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Water Tank Structural Analysis Report

Terra Consulting Group Project #: 54-1540 REV 1

October 29, 2024

Site Information

PSLC: 237385
Site Name: Willard Water Tank - A
MDG Location No. 5000309199
Carrier Name: Verizon Wireless
Address: 512 E. Jackson Street
Willard, MO 65781
GREENE COUNTY
Latitude: 37.299261°
Longitude: -93.418025°

Structure Information

Tower Type: 124-Ft Water Tank

FUZE ID # 16947572

Analysis Results

Water Tank: **Sufficient**

Report Prepared By: Matthew Wozniak, P.E.

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Matthew Wozniak



10/25/24

Executive Summary:

The objective of this report is to determine the capacity of the water tank tower at the subject facility to support the final wireless telecommunications configuration, per the applicable codes and standards. Any modification listed under Sources of Information was assumed completed and was included in this analysis.

Sources of Information:

Document Type	Remarks
<i>Radio Frequency Data Sheet (RFDS)</i>	<i>Verizon RFDS, FUZE # 16947572, dated October 2, 2024</i>
<i>Mapping Report</i>	<i>Hightower Solutions, dated August 28, 2013</i>
<i>Structural Analysis Report</i>	<i>Destek Engineering, dated December 31, 2013</i>
<i>Water Tank Drawings</i>	<i>Caldwell Tanks, inc., #E-3975, May, 1996</i>

Analysis Criteria:

Water Tank Analysis:

Codes and Standards: ANSI AWWA D100-11

Wind Parameters: Basic Wind Speed, V: 90 mph
Importance Factor: 1.15
Wind Exposure Category: C
Gust Effect Factor: 1.0

Seismic Parameters: S_s: 0.176
S₁: 0.1



Final Loading Configuration:

The following equipment has been considered for the analysis of the tower:

Mount Elevation (ft)	Equipment Elevation (ft)	Quantity	Manufacturer	Model	Feedlines (in)	Status	Carrier
120	127	3	Ericsson	AIR6419	(3) 1-5/8" Hybrid	Added	VZW
		6	Commscope	NHH-65C-R2B			
		3	Ericsson	4890			
		3	Ericsson	4490			
		3	-	RVZDC-6627-PF-48			
120	127	3	Kathrein Scala	80010692V01	(10) 1-5/8" Coax (Esimated from Photos)	Retained	Other
		3	Triasx	TMA2061F1V1-1			
		4	Antel	BSA-185065/10CF			
		1	Antel	BXA-185063/9CF			
102	102	3	-	Panel Antenna	(3) Hybrid	Retained	Other
		3	-	Panel Antenna			
		6	-	RRH			
		1	-	Dish			

Analysis Results:

Component	Utilization %	Pass/Fail
Water Tank Structure	<i>See Recommendations</i>	<i>Pass</i>
Structure Rating – (Controlling Utilization of all Components)		Sufficient

Recommendation:

Based on the ANSI AWWA D100 and Section 3403 of the 2018 IBC, an increase in wind loads of less than 10% and an increase in gravity load of less than 5% is considered acceptable. Based on this, the relatively small gravity loads produced by Verizon Wireless' proposed equipment are negligible compared to the overall water tank structure. The wind loads produced by Verizon Wireless' proposed equipment and existing equipment of the other carriers exceeds 10% compared to the overall water tank structure.

Per the tank drawings by Caldwell Tanks, Inc. from May of 1996, the water tank structure was designed for a base moment due to seismic forces of 7001320 ft-lbs and a base moment due to wind forces of 3781760 ft-lbs. The design base shear due to wind is 51930 lbs and 69620 lbs due to seismic. The design base moment due to seismic forces is 85% greater than the design base moment due to wind. Although the wind forces exceed the original design wind forces by greater than 10%, the original tank design was controlled by the seismic forces. The increased wind forces are less than the original seismic design forces and therefore are considered acceptable.

The water tank was designed for a total vertical load 2822420 lbs. The percentage increase of vertical loads due to the weight of the additional VZW and other carrier equipment is less than 1% and is negligible compared to the overall water tank structure.

Considering the small percentage increase in base moment and vertical load compared to the original water tank design reactions, it is our opinion that the existing water tank has sufficient capacity to support the proposed loading.

ANSI/ASSP rigging plan review services compliant with the requirements of ANSI/TIA 322 are available for a Construction Class IV site or other, if required. Separate review fees will apply.

Attachments:

1. Analysis Calculations



Water Tank Stability Check

Wind Load Calculations (AWWA D100-11)

Pw:	Wind Pressure	=	$qz * G * Cf$	>=	$30 * Cf$	(psf)	AWWA Section 3.1.4
G:	Gust Effect Factor	=	1.0				AWWA Section 3.1.4
Cf:	Force coefficient	=	Flat	F	1.0		
		=	Cylindrical	C	0.6		AWWA Table 2
		=	Double Curve	DC	0.5		
z:	Height above Grade	ft				AWWA Section 3.1.4	
Kz:	Velocity Pressure	=	$2.01 * (z/zg)^{(2/\alpha)}$				ASCE7-15 or
	Coefficient at z						AWWA Table 3
			$Kz(\min) \leq Kz \leq 2.01$				
I:	Importance Factor	=	1.15				AWWA Section 3.1.4
V:	Basic Wind Speed	=	90	mph			Figure 1, Page 14-18
	Wind Exposure	=	C				
qz:	Velocity Pressure	=	$0.00256 * Kz * I * V^2$				AWWA Section 3.1.4
Top of Tank:		=	123.67	ft			



Tank Area

Member		# of Members	Length or Diameter (ft)	Width (ft)	Depth (ft)	Area (ft)	C/L Elev. (ft)	Kz	Shape/Cf		qz (psf)	Pw (psf)	Wind Load (k)	Base Moment (kip ft)
Tank	Top	1	43.3	12	12	457.8	118.67	1.31	DC	0.5	31.29	15.64	7.16	849.88
Tank	Body	1	43.3	13	13	562.9	105.17	1.28	C	0.6	30.50	18.30	10.30	1083.45
Tank	Bottom	1	43.3	12	12	538.6	87.9267	1.23	DC	0.5	29.37	15.00	8.08	710.41
Tank Legs		5	99	1.5	1.5	743	49.50	1.09	C	0.6	25.99	18.00	13.37	661.57
Riser Cone		1	6.75	10	10	68	83.00	1.22	C	0.6	29.02	18.00	1.22	100.85
Riser		1	77	3.5	3.5	270	38.5	1.09	C	0.6	25.99	18.00	4.85	186.76
Horizontal 1		5	26.5	0.67	0.67	88.3775	49.5	1.09	F	1	25.99	30.00	2.65	131.24
Diagonal 1	1.25"	10	54	0.1	0.1	56.16	74.25	1.19	C	0.6	28.35	18.00	1.01	75.06
Diagonal 2	1.5"	10	54	0.13	0.13	67.5	24.75	1.09	C	0.6	25.99	18.00	1.22	30.07
Handrail		1	45	0.67	0.67	30.015	99	1.26	F	1	30.12	30.12	0.90	89.49
10% Misc. (vent, over flow pipe, etc)							78.73						5.08	399.59
Totals:													55.83	4318.36



Antennas

Wind Direction 80 °

Manufacturer	Antenna	#	Ht (in)	W (in)	D (in)	Frontal Area (sf)	Side Area (sf)	Wt / unit (lbs)	Total Wt (lbs)	AZ °	Project Area (sf)	TL Project Area (sf)	Elev. (ft)	Shape	Cf	qz (psf)	Pw (psf)	Wind Load (k)	Moment (kip ft)
ERICSSON	AIR6419	1	31.3	16.1	9.8	3.5	2.13	71	71	40	4.05	4.05	127	F	1	31.7	31.7	0.13	16.32
ERICSSON	AIR6419	1	31.3	16.1	9.8	3.5	2.13	71	71	160	2.71	2.71	127	F	1	31.7	31.7	0.09	10.92
ERICSSON	AIR6419	1	31.3	16.1	9.8	3.5	2.13	71	71	280	4.02	4.02	127	F	1	31.7	31.7	0.13	16.20
COMMSCOPE	NHH-65C-R2B	2	96.0	11.9	7.1	7.9	4.73	51.6	103	40	9.12	18.24	127	F	1	31.7	31.7	0.58	73.52
COMMSCOPE	NHH-65C-R2B	2	96.0	11.9	7.1	7.9	4.73	51.6	103	160	6.0	12.1	127	F	1	31.7	31.7	0.38	48.69
COMMSCOPE	NHH-65C-R2B	2	96.0	11.9	7.1	7.9	4.73	51.6	103	280	9.07	18.14	127	F	1	31.7	31.7	0.58	73.12
ERICSSON	4490	1	20.6	15.7	7.0	2.25	1.00	68.4	68.4	40	2.36	2.36	127	F	1	31.7	31.7	0.07	9.51
ERICSSON	4490	1	20.6	15.7	7.0	2.25	1.00	68.4	68.4	160	1.38	1.38	127	F	1	31.7	31.7	0.04	5.56
ERICSSON	4490	1	20.6	15.7	7.0	2.25	1.00	68.4	68.4	280	2.45	2.45	127	F	1	31.7	31.7	0.08	9.88
ERICSSON	4890	1	20.6	15.7	7.2	2.25	1.03	69.5	69.5	40	2.38	2.38	127	F	1	31.7	31.7	0.08	9.59
ERICSSON	4890	1	20.6	15.7	7.2	2.25	1.03	69.5	69.5	160	1.40	1.40	127	F	1	31.7	31.7	0.04	5.64
ERICSSON	4890	1	20.6	15.7	7.2	2.25	1.03	69.5	69.5	280	2.46	2.46	127	F	1	31.7	31.7	0.08	9.92
RAYCAP	RVZDC-6627-PF-48	1	28.9	15.7	10.3	3.16	2.07	32	32	40	3.75	3.75	127	F	1	31.7	31.7	0.12	15.12
RAYCAP	RVZDC-6627-PF-48	1	28.9	15.7	10.3	3.16	2.07	32	32	160	2.59	2.59	127	F	1	31.7	31.7	0.08	10.44
RAYCAP	RVZDC-6627-PF-48	1	28.9	15.7	10.3	3.16	2.07	32	32	280	3.68	3.68	127	F	1	31.7	31.7	0.12	14.83
GENERIC PANEL	6'x2'	1	72.0	24.0	8.0	12.00	4.00	50	50	70	12.51	12.51	102	F	1	30.3	30.3	0.38	38.67
GENERIC PANEL	6'x2'	1	72.0	24.0	8.0	12.00	4.00	50	50	190	7.86	7.86	102	F	1	30.3	30.3	0.24	24.30
GENERIC PANEL	6'x2'	1	72.0	24.0	8.0	12.00	4.00	50	50	310	10.78	10.78	102	F	1	30.3	30.3	0.33	33.32
GENERIC PANEL	3'x1.5'	1	36.0	18.0	8.0	4.50	2.00	40	40	70	4.78	4.78	102	F	1	30.3	30.3	0.14	14.78
GENERIC PANEL	3'x1.5'	1	36.0	18.0	8.0	4.50	2.00	40	40	190	3.42	3.42	102	F	1	30.3	30.3	0.10	10.57
GENERIC PANEL	3'x1.5'	1	36.0	18.0	8.0	4.50	2.00	40	40	310	4.42	4.42	102	F	1	30.3	30.3	0.13	13.66
GENERIC PANEL	RRH	2	24.0	12.0	9.0	2.00	1.50	50	100	70	2.23	4.46	102	F	1	30.3	30.3	0.14	13.79
GENERIC PANEL	RRH	2	24.0	12.0	9.0	2.00	1.50	50	100	190	2.09	4.18	102	F	1	30.3	30.3	0.13	12.92
GENERIC PANEL	RRH	2	24.0	12.0	9.0	2.00	1.50	50	100	310	2.43	4.86	102	F	1	30.3	30.3	0.15	15.02
GENERIC PANEL	DISH	1	26.0	26.0	12.0	4.7	2.17	40	40	90	5.00	5.00	102	F	1	30.3	30.3	0.15	15.46
KATHREIN SCALE	80010692V01	1	103.2	11.8	6.0	8.5	4.30	73.2	73.2	20	7.95	7.95	127	F	1	31.7	31.7	0.25	32.04



KATHREIN SCAL	80010692V01	1	103.2	11.8	6.0	8.5	4.30	73.2	73.2	140	7.95	7.95	127	F	1	31.7	31.7	0.25	32.04
KATHREIN SCAL	80010692V01	1	103.2	11.8	6.0	8.5	4.30	73.2	73.2	260	8.46	8.46	127	F	1	31.7	31.7	0.27	34.10
GENERIC PANE	TMA2061F1V1-1	1	14.3	7.9	5.2	0.8	0.51	50	50	20	0.8	0.8	127	F	1	31.7	31.7	0.03	3.39
GENERIC PANE	TMA2061F1V1-1	1	14.3	7.9	5.2	0.8	0.51	50	50	140	0.84	0.84	127	F	1	31.7	31.7	0.03	3.39
GENERIC PANE	TMA2061F1V1-1	1	14.3	7.9	5.2	0.78	0.51	50	50	260	0.78	0.78	127	F	1	31.7	31.7	0.02	3.14
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	20	2.04	2.04	127	F	1	31.7	31.7	0.06	8.22
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	140	2.04	2.04	127	F	1	31.7	31.7	0.06	8.22
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	260	2.63	2.63	127	F	1	31.7	31.7	0.08	10.60
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	260	2.63	2.63	127	F	1	31.7	31.7	0.08	10.60
ANTEL	BXA-185063/9CF	1	48.8	6.1	3.2	2.07	1.08	10	10	20	1.97	1.97	127	F	1	31.7	31.7	0.06	7.94
Totals																		5.690	675.45

Antenna Mount Areas

Member	#	Length or Diam. (in)	W (in)	D (in)	Project Area (sf)	TL Project Area (sf)	Elev. (ft)	Shape	Cf	qz (psf)	Pw (psf)	Antenna Cover (%)	Wind Load (k)	Moment (kip ft)	Wt / ft (lb)	Wt (lb)
VZW Corral	1	288	12	12	24	24	123	F	1	31.5	31.5	5.0%	0.72	88.41	3.66	88
VZW Mount Pipes	21	102	2.88	2.88	2.04	42.84	127	C	0.6	31.7	19.0	30.0%	0.57	72.52	4.75	848
Carrier Mount Pipes	10	96	2.38	2.38	1.59	15.8667	102	C	0.6	30.3	18.2	40.0%	0.17	17.66	7.58	606
Totals													1.46	178.59		

Cables

Cables	Quantity	Quantity in Wind	Width Exp. To Wind (in)	Shape / Cf	Cable Length (ft)	CL Elev (ft)	Projected Area	Wt (lb/ft)	qz (psf)	Pw (psf)	TL Wt. (lb)	Wind Load (k)	Moment (k ft)
VZW Cables	3	2	1.625	C 0.6	127	63.5	34.3958333	0.82	27.4	18.0	312.42	0.619	39.31
Other	3	1	1.625	C 0.6	102	51	13.8125	0.82	26.2	18.0	250.92	0.249	12.68
Other	10	3	1.625	C 0.6	127	63.5	51.59375	0.82	27.4	18.0	1041.4	0.929	58.97

JOB NUMBER: E-3975
 DATE : 04/09/96
 INPUT BY : TLR
 CHECKED BY: 6-20-96

VERTICAL LOADS

DOME HEAD (LBS)	7800.
TOP KNUCKLE (LBS)	15190.
STRAIGHT SHELL (LBS)	17360.
BOTTOM KNUCKLE (LBS)	15220.
BOTTOM TAIL (LBS)	5920.
CONE SECTION (LBS)	2410.
TEN & COMP RINGS (LBS)	2520.
INSERT PLATES (LBS)	3000.
BALCONY GIRDER (LBS)	4680.
COLUMNS (LBS)	53090.
STRUTS (LBS)	2390.
TIE RODS (LBS)	7510.
RISER RODS (LBS)	770.
BASE PLATES (LBS)	2910.
RISER (LBS)	14610.
SMALL PIECES (LBS)	1220.
<hr/>	
TOTAL STEEL WEIGHT (LBS)	156490.
WEIGHT OF WATER (LBS)	2636570.
WEIGHT OF SNOW (LBS)	29360.
<hr/>	
TOTAL WEIGHT ON BASE	2822420.

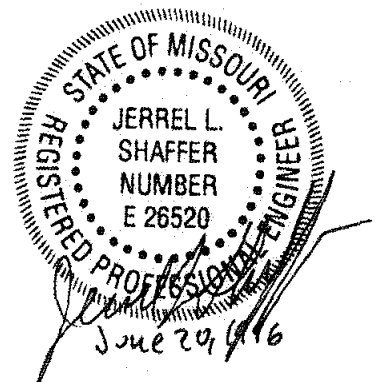
COLUMN FOUNDATION DESIGN LOADS

TOTAL VERTICAL LOADS AT BASE OF COLUMNS

WATER (LBS)	1957490.
STEEL (LBS)	133180.
SNOW (LBS)	29360.

MOMENTS AND SHEARS AT BASE

WIND MOMENT (FT-LBS)	3791760.
WIND SHEAR (LBS)	51930.
SEISMIC MOMENT (FT-LBS)	7001320.
SEISMIC SHEAR (LBS)	89620.



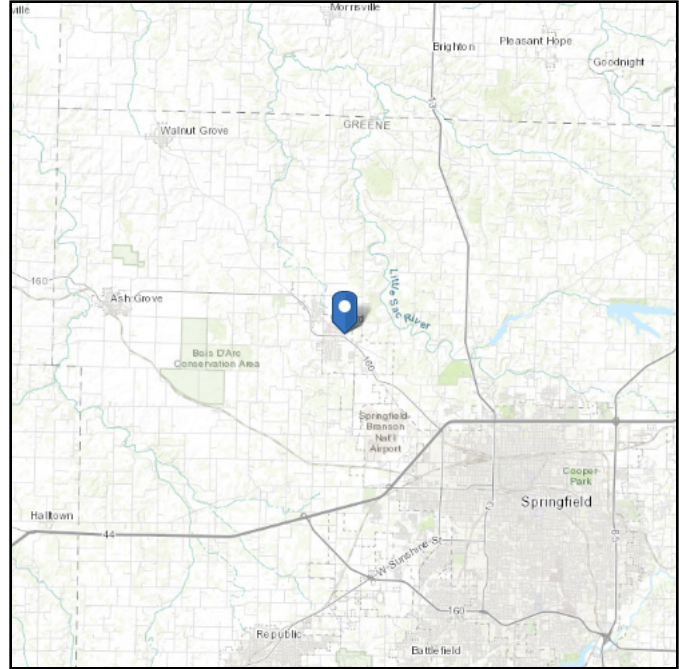
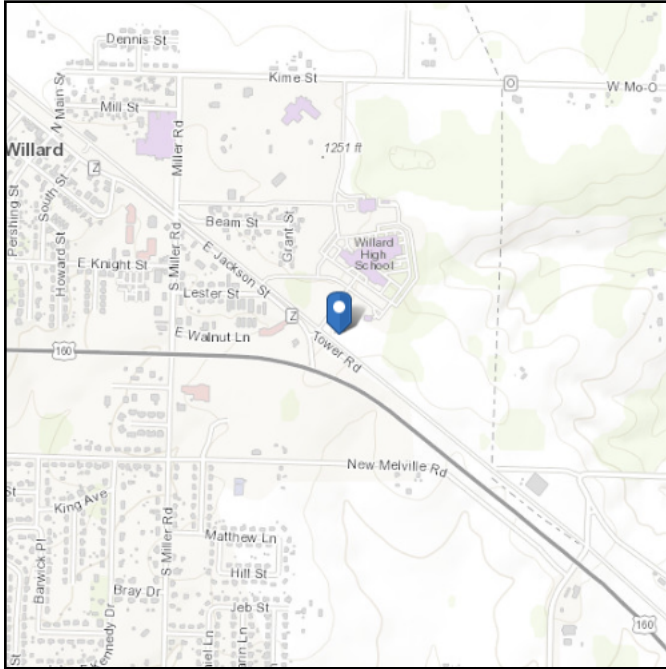


ASCE Hazards Report

Address:
No Address at This Location

Standard: ASCE/SEI 7-16
Risk Category: II
Soil Class: D - Default (see Section 11.4.3)

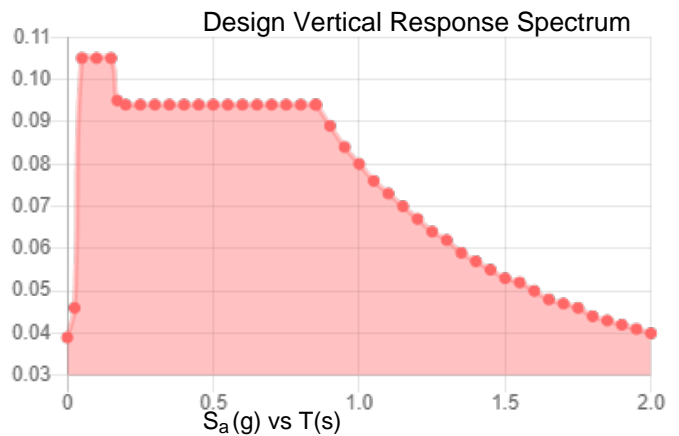
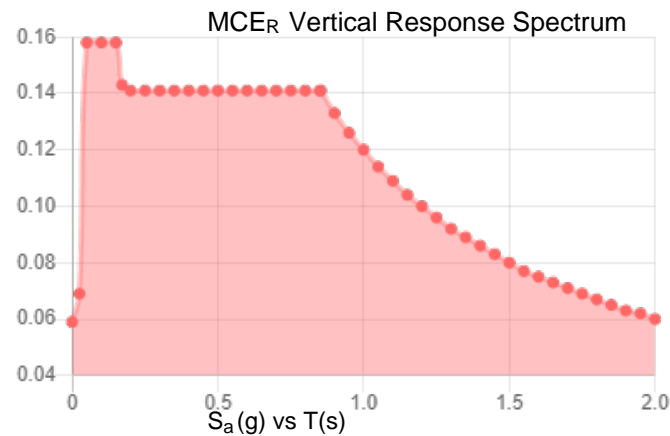
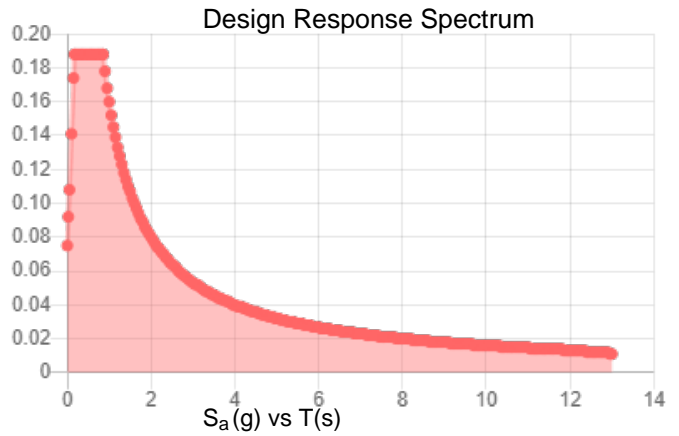
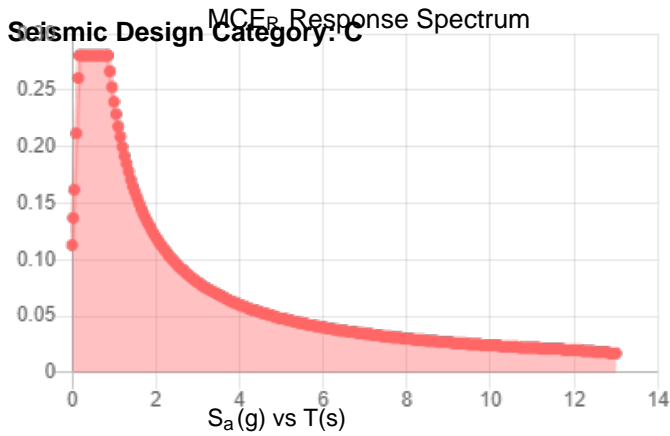
Latitude: 37.299261
Longitude: -93.418025
Elevation: 1239.9757962277806 ft (NAVD 88)



Site Soil Class: D - Default (see Section 11.4.3)

Results:

S_s :	0.176	S_{D1} :	0.16
S_1 :	0.1	T_L :	12
F_a :	1.6	PGA :	0.084
F_v :	2.4	PGA _M :	0.134
S_{MS} :	0.281	F_{PGA} :	1.6
S_{M1} :	0.24	I_e :	1
S_{DS} :	0.188	C_v :	0.7



Data Accessed: Thu Jul 25 2024

Date Source:

USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.

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