Flue Gas Desulfurization Emergency Pond Location Restrictions Demonstration

W.A. Parish Electric Generating Station
Thompsons, Texas

October 2018

Prepared For:

NRG Texas Power LLC

Tony Dworaczyk, P.G.
Senior Project Manager

Jason Leik, P.E.
Program Manager

Table of Contents

Certification ii

Section 1 Background 1
1.1 Site Setting 1
1.2 Existing and Future Conditions 2

Section 2 Location Restrictions 3
2.1 §257.60 – Placement above the Uppermost Aquifer 3
2.2 §257.61 – Wetlands 4
2.3 §257.62 – Fault areas 4
2.4 §257.63 – Seismic Impact Zones 5
2.5 §257.64 – Unstable Areas 5

Section 3 Conclusions 7

Section 4 References 8

List of Figures

Figure 1 Facility Location Map
Figure 2 FGD E Pond Site Map

List of Appendices

Appendix A Photographs
Appendix B National Wetlands Inventory Mapper
Appendix C USGS Texas Geology Web Map Viewer
Appendix D U.S. Seismic Design Maps

Certification

I, the undersigned Texas Professional Engineer, hereby certify that I am familiar with the technical requirements of Title 40 Code of Federal Regulations Part 257 Subpart D (§257). I also certify that it is my professional opinion that, to the best of my knowledge, information, and belief, that the information in this demonstration is in accordance with current good and accepted engineering practice(s) and standard(s), and meets the requirements of §257.60 through §257.64.

For the purpose of this document, "certify" and "certification" shall be interpreted and construed to be a "statement of professional opinion". The certification is understood and intended to be an expression of my professional opinion as a Texas Licensed Professional Engineer, based upon knowledge, information, and belief. The statement(s) of professional opinion are not and shall not be interpreted or construed to be a guarantee or a warranty of the analysis herein.

Jason Leik

Jason Leik, P.E.

91043

Texas License Number

Signature of Professional Engineer

10/12/18

Date

FIRM #3775

Section 1
Background

The purpose of this document is to demonstrate the compliance of the existing flue gas desulfurization (FGD) Emergency Pond (E Pond) impoundment at the W.A. Parish Electric Generating Station (Station) with the location restrictions outlined in the Environmental Protection Agency's (EPA's) final coal combustion residuals (CCR) rule (Title 40 Code of Federal Regulations Parts 257 and 261) Subpart D - "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" (§257.60 through §257.64, federal rule). The E Pond is considered a CCR surface impoundment according to the federal rule (§257.53). This document includes information from a desktop study and Site visit to demonstrate that the E Pond is in compliance with placement above the uppermost aquifer (§257.60), and location with respect to wetlands (§257.61), fault areas (§257.62), seismic impact zones (§257.63), and unstable areas (§257.64).

1.1 Site Setting

The NRG Texas Power LLC (NRG) Station is located in Thompsons, Fort Bend County, Texas, adjacent to Smithers Lake (Figure 1). The electricity generating portion of the Site, or the main Plant Operations Area (Plant Area) is located along the southeastern shore of the lake.

According to the Geologic Atlas of Texas, Houston Sheet (BEG 1982), the Site is underlain by alluvium and the Beaumont Formation (also commonly referred to as Beaumont Clay). The alluvium is present at the SWDA CCR units and along the Brazos River, which is located approximately 0.9 miles from the northern boundary of the SWDA CCR units. The alluvium is not present at the Plant Area (or the E Pond), which is consistent with this area being located outside of the Brazos River floodplain zone (FBC 2018). Both the alluvium and the Beaumont Formation are comprised of clay, silt, and sand, and may include stream channel, point bar, natural levee, backswamp, and coastal marsh and mud flat deposits. The thickness of the Beaumont Formation is approximately 100 feet.

The alluvium and Beaumont Formation are located within the upper unit of the Chicot aquifer system. At most locations throughout Fort Bend County, the Chicot aquifer system is under confined conditions (TWDB 1990). The Chicot aquifer system is primarily recharged by precipitation at locations where it outcrops in Austin, Harris, and Waller Counties; groundwater then flows laterally within Fort Bend County (TWDB 1990).

1.2 Existing and Future Conditions

Some of the units managing coal combustion residuals at the Station are subject to the EPA's final rule for the regulation and management of CCR under the Resource Conservation and Recovery Act (RCRA) Title 40, Code of Federal Regulations, Part 257 (40 CFR §257) (CCR rule, effective date October 17, 2015) and the CCR Remand Rule Proposal (March 1, 2018). CCR generated at the Station consist of fly ash, bottom ash, and FGD scrubber sludge, which have been classified by the Texas Commission on Environmental Quality (TCEQ) as Class II Nonhazardous. The Site has three active CCR management units that are subject to regulation under the CCR Rule and the CCR Remand Rule Proposal, as follows:

- Solid Waste Disposal Area (SWMU 001), which consists of active CCR management areas Cell 1C, Cell 2A, Cell 2B, and Cell 3 (the inactive cells at the SWDA are not subject to the CCR Rule);
- Air Preheater Pond (APH Pond, SWMU 021); and
- FGD Emergency Pond (E Pond, SWMU 020).

The E Pond is located in the central portion of the Plant Area as shown on Figure 2. The dimensions of the E Pond are approximately 200 feet by 110 feet and the aerial extent is approximately 0.5 acres. The E Pond is certified to be lined with a minimum of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} centimeters per second (cm/sec) (Sargent & Lundy 2016). According to NRG, the E Pond receives storm water runoff from the FGD dewatering area and also blowdown from the FGD system. This pond may also receive the contents of an FGD process vessel when the FGD system is not in operation.

Section 2
Location Restrictions

The location restrictions designated in the federal CCR rule are presented below with a corresponding demonstration to show compliance with each restriction. The location restrictions include placement above the uppermost aquifer, wetlands, fault areas, seismic impact zones, and unstable areas. Supporting information for the demonstrations is included in the appendices.

2.1 §257.60 – Placement above the Uppermost Aquifer

The federal CCR rule requires that CCR units such as the E Pond must be constructed with a base that is located no less than 1.52 meters (five feet) above the upper limit of the uppermost aquifer, or must demonstrate there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevations (including the seasonal high water table).

Based on a review of Site-specific data, the uppermost *usable* aquifer was determined to be present as a confined system located approximately 15 to 45 feet below ground surface (bgs). The E Pond unit is constructed within the sand, silt, and clay that overly the uppermost *usable* aquifer. The bottom of the clay liner is approximately nine feet above the bottom of the confining unit. The clay/silty clay confining layer isolates the E Pond from the uppermost aquifer and eliminates the potential for a hydraulic connection.

To determine the potential maximum water table, groundwater elevation data from surrounding wells (MW-36, MW-37, MW-38, MW-60, and MW-61) was collected between December 2016 and May 2018. Due to the confined conditions, hydrostatic pressure causes the water levels in the surrounding wells to artificially rise above the confining unit. However, the potential rise in groundwater elevations beneath the E Pond is vertically limited by the presence of the confining layer.

Based on this demonstration, the base of the E Pond is located greater than five feet above the upper limit of the uppermost aquifer; therefore, the E Pond is in compliance with the requirements of §257.60.

2.2 §257.61 – Wetlands

The CCR location standards restrict existing and new CCR surface impoundments from being located in wetlands, as defined by 40 CFR 232.2 (40 CFR 257.61(a)). Wetlands are defined in 40 CFR 232.2's definition of *Waters of the United States* (3)(iv) as, "…those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." TRC reviewed historical aerial photographs and topographic maps to ascertain whether or not the E Pond is located in a wetland.

Based on a review of historical documentation and Site-specific data, TRC is of the opinion that the E Pond is not located in an area exhibiting wetland characteristics.

The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) Mapper (Appendix B**)** was accessed to evaluate wetland conditions in the vicinity of the E Pond. The NWI identifies areas exhibiting wetland characteristics and is based on biological attributes visible in aerial imagery.

The NWI Mapper shows that the E Pond is not located in a wetland. TRC concludes that the E Pond is not located in a wetland. The E Pond's use as a CCR surface impoundment does not characterize it as a wetland, as defined in 40 CFR 232.2.

Evidence of wetlands in the E Pond area is not supported by this determination; therefore, the E Pond is not located in a wetland and is in compliance with the requirements of §257.61.

2.3 §257.62 – Fault areas

The federal CCR rule requires that CCR units not be located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in Holocene time (11,700 years ago through the present) unless the owner or operator demonstrates that an alternative setback distance of less than 60 meters (200 feet) will prevent damage to the structural integrity of the CCR unit. To determine recent fault activity in the area, subsurface exploration and regional geologic information was reviewed.

As shown on the USGS Texas Geology Web Map Viewer (Appendix C), no faults have been mapped in the E Pond area. The closest fault line to the E Pond is approximately 26 miles to the northeast of the Site.

Evidence of active faulting during the Holocene in the E Pond area is not supported by this determination; therefore, the E Pond is not located in an active fault area and is in compliance with the requirements of §257.62.

2.4 §257.63 – Seismic Impact Zones

The federal CCR rule requires that CCR units not be located in seismic impact zones unless the owner or operator demonstrates that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the Site. The federal CCR rule defines a seismic impact zone as "an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitation pull (g), will exceed 0.10 g in 50 years".

To determine whether the E Pond is located in a seismic impact zone, the 2015 National Earthquake Hazards Reduction Program U.S. Seismic Design Maps website (Appendix D) was reviewed. The E Pond area indicates a mapped peak ground acceleration of 0.084 g. This calculated design peak ground acceleration value is less than 0.10 g in 50 years.

Evidence of a seismic impact zone is not supported by this determination; therefore, the E Pond is not located in a seismic impact zone and is in compliance with the requirements of §257.63.

2.5 §257.64 – Unstable Areas

The federal CCR rule requires that CCR units not be located in an unstable area unless the owner or operator demonstrates that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted. Factors associated with soil conditions resulting in significant differential settlement, geologic or geomorphologic features, and human-made features or events must be evaluated to determine compliance.

This demonstration was performed by conducting a visual inspection of the Station. Overall, the impoundment was found to be in good condition. The area in and around the facility is very flat topographically. The Plant is located on the southeastern shore of Smithers Lake, with the E Pond impoundment located within the Plant Area south of Smithers Lake.

The E Pond is a clay-lined impoundment located within the process area of the Plant. The exterior walls of the impoundment are sloped to allow loading of CCR and show evidence of wear consistent with that activity. The berm is in good condition along all sides except the west and south sides, which had been covered with soil and were not visible during the inspection. All berms were flat and even with no significant cracks, bulging, or settlement. There are two

storm water inlets to the unit, one in the southwest corner and one in the southeast corner. Berms were concrete and were therefore not vegetated. The pond was surrounded by process units to the east and north, and paved surfaces to the south and west.

Evidence of unstable areas was not observed during the inspection of the E Pond impoundment; therefore, the E Pond is in compliance with the requirements of §257.64.

Section 3
Conclusions

Based on the evaluation provided in this demonstration, the E Pond at the W.A. Parish Electric Generating Station is in compliance with the location restrictions provided in §257.60 through §257.64 of the CCR rule. No additional action, justification, or demonstration is required to document compliance with the location restrictions provided in the CCR rule after this demonstration has been placed into the operating record, posted to the publicly accessible website, and provided for government notification.

Section 4
References

BEG 1982. Geologic Atlas of Texas, Houston Sheet. The University of Texas at Austin, Bureau of Economic Geology. Revised 1982.

Fort Bend County, Texas. Floodplain Mapping Tool. Accessed [9/15/2018].

Google Earth Pro. Available online at https://earth.google.com/download-earth.html. Accessed [9/14/2018].

Sargent & Lundy LLC, Liner Documentation for Existing CCR Surface Impoundments. October 7, 2016.

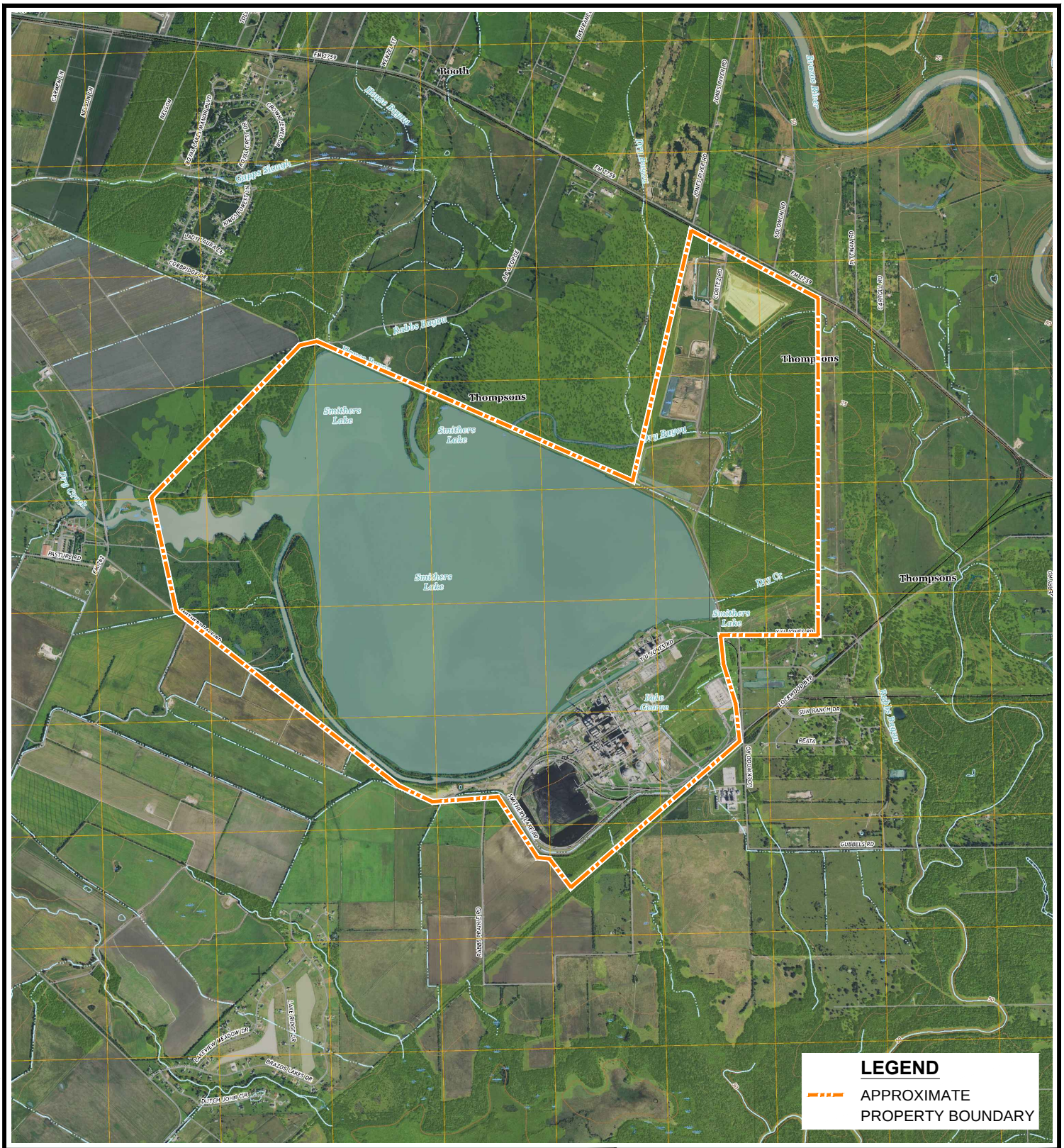
Thorkildsen, David, Texas Water Development Board. Evaluation of Water Resources of Fort Bend County, Texas, Report 321. January 1990.

United States Geological Survey (USGS). 2015. U.S. Seismic Design Maps: 2015 National Earthquake Hazards Reduction Program Provisions. Available online at http://earthquake.usgs.gov/designmaps/beta/us/. Accessed [9/10/2018].

U.S. Fish and Wildlife Service National Wetlands Inventory (NWI). 2018. "Wetland Mapper." Available online at https://www.fws.gov/wetlands/data/mapper.html. Accessed [9/14/2018].

United States Geological Survey (USGS). 2018. USGS - Texas Geology Web Map Viewer: Available online at https://txpub.usgs.gov/dss/texasgeology/. Accessed [9/14/2018].

Figures



REFERENCE: U.S.G.S. 7.5 MINUTE TOPOGRAPHIC QUADRANGLES
MISSOURI CITY, TEXAS (2016) / SMITHERS LAKE, TEXAS (2016) / SUGAR LAND, TEXAS (2016) / THOMPSONS, TEXAS (2016)

TEXAS
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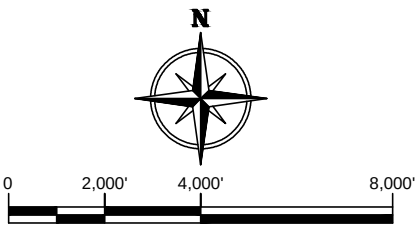


SCALE IN FEET
1" = 4,000'-0"

PROJECT:
NRG TEXAS POWER, LLC
W.A. Parish Station
Thompsons, Texas

TITLE:
SITE LOCATION MAP

DRAWN BY:	O. Fonseka	PROJECT No.:	294645.0000.0000
CHECKED BY:	T. Dworaczyk		
APPROVED BY:	T. Dworaczyk		**FIGURE 1**
DATE:	September 2018		

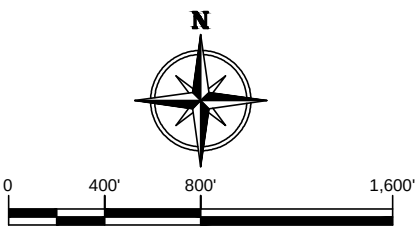
TRC
10550 Richmond Ave.
Suite 210
Houston, TX 77042
Phone: 713.244.1000

FILE: Fig X - NRG-WAParishStation - Site Location Map.dwg

HOU M:\ACAD-TRC\DRAFTING\NRG\W.A. Parish Station - Thompons-TX\ Fig X - NRG-WAParishStation - Site Location Map.dwg 09/25/18

IMAGERY SOURCE: Google Earth (10/28/2017)

TEXAS
SUBJECT SITE LOCATION



SCALE IN FEET
1" = 800'-0"

PROJECT:
NRG TEXAS POWER, LLC
W.A. Parish Station
Thompsons, Texas

TITLE:
FGD EMERGENCY POND

DRAWN BY:	O. Fonseka	PROJECT No.:	294645.0000.0000
CHECKED BY:	T. Dworaczyk		
APPROVED BY:	T. Dworaczyk		**FIGURE 2**
DATE:	September 2018		

TRC
10550 Richmond Ave.
Suite 210
Houston, TX 77042
Phone: 713.244.1000

FILE: Fig 2 - NRG-WAParishStation - FGD Emergency Pond.dwg

HOU M:\ACAD-TRC\DRAFTING\NRG\W.A. Parish Station - Thompons-TX\ Fig 2 - NRG-WAParishStation - FGD Emergency Pond.dwg 09/26/18

Appendix A
Photographs

Location: N Side E Pond facing SE

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: N Side E Pond facing S

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: N Side E Pond facing S

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: N Side E Pond facing S

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: N Side E Pond facing N

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: NW Corner E Pond facing SE

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: NW Corner E Pond facing SE

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: NW Corner E Pond facing N

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: SE Corner E Pond Stormwater Discharge

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: SE Corner E Pond facing NE

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: S Side E Pond facing N

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: SE Corner E Pond

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: Middle of E Pond facing NW

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: Middle of E Pond facing NE

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Location: N Corner E Pond facing SW

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

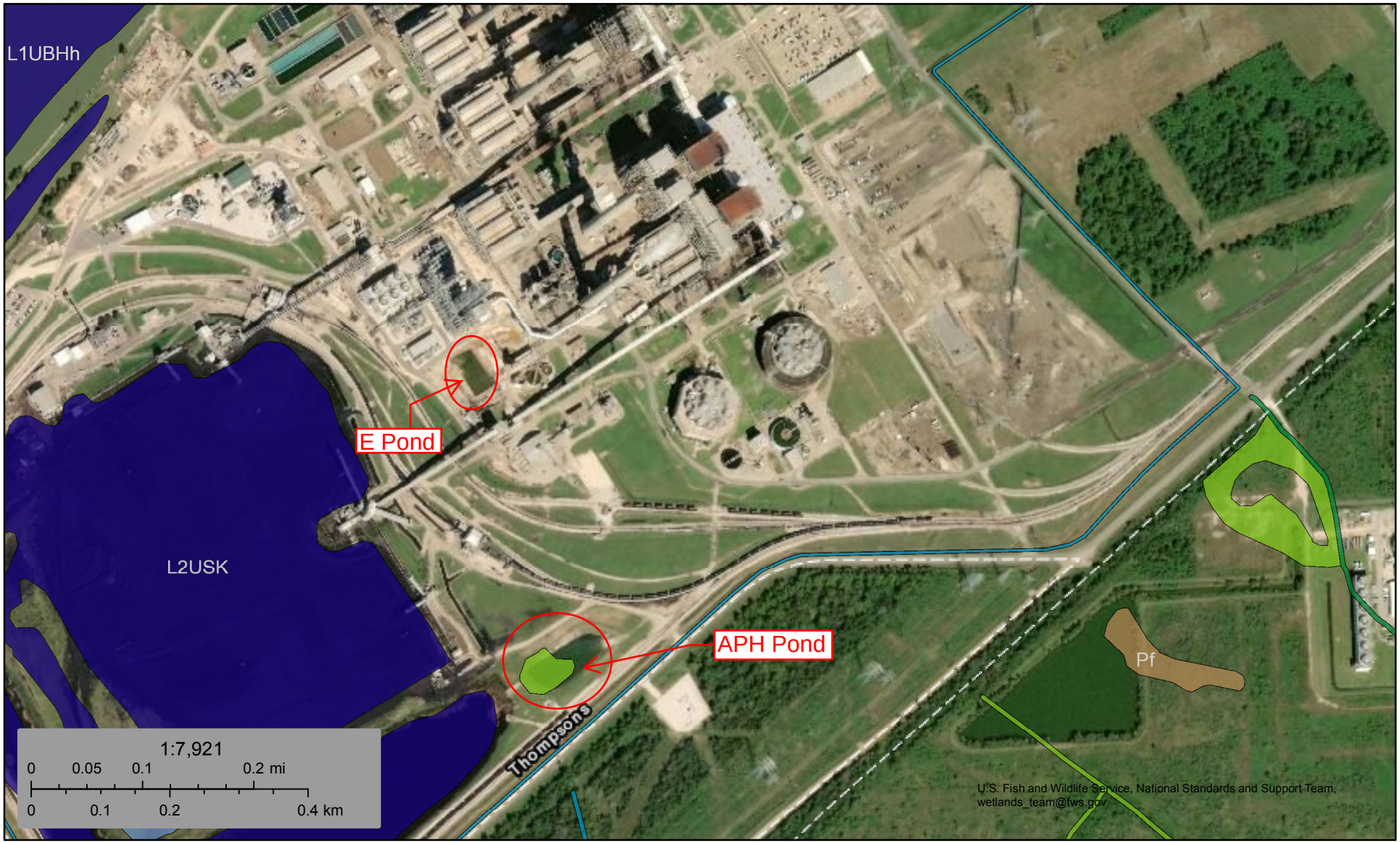
Location: N Corner E Pond facing SE

Site: WA Parish Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/11/18

Appendix B
National Wetlands Inventory Mapper

U.S. Fish and Wildlife Service
National Wetlands Inventory

Parish Location E Pond and APH Pond



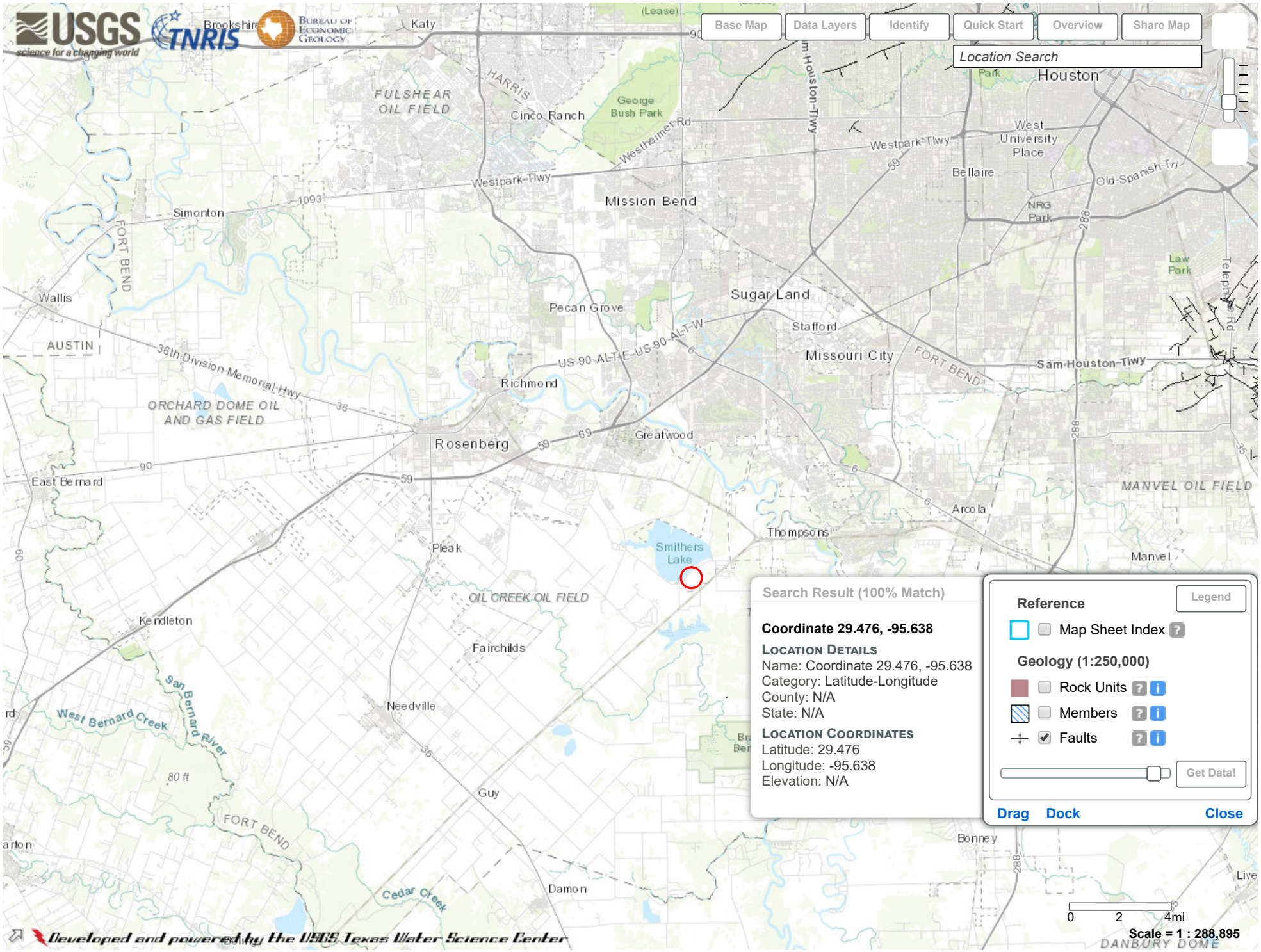
September 14, 2018

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

Appendix C
USGS Texas Geology Web Map Viewer


USGS
science for a changing world
TNRIS
Bureau of Economic Geology
Base Map
Data Layers
Identify
Quick Start
Overview
Share Map
Location Search
Houston
Katy
Brookshire
FULSHEAR OIL FIELD
HARRIS
Cinco Ranch
George Bush Park
Westheimer Rd
Westpark Tlwy
West University Place
Bellaire
Old Spanish Trl
Mission Bend
Simonton
FORT BEND
1093
NRG Park
Law Park
Wallis
Pecan Grove
Sugar Land
Stafford
AUSTIN
36th Division Memorial Hwy
US 90 ALT E
US 90 ALT W
Missouri City
Sam Houston Tlwy
Richmond
ORCHARD DOME OIL AND GAS FIELD
Rosenberg
Greatwood
East Bernard
MANVEL OIL FIELD
Arcola
Thompsons
Smithers Lake
Pleak
Manvel
OIL CREEK OIL FIELD
Kendleton
Fairchilds
San Bernard River
West Bernard Creek
Needville
80 ft
Guy
FORT BEND
Cedar Creek
Damon
Bonney
DANBURY DOME
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Category: Latitude-Longitude
County: N/A
State: N/A
LOCATION COORDINATES
Latitude: 29.476
Longitude: -95.638
Elevation: N/A
Legend
Reference
Map Sheet Index
Geology (1:250,000)
Rock Units
Members
Faults
Get Data!
Drag
Dock
Close
0 2 4mi
Scale = 1 : 288,895
Developed and powered by the USGS Texas Water Science Center

Appendix D
U.S. Seismic Design Maps

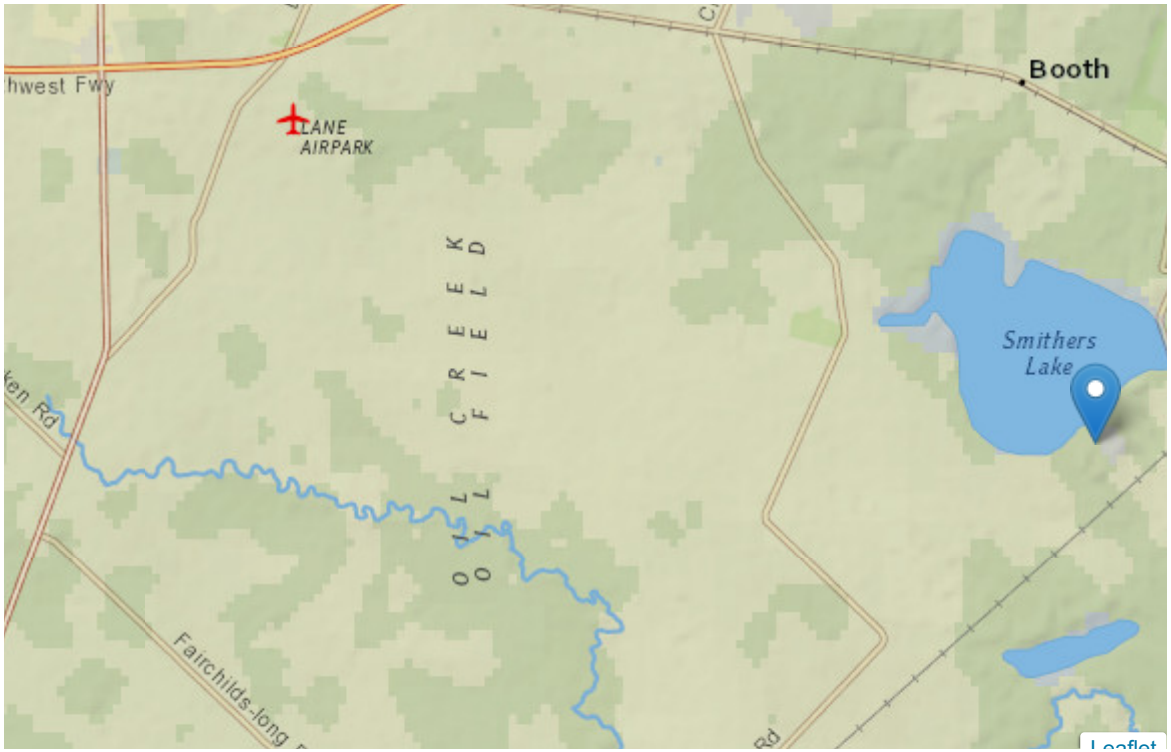
U.S. Geological Survey - Earthquake Hazards Program

Due to insufficient resources and the recent development of similar web tools by third parties, this spring the USGS will be streamlining the two U.S. Seismic Design Maps web applications, including the one below. Whereas the current applications each interact with users through a graphical user interface (GUI), the new web services will receive the inputs (e.g. latitude and longitude) in the form of a web address and return the outputs (e.g. S_{DS} and S_{D1}) in text form, without supplementary graphics. Though designed primarily to be read by the aforementioned third-party web GUIs, the text outputs are also human-readable. To preview the new web services, please click here. Step-by-step instructions for using one of these web services, namely that for the recently published 2016 ASCE 7 Standard, are posted here.

E Pond-Parish

Latitude = 29.476°N, Longitude = 95.638°W

Location



Reference Document

2015 NEHRP Provisions

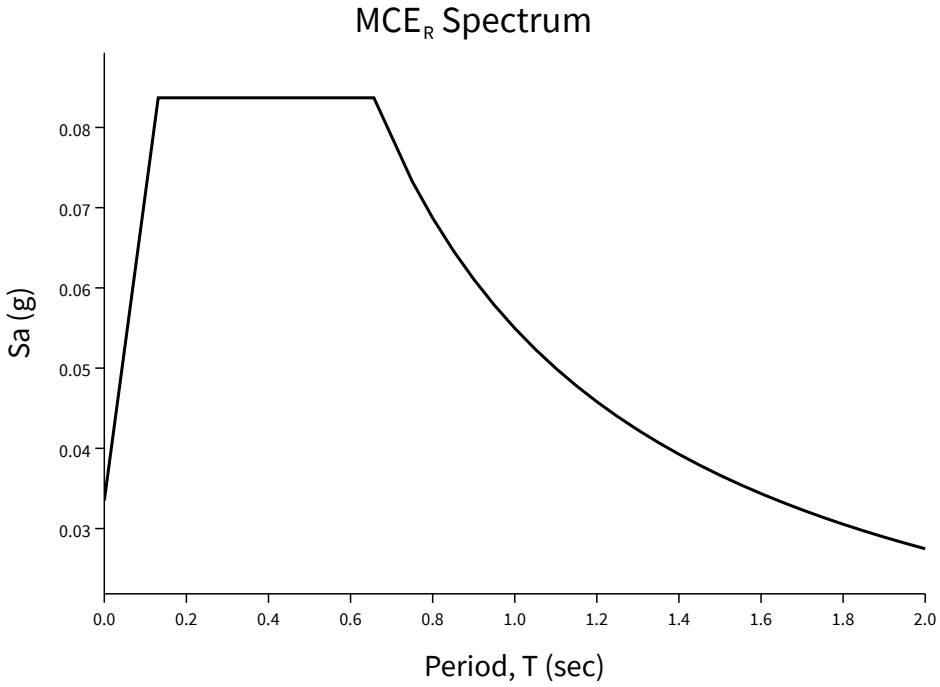
Site Class

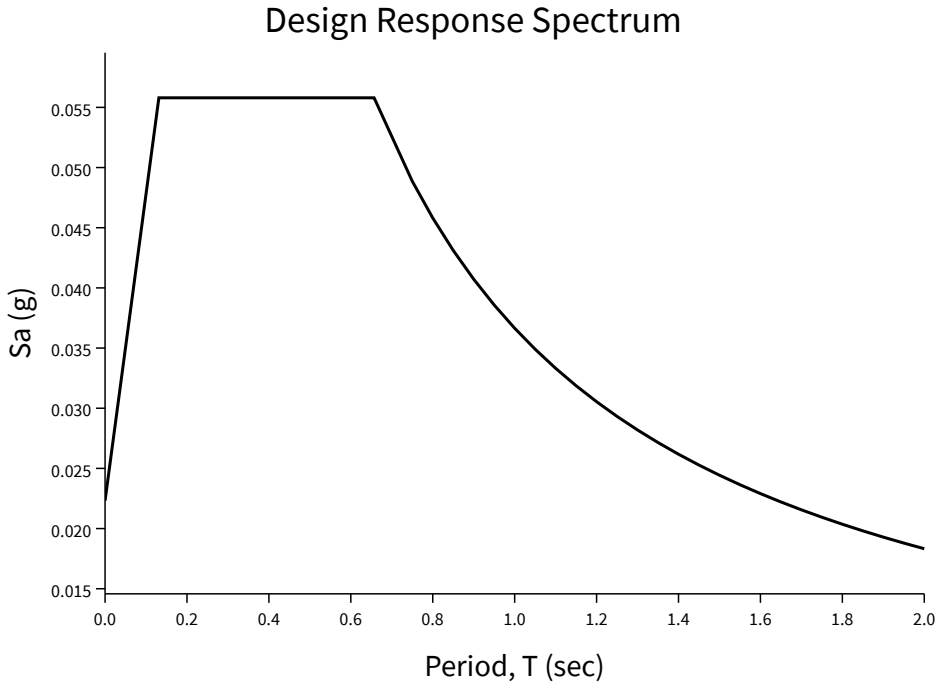
C: Very Dense Soil and Soft Rock

Risk Category

I or II or III

S_S =	0.064 g	S_{MS} =	0.084 g	S_{DS} =	0.056 g
S_1 =	0.037 g	S_{M1} =	0.055 g	S_{D1} =	0.037 g





Mapped Acceleration Parameters, Long-Period Transition Periods, and Risk Coefficients

Note: The S_S and S_1 ground motion maps provided below are for the direction of maximmum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) 1.3 (to obtain S_1).

- FIGURE 22-1 S_S Risk-Targeted Maximum Considered Earthquake (MCE_R) Ground Motion Parameter for the Conterminous United States for 0.2 s Spectral Response Acceleration (5% of Critical Damping), Site Class B
- FIGURE 22-2 S_1 Risk-Targeted Maximum Considered Earthquake (MCE_R) Ground Motion Parameter for the Conterminous United States for 1.0 s Spectral Response Acceleration (5% of Critical Damping), Site Class B
- FIGURE 22-9 Maximum Considered Earthquake Geometric Mean (MCE_G) PGA, %g, Site Class B for the Conterminous United States
- FIGURE 22-14 Mapped Long-Period Transition Period, T_L (s), for the Conterminous United States
- FIGURE 22-18 Mapped Risk Coefficient at 0.2 s Spectral Response Period, C_{RS}
- FIGURE 22-19 Mapped Risk Coefficient at 1.0 s Spectral Response Period, C_{R1}

Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site class as Site Class , based on the site soil properties in accordance with Chapter 20.

Table 20.3-1 Site Classification

Site Class	$\bar{v}_S$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index PI > 20 • Moisture content w ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		
For SI: 1ft/s = 0.3048 m/s 1lb/ft^2 = 0.0479 kN/m^2			

Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Risk-targeted Ground Motion (0.2 s)	$C_{RS}S_{SUH} = 0.952 \times 0.068 = 0.064$ g
Deterministic Ground Motion (0.2 s)	$S_{SD} = 1.500$ g
	$S_S \equiv$ "Lesser of $C_{RS}S_{SUH}$ and S_{SD}" $= 0.064$ g
Risk-targeted Ground Motion (1.0 s)	$C_{R1}S_{1UH} = 0.888 \times 0.041 = 0.037$ g
Deterministic Ground Motion (1.0 s)	$S_{1D} = 0.600$ g
	$S_1 \equiv$ "Lesser of $C_{R1}S_{1UH}$ and S_{1D}" $= 0.037$ g

Table 11.4-1: Site Coefficient F_a

Site Class	Spectral Reponse Acceleration Parameter at Short Period					
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S = 1.25$	$S_S \geq 1.50$
A	0.8	0.8	0.8	0.8	0.8	0.8
B (measured)	0.9	0.9	0.9	0.9	0.9	0.9
B (unmeasured)	1.0	1.0	1.0	1.0	1.0	1.0

Site Class	Spectral Reponse Acceleration Parameter at Short Period					
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S = 1.25$	$S_S \geq 1.50$
C	1.3	1.3	1.2	1.2	1.2	1.2
D (determined)	1.6	1.4	1.2	1.1	1.0	1.0
D (default)	1.6	1.4	1.2	1.2	1.2	1.2
E	2.4	1.7	1.3	1.2 *	1.2 *	1.2 *
F	See Section 11.4.7					

* For Site Class E and $S_S \geq 1.0$ g, see the requirements for site-specific ground motions in Section 11.4.7 of the 2015 NEHRP Provisions. Here the exception to those requirements allowing F_a to be taken as equal to that of Site Class C has been invoked.

Note: Use straight-line interpolation for intermediate values of S_S.

Note: Where Site Class B is selected, but site-specific velocity measurements are not made, the value of F_a shall be taken as 1.0 per Section 11.4.2.

Note: Where Site Class D is selected as the default site class per Section 11.4.2, the value of F_a shall not be less than 1.2 per Section 11.4.3.

For Site Class = C and $S_S = 0.064$ g, $F_a = 1.300$

Table 11.4-2: Site Coefficient F_v

Site Class	Spectral Response Acceleration Parameter at 1-Second Period					
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 = 0.50$	$S_1 \geq 0.60$
A	0.8	0.8	0.8	0.8	0.8	0.8
B (measured)	0.8	0.8	0.8	0.8	0.8	0.8
B (unmeasured)	1.0	1.0	1.0	1.0	1.0	1.0
C	1.5	1.5	1.5	1.5	1.5	1.4
D (determined)	2.4	2.2 [1]	2.0 [1]	1.9 [1]	1.8 [1]	1.7 [1]
D (default)	2.4	2.2 [1]	2.0 [1]	1.9 [1]	1.8 [1]	1.7 [1]
E	4.2	3.3 [1]	2.8 [1]	2.4 [1]	2.2 [1]	2.0 [1]
F	See Section 11.4.7					

[1] For Site Class D or E and $S_1 \geq 0.2$ g, site-specific ground motions might be required. See Section 11.4.7 of the 2015 NEHRP Provisions.

Note: Use straight-line interpolation for intermediate values of S_1.

Note: Where Site Class B is selected, but site-specific velocity measurements are not made, the value of F_v shall be taken as 1.0 per Section 11.4.2.

For Site Class = C and S_1 = 0.037 g, F_v = 1.500

Site-adjusted MCE_R (0.2 s)

$$S_{MS} = F_a S_S = 1.300 \times 0.064 = 0.084 \text{ g}$$

Site-adjusted MCE_R (1.0 s)

$$S_{M1} = F_v S_1 = 1.500 \times 0.037 = 0.055 \text{ g}$$

Design Spectral Acceleration Parameters

Design Ground Motion (0.2 s)

$S_{DS} = ⅔\ S_{MS} = ⅔ \times 0.084 = 0.056$ g

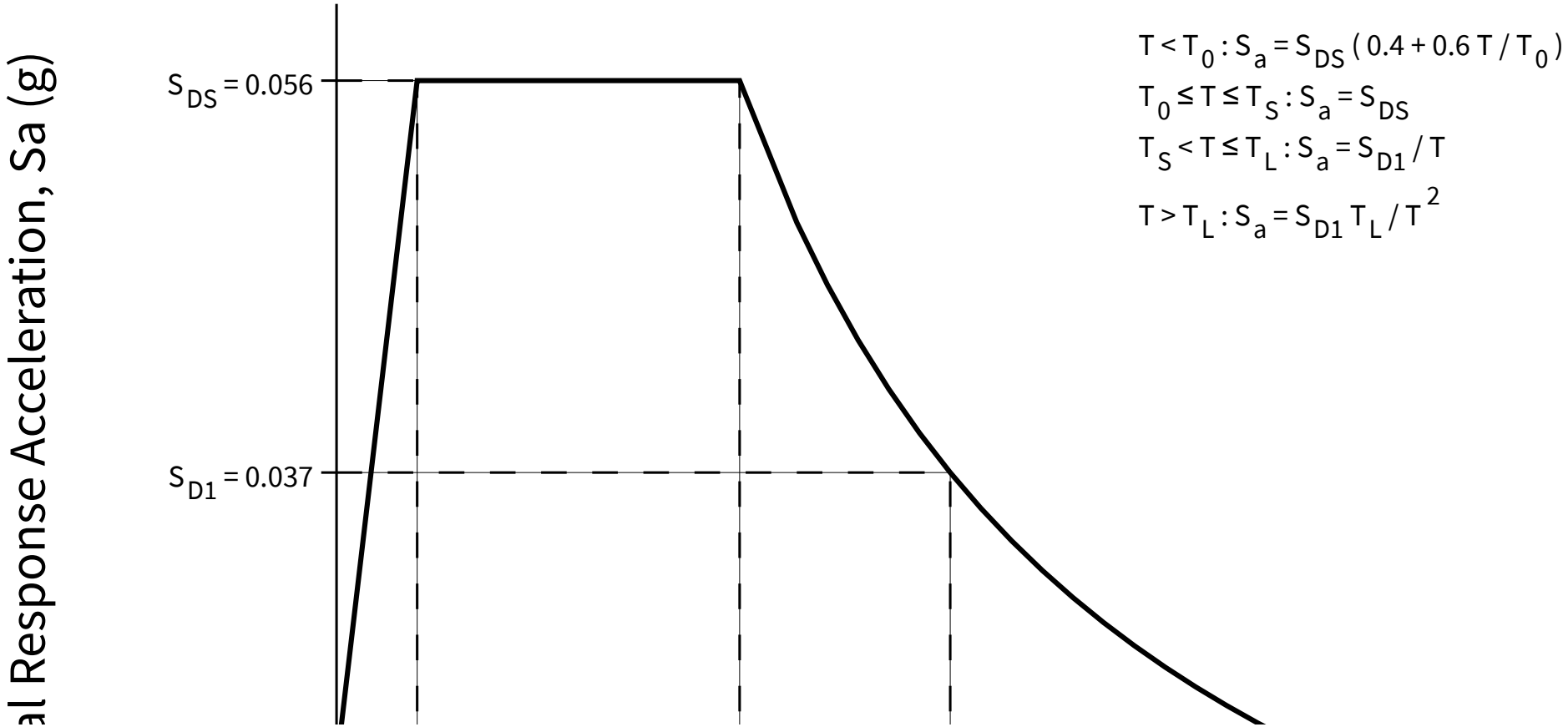
Design Ground Motion (1.0 s)

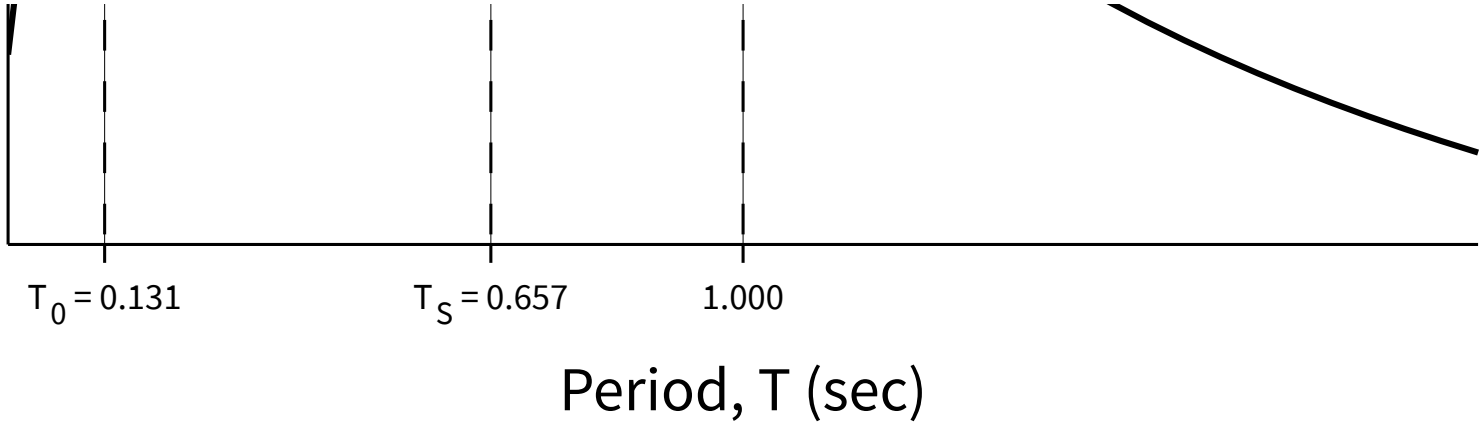
$S_{D1} = ⅔\ S_{M1} = ⅔ \times 0.055 = 0.037$ g

Design Response Spectrum

Long-Period Transition Period = T_L = 12 s

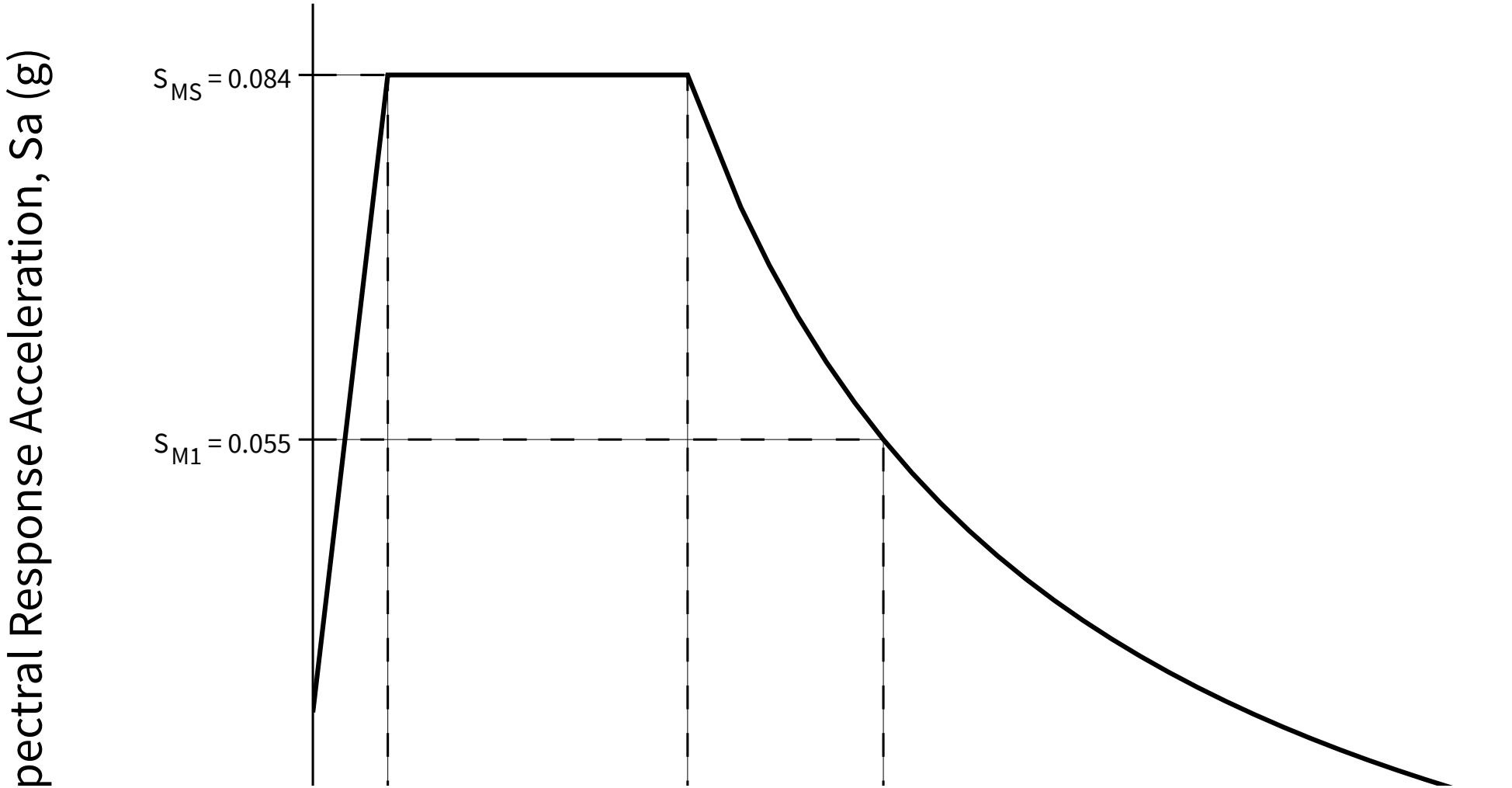
Figure 11.4-1: Design Response Spectrum

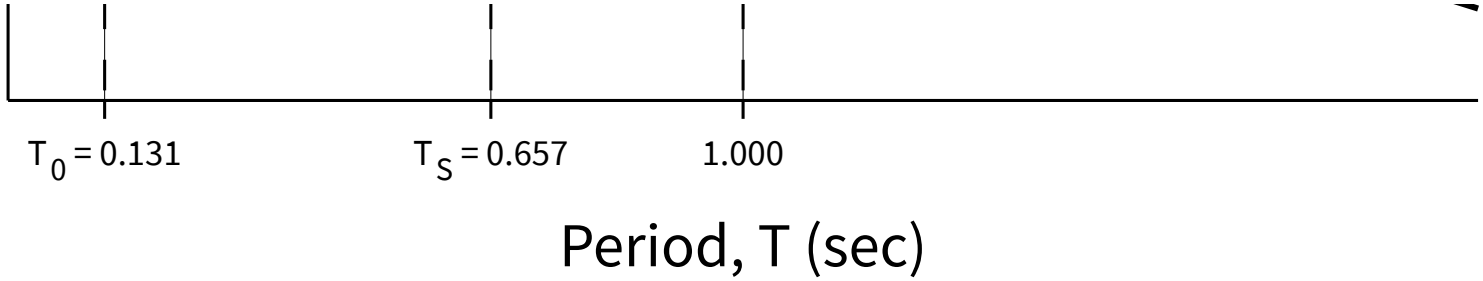



Spectra
T0 = 0.131
TS = 0.657
1.000
Period, T (sec)

MCE_R Response Spectrum

The MCE_R response spectrum is determined by multiplying the design response spectrum above by 1.5.




S_a
$T_0 = 0.131$
$T_S = 0.657$
1.000
Period, T (sec)

Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

Table 11.8-1: Site Coefficient for F_{PGA}

Site Class	Mapped MCE Geometric Mean (MCE_G) Peak Ground Acceleration					
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA = 0.50	PGA ≥ 0.60
A	0.8	0.8	0.8	0.8	0.8	0.8
B (measured)	0.9	0.9	0.9	0.9	0.9	0.9
B (unmeasured)	1.0	1.0	1.0	1.0	1.0	1.0
C	1.3	1.2	1.2	1.2	1.2	1.2
D (determined)	1.6	1.4	1.3	1.2	1.1	1.1
D (default)	1.6	1.4	1.3	1.2	1.2	1.2
E	2.4	1.9	1.6	1.4	1.2	1.1
F	See Section 11.4.7					

Note: Use straight-line interpolation for intermediate values of PGA

Note: Where Site Class D is selected as the default site class per Section 11.4.2, the value of F_{pga} shall not be less than 1.2.

For Site Class = C and PGA = 0.031 g, F_{PGA} = 1.300

Mapped MCE_G

PGA = 0.031 g

Site-adjusted MCE_G

$PGA_M = F_{PGA}PGA = 1.300 \times 0.031 = 0.040$ g