United States Department of Agriculture

NRCS

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SUBJECT: ECS – Agronomy – Guanica Lagoon Salinity Study

DATE: September 27, 2012

TO: Edwin Almodovar, Director, Caribbean Area, NRCS, San Juan, Puerto Rico

FILE CODE: 190-11

The attached report is submitted pursuant to the request for assistance received in February 2011, for assistance in salinity mapping in the Guanica Lagoon site near Guanica, Puerto Rico. Mapping was conducted by Dennis Neffendorf, Agronomist, Central National Technology Support Center (retired). Soil sampling was conducted by Puerto Rico Soil Science staff, and GIS processing was conducted by Lisa Vandiver, NOAA. The results of the study indicate that there is little potential for increases in soil salinity levels due to an increase in ponding in Guanica Lagoon.

This effort was initiated in 2010 as part of the Chief's Coral Reef Initiative. The restoration of the original hydrology of Guanica Lagoon has the potential to provide nutrient cycling for surface runoff originating in the Lajas Valley.

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Guanica Lagoon Area Salinity Study
Final Report

Introduction

The Guanica Lagoon area lies at the eastern, downstream end of the Lajas Valley in southwestern Puerto Rice. Surface runoff is ponded at this location during the seasonal wet period, and is detained before it enters the Rio Loco River near it's outlet to the Caribbean Sea. The health of the coral reefs offshore have been impacted by nutrients and sediment delivered by the Rio Loco into Guanica Bay. The Lajas Valley is one of the major tributaries to the Rio Loco, and its land use is agricultural with large scale production of papayas, mangoes, and other crops. Guanica Lagoon formerly existed as a large depressional wetland, which ponded water to a depth of several feet before overflows exited over a natural levee of the Rio Loco. The wetland was drained by the construction of a large main drain, and several associated laterals. Surface runoff from the Lajas Valley, which formerly ponded in the lagoon for several weeks, now travels through the basin directly into the river. The restoration of the original depth and duration of ponding in Guanica Lagoon has been proposed as part of a broad strategy for reducing impacts to the reef. This restoration would allow bio-geochemical processes to improve the quality of the water delivered to the river, and thus reduce the nutrient and sediment loads to the reef. The lagoon can then act as a sink for sediment and phosphorous, and allow denitrification processes to occur.

The Lajas Valley has known areas where salt concentrations reduce productivity. There is a concern that an increase in the depth and duration of flooding in the lagoon will increase salt concentrations on upstream adjacent cropland. To investigate this potential, a mapping effort was conducted on select areas of Guanica lagoon in June 2011, using a Dual EM meter. This device directly reads the electrical conductivity of the soil at the surface, and at 4 meters. The results are expressed in desisiemens. The readings can be used to indicate the relative concentrations of salt, as well as whether the concentrations increase or decrease with depth. After the mapping effort, soil samples were collected for laboratory analysis from locations within the mapped areas. The interpretations presented in this report are the result of an analysis of the Dual EM data along with the soil laboratory data, and available NRCS Soil Survey information for the soil map units in the lagoon area.

Data Sources

Soil Survey Data

The soils in the lagoon area are predominately of one map unit, Guanica Clay. This soil is a Calciaquert. The Water Features Report from Web Soil Survey states that Guanica clay experiences frequent and long-term ponding during the months of August, September, and October, but no dynamic flooding. These water features interpretations are indicative of a depressional wetland soil where surface runoff ponds in a closed topographic depression, and is not subject to dynamic flooding from a stream hydrograph. The depth to water table is shown as >200 cm. This indicates that water is supplied as surface water, a condition known as episaturation. The Physical Soil Properties shows the saturated hydraulic conductivity, Ksat, to be in the range of 0.01 to 0.1 micrometers/sec, which is an extremely low rate of movement. This Ksat value is constant throughout the entire profile, described to a depth of 79 inches. The Water Features, Physical Soil Properties, and Depth to Water Table reports are included in the Appendix.

Taken together, the information from the Web Soil Survey reports are consistent with a wetland in the Depressional wetland class as defined by the Hydrogeomorphic (HGM) wetland classification system. The Guanica clay soils can be further defined as existing in a Recharge Depression subclass. The direction of movement of water into and out of a wetland is defined in the HGM system as hydrodynamics. In a Recharge Depressional HGM class wetland, surface water moves horizontally into the wetland as surface runoff, and leaves as vertical downward movement to a dis-connected deeper water table, and as vertical upward movement as evapotranspiration. The hydrodynamics of the Recharge Depressional wetland are illustrated in Figure 1, below.

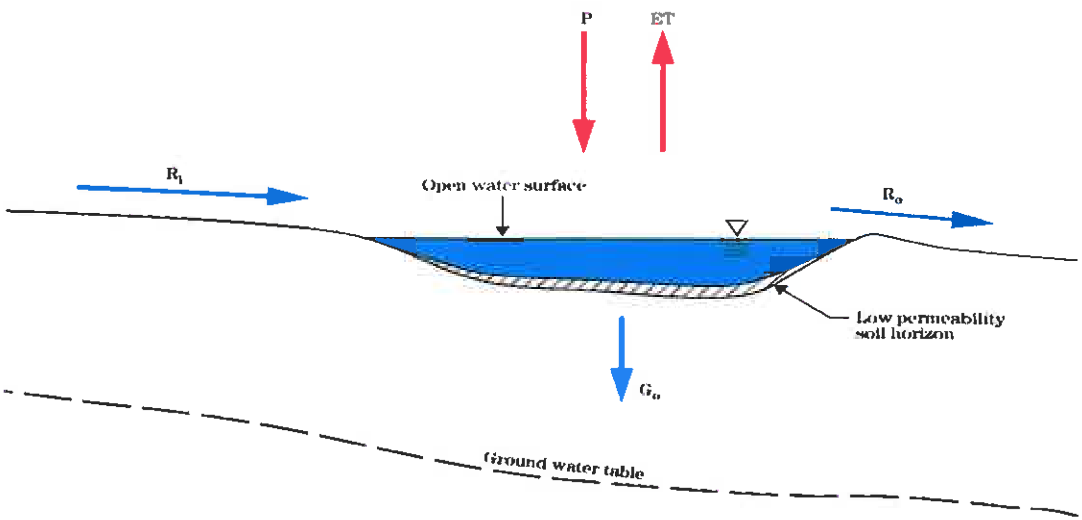


Figure 1 – Hydrodynamics of Recharge Depressional Wetlands

In the above illustration, the Ri vector represents surface runoff from the Lajas Valley; the Ro vector represents water delivered to the Rio Loco as the lagoons storage is filled to capacity. The Go vector represents the extremely low rate of water percolation downward to the water table. The water table in the case of Guanica Clay is in excess of 200 cm below the lagoon floor.

In these Recharge Depressional systems, water does not move into or out of the system as groundwater. In the case of Guanica clay, the low Ksat values preclude horizontal groundwater movement. Surface water "perches" on the surface on these low conductivity soils, and most of the water lost is though overflow water and evapotranspiration. The soil profile is in an unsaturated condition at depth. There are no indicators in the Guanica clay description that provide evidence of a high groundwater table. Without a steady high water table, there is no potential for subsurface movement of groundwater from an expanded lagoon.

<u>Dual EM Mapping</u>

The areas mapped were chosen to be representative of the soil conditions across the extent of the lagoon. The device collected data from the soil surface and at a depth of 4 meters. The data was processed using ArcMap 9.3, and is expressed as two separate layers. The associated files have been transferred to NRCS Puerto Rico and other entities involved in the Guanica lagoon restoration effort. Figures 2 and 3 show a view of the GIS map produced from the Dual EM readings. Figure 2 shows the electrical conductivity in the first 2 meters from the soil surface, and Figure 3 shows the conductivity in the soil below 2 meters. The area includes the lower Lajas Valley, with the Guanica Lagoon outlined in blue.

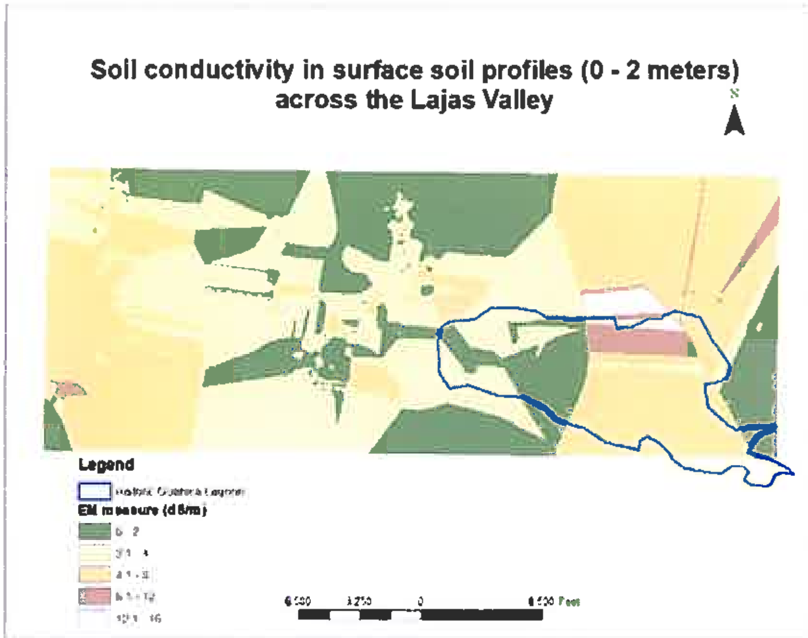


Figure 2 – GIS Map of Electrical Conductivity in Guanica Lagoon Near the Surface

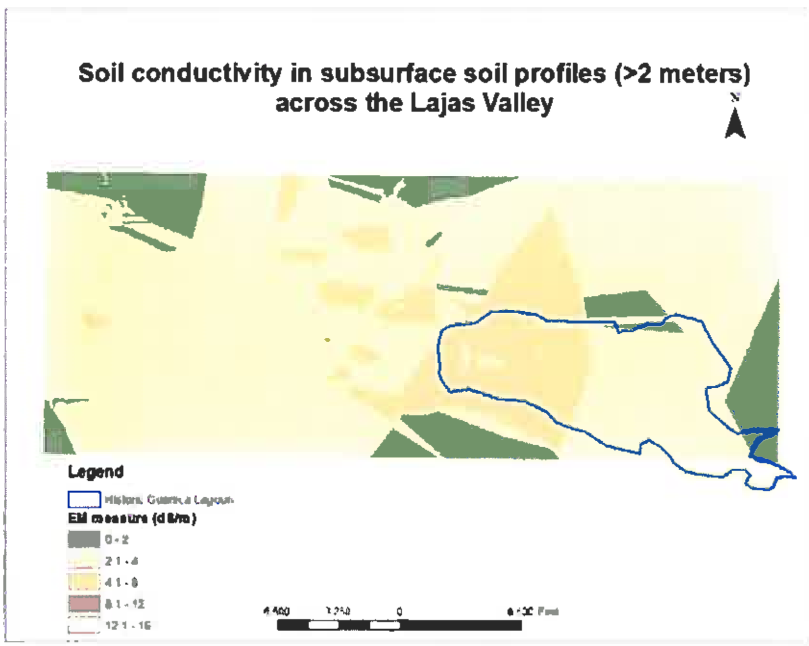


Figure 3 – GIS Map of Electrical Conductivity in Guanica Lagoon Below 2 Meters

The results of the mapping effort show a consistent increase in electrical conductivity with depth. This is consistent with the soil hydrodynamics of a Recharge Depressional wetland. Surface water enters the lagoon with a certain concentration of dissolved minerals, including salt. Water with dissolved minerals can only move vertically downward. At depth, the matric potential of vegetation acts to remove pure water, leaving salts behind. This results in an increasing concentration of salt. The actual relationship between depth and salt concentration is a function of the rooting zone properties of the lagoons vegetation.

Soil Sampling

Soil logging and sampling was conducted by Soil Scientists on the NRCS Puerto Rico staff. Two or more samples were collected per bore hole, and the holes were logged. The samples were transmitted to Ward Laboratories, Kearney, Nebraska, and the results were completed with Ward's soil report of January, 2012. This laboratory analysis conducted a comprehensive testing effort, which included saturated paste ECe, mmoh/cm, and Na concentration, ppm. In the majority of samples, there is a consistent increase in ECe and Na concentration with depth. The Ward Laboratories soil report has been transmitted previously.

Use of Dual EM and Soil Sampling

Originally, the soil sampling effort was intended to provide calibration data for the Dual EM map results. With the use of soil laboratory analysis, the conductivity readings can be converted to salt concentrations. For this calibration effort, the soil samples must be taken from precise locations dictated by a statistical analysis program using Dual EM data. The samples must then be collected at the same surface and 4 meter depths which were sampled by the Dual EM device. Conditions on the ground and workload constraints precluded the close coordination needed to ensure that these samples were taken in accordance with the needs of the calibration effort. However, the results of the soil sampling effort still provided valuable data for determining the source and movement of salts. Likewise, the Dual EM readings also provide valuable information on the concentrations of salts which effect electrical conductivity. However, soil sampling and Dual EM mapping must be analyzed as separate data sources.

Other Sources of Information

Conversations with various parties involved in the Guanica lagoon effort have provided some information on the potential sources of salt in the Lajas Valley watershed. There are known areas along the valley margins where groundwater emerges at the surface. These areas seem to contain high concentrations of salts. These areas, as described, are consistent with wetlands of the Stratigraphic Slope HGM wetland class. In these wetlands, the dominant water source is groundwater. The hydrodynamics of this wetland class are illustrated in Figures 3 and 4. The Gi vectors represent groundwater flow into the wetland, and the Ro vectors represent surface runoff out, as spring or seep flow.

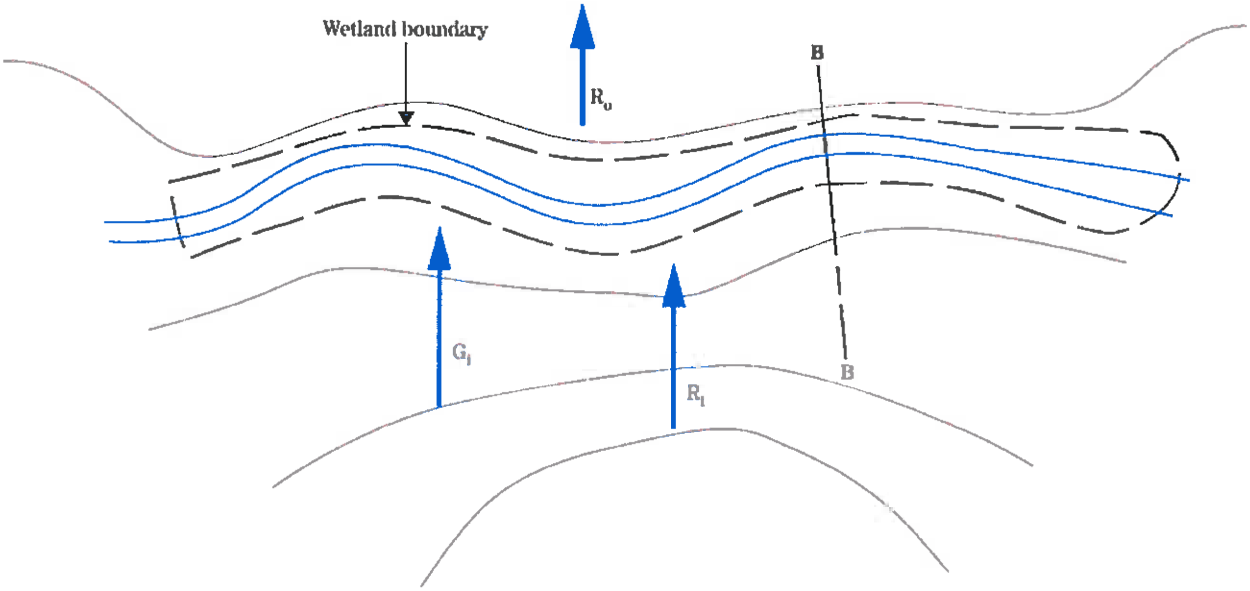


Figure 3 – Stratigraphic Slope HGM Wetland Class Plan View

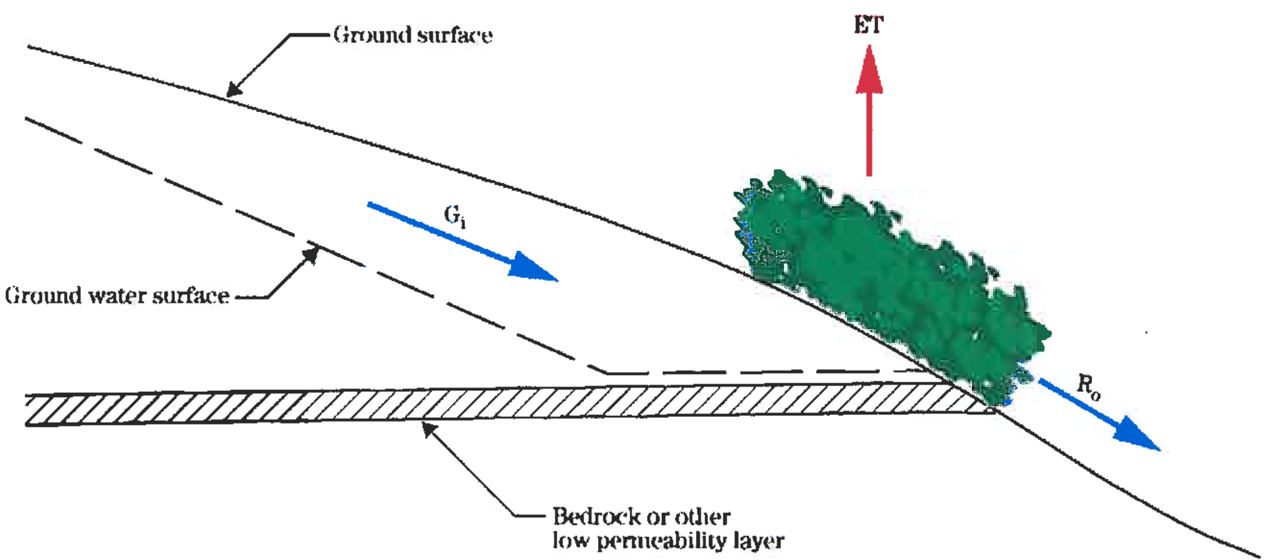


Figure 4 – Stratigraphic Slope HGM Wetland Class Section B-B

Groundwater moving though soil and rock layers containing minerals emerges with concentrations of these minerals dissolved. Marine shales are geologic formations which commonly contain high concentrations of salts. If groundwater discharge areas at the margins of the Lajas Valley are coincident with shale outcrops, this might be a significant source of salt. Once the groundwater emerges to the surface in the Lajas Valley, it encounters Guanica clay or similar soils with no ability to allow water to re-enter the water table. From the point of discharge, the water is surface water which flows into the lagoon.

Interpretations
The soils data for Guanica Clay in Web Soil Survey, the electrical conductivity mapping with the Dual EM, and the soils laboratory analysis mutually support the following conclusions:

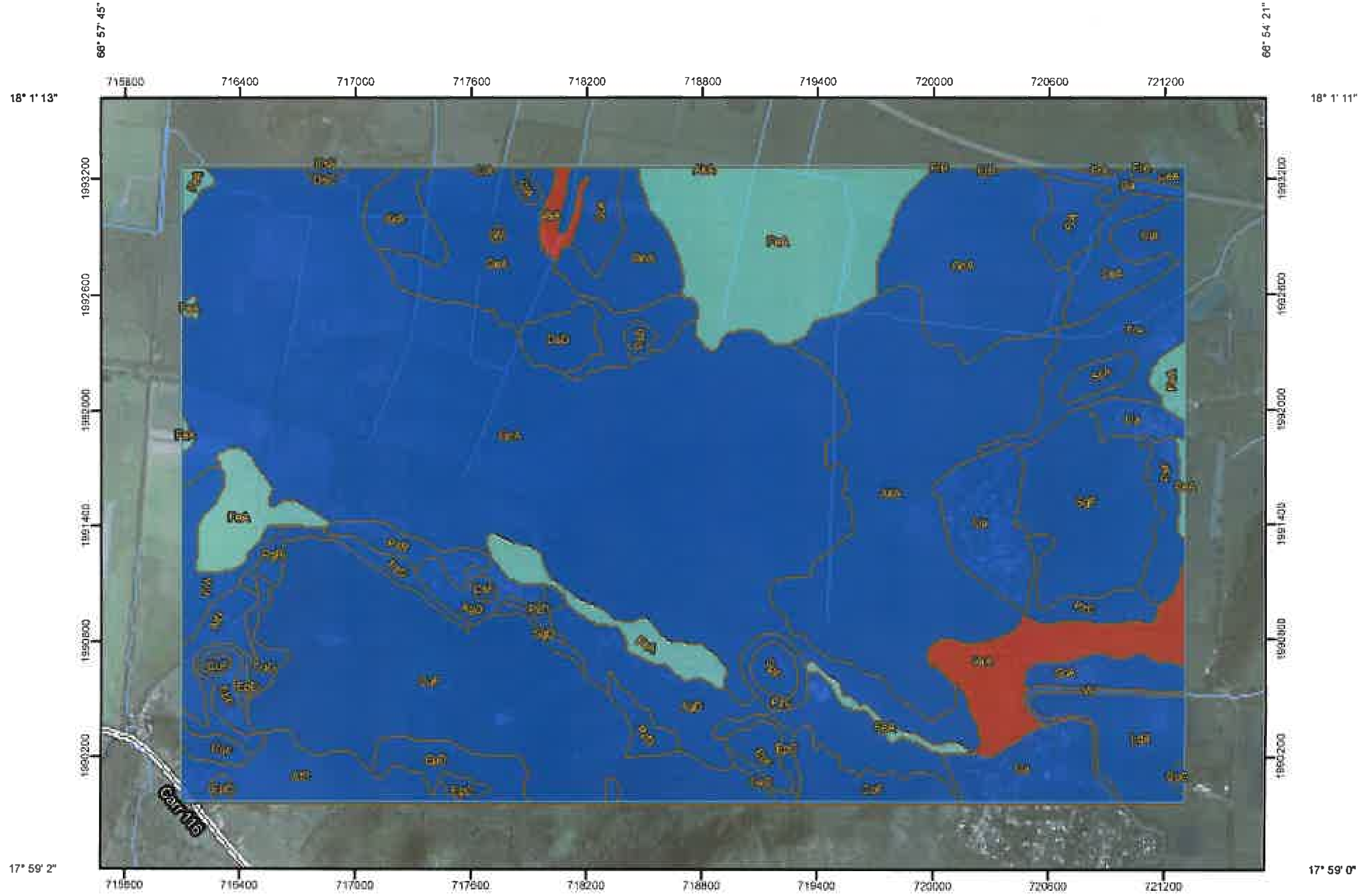
1. The Guanica lagoon existed as a Recharge Depressional wetland prior to drainage. This wetland received surface runoff from the Lajas Valley, and ponded water above a deeper groundwater table, from which it was hydraulically disconnected.
2. Minerals, including salt, which are dissolved with surface runoff water move slowly downward through very low permeability soils. Vegetation removes water from this unsaturated profile, leaving behind salts.
3. The presence of salts in the soil profile is associated only with areas where surface ponding exists.
4. Since there is no shallow water table capable of moving salt laden water into or out of the lagoon, there is no potential for groundwater effects to increase salinity levels in land areas outside of ponded areas.
5. The areas subject to increases in salinity from an increase in depth will be limited largely to the areas actually subject to increased inundation only.

If the lagoon were supplied with groundwater, the groundwater surface profile would be driven upward at the margins of the lagoon because of the planned increase in lagoon depth and duration of ponding. If this groundwater carried concentrations of salts, salinity effects would be felt in areas subject to this groundwater rise. However, evidence provided by soils, electrical conductivity, and soil laboratory analysis mutually support the conclusion that this is not a system supplied by groundwater.

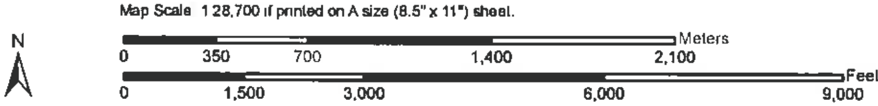
Other Comments
Local landowners are experiencing negative impacts from salts delivered to cropland areas in the Lajas Valley. While the increase in depth and duration of ponding in the lagoon will have minimal impact on the adjacent cropland, the Lajas Valley area can minimize the effects of salinity by maintaining the existing drainage network. This maintenance will have no negative impact on the downstream lagoon. A project that incorporates lagoon restoration, along with drainage improvements, would meet the objectives of coral reef protection while maintaining and improving the conditions on the remaining Lajas Valley cropland.

Appendix

1. Soil Survey Water Features Report
2. Soil Survey Physical Soil Properties Report
3. Soil Survey Depth to Water Table Report



Map Scale 1:28,700 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

- 0 - 25
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- > 200

Political Features

Cities

Water Features

Streams and Canals

Transportation

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

MAP INFORMATION

Map Scale: 1:28,700 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

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

Soil Survey Area: San German Area, Southwestern Puerto Rico
Survey Area Data: Version 3, Dec 8, 2008

Date(s) aerial images were photographed: 2004

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.

Depth to Water Table

Depth to Water Table— Summary by Map Unit — San German Area, Southwestern Puerto Rico (PR787)				
Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
AgD	Aguilita silty clay loam, 5 to 20 percent slopes	>200	142.2	3.3%
AkA	Aguirre clay, occasionally ponded	>200	439.7	10.3%
AtD	Altamira gravelly clay, 2 to 20 percent slopes	>200	105.0	2.5%
CeA	Cartagena clay, 0 to 2 percent slopes	>200	196.4	4.6%
CtA	Cortada silty clay loam, 0 to 2 percent slopes, occasionally flooded	>200	28.8	0.7%
CuD	Costa-Pitahaya complex, 5 to 20 percent slopes	>200	16.1	0.4%
CuF	Costa-Pitahaya complex, 20 to 60 percent slopes	>200	467.1	11.0%
DsC	Descalabrado clay, 2 to 12 percent slopes	>200	2.4	0.1%
DsD	Descalabrado clay, 12 to 20 percent slopes	>200	32.0	0.8%
DsF	Descalabrado clay, 20 to 60 percent slopes	>200	4.7	0.1%
EpC	El Papayo gravelly clay loam, 2 to 12 percent slopes	>200	15.3	0.4%
EpD	El Papayo gravelly clay loam, 12 to 20 percent slopes	>200	57.9	1.4%
EpF	El Papayo gravelly clay loam, 20 to 60 percent slopes	>200	29.9	0.7%
FeA	Fe clay, 0 to 2 percent slopes	122	364.6	8.6%
FrA	Fraternidad clay, 0 to 2 percent slopes	>200	147.8	3.5%
FrB	Fraternidad clay, 2 to 5 percent slopes	>200	1.5	0.0%
GnA	Guanica clay, 0 to 1 percent slopes	>200	1,456.9	34.3%
GyC	Guayacan clay, 5 to 12 percent slopes	>200	5.5	0.1%
LdA	La Luna silty clay loam, 0 to 2 percent slopes, occasionally flooded	>200	67.3	1.6%
PgB	Parguera clay, 2 to 5 percent slopes	>200	12.0	0.3%
PsF	Pitahaya-Limestone outcrop-Seboruco complex, 40 to 60 percent slopes	>200	32.4	0.8%

Depth to Water Table— Summary by Map Unit — San German Area, Southwestern Puerto Rico (PR787)				
Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
PzB	Pozo Blanco clay, 0 to 5 percent slopes	>200	23.9	0.6%
PzC	Pozo Blanco clay, 5 to 12 percent slopes	>200	53.8	1.3%
PzD	Pozo Blanco clay, 12 to 20 percent slopes	>200	22.4	0.5%
ScA	San Anton clay loam, 0 to 2 percent slopes, occasionally flooded	>200	78.3	1.8%
SgD	San German-Duey complex, 5 to 20 percent slopes	>200	5.7	0.1%
SgF	San German-Duey complex, 20 to 60 percent slopes	>200	149.1	3.5%
Ua	Urban land	>200	169.2	4.0%
VaA	Vayas silty clay, 0 to 2 percent slopes, occasionally flooded	10	111.1	2.6%
W	Water	>200	11.8	0.3%
Totals for Area of Interest			**4,250.9**	**100.0%**

Description

"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Rating Options

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: *None Specified*

Tie-break Rule: Lower

Interpret Nulls as Zero: No

Beginning Month: January

Ending Month: December

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Report—Physical Soil Properties

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
AgD—Aguilita silty clay loam, 5 to 20 percent slopes														
Aguilita	0-6	-19-	-51-	30-30- 45	1.30-1.40	1.00-10.00	0.12-0.18	3.0-6.0	5.0-10.0	.24	.24	3	4L	86
	6-23	-35-	-35-	28-30- 40	1.20-1.30	1.00-10.00	0.08-0.15	3.0-6.0	0.5-4.0	.17	.24			
	23-60	-45-	-45-	8-10- 30	1.10-1.20	1.00-10.00	0.08-0.15	3.0-6.0	0.5-2.0	.17	.24			
AkA—Aguirre clay, occasionally ponded														
Aguirre	0-18	-11-	-25-	60-64- 68	0.95-1.35	0.01-0.10	0.38-0.51	9.0-27.0	3.0-5.0	.24	.24	5	4	86
	18-80	-11-	-25-	60-64- 68	0.95-1.30	0.01-0.10	0.38-0.51	9.0-27.0	1.0-4.0	.24	.24			
AtD—Altamira gravelly clay, 2 to 20 percent slopes														
Altamira	0-8	-23-	-27-	25-50- 55	1.30-1.40	0.10-1.00	0.12-0.20	3.0-5.9	2.0-4.0	.24	.24	3	4L	86
	8-14	-22-	-33-	20-45- 50	1.20-1.25	0.10-1.00	0.12-0.20	3.0-6.0	0.5-2.0	.17	.24			
	14-43	-29-	-38-	15-33- 35	1.05-1.10	1.00-10.00	0.10-0.18	4.0-9.0	0.0-1.0	.28	.28			
	43-54	-39-	-37-	15-24- 35	1.05-1.15	10.00-100.00	0.10-0.18	9.0-30.0	0.0-1.0	.32	.32			
	54-79	—	—	—	—	—	—	—	—					

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
CeA—Cartagena clay, 0 to 2 percent slopes														
Cartagena	0-7	- 8-	-33-	30-60- 60	1.25-1.60	0.10-1.00	0.13-0.16	9.0-25.0	2.0-4.0	.24	.24	5	4	86
	7-15	- 9-	-33-	30-58- 60	1.25-1.60	0.10-1.00	0.13-0.16	9.0-25.0	2.0-4.0	.24	.24			
	15-46	-10-	-29-	40-61- 61	1.25-1.60	0.10-1.00	0.10-0.13	9.0-25.0	1.0-2.5	.24	.24			
	46-60	-10-	-28-	50-62- 65	1.25-1.60	0.10-1.00	0.10-0.13	9.0-25.0	0.0-1.0	.24	.24			
ClA—Cortada silty clay loam, 0 to 2 percent slopes, occasionally flooded														
Cortada	0-6	-15-	-55-	10-30- 38	1.10-1.15	1.00-10.00	0.21-0.22	0.0-2.9	4.0-8.0	.20	.20	5	4	86
	6-15	-18-	-44-	10-38- 38	1.10-1.15	1.00-10.00	0.18-0.20	0.0-2.9	4.0-8.0	.20	.20			
	15-23	-18-	-47-	30-35- 38	1.15-1.30	1.00-10.00	0.20-0.22	0.0-2.9	2.0-4.0	.20	.20			
	23-34	-30-	-34-	30-36- 38	1.15-1.25	1.00-10.00	0.18-0.20	0.0-2.9	2.0-4.0	.17	.17			
	34-45	-50-	-20-	30-30- 38	1.15-1.25	1.00-10.00	0.18-0.20	0.0-2.9	2.0-4.0	.20	.20			
	45-56	-55-	-30-	10-15- 35	1.15-1.25	10.00-100.00	0.18-0.20	0.0-2.9	0.5-2.0	.20	.20			
	56-63	-45-	-37-	10-18- 35	1.15-1.25	10.00-100.00	0.18-0.20	0.0-2.9	0.5-2.0	.20	.20			
	63-80	-50-	-20-	20-30- 33	1.15-1.25	1.00-10.00	0.18-0.20	0.0-2.9	0.5-2.0	.17	.17			

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
CuD—Costa-Pitahaya complex, 5 to 20 percent slopes														
Costa	0-7	-19-	-36-	30-45- 60	0.90-1.00	0.10-1.00	0.05-0.10	0.0-2.9	2.0-8.0	.24	.28	1	8	0
	7-11	-12-	-35-	30-54- 65	0.95-1.05	0.10-1.00	0.05-0.10	0.0-2.9	1.0-2.0	.24	.28			
	11-19	-12-	-44-	30-44- 60	1.04-1.14	0.10-1.00	0.05-0.10	0.0-2.9	0.0-0.4	.24	.28			
	19-43	—	—	—	—	—	—	—	—					
	43-63	—	—	—	—	—	—	—	—					
Pitahaya	0-2	-19-	-27-	35-54- 60	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	2.0-8.0	.24	.28	1	8	0
	2-11	-25-	-24-	35-51- 60	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	1.0-2.0	.24	.28			
	11-27	—	—	—	—	—	—	—	—					
	27-80	—	—	—	—	—	—	—	—					

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
CuF—Costa-Pitahaya complex, 20 to 60 percent slopes														
Costa	0-7	-19-	-36-	30-45- 60	0.90-1.00	0.10-1.00	0.05-0.10	0.0-2.9	2.0-8.0	.24	.28	1	8	0
	7-11	-12-	-35-	30-54- 65	0.95-1.05	0.10-1.00	0.05-0.10	0.0-2.9	1.0-2.0	.24	.28			
	11-19	-12-	-44-	30-44- 60	1.04-1.14	0.10-1.00	0.05-0.10	0.0-2.9	0.0-0.4	.24	.28			
	19-43	—	—	—	—	—	—	—	—					
	43-63	—	—	—	—	—	—	—	—					
Pitahaya	0-2	-19-	-27-	35-54- 60	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	2.0-8.0	.24	.28	1	8	0
	2-11	-25-	-24-	35-51- 60	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	1.0-2.0	.24	.28			
	11-27	—	—	—	—	—	—	—	—					
	27-80	—	—	—	—	—	—	—	—					
DsC—Descalabrado clay, 2 to 12 percent slopes														
Descalabrado	0-5	-18-	-37-	35-44- 45	1.34-1.36	0.10-1.00	0.15-0.20	6.0-8.9	2.5-5.0	.24	.24	1	4	86
	5-10	-19-	-37-	35-44- 45	1.30-1.40	0.10-1.00	0.10-0.15	6.0-8.9	1.8-4.0	.17	.24			
	10-18	—	—	—	—	—	—	—	—					
	>18	—	—	—	—	—	—	—	—					

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
DsD—Descalabrado clay, 12 to 20 percent slopes														
Descalabrado	0-5	-18-	-37-	35-44- 45	1.34-1.36	0.10-1.00	0.15-0.20	6.0-8.9	2.5-5.0	.24	.24	1	4	86
	5-10	-19-	-37-	35-44- 45	1.30-1.40	0.10-1.00	0.10-0.15	6.0-8.9	1.8-4.0	.17	.24			
	10-18	—	—	—	—	—	—	—	—					
	>18	—	—	—	—	—	—	—	—					
DsF—Descalabrado clay, 20 to 60 percent slopes														
Descalabrado	0-5	-18-	-37-	35-44- 45	1.34-1.36	0.10-1.00	0.15-0.20	6.0-8.9	2.5-5.0	.24	.24	1	4	86
	5-10	-19-	-37-	35-44- 45	1.30-1.40	0.10-1.00	0.10-0.15	6.0-8.9	1.8-4.0	.17	.24			
	10-18	—	—	—	—	—	—	—	—					
	>18	—	—	—	—	—	—	—	—					
EpC—El Papayo gravelly clay loam, 2 to 12 percent slopes														
El papayo	0-2	-25-	-40-	28-35- 40	1.34-1.36	1.00-10.00	0.15-0.20	6.0-8.9	2.0-4.0	.24	.24	1	4	86
	2-14	-25-	-25-	30-50- 60	1.30-1.40	0.10-1.00	0.10-0.15	6.0-8.9	1.0-2.0	.17	.24			
	14-16	—	—	—	—	—	—	—	—					
	>16	—	—	—	—	—	—	—	—					

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
EpD—El Papayo gravelly clay loam, 12 to 20 percent slopes														
El papayo	0-2	-25-	-40-	28-35- 40	1.34-1.36	1.00-10.00	0.15-0.20	6.0-8.9	2.0-4.0	.24	.24	1	4	86
	2-14	-25-	-25-	30-50- 60	1.30-1.40	0.10-1.00	0.10-0.15	6.0-8.9	1.0-2.0	.17	.24			
	14-16	—	—	—	—	—	—	—	—					
	>16	—	—	—	—	—	—	—	—					
EpF—El Papayo gravelly clay loam, 20 to 60 percent slopes														
El papayo	0-2	-25-	-40-	28-35- 40	1.34-1.36	1.00-10.00	0.15-0.20	6.0-8.9	2.0-4.0	.24	.24	1	4	86
	2-14	-25-	-25-	30-50- 60	1.30-1.40	0.10-1.00	0.10-0.15	6.0-8.9	1.0-2.0	.17	.24			
	14-16	—	—	—	—	—	—	—	—					
	>16	—	—	—	—	—	—	—	—					
FeA—Fe clay, 0 to 2 percent slopes														
Fe	0-7	-19-	-31-	45-50- 58	1.30-1.40	0.10-1.00	0.13-0.16	6.0-8.9	3.0-5.0	.24	.24	5	4	86
	7-17	-15-	-31-	45-54- 58	1.30-1.40	0.10-1.00	0.12-0.14	9.0-25.0	1.0-5.0	.24	.24			
	17-42	-12-	-33-	50-55- 58	1.30-1.40	0.10-1.00	0.10-0.13	9.0-25.0	0.1-3.0	.24	.24			
	42-56	-21-	-30-	45-49- 58	1.30-1.40	0.10-1.00	0.10-0.13	9.0-25.0	0.1-3.0	.24	.24			

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
FrA—Fraternidad clay, 0 to 2 percent slopes														
Fraternidad	0-13	-23-	-29-	40-48- 60	1.17-1.25	0.01-0.10	0.12-0.18	9.0-16.0	2.0-4.0	.24	.24	5	4	86
	13-17	-18-	-22-	40-60- 60	1.17-1.25	0.01-0.10	0.12-0.18	9.0-16.0	1.0-2.0	.24	.24			
	17-65	- 9-	-26-	40-66- 66	1.20-1.25	0.01-0.10	0.12-0.18	9.0-18.0	0.0-0.5	.24	.24			
FrB—Fraternidad clay, 2 to 5 percent slopes														
Fraternidad	0-13	-23-	-29-	40-48- 60	1.17-1.25	0.01-0.10	0.12-0.18	9.0-16.0	2.0-4.0	.24	.24	5	4	86
	13-17	-18-	-22-	40-60- 60	1.17-1.25	0.01-0.10	0.12-0.18	9.0-16.0	1.0-2.0	.24	.24			
	17-65	- 9-	-26-	40-66- 66	1.20-1.25	0.01-0.10	0.12-0.18	9.0-18.0	0.0-0.5	.24	.24			
GnA—Guanica clay, 0 to 1 percent slopes														
Guanica	0-4	- 3-	-15-	65-82- 85	0.90-1.20	0.01-0.10	0.09-0.15	9.0-25.0	3.0-5.5	.24	.24	5	4	86
	4-12	- 5-	-16-	65-80- 85	0.90-1.20	0.01-0.10	0.10-0.15	9.0-25.0	1.0-3.5	.24	.24			
	12-52	- 4-	-21-	60-75- 85	0.90-1.20	0.01-0.10	0.07-0.11	9.0-25.0	0.5-1.5	.24	.24			
	52-79	- 2-	-25-	60-73- 85	0.90-1.20	0.01-0.10	0.05-0.10	9.0-25.0	0.0-0.5	.24	.24			

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
GyC—Guayacan clay, 5 to 12 percent slopes														
Guayacan	0-8	-28-	-27-	20-46- 60	1.10-1.15	0.10-1.00	0.10-0.15	0.0-2.9	2.0-8.0	.10	.17	3	4L	86
	8-12	-26-	-27-	20-47- 60	1.25-1.40	0.10-1.00	0.10-0.20	0.0-2.9	1.0-2.0	.10	.15			
	12-26	-31-	-28-	20-41- 60	1.25-1.40	0.10-1.00	0.10-0.20	0.0-2.9	1.0-2.0	.10	.15			
	26-45	-44-	-33-	10-23- 50	1.20-1.30	1.00-10.00	0.08-0.15	0.0-2.9	0.0	.20	.20			
	45-59	-44-	-31-	5-25- 40	1.20-1.70	1.00-10.00	0.08-0.15	0.0-2.9	0.0	.32	.32			
	59-76	- 9-	-80-	5-10- 40	1.50-1.71	1.00-10.00	0.08-0.15	0.0-2.9	0.0	.20	.20			
	76-91	-30-	-32-	5-38- 40	1.20-1.30	1.00-10.00	0.08-0.15	0.0-2.9	0.0	.20	.20			
LdA—La Luna silty clay loam, 0 to 2 percent slopes, occasionally flooded														
La luna	0-11	-10-	-60-	27-30- 40	1.10-1.15	0.10-10.00	0.21-0.22	0.0-2.9	4.0-6.0	.20	.20	5	4	86
	11-20	- 6-	-55-	27-39- 40	1.10-1.15	0.10-1.00	0.18-0.20	0.0-2.9	3.0-4.0	.20	.20			
	20-58	- 7-	-54-	27-39- 40	1.15-1.30	0.10-1.00	0.20-0.22	0.0-2.9	1.0-2.0	.17	.17			
	58-75	- 6-	-55-	20-39- 40	1.15-1.25	0.10-1.00	0.18-0.20	0.0-2.9	0.5-2.0	.20	.20			

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
PgB—Parguera clay, 2 to 5 percent slopes														
Parguera	0-7	-11-	-30-	38-59- 60	1.00-1.25	0.10-1.00	0.12-0.18	0.0-3.0	2.0-7.0	.24	.24	5	4	86
	7-22	-23-	-28-	38-49- 60	1.20-1.25	0.10-1.00	0.12-0.18	0.0-3.0	2.0-3.0	.24	.24			
	22-39	-44-	-22-	15-34- 60	1.20-1.40	1.00-10.00	0.09-0.18	0.0-3.0	0.6-2.0	.24	.24			
	39-57	-61-	-21-	15-18- 60	1.20-1.25	1.00-10.00	0.12-0.18	0.0-3.0	0.2-2.0	.24	.24			
	57-79	-15-	-33-	50-52- 60	1.20-1.40	0.10-1.00	0.12-0.18	0.0-3.0	0.2-1.0	.24	.24			

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
PsF—Pitahaya-Limestone outcrop-Seboruco complex, 40 to 60 percent slopes														
Pitahaya	0-2	-19-	-27-	35-54- 60	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	2.0-8.0	.24	.28	1	8	0
	2-11	-25-	-24-	35-51- 60	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	1.0-2.0	.24	.28			
	11-27	—	—	—	—	—	—	—	—					
	27-80	—	—	—	—	—	—	—	—					
Limestone outcrop, aridic soil moisture regime	—	—	—	—	—	—	—	—	—					
Seboruco	0-2	-15-	-55-	15-30- 40	1.45-1.55	1.00-10.00	0.08-0.12	1.0-3.0	2.0-4.0	.17	.28	3	4	86
	2-7	-15-	-50-	30-35- 50	1.45-1.55	1.00-10.00	0.05-0.10	1.0-3.0	2.0-4.0	.17	.28			
	7-11	-15-	-43-	30-42- 50	1.40-1.50	0.10-1.00	0.05-0.10	1.0-3.0	2.0-4.0	.17	.28			
	11-19	-25-	-55-	15-20- 50	1.45-1.55	1.00-10.00	0.05-0.10	1.0-3.0	1.0-2.0	.17	.28			
	19-26	-25-	-55-	15-20- 50	1.45-1.55	1.00-10.00	0.05-0.10	1.0-3.0	1.0-2.0	.17	.28			
	26-31	-40-	-40-	10-20- 30	1.45-1.55	1.00-10.00	0.05-0.10	1.0-3.0	1.0-2.0	.17	.28			
	>31	—	—	—	—	—	—	—	—					

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
PzB—Pozo Blanco clay, 0 to 5 percent slopes														
Pozo blanco	0-7	-28-	-27-	40-46- 60	1.10-1.40	0.10-1.00	0.10-0.15	0.0-2.9	5.0-10.0	.10	.17	3	4L	86
	7-22	-26-	-27-	30-47- 60	1.20-1.30	0.10-1.00	0.10-0.20	0.0-2.9	3.0-7.0	.10	.15			
	22-30	-30-	-38-	20-32- 60	1.20-1.40	0.10-1.00	0.10-0.20	0.0-2.9	1.0-2.0	.10	.15			
	30-60	-44-	-33-	15-23- 40	1.20-1.30	1.00-10.00	0.08-0.15	0.0-2.9	0.5-1.0	.20	.20			
PzC—Pozo Blanco clay, 5 to 12 percent slopes														
Pozo blanco	0-7	-28-	-27-	40-46- 60	1.10-1.40	0.10-1.00	0.10-0.15	0.0-2.9	5.0-10.0	.10	.17	3	4L	86
	7-22	-26-	-27-	30-47- 60	1.20-1.30	0.10-1.00	0.10-0.20	0.0-2.9	3.0-7.0	.10	.15			
	22-30	-30-	-38-	20-32- 60	1.20-1.40	0.10-1.00	0.10-0.20	0.0-2.9	1.0-2.0	.10	.15			
	30-60	-44-	-33-	15-23- 40	1.20-1.30	1.00-10.00	0.08-0.15	0.0-2.9	0.5-1.0	.20	.20			
PzD—Pozo Blanco clay, 12 to 20 percent slopes														
Pozo blanco	0-7	-28-	-27-	40-46- 60	1.10-1.40	0.10-1.00	0.10-0.15	0.0-2.9	5.0-10.0	.10	.17	3	4L	86
	7-22	-26-	-27-	30-47- 60	1.20-1.30	0.10-1.00	0.10-0.20	0.0-2.9	3.0-7.0	.10	.15			
	22-30	-30-	-38-	20-32- 60	1.20-1.40	0.10-1.00	0.10-0.20	0.0-2.9	1.0-2.0	.10	.15			
	30-60	-44-	-33-	15-23- 40	1.20-1.30	1.00-10.00	0.08-0.15	0.0-2.9	0.5-1.0	.20	.20			

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
ScA—San Anton clay loam, 0 to 2 percent slopes, occasionally flooded														
San anton	0-8	-30-	-35-	28-35- 45	1.25-1.35	4.00-14.00	0.11-0.20	3.0-5.9	2.0-6.0	.17	.20	5	4	86
	8-13	-23-	-40-	28-37- 45	1.25-1.35	4.00-14.00	0.10-0.20	0.0-2.9	2.0-3.0	.17	.24			
	13-24	-19-	-43-	22-38- 45	1.23-1.35	4.00-14.00	0.12-0.20	3.0-5.9	0.3-2.0	.17	.17			
	24-31	-22-	-38-	22-40- 50	1.23-1.35	4.00-14.00	0.12-0.20	3.0-5.9	0.3-2.0	.17	.17			
	31-41	-60-	-18-	22-22- 45	1.40-1.45	4.00-42.00	0.12-0.20	0.0-2.9	0.3-2.0	.17	.17			
	41-54	-47-	-28-	22-25- 45	1.23-1.35	4.00-42.00	0.12-0.20	3.0-5.9	0.3-2.0	.17	.17			
	54-70	-51-	-26-	22-23- 45	1.20-1.35	4.00-42.00	0.12-0.20	0.0-2.9	0.3-2.0	.17	.17			
SgD—San German-Duey complex, 5 to 20 percent slopes														
San german	0-4	-35-	-30-	35-35- 50	1.40-1.50	0.10-1.00	0.05-0.10	0.0-2.9	2.0-25.0	.24	.28	1	8	0
	4-10	-32-	-30-	35-38- 50	1.40-1.50	0.10-1.00	0.05-0.10	0.0-2.9	1.0-25.0	.24	.28			
	10-60	—	—	—	—	—	—	—	—					
Duey	0-13	-22-	-39-	30-39- 50	1.40-1.50	14.00-42.00	0.05-0.10	0.0-2.9	2.0-4.0	.24	.28	1	8	0
	13-17	-25-	-45-	30-30- 60	1.40-1.50	14.00-42.00	0.05-0.10	0.0-2.9	1.0-3.0	.24	.28			
	17-35	—	—	—	—	—	—	—	—					
	35-80	—	—	—	—	—	—	—	—					

Physical Soil Properties– San German Area, Southwestern Puerto Rico														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
SgF—San German-Duey complex, 20 to 60 percent slopes														
San german	0-4	-35-	-30-	35-35- 50	1.40-1.50	0.10-1.00	0.05-0.10	0.0-2.9	2.0-25.0	.24	.28	1	8	0
	4-10	-32-	-30-	35-38- 50	1.40-1.50	0.10-1.00	0.05-0.10	0.0-2.9	1.0-25.0	.24	.28			
	10-60	—	—	—	—	—	—	—	—					
Duey	0-13	-22-	-39-	30-39- 50	1.40-1.50	14.00-42.00	0.05-0.10	0.0-2.9	2.0-4.0	.24	.28	1	8	0
	13-17	-25-	-45-	30-30- 60	1.40-1.50	14.00-42.00	0.05-0.10	0.0-2.9	1.0-3.0	.24	.28			
	17-35	—	—	—	—	—	—	—	—					
	35-80	—	—	—	—	—	—	—	—					
Ua—Urban land														
Urban land	—	—	—	—	—	—	—	—	—					
VaA—Vayas silty clay, 0 to 2 percent slopes, occasionally flooded														
Vayas	0-5	-15-	-53-	28-32- 60	1.30-1.40	0.10-1.00	0.14-0.22	6.0-9.0	2.0-4.0	.24	.24	5	4	86
	5-12	-10-	-55-	28-35- 60	1.30-1.40	0.10-1.00	0.12-0.18	3.0-6.0	0.3-2.0	.24	.24			
	12-23	- 8-	-54-	28-38- 60	1.30-1.40	0.10-1.00	0.12-0.18	3.0-6.0	0.2-1.0	.24	.24			
	23-62	- 8-	-54-	10-38- 60	1.30-1.35	0.10-1.00	0.12-0.18	3.0-6.0	0.2-0.5	.24	.24			
W—Water														
Water	—	—	—	—	—	—	—	—	—					

Data Source Information

Soil Survey Area: San German Area, Southwestern Puerto Rico
Survey Area Data: Version 3, Dec 8, 2008

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Report—Water Features

Water Features– San German Area, Southwestern Puerto Rico										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
AgD—Aguilita silty clay loam, 5 to 20 percent slopes										
Aguilita	C	Medium	Jan-Dec	—	—	—	—	None	—	—
AkA—Aguirre clay, occasionally ponded										
Aguirre	D	Negligible	August	—	—	0.0-2.0	Brief	Occasional	—	None
	D	Negligible	September	—	—	0.0-2.0	Brief	Occasional	—	None
	D	Negligible	October	—	—	0.0-2.0	Brief	Occasional	—	None
AtD—Altamira gravelly clay, 2 to 20 percent slopes										
Altamira	D	Medium	Jan-Dec	—	—	—	—	None	—	—
CeA—Cartagena clay, 0 to 2 percent slopes										
Cartagena	D	Low	Jan-Dec	—	—	—	—	None	—	—
CtA—Cortada silty clay loam, 0 to 2 percent slopes, occasionally flooded										
Cortada	C	Negligible	August	—	—	—	—	None	Brief	Occasional
	C	Negligible	September	—	—	—	—	None	Brief	Occasional
	C	Negligible	October	—	—	—	—	None	Brief	Occasional

Water Features– San German Area, Southwestern Puerto Rico										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
CuD—Costa-Pilahaya complex, 5 to 20 percent slopes										
Costa	D	Very high	Jan-Dec	—	—	—	—	None	—	—
Pilahaya	D	Very high	Jan-Dec	—	—	—	—	None	—	—
CuF—Costa-Pilahaya complex, 20 to 60 percent slopes										
Costa	D	Very high	Jan-Dec	—	—	—	—	None	—	—
Pitahaya	D	Very high	Jan-Dec	—	—	—	—	None	—	—
DsC—Descalabrado clay, 2 to 12 percent slopes										
Descalabrado	D	Medium	Jan-Dec	—	—	—	—	None	—	—
DsD—Descalabrado clay, 12 to 20 percent slopes										
Descalabrado	D	Medium	Jan-Dec	—	—	—	—	None	—	—
DsF—Descalabrado clay, 20 to 60 percent slopes										
Descalabrado	D	High	Jan-Dec	—	—	—	—	None	—	—
EpC—El Papayo gravelly clay loam, 2 to 12 percent slopes										
El papayo	D	Medium	Jan-Dec	—	—	—	—	None	—	—
EpD—El Papayo gravelly clay loam, 12 to 20 percent slopes										
El papayo	D	Medium	Jan-Dec	—	—	—	—	None	—	—

Water Features– San German Area, Southwestern Puerto Rico										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
EpF—El Papayo gravelly clay loam, 20 to 60 percent slopes										
El papayo	D	High	Jan-Dec	—	—	—	—	None	—	—
FeA—Fe clay, 0 to 2 percent slopes										
Fe	D	Medium	September	4.0-6.0	>6.0	—	—	None	—	None
	D	Medium	October	4.0-6.0	>6.0	—	—	None	—	None
	D	Medium	November	4.0-6.0	>6.0	—	—	None	—	None
FrA—Fraternidad clay, 0 to 2 percent slopes										
Fraternidad	D	Medium	Jan-Dec	—	—	—	—	None	—	—
FrB—Fraternidad clay, 2 to 5 percent slopes										
Fraternidad	D	Medium	Jan-Dec	—	—	—	—	None	—	—
GnA—Guanica clay, 0 to 1 percent slopes										
Guanica	D	Negligible	August	—	—	0.0-1.5	Long	Frequent	—	None
	D	Negligible	September	—	—	0.0-1.5	Long	Frequent	—	None
	D	Negligible	October	—	—	0.0-1.5	Long	Frequent	—	None
GyC—Guayacan clay, 5 to 12 percent slopes										
Guayacan	D	High	Jan-Dec	—	—	—	—	None	—	—

Water Features– San German Area, Southwestern Puerto Rico

Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
LdA—La Luna silty clay loam, 0 to 2 percent slopes, occasionally flooded										
La luna	D	Negligible	August	—	—	—	—	None	Very brief	Occasional
	D	Negligible	September	—	—	—	—	None	Very brief	Occasional
	D	Negligible	October	—	—	—	—	None	Very brief	Occasional
PgB—Parguera clay, 2 to 5 percent slopes										
Parguera	D	Medium	Jan-Dec	—	—	—	—	None	—	—
PsF—Pitahaya-Limestone outcrop-Seboruco complex, 40 to 60 percent slopes										
Pitahaya	D	Very high	Jan-Dec	—	—	—	—	None	—	—
Limestone outcrop, aridic soil moisture regime	—	Very high	Jan-Dec	—	—	—	—	None	—	—
Seboruco	D	Very high	Jan-Dec	—	—	—	—	None	—	—
PzB—Pozo Blanco clay, 0 to 5 percent slopes										
Pozo blanco	D	Medium	Jan-Dec	—	—	—	—	None	—	—
PzC—Pozo Blanco clay, 5 to 12 percent slopes										
Pozo blanco	D	Medium	Jan-Dec	—	—	—	—	None	—	—
PzD—Pozo Blanco clay, 12 to 20 percent slopes										
Pozo blanco	D	High	Jan-Dec	—	—	—	—	None	—	—

Water Features– San German Area, Southwestern Puerto Rico										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
ScA—San Anton clay loam, 0 to 2 percent slopes, occasionally flooded										
San anton	C	Negligible	August	—	—	—	—	None	Brief	Occasional
	C	Negligible	September	—	—	—	—	None	Brief	Occasional
	C	Negligible	October	—	—	—	—	None	Brief	Occasional
SgD—San German-Duey complex, 5 to 20 percent slopes										
San german	D	High	Jan-Dec	—	—	—	—	None	—	—
Duey	D	Very high	Jan-Dec	—	—	—	—	None	—	—
SgF—San German-Duey complex, 20 to 60 percent slopes										
San german	D	Very high	Jan-Dec	—	—	—	—	None	—	—
Duey	D	Very high	Jan-Dec	—	—	—	—	None	—	—
Ua—Urban land										
Urban land	—	—	Jan-Dec	—	—	—	—	None	—	—

Water Features– San German Area, Southwestern Puerto Rico										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
VaA—Vayas silty clay, 0 to 2 percent slopes, occasionally flooded										
Vayas	D	Negligible	January	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	February	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	March	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	April	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	May	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	June	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	July	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	August	0.3-1.6	1.6-6.0	—	—	None	Brief	Occasional
	D	Negligible	September	0.3-1.6	1.6-6.0	—	—	None	Brief	Occasional
	D	Negligible	October	0.3-1.6	1.6-6.0	—	—	None	Brief	Occasional
	D	Negligible	November	0.3-1.6	1.6-6.0	—	—	None	—	None
	D	Negligible	December	0.3-1.6	1.6-6.0	—	—	None	—	None
W—Water										
Water	—	—	Jan-Dec	—	—	—	—	None	—	—

Data Source Information

Soil Survey Area: San German Area, Southwestern Puerto Rico
Survey Area Data: Version 3, Dec 8, 2008