ATTACHMENT – T

GEOTECHNICAL REPORT
PART R-1

September 20, 2019

Revised Addendum Geotechnical Report

Metro Pentagon City Station Elevator Shaft Arlington County, Virginia

Project Number: GEO 110712.14A

Revised on September 20, 2019

Prepared for

STV Group Incorporated

2722 Merrilee Drive, Suite 350
Fairfax, Virginia 22031

Prepared by

14241 Midlothian Turnpike, Suite 230
Midlothian, VA 23113

Revised on September 20, 2019

STV Group Incorporated
2722 Merrilee Drive, Suite 350
Fairfax, Virginia 22031

Attention: Mr. Christopher Kocher, P.E.
Engineering Director

Re: Revised Addendum Geotechnical Report
Metro Pentagon City Station Elevator Shaft
Arlington County, Virginia

DMY Project Number: GEO 110712.14A

Dear Mr. Kocher:

DMY Inc. is pleased to submit this revised addendum geotechnical report for the proposed Metro Pentagon City Station elevator shaft located in Arlington County, Virginia. We are pleased to transmit herewith an electronic copy of our report.

Project Information

DMY Inc. provided a geotechnical report to STV Group Incorporated for the proposed Pentagon City Metrorail station elevator shaft on August 30, 2013. One boring of forty-five feet was conducted in the field for the project (Appendix). Based on the soil exploration program conducted in the field, laboratory testing results, and design information provided, DMY recommended a shallow mat foundation bearing on the compacted engineered fill, which requires approximately ten (10) feet undercut and backfill of the very loose sandy soils below the elevation of the mat foundation.

Based on the review comments from Washington Metropolitan Area Transit Authority (WMATA) in 2018, a deep foundation system in lieu of undercut and replacement of the soft soils is preferred method of construction.

Deep Foundation Recommendations

The one field soil boring conducted in 2013 indicated a layer of very loose sand soils encountered from elevation 10 to 20 feet. Below this loose sand soil, a layer of dense to very dense sand with gravel was encountered to the maximum boring depth of 45 feet deep. Based on our knowledge and experiences with local geology setting and other public records, including a report of subsurface exploration and geotechnical engineering analysis for South Clark Street bridge replacement located in Arlington County, Virginia, provided by ECS Mid-Atlantic LLC in 2014, it is our opinion that this dense to very dense alluvial deposit could extend to a significant depth below 45

feet. This soil profile is consistent with the description of regional geology contained in DMY's Geotechnical Report dated August 30, 2013.

Based on the 90% design plan provided by STV, the footprint of the proposed elevator shaft occupies an area of approximately 27' x 28'. The proposed shaft foundation is at approximate elevation of 19.0 feet. The ground surface is at approximate elevation 46 feet.

Given constrained construction space, considering the constructability of various foundation type, and WMATA design criteria, WMATA Standard Specifications, as an alternative to the shallow foundation recommended in the original geotechnical report, the elevator shaft mat foundation could be supported by helical piles bearing on dense to very dense sandy soils below approximately elevation 10.Based on the total load of 1,270 kips for the elevator shaft provided by STV, we recommend that individual helical pile be designed with ultimate bearing capacity of 180 kips. With factor of safety of 2, the maximum allowable bearing capacity for design should be 90 kips. The total settlement should be less than 0.5-inch, in our opinion.

Please note that a buckling analysis must be conducted for the helical piles due to very loose sandy soils encountered from elevation 10 to 20 feet (approximately 27 to 37 deep below the existing ground surface). The buckling analysis prescribed in ICC AC358 and the International Building Code (IBC) requires the piles to be designed as a free-standing columns when very soft or very loose soils are present. Should the unsupported pile length indicated by the available boring data be a limiting condition on the pile shaft design, it may be practical to perform a second boring near the project site with closer sample spacing to reduce the estimated design unsupported shaft length.

Please also note that individual helical pile should be spaced at minimum three time the diameter of the helix.

Per WMATA requirements for this project, at least one static pile load test should be conducted in accordance with ASTM D1143, Quick Load Test Method. The test equipment should have a capacity greater than two times the pile design load and having means of determining applied load to within five (5) percent of test load. The test equipment should be capable of measuring total settlement at the top of the pile to nearest 0.001 inch. The pile load test should not commence loading the pile within 72 hours after installation of the pile. The maximum test load should be equal to 180 kip or the ultimate bearing capacity, whichever occurs first.

Please note that this report was prepared based on one boring of forty-five-foot depth conducted in 2013 and other public information obtained. Discontinuity in soil type and geology may exist, including abrupt strata changes and soil strength variations. The extent of these variations may not be fully determined from the boring. Additional geotechnical investigation to deeper soils is recommended.

Limitations

This report has been prepared for the exclusive use of **STV Incorporated** for the Metro Pentagon City Station Elevator Shaft project. Our conclusions and recommendations have been rendered in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical engineering profession in the Commonwealth of Virginia at the time of our study. We make no other warranty, express or implied.

Conclusions and recommendations presented in this report are based upon the available soil information, currently accepted engineering principles, and design details furnished by the client. **DMY** should be notified of any revisions to the scope of this project so that these revisions may be evaluated against the subsurface conditions. Should it be necessary to revise the recommendations outlined in this report, **DMY** will submit a written report to address any necessary changes to our recommendations. No other warranties, expressed or implied, are made.

We appreciate the opportunity to offer these services. If you have any questions regarding this report or if we may be of further assistance to you, please contact our office at (804)-381-4800.

Respectfully yours,

DMY Inc.

John Z. Ding, P.E.
Principal Engineer

Richard M. Simon, P.E., Ph.D.
Senior Principal Engineer

Appendix:

Soil Boring Log BH-1

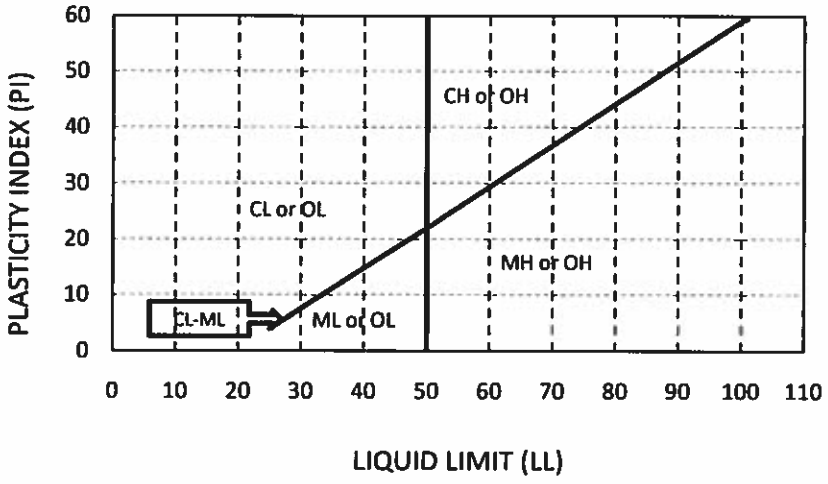
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the United Soil Classification System (USCS) on the boring logs presented in this report. Grain size analysis and Atterberg limits tests are often performed on selected samples to aid in classification. The classification system in briefly outline on this chart. For a more detailed description of the system, see the "The Unified Soil Classification System" Corps of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T

MAJOR DIVISIONS				GROUP SYMBO	TYPICAL NAMES
COARSE - GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
				GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot below the "A" line & hatched zone on plasticity chart	GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well graded sands, gravelly sands.
				SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	SM	Silty sands, sand-silt mixtures.
			Limits plot below the "A" line & hatched zone on plasticity chart	SC	Clayey sands, sand-clay mixtures.
FINE - GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits Plot Below "A" & hatched Zone on Plasticity Chart)	SILTS OF LOW PLASTICITY (Liquid Limit less than 50)		ML	Inorganic silts, non-plastic or slightly plastic.
		SILTS OF HIGH PLASTICITY (Liquid Limit more than 50)		MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts
	CLAYS (Limits Plot Above "A" & hatched Zone on Plasticity Chart)	CLAYS OF LOW PLASTICITY (Liquid Limit less than 50)		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit more than 50)		CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE:
Coarse grained soils with between 5% & 12 % passing the No. 200 sieve and fine grained soils with Atterberg limits plotting in the hatched zone on the plasticity chart shall have dual symbol. In Arizona, local streams contain sand, gravel & cobble type material, which are locally known as SGC or riverrun material. THe USCS is not used to divide and symbolize the material.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT		PARTICLE SIZE RANGE
Cobbles		Above 3 in.
Gravel		3 in. to No. 4 sieve
	Coarse gravel	3 in. to 3/4 in.
	Fine gravel	3/4 in. to No. 4 sieve
Sand		No. 4 to No. 200
	Coarse	No. 4 to No. 10
	Medium	No. 10 to No. 40
	Fine gravel	No. 40 to No. 200
Fines	(silt & clay)	Below No. 200 sieve
	Clay	Smaller than 2 microns
	Colloid	Smaller than 5 microns

DMY Inc.
14241 Midlothian Turnpike, Suite 230
Midlothian, VA 23113

Descriptions of Soil
(Unified Soil Classification System)

PARTICLE SIZE IDENTIFICATION

Description	Size
Boulders	· Diameter: 12 inches or larger
Cobbles	· Diameter: 3 to 12 inches
Gravel	· Coarse - 3/4 to 3 inches · Fine - 3/4 to No. 4
Sand	· Coarse - No. 10 to No. 4 (Diameter of pencil lead) · Medium - No. 40 to No. 10 (Diameter of broom straw) · Fine - No. 200 to No. 40 (Diameter of human hair)
Silt and Clay	· Passing No. 200 (Cannot see particles)

RELATIVE PROPORTIONS

Description	Percent by Weight (%)
Trace	0-5
Few	5-10
Little	10-20
Some	20-35
And	35-50

MOISTURE CONDITIONS

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

COHESIVE SOILS (Silt and Clay)

CONSISTENCY

Description	Blows/ft
Very Soft	2
Soft	3-5
Medium Stiff	6-9
Stiff	10-16
Very Stiff	17-30
Hard	>31

PLASTICITY

Degree of Plasticity	Plasticity Index
None	0-4
Slight	5-7
Medium	8-22
High to Very High	Over 22

COHESIONLESS SOIL (Sand, Gravel, and larger)
RELATIVE DENSITY

Description	Blows/ft	Description	Blows/ft
Very Loose	<4	Dense	31-50
Loose	4-10	Very Dense	>50
Medium Dense	11-30		

dmy
14241 Midlothian Turenpike
Suite 300
Midlothian, VA 23113
(804)-381-4800
www.dmy-inc.com

PROJECT #:	Metro Pentagon City Statiob Elevator Shaft	BH-1	
LOCATION:	Arlington, Virginia	PAGE 1 OF 3	
STRUCTURE:			
STATION:		OFFSET:	
LATITUDE:	38.863023N	LONGITUDE:	-77.059748W
SURFACE ELEVATION:	45.75 feet	COORD DATUM:	

FIELD DATA

														LAB DATA		
		SOIL				ROCK										
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION HAMMER BLOWS	SOIL RECOVERRY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	DIP° STRATA	DIP° JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
												LL	PI	
0											5" Concrete			
	45													
1											8" Aggregate Base(#57 Stone)			
	44				1.5									
2														
	43													
3											Medium Stiff to Gray Lean CLAY (CL) Fill, Trace of Gravel, Moist			
	42	8-8-4	11											
4					4									
	41													
5														
	40													
6		2-2-2	56								Soft Gray Silt (ML) Fill, Trace of Gravel, Moist			
	39				6.5									
7														
	38													
8					8						Medium Stiff Brown Lean Clay (CL) Fill, Trace of Gravel, Moist			
	37													
9														
	36	4-7-7	89											
10					10									
	35													
11														18
	34													
12														
	33										Loose Brown Silty Sand (SM) Trace of Gravel, Moist			
13														
	32													
14														
	31	3-5-7	100											
15					15									

Date (s) Drilled: 8/19/2013
Drilling Method (s): 4.25" HAS
SPT Method (s): Automatic Hammer
Other Test (s):
Driller: Connelly & Associates
Logger: John D

GROUND WATER
Groundwater Encountered at 28.5 feet
No Long Term Measurements Taken

REMARKS: Boring Backfilled upon completion

dmy
14241 Midlothian Turenpike
Suite 300
Midlothian, VA 23113
(804)-381-4800
www.dmy-inc.com

PROJECT #:	**Metro Pentagon City Station Elevator Shaft**	**BH-1**	
LOCATION:	Arlington, Virginia	**PAGE 2 OF 3**	
STRUCTURE:			
STATION:		OFFSET:	
LATITUDE:	38.863023N	LONGITUDE:	-77.059748W
SURFACE ELEVATION:	45.75 feet	COORD DATUM:	

FIELD DATA

Date (s) Drilled:	8/19/2013
Drilling Method (s):	4.25" HAS
SPT Method (s):	Automatic Hammer
Other Test (s):	
Driller:	Connelly & Associates
Logger:	John D

GROUND WATER

Groundwater Encountered at 28.5 feet
No Long Term Measurements Taken

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION HAMMER BLOWS	SOIL: SOIL RECOVERRY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERTY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP° STRATA	ROCK: DIP° JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LAB DATA: LIQUID LIMIT (LL)	LAB DATA: PLASTICITY INDEX (PI)	LAB DATA: MOISTURE CONTENT (%)
15	30													
16	29													
17	28										Loose Gray Silty SAND (**SM**) Fill, Trace of Gravel, Moist			13
18	27													
19	26	6-7-8	67											
20	25				20									
21	24													
22	23													
23	22										Loose Brown Silty Sand (**SM**) Fill, Trace of Gravel, Moist			
24	21	3-3-4	89											
25	20				25									
26	19													
27	18													
28	17										Very Loose Brown Silty Sand (**SM**), Wet			
29	16	1-1-1	89											
30					30									

REMARKS: Boring Backfilled upon completion

dmy
14241 Midlothian Turenpike
Suite 300
Midlothian, VA 23113
(804)-381-4800
www.dmy-inc.com

PROJECT #:	**Metro Pentagon City Station Elevator Shaft**	BH-1
LOCATION:	Arlington, Virginia	PAGE 3 OF 3
STRUCTURE:		
STATION:		OFFSET:
LATITUDE:	38.863023N	LONGITUDE: -77.059748W
SURFACE ELEVATION:	45.75 feet	COORD.DATUM:
Date (s) Drilled:	8/19/2013	
Drilling Method (s):	4.25" HAS	
SPT Method (s):	Automatic Hammer	
Other Test (s):		
Driller:	Connelly & Associates	
Logger:	John D	

GROUND WATER
Groundwater Encountered at 28.5 feet
No Long Term Measurements Taken

FIELD DATA												LAB DATA		
		SOIL				ROCK								
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION HAMMER BLOWS	SOIL RECOVERRY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	DIP* STRATA	DIP* JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
30	15													
31	14													
32	13													
33	12													
34	11	Weight of Hammer	50		35						Very Loose Brown Silty SAND (**SM**) Fill, Trace of Gravel, Wet			
35	10													
36	9													
37	8													
38	7													
39	6	33-22-16	100		40									
40	5													
41	4													
42	3										Very Dense Brown Sand with GRAVEL (**SM**), Wet			17
43	2													
44	1	22-14-10	56		45									
45	0										Boring Terminated at Elevation 0.5 feet on August 19, 2013			

REMARKS: Boring Backfilled upon completion