Appendix I – Geotechnical Engineering

Mitchell Lake, San Antonio, TX

General Investigations Feasibility Study

Integrated Draft Feasibility Report and Environmental Impact Assessment

August 2020

US Army Corps of Engineers®
Fort Worth District

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EXECUTIVE SUMMARY

MITCHELL LAKE ECOLOGICAL RESTORATION
GEOTECHNICAL CONSIDERATIONS

This report is an Appendix to the Feasibility Study for the ecological restoration of Mitchell Lake located in south San Antonio, Bexar County,

The Feasibility Study conducted by the Fort Worth District of the US Army Corps of Engineers identified a number of ecological improvements that would enhance habitat diversity, preserve and enhance the wetlands and manage or control invasive plane species.

Geotechnical aspects of the proposed enhancements include a survey of existing soil conditions, an evaluation of the potential opportunities and risks involved with the proposed structural and non- structural improvements and planning the necessary geotechnical exploration to facilitate the design of the ecologic improvements after the tentative plan selection is approved by the vertical team.

This geotechnical appendix addresses these issues as they relate to the path forward.

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List of Acronyms

AOI	Area of Interest
ASTM	American Society for Testing of Materials
NRCS	National Resource Conservation Service
SWF	Southwest District of the USACE (Generally implies Fort Worth District)
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

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1 Background

The Mitchell Lake Ecological Enhancement Feasibility study was initiated at the Fort Worth District (SWF) of the US Army Corps of Engineers in September 2018. The project team included ecologists, environmental scientists, cultural resources, economists and engineers from various disciplines. Based on desk studies, field visits and planning sessions, each discipline produced documentation that was compiled and a proposed path forward was presented for review.

The planned path forward includes a number of elements that present opportunities for ecological enhancement of the Mitchell Lake system. Apart from the 600 acre lake, the system is also a wetland and recreational complex that encompasses a total of about 1,200 acres. Therefore the study area is much larger than the lake itself as shown in Figure 1 in the following discussion on existing conditions. Average depth of water in the lake is estimated at 8 feet.

Geotechnical data available at this time essentially consists of National Resource Conservation Service (NRCS) Soil Survey maps. As Mitchell Lake is located within the overall encasement of the Edwards Aquifer water quality is one of the major concerns. From a geotechnical point of view any deep excavation would require further site specific data besides the soil survey data. At this time no deep soil borings are planned, but as the plans develop for structural improvements, geotechnical investigations will be required.

Recommendations in this report are therefore confined to issues relating to planting, drainage, shallow excavations and potential issues with the siting of new structures.

1.1 Desk Studies

Geotechnical information on the Mitchell Lake and the surrounding area was obtained from NRCS soil surveys and geological information from various sources such as the Texas Geological Society, University of Texas system documents and research papers and the experience of SWF in the general region. The relevant data as it applies to the proposed ecological improvements is discussed in this report.

The recommended plan (Plan 10 in the main report) provides for the enhancement of emergent wetlands, submergent / emergent wetlands and mudflats. Additional geotechnical studies to sample and test the existing soil physical and chemical properties are needed to support the recommended plan. These tests would include, but not limited to, soil classification tests, organic content, pH, Redox potential, and total nutrient content. Tests on water samples would also be conducted to determine water quality. Tests on water samples would include, but not limited to, total solids, total dissolved solids, total suspended solids, pH, TKN, hardness, in accordance with applicable EPA standard test methods. Samples would be collected from each of the three different areas stated above at a rate of at least one sample per 10 acres of the area to be improved or as directed by the project environmental engineers and biologists. Tentatively, this represents 21 sampling locations, though it is likely to change depending on accessibility and sampling techniques. Geotechnical studies may also be required for the siting of new water control structures.

This report lists the predominant soil types encountered within the study area and the potential opportunities and risks involved with each type of ecological enhancement considered, from a geotechnical point of view.

The soils within the study area, which covers approximately 3,700 acres including the lake itself, consist mainly of sandy and clayey loams and sandy soils. This description of the soils is generally used only by the NRCS and is associated with agricultural and ecological terminology. The equivalent engineering terminology for these soils would include silty sands, silty clays and clayey sands.

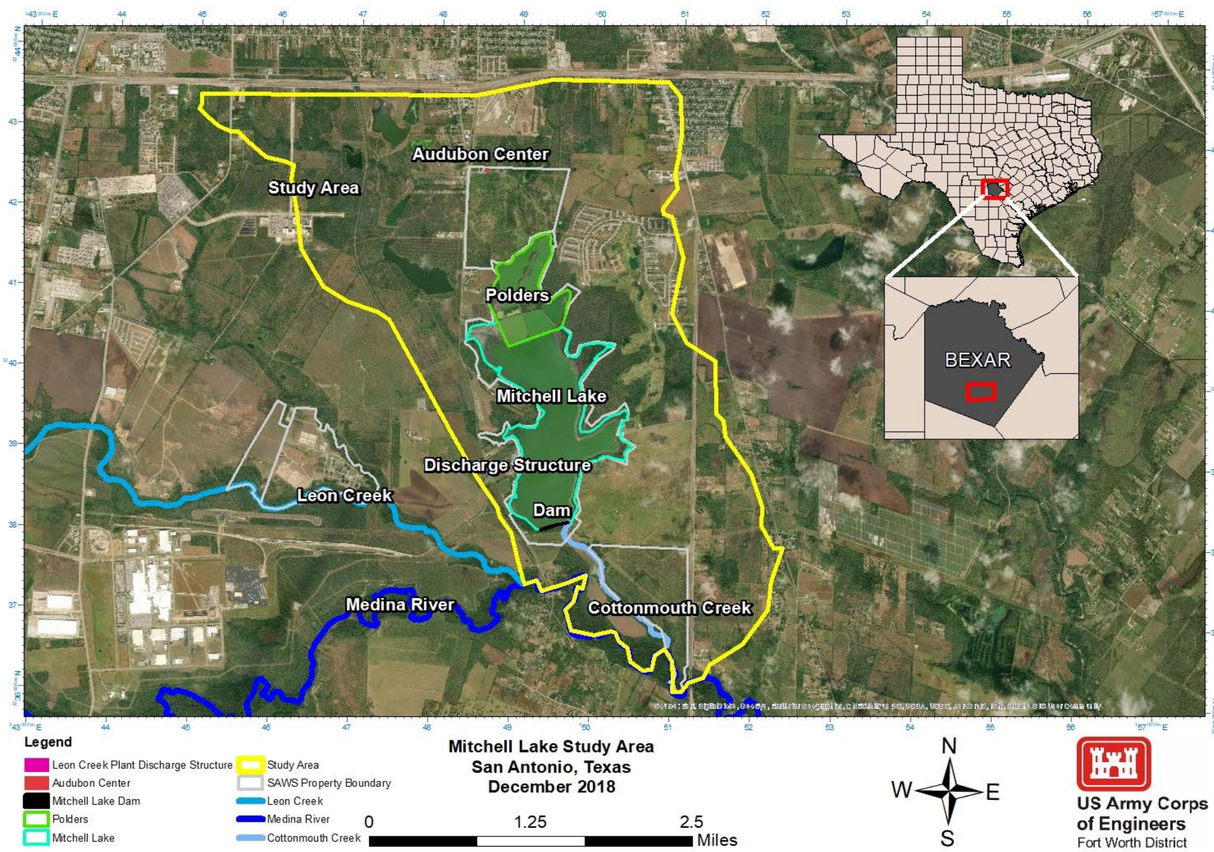
For the purposes of this report, the discussion focuses on the soil survey data and generalized geological information available in public records.

2 Existing Conditions

2.1 General Description

The Mitchell Lake study area is shown in Figure 1 below.

Figure 1: Mitchell Lake Study Area



Mitchell Lake is located in the southern sector of San Antonio, Texas and is accessible from Interstate Loop 410, off Pleasanton Road. Mitchell Lake Audubon Center is located north of the lake itself and the rest of the lake is accessible by trails. The lake itself consists of the major water body and basins isolated by berms that are numbered basins and two water bodies named West Polder and East Polder on the northeast side of the lake. Cottonmouth Creek is linked to the lake and conveys the discharge from the lake through the dam located at the south end of the lake.

The lake is over 120 miles from any other salt water flats and has become a natural bird sanctuary. This attracts visitors and nature enthusiasts who can spot nearly 20 species of birds, both native and migratory. Mitchell Lake therefore is one of the few areas inland where migratory birds can rest and feed. According to a document prepared by the US Army Corps of Engineers 338 species of migratory species have been spotted, all protected under the Migratory Bird Treaty Act. The ecological team from SWF were able to photograph 19 different bird species during their site visit in November 2018.

2.2 General Geology

San Antonio and Bexar County are on the boundary between the Gulf Coastal and Great Plains physiographical provinces. Dividing these two provinces in this region of Texas is the Balcones Escarpment, part of the Balcones Fault Zone. The escarpment extends from near Del Rio, Texas northwest through Bexar County to Austin. Remnants of the escarpment extend as far north as Waco. The Balcones Escarpment rises approximately 1,000 feet above the coastal prairie to the south and east, creating a marked influence on the area's environment. Northwest of the escarpment lies the Edwards Plateau area of the Great Plains Province. Since the plateau's formation, it has eroded, becoming a rugged hilly region dissected by numerous small streams with elevations ranging from 1,100 to 1,900 feet. Southeast of the escarpment and running along at the base lies the Blackland Prairie area of the Gulf Coastal Province, with its gently rolling hills. The San Antonio and Bexar county area are comprised of eight minor physiographic Divisions. These are: the Glen Rose Hills, the Edwards Flint Hills, the Del Rio Hills, the Austin Hills, the Taylor-Navarro Plain, the Stream Terrace Plain, the Midway-Wilcox Hills, and the Sand Hills. Most of San Antonio lies on the Taylor-Navarro Plain that forms a wide belt passing through the center of Bexar County. The relatively nonresistant strata of the late Cretaceous and early Tertiary formations formed the plain. Overlaying the Taylor-Navarro Plain is the Stream Terrace Plain, an alluvial gravel terrace deposited by streams eroding the Edwards Plateau and Balcones Escarpment. The Austin Hills form a belt passing north of the Taylor-Navarro Plain and through the northern portion of the city of San Antonio. North of the Austin Hills lie the Del Rio Plain, the Edwards Flint Hills, and the Glen Rose Hills. The Del Rio Plain is located north of and adjacent to the Austin Hills division. The Edwards Flint Hills are located north of, and adjacent to the Del Rio Plain division and along the northern extremity of San Antonio. The Edwards Flint Hills is a belt of hilly country in which the flint rock is extremely abundant in the soils and surface debris. The prevailing rock is the Edwards limestone from which the flints have been derived by weathering. The Glen Rose Hills are located north of, and adjacent to, the Edwards Flint Hills division, and north of San Antonio. The Glen Rose Hills division, being northwest of the Balcones Escarpment, forms the eastern margin of the Edwards Plateau. This area is of the maximum elevation for the county, approximately 1,900 feet above sea level. South of Taylor-Navarro Plain of San Antonio are the Midway-Wilcox Hills and the Carrizo Sand Hills. The Midway-Wilcox division forms a belt across the country which includes low hills together with level lands. The Carrizo Sand Hills division is located south of and adjacent to the Midway-Wilcox Hills division. The surface exposures of the Carrizo formation are characterized by low hills and very sandy soil.

Leon Creek is located on the western edge of San Antonio in Bexar County. The area is within the Balcones Fault Zone, an area characterized by numerous parallel and en echelon faults, downthrown to the south. The topography is characterized by a gently rolling land surface that slopes southeastward toward the Gulf of Mexico. Primary material underlying the Leon Creek area examined from an earlier study conducted by SWF in 2007 consists of strata belonging to three geologic formations. The Edwards Limestone underlying the northern portion of the area. The Taylor Marl, underlying the middle portion consists of soft to moderately hard, calcareous shale. The southern portion of the area is underlain by the Navarro Group consisting of sandy, silty clay shale.

2.3 Soil Survey

NRCS Soil Survey maps for the study area were observed to evaluate the type of soils and their implications for the proposed ecosystem restoration and enhancement alternatives. The predominant soil type within the study area is Houston Black Clay (HsB) which covers about 740 acres or 12.7% of the study area marked in the soil survey map. Of course, Mitchell Lake covers about 12.9% of the Area of Interest (AOI).

Please note that the study area drawn to extract the soil survey map is much larger than the Study Area (3,768 acres) shown in Figure 1 because the AOI sketched on the web soil survey map is very approximate and consists of a polygon drawn using salient inflection points. It should also be noted that the study area used by the Hydraulics and Hydrology Section differs from both these areas and is larger, as they mapped the drainage area in their study. However, this does not influence the fact that the major soil unit mapped is the Houston Black Clay.

Clay, clay loam and gravely clays make up about 55% of the soils within the AOI. These would include Houston Black clays (HsA and HsB), Heiden clays (HnC2 and HnB) and Branyon clay (HtA). Sandy loams and loamy sands make up about 20.5% of the AOI. These soils include Floresville fine sandy loams (WeC2 and WbB), Miguel fine sandy loams (CfB and CkC2), and Zavala fine sandy loam (Za). Waters of Mitchell Lake take up about 12.7%. Thus, for practical purposes, we can estimate that about 55% of the AOI are clayey soils and about 20.5% are sandy soils. The minor soils consisting of alluvial soils, gravely clays and rock outcrop cover about 11.1% of the AOI and waters of Mitchell Lake cover about 12.9% (751.5 acres). A brief description of the major soil types identified above follows.

2.3.1 Houston Black Clay (HsB)

Houston Black Clay occurs in gently sloping ground, 1 to 3% slopes and is predominantly a high plasticity clay. HsB soil covers about 12.9% or 741.3 acres of the AOI. It is an expansive clay that experiences high volume change when it absorbs water and forms tension cracks when dry. It is generally a product of weathered calcareous mudstone of upper cretaceous age. The permeability of the clay is very low and hence when saturated, it tends to permit surficial flow. However, the molecular structure of the clay mineral absorbs considerable volume of inter-lattice water and hence can exert swell pressures that could be detrimental to light structures built directly on the clay.

2.3.2 Miguel Fine Sandy Loam (CfB)

Sandy loam is a term applied to sandy soils that contain over 30% of fines composed of silt or clay. Generally classified as silty sand (SM) or clayey sand (SC) in engineering classification (ASTM D 2487) the agricultural implications of a soil described as sandy loam is that it would support adequate water retention to support plant growth, while retaining a medium rate of permeability (between sand and clay). The permeability of these soils may vary by an order of 10 to 50 depending on their relative density in their natural state, which could be estimated by geotechnical field and laboratory tests. These soils are the product of weathered sandstone, siltstone and in some cases, mudstone.

2.3.3 Floresville Fine Sandy Loam (WeC2)

Floresville fine sandy loam is non-calcareous sandy loam that is primarily a weathered product of sandstone of Tertiary age. It occurs in 1 to 3% slopes and supports pasture vegetation. The permeability of this soil type is medium to low as the clay content tends to be high (about 35 to 50%). As far as engineering properties are concerned, this type of soil may be expected to behave as a clayey sand or sandy clay depending upon the clay content. Site specific information would be required for siting engineered structures, as the soil is amenable to compaction when the clay content is 35% or lesser.

2.3.4 *Houston Black Gravelly Clay (HuB)*

Houston gravelly black clay is very similar to Houston Black clay, except that the gravel component of the clay consists of calcareous fragments, as the soil is derived from the weathering product of the calcareous mudstone of upper cretaceous age. It generally supports farmland and pasture, but exhibits a moderately higher permeability due to the presence of gravel particles, which may range in size from ¾" to 4". Gravelly clay is more dominant in Bexar County as compared to other soils that contain no gravel.

The soil types that appear in the Soil survey map and their respective coverage in the AOI are listed in the Table below in the order of the area of coverage.

Table 1 – Map Unit Names

Map Unit Symbol	Soil Type	Map Unit Name	Acres in AOI	Percent of AOI
W		Water	751.5	12.9%
HsB	Clay	Houston Black clay, 1 to 3 percent slopes	741.3	12.7%
WeC2	Sandy Loam	Floresville fine sandy loam, 1 to 5 percent slopes, eroded	382.5	6.6%
HuB	Gravely Clay	Houston Black gravelly clay, 1 to 3 percent slopes	353.4	6.1%
CfB	Sandy Loam	Miguel fine sandy loam, 1 to 3 percent slopes	351.4	6.0%
Tf	Alluvium	Tinn and Frio soils, 0 to 1 percent slopes, frequently flooded	341.7	5.9%
HnC2	Clay	Heiden clay, 3 to 5 percent slopes, eroded	308.5	5.3%
SaC	Clay Loam	San Antonio clay loam, 3 to 5 percent slopes	300.1	5.2%
Fr	Clay Loam	Loire clay loam, 0 to 2 percent slopes, occasionally flooded	281.8	4.8%
HgD	Rock	Rock outcrop-Olmos complex, 5 to 25 percent slopes	222.9	3.8%
SaB	Clay Loam	San Antonio clay loam, 1 to 3 percent slopes	217.0	3.7%
VcB	Clay Loam	Sunev clay loam, 1 to 3 percent slopes	215.1	3.7%
HuC	Gravely Clay	Houston Black gravelly clay, 3 to 5 percent slopes	180.4	3.1%
WbB	Sandy Loam	Floresville fine sandy loam, 1 to 3 percent slopes	140.6	2.4%
HnB	Clay	Heiden clay, 1 to 3 percent slopes	127.5	2.2%
WmA	Clay Loam	Willacy loam, 0 to 1 percent slopes	121.7	2.1%
CkC2	Sandy Loam	Miguel fine sandy loam, 2 to 5 percent slopes, eroded	116.6	2.0%
HtA	Clay	Branyon clay, 0 to 1 percent slopes	116.5	2.0%
HkC	Loamy Sand	Wilco loamy fine sand, 3 to 5 percent slopes	109.6	1.9%
VcA	Clay Loam	Sunev clay loam, 0 to 1 percent slopes	104.5	1.8%
HsA	Clay	Houston Black clay, 0 to 1 percent slopes	93.0	1.6%
HkB	Loamy Sand	Wilco loamy fine sand, 0 to 3 percent slopes	78.1	1.3%
WmB	Clay Loam	Willacy loam, 1 to 3 percent slopes	69.6	1.2%
Zg	Alluvium	Zavala and Gowen soils, 0 to 2 percent slopes, frequently flooded	46.4	0.8%
Za	Sandy Loam	Zavala fine sandy loam, 0 to 2 percent slopes, occasionally flooded	19.2	0.3%
Gu	Alluvium	Gullied land-Sunev complex, 3 to 20 percent slopes	16.2	0.3%
Pt	Quarry	Pits and Quarries, 1 to 90 percent slopes	9.9	0.2%
Totals for Area of Interest			**5,817.2**	**100.0%**

A summary of the above table with the soils grouped by their estimated engineering properties is shown in the table below.

Table 2 – Estimated Engineering Properties of soils

NRCS Soil Type	ASTM D 2487 Classification	Area in AOI	% of AOI	Estimated Engineering Properties
Clay Loam	CL	1345.2	23.10%	Cohesive, low permeability (10^{-3} to 10^{-5} cm/sec)
Sandy Loam	SP-SC	803.0	13.80%	C-ϕ soils, medium permeability (10^{-2} to 10^{-4} cm/sec)
Clay	CH	945.6	16.30%	Cohesive to expansive, very low permeability (10^{-7} to 10^{-9} cm/sec)
Alluvium	Varies	1177.3	20.20%	Mixed soils may vary in composition depending on depositional history
Gravely Clay	GC	290.0	5.00%	Clay fraction is cohesive, low permeability (10^{-3} to 10^{-5} cm/sec)
Loamy Sand	SP or SW	88.0	1.50%	Granular soil, high permeability (10^{-2} to 1 cm/sec)
Other soils/rock		416.6	7.20%	
Water		751.5	12.90%	
Total Area		5817.2	100.00%	

It should be noted that the soil classification terminology used in the soil survey maps is different from engineering classification of soils recommended by ASTM D 2487 Standard. A figure and Table in the Appendix show the comparative particle sizes use by different classification systems. Please note that this shows only the terminology used according to the particle size and does not represent the different classification systems.

The estimated engineering properties in the table above are generalized based on the soil classification. Field tests and Laboratory tests on representative soil samples should be relied upon for the design of pipelines, foundations, ponds, and structures and for selection of particular areas as sources for borrow materials.

2.4 Existing Problems

The use of Mitchell Lake a receiving basin for wastewater sludge in the 20th century left a legacy of water quality problems that impact the flora and fauna. Although the discharge of sludge was eliminated in 1987, Mitchell Lake remains with large daily variations in dissolved oxygen and pH levels. Under normal operating conditions, there are no discharges from Mitchell Lake, and hence the total dissolved solids remain high. These factors have an adverse impact on supporting aquatic culture that needs restoration.

Water level of the lake is controlled by the dam at the south end of the lake. This dam, built in 1901 gave the lake a permanent existence after being a seasonal marsh land historically for centuries. The water surface elevation is maintained at an elevation of 520.4 feet MSL through surface water runoff and inputs from the Leon Creek WWTP west of the lake. Input from Leon Creek WWTP is intended to compensate for evaporation losses. Discharge from the lake is not allowed because of the water quality, but extreme precipitation events do cause uncontrolled discharges over the water control structures. In future, the water elevation is proposed to be lowered to 517 or 518 feet MSL to provide additional storage to provide for extreme precipitation events.

Apart from the lake, there are other control structures that are in various state of disrepair and need restoration or replacement. The berms around the lake as well as the east and west polders require maintenance.

The lake also needs a comprehensive maintenance plan as piecemeal repairs would not be sufficient to restore the lake and its surrounding areas at a sustainable level.

2.5 Potential Opportunities

The most significant benefit of Mitchell Lake is the biodiversity it supports. However, as it attracts more migratory birds, it becomes more valuable not only for the birds but also for the flora and fauna supported by the wetlands. This feasibility study has identified a number of potential improvements that would enhance and maintain a better quality of water, better ecological diversity and also provide an outstanding recreational facility. Apart from the casual and professional birdwatchers, the Audubon Society also hosts over 3,000 school children annually and attracts visitors from other areas.

Though a number of potential improvements are possible, this study intends to narrow the opportunities down to a limited number of manageable and cost effective improvements. The proposed plan identified as Plan 10 includes the improvements to the polders, the skip ponds, central wetlands and bird pond wetlands. The plan includes adding improvements to drainage features such as swales, and a pipeline to move water from Mitchell Lake to the central wetlands to manage the water levels in the wetlands.

Geotechnical investigations would be planned in line with the tentative plan selected (TSP) and may range from conducting field and laboratory tests on representative soil samples for engineering and chemical properties of the soils. Geotechnical investigations may also need to be combined or coordinated with environmental drilling and sampling.

3 Expected Future Without-Project Conditions

Studies conducted or proposed by SWF on Leon Creek and Medina River stress the importance of riparian restoration. However, for various reasons which include funding and flooding events, these restorations have not been carried out. Confluence of Leon Creek and Medina River is located southwest of the south end of Mitchell Lake, the water quality and flow conditions impact the performance of Mitchell Lake as an ecological balance mechanism.

Maintenance of the bodies of water including Mitchell Lake, Leon Creek, Medina River and Cottonmouth Creek is an important element in enhancing the future conditions. As the areas around the lake develop, attracted by the presence of the University of Texas campus and Lackland Air Force base to the west, and the San Antonio Mission to the east, there would be more adverse impact on the functionality of Mitchell Lake as an ecological asset.

4 Future With-Project Conditions

The plans selected as an outcome of this feasibility study will result in implementing strategies to enhance the ecological value of Mitchell Lake. The draft feasibility study recommended a tentatively selected plan identified as Plan 10 in the report, which includes the following elements:

- Three distinct habitat types – emerging wetlands, submergent/emergent wetland and mudflats.
- Resilient habitat for migratory birds
- Creation of a complex of wetlands that that would have an ancillary impact on improving water quality.
- The restoration of proposed restoration areas.

The geotechnical studies for the proposed plan (Plan 10) would include determination of the soil properties (both physical and chemical) for the creation and sustenance of the proposed wetlands. Determination of the soil permeability would be required to determine the suitability of the surficial soils for the planning of the ecosystem restoration of the proposed restoration areas.

Geotechnical studies tailored to provide necessary and sufficient data for the design of these measures would include soil sampling from the existing wetlands, proposed restoration areas and areas surrounding the lake, and conducting physical and chemical tests on the soil samples. It would also be necessary to conduct similar tests on the water samples from these areas as some of the chemical present in the water may be leachates from the soil. Tests on soil samples should also include chemical analysis for the presence of toxic chemicals such as fertilizers and pesticides, and well as heavy metals as these would impact the sustenance of the wetlands.

5 *References

- https://websoilsurvey.sc.egov.usda.gov
- Ted Arnow, 1963, Ground-water Geology of Bexar County, Texas, US Government Printing Office, Washington DC.
- US Geological Survey 7.5 Minute Series Map of Bexar County
- Hans F. Winterkorn and H-Y Fang, Foundation Engineering Handbook, 1975, Van Nostrand Reinhold, New York, NY
- Internal Memorandum from San Antonio Water System (SAWS) to USACE-SWF dated 09 January 2020

Appendix – Soil Survey Map	Page 1 and 2
Appendix – Soil Classification Systems	Page 3 and 4

Soil Map—Bexar County, Texas
(Mitchell Lake Study Area)

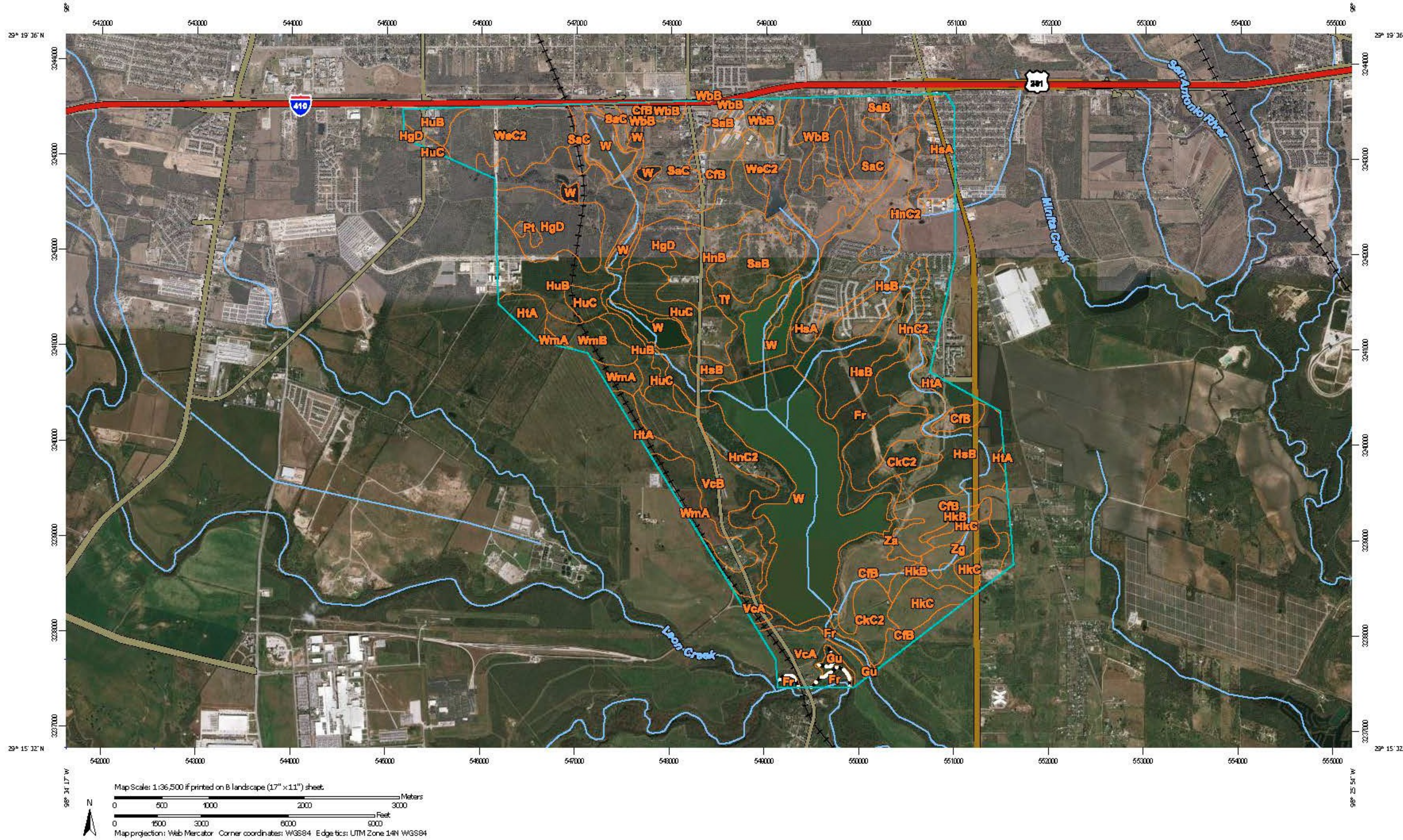


Figure 2: Soil Survey Map

Soil Map—Bexar County, Texas
(Mitchell Lake Study Area)

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 1:24,000.

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: Bexar County, Texas
Survey Area Data: Version 22, Sep 14, 2018

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

Date(s) aerial images were photographed: Jul 16, 2018—Apr 9, 2019

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.

USDA **Natural Resources Conservation Service**

Web Soil Survey
National Cooperative Soil Survey

8/7/2019
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Figure 3: Soil Survey Map Legend

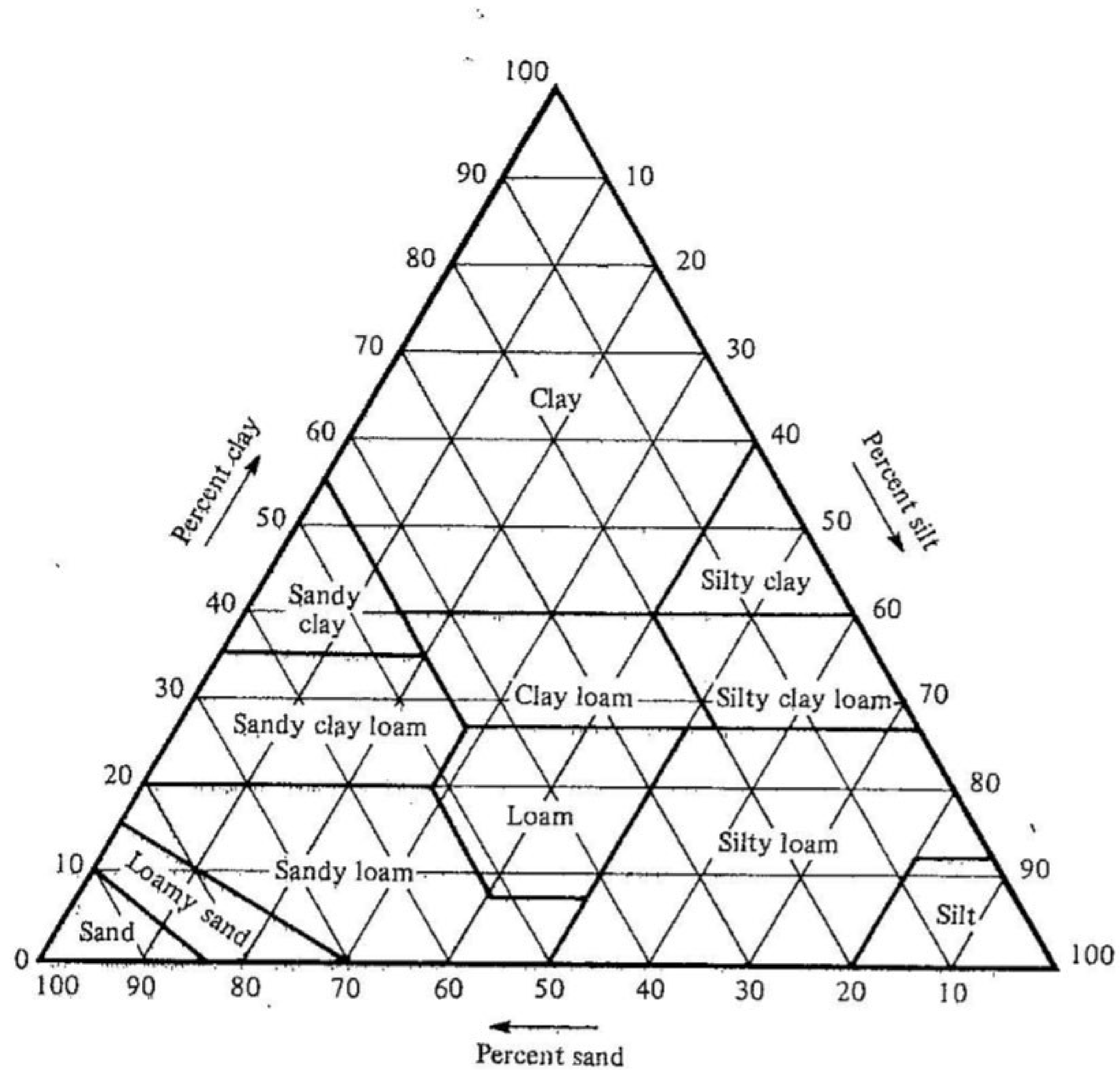
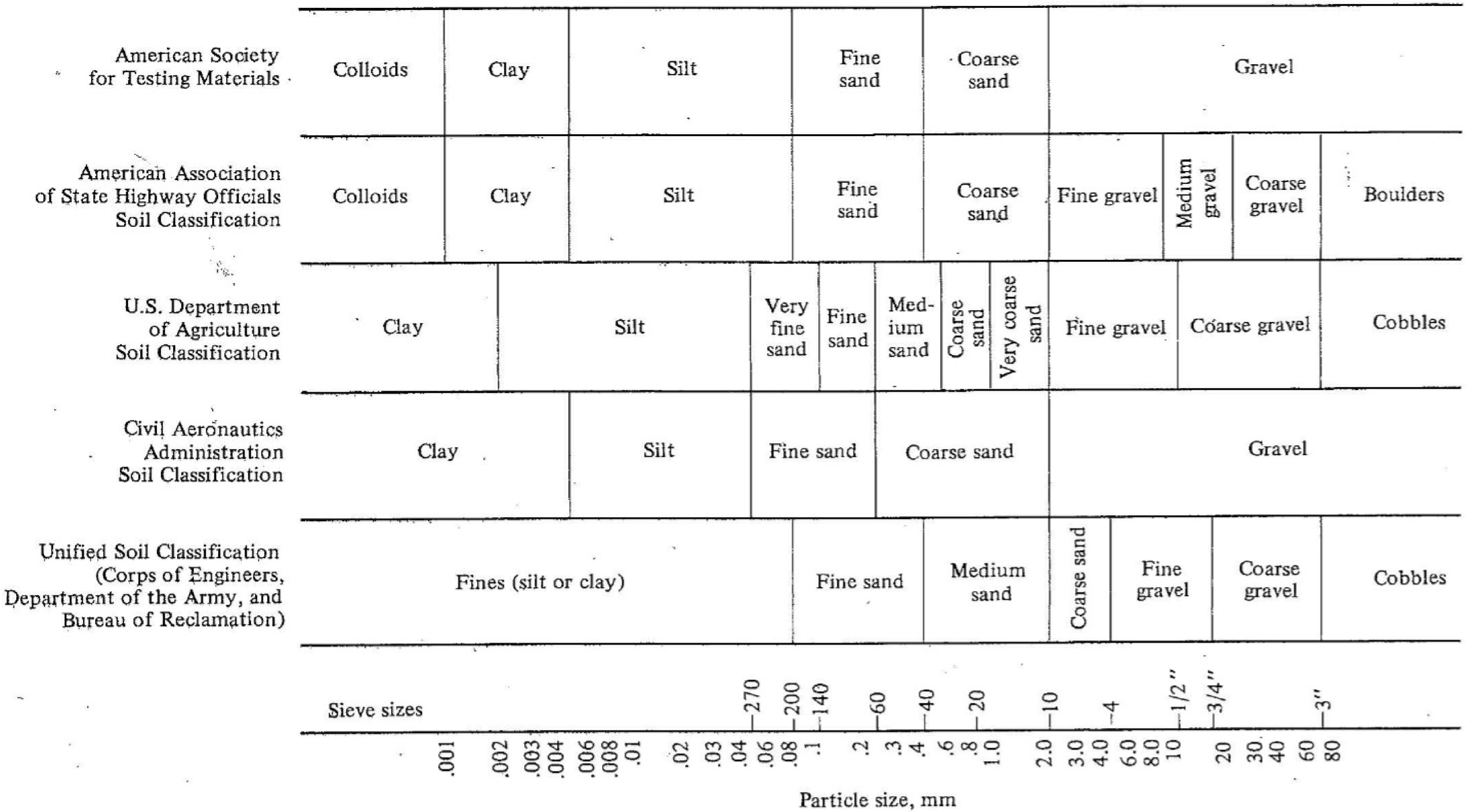


Figure 4: Soil Classification Chart

SOIL CLASSFICATION SYSTEM USED BY NRCS (ALSO CALLED USDA SOIL CLASSIFACTION SYSTEM) IN THE SOIL SURVEY MAPS.



SOIL-SEPARATE SIZE LIMITS OF ASTM, AASHTO, USDA, CAA, CORPS OF ENGINEERS AND USBR (1975)

Figure 5: Comparison of Soil Classification Systems