Location Restrictions Demonstrations

DTE Electric Company
River Rouge Power Plant Bottom Ash Basin
Coal Combustion Residual Unit

1 Belanger Park Drive
River Rouge, Michigan

October 2018

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Prepared For
DTE Electric Company

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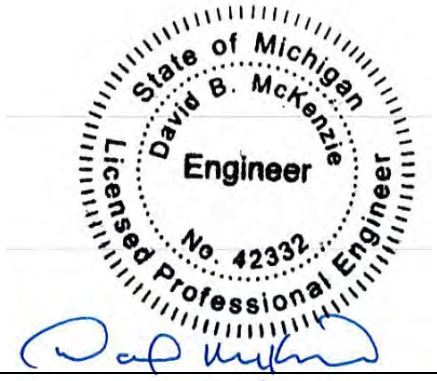
Certification

I, the undersigned Michigan 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 Michigan 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.



Seal/Date 10/15/18

David B McKenzie, P.E.

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Section 1
Background

The purpose of this document is to determine whether the Coal Combustion Residual (CCR) Bottom Ash Basin (BAB) at the River Rouge Power Plant (RRPP) is in compliance with the location restrictions outlined in the Environmental Protection Agency's (EPA) final 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 BAB is considered a CCR surface impoundment according to the federal rule (§257.53).

This document includes information from a desktop study and well installation activities, and also includes engineering calculations to demonstrate that the BAB complies with placement above the uppermost aquifer criteria (§257.60), and with location criteria with respect to wetlands (§257.61), fault areas (§257.62), seismic impact zones (§257.63), and unstable areas (§257.64).

Supporting documents are provided in appendices to this demonstration.

1.1 Facility and CCR Unit Information

The RRPP property is located at the confluence of the Rouge River and the Detroit River, at 1 Belanger Park Drive, within the City of River Rouge in Wayne County, Michigan. The RRPP was constructed in the early 1950s, just northeast of the DTE Electric RRPP. The BAB CCR unit was originally constructed during the power plant construction by incising 2H:1V side slopes into native site soils. In 1998, the impoundment was reconstructed in place by installing steel sheet pile walls around the perimeter of the BAB to an approximate depth of 30 feet below ground surface (ft bgs). The tip of the perimeter wall was installed to an elevation of 550 ft MSL and the top of the wall was cut at 580.33 ft MSL. The steel basin walls are tied back on 20-ft centers to a 10-ft deep secondary sheet pile anchor wall to maximize the stability of the basin perimeter sheeting. The base of the basin is maintained at a depth of 569 ft MSL by periodically dredging accumulated CCR.

The BAB is used for receiving sluiced bottom ash and other process flow effluent pumped from the power plant to the eastern end of the BAB. There is a sheet pile weir near the middle of the BAB that maintains the water elevation in the eastern portion to approximately 577.5 feet through gravity flow. The water in the western portion of the BAB is maintained at an elevation of no higher than 577 feet. Water in the western portion of the BAB is either recirculated back to the RRPP, discharged into the Detroit River in accordance with a National Pollution Discharge Elimination System (NPDES) permit, or may be discharged under permit to the City of River

Rouge sewer system for treatment at Wayne County's Downriver Wastewater Treatment Facility (DWTP). The CCR retained in the BAB is routinely cleaned out and either sold for beneficial reuse or is disposed at the Sibley Quarry Landfill (SQL).

1.2 Site Setting

The RRPP BAB CCR unit is located immediately adjacent to the Rouge River near the intersection of the Rouge River and Detroit River (Figure 1). A groundwater monitoring system has been established for the RRPP BAB CCR unit as detailed in the *Groundwater Monitoring System Summary Report – DTE Electric Company River Rouge Power Plant Bottom Ash Basin Coal Combustion Residual Unit* (GWMS Report) (TRC, October 2017). The detection monitoring well network for the BAB CCR unit currently consists of five monitoring wells that are screened in the uppermost aquifer. The monitoring well boring logs are included in Appendix A.

The RRPP CCR unit is underlain initially by approximately 10 feet of surficial fill of various composition (gravel, sand, silt and clay, brick and/or concrete fragments). The fill is partially saturated in some areas, but is not continuously saturated across the RRPP, does not represent a significant, usable source of water, and is, therefore, not an aquifer. An organic layer is often encountered beneath the surficial fill that is then underlain by a silt/clay-rich unit that ranges from 3 to about 8 feet thick near the BAB. Beneath the silt/clay-rich unit, there is a saturated sand and gravel unit that often coarsens from sand to gravel with depth. This coarse-grained sand and gravel unit is present from as shallow as 15 ft bgs to as deep as 25.5 ft bgs. This same coarse-grained unit is observed in most of the historical boring logs across the RRPP and appears to be a relatively continuous unit across the RRPP. The hydraulic conductivity measured in this unit using single well hydraulic conductivity tests (e.g., slug tests) ranged from 9.5 to 120 feet/day, with a geometric mean of approximately 25.5 feet/day. Based on this information, this coarse-grained sand and gravel unit represents the uppermost aquifer present at the RRPP BAB CCR unit.

The coarse-grained sand and gravel uppermost aquifer is underlain by a more than 60-foot-thick contiguous silty clay-rich deposit that serves as a natural lower confining hydraulic barrier that isolates the uppermost aquifer from the underlying Dundee limestone that represents the next aquifer. There is no apparent hydraulic connection between the uppermost aquifer and the Dundee limestone aquifer, and the limestone aquifer is artesian.

A definitive groundwater flow direction to the northeast with an average gradient of 0.00067 foot/foot (using data from June 2016 through September 2017) within the uppermost aquifer is evident around the RRPP BAB CCR unit, with potential groundwater velocities within the uppermost aquifer ranging from approximately 5.8 to 73 feet/year.

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, within wetlands, near fault areas, within seismic impact zones, and in unstable areas based on geologic and geomorphologic information. Supporting information for the demonstrations is included in the appendices to this report.

2.1 §257.60 – Placement above the Uppermost Aquifer

The federal CCR rule requires that CCR units such as the RRPP BAB 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 that 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). As stated in Section 1.1 (above), the perimeter of each BAB is constructed of steel sheet piling installed to a depth of approximately 30 ft below ground surface. The top of the wall elevation is 580.33 ft MSL and the tip of the wall elevation is 550 ft MSL. The design dredge depth for the basin is 569 ft MSL. The uppermost aquifer is found at an approximate elevation of 563 to 565.5 ft MSL. Cross-sections showing the installation top and bottom elevation of the sheet pile and approximate pond bottom elevation for the BAB are included in Appendix B.

Based on this demonstration, the base of the BAB is not located greater than five feet above the upper limit of the uppermost aquifer; therefore, the BAB is not in compliance with the requirements of §257.60 and is subject to closure requirements under 40 CFR 257.101(b)(1). Because of this condition, DTE Electric, beginning in late 2017, as a presumptive remedy designed, constructed and by March of 2018, initiated the operations of a groundwater capture system around the perimeter of the BAB to effectively control the uncertainty around the potential migration of CCR constituents from the RRPP BAB to groundwater. With this installed system operating continuously since March 2018, the groundwater level of the uppermost aquifer in the area of the BAB has been depressed, thereby maintaining groundwater hydraulic capture within the uppermost aquifer around the BAB.

2.2 §257.61 – Wetlands

The CCR location standards restrict existing and new CCR surface impoundments from being located in wetlands, as defined at 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 National Wetland Inventory (NWI) Maps and Michigan Resource Information System (MIRIS) Land Cover Maps archived and available through Michigan Department of Natural Resources (MDNR), Michigan Resource Inventory Program (MRIP) to ascertain whether or not the RRPP BAB is located in wetlands.

As shown on the site maps in Appendix C, soils along the Detroit River at the site are designated primarily as fluvial deposits and/or wetland soils. NWI (2005) recognizes one area located approximately ½-mile west of the BAB and along the Rouge River as a wetland. This wetland area is not immediately adjacent to the BAB, and therefore, there is no risk of impact to this area from the BAB operations.

Based on TRC's review of wetland inventory resources and current site conditions, TRC is of the opinion that the RRPP BAB is not located in an area exhibiting wetland characteristics, and any continued operations at the BAB will have no potential to impact any wetlands near the CCR unit. TRC also concludes that, due to their use as NPDES treatment units, these basins are not wetlands, as defined in 40 CFR 232.2.

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 (within the most recent 11,700 years) 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. As shown on the U.S. Quaternary Folds and Faults Database Map (USGS, Accessed 9/7/2018) in Appendix D, no faults have been mapped near the RRPP BAB.

Evidence of active faulting during the Holocene in the RRPP BAB area is not supported by this determination; therefore, the BAB 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 RRPP BAB is located in a seismic impact zone, the USGS Earthquake Hazards Program was consulted to determine the earthquake hazard for the RRPP. The 2015 National Earthquake Hazards Reduction Program U.S. seismic design maps website (USGS 2015; Appendix E) indicates a mapped peak ground acceleration of 0.053 g for the Station area. Using the default site adjustment factor results in a design peak ground acceleration of 0.085 g in 50 years. Since this calculation indicates that the design peak ground acceleration value will not exceed 0.10 g in 50 years, the RRPP BAB is not located in a seismic impact zone, and therefore, the RRPP BAB 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 reviewing geotechnical data, local geology and topography, and evaluating human-made features at the BAB area.

The geotechnical exploration performed at the RRPP BAB area identified a mix of silt, clay, sand, gravel, and fill overlying a sand and gravel uppermost aquifer. The uppermost aquifer is underlain be approximately 60 feet of firm silty clay which isolates the uppermost aquifer from the underlying Dundee limestone (Appendix B). These observations suggest that there are no unstable soil or underlying bedrock conditions proximal to the BAB. Additionally, the perimeter walls of the RRPP BAB are constructed of steel sheet pile driven through the surficial fill and sand/gravel and into the underlying clay, and these perimeter walls are tied back to driven steel sheets located 15 feet behind the BAB perimeter walls. These tie-backs further serve to stabilize the BAB walls and minimize potential for sidewall collapse.

Human-made features at the facility include seawall placement along portions of the Detroit River and Rouge River for shoreline protection to further minimize any instability of site soils caused by hydrologic forces from the adjacent water bodies.

Evidence of unstable areas due to soil conditions resulting in significant differential settling, geologic or geomorphologic features, or human-made features or events is not supported by this determination; therefore, the RRPP BAB is not located in an unstable area. The BAB is in compliance with the requirements of §257.64.

Section 3
Conclusions

Based on the evaluation provided in this demonstration, the RRPP BAB is in compliance with the location restrictions provided in §257.61 through §257.64 of the CCR rule. However, based on the evaluation provided in this demonstration, the RRPP BAB is not in compliance with the location restrictions provided in §257.60 of the CCR rule (due to placement of CCR within 5 ft of the uppermost aquifer) and is therefore subject to the closure requirements of 40 CFR 257.101(b)(1). A groundwater extraction system, installed around the perimeter of the BAB, has been operating continuously since March 2018 effectively capturing groundwater in the vicinity of the RRPP BAB CCR unit, and eliminates the potential for Appendix III and Appendix IV parameters to migrate from the RRPP BAB CCR unit. This demonstration will be placed into the operating record, posted to the publicly-accessible website, and government notifications provided.

Section 4
References

Cowardin, L.M., Carter, V., Golet, F.C., and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish & Wildlife Service Pub. FWS/OBS-79/31, Washington, DC.

TRC. January 2018. Annual Groundwater Monitoring Report – DTE Electric Company River Rouge Power Plant Bottom Ash Basin Coal Combustion Residual Unit.

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United States Fish and Wildlife Service. 2010. "Wetlands Mapper." National Wetlands Inventory. Available online at http://geohazards.usgs.gov/deaggint/2008/. Accessed [8/17/2018].

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USGS. U.S. Quaternary Faults and Fold Database. USGS Geologic Hazards Science Center, Golden, CO Available online at https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=db287853794f4555b8e93e42290e9716. Accessed [9/7/2018].

Appendix A
Monitoring Well Boring Logs

WELL CONSTRUCTION LOG

WELL NO. MW-16-01

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	6/13/16	6/13/16	231828.0005.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	580.46	583.02	26.5	6/4

Boring Location: N of bottom ash basin, farthest well to the E.	Personnel	Drilling Equipment:
N: 284822.46 E: 13463082.55	Logged By - C. Scieszka Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
River Rouge	Wayne	Michigan	While Drilling: Date/Time After Drilling: Date/Time 6/14/16 10:45 ▼ Depth (ft bgs) 5.38

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	PID (PPM)	COMMENTS
1 CS	100		0	**SILTY SAND WITH GRAVEL** mostly fine to medium sand, little fine to coarse gravel, little silt, dark gray (10YR 4/1) to brown (10YR 5/3), no odor, dry, loose.	SM			<1	Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
				GRAVEL WITH SAND mostly fine to coarse gravel, little fine to coarse sand, trace to few silt, gray (10YR 5/1), no odor, dry, loose.	GW			<1	
			5	**SILTY CLAY WITH GRAVEL** mostly clay, little silt, little fine to coarse gravel, low plasticity, black (10YR 2/1), no odor, dry, stiff, trace slag fragments. Change to slight odor at 5.5 feet.	CL-ML			<1	
2 CS	100			**SILTY SAND WITH GRAVEL** mostly fine to medium sand, little fine to coarse gravel, little silt, dark gray (10YR 4/1) to brown (10YR 5/3), no odor, dry, loose, trace brick fragments present. Change to black (10YR 2/1), strong odor, saturated, metallic sheen on soil grains at 8.5 feet.	SM			<1	
			10	**CLAY** mostly clay, trace silt, high plasticity, dark gray (10YR 4/1), slight hydrocarbon odor, moist, soft. Change to no odor at 10.0 feet.	CL				
3 ST	100								
4 CS	100		15	**SANDY SILT** mostly silt, some fine to medium sand, trace clay, very low plasticity, dark gray (10YR 4/1), no odor, saturated, stiff.	ML				
				SAND mostly fine to medium sand, trace to few silt, dark gray (10YR 4/1), no odor, saturated, dense.	SP				
			20						
5 CS	100			**SILTY CLAY** mostly clay, little silt, low to medium plasticity, dark gray (10YR 4/1), no odor, moist, stiff to very stiff.	CL-ML				
					GW				
			25	**GRAVEL** mostly fine to coarse gravel, few fine to coarse sand, trace silt, dark gray (10YR 5/1), no odor, saturated, loose.	CL				
				CLAY mostly clay, trace silt, high plasticity, brown (10YR 5/3), no odor, moist, very soft. End of boring at 26.5 feet below ground surface.					

SOIL BORING WELL CONSTRUCTION LOG 231828.0005.0000.GPJ TRC_CORP.GDT 231828.0005.0000 7/13/16

Signature: [signature]

Checked By: M. Powers

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WELL CONSTRUCTION LOG

WELL NO. MW-16-02

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	6/10/16	6/13/16	231828.0005.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	579.86	582.79	25.5	6/4

Boring Location: N of bottom ash basin, middle well.	Personnel	Drilling Equipment:
N: 284900.37 E: 13462923.81	Logged By - C. Scieszka Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
River Rouge	Wayne	Michigan	While Drilling: Date/Time After Drilling: Date/Time 6/14/16 10:50 ▼ Depth (ft bgs) 4.87

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	PID (PPM)	COMMENTS
1 CS	100		0	**GRAVEL WITH SAND** mostly fine to coarse gravel, few to little fine to coarse sand, trace silt, dark grayish brown (10YR 4/2), no odor, dry, loose. Change to few silt, trace clay, trace slag fragments present at 2.0 feet.	GW			<1	Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
			5 ▼	**SILTY SAND WITH GRAVEL** mostly fine sand, few to little silt, few to little fine to coarse gravel, dark gray (10YR 4/1), no odor, dry, loose. Change to moist, brick fragments present at 5.5 to 6.0 feet.	SM			<1	
2 CS	90			**SAND** mostly fine to coarse sand, trace to few silt, trace fine to coarse gravel, gray (10YR 5/1), no odor, saturated, medium dense.	SW			15.3	
			10	**PEAT** black (10YR 2/1), no odor, moist, soft, wood chip fragments present.					
3 ST	75			**SANDY SILT** mostly silt, little fine sand, trace to few clay, low plasticity, very dark gray (10YR 3/1), no odor, moist, stiff.	ML				
			15						
4 CS	100			**SILTY SAND** mostly fine sand, little silt, dark gray (10YR 4/1), no odor, saturated, dense.	SM				
			20	**SAND** mostly fine to medium sand, dark gray (10YR 4/1), no odor, saturated, loose. Change to mostly fine to coarse sand at 20.0 feet.	SP				
5 CS	100			Change to wood fragment present, approximately 1-inch thick interval at 21.5 feet. Change to few shells present at 22.0 feet.	CL				
				CLAY mostly clay, trace silt, high plasticity, gray (10YR 5/1), no odor, moist, stiff.	GW				
			25	**GRAVEL** mostly fine to coarse gravel, few fine to coarse sand, color varies with grain, no odor, saturated, loose.	CL				
				CLAY mostly clay, trace silt, high plasticity, brown (10YR 5/3), no odor, moist, very soft. End of boring at 25.5 feet below ground surface.					

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Signature: Clin Scieszka

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WELL CONSTRUCTION LOG

TRC

WELL NO. MW-16-03

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	6/10/16	6/10/16	231828.0005.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	579.90	582.75	30.0	6/4

Boring Location:	Personnel	Drilling Equipment:
N of bottom ash basin, farthest well to the W. N: 285003.95 E: 13462772.52	Logged By - C. Scieszka Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
River Rouge	Wayne	Michigan	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time 6/14/16 10:55 ▼ Depth (ft bgs) 5.14

SAMPLE Number and Type	Recovery (%)	Blow Counts	Depth in Feet	Lithologic Description	USCS	PID (PPM)	Comments
1 CS	95		0	**GRAVEL** mostly coarse gravel, light gray (10YR 7/1), no odor, moist, very loose.	GP		Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
				SILTY CLAY mostly clay, some silt, low plasticity, brown (10YR 4/3), no odor, dry, stiff.	CL-ML	<1 <1 1.1	
			5 ▼				
2 CS	50					27.5	
			10	**SAND** mostly medium to coarse sand, trace silt, trace fine to coarse gravel, black (10YR 2/1), moderate to strong odor, moist, loose.	SP	129.6	
3 ST	80			**PEAT** black (10YR 2/1), moderate to strong odor, moist, soft. Change to wood and high organic content present at 10.5 feet.	CL		
4 CS	100		15	**CLAY** mostly clay, trace silt, trace fine sand, high plasticity, black (10YR 2/1), to dark gray (10YR 4/1), moderate odor, soft to medium stiff. **SANDY SILT** mostly silt, little fine sand, non plastic, dark gray (10YR 4/1), slight odor, saturated, stiff. Change to no odor at 16.0 feet.	ML		
				SAND mostly medium to coarse sand, trace silt, dark gray (10YR 5/1), no odor, saturated, loose. Change to trace to few silt at 17.5 feet. Change to no silt at 19.5 feet.	SP		
5 CS	100		20	**SAND WITH GRAVEL** mostly medium to coarse sand, little fine to coarse gravel, trace silt, dark gray (10YR 4/1), no odor, saturated, loose.	SP		
			25	**CLAY** mostly clay, trace silt, trace coarse sand, high plasticity, gray (10YR 5/1), no odor, moist, very soft to soft.	CL		
			30	End of boring at 30.0 feet below ground surface.			

Signature: [signature]

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WELL CONSTRUCTION LOG

WELL NO. MW-16-04S

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	4/6/16	4/6/16	231828.0005.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	580.65	582.41	25.0	6/4

Boring Location: 10 feet west of MW-16-04.	Personnel	Drilling Equipment:
N: 284814.39 E: 13462847.74	Logged By - A. Knutson Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
River Rouge	Wayne	Michigan	While Drilling: Date/Time — Depth (ft bgs) After Drilling: Date/Time 6/14/16 11:04 ▼ Depth (ft bgs) 4.10

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	PID (PPM)	COMMENTS
			0	**SAND** mostly fine to coarse sand, few fine to coarse gravel, trace silt, dark gray (10YR 4/1), no odor, dry, loose.	SW				Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
				GRAVEL WITH SAND mostly coarse gravel, some fine to coarse sand, trace silt, dark gray (10YR 4/1), no odor, saturated. ▼	GP			<1.0	
1 CS	90		5	**SAND** mostly fine to coarse sand, yellowish brown (10YR 5/8), no odor, saturated.	SW				
				SILT mostly silt, few fine to coarse sand, dark gray (10YR 4/1), no odor, saturated, brick fragments present.	ML			<1.0	
				CLAY mostly clay, few silt, trace fine to coarse gravel, medium plasticity, no odor, moist.	CL				
2 CS	90		10	**PEAT** high organic content, dark brown (10YR 2/2), natural organic odor, moist, soft, wood fragments present.				<1.0	
3 ST	100			**SANDY SILT** mostly silt, few to little sand, nonplastic, dark gray, no odor, moist, medium stiff.	ML				
4 CS	100		15	**SILTY SAND** mostly fine sand, few to little silt, dark gray (10YR 4/1), no odor, moist to saturated.	SP			<1.0	
				SAND mostly fine to coarse sand, dark gray (10YR 4/1), no odor, saturated.	SW				
5 CS	100		20	Change to shells present at 23.0 feet.				<1.0	
				GRAVEL mostly fine to coarse gravel, few fine to coarse sand, dark gray (10YR 4/1), no odor, saturated, loose.	GW				
			25	**CLAY** mostly clay, trace silt, high plasticity, brown (10YR 5/3), no odor, moist, soft.	CL				
				End of boring at 25.0 feet below ground surface.					

SOIL BORING WELL CONSTRUCTION LOG 231828.0005.0000.GPJ TRC_CORP.GDT 231828.0005.0000 7/13/16

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WELL CONSTRUCTION LOG

WELL NO. MW-16-04D

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	2/23/16	2/25/16	231828.0005.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stock Drilling	Sonic	580.28	581.83	97.0	6

Boring Location: 100 feet east of basin bridge, 25 feet south of basin.	Personnel	Drilling Equipment:
N: 284811.70 E: 13462855.24	Logged By - C. Scieszka Driller - A. Goldsmith	TSi 150cc

Civil Town/City/or Village:	County:	State:	Water Level Observations:
River Rouge	Wayne	Michigan	While Drilling: Date/Time Depth (ft bgs) After Drilling: Date/Time Depth (ft bgs)

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 CS	55		5	**SAND** mostly fine to coarse sand, trace to few silt, trace fine gravel, dark gray (10YR 4/1), no odor, dry, loose.	SW			Continuous sampling with 4-inch diameter casing from ground surface to terminus of soil boring, over-drilled with 6-inch diameter casing to install monitoring well.
				SAND WITH SILT mostly fine to coarse sand, few to little silt, dark gray (10YR 4/1), no odor, moist, medium dense.	SW-SM			
			10	**SILTY CLAY** mostly clay, little to some silt, trace to few fine to coarse gravel, medium plasticity, dark gray (10YR 4/1), no odor, moist, soft to medium stiff.	CL-ML			
2 CS	90		15	**PEAT** high organic content, very dark brown (10YR 2/2), natural organic odor, moist, soft to medium stiff.	ML			
				SANDY SILT mostly silt, little to some fine sand, nonplastic, dark gray (10YR 4/1), no odor, moist, medium stiff.				
				SILTY SAND mostly fine sand, little silt, dark gray (10YR 4/1), no odor, moist, medium dense.	SM			
			20	**SAND** mostly fine sand, trace silt, dark gray (10YR 4/1), no odor, saturated, loose.	SP			
				Change to wood fragment present at 21.0 feet.				
3 CS	100			**GRAVEL WITH SAND** mostly fine to coarse gravel, little to some sand, dark gray (10YR 4/1), no odor, saturated, loose.	GW			
			25	**CLAY** mostly clay, trace silt, high plasticity, brown (10YR 5/3), no odor, moist, very soft.				
			30	Change to trace fine gravel, trace coarse sand at 30.0 feet.	CL			
4 CS	90		35					
			40					

SOIL BORING WELL CONSTRUCTION LOG 231828.0005.0000.GPJ TRC_CORP.GDT 231828.0005.0000 7/13/16

Signature: _____

Firm: TRC Environmental Corporation
1540 Eisenhower Place Ann Arbor, Michigan
734-971-7080
Fax 734-971-9022

Checked By: M. Powers

WELL CONSTRUCTION LOG

WELL NO. MW-16-04D

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
5 CS	90		45					
6 ST	90		50					
7 CS	100		55					
8 CS	100		60		CL			
9 CS	75		65					
			70					
			75	Change to gray (10YR 5/1) at 79.0 feet.				
10 CS	80		80	**SILTY CLAY** mostly clay, little to some silt, trace to few fine to coarse gravel, trace to few fine to coarse sand, low plasticity, dark gray (10YR 4/1), no odor, dry, hard.	CL-ML			
			85	**LIMESTONE** white (10YR 8/1), dry, slight to moderate sulfur odor. Change to wet at 88.0 feet.				
11 CS	50		90	Change to dark gray (10YR 4/1) at 90.0 feet.				
			95	Change to white (10YR 8/1) at 96.0 feet.				
				End of boring at 97.0 feet below ground surface.				

SOIL BORING WELL CONSTRUCTION LOG 231828.0005.0000.GPJ TRC_CORP.GDT 231828.0005.0000 7/13/16

WELL CONSTRUCTION LOG

TRC

WELL NO. MW-17-06

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	6/6/17	6/7/17	277472.0000.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stearns Drilling	Direct Push	579.9	583.01	25.0	3.75

Boring Location: E side of grassy berm located N of parking lot SW of power plant building.
N: 284345.83 E: 13462436.31

Personnel
Logged By - C. Scieszka
Driller - G. Geerligs

Drilling Equipment: Geoprobe 7822DT

Civil Town/City/or Village:	County:	State:
River Rouge	Wayne	Michigan

Water Level Observations:
While Drilling: Date/Time 6/6/17 00:00 ▽ Depth (ft bgs) 15.5
After Drilling: Date/Time 6/7/17 09:00 ▼ Depth (ft bgs) 3.99

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	PID (PPM)	COMMENTS
1 GP	70		0	**GRAVEL WITH SAND** mostly fine to coarse gravel, little fine to coarse sand, trace silt, dark grayish brown (10YR 4/2), no odor, dry, dense.				<1	
				SANDY CLAY mostly clay, little to some fine to medium sand, trace silt, trace fine gravel, low plasticity, very dark gray (10YR 3/1), no odor, moist, stiff to very stiff, fill.				<1	
			5	0.5-inch thick interval of brick at 4.5 feet.					
2 GP	50							<1	
								<1	
3 GP	50		10	**SILTY GRAVEL WITH SAND** mostly fine to coarse gravel, some silt, little fine to coarse sand, trace clay, black (10YR 2/1), no odor, hard, dry, trace fine slag and coal fragments present.	GM			<1	
				PEAT 2-inch thick interval of peat, black (10YR 2/1), slight natural odor, moist, soft.	CL				
				CLAY WITH SAND mostly clay, few to little fine to medium sand, low to medium plasticity, dark gray (10YR 4/1), no odor, moist, medium stiff.	CL			<1	
4 GP	60		15	Grades to **SANDY CLAY** mostly clay, little to some fine to medium sand, low plasticity, light olive gray (5Y 7/2), no odor, moist, medium stiff.					
				SILTY SAND mostly fine sand, little silt, dark gray (10YR 4/1) with yellowish brown (10YR 5/6) mottles, no odor, saturated, dense.	SM				
5 GP	70		20	Change to trace fine to coarse gravel at 20.0 feet.					
				GRAVEL WITH SAND mostly fine to coarse subrounded gravel, little medium to coarse sand, dark gray (10YR 4/1), no odor, saturated, dense.	GW				
			25	**CLAY** mostly clay, trace fine to medium sand, trace silt, medium plasticity, dark grayish brown (10YR 4/2), no odor, moist, medium stiff.	CL				
				End of boring at 25.0 feet below ground surface.					

SOIL BORING WELL CONSTRUCTION LOG 277472 (2017 MWS).GPJ TRC_CORP.GDT 8/28/17

Signature: [signature]

Checked By: T. Hess

Firm: TRC Environmental Corporation
1540 Eisenhower Place Ann Arbor, MI 48108
734.971.7080
Fax 734.971.9022

WELL CONSTRUCTION LOG

WELL NO. MW-17-07

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
DTE Electric Company River Rouge Power Plant	6/14/17	6/14/17	277472.0000.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stearns Drilling	Direct Push/Hollow Stem Auger	580.0	583.05	25.0	8/3.75/2

Boring Location: N of entrance road, near Belanger Park entrance, adjacent to S property boundary.
N: 283337.37 E: 13461939.92

Personnel
Logged By - C. Scieszka
Driller - G. Geerligs

Drilling Equipment: Geoprobe 7822DT

Civil Town/City/or Village:	County:	State:
River Rouge	Wayne	Michigan

Water Level Observations:
While Drilling: Date/Time 6/14/17 00:00 ▽ Depth (ft bgs) 2.5
After Drilling: Date/Time 6/15/17 11:45 ▼ Depth (ft bgs) 3.44

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	PID (PPM)	COMMENTS
1 GP	90		0	**SILTY SAND** mostly fine to medium sand, little to some silt, trace to few fine gravel, brown (10YR 5/3), no odor, dry, loose.	SM			<1	Soil sample and duplicate sample collected (0-2') at 1100.
				SILTY CLAY WITH SAND AND GRAVEL mostly clay, some silt, few to little fine to coarse sand, few to little fine to coarse gravel, no to low plasticity, very dark brown (10YR 3/3), no odor, dry, stiff, trace to few slag, cinder, and wood fragments present.	CL-ML				
2 GP	100		5	**COAL WITH SLAG FILL** mostly fine to medium sand sized coal fragments, few to little slag fragments, trace silt, black (10YR 2/1), no odor, saturated, medium dense. Change to slight hydrocarbon odor, very slight sheen on pore water at 5.0 feet.					
				CLAY mostly clay, trace silt, medium plasticity, dark gray (10YR 4/1), no odor, moist, soft.	CL				
3 GP	80		10	**PEAT** high organic content, woody, very dark brown (10YR 3/3), no odor, dry to moist, spongy.					Hollow stem augers set at 10.0 feet below ground surface prior to drilling through confining clay unit.
				CLAY mostly clay, trace to few silt, medium plasticity, black (10YR 2/1), no odor, moist, soft. Change to no silt, greenish gray (GLEY1 5/1), medium stiff at 11.0 feet.	CL				
			15	Change to dark gray (10YR 4/1) at 15.0 feet.					
4 GP	85			**SILT WITH SAND** mostly silt, few to little fine to medium sand, no plasticity, gray (10YR 5/1), no odor, moist to saturated, stiff.	ML				
				Change to brown (10YR 5/3) at 18.5 feet.					
5 GP	90		20	**CLAY** mostly clay, trace silt, medium plasticity, gray (10YR 5/1), no odor, moist, medium stiff. 0.25-inch thick sand with gravel seam, mostly fine to coarse sand, few to little fine gravel, yellowish brown (10YR 5/6), no odor, saturated, dense at 20.5 feet. Change to trace coarse sand to fine gravel, gray (10YR 5/1) with light reddish brown (5YR 6/4) mottles, dry to moist, very stiff at 21.0 feet.	CL				
			25	Change to moist, medium stiff at 24.0 feet. End of boring at 25.0 feet below ground surface.					

SOIL BORING WELL CONSTRUCTION LOG 277472 (2017 MWS).GPJ TRC_CORP.GDT 8/28/17

Signature: [signature]

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Checked By: T. Hess

Appendix B
Cross Sections

LEGEND

- DOWN-GRADIENT WELL
- UP-GRADIENT WELL
- MONITORING POINT
- BEDROCK MONITORING WELL
- CROSS SECTIONS

NOTES

1. BASE MAP IMAGERY FROM ESRI/MICROSOFT, "WORLD IMAGERY", WEB BASEMAP SERVICE LAYER.
2. WELL LOCATIONS SURVEYED BY BMJ ENGINEERS AND SURVEYORS INC. IN JUNE 2016.

N

0 100 200 Feet

1 " = 100 '

1:1,200

PROJECT:

DTE ELECTRIC COMPANY
RIVER ROUGE POWER PLANT BOTTOM ASH BASINS
1 BELANGER PARK DRIVE
RIVER ROUGE, MICHIGAN

TITLE:

CROSS-SECTION LOCATOR MAP

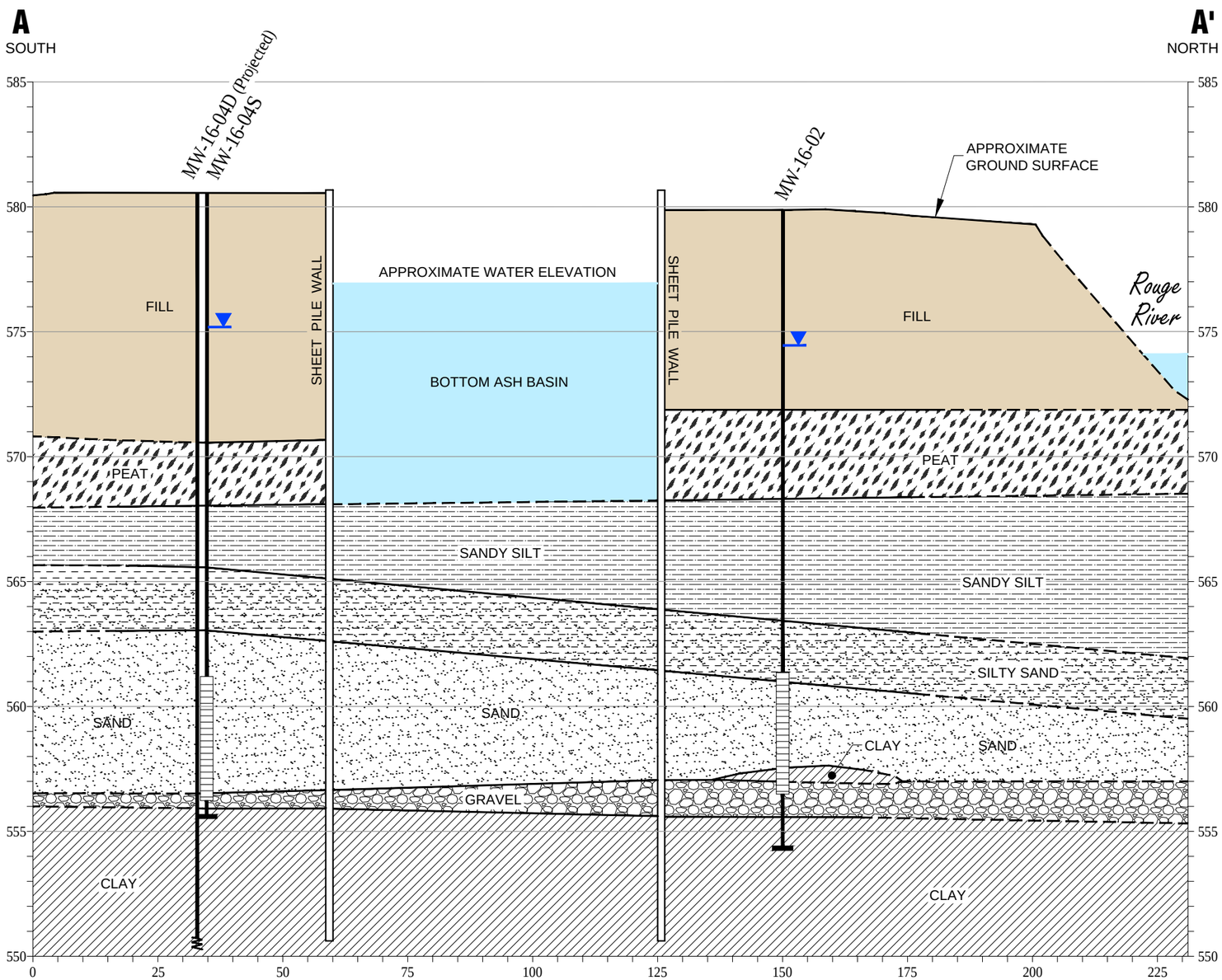
DRAWN BY:	B DEEGAN	PROJ NO.:	2254222.0005
CHECKED BY:	J.KRENZ		
APPROVED BY:	V.BUENING		**FIGURE B-1**
DATE:	FEBRUARY 2017		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 254222-0005-002.mxd

TRC - GIS
Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0
Plot Date: 2/23/2017, 11:56:22 AM by BDEEGAN -- LAYOUT: ANSI B(11"x17")
Path: E:\DTE\CCR_Sites\2016_231828\254222-0005-002.mxd

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 03/10/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

Lithology Key

- FILL
- PEAT
- CLAY
- SANDY SILT
- SILTY SAND
- SAND
- GRAVEL
- SAND WITH GRAVEL
- SILTY CLAY

NOTE

1. ROUGE RIVER WATER ELEVATION AT 574.10' IS APPROXIMATE.

SCALE IN FEET
VERTICAL 5 0
HORIZONTAL 0 25

PROJECT:
DTE ELECTRIC COMPANY
COAL COMBUSTIBLE RESIDUALS
RIVER ROUGE POWER PLANT
RIVER ROUGE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS-SECTION A-A'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0005
CHECKED BY:	J.KRENZ		
APPROVED BY:	V.BUENING		**FIGURE B-2**
DATE:	MAY 2017		

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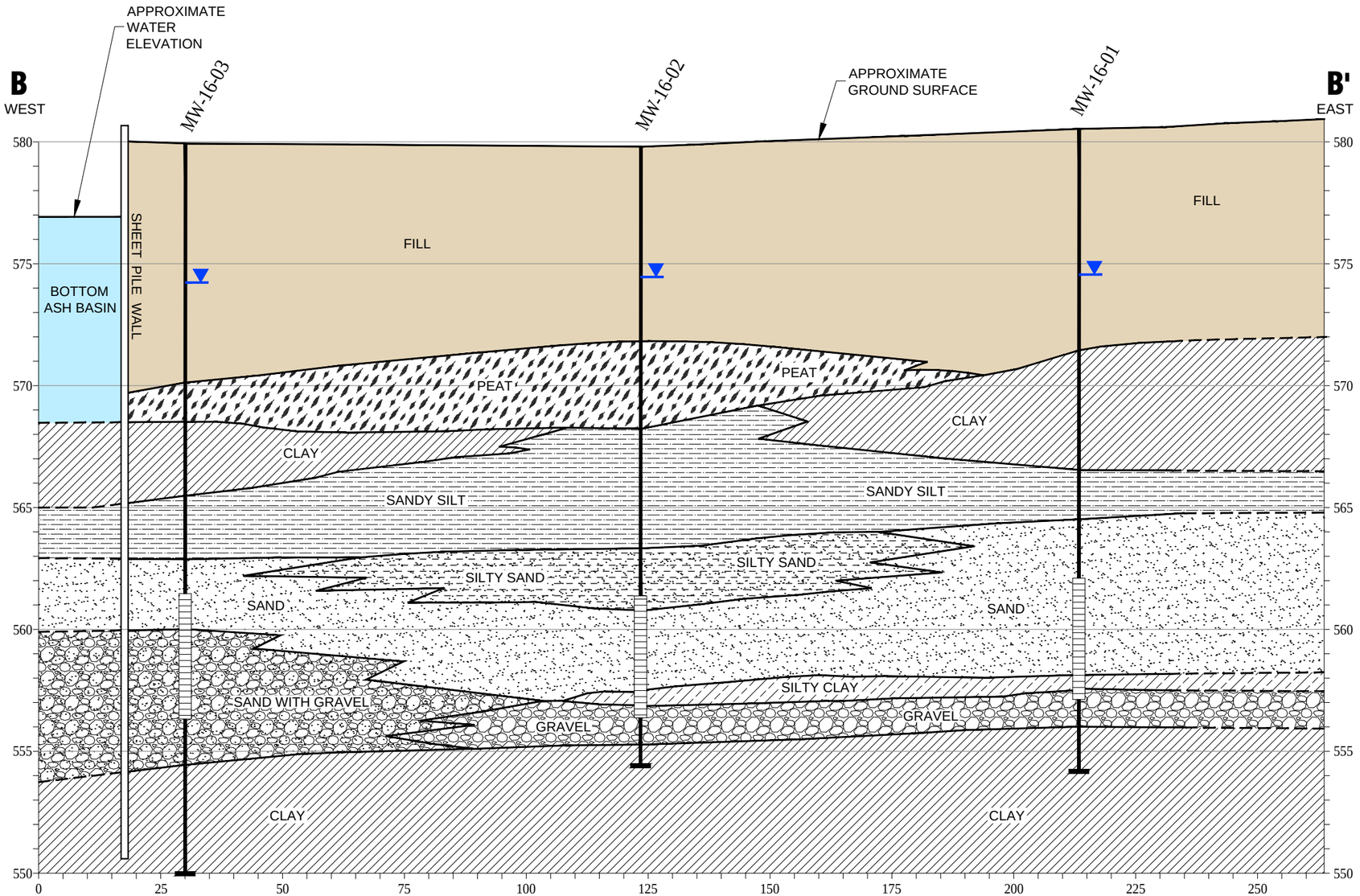
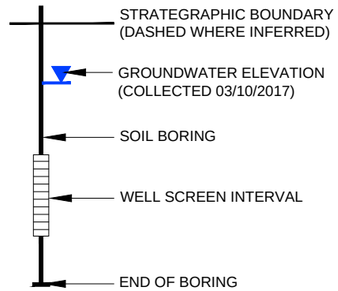
FILE NO.: 265996.0005.01.XS AA-BB.dwg

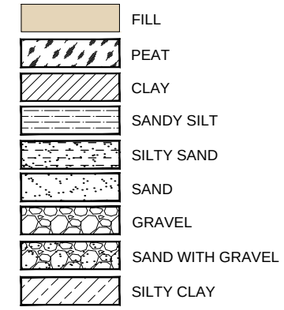
GENERALIZED GEOLOGIC CROSS-SECTION B-B'

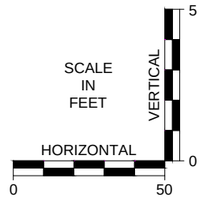


LEGEND



Lithology Key





PROJECT:	DTE ELECTRIC COMPANY COAL COMBUSTIBLE RESIDUALS RIVER ROUGE POWER PLANT RIVER ROUGE, MICHIGAN
TITLE:	GENERALIZED GEOLOGIC CROSS-SECTION B-B'

DRAWN BY:	D.STEHLE	PROJ NO.:	265996.0005
CHECKED BY:	J.KRENZ		
APPROVED BY:	V.BUENING		FIGURE B-3
DATE:	MAY 2017		

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Ann Arbor, MI 48108
Phone: 734.971.7080
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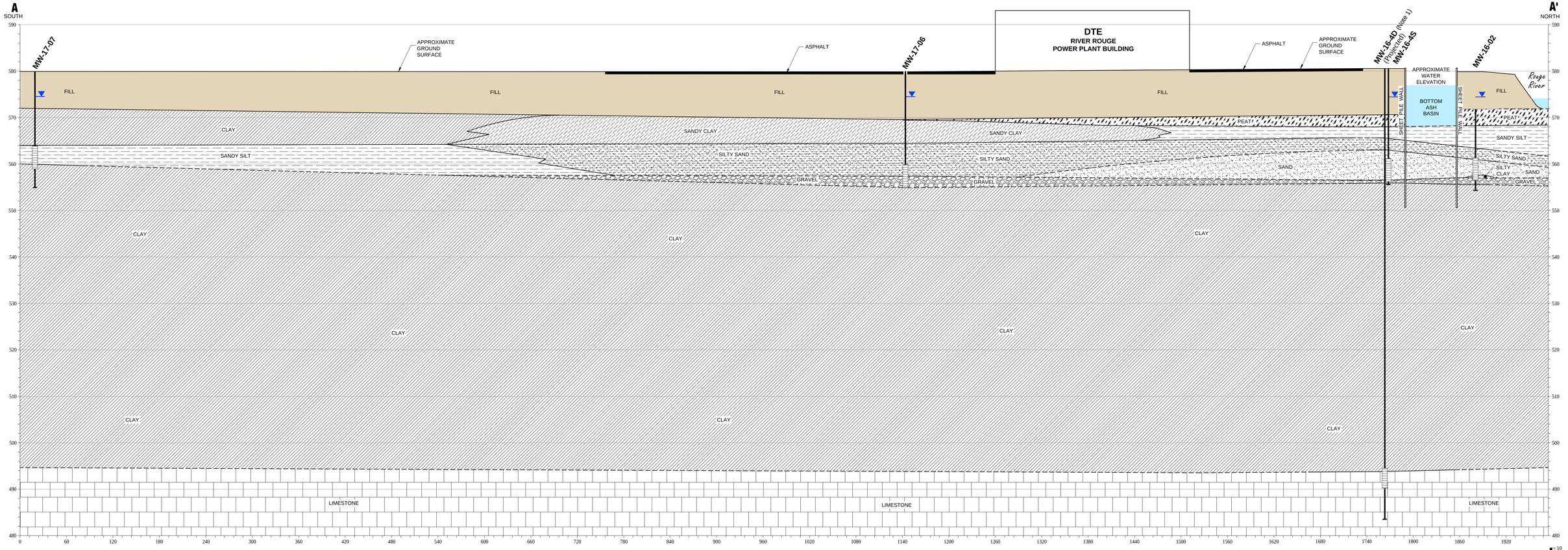
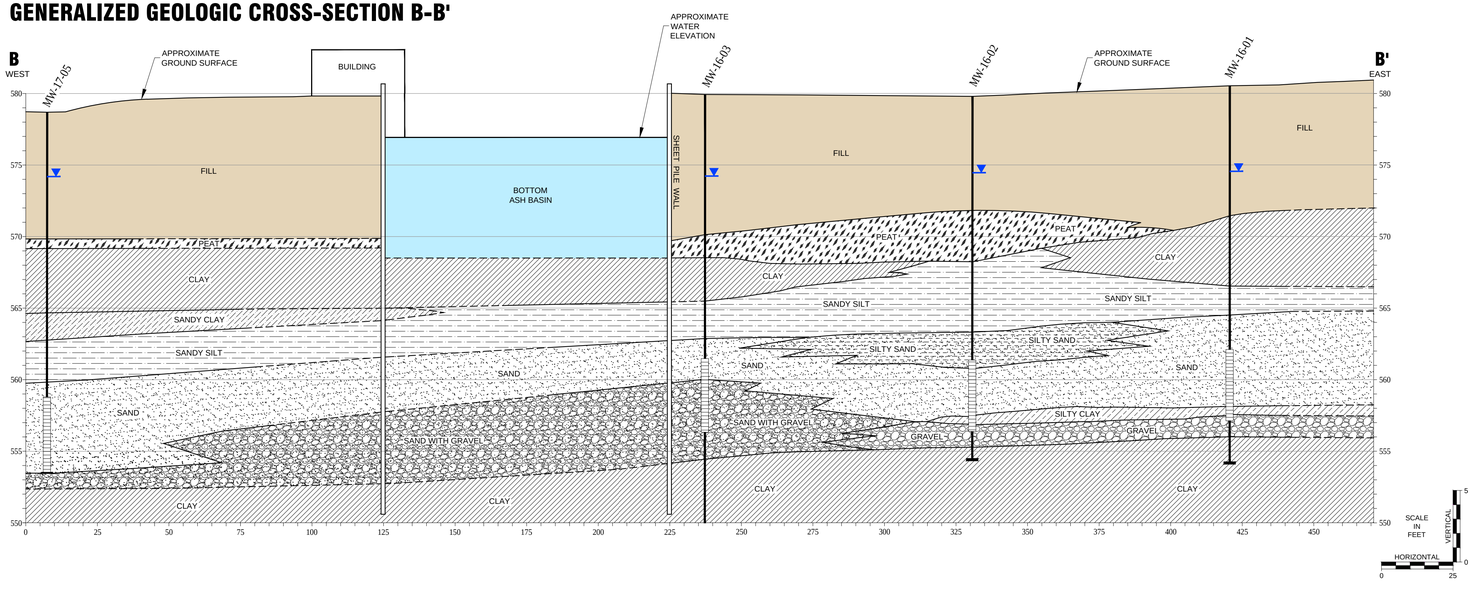
FILE NO.: 265996.0005.01.XS AA-BB.dwg

GENERALIZED GEOLOGIC CROSS-SECTION A-A'



GENERALIZED GEOLOGIC CROSS-SECTION B-B'



LEGEND

- STRATEGRAPHIC BOUNDARY (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (COLLECTED 03/10/2017)
- SOIL BORING
- WELL SCREEN INTERVAL
- END OF BORING

NOTE

1. ARTESIAN MONITORING WELL.

Lithology Key

- CLAY
- FILL
- GRAVEL
- LIMESTONE
- PEAT
- SAND
- SANDY CLAY
- SANDY SILT
- SILTY CLAY
- SILTY SAND

PROJECT:	DTE ELECTRIC COMPANY COAL COMBUSTION RESIDUALS RIVER ROUGE POWER PLANT RIVER ROUGE, MICHIGAN
TITLE:	GENERALIZED GEOLOGIC CROSS-SECTIONS A-A' AND B-B'
DRAWN BY:	D.STEHLE
CHECKED BY:	C.SCIESZKA
APPROVED BY:	V.BUENING
DATE:	SEPTEMBER 2017
PROJ. NO.:	265996.0005.01
	FIGURE B-4

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FILE NO.: 265996.0005.01.04.dwg

24x36 -- ATTACHED XREFS: -- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\DTE\River Rouge\265996\0005\01\ 265996.0005.01.04.dwg -- PLOT DATE: September 06, 2017 - 8:42AM -- LAYOUT: FIG04AA-BB

Version: 2017-03-03

Appendix C
National Wetland Inventory Map

Wetlands Map Viewer

August 17, 2018

Part 303 Final Wetlands Inventory

- Wetlands as identified on NWI and MIRIS maps
- Soil areas which include wetland soils
- Wetlands as identified on NWI and MIRIS maps and soil areas which include wetland soils
- Gage Stations
- National Wetlands Inventory 2005

1:15,307

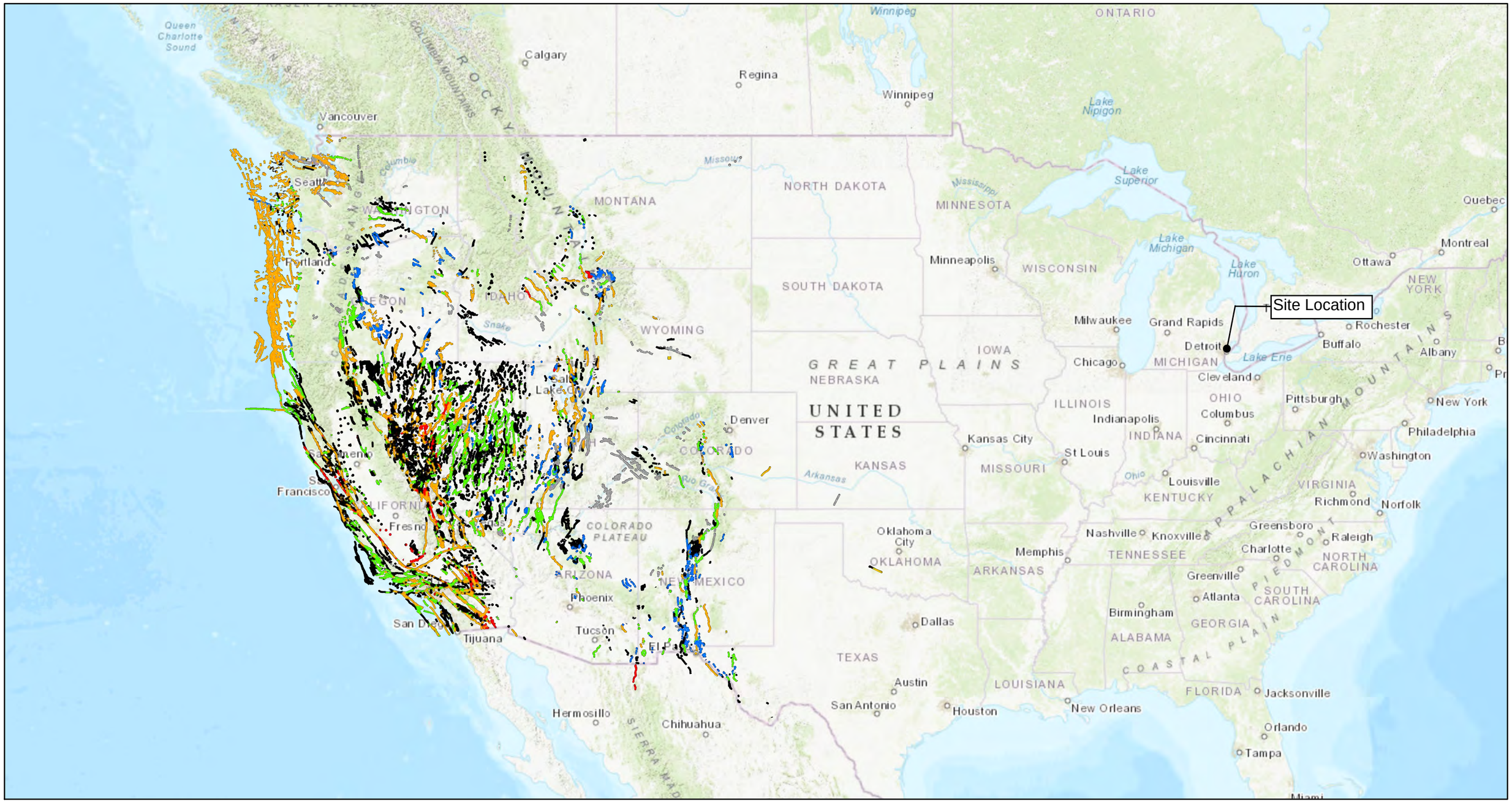
0 0.125 0.25 0.5 mi

0 0.2 0.4 0.8 km

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Appendix D
U.S. Quaternary Faults and Folds Map

US Quaternary Faults and Folds



9/7/2018, 3:20:39 PM

1:18,489,298

Quaternary faults

- unspecified age, well constrained location
- unspecified age, moderately constrained location
- unspecified age, inferred location
- undifferentiated Quaternary (< 130,000 years), well constrained location
- undifferentiated Quaternary (< 130,000 years), moderately constrained location
- undifferentiated Quaternary (< 130,000 years), inferred location
- middle and late Quaternary (< 1.6 million years), well constrained location
- middle and late Quaternary (< 1.6 million years), moderately constrained location
- middle and late Quaternary (< 1.6 million years), inferred location
- latest Quaternary (<15,000 years), well constrained location
- latest Quaternary (<15,000 years), moderately constrained location
- latest Quaternary (<15,000 years), inferred location
- late Quaternary (< 130,000 years), well constrained location

0 175 350 700 mi

0 275 550 1,100 km

Appendix E
U.S. Seismic Design Maps and Calculations

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.

RRPP BAB - Seismic Impact Zone

Latitude = 42.274°N, Longitude = 83.112°W

Location

Reference Document

2015 NEHRP Provisions

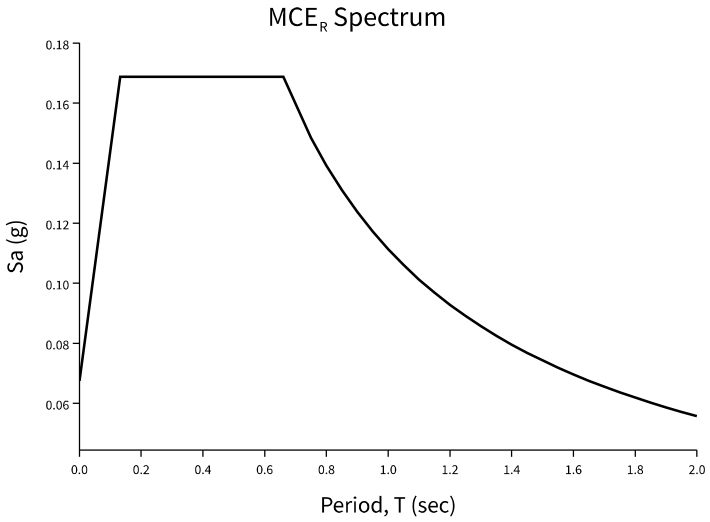
Site Class

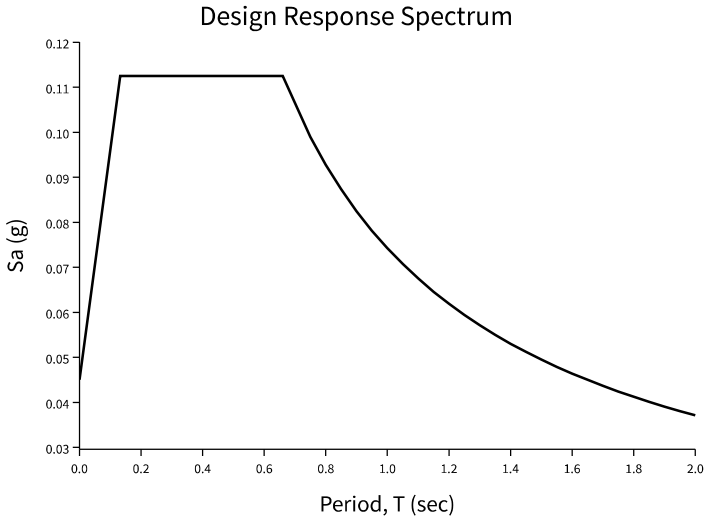
D (default): Stiff Soil

Risk Category

I or II or III

S_S =	0.105 g	**S_{MS} =**	0.169 g	**S_{DS} =**	0.113 g
S_1 =	0.046 g	**S_{M1} =**	0.111 g	**S_{D1} =**	0.074 g


MCE$_R$ Spectrum
Sa (g)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Period, T (sec)


Design Response Spectrum
Sa (g)
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Period, T (sec)

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)	$C_{RS}S_{SUH} = 0.946 \times 0.112 = 0.105$ g
Deterministic Ground Motion (0.2 s)	$S_{SD} = 1.500$ g
	$S_S \equiv$ "Lesser of $C_{RS}S_{SUH}$ and S_{SD}" = 0.105 g
Risk-targeted Ground Motion (1.0 s)	$C_{R1}S_{1UH} = 0.907 \times 0.051 = 0.046$ 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
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 = D (default) and S_S = 0.105 g, F_a = 1.600

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 = D (default) and S_1 = 0.046 g, F_v = 2.400

Site-adjusted MCE_R (0.2 s)

$$S_{MS} = F_a S_S = 1.600 \times 0.105 = 0.169 \text{ g}$$

Site-adjusted MCE_R (1.0 s)

$$S_{M1} = F_v S_1 = 2.400 \times 0.046 = 0.111 \text{ g}$$

Design Spectral Acceleration Parameters

Design Ground Motion (0.2 s)

$S_{DS} = ⅔\ S_{MS} = ⅔ \times 0.169 = 0.113$ g

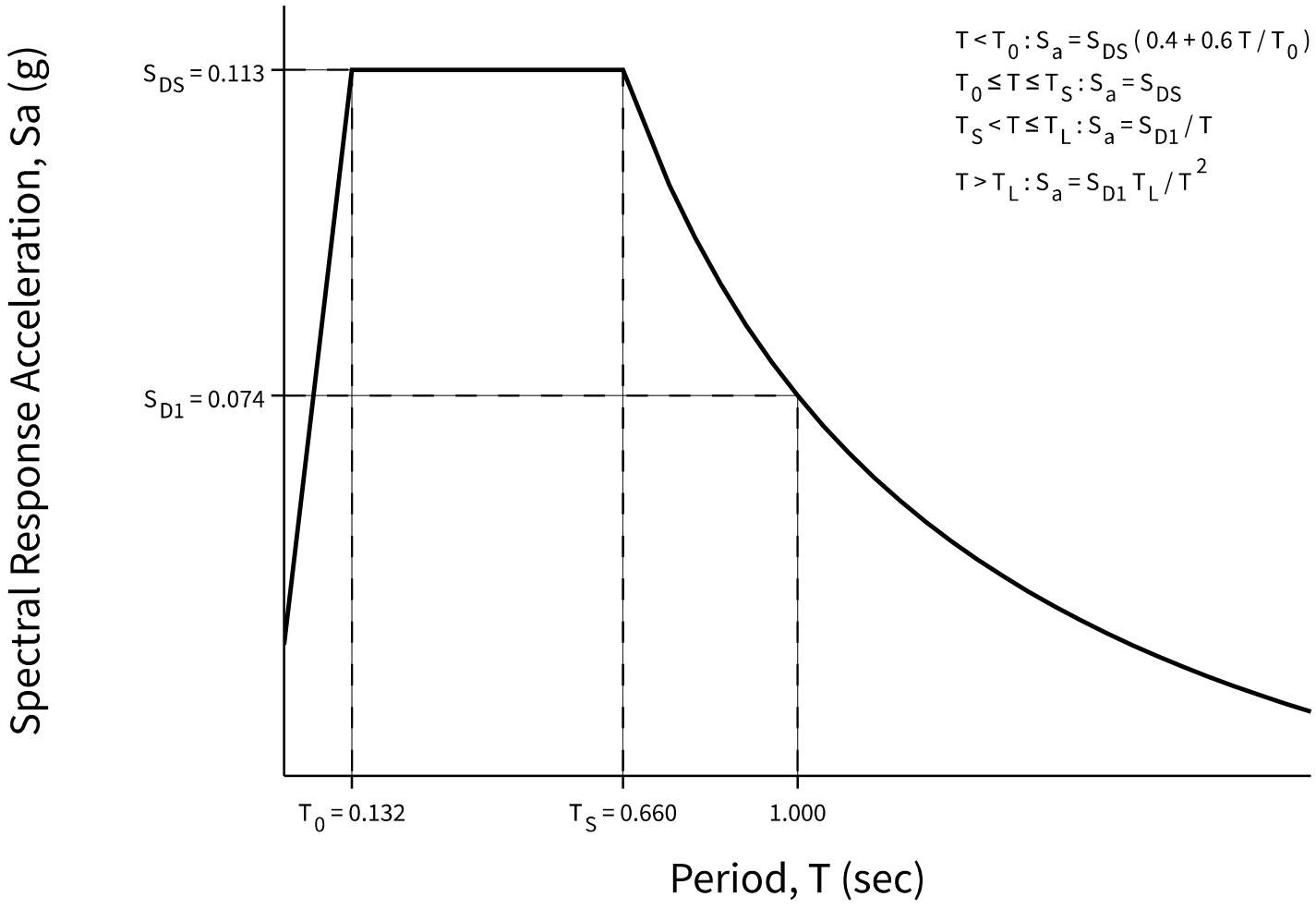
Design Ground Motion (1.0 s)

$S_{D1} = ⅔\ S_{M1} = ⅔ \times 0.111 = 0.074$ g

Design Response Spectrum

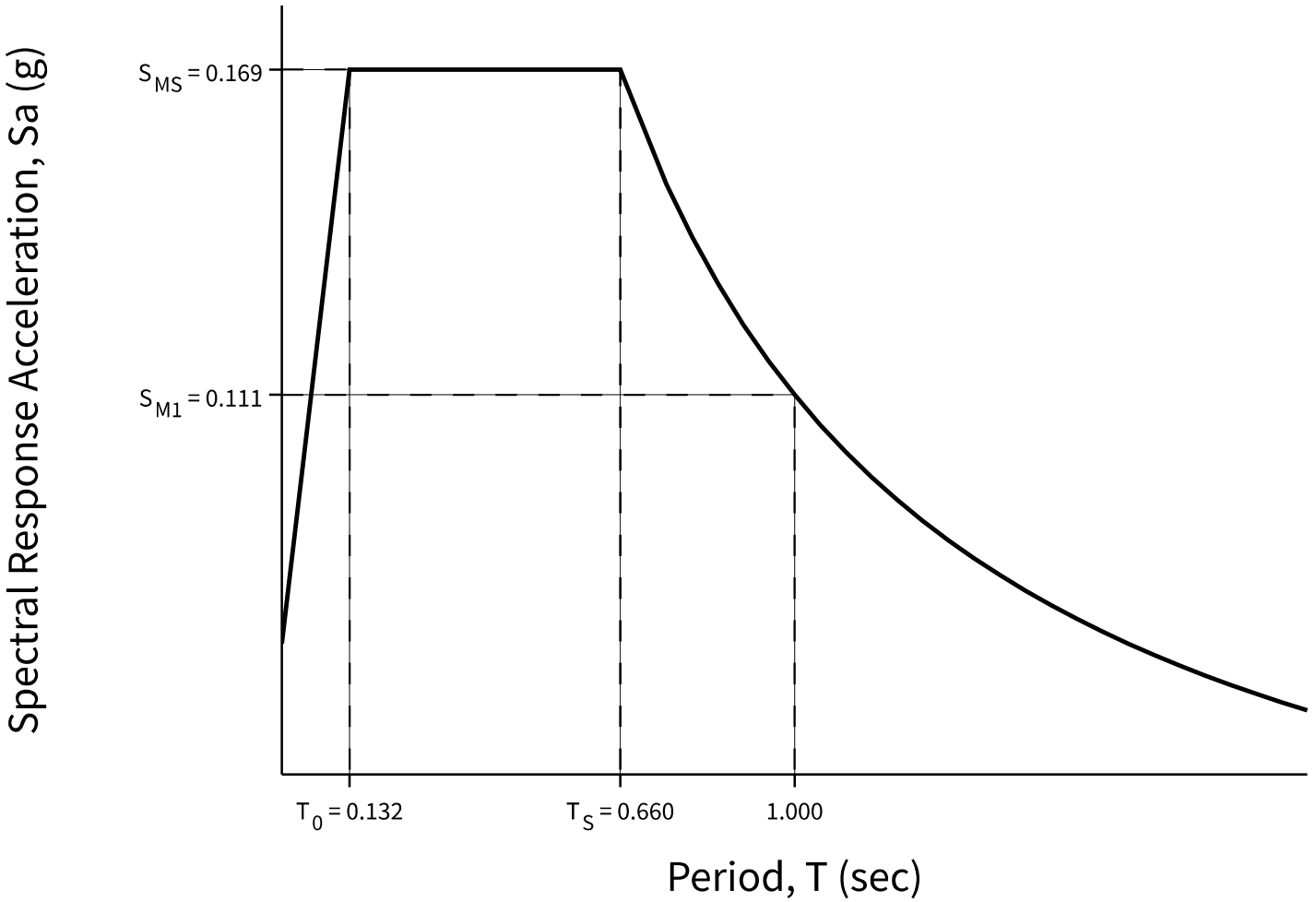
Long-Period Transition Period = T_L = 12 s

Figure 11.4-1: Design Response Spectrum



MCE_R Response Spectrum

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



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 = D (default) and PGA = 0.053 g, F_{PGA} = 1.600

Mapped MCE_G

PGA = 0.053 g

Site-adjusted MCE_G

$PGA_M = F_{PGA}PGA = 1.600 \times 0.053 = 0.085$ g