Secondary Emergency Pond (Unit 003)
Location Restrictions Demonstration

Limestone Electric Generating Station
Jewett, Texas

October 2018

Prepared For:

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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 Secondary Emergency Pond (Unit 003) (Secondary E Pond) at the Limestone 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 Secondary E Pond is considered a CCR surface impoundment according to the federal rule (§257.53). This document includes information from a desktop study, Site visit, and engineering calculations to demonstrate that the Secondary 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

NRG Texas Power, LLC's (NRG) Station is located in Jewett, Texas (Figure 1). The Site is located northwest of Jewett, near the borders of Limestone, Freestone, and Leon Counties. The Site is bisected by Farm-to-Market Road 39 (FM39) with the electricity generating portion of the Site to the west of FM39 in Limestone County and a solid waste disposal area (SWDA) to the east of FM39 in Freestone County.

According to the Geologic Atlas of Texas, Waco Sheet (BEG 1972), the Site is primarily located within the outcrop of the Calvert Bluff Formation of the Wilcox Group. Minor portions of the southeast corner of the Site are located within the outcrop of the Carrizo Sand and minor portions of the southwest corner of the Site are immediately underlain by alluvium. The Calvert Bluff Formation underlies both the Carrizo Sand and alluvium where present.

The Secondary E Pond is located solely within the mapped outcrop of the Calvert Bluff Formation (BEG 1972), but Site investigation data indicates it may also be located within the outcrop of the Carrizo Sand. The Calvert Bluff Formation is mostly mudstone interbedded with fine sandstone, lignite, and ironstone concretions. The mudstone contains silt and very fine sand laminae. The Carrizo Sand consists of very fine sand with partings of silty clay, carbonaceous clay, and ironstone. The Carrizo Sand and the Wilcox Group comprise the Carrizo-Wilcox aquifer, which is recognized by the Texas Water Development Board (TWDB) as

a major aquifer system in Texas. The Site is located within the outcrop, or the recharge zone, of the Carrizo-Wilcox aquifer (TWDB 2011).

1.2 Existing and Future Conditions

The Site utilizes lignite and western coal as a fuel source to power the boilers. The spent coal fuels or CCR have been classified by the Texas Commission on Environmental Quality (TCEQ) as Class II Nonhazardous waste and consist of fly ash, bottom ash and flue gas desulfurization (FGD) scrubber sludge.

The Site has two active CCR management units, the Landfill (Unit 004) and the Secondary E Pond (Unit 003) that are subject to regulation under the CCR Rule and the CCR Remand Rule Proposal. Both active CCR units are located within the western portion of the Site as shown on Figure 2. Secondary E Pond (Unit 003) is used for the stabilization of FGD residuals from the chloride purge storage tank, and wastewater from Unit 019 E Pond, which includes FGD wastewater and storm water containing FGD solids, bottom ash and fly ash. These materials are temporarily stored in the Unit 003 Secondary E Pond prior to final disposal in the on-Site landfill.

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 Secondary 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 the groundwater elevations (including the seasonal high water table).

The Secondary E Pond is located solely within the mapped outcrop of the Calvert Bluff Formation (BEG 1972), but site investigation data indicate it may also be located within the outcrop of the Carrizo Sand. The Calvert Bluff Formation is mostly mudstone interbedded with fine sandstone, lignite, and ironstone concretions. The mudstone contains silt and very fine sand laminae. The Carrizo Sand consists of very fine sand with partings of silty clay, carbonaceous clay, and ironstone. The Carrizo Sand and the Wilcox Group comprise the Carrizo-Wilcox aquifer, which is recognized by the Texas Water Development Board (TWDB) as a major aquifer system in Texas. The Site is located within the outcrop, or the recharge zone, of the Carrizo-Wilcox aquifer (TWDB 2011).

Site investigations were conducted at the Site by Espey, Huston & Associated in 1986; Radian International in 1996 and 1997; EPRI in 2007; and Environmental Resources Management, Inc. (ERM) in 2016. The results of these investigations were summarized in the October 2017 *Ground Water Monitoring Networks for Coal Combustion Residual (CCR) Rule Compliance* report (ERM 2017b). Boring logs indicate the lithology at the Secondary E Pond consists primarily of silty sand with clayey sand and sandy clay to approximately 60 feet below ground surface (bgs), which appears to be consistent with the Carrizo Sand. Interbedded mud, silt, and sand consistent with the Calvert Bluff Formation was present at approximately 60 feet bgs in the vicinity of the Secondary E Pond.

To determine the potential maximum water table, groundwater elevation data from surrounding wells (MW-05, MW-26, MW-29, MW-43, and MW-44) was collected between January 2017 and May 2018. The maximum water table elevation observed during this time was 423.98 feet above mean sea level (famsl), which is approximately 49 feet below the bottom of the Secondary E Pond clay liner.

Based on this demonstration, the base of the Secondary E Pond is located greater than five feet above the upper limit of the uppermost aquifer; therefore, the Secondary 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 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 Secondary E Pond is located in a wetland.

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 Secondary 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 Secondary E Pond is not located in a wetland. The Secondary 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 Secondary E Pond area is not supported by this determination; therefore, the Secondary 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 were reviewed.

As shown on the USGS Texas Geology Web Map Viewer (Appendix C), no faults have been mapped in the Secondary E Pond area. The closest fault line to the Secondary E Pond at the Limestone Station is approximately 20 miles to the north of the Site.

Evidence of active faulting during the Holocene in the Secondary E Pond area is not supported by this determination; therefore, the Secondary 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 Secondary 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 Secondary E Pond area indicates a mapped peak ground acceleration of 0.095 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 Secondary 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 existing berms were in good condition and no bulging or settlement was observed. No

areas of erosion were observed on exterior berms. The areas around the perimeter of the berm were vegetated and no large trees or areas of distressed vegetation were observed. No significant animal damage or human-made features around the perimeter of the berms that would cause instability were observed. No seeps were observed on the outside of any berms.

There is a wide area of soil that extends away from the impoundment in the area to the west. The west edge of this area is not sloped like a berm and has some significant erosion, as well as a large amount of woody vegetation. However, this area is located at least 50 feet from the primary berm and should not affect the performance of the impoundment.

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

Section 3
Conclusions

Based on the evaluation provided in this demonstration, the Secondary E Pond at the Limestone 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

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.

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 [9/14/2018].

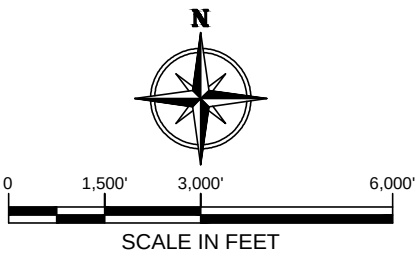
U.S. Fish and Wildlife Service National Wetlands Inventory (NWI). 2018. "Wetland Mapper." Available online at https://www.fws.gov/wetlands/data/mapper.html. Accessed [9/14/2018].

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
DONIE, TEXAS (2016)
FARRAR, TEXAS (2016)

TEXAS
QUADRANGLE LOCATION



SCALE IN FEET
1" = 3,000'-0"

PROJECT:
NRG TEXAS POWER, LLC
Limestone Electric Generating Station
Jewett, Texas

TITLE:
SITE LOCATION MAP

DRAWN BY:	O. Fonseka	PROJECT No.:	298367.0000.0000
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 1 - NRG-LimestoneStation - Site Location Map.dwg

HOU M:\ACAD-TRC\DRAFTING\NRG\Limestone Station - Jewett-TX\ Fig 1 - NRG-LimestoneStation - Site Location Map.dwg 09/26/18

PROJECT:
NRG TEXAS POWER, LLC
Limestone Electric Generating Station
Jewett, Texas

TITLE:
SECONDARY E POND

DRAWN BY:	O. Fonseka	PROJECT No.:	298367.0000.0000
CHECKED BY:	T. Dworaczyk		**FIGURE 2**
APPROVED BY:	T. Dworaczyk		
DATE:	September 2018		

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

FILE: Fig 2 - NRG-LimestoneStation - Secondary E Pond.dwg

HOU M:\AC\AD-TRC\DRAFTING\NRG\Limestone Station - Jewett-TX\ Fig 2 - NRG-LimestoneStation - Secondary E Pond.dwg 09/26/18

Appendix A
Photographs

Location: SW Corner of E Pond Facing E

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SW Corner of E Pond Facing E

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SW Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SW Corner of E Pond Facing N

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SW Corner of E Pond Facing E

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: W Side of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: West Side of E Pond Facing N

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SE Corner of E Pond Facing N

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SE Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SE Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SE Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NE Corner of E Pond Facing S

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NE Corner of E Pond Facing S

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NE Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NE Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: SE Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NW Corner of E Pond Facing S

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NW Corner of E Pond Facing W

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NW Corner of E Pond Facing E

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Location: NW Corner of E Pond – surficial animal damage

Site: Limestone Owner: NRG Photograph Taken by: Jason Leik Date of Inspection: 9/10/18

Appendix B
National Wetlands Inventory Mapper

U.S. Fish and Wildlife Service
National Wetlands Inventory

Limestone Location

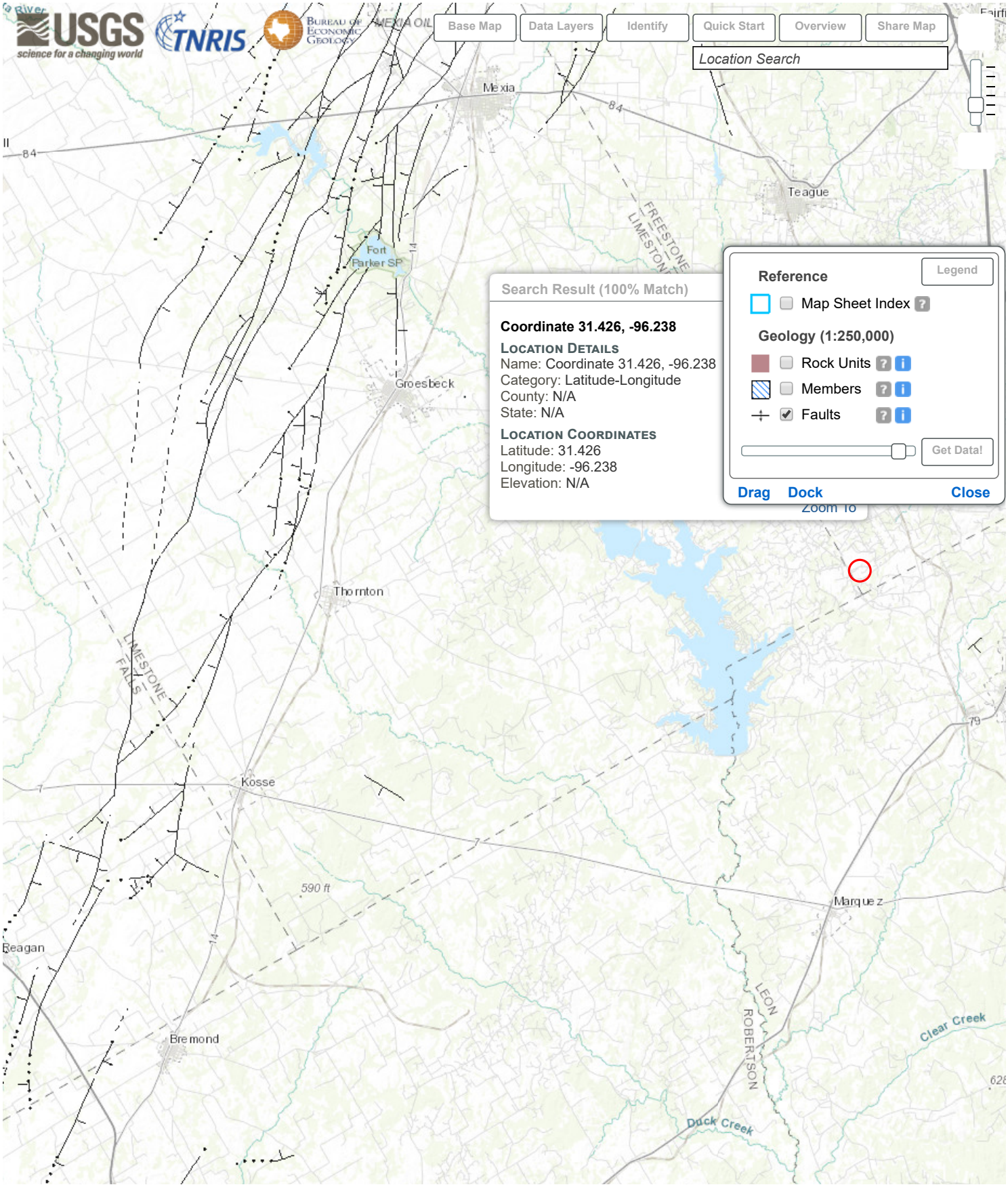
September 13, 2018

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



0 2 4mi

Scale = 1 : 288,895

Developed and powered by the USGS Texas Water Science Center

Appendix D
U.S. Seismic Design Maps

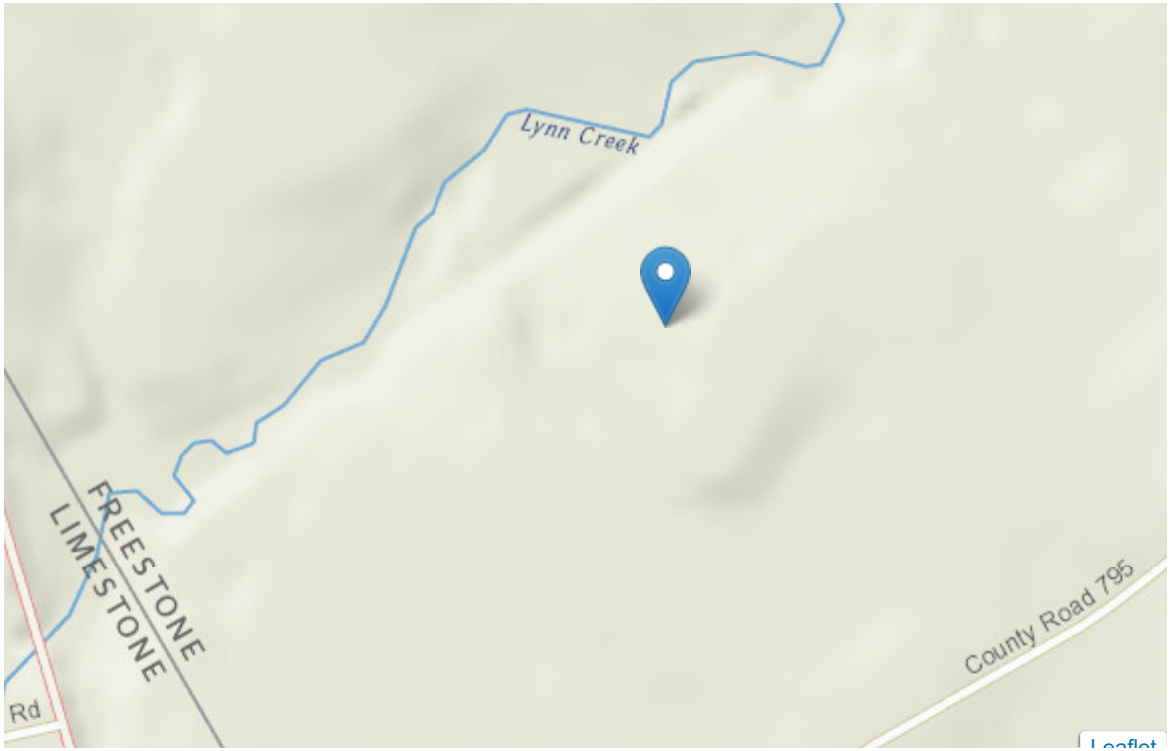
U.S. Geological Survey - Earthquake Hazards Program

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.

Secondary E Pond- Limestone

Latitude = 31.426°N, Longitude = 96.238°W

Location



Reference Document

2015 NEHRP Provisions

Site Class

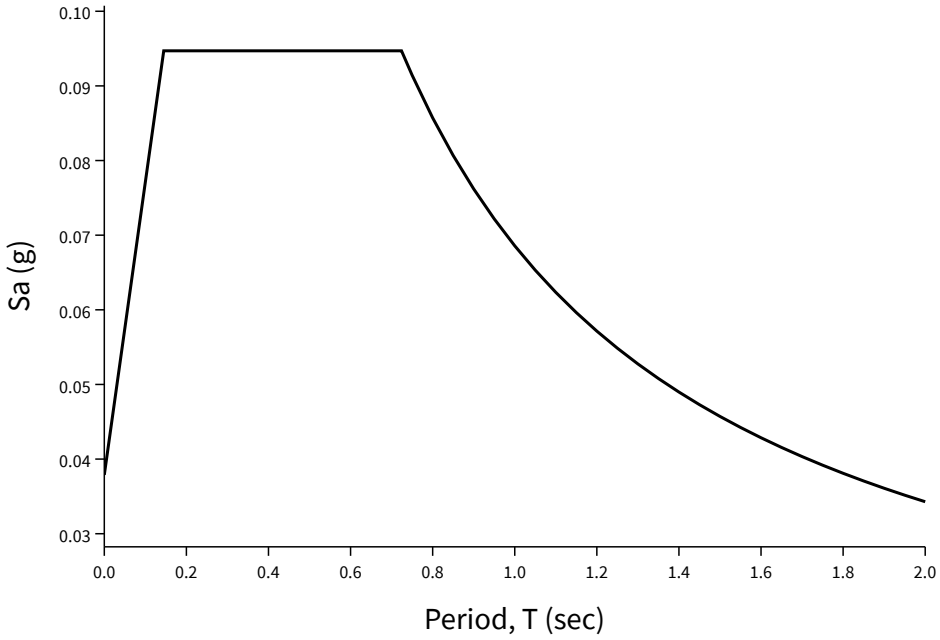
C: Very Dense Soil and Soft Rock

Risk Category

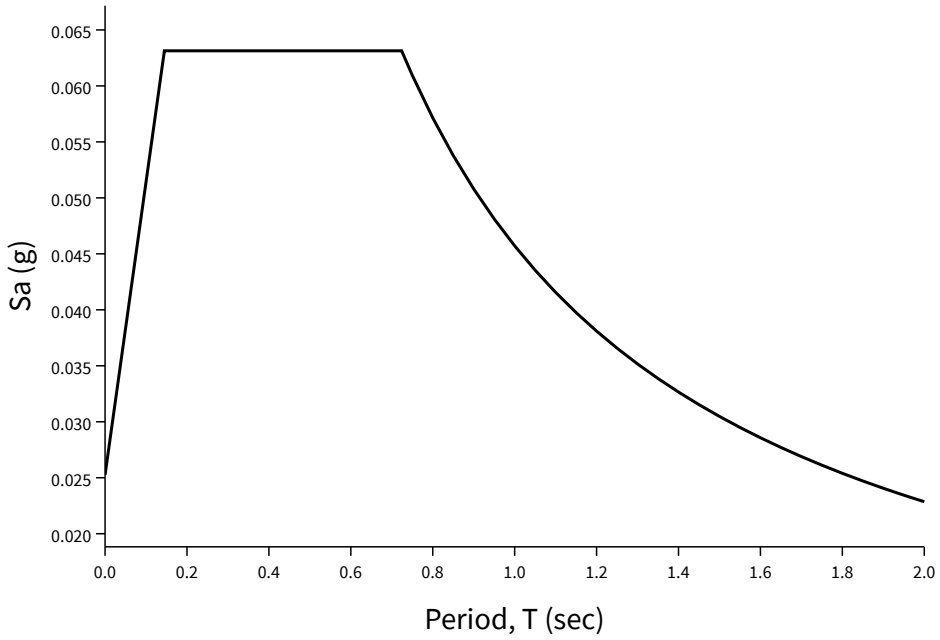
I or II or III

S_S =	0.073 g	S_{MS} =	0.095 g	S_{DS} =	0.063 g
S_1 =	0.046 g	S_{M1} =	0.069 g	S_{D1} =	0.046 g

MCE$_R$ Spectrum



Design Response Spectrum



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)	$C_{RS}S_{SUH} = 0.949 \times 0.077 = 0.073$ g
Deterministic Ground Motion (0.2 s)	$S_{SD} = 1.500$ g
	$S_S \equiv$ "Lesser of $C_{RS}S_{SUH}$ and S_{SD}" = 0.073 g
Risk-targeted Ground Motion (1.0 s)	$C_{R1}S_{1UH} = 0.886 \times 0.052 = 0.046$ g
Deterministic Ground Motion (1.0 s)	$S_{1D} = 0.600$ g
	$S_1 \equiv$ "Lesser of $C_{R1}S_{1UH}$ and S_{1D}" = 0.046 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 = 0.073 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 = 0.046 g, F_v = 1.500

Site-adjusted MCE_R (0.2 s)

$$S_{MS} = F_a S_S = 1.300 \times 0.073 = 0.095 \text{ g}$$

Site-adjusted MCE_R (1.0 s)

$$S_{M1} = F_v S_1 = 1.500 \times 0.046 = 0.069 \text{ g}$$

Design Spectral Acceleration Parameters

Design Ground Motion (0.2 s)

$S_{DS} = ⅔\ S_{MS} = ⅔ \times 0.095 = 0.063$ g

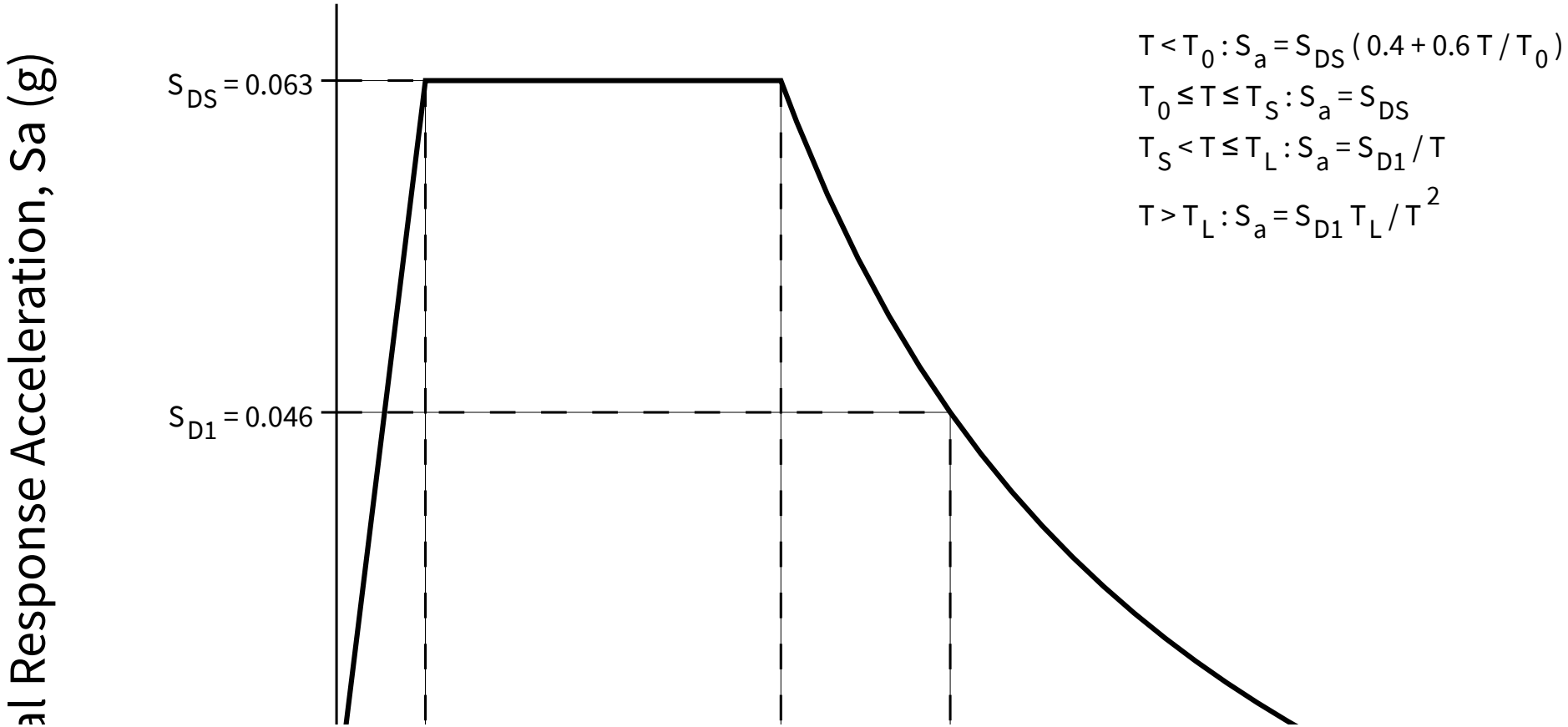
Design Ground Motion (1.0 s)

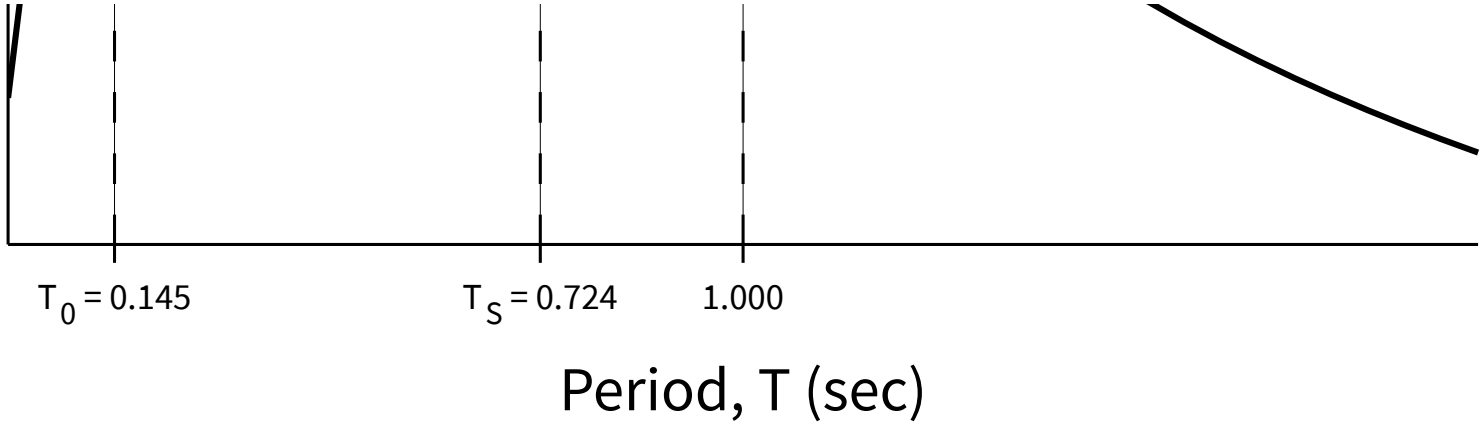
$S_{D1} = ⅔\ S_{M1} = ⅔ \times 0.069 = 0.046$ g

Design Response Spectrum

Long-Period Transition Period = T_L = 12 s

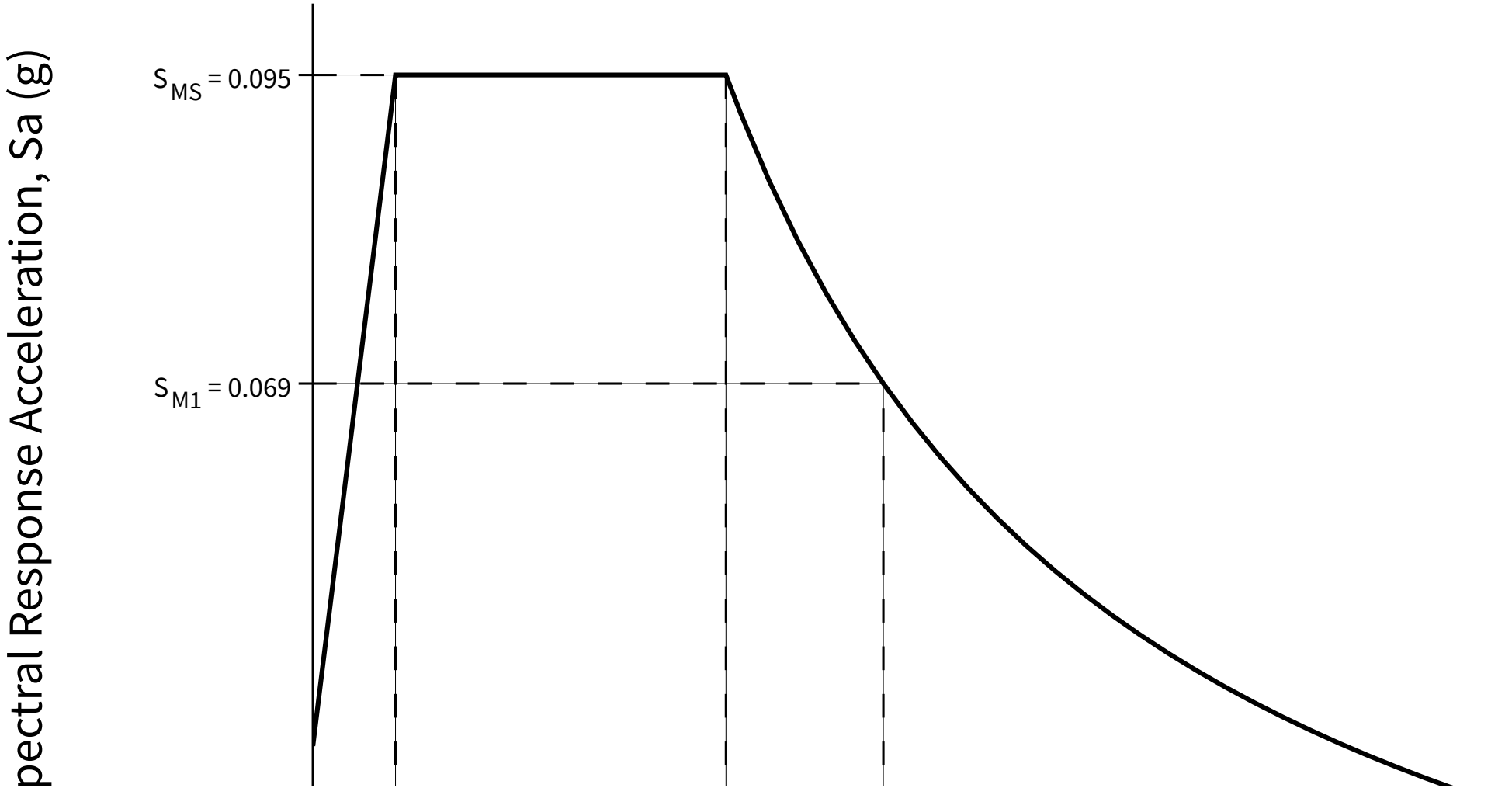
Figure 11.4-1: Design Response Spectrum

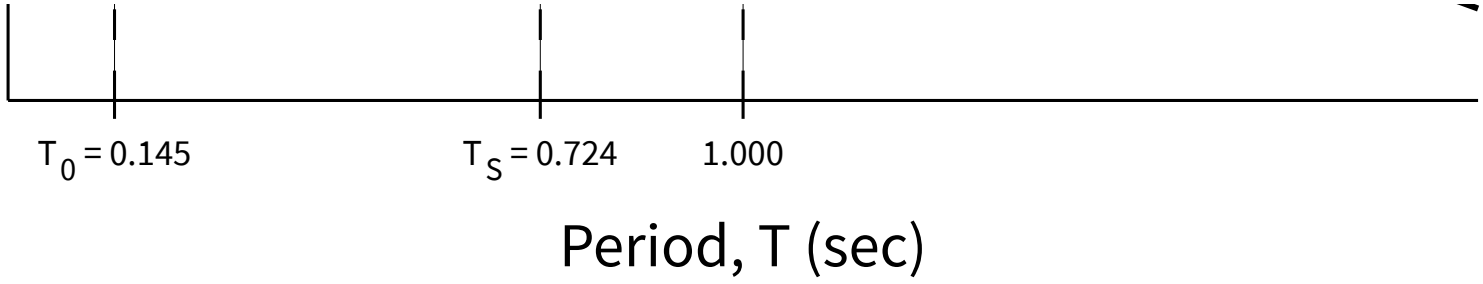



Spectra
T 0 = 0.145
T S = 0.724
1.000
Period, T (sec)

MCE_R Response Spectrum

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




$T_0 = 0.145$
$T_S = 0.724$
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 = 0.035 g, F_{PGA} = 1.300

Mapped MCE_G

PGA = 0.035 g

Site-adjusted MCE_G

$PGA_M = F_{PGA}PGA = 1.300 \times 0.035 = 0.045$ g