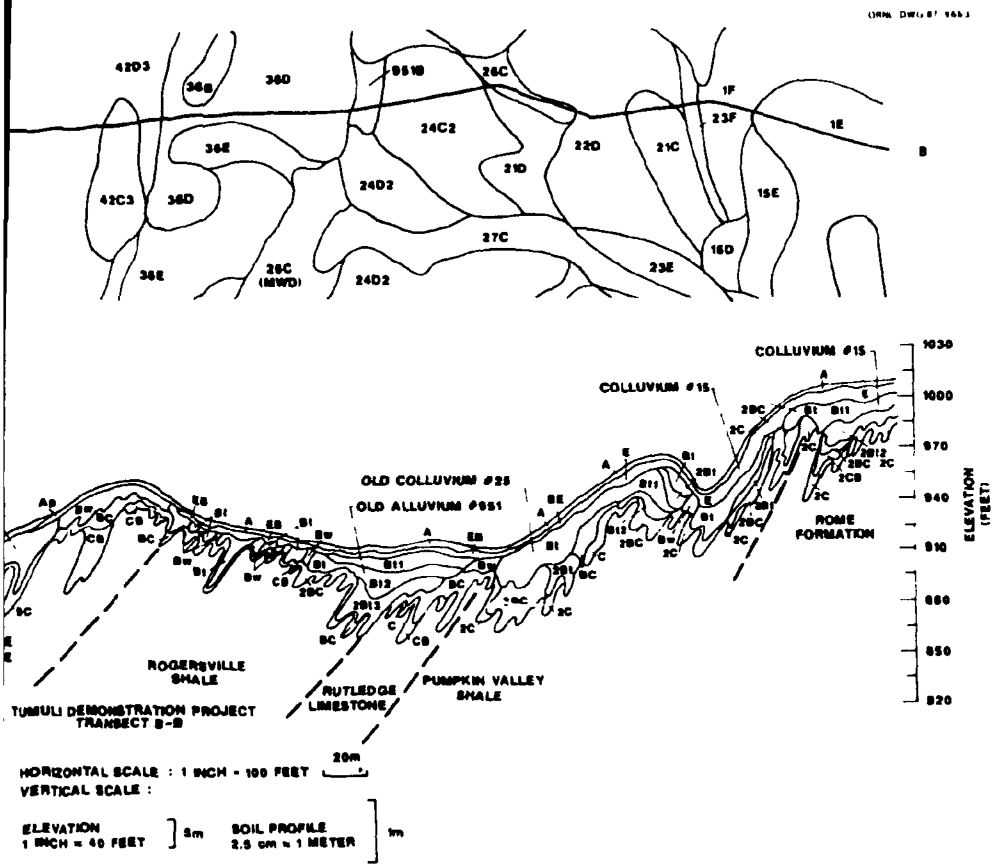


Fig. C-2 Transect B-B'. (1 ft = 0.304


42D3
36B
36D
951B
26C
24C2
1F
23F
1E
B
36E
21D
22D
21C
42C3
36D
24D2
15E
27C
15D
23E
36E
25C (MWD)
24D2
COLLUVIUM #15
COLLUVIUM #15
OLD COLLUVIUM #25
OLD ALLUVIUM #951
ROME FORMATION
ROGERSVILLE SHALE
RUTLEDGE LIMESTONE
PUMPKIN VALLEY SHALE
ELEVATION (FEET)
1030
1000
970
940
910
880
850
820
TUMULI DEMONSTRATION PROJECT TRANSECT B-B
20m
HORIZONTAL SCALE : 1 INCH = 100 FEET
VERTICAL SCALE :
ELEVATION 1 INCH = 40 FEET
5m
SOIL PROFILE 2.5 cm = 1 METER
1m

≈ 0.3048 m.)

Selection of the sites of Transects A-A' and B-B' were based on three criteria: (1) accessibility; (2) total coverage of the soils, geology, and landforms between Pine Ridge and Bear Creek; and (3) near-perpendicular strike placement with respect to each transect. Accessibility was a problem in the area due to very thick vegetation. Thus, both transects were located parallel to telephone line rights-of-way and/or roads. The two transect locations selected were the most desirable locations that satisfied all criteria. Observations from the transects were used to develop a three-dimensional view of soil formation, weathering, and spatial distribution of LLWDDD soils.

Transect data points were stepped off at ~7.5-m intervals and flagged. The accuracy of the steps was periodically measured by tape. In areas of residual soils that had been classified as Ruptic Ultic Dystrochrepts, additional observations were made at a 1.0-m distance, across strike from the primary observation point. Data points (a total of 134) were laid off for Transect A-A' and a total of 104 for Transect B-B'. Soil profiles were observed, using a 1.0-cm-diam core sampling device that extracted a core to a depth of 120 cm. A barrel auger 1.5 m in length was used to evaluate horizons below this depth. Areas where the soil solum was deeper than 1.5 m were flagged for later trench excavation. Soil profiles were observed down to and into the upper paralithic (Cr horizon) saprolite. The horizonation, depths, colors, textures, and unusual features of the soil were recorded. Transect data were illustrated in Figs. C-1 and C-2, showing detailed soil horizonation, thicknesses of horizons, depth to paralithic saprolite, topographic relief, other special geomorphic features, and the underlying geology.

C.1 INTERPRETATION OF RESULTS

C.1.1 Transect A-A'

Transect A-A' (Fig. C-1) begins at Bear Creek, extends westerly, and ends where Bear Creek flows through the Pine Ridge water gap along Route 95 (Fig. 5a). The majority of the soils along this transect have an alluvial origin and range in age from the Modern back into the Pleistocene. Beginning at Bear Creek, the alluvium is Modern (<300 years) to late Holocene (<2800 years) in age, with evident stratification. The floodplain also contains numerous shallow channel beds, evidence of a past braided stream. Where older soils are present on these floodplain and low-terrace landforms, they are usually buried, wet, and gleyed. The first of two stream terraces occur ~106 m up the transect. The lower terrace contains older alluvium (Holocene in age, but >2800 years) that has had sufficient time to develop argillic horizons (No. 94 soil), yet still preserves remnants of channel beds. Unlike the Modern floodplain alluvium, the terrace alluvium contains no chert from the Knox Group dolomites. The base of the lower terrace contains a pocket of colluvium that contains shale fragments. A colluvial layer of similar composition exists in the second terrace level, which suggests that, following stream degradation of part of the higher terrace, colluviation occurred, followed by a new episode of stream aggradation brought about by increased flooding and deposition of sediments on older truncated soils. This activity was followed by another period of stream entrenchment and lateral cutting meanders, which formed the lower terrace. Continued downcutting to hard Maynardville Limestone and lateral meander cutting produced the current floodplain and low terraces of Bear Creek (No. 98, No. 100, and No. 102 soils). The upper terrace has a redder (2.5YR 5/6 vs 10YR 5/6) and finer-textured subsoil, with little evidence of alluvial stratification (older No. 94 soil). Four trenches were dug in this area of the transect [described in detail in Appendix B as the telephone line trench transect (Fig. B-4)]. About 212 m west, the terraces cover Nolichucky residuum. As is the case with most Nolichucky soils, past erosion was very severe, and current depth to Cr material is generally <50 cm. Most soils, even on gentle slopes, have lost most of their upper soil horizons, including most of a clayey Bt (argillic) horizon. However, the presence of thick clay films and clay-plugged pores in the uppermost saprolite is evidence that there were Bt horizons in these soils before the most recent cycle of anthropogenically induced and accelerated erosion. Soils on obsequent (northwest aspect) slopes are less developed and seem to have been more eroded by past agricultural activities. The sola of soils on nearly level and very gently sloping summits are only slightly thicker, but they have also been severely eroded from past intensive agricultural land use. Nolichucky residuum continues for ~45 m west.

For the next ~182 m, a blanket of alluvium (No. 951), 50-cm to >2.0-m thick, covers the Nolichucky residuum. This alluvial material has uniform very fine sandy loam to silt loam textures, few if any coarse fragments, and a characteristic brownish yellow (10YR 6/6) upper subsoil. Because of the uniform textures and absence of rock fragments, it was presumably deposited in a low-energy backwater or shallow lake environment. With the exception of a few residual and colluvial islands on the Maryville and Pumpkin Valley Formations, the remaining ~758 m of transect traverses this material. At the base of slopes, No. 47 and No. 49 colluvium covers No. 951 alluvium. The No. 49 colluvium is fairly old, reddish, and contains numerous clay skins. This finding suggests that the material is at least late Pleistocene in age. Transect A-A' cuts through a paleochannel of Bear Creek and transversely across the edge of the same channel. Here, the water table is near or at the soil surface during the wet season and within 1.0 m during the summer. As a result, a good deal of iron stripping (ferrolysis) has occurred in the subsurface, and gleyed colors (e.g., 2.5Y 6/4 to 5 BG) predominate at depths >1.0 m. In the lowest areas, large nodules of iron oxyhydroxides and manganese oxides have formed near the contact with the underlying residuum. The No. 951 alluvial material already described covers much of the landscape below elevations of 257 m and is the younger of at least two major alluvial deposits known to exist in the valley. At higher elevations only remnants of alluvium having similar morphology are still preserved [for example, in the saddle trench (Fig. B-1) along Transect B-B']. These older soils at higher elevation are currently identified by the No. 951 symbol and will remain so until laboratory and mineralogical characterization shows that they are more weathered and should be identified by a different symbol.

C.1.2 <u>Transect B-B'</u>

Transect B-B' (Fig. C-2) demonstrates the extreme differential weathering, colluviation, and accelerated erosion that has occurred on Conasauga Group landscapes. Only the first 76 m of the transect, running northwestward from Bear Creek, and a saddle ~576 m up the transect, contain significant alluvial deposits. The alluvial features are a 30-m-wide segment of stratified, loamy, Modern-age Bear Creek floodplain alluvium (No. 98 soils). A unit of No. 951 soils at an elevation from 251 to 254 m occupies terraces bordering the Modern-age Bear Creek floodplain. These soils are similar in morphologic features to the No. 951 soils found along Transect A-A' at the same elevation. The No. 951 soils grade into the truncated and partially exhumed remnants of older and redder alluvium (No. 94 soils) before ending in the Nolichucky residuum at 256-m elevation. The discontinuity between the No. 951 and No. 94 soils is plugged with large manganese oxide nodules from 2.0 to 10 mm in size. The oldest alluvium (also identified by the No. 951 symbol) occurs on a saddle ~576 m up the transect; it is older, contains more fragments, and occurs at a higher elevation than the lower more widespread alluvial sediments at 251 to 254 m. The source of the saddle alluvium was probably local and was deposited by a paleostream. The soils and stratigraphy of the saddle trench are presented in Appendix B. Evidence of stream piracy exists to the right of this saddle, which is located astride the trace of the Rutledge Formation.

In describing the residual soils up the transect from Bear Creek, the first residual soils encountered are on the Nolichucky Formation. Most of the Nolichucky soils occur on gently rolling topography, but have been eroded almost to paralithic saprolite due to past farming activities and present forestry land management practices. Because the upper Nolichucky contains limestone lenses and dips southeastward at a 30° angle, extreme subsurface expressions of differential weathering are present (see Fig. D-1). Mineral weathering was more intense where limestones predominated, leaving very soft clayey saprolite zones between harder and less weathered saprolite derived from shale. This activity results in ruptic soil horizonation and extremely variable depth to leached saprolite (Cr horizon). The dominant soils on the Nolichucky would classify as Ruptic Ultic Dystrochrepts, having Bw and Bt horizons alternating at intervals of ~1 m. These are interrupted by harder strata of paralithic saprolite. This finding was made by subsampling across strike 1 m above and below each data point.

The dominant residual soils on the Maryville Formation are also classified as Ruptic Ultic Dystrochrepts (Fig. D-2). Saprolite that weathered from rock of the Maryville Formation consists of soil material high in silt and clay, very fine grained sandy strata, and clay-rich strata that weathered from argillaceous limestone. Each type of rock weathers differentially, depending on the porosity of each individual stratum as influenced by the joint and fracture system imposed on these rock units. The Maryville Formation is a stronger ridge-former than is the Nolichucky Formation. The Maryville Formation forms a small ridge of ~45 m total relief. Its soils tend to be deeper than Nolichucky soils, but still exhibit evidence of severe erosion from past agriculture and forest uses. Soil solum thicknesses range from 40 to 60 cm along this transect. Deep gullies resulting from past land management practices were noted on southerly sideslopes along the transect. Intermixed with these Modern-age gullies are gullies filled with old colluvium. This gully fill material (No. 49 soil) is Pleistocene in age. It has a clayey subsoil with reddish 5YR to 2.5YR hues. Soils that formed in either the No. 47 (later Pleistocene) or the No. 49 colluvium average 60 to 120 cm in thickness above residual saprolite.

Rogersville residual soils are on the north aspect (obsequent slope) of the Maryville ridge. Most of the soils are shallow and have alternating or ruptic Bw and Bt horizonation (Figs. D-3 and D-4). Most of the Rogersville soils are severely eroded Ruptic Ultic Dystrochrepts or Typic Dystrocrepts. The paralithic Cr saprolite is greenish gray; the subsurface soils have more oxidized and weathered 7.5YR and 5YR hues. Surface textures are clay or clay-loam whenever remnants of Bt horizons are present. Colluvium was less prominent along this portion of the transect. At the foot of the ridge, Rogersville or Rutledge residuum is buried by saddle alluvium (No. 951 soils in Fig. B-1).

Past the saddle (~576 m up the transect), two older colluvium units were encountered. The oldest of these units (the No. 25 soils) occur directly over residuum and beneath less developed Pumpkin Valley No. 26 soils. A trench was dug along the saddle and lower Pine Ridge footslope by D. A. Lietzke. Data from this saddle trench (see Appendix B and Fig. B-1) and earlier soil survey work above the Y-12 Plant burial grounds indicate that this may be one of the oldest soils preserved on the site. The No. 25 soil has a Bt subsoil horizon that is reddish (e.g., 5YR 4/4) and has a clay-loam to clay texture. The younger overlying No. 26 unit, formed from similar colluvial parent materials, is yellower (hue of 7.5YR), with less strongly developed soil horizonation and a Bt horizon with a loam to clay-loam texture. The rock fragments in No. 26 soils are less weathered than those in the older No. 25 soils; the residual saprolite beneath has no hard fragments. There are small areas of Pumpkin Valley residual soils that are not completely covered by colluvium (Figs. D-5 and D-6). Farther upslope, the transect crosses a small drain and runs up the center of a hollow. At this point, the basal No. 25 soils thin out, leaving a colluvium (No. 26 soil) from 50- to 75-cm thick over a thin Pumpkin Valley residuum (No. 24 soil). The No. 26 colluvial unit is usually higher in Rome sandstone fragments than the No. 25 soils. This hollow is separated from Pine Ridge by a drainageway running subparallel to the ridge, so the sandstone fra[illegible]ts in the No. 26 soil would have had to have been transported into the area during a time before headward cutting of the drain eliminated the source of Rome fragments. Thus, the material present in this particular No. 26 unit is also fairly old.

About 76 m up the transect from the saddle, the transect path leaves the hollow sideslope and rises onto a spur ridge that runs subparallel to Pine Ridge. The summit is capped by an unusual, unnamed colluvial soil, which resembles the No. 25 soil in age, based on similar morphology and highly weathered coarse fragments. This soil, however, formed in Rome-derived old colluvium (older than the No. 15 soil) and is redder and finer textured than the younger No. 15 soil. It rests upon a deep well-developed paleosol (No. 20). This particular paleosol formed in saprolite from interbedded siltstone and very fine grained sandstone that contained glauconite. The subsoil has a high iron oxide content and has a reddish clayey subsoil Bt horizon. On the north aspect of this spur ridge, the Pumpkin Valley No. 23 soils are shallow Typic Dystrochrepts. The youngest No. 27 colluvial soils occur in the hollow between the narrow subparallel spur and the main crestal summit of Pine Ridge. They seldom exhibit more soil development than a Bw horizon, are skeletal, and are easily erodible because of their location on steep slopes. Along this transect, the No. 27 soils are in the drain parallel to Pine Ridge, and about one-fourth of the way up the south side of the ridge. This drain is in the trace of the Rome-Pumpkin Valley boundary. The top few centimeters of the No. 27 soils in this drainageway are derived from a loamy very fine sand colluvium derived from higher Rome soils.

The last 91 m of the transect traverses residual soils formed in saprolite weathered from members of the Rome Formation and Rome-derived colluvium. The No. 1 residual soils are formed in saprolite of feldspathic sandstone and have a high content of very fine sand. They have thick E horizons with loamy very fine sand texture and Bt horizons with strong brown to reddish yellow hues and very fine sandy loam or loamy very fine sand textures. The No. 1 soils continue to the end of the transect, which terminates near the summit of Pine Ridge. Interspersed in slightly concave areas are small areas of No. 15

soils. Sandstone fragments are very common on the surface of the No. 15 colluvial soils and in the upper part of the soil horizons. The mappable areas of No. 15 soils are located on a bench landform that occupies the boundary zone between the Rome Formation and Pumpkin Valley Formation. (The crestal No. 4 soils were not encountered in this transect.)

APPENDIX D

PHOTOGRAPHS AND DESCRIPTIONS OF SOIL PROFILES OF PITS SAMPLED FOR CHARACTERIZATION

YP 4406

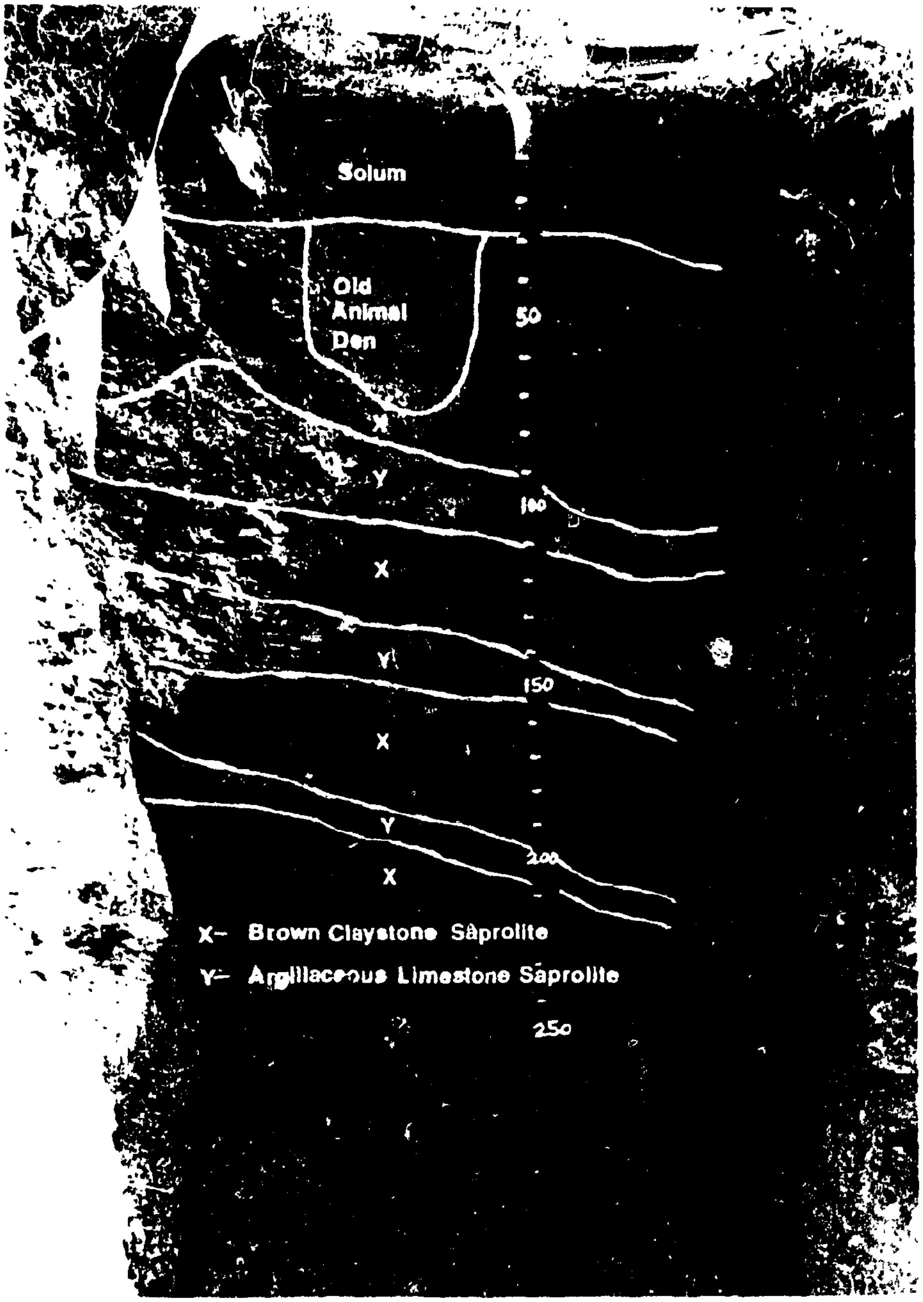


Fig. D-1. Photograph of Nolichucky pit. Values are given in centimeters.

NOLICHUCKY PIT SOILS

Soil No: 51B3 (Fig. D-1).
Location: LLWDDD site. E30230, N29250, Y-12 grid.
Series Classification: Ruptic Ultic Dystrochrepts: loamy-skeletal, mixed thermic.
Classification: Ruptic Aquultic Dystrochrepts; loamy-skeletal, mixed, thermic.
Geomorphic Position: Upper slightly convex sideslope of low hillside.
Slope: 4% with southeast aspect.
Parent Material: Saprolite from claystone, siltstone, and argillaceous limestone as well as thin strata of very fine sandy loam.

Described By: R. E. Lambert, D. A. Lietzke, and A. B. Jenkins, March 13, 1987.

Notes: Because of the ruptic nature of the soil, it was necessary to describe three profiles (argillic, cambric, and ruptic parts) in order to encompass the "cyclic" variability of one pedon.

Argillic Part

O: 2 to 0 cm; leaf litter.

Ap: 0 to 18 cm; dark yellowish brown (10YR 4/4) shaly silt loam; moderate fine granular structure; very friable; many fine and medium roots between peds; many fine pores; pH 4.7; abrupt wavy boundary.

Bt: 18 to 33 cm; mottled yellowish red (5YR 5/8), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6) silty clay; moderate medium subangular blocky structure; firm; common fine prominent brownish gray (10YR 6/2) mottles in ped interiors; many continuous and distinct brown (7.5YR 5/4) clay films on ped faces; few fine and medium roots between peds; common fine pores; pH 4.8; clear irregular boundary. (Argillic horizon part of pedon.)

BC: 33 to 64 cm; strong brown (7.5YR 5/6) shaly silty clay loam; weak medium subangular blocky structure; firm; common medium prominent light brownish gray (2.5Y 6/2) mottles in ped interiors; many continuous distinct brown (7.5YR 5/4) clay films on ped faces and coating rock fragments; common discontinuous prominent red (2.5YR 4/6) iron stains on some ped faces; common fine and medium roots; few to common pores; pH 4.8; abrupt inclined boundary. (Thin sandstone strata are 10YR 6/8.)

C: 64 to 71 cm; strong brown (7.5YR 5/6) very shaly, silty clay loam; massive rock-controlled structure; firm; common discontinuous faint brown (7.5YR 5/4) clay films on rock fragments; few fine roots in cracks; common fine pores; about 50% shale and siltstone fragments; pH 4.8; abrupt inclined boundary.

2CB: 71 to 81 cm; yellowish red (5YR 5/6) silty clay; massiv [illegible]; many discontinuous distinct brown (7.5YR 5/4) clay films on [illegible] and joint faces; few fine roots; few fine pores; pH 4.8; abr[illegible] irregular inclined boundary. (Argillaceous limestone saprolite stratum sandwiched between shale and siltstone saprolite.)

3Cr: 81 to 92 cm; oxidized and leached saprolite from siltstone and shale; fragment interiors are strong brown (7.5YR 5/6); common discontinuous prominent red (2.5YR 4/6) iron-clay films on fragment faces; water flow zones are light brownish gray (2.5Y 6/2).

4Cr2: 92 to 100 cm; oxidized and leached saprolite from siltstone and claystone; fragment interiors are yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); very firm; many discontinuous prominent red (10R 4/8) stains on fragment faces; few discontinuous distinct strong brown (7.5YR 4/6) clay coatings on fragment faces in flow zones; very few fine roots in flow zones; pH 4.8.

<u>Cambic Part (located ~1 m away from the argillic part)</u>

O: 2 to 0 cm; leaf litter; abrupt smooth boundary.

Ap: 0 to 20 cm; dark yellowish brown (10YR 4/4) silt loam; moderate fine granular structure; very friable; many fine roots throughout; many fine and medium tubular pores; pH 4.7; abrupt wavy boundary.

Bw: 20 to 40 cm; brown (7.5YR 5/4) extremely shaly silty clay loam; weak medium subangular blocky structure; firm; many continuous faint brown (7.5YR 5/4) clay films on some ped faces and on most shale fragments; few fine roots; many pores; pH 4.8; clear irregular inclined boundary. (Cambic part of soil profile.)

Cr: 40 to 70 cm; oxidized and leached saprolite from claystone and siltstone; fragment interiors have red (10R 4/8) iron coatings on some fragment faces; common discontinuous prominent black manganese coatings on other fragment faces; many discontinuous brown (7.5YR 5/4) clay films on other rock fragments in more permeable zones; water flow zones have gray (10YR 5/1) streaks; root mats continue down through gray areas; pH 4.8.

<u>Ruptic Part (located ~1 m away from the cambic part)</u>

Ap: 0 to 18 cm; dark yellowish brown (10YR 4/4) shaly silt loam; weak fine granular structure; very friable; many fine and medium roots between peds; many fine pores; pH 4.7; abrupt wavy boundary.

Cr: 18 to 30 cm; oxidized and leached saprolite from siltstone and claystone; fragment interiors are yellowish brown (10YR 5/6) or strong brown (7.5YR 5/6); rock-controlled structure; very firm; fragments are coated with either brown (7.5YR 5/4) clay or black manganese coatings; few fine roots in cracks; pH 4.8; abrupt inclined boundary.

2Bt: 30 to 66 cm; yellowish brown (10YR 5/6) silty clay loam; moderate coarse subangular blocky structure; firm; common fine prominent gray (10YR 6/1) mottles in ped interiors; ped exteriors are coated with continuous brown (7.5YR 5/4) clay; common fine and medium roots between peds; common fine and medium pores; pH 4.8; abrupt inclined boundary. (This horizon formed in saprolite from argillaceous limestone. This section was described as being directly above the massive C horizon beneath, which perched water in this Bt zone.)

3Cr: 66 to 117 cm; oxidized and leached saprolite from siltstone and claystone; rock-controlled structure; very firm; many discontinuous prominent red (2.5YR 4/6) iron stains on some fragment faces; other fragments are partially coated with black manganese oxides; no clay films were noted on fragments; water seems to flow in the unsaturated mode in this material; pH 4.9.

YP 4407

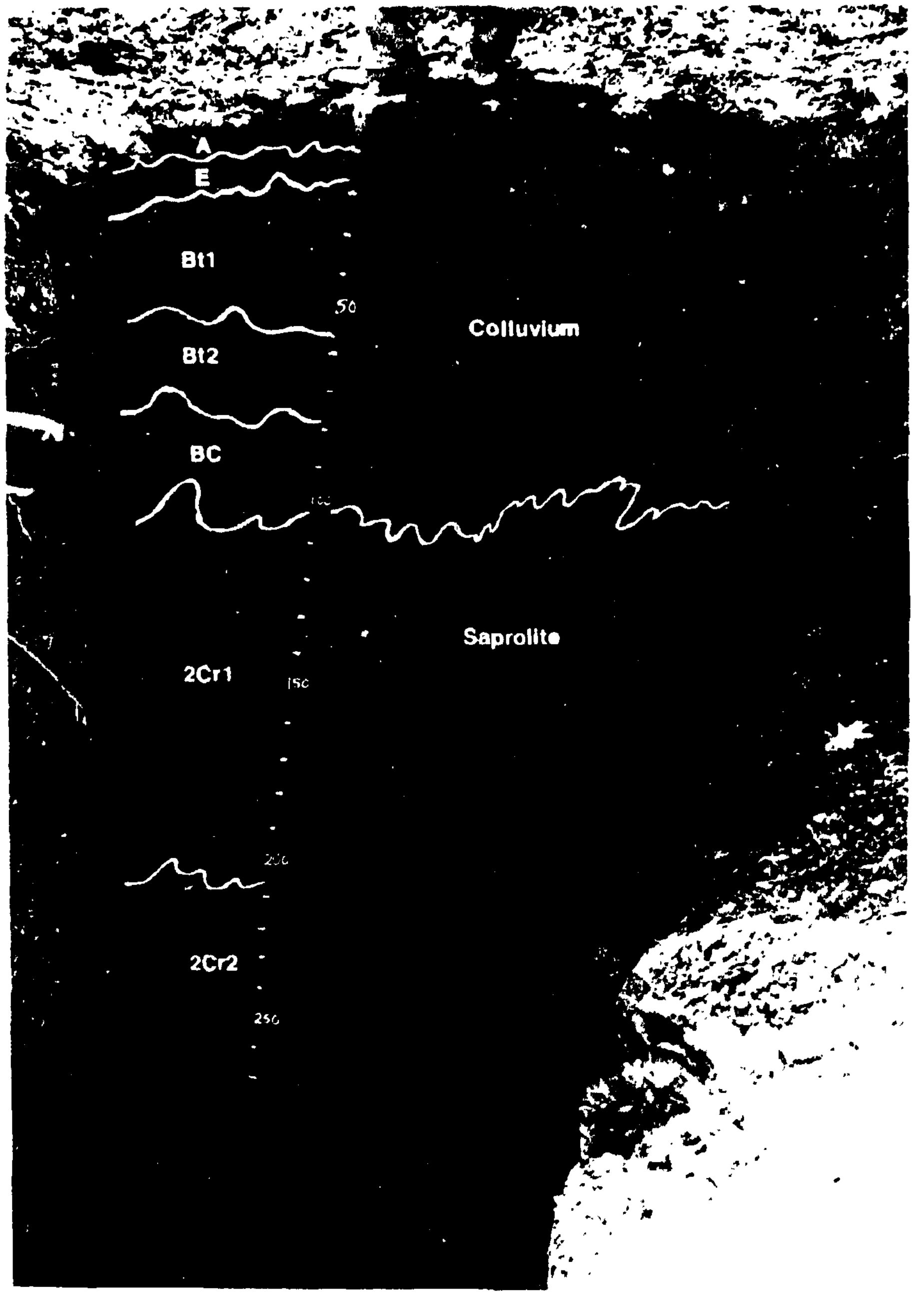


Fig. D-2. Photograph of No. 49 Rogersville-Maryville-Nolichucky (R-M-N) colluvium pit. Values are given in centimeters.

ROGERSVILLE-MARYVILLE-NOLICHUCKY COLLUVIAL SOILS

Soil No: 49D (Fig. D-2).
Location: LLWDDD Site. E2060, N30200, Y-12 grid.
Classification: Typic Hapludults; clayey, mixed, thermic.
Geomorphic Position: Narrow old gully fill on upper slightly convex sideslope of hillside.
Slope: 18% with southeast aspect.
Parent Material: Old colluvium derived from Maryville and Rogersville residuum

Described By: R. E. Lambert and P. D. Alley, June 11, 1987.

O: 2 to 0 cm; leaf litter and pine needles; abrupt wavy boundary.

A: 0 to 5 cm; very dark grayish brown (10YR 3/2) loam; moderate fine and medium granular structure; friable; many fine roots throughout; many fine pores; pH 4.6; clear smooth boundary.

E: 5 to 14 cm; dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; common fine roots throughout; common fine pores; pH 4.7; clear smooth boundary.

Bt1: 14 to 50 cm; mottled yellowish red (5YR 4/6 and 5/8) clay; strong medium subangular blocky structure; firm; many continuous faint yellowish red (5YR 4/6) clay films on faces of peds; few fine roots between peds; few to common pores; pH 4.6; gradual wavy boundary.

Bt2. 50 to 84 cm; mottled yellowish brown (10YR 5/4), strong brown (7.5YR 5/6), and red (2.5YR 4/6) clay loam; moderate medium subangular blocky structure; firm; common discontinuous distinct yellowish brown (10YR 5/4) clay films on faces of some peds; few fine roots between peds; pH 4.8; clear wavy boundary.

2CB: 84 to 102 cm; highly mottled red (2.5YR 4/6), black (5Y 2/1), and olive (5Y 5/6) saprolite that crushes to extremely shaly clay loam; very firm; many continuous distinct red (2.5YR 4/6) clay films on rock fragments; common patchy black manganese coatings on some fragment faces; few fine roots on fragment faces; pH 4.8; clear steeply inclined boundary.

2Cr1: 102 to 149 cm; oxidized and leached saprolite from claystone and siltstone; fragment interiors are olive brown (2.5Y 4/4); very firm; many continuous prominent dark red (10R 3/6) iron oxide coatings and black manganese coatings on fragment faces; few fine root mats in upper part where roots extend downward on dip planes; pH 4.8; steeply inclined gradual boundary (60° dip).

2Cr2: 148 to 300 cm; oxidized and leached saprolite from claystone and siltstone; fragment interiors are olive (5Y 4/4) to olive gray (5Y 5/2); very firm; most fragments are coated with weak red (10R 4/4) iron oxides or black manganese oxides; some fragments in water flow zones are coated with olive gray (5Y 5/2) clay; pH 5.2.

MARYVILLE SOILS

Soil No: 42D (Not shown in Fig. D-2).
Location: LLWDDD site. E32060, N30200, Y-12 grid.
Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.
Geomorphic Position: Upper third of convex sideslope.
Slope: 18% with southeast aspect.
Parent Material: Saprolite from claystone, siltstone, and thin strata of very fine sandstone.

Described By: R. E. Lambert and P. D. Alley, June 11, 1987.

A: 0 to 5 cm; dark brown (10YR 3/3) shaly loam; moderate fine and medium granular structure; friable; many fine roots and pores throughout; pH 4.7; clear smooth boundary.

Bw: 5 to 16 cm; dark yellowish brown (10YR 4/4) very shaly loam; weak fine and medium subangular blocky structure; firm; common fine and medium roots and pores throughout; pH 4.7; gradual inclined boundary.

Cr: 16 to 50 cm; multicolored Maryville saprolite.

Notes: The intermittent Bt horizon occurs at about the same depth as the Bw horizon and extends deeper downdip into the Cr horizon beneath. It has 5YR to 2.5YR hues and a clayey texture.

YP 4408

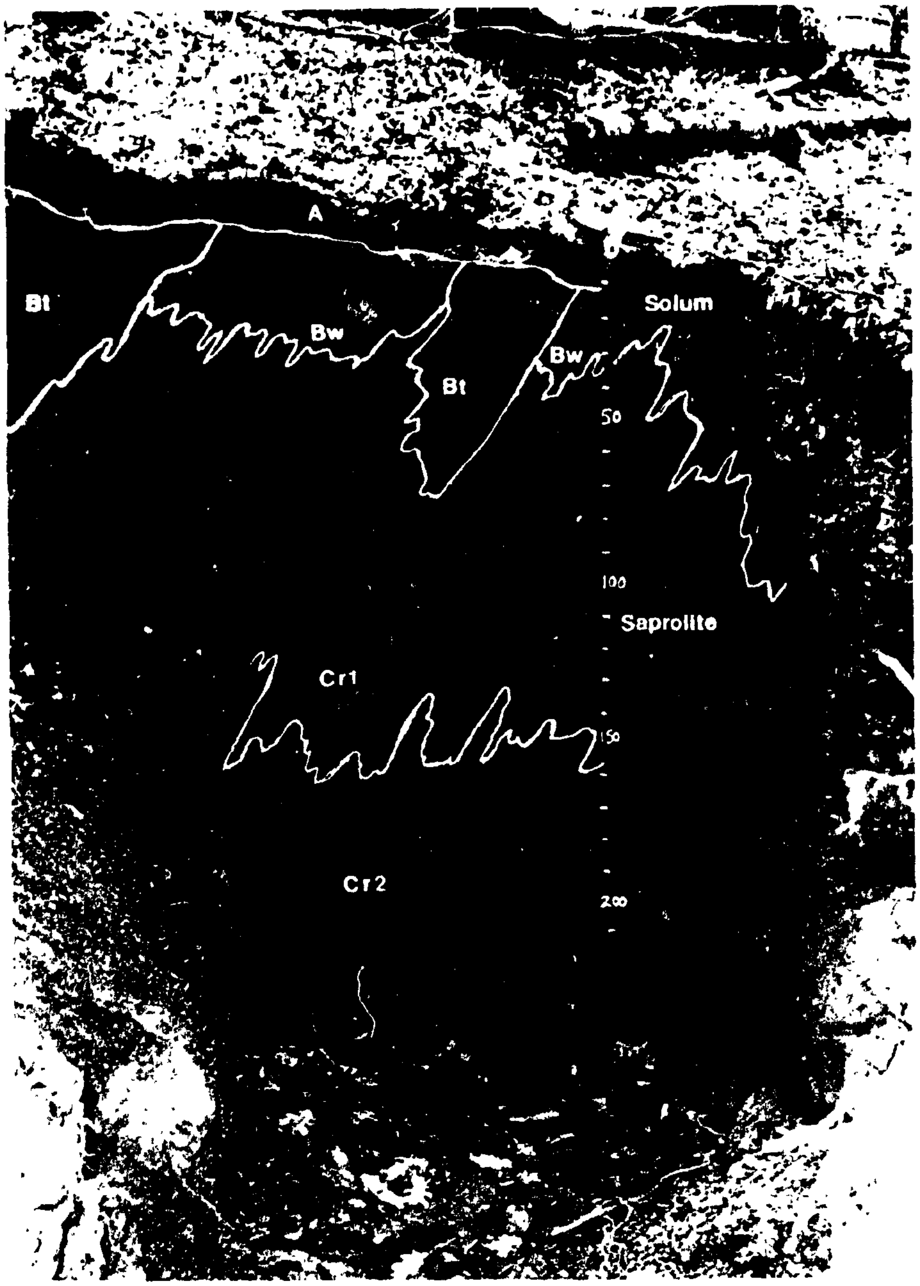


Fig. D-3. Photograph of Rogersville slightly eroded pit. Values are given in centimeters.

ROGERSVILLE SOILS (SLIGHTLY ERODED PIT)

Soil No: 36D (Profile 36-N), slightly eroded (Fig. D-3).
Location: LLWDDD site. E32325, N30480, Y-12 grid.
Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.
Geomorphic Position: Upper third of summit with northwest aspect.
Parent Material: Saprolite from claystone and siltstone plus strata of glauconitic very fine grained sandstone.

Described By: R. E. Lambert, June 25, 1987.

Cambic Part

O: 3 to 0 cm; leaf litter and thin sapric material with many fine roots; abrupt smooth boundary.

A: 0 to 9 cm; dark grayish brown (10YR 4/2) shaly silt loam; moderate fine granular structure; very friable; many fine roots and pores throughout; pH 4.4; clear wavy boundary.

Bw: 9 to 29 cm; yellowish brown (10YR 5/6) very shaly loam; weak fine and medium subangular blocky structure; firm; few patchy brown (10YR 5/3) silt coatings on ped faces; few fine roots and common to many pores; pH 4.6; gradual wavy boundary.

Cr1: 29 to 130 cm; variegated pale olive (5Y 6/4), yellowish red (5YR 5/6), and light gray (5BG 7/1) oxidized and leached saprolite from claystone and siltstone; extremely firm; many nearly continuous distinct yellowish red (5YR 5/6) clay films on fragment faces; common patchy prominent red (10R 4/8) iron stains on some fragments; fine root mats in upper part; pH 4.7; gradual inclined boundary. (This zone contains thin glauconitic sandstone strata.)

Cr2: 130 to 200 cm; light gray (5BG 7/1), yellowish red (5YR 5/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; few patchy prominent black manganese oxide coatings on some fragment faces and dark red (10R 3/6) iron coatings on other fragments; few patchy distinct yellowish red (5YR 5/6) clay films coating fragment faces in water flow zones; pH 5.0. (Note: BG hues are descriptive of less oxidized fragment interiors.)

Argillic Part

A: 0 to 9 cm; dark grayish brown (10YR 4/2) shaly silt loam; moderate fine granular structure; very friable; many fine roots and pores throughout; pH 4.4; clear wavy boundary.

E: 9 to 30 cm; brown (10YR 5/3) shaly silt loam; weak fine subangular blocky structure; friable; few fine roots throughout; many fine pores; pH 4.4; clear wavy boundary.

Bt: 30 to 50 cm; yellowish red (5YR 5/6) shaly clay; moderate medium subangular blocky structure; firm; many continuous yellowish red (5YR4/6) clay films on ped faces; few fine roots between peds; common pores; pH 4.6; clear highly irregular boundary.

Cr1: 50 to 95 cm; dark yellowish brown (10YR 4/6), yellowish red (5YR 4/6), light olive brown (2.5Y 5/6) oxidized and leached saprolite from claystone and siltstone; very firm; many nearly continuous distinct yellowish red (5YR 4/6) clay films on fragment faces; few patchy prominent red (10R 4/6) iron stains on some fragments; few fine root mats in upper part; pH 4.7.

YP 5216

Fig. D-4. Photograph of Rogersville moderately eroded pit. Values are given in centimeters.

ROGERSVILLE SOILS (MODERATELY ERODED PIT)

Soil No: 36D (Profile 36-E), moderately eroded (Fig. D-4).
Location: LLWDDD site. E32025, N30540, Y-12 grid.
Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.
Geomorphic Position: Upper convex sideslopes and summits of low hills.
Slope: 10% with west aspect.
Parent Material: Saprolite from claystone, siltstone, and thin-to-thick strata of glauconitic very fine grained sandstone

Described By: R. E. Lambert. March 14, 1987.

Cambic Part

O: 2 to 0 cm; leaf litter.

A: 0 to 4 cm; very dark grayish brown (10YR 3/2) shaly clay loam; moderate medium granular structure; friable; many fine roots and pores throughout; pH 4.5; abrupt wavy boundary.

Bw: 4 to 25 cm; yellowish brown (10YR 5/4) shaly loam; moderate fine and medium subangular blocky structure; friable; common patchy yellowish brown (10YR 5/6) clay films on ped faces and coating most fragments in the lower part; common medium and fine roots and pores throughout; pH 4.5; gradual inclined boundary.

Cr1: 25 to 200 cm; variegated light gray (5BG 7/1), yellowish red (5YR 5/6), and yellowish brown (10YR 5/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common discontinuous yellowish red (5YR 5/6) iron-clay films on fragment faces; and discontinuous yellowish brown (10YR 5/6) clay films on fragment faces; few root mats in upper part; pH 4.7; clear inclined boundary.

Cr2: 200 to 300 cm; variegated light gray (5BG 7/1), reddish yellow (5YR 6/6), and red (2.5YR 4/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common distinct reddish yellow (5YR 5/6) and red (2.5YR 4/6) iron-clay coatings on fragment faces; pH 5.0.

Argillic Part

O: 2 to 0 cm; leaf litter.

A: 0 to 4 cm; very dark grayish brown (10YR 3/2) shaly clay loam; moderate medium granular structure; friable; many fine roots and pores throughout; pH 4.5; abrupt wavy boundary.

E: 4 to 12 cm; yellowish brown (10YR 5/4) shaly clay loam; moderate fine and medium subangular blocky structure; friable; common fine and medium roots and pores throughout; pH 4.5; clear wavy boundary.

Bt1: 12 to 25 cm; yellowish brown (10YR 5/6) shaly clay loam; moderate medium subangular blocky structure; firm; discontinuous brown (10YR 5/3) skeletons on some ped faces; common fine and medium roots between peds; common pores; pH 4.6; clear wavy boundary.

Bt2: 25 to 33 cm; yellowish brown (10YR 5/6) very shaly clay loam; moderate medium subangular blocky structure; firm; discontinuous yellowish brown (10YR 5/4) clay films on ped faces and coating most fragments; common fine pores; pH 4.7; clear irregular boundary.

Cr1: 33 to 200 cm; variegated light gray (5BG 7/1), yellowish red (5YR 5/6), and yellowish brown (10YR 5/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common discontinuous yellowish red (5YR 5/6) iron-clay films on fragment faces; and discontinuous yellowish brown (10YR 5/6) clay films on fragment faces; few root mats in upper part; pH 4.7; clear inclined boundary.

Cr2: 200 to 300 cm; variegated light gray (5BG 7/1), reddish yellow (7.5YR 6/6), and red (2.5YR 4/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common distinct reddish yellow (7.5YR 6/6) and red (2.5YR 4/6) iron-clay coatings on fragment faces; pH 5.0. (A glauconitic zone had a 1:1 water:soil pH of 4.3.)

YP 4409

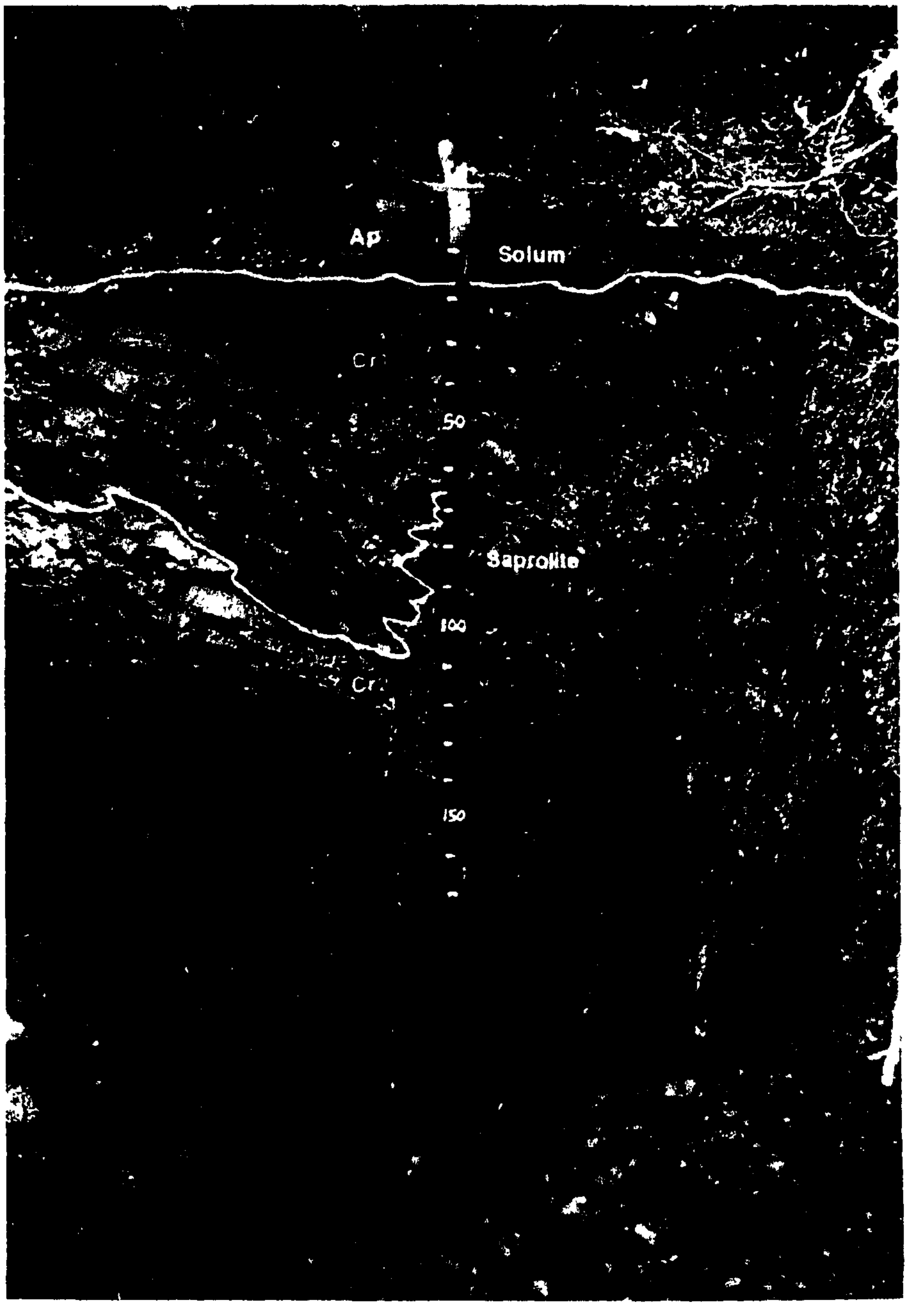


Fig. D-5. Photograph of Pumpkin Valley severely eroded pit. Values are given in centimeters.

PUMPKIN VALLEY SOILS (SEVERELY ERODED PIT)

Soil No: 24C3 (Profile 24-E), severely eroded (Fig. D-5).
Location: LLWDDD site. E29250, N30815, Y-12 grid.
Series Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.
Pedon Classification: Typic Udorthents; loamy-skeletal, mixed, thermic.
Geomorphic Position: Convex sideslopes and summits of low hills.
Slope: 13% with southeast aspect.
Parent Material: Saprolite from claystone, siltstone, and thin to thick strata of glauconitic very fine grained sandstone.

Described By: R. E. Lambert, May 21, 1987.

Ap: 0 to 15 cm; dark brown (10YR 4/3) shaly loam; moderate fine and medium granular structure; friable; common fine and medium roots and pores throughout; pH 4.9; clear smooth boundary.

Cr1: 15 to 58 cm; variegated strata of dark reddish brown (5YR 4/2), yellowish brown (10YR 6/8), and red (2.5YR 4/6) oxidized and leached saprolite from siltstone, claystone, and glauconitic very fine grained sandstone; extremely firm; common discontinuous dark brown (10YR 4/3) iron oxyhydroxide stains on fragments; few root mats in upper part that extend downward along dip planes; pH 5.1; gradual inclined boundary.

Cr2: 58 to 200 cm; variegated strata of dark reddish gray (5YR 4/2), light gray (5BG 7/1), and brown (10YR 5/3) oxidized and leached saprolite from siltstone, claystone and glauconitic very fine grained sandstone; extremely firm; common discontinuous dusky red (10R 3/4) iron stains on fragment faces, and black manganese oxide coatings on other fragment faces; pH 4.9.

YP 4410

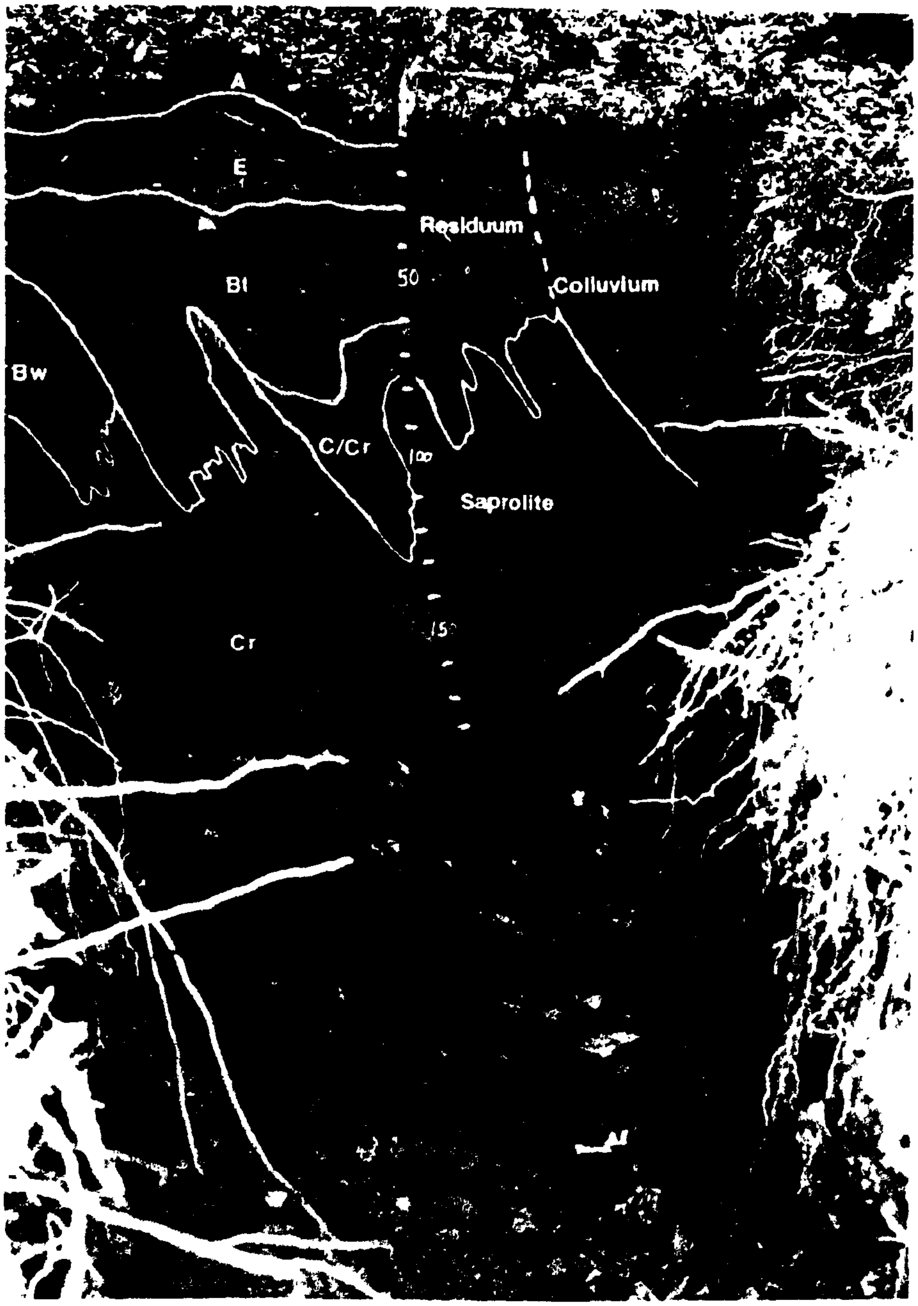


Fig. D-6. Photograph of Pumpkin Valley moderately eroded pit. Values are given in centimeters.

PUMPKIN VALLEY SOILS (MODERATELY ERODED PIT)

Soil No: 24C2 (Profile 24-N), moderately eroded (Fig. D-6).
Location: LLWDDD site. E32275, N30840, Y-12 grid.
Series Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.
Geomorphic Position: Convex sideslopes and summits of low hills.
Slope: 10% with southeast aspect.
Parent Material: Saprolite from claystone, siltstone, and thin to thick strata of glauconitic very fine grained sandstone of middle member.

Described by: D. A. Lietzke and R. E. Lambert, April 3, 1987.

O: 2 to 0 cm; leaf litter.

A: 0 to 8 cm; dark grayish brown (10YR 4/2) shaly loam; moderate fine granular structure; friable; common to many fine and medium roots and pores throughout; pH 4.5; clear smooth boundary.

E: 8 to 25 cm; light yellowish brown (10YR 6/4) shaly loam; weak fine and medium subangular blocky structure; friable; common fine roots throughout; many pores; pH 4.5; gradual wavy boundary. (Gradual boundary includes a thin strong brown [7.5YR 4/4] Btl horizon in some places.)

Bw: 25 to 55 cm; yellowish red (5YR 4/6) very shaly clay loam; weak fine and medium subangular blocky structure; firm; nearly continuous red (2.5YR 4/8) clay films on fragment faces and on some ped faces; few patchy red (10R 4/8) iron oxide-clay coatings on some fragment faces; few to common fine roots; common to many pores; pH 4.7; clear inclined boundary. (Cambic horizon part of pedon.)

Bt: 25 to 66 cm; yellowish red (5YR 4/6) shaly clay; moderate medium subangular blocky structure; firm; continuous reddish brown (5YR 4/4) clay films on ped faces; few to common fine roots between peds; many pores; pH 4.5; clear inclined boundary. (Argillic horizon part of pedon.)

B/Cr: 55 to 118 cm; weak red (2.5YR 4/2) extremely shaly clay; weak medium subangular blocky structure (B part) and massive (Cr part); very firm; nearly continuous reddish brown (5YR 4/4) clay films on fragment faces; few fine roots; many pores; pH 4.7; abrupt irregular inclined boundary.

Cr: 118 to 200 cm; highly variegated weak red (2.5YR 4/2) and red (2.5YR 5/6) oxidized and leached saprolite from siltstone, claystone, and glauconitic very fine grained sandstone; extremely firm; nearly continuous reddish brown (5YR 4/4) clay coatings on fragment faces; patchy red (10R 4/8) iron oxide coatings on some fragment faces; very few fine roots in cracks; pH 4.8.

YP 4405

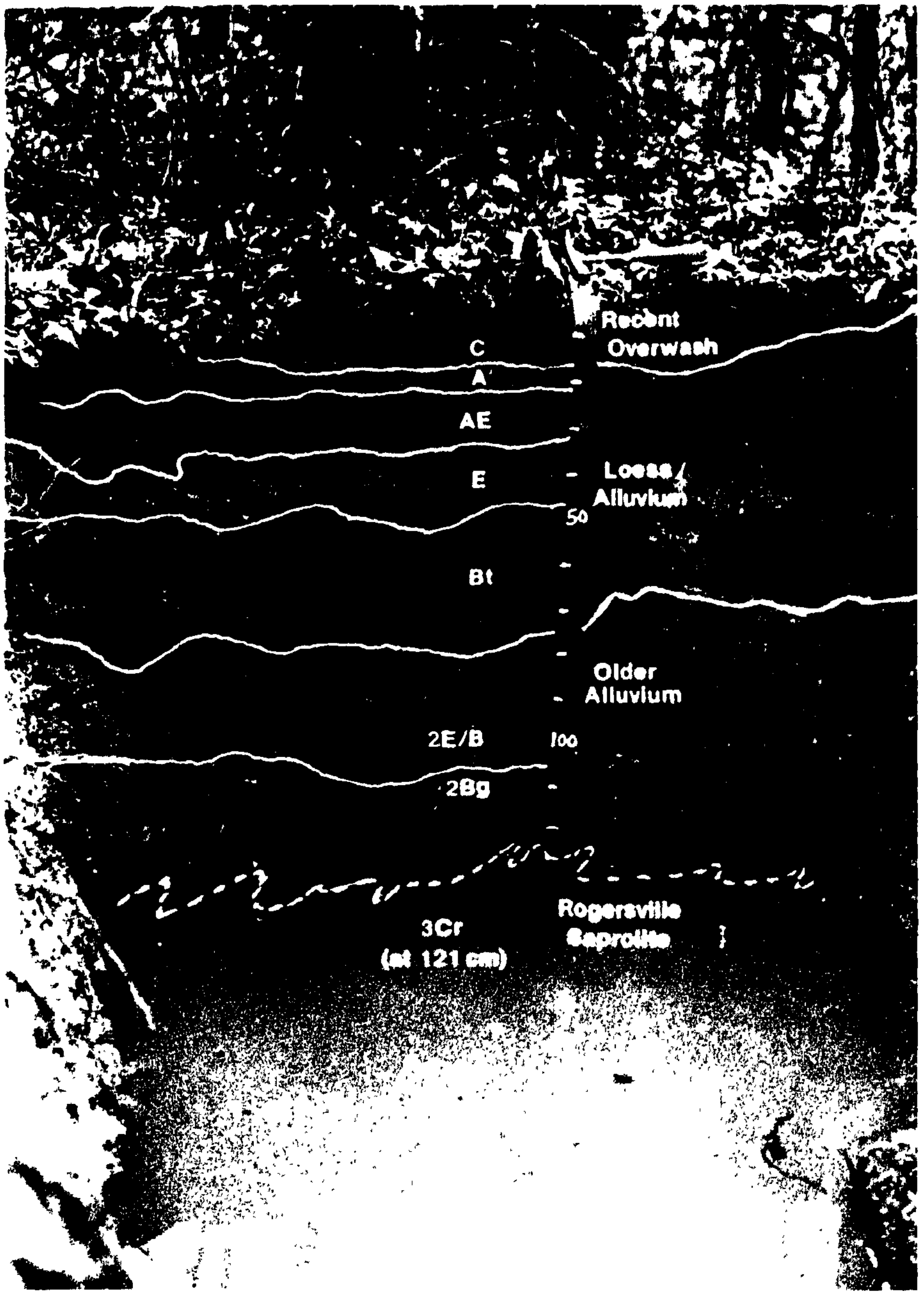


Fig. D-7. Photograph of old alluvium pit. Values are given in centimeters.

OLD ALLUVIUM PIT

Soil No: 951B (Fig. D-7).
Location: LLWDDD site. E28360, N30175, Y-12 grid.
Series Classification: Typic Hapludults; fine-loamy, mixed, thermic.
Geomorphic Position: Slightly dissected terraces with some convexity.
Slope: 5% with west aspect.
Parent Material: Pleistocene alluvium derived from mostly local sources.

Described By: R. E. Lambert, June 15, 1987.

O: 2 to 0 cm; leaf litter.

C: 0 to 20 cm; dark brown (10YR 4/3) silt loam; massive; very friable; many fine roots and pores; clear broken boundary. (This soil material, derived from clearing and bulldozing, was pushed from the telephone cable right-of-way where this pit was located.)

A: 20 to 28 cm; very dark grayish brown (10YR 3/2) silt loam; weak fine granular blocky structure; very friable; common fine roots throughout; many pores; pH 4.3; clear smooth boundary.

E1: 28 to 37 cm; brown (10YR 5/3) silt loam; weak fine subangular blocky structure; very friable; few fine roots throughout; many pores; pH 4.0; clear smooth boundary.

E2: 37 to 48 cm; light yellowish brown (10YR 6/4) silt loam; weak fine subangular blocky structure; very friable; very few fine roots throughout; many pores; pH 4.1; gradual wavy boundary.

Bt: 48 to 76 cm; brownish yellow (10YR 6/6) and light yellowish brown (10YR 6/4) clay loam; strong medium subangular blocky structure; friable; thin discontinuous light yellowish brown (10YR 6/4) clay films on ped faces; few patchy black manganese oxide stains on some ped faces; common to many 1.0- to 2.0-mm iron-manganese nodules; few to common roots between peds; common to many pores; pH 4.4; clear wavy boundary.

2E/B: 76 to 101 cm; light yellowish brown (2.5Y 6/4) silt loam (E part) and mottled yellowish red (5YR 5/6) and brownish yellow (10YR 6/8) loam; moderate medium and coarse subangular blocky structure; very friable; thin patchy yellowish brown (10YR 5/6) clay films on some peds (B part) and brownish yellow (10YR 6/8) skeletons on some peds (E part); few fine roots between peds; many pores; pH 4.4; clear wavy boundary.

2Btg: 101 to 121 cm; highly mottled light gray (5Y 7/2), yellowish brown (10YR 5/6), and light red (2.5YR 6/6) loam; weak to moderate medium prismatic structure parting to moderate medium and coarse subangular blocky structure; friable; continuous yellowish brown (10YR 5/6) clay films on prism faces; few patchy manganese oxide coatings on some peds in prism interiors; light gray (5G 6/1) reduced zones in root channels; few fine roots between prisms; pH 4.8; abrupt wavy boundary.

3Cr: 121 to 200 cm; olive brown (2.5Y 4/4) and strong brown (7.5YR 5/6) extremely shaly loam Rogersville saprolite; many discontinuous manganese oxide stains on fragment faces; some strong brown (7.5YR 5/6) iron oxyhydroxides on other fragment faces and few dusky red (2.5YR 3/2) iron oxide stains on other fragment faces; light gray (5G 6/1) reduced zones around fine root mats along joint planes; pH 6.3.

YP 4412

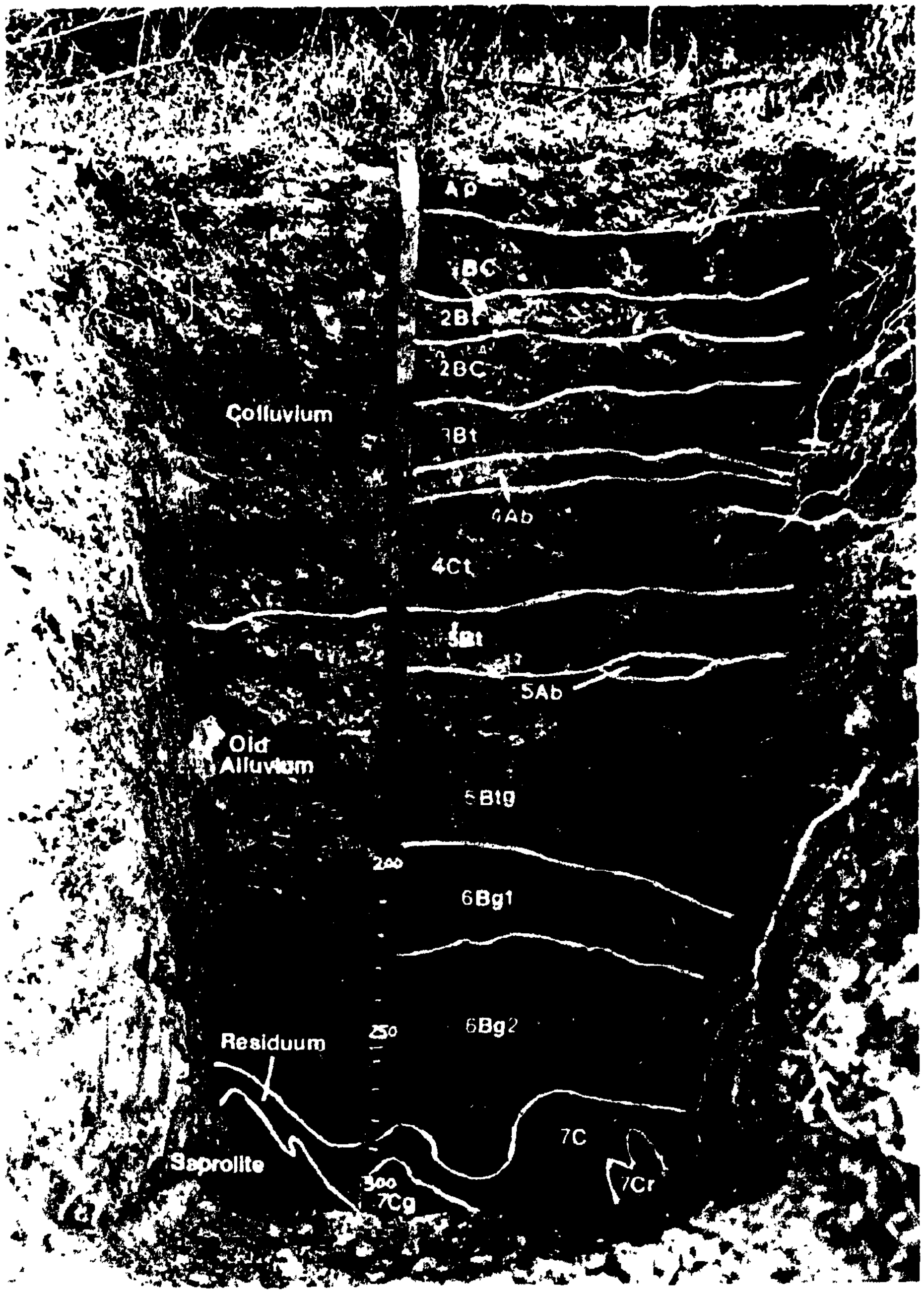


Fig. D-8. Photograph of Pumpkin Valley colluvium over old alluvium over Pumpkin Valley residuum pit. Values are given in centimeters.

PUMPKIN VALLEY COLLUVIUM OVER OLD ALLUVIUM OVER PUMPKIN VALLEY RESIDUUM PIT

Soil No: 26/951 C3 (Fig. D-8).
Location: LLWDDD site. E27875, N30780, Y-12 grid
Series Classification: Typic Hapludults; fine-loamy, mixed, thermic.
Geomorphic Position: alluvium-covered toeslope with some convexity
Slope: 10% with west aspect.
Parent Material: Pumpkin Valley colluvium over Pleistocene alluvium, derived from mostly local sources, over Pumpkin Valley residuum.

Described By: R. E. Lambert and D. A. Lietzke, June 9, 1987.

Ap: 0 to 21 cm; dark brown (10YR 4/3) gravelly loam; moderate medium and coarse granular structure; friable; common fine and very fine roots throughout; many pores throughout; pH 4.7; abrupt smooth boundary.

Bt1: 21 to 43 cm; yellowish red (5YR 4/6) and brownish yellow (10YR 6/8) gravelly clay loam; weak fine and medium subangular blocky structure; firm; thin continuous reddish brown (5YR 4/6) clay films on ped faces; few fine roots between peds; many pores; pH 4.9; clear wavy boundary. (Base of youngest colluvium.)

2Bt2: 43 to 55 cm; yellowish red (5YR 4/6) and reddish brown (5YR 4/4) clay loam; moderate medium subangular blocky structure; firm; thin continuous reddish brown (5YR 4/4) clay films on ped faces; few fine roots between peds; many pores; pH 4.9; clear wavy boundary.

2BC: 55 to 74 cm; yellowish red (5YR 4/6) and yellow (5Y 7/6) gravelly clay loam; weak medium subangular blocky structure; firm; thin discontinuous yellowish red (5YR 4/6) clay films on ped faces; few patchy manganese oxide coatings on some ped faces; few fine roots; many fine pores; pH 4.9; clear wavy boundary.

3Bt: 74 to 87 cm; reddish brown (5YR 4/4) and yellowish red (5YR 4/6) clay loam; moderate medium subangular blocky structure; firm; thin continuous yellowish red (5YR 4/6) clay films on ped faces; few fine roots between peds; many fine pores; pH 4.9; clear wavy boundary. (Base of intermediate colluvium.)

4Ab: 87 to 95 cm; mottled light brownish gray (2.5Y 6/2) and yellowish red (5YR 4/6) loam; weak fine and medium subangular blocky structure; firm; thin patchy yellowish red (5YR 4/6) clay films on ped faces and patchy strong brown (7.5YR 4/4) iron oxyhydroxide stains throughout; few to common fine roots between peds; many fine pores; pH 4.9; clear irregular boundary.

4Bt': 95 to 122 cm; brownish yellow (10YR 6/8), yellow (2.5Y 8/8), and light greenish gray (5BG 6/2) gravelly clay loam; weak fine and medium subangular blocky structure; very firm; thin discontinuous dark yellowish brown (10YR 4/4) clay films on ped faces; common patchy strong brown (7.5YR 5/6) iron oxyhydroxide coatings on some ped faces; very few fine roots between peds; many fine pores; pH 4.9; clear wavy boundary. (Base of oldest colluvium.)

5Bt'1: 122 to 146 cm; dark brown (7.5YR 4/4), yellowish brown (10YR 5/4), and brownish yellow (10YR 6/8) loam; moderate medium subangular blocky structure; very firm; thin discontinuous dark brown (7.5YR 4/4) clay films on ped faces; patchy manganese oxide stains on some ped faces; very few fine roots between peds; common fine pores; pH 4.9; clear wavy boundary.

5Bt'2: 146 to 202 cm; dark brown (7.5YR 4/4) and yellowish brown (10YR 5/4) clay loam; weak coarse subangular blocky structure; very firm; thin continuous dark brown (7.5YR 4/4) clay films on ped faces; patchy manganese oxide stains on ped faces; very few fine roots between peds; many fine pores; pH 4.9; clear wavy boundary. (Base of upper alluvium.)

6Bw1: 202 to 234 cm; light olive brown (2.5Y 5/4) loam; weak medium subangular blocky structure; firm; patchy manganese oxide coatings on some ped faces, and patchy brownish yellow (10YR 6/8) iron oxyhydroxide stains on other ped faces; very few fine roots between peds; pH 4.9; clear wavy boundary.

6Bw2: 234 to 270 cm; mottled dark yellowish brown (10YR 4/8) and light olive brown (2.5Y 5/4) loam; weak medium subangular blocky structure; firm; thin discontinuous reddish brown (5YR 4/4) clay films on faces of primary peds; patchy manganese coatings on secondary ped faces; very few fine roots between peds; few to common fine pores; pH 4.9; clear wavy boundary. (Base of older alluvium.)

7C: 270 to 325 cm; mottled brownish yellow (10YR 6/8), yellow (2.5Y 7/8), and olive yellow (5Y 6/6) oxidized and leached saprolite from middle member of Pumpkin Valley Formation; contains greenish glauconitic strata; firm; common patchy dark red (10R 3/6) iron stains on joint and fracture faces; few very fine roots along dip planes; pH 5.0; clear inclined boundary. (Pumpkin Valley residuum.)

7Cr: 325 to 350 cm; highly variegated and mottled oxidized and leached saprolite from middle member of Pumpkin Valley; very firm; few root mats in upper part along dip planes; pH 5.1.

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