

## Soil Survey of the Lalo Farm, Mangilao, Guam

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The Lalo Farm consists of approximately 8.2 acres owned by the Department of Agriculture, Government of Guam, and used for crop research and demonstration purposes. It is located in one of the oldest agricultural areas on the island. The length of time this land has been farmed is not known, but it is generally believed to be in excess of 50 years.

Geologically, this farm lies in the hilly land physiographic unit of Central Guam. It is on the more gently sloping portion of the hilly land, lying less than one mile from the boundary where the hilly land grades into the plateau land of North Guam. This area is characterized by having only minor development of surface drainage. Small valleys exist, few if any of which have streams flowing through them. Many of these valleys have no outlet, being closed at both ends. This area is underlain by a permeable limestone, which makes the problem of standing water in these closed valleys or depressions much less serious than would ordinarily be expected. The southeast corner of the Lalo Farm lies in one of these closed valleys or depressions.

Nearly all crops grown on Guam have been grown successfully on this farm. Crops which are presently being grown successfully on the Lalo Farm include the following: cassava, taro, arrow root, corn, peanuts, sweet-potatoes, tomatoes, cucumbers, yard-long beans, eggplant, avocado, bananas, lime, clover, and alfalfa.

Preliminary identification of the soils in this survey was based on soil series descriptions contained in the report of a detailed-reconnaissance soil survey of Guam which was conducted from October 1952 to October 1954 by Carl H. Stensland and J. E. Passeur, Soil Scientists, as part of a combined rock, soil, water and vegetation study. In this detailed-reconnaissance soil survey, the entire Lalo Farm was included in soil Unit 3 (Chacha-Saipan clays). For the research and demonstration purposes which the Lalo Farm is being used, a more detailed soil survey was desired.

In this survey, five different soils were mapped. They are Chacha clay, Saipan clay, Yona clay, Toto clay and Pago clay. These soils were formed from volcanic clays which were laid down in and on the underlying limestone.

During the course of the survey, soil profiles were described in detail and samples taken of each horizon at nine different locations in the various soils of the Lalo Farm. It is hoped that laboratory analyses of these samples can be obtained in the near future.

<sup>1</sup> This soil survey of the Lalo Farm at Mangilao, Guam, was conducted during April, May, and June, 1964. At the time this study was made, he was serving on a tour of active duty with the United States Navy, and was stationed at the U.S. Naval Communications Station, Finegayan, Guam. This study was made during the author's off-duty hours, and in collaboration with the Plant Industry Division of the Guam Department of Agriculture. The author wishes to thank Dr. Albert A. LaPlante, Chief Agriculturist, Frank B. Aguon, Agriculturist, and Paul A. Hansen, Chief of Extension, all of the Guam Ed. Department of Agriculture, for their cooperation and assistance in carrying out this study.

### CHACHA CLAY

Chacha clay is the most extensive unit mapped in this survey. It occupies approximately 2.9 acres or 36 % of the Lalo Farm. It is a moderately deep<sup>2</sup> clayey Latosol developed in clays of volcanic origin which were deposited in and on the limestone. The subsoil of Chacha clay is strong brown to yellowish brown in color. Fragmented limestone mixed with the soil material occurs at depths ranging from one to four feet.<sup>3</sup> Chacha clay occurs in association with Saipan and Yona clays. It differs from Yona clay in having more development and greater depth to limestone and from Saipan clay in having a strong brown to yellowish brown subsoil.

Chacha clay is moderately well drained, although it may become water-logged at times during the wet season. This soil is one of the most productive in the area. All of the crops grown on the Lalo Farm have done well on Chacha clay.

The following is a profile description of Chacha clay located at soil sample site #5, 360 feet south and 200 feet west of northeast corner of the Lalo Farm, on a south-southwest facing slope of approximately five percent.

- A 0-10 inches: Very dark grayish brown (10YR 3/2 moist) clay; moderate medium blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; few black and brown moderately hard pellets or concretions; numerous roots; clear lower boundary.
- B<sub>1</sub> 10-15 inches: Brown to strong brown (7.5YR 4.5/5 moist) clay; moderate medium subangular blocky breaks to strong fine granular structure; firm when moist, very hard when dry; numerous root channels filled with very dark grayish brown topsoil; few small to large black concretions; grades to:
- B<sub>21</sub> 15-21 inches: Strong brown (7.5YR 5/6 moist) clay; moderate medium and fine angular and subangular blocky structure; firm when moist, very hard when dry; few fine and medium mottles of yellowish red (5YR 5/6 moist), numerous root channels filled with very dark grayish brown topsoil; few small and medium black concretions; grades to:
- B<sub>22</sub> 21-48 inches: Strong brown (7.5YR 5/6 moist) clay, moderate medium and fine angular and subangular blocky structure; firm when moist, very hard when dry; few root channels filled with dark grayish brown (10YR 4/2); few fine medium black concretions; abrupt lower boundary.
- B<sub>3ca</sub> 48-50 inches plus: Mixed strong brown clay and white, pitted small to large limestone fragments.

### SAIPAN CLAY

Saipan clay is the least extensive unit mapped in this survey, occupying approximately 0.8 acres or 10 % of the Lalo Farm. Like the Chacha clay, it is a moderately deep<sup>4</sup> clayey Latosol developed in clays of volcanic origin which

<sup>2</sup> In the report of the reconnaissance survey of 1952-1954, Chacha and Saipan clays were described as being moderately deep to very deep. On the Lalo Farm, they are moderately deep.

<sup>3</sup> Stensland reported finding depth to limestone varying from 1 to 10 feet in Chacha and Saipan clays.

<sup>4</sup> Same as (2)

were deposited in and on the limestone. The subsoil of Saipan clay is yellowish red, to reddish yellow. Fragmented limestone mixed with the soil material may occur at depths ranging from 18 inches to more than four feet.<sup>5</sup>

Saipan clay occurs in association with Chacha and Yona clays. It differs from Chacha clay in having a yellowish red to reddish yellow subsoil, and from Yona clay in having more development, greater depth to the fragmented limestone, and generally in having more red in the subsoil.

Like the Chacha clay, Saipan clay is moderately well drained, although internal drainage is sometimes not rapid enough to prevent water-logging during the wet season. Also, like the Chacha clay, Saipan clay appears to be one of the most productive soils in the area. All crops grown on the Lalo Farm do well on this soil.

The following profile of Saipan clay is near modal for the soil as it occurs on the Lalo Farm. It is located at soil sample site #9, 360 feet south and 250 feet west of the northeast corner of the Lalo Farm on a south-southwest facing slope of approximately 4%.

- A 0-8 inches: Very dark grayish brown (10YR 3/2 moist) clay; moderate medium angular blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; numerous roots; few small black and brown pellets or concretions; clear lower boundary.
- B<sub>1</sub> 8-12 inches: Yellowish red (5YR 4/6 moist) to reddish brown (2.5YR 4/4 dry) clay; strong medium angular blocky structure; firm when moist, very hard when dry; ped surfaces coated with clay films; numerous root channels filled with very dark grayish brown topsoil; few small and medium black concretions; few roots; clear lower boundary.
- B<sub>21</sub> 12-34 inches: Yellowish red (5YR 4/6 moist) to reddish brown (2.5YR 4/4 dry) clay; moderate medium subangular blocky breaks to strong fine angular blocky structure; firm when moist, very hard when dry; ped surfaces coated with clay films; few root channels filled with very dark grayish brown; few medium mottles of strong brown (7.5YR 5/6); few small to medium black concretions; clear lower boundary.
- B<sub>22</sub> 34-40 inches: Yellowish red (5YR 4/8 moist) clay; moderate medium subangular blocky breaks to strong fine angular blocky structure; firm when moist, very hard when dry; common small patches of yellowish red (5YR 4/6) and dark brown (7.5YR 3/2); peds coated with clay films; common small to large black concretions; clear lower boundary.
- B<sub>3ca</sub> 40-44 inches plus: Mixed yellowish red clay and white, pitted small to large limestone fragments.

The following is a profile of Saipan clay on which moderately severe erosion has taken place. It is located at soil sample site #2, 55 feet south and 60 feet west of the northeast corner of the Lalo Farm on a west facing slope of approximately 5%.

- A 0-5 inches: Very dark grayish brown (10YR 3/2 moist) clay; moderate medium and fine granular structure; firm when moist, very hard when dry; numerous roots; few small to medium black and brown pellets or

<sup>5</sup> Same as (3)

concretions; few small limestone fragments, clear lower boundary.

- B<sub>1</sub> 5-10 inches: Brown to dark brown (7.5YR 4/4 moist) clay; moderate medium and fine subangular blocky structure; firm when moist, very hard when dry; common small and medium black and brown pellets or concretions; few roots; few root channels filled with very dark grayish brown topsoil; grades to:
- B<sub>21</sub> 10-20 inches: Yellowish red (5YR 4/6 moist) clay; strong medium blocky structure; firm when moist, very hard when dry; few small and medium mottles of strong brown (7.5YR 5/6); peds coated with clay films; few old root channels filled with very dark grayish brown; few roots; grades to:
- B<sub>22</sub> 20-40 inches: Yellowish red (5YR 4/8 moist) clay; strong medium subangular blocky structure; firm when moist, very hard when dry; few small and medium mottles of strong brown (7.5YR 5/6); peds coated with clay films; few small black concretions; few roots.

The following is a profile of Saipan clay described at soil sample site #3, located 200 feet south and 130 feet west of the northeast corner of the Lalo Farm on a southwest facing slope of approximately 6%. This profile is approaching Saipan clay, shallow stony phase.

- A 0-11 inches: Brown to dark brown (10YR 4/3 moist) clay; moderate medium blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; few small and medium black and brown concretions or pellets; few fine and medium mottles of yellowish red (5YR 4/8); few small and medium limestone fragments; clear lower boundary.
- B<sub>1</sub> 11-13 inches: Strong brown (7.5YR 5/6 moist) to yellowish red (5YR 5/8 dry) clay; strong medium and fine angular blocky structure; firm when moist, very hard when dry; few root channels filled with brown to dark brown; few small black and brown concretions or pellets; clear lower boundary.
- B<sub>2</sub> 13-24 inches: Yellowish red (5YR 4/6 moist) clay; strong medium blocky structure, firm when moist, very hard when dry; peds coated with clay films; few root channels filled with brown to dark brown; few roots; few small and medium black and brown concretions or pellets; clear lower boundary.
- B<sub>3ca</sub> 24-26 inches plus: Mixed yellowish red clay and white, pitted, small to large limestone fragments.

### TOTO CLAY

Toto clay, occupying approximately 1.5 acres or 18% of the Lalo Farm, is the third most extensive unit mapped in this survey. Toto clay is a deep pale olive to pale yellow, reddish mottled clay Grumosol on limestone.

A characteristic of Toto clay mentioned by Stensland in his report of the 1952-1954 detailed-reconnaissance survey, is the "gilgai" type microrelief (uneven soil surface containing alternate small humps and depressions every few feet). This characteristic is not in evidence on the Lalo farm, except in one small area

of Toto clay mapped adjacent to the east edge of the farm, where there appear to be remnants of such microrelief. A possible reason for the lack of such microrelief here is that many years of cultivation have smoothed out formerly existing micro humps and depressions. This may also offer an explanation for the large variation in thickness of the strong brown horizon of transition between the dark brown or dark grayish brown surface soil and the pale olive or pale yellow subsoil. This transition horizon ranges in thickness from about 6 inches to about 18 inches in the areas of Toto clay where the gilgai microrelief is not evident.

Toto clay is developed in volcanic clays of the bentonitic type. Bentonitic clays are characterized by unusual shrinkage when dry and swelling or expansion when wet. This characteristic is manifest in Toto clay. In dry weather the clay shrinks, causing large cracks to form in the soil. In wet weather the clay swells or expands impeding the downward flow of water and causing the soil to become water-logged. This presents a definite limitation to the farming of this soil during the wet season. This soil remains wet for a considerably longer period of time following a rain than other soils in the same area.

Limestone was not encountered in Toto clay in the four foot depth dug in this survey. Stensland reported the depth to limestone bedrock beneath Toto clay to range from about 5 to 30 feet and to average 10 to 20 feet.

Excellent crops have been observed growing on Toto clay during the dry season. Crops observed growing successfully on this soil on the Lalo Farm include cucumbers, corn, yard-long beans, taro, and arrow-root. Hilo grass was observed doing very well on Toto clay on the old Government of Guam Department of Agriculture dairy farm located about 1 mile west of the Lalo Farm. Hilo grass is an introduced grass which makes very good pasture for livestock.

The following profile of Toto clay is located at soil sample site #7, 450 feet south and 405 feet west of the northeast corner of the Lalo Farm, or about 325 feet north of the Santa Teresita Church and about 65 feet east of route 10. It is toward the bottom of a south facing slope, the slope at this location being about 2%.

- A 0-8 inches: Dark brown (7.5YR 3/2 moist) to dark reddish brown (5YR 4/2 dry) clay; moderate medium subangular blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; numerous roots, few black, brown, and red small and medium pellets or concretions; few small white limestone fragments; clear lower boundary.
- AB 8-14 inches: Strong brown (7.5YR 5/8 moist) clay; moderate medium and fine blocky structure; firm when moist, very hard when dry; common medium mottles of dark red (2.5YR 3/6); few root channels filled with dark brown topsoil; few root channels filled with partially decayed roots; few roots; few small black concretions; grades to:
- B 14-48 inches: Pale olive (5Y 6/3 moist) clay; moderate medium subangular blocky structure; firm when moist, hard when dry; many medium and coarse prominent mottles of dark red (2.5YR 3/6) to strong brown (7.5YR 5/6); few roots; few partially decayed roots.

The following is a profile of Toto clay located at soil sample site #6, 500 feet south, and 305 feet west of northeast corner of the Lalo Farm. It is near

the bottom of a south facing slope, the slope at this point approximately 2 %.

- A<sub>1p</sub> 0-8 inches: Very dark grayish brown (10YR 3/2 moist) clay; moderate medium angular and subangular blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; few small black and brown pellets or concretions; few small white limestone fragments; few roots; abrupt lower boundary.
- A<sub>1</sub> 8-14 inches: Dark brown (7.5YR 3/2 moist) clay; moderate medium subangular blocky breaks to strong medium and fine granular structure; firm when moist, hard when dry; common small black and brown pellets or concretions; few roots; grades to:
- AB 14-24 inches: Strong brown (7.5YR 5/6 moist) clay; moderate medium and fine angular and subangular blocky structure; firm when moist, hard when dry; few medium mottles of red (10R 4/8); few root channels filled with very dark grayish brown topsoil; clear lower boundary.
- B<sub>1</sub> 24-32 inches: Strong brown (7.5YR 5/8 moist) mixed with pale olive (5Y 6/4 moist) clay; moderate medium angular blocky breaks to strong medium and fine granular structure; firm when moist, hard when dry; common small to large mottles of red (10R 4/8); few root channels filled with very dark grayish brown; clear lower boundary.
- B<sub>2</sub> 32-48 inches: Pale olive (5Y 6/4 moist) clay; moderate medium and fine subangular blocky breaks to strong medium and fine granular structure; firm when moist, hard when dry; many small to large mottles of dusky red (10R 3/3) to strong brown (7.5YR 5/8).

The following profile of Toto clay is located at soil sample site #4, 310 feet south and 30 feet west of the northeast corner of the Lalo Farm. It is located at the top of a small micro-hump, believed to be a remnant of the "gilgai" type microrelief on which Toto clay has been described as occurring. Considerable sheet erosion appears to have taken place at this location.

- A 0-8 inches: Brown (7.5YR 4/3 moist) to dark brown (7.5YR 3/2 dry) clay; moderate medium and fine subangular blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; few small to medium white pitted limestone fragments; few small black and brown pellets or concretions; few roots; clear lower boundary.
- B 8-34 inches plus: Pale olive (5Y 6/3 moist) clay; strong medium and fine angular and subangular blocky structure; firm when moist, very hard when dry; many small to large mottles of dusky red (2.5YR 3/2) to strong brown (7.5YR 5/6); few old root channels filled with dark brown topsoil; few roots.

### YONA CLAY

Yona clay is the second most extensive unit mapped in this survey. It occupies approximately 1.9 acres or 23 % of the Lalo Farm. This soil is a shallow Lithosol developed in clays of volcanic origin which were deposited in and on the limestone.

Yona clay is characterized by having many fragments of fractured, pitted limestone occurring within 12 inches of the surface. In most places, these

limestone fragments occur at the surface, and become more numerous with increasing depth. Beneath the surface, the soil matrix is clay, predominantly strong brown to yellowish brown in color, but it may range toward reddish yellow and yellowish red in places adjacent to areas of Saipan clay. Gradation toward a shallow stony phase of Chacha clay is evident in some places. Gradation toward a shallow stony phase of Saipan clay is evident in one area about 500-600 feet south and 100-200 feet west of the northeast corner of the Lalo Farm.

Yona clay is the best drained soil on the Lalo Farm. Good drainage is enhanced by the occurrence of this soil, generally higher and on the steeper portion of the slope, and by the shallow depth to the permeable limestone substratum. These factors make cultivation of this soil possible at times during the wet season when other soils may be water-logged. However, during the dry season, the natural productivity of Yona clay is relatively low. Because of limited depth, this soil has a relatively low capacity for storing both soil moisture and plant nutrients.

A crop of peanuts was observed doing well and a crop of corn was observed doing fairly well on Yona clay during the course of this survey.

The following profile is representative of the Yona clay mapped in this survey. It is located at soil sample site #1, 100 feet south and 90 feet west of the northeast corner of Lalo Farm. It is on a southwest facing slope of approximately 4%.

A 0-5 inches: Dark yellowish brown (10YR 3/4 moist) clay; moderate medium and fine blocky breaks to strong medium and fine granular structure; firm when moist, hard when dry; common small and medium white pitted limestone fragments; numerous roots; few small brown and black pellets or concretions; clear lower boundary.

C<sub>1</sub> 5-24 inches: Contains an estimated 50% strong brown (7.5YR 5/8 moist) clay, and an estimated 50% white, pitted small to large limestone fragments; clay portion contains common medium and large mottles of dark brown or brown (7.5YR 4/4 moist); few roots; grades to:

C<sub>2</sub> 24-34 inches plus: Contains an estimated 75% white, pitted, small to large limestone fragments, and an estimated 25% strong brown clay.

### PAGO CLAY

Approximately 1.1 acres or 13% of the Lalo Farm lies on the floor of a closed upland valley or depression. This unit was mapped as Pago clay, an Alluvial soil, which heretofore had been mapped only in the valley bottoms of larger streams and alluvial fans of smaller streams in the southern half of Guam. This unit as it occurs in this survey is not believed to be a true alluvial soil because there is no stream to have deposited the material. It appears to be of a colluvial nature, much of the soil material having been washed in from adjacent slopes. However, the characteristics of this soil seem to be consistent enough with Pago clay to map it as such for the time being. Possibly at some future date sufficient investigations will be made of the soils in the bottoms of these upland valleys or depressions to warrant the defining and naming of a new soil.

This is a deep soil, dark to a depth of 24 inches near adjoining areas of

Chacha clay and to a depth of 50 inches in the southeast corner of the farm, which is the lowest part of the area. This unit slopes at the rate of about  $\frac{1}{2}$  of 1 % toward the southeast. The extreme southeast corner of the Lalo Farm is near the lowest lying area of this valley or depression. In the wet season, water stands in this area making cultivation impossible. During the dry season, this soil can be successfully cultivated and has raised very good crops of taro and corn.

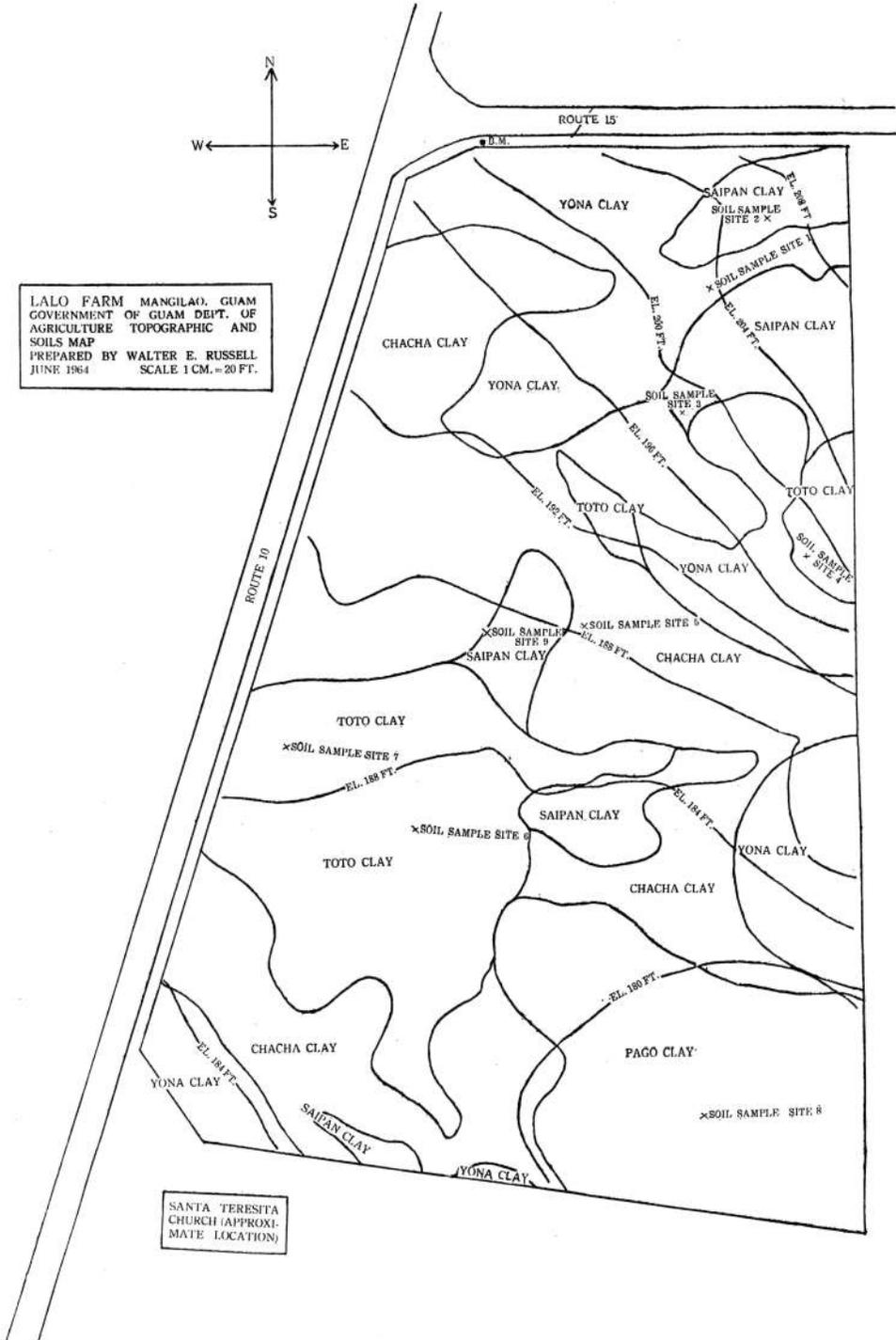
The following profile is representative of the Pago clay mapped in this survey. It is located at soil sample site #8, 90 feet north and 110 feet west of the southeast corner of the Lalo Farm.

- A<sub>1p</sub> 0-8 inches: Very dark grayish brown (10YR 3/2 moist) clay; strong medium and fine granular structure; firm when moist, hard when dry; numerous roots; few white small pitted limestone fragments; few small black and brown pellets or concretions; clear lower boundary.
- A<sub>1</sub> 8-26 inches: Very dark grayish brown (10YR 3/2 moist) clay; moderate medium and fine angular and subangular blocky structure; firm when moist, very hard when dry; few roots; few small and medium black and brown pellets or concretions; clear lower boundary.
- C<sub>1</sub> 26-31 inches: Dark yellowish brown (10YR 3/4 moist) clay; moderate medium and fine angular and subangular blocky structure; firm when moist, hard when dry; common medium and large black pellets or concretions; few roots; clear lower boundary.
- C<sub>2</sub> 31-48 inches plus: Strong brown (7.5YR 5/6 moist) clay; moderate medium and fine angular and subangular blocky breaks to strong medium and fine granular structure; firm when moist, very hard when dry; few small and medium mottles of yellowish red (5 YR 5/8); common small and medium black pellets or concretions.

### References

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- Soil Survey Staff, 1951, *Soil Color in Soil Survey Manual*, U.S. Dept. of agriculture Handbook no. 18, pp. 189-203: U.S. Government Printing Office, Washington 25, D.C.

NOTE: The horizon designations in the soil profile descriptions are merely tentative.



Map 1