MCCOMBS MEGA-SITE

PRELIMINARY ENGINEERING REPORT FOR SANITARY SEWER SERVICE

Prepared for:

AUGUSTA ECONOMIC DEVELOPMENT AUTHORITY
ATTENTION: CAL WRAY

Prepared by:

CRANSTON

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EXECUTIVE SUMMARY

The Augusta Economic Development Authority is evaluating potential infrastructure improvements to support economic development and job creation in Richmond County. This report is specific to proposed sanitary sewer improvements that would serve a new industrial development identified as the McCombs Road Mega-Site. However, in providing new sewer infrastructure for the Mega-Site, additional service areas are created. This means large areas currently not served by public sanitary sewer facilities would have access to sewer, which could serve as a catalyst for growth and a greater economic impact.

Preceding this analysis, the Augusta Economic Development Authority has completed the following studies relating to the proposed Mega-Site:

- Geotechnical Exploration by WSP, dated 10/28/2022
- Cultural Resources Study by Brockington, dated October 11, 2022
- Phase I Environmental Site Assessment by Wood, dated August 2, 2022
- Threatened and Endangered Species Survey by Resource + Land Consultants, dated October 2022

The contemplated McCombs Road Mega-Site is in southern Richmond County near the Burke County line just north of McBean Creek. The Mega-Site is more specifically located in the area bound by Highway 56 to the east, Old Waynesboro Road to the west, and McCombs Road to the north. Railroad tracks operated by Norfolk Southern serve as the site's southern boundary. The Mega-Site encompasses approximately 1,150-acres and multiple parcels of land, most of which are zoned as Agriculture (A). Several smaller parcels of residential land lie along McCombs Road, just north of the site, and are not currently envisioned in the proposed development.

The existing site conditions are characterized as generally undeveloped land with moderately to steeply sloping topography with upwards of approximately 150-feet of topographic relief across the site. Multiple tributaries to McBean Creek are located within the project limits. Based on a wetland delineation authorized by the Augusta Economic Development Authority, jurisdictional wetlands are located along the southern project limits near the Norfolk Southern railroad and along the tributaries to McBean Creek that extend south to north across the site.

Existing public utilities in the vicinity of the proposed Mega-Site are limited to a 12-inch diameter water main along McCombs Road, which connects to a 12-inch diameter water main on Highway 56. Based on Augusta GIS data, the water main reduces to 10-inch diameter as it extends to the west of Old Waynesboro Road. Public sanitary sewer facilities are not located in close proximity to the Mega-Site. The closest sewer infrastructure is located along Horseshoe Road north of the Augusta Corporate Park. Horseshoe Road is approximately 3-miles north of the proposed Mega-Site as measured along Highway 56. Horseshoe Road is approximately 175-feet upgradient of the lower portions of the Mega-Site.

At the direction of Augusta Economic Development Authority and the Augusta Utilities Department, Cranston initiated preliminary engineering services to develop conceptual recommendations for providing sanitary sewer service to the Mega-Site. Conceptual sewer flow data from multiple prospective industries was provided to us and reviewed. A team comprised of staff from the Augusta Utilities Department (AUD), Augusta Economic Development Authority (AEDA), and Cranston, LLC collectively agreed to base the preliminary sewer recommendations on a contributing flow rate of 1.5-2.0 million gallons per day (MGD).

Multiple infrastructure improvement alternatives were developed and collectively reviewed with AEDA and AUD. Alternatives included various pump station locations and gravity sewer and force main alignments. While proposed site development plans and utility layouts for the Mega-Site were not completed as part of this analysis, on-site improvements are envisioned to include new sewer laterals that collect and convey flow by gravity to a new pump station within the Mega-Site. The first option considered included a scenario where the Mega-Site effluent is pumped directly from the Mega-Site along Highway 56 to the existing gravity system along Horseshoe Road. Effluent would then be conveyed by gravity to the Spirit Creek Pump Station. A second alternative involved pumping from the Mega-Site to a second pump station along Little McBean Creek just east of Highway 56. Flows would then be pumped to the gravity system on Horseshoe Road and ultimately discharged into the Spirit Creek Pump Station. This alternative would allow a future gravity sewer extension in the Little McBean Creek basin that would increase sewer service capacity and support growth in the Little McBean Creek basin. A third alternative was evaluated that included pumping the Mega-Site's effluent north to the limits of the Little Spirit Creek Basin near Clark Road. From that point, flow would be conveyed by gravity to a new trunk main along Little Spirit Creek. The new trunk main would convey flow downstream (to the east) to the Spirit Creek Pump Station and is envisioned to extend upstream (to the west) to Old Waynesboro Road. This alternative would provide effective collection and conveyance of the Mega-Site's effluent while also providing new sewer infrastructure in an area that does not have public sewer access. This alternative is recommended as it addresses the sewer needs of the Mega-Site and provides public sewer service to a larger area than the other alternatives through construction of the Little Spirit Creek Trunk Main.

EXISTING CONDITIONS

The proposed Mega-Site is located approximately 18-miles from Downtown Augusta in Richmond County, Georgia just north of the Burke County line. Site topography ranges from 3-10%. However, grades exceed 25% in limited areas. The site drains from north to south through multiple tributaries of McBean Creek.

Soil classifications vary and are generally sandy in nature. Four hydrologic soil groups exist throughout the project area. Troup Fine Sand is the most prominent soil type and is characterized with a B hydrologic soil classification. Please Appendix C for soils data.

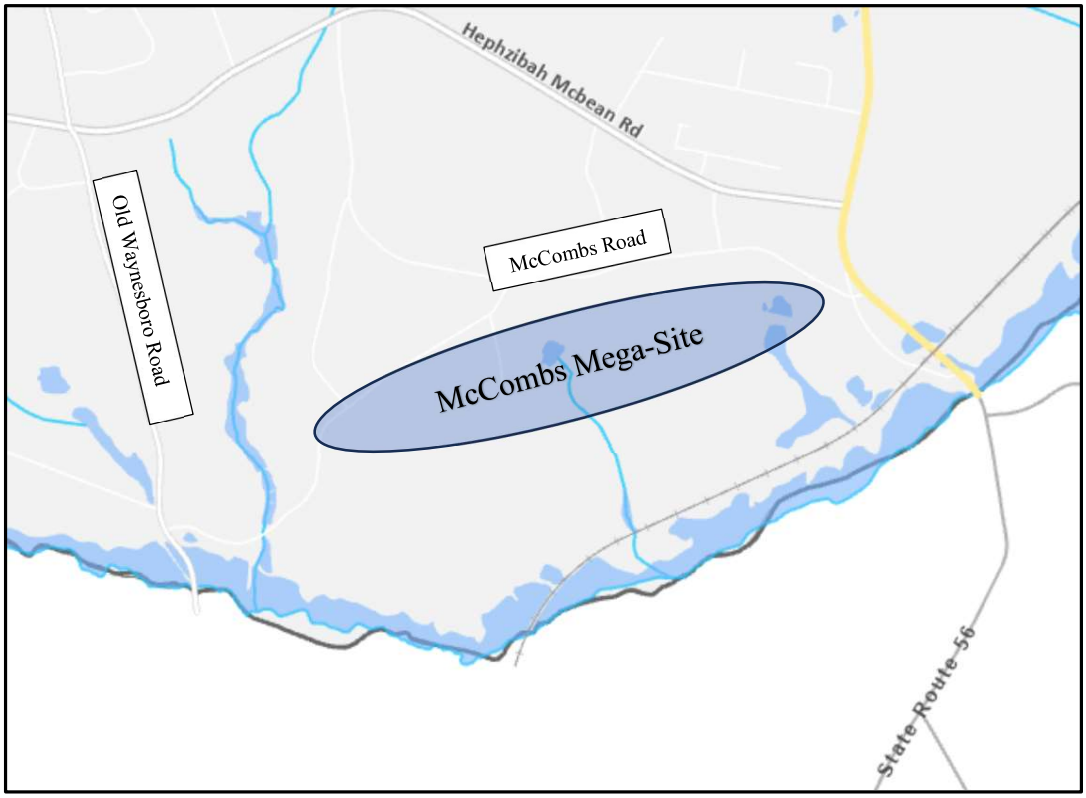


Figure 1: Vicinity Map

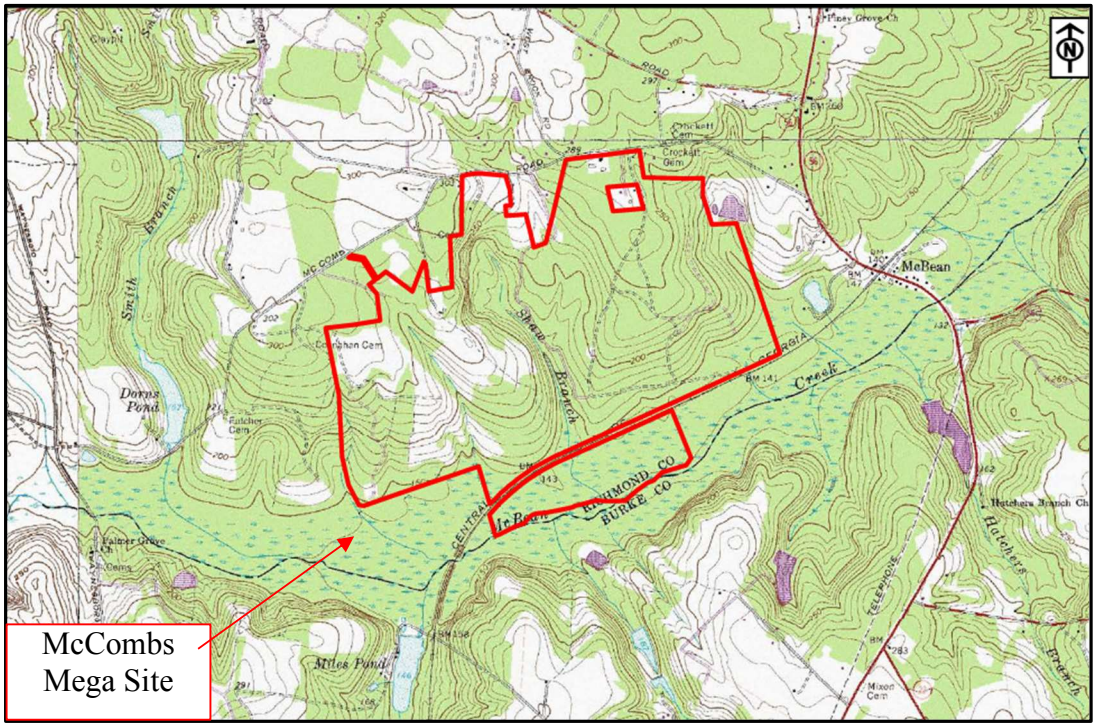


Figure 2: USGS Map

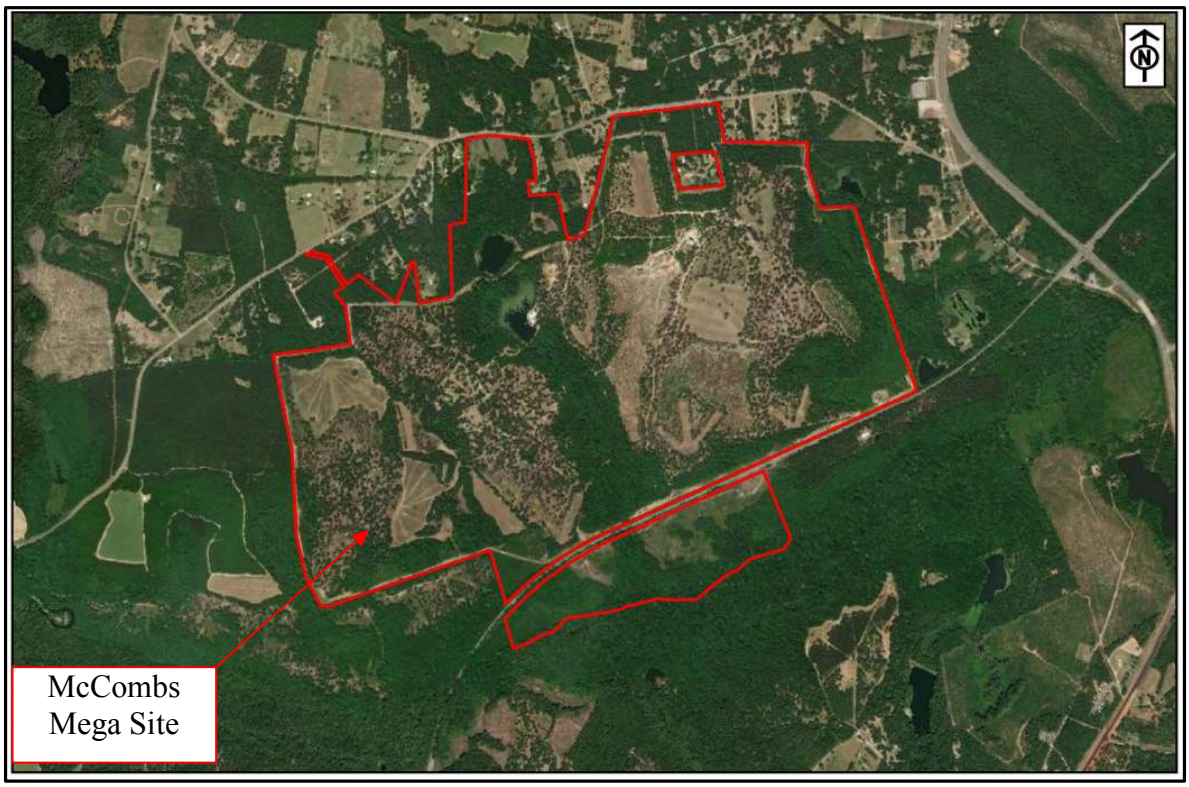


Figure 3: Aerial Image

A 12-inch diameter water main is located along McCombs Road and is accessible to the site. The McCombs Road water main connects to a 12-inch water main along Highway 56 and extends west across Old Waynesboro Road to Highway 25 with varying diameter. Public sanitary sewer infrastructure is not located along McCombs Road or in close proximity to the site. The closest sewer infrastructure is approximately 3.3-miles to the north along Horseshoe Road, which is tributary to the Spirit Creek Pump Station and ultimately the Messerly Wastewater Treatment Plant (WWTP).

PROPOSED CONDITIONS

The proposed Mega-Site is envisioned as an industrial development potentially comprised of one or more industrial sites across approximately 1,150-acres in south Richmond County, Georgia. The recommended alternative includes routing the Mega-Site effluent from an on-site pump station to the north through McCombs Road, Westbrook Road, Hephzibah McBean Road, and Clark Road. The force main would discharge into a new gravity sewer at the limits of the Little Spirit Creek basin. The new gravity sewer would then connect to a new 24-inch diameter trunk main along Little Spirit Creek. The trunk main would extend downstream to Highway 56 where it would connect to an existing 30-inch sanitary sewer main that was installed approximately 20-years ago for future service to the Little Spirit Creek Basin. The flow would then be conveyed to the Spirit

Creek Pump Station. The concept also includes the extension of the trunk main upstream along Little Spirit Creek to Old Waynesboro Road.

Please refer to the Appendix for the Concept Plan.

Design Considerations

While detailed design and hydraulic calculations have not been included, the proposed Mega-Site pump station is anticipated to include submersible pumps inside of a wet-well. The proposed pump station will need to overcome a static head of approximately 150-feet. Conceptual estimates are based on a 14-inch dimeter force main that would extend approximately 19,550-feet from the pump station to a receiving manhole near the basin limits of Little Spirit Creek just north of Clark Road. Considerations associated with the Little Spirit Creek trunk main alignment include potential environmental impacts, stream crossings, and likely high ground water levels. Significant easement acquisition would also be required.

Pump quantities, sizing, and sequencing will require detailed engineering design and coordination. Specific attention should be directed to the project timelines and final accounting of wastewater demands. Pump selections will need to consider a wide range of operating conditions. The initial pumping system may require functional changes based on the introduction of additional flows from the subsequent developments. Consideration should be given to pumps that can accommodate larger impellers and wet well configurations that ease pump change-out while avoiding a shut-down. Pump station site improvements are anticipated to include new electrical service, emergency power connections, control systems, lighting, and fencing.

OPINION OF PROBABLE CONSTRUCTION COST:

The budgetary, planning-level construction costs shown below reflect our opinion of the future construction costs associated with providing sanitary sewer infrastructure to serve the McCombs Road Mega-Site. The budgetary cost estimated for sewer improvements is approximately $23M including a 30% contingency. The costs include sewer infrastructure such as the pump station, force main, and gravity piping. Anticipated incidental construction costs are also include to budget for likely impacts to existing roads and driveways, utility relocations, and unforeseen subsurface conditions. Final pipe sizes and quantities will be greatly influenced by final development plans, build-out timing, and wastewater contributions.

PERMITTING REQUIREMENTS:

The following permit approvals are anticipated:

Agency	Approval / Permit	Status
Augusta, Georgia	AUD Design Approval	Submitted upon Completion of Design
Augusta, Georgia	AED Land Disturbance	Submitted upon Completion of Design
Georgia EPD	NDPES/NOI	Submitted upon Completion of Design
Corps of Engineers*	Wetlands Permit	Pending Prelim. Design and Impact Analysis

*Dependent on development limits and impacts.

TENTATIVE SCHEDULE:

The estimated time to complete the concept development and final engineering design is 4-6 months following completion of a topographic survey. This will include completion of the Concept Report and a collaborative Final Engineering design process between the City of Augusta, Augusta Economic Development Authority, and Cranston. A 4-month duration is anticipated for procurement review, approval, bidding, and issuance of the notice to proceed to the successful contractor. A construction duration of 12- months is estimated based on our current understanding of the contemplated infrastructure improvements.

APPENDIX

APPENDIX A

SAVANNAH RIVER
TO MESSERLY WASTE WATER TREATMENT PLANT
SPIRIT CREEK
US 25
BROWN ROAD
GA 88
BOGGY BRANCH
48"
20"FM
EX SPIRIT CREEK PUMP STATION
NEW 24" GRAVITY SEWER IN LITTLE SPIRIT CREEK BASIN. FLOW ROUTED TO EX. 30" GRAVITY SEWER AT HWY. 56 AND THEN SPIRIT CREEK PUMP STATION
EX. BOOSTER PUMP STATION
BENNOCK MILL ROAD
20"
15"
LITTLE SPIRIT CREEK
NEW 18" GRAVITY SEWER
NEW 15" GRAVITY SEWER
EX. ELEVATED TANK
HORSESHOE ROAD
AUGUSTA CORPORATE PARK
CLARK ROAD
LITTLE McBEAN CREEK
SPIRIT CREEK BASIN
NEW FORCE MAIN FROM McCOMBS SITE TO NEW GRAVITY CONNECTION IN LITTLE SPIRIT CREEK BASIN
HEPHZIBAH MCBEAN ROAD
VALENCIA WAY
GA 56
OLD WAYNESBORO ROAD
McCOMBS INDUSTRIAL SITE
NORFOLK SOUTHERN RAILROAD
NEW SANITARY SEWER PUMP STATION FOR MCCOMBS PROPERTY INDUSTRIAL DEVELOPMENT. ON-SITE GRAVITY SEWER SYSTEMS TO THE PUMP STATION ARE NOT SHOWN
McBEAN CREEK

PROJECT NARRATIVE

THE McCOMBS MEGA-SITE PUMPS TO LITTLE SPIRIT CREEK BASIN WHERE IT IS INTERCEPTED BY A NEW GRAVITY SEWER TRUNK MAIN AND ROUTED TO AN EXISTING 30" GRAVITY SEWER AT HIGHWAY 56. TRUNK MAIN IMPROVEMENTS ALONG LITTLE SPIRIT CREEK EXTEND UPSTREAM TO OLD WAYNESBORO ROAD.

LEGEND

- AUGUSTA CORPORATE PARK
- McCOMBS SITE
- PROTECTED WETLANDS
- STREAM, CREEK, OR RIVER
- TRIBUTARY
- DRAINAGE BASIN LIMITS
- EXISTING WATER
- EXISTING SANITARY
- PROPOSED SANITARY GRAVITY MAIN
- PROPOSED SANITARY FORCE MAIN

CONCEPT PLAN

FOR

MCCOMBS MEGA-SITE

SEWER INFRASTRUCTURE CONCEPTS

AUGUSTA ECONOMIC DEVELOPMENT AUTHORITY

SEPTEMBER 4, 2024

NOT TO SCALE

CRANSTON

E01
2024-0212

G:\PROJECTS\2024\2024-0212_AEDA - MCCOMBS ROAD INDUSTRIAL SITE\AC-DRAWINGS\X-REFS\2024_0212_EXBT_PLOWC 9/5/2024 1:39 PM

APPENDIX B

CRANSTON

McCOMBS MEGA-SITE
RICHMOND COUNTY, GEORGIA
BUDGETARY OPINION OF PROBABLE CONSTRUCTION COST

PROJECT NARRATIVE:

The budgetary, planning-level costs shown below reflect our opinion of the future construction costs associated with providing sanitary sewer infrastructure to serve the McCombs Road Mega-Site.

The conceptual improvements include routing the Mega-Site flow from an on-site pump station to the north through McCombs Road, Westbrook Road, Hephzibah McBean Road , and Clark Road. The force main would discharge into a new gravity sewer at the limits of the Little Spirit Creek basin. The new gravity sewer would then connect to a new 24" diameter trunk main along Little Spirit Creek. The trunk main would extend downstream to Highway 56 where it would connect to an existing 30" sewer main that was installed approximately 20-years ago for future service to the Little Spirit Creek Basin. The flow is then conveyed to the Spirit Creek Pump Station. The concept also includes the extension of the trunk main upstream along Little Spirit Creek to Old Waynesboro Road.

McCombs Mega-Site - Sewer Improvements

PAY ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
1	SANITARY SEWER LIFT STATION, COMPLETE - INCLUDING PUMPS, PIPING, VALVES, ELECTRICAL, ETC.	1	EA	$ 1,500,000.00	$ 1,500,000.00
2	14" HDPE FORCE MAIN, COMPLETE (ROUTED TO NEW TO LITTLE SPIRIT CREEK GRAVITY SYSTEM)	19,550	LF	$ 175.00	$ 3,421,250.00
3	15" DIA. PVC SANITARY SEWER PIPE, SDR 26, COMPLETE (NEW GRAVITY LINE ALONG TRIB. TO LITTLE SPIRIT CREEK)	6,850	LF	$ 210.00	$ 1,438,500.00
4	18" DIA. PVC SANITARY SEWER PIPE, SDR 26, COMPLETE (NEW LITTLE SPIRIT CREEK TRUNK MAIN)	13,115	LF	$ 275.00	$ 3,606,625.00
5	24" DIA. PVC SANITARY SEWER PIPE, SDR 26, COMPLETE (NEW LITTLE SPIRIT CREEK TRUNK MAIN)	12,350	LF	$ 350.00	$ 4,322,500.00
6	4'-0 DIAMETER PRECAST CONCRETE MANHOLE	150	EA	$ 12,000.00	$ 1,800,000.00
7	INCIDENTAL CONSTRUCTION (ROADWAY RECONSTRUCTION, UTILITY RELOCATIONS, UNFORESEEN SUBSURFACE CONDITIONS, ETC.)	1	LS	$ 1,580,000.00	$ 1,580,000.00
				SUB-TOTAL	$ 17,668,875.00
				CONTINGENCY (30%)	$ 5,300,662.50
				SUB TOTAL - MEGA SITE	**$ 22,969,537.50**

PRELIM. OPERATING CONDITIONS:
1.5 - 2.0 MGD
200' - 220' TDH

A. COSTS FOR UPGRADING THE EXISTING RECEIVING SYSTEM(S) ARE NOT INCLUDED.

B. COSTS EXCLUDE ASSUMPTIONS PERTAINING TO PROPERTY ACQUISITION OR ENVIRONMENTAL IMPACTS.

APPENDIX C

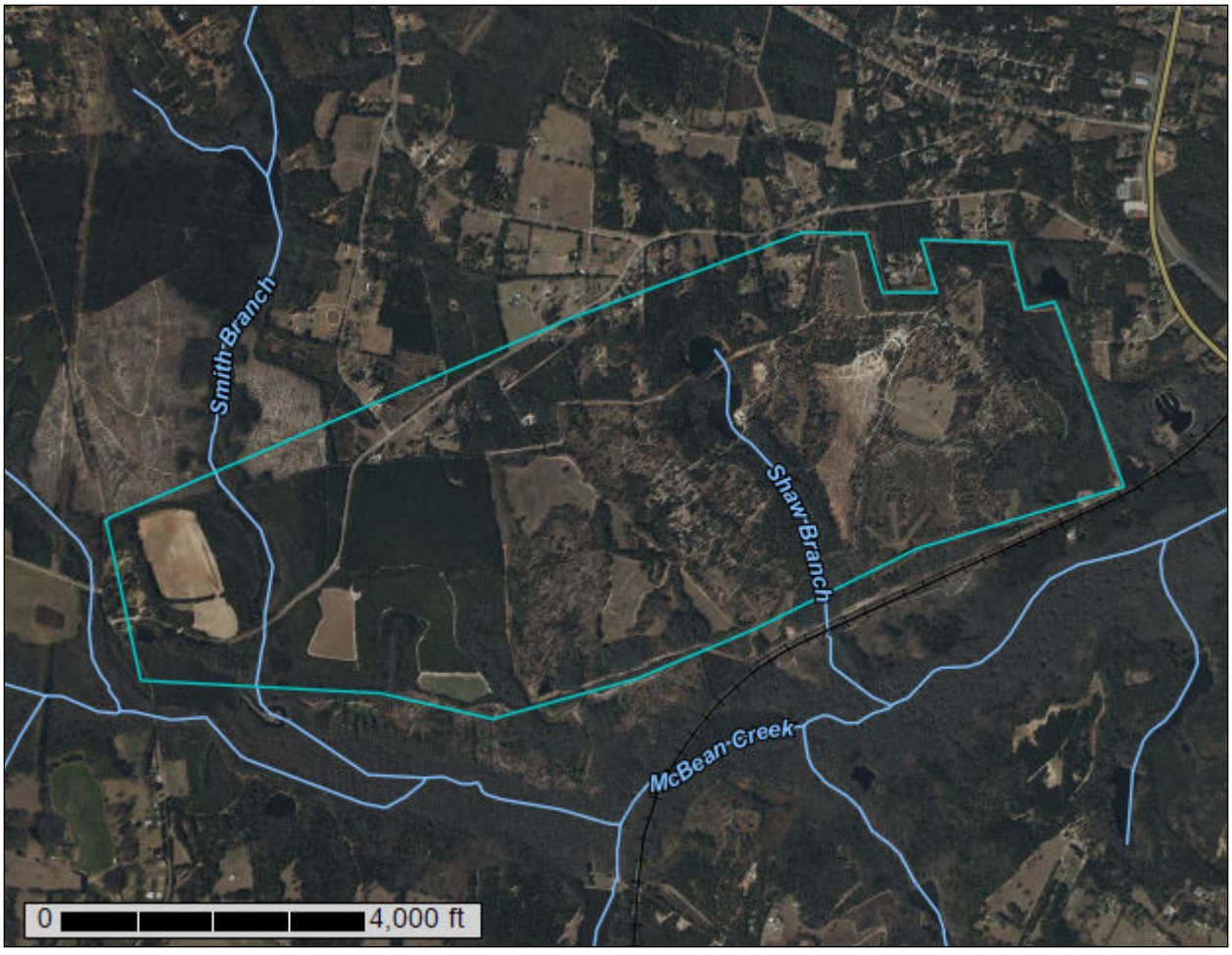
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Richmond County, Georgia



September 6, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

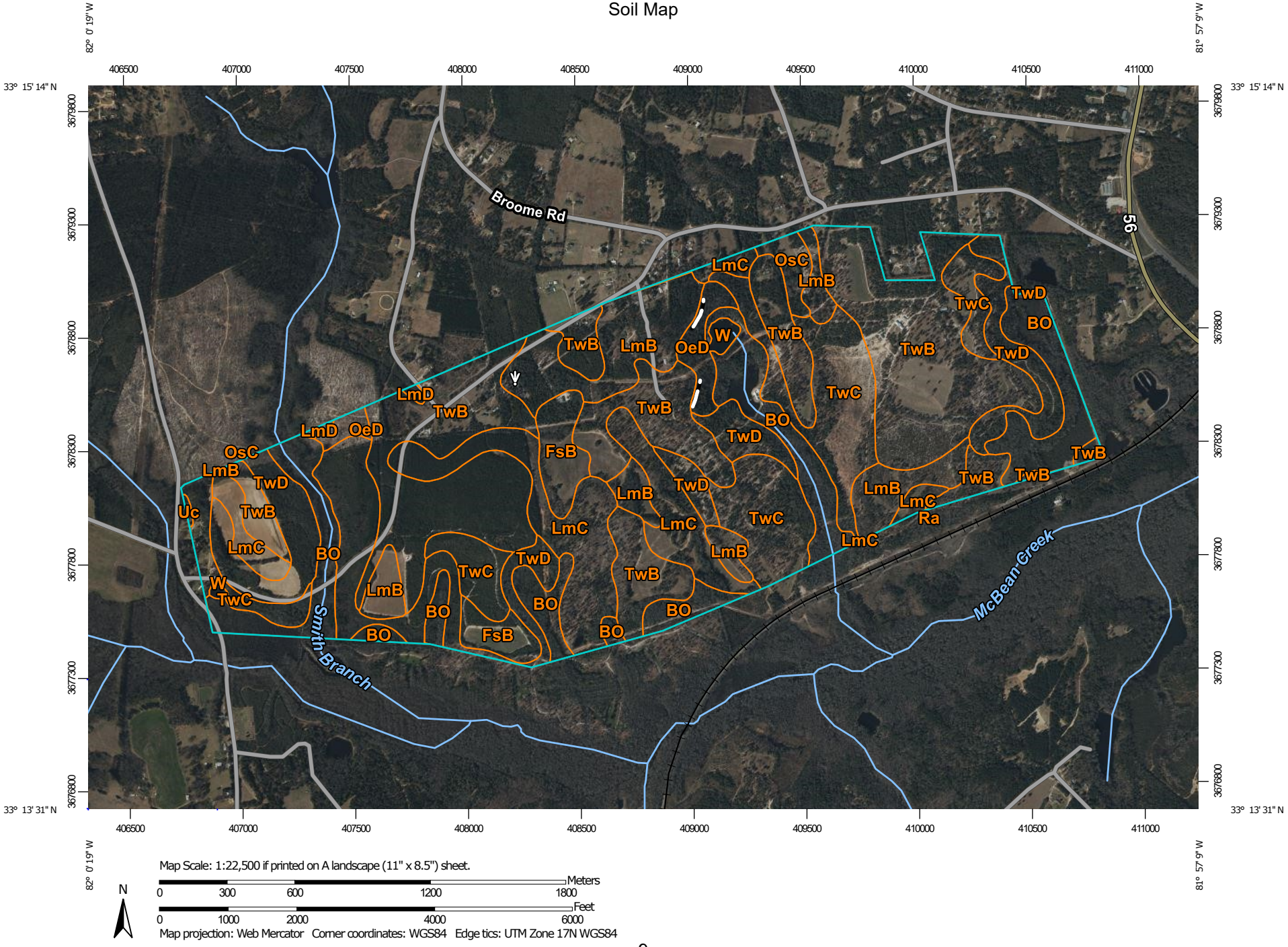
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.



Map Scale: 1:22,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 300 600 1200 1800

Feet
0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Richmond County, Georgia
Survey Area Data: Version 17, Aug 30, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 11, 2020—Mar 12, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BO	Bibb and Osier soils	154.4	13.1%
FsB	Fuquay loamy sand, 1 to 5 percent slopes	37.1	3.2%
LmB	Lucy loamy sand, 1 to 5 percent slopes	117.0	10.0%
LmC	Lucy loamy sand, 5 to 8 percent slopes	122.9	10.5%
LmD	Lucy loamy sand, 8 to 15 percent slopes	2.2	0.2%
OeD	Orangeburg loamy sand, 8 to 15 percent slopes	21.2	1.8%
OsC	Orangeburg sandy loam, 5 to 8 percent slopes	10.9	0.9%
Ra	Rains loamy sand	0.0	0.0%
TwB	Troup fine sand, 1 to 5 percent slopes	381.4	32.5%
TwC	Troup fine sand, 5 to 10 percent slopes	162.8	13.9%
TwD	Troup fine sand, 10 to 17 percent slopes	158.6	13.5%
Uc	Udorthents, sandy and loamy	0.8	0.1%
W	Water	5.0	0.4%
Totals for Area of Interest		**1,174.4**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion

of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Richmond County, Georgia

BO—Bibb and Osier soils

Map Unit Setting

National map unit symbol: bx1h
Elevation: 20 to 450 feet
Mean annual precipitation: 44 to 60 inches
Mean annual air temperature: 59 to 64 degrees F
Frost-free period: 190 to 230 days
Farmland classification: Not prime farmland

Map Unit Composition

Bibb and similar soils: 70 percent
Osier and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bibb

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 40 inches: fine sandy loam
H2 - 40 to 62 inches: loamy fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Ecological site: F137XY010SC - Flood Plains And Seepage Swamps
Hydric soil rating: Yes

Description of Osier

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 13 inches: loamy fine sand
H2 - 13 to 45 inches: loamy fine sand
H3 - 45 to 65 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F137XY010SC - Flood Plains And Seepage Swamps
Hydric soil rating: Yes

FsB—Fuquay loamy sand, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: bx1w
Elevation: 110 to 540 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Fuquay and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fuquay

Setting

Landform: Interfluves
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 30 inches: loamy sand
H2 - 30 to 35 inches: sandy loam
H3 - 35 to 65 inches: sandy clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 48 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C
Ecological site: F137XY040SC - Loamy Summit Woodland
Hydric soil rating: No

LmB—Lucy loamy sand, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: bx2c
Elevation: 150 to 520 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Lucy and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lucy

Setting

Landform: Interfluves
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 29 inches: loamy sand
H2 - 29 to 32 inches: sandy loam
H3 - 32 to 80 inches: sandy clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Hydric soil rating: No

LmC—Lucy loamy sand, 5 to 8 percent slopes

Map Unit Setting

National map unit symbol: bx2d
Elevation: 150 to 560 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Lucy and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lucy

Setting

Landform: Hills
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 29 inches: loamy sand
H2 - 29 to 32 inches: sandy loam
H3 - 32 to 80 inches: sandy clay loam

Properties and qualities

Slope: 5 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s

Hydrologic Soil Group: B
Hydric soil rating: No

LmD—Lucy loamy sand, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: bx2f
Elevation: 110 to 510 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Lucy and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lucy

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 29 inches: loamy sand
H2 - 29 to 32 inches: sandy loam
H3 - 32 to 80 inches: sandy clay loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: B
Hydric soil rating: No

OeD—Orangeburg loamy sand, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: bx2k
Elevation: 170 to 500 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Orangeburg and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Orangeburg

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 10 inches: loamy sand
H2 - 10 to 50 inches: sandy clay loam
H3 - 50 to 64 inches: sandy clay loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Hydric soil rating: No

OsC—Orangeburg sandy loam, 5 to 8 percent slopes

Map Unit Setting

National map unit symbol: bx2l
Elevation: 170 to 500 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Orangeburg and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Orangeburg

Setting

Landform: Hills
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 10 inches: sandy loam
H2 - 10 to 50 inches: sandy clay loam
H3 - 50 to 64 inches: sandy clay loam

Properties and qualities

Slope: 5 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Ra—Rains loamy sand

Map Unit Setting

National map unit symbol: bx2n
Elevation: 40 to 450 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Rains and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rains

Setting

Landform: Depressions on stream terraces, flats
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Alluvium

Typical profile

H1 - 0 to 15 inches: loamy sand
H2 - 15 to 44 inches: sandy clay loam
H3 - 44 to 65 inches: sandy clay loam
H4 - 65 to 69 inches: sandy clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

TwB—Troup fine sand, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: bx2t
Elevation: 100 to 540 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Troup and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Troup

Setting

Landform: Interfluves
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 54 inches: fine sand
H2 - 54 to 80 inches: sandy clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F137XY060GA - Loamy Upland Woodland, Thick Sandy Surface
Hydric soil rating: No

TwC—Troup fine sand, 5 to 10 percent slopes

Map Unit Setting

National map unit symbol: bx2v
Elevation: 110 to 540 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Troup and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Troup

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 54 inches: fine sand
H2 - 54 to 80 inches: sandy clay loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F137XY060GA - Loamy Upland Woodland, Thick Sandy Surface
Hydric soil rating: No

TwD—Troup fine sand, 10 to 17 percent slopes

Map Unit Setting

National map unit symbol: bx2w
Elevation: 110 to 510 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 230 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Troup and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Troup

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 54 inches: fine sand
H2 - 54 to 80 inches: sandy clay loam

Properties and qualities

Slope: 10 to 17 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F137XY060GA - Loamy Upland Woodland, Thick Sandy Surface
Hydric soil rating: No

Uc—Udorthents, sandy and loamy

Map Unit Setting

National map unit symbol: bx2z
Elevation: 100 to 510 feet
Mean annual precipitation: 45 to 45 inches
Mean annual air temperature: 64 degrees F
Frost-free period: 235 to 245 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Properties and qualities

Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf