PROJECT: 35013

REFERENCE: U-4015A

STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	U-4015A	1	18

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

STRUCTURE SUBSURFACE INVESTIGATION

COUNTY **GUILFORD**

PROJECT DESCRIPTION **GALLIMORE DAIRY RD. WIDENING FROM NC 68 (LYNWOOD SMITH EXPY.) TO AIRPARK RD IN GREENSBORO**

SITE DESCRIPTION
WALL NO. 1: –L– STA. 27+25 TO –L– STA. 29+50 (LT)
WALL NO. 2: –L– STA. 44+00 TO –L– STA. 45+00 (LT)
WALL NO. 3: –L– STA. 48+00 TO –L– STA. 53+00 (LT)

INVENTORY

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CAUTION NOTICE

THE SUBSURFACE INFORMATION AND THE SUBSURFACE INVESTIGATION ON WHICH IT IS BASED WERE MADE FOR THE PURPOSE OF STUDY, PLANNING AND DESIGN, AND NOT FOR CONSTRUCTION OR PAY PURPOSES. THE VARIOUS FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA AVAILABLE MAY BE REVIEWED OR INSPECTED IN RALEIGH BY CONTACTING THE N. C. DEPARTMENT OF TRANSPORTATION, GEOTECHNICAL ENGINEERING UNIT AT (919) 707-6850. THE SUBSURFACE PLANS AND REPORTS, FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA ARE NOT PART OF THE CONTRACT.

GENERAL SOIL AND ROCK STRATA DESCRIPTIONS AND INDICATED BOUNDARIES ARE BASED ON A GEOTECHNICAL INTERPRETATION OF ALL AVAILABLE SUBSURFACE DATA AND MAY NOT NECESSARILY REFLECT THE ACTUAL SUBSURFACE CONDITIONS BETWEEN BORINGS OR BETWEEN SAMPLED STRATA WITHIN THE BOREHOLE. THE LABORATORY SAMPLE DATA AND THE IN SITU (IN-PLACE) TEST DATA CAN BE RELIED ON ONLY TO THE DEGREE OF RELIABILITY INHERENT IN THE STANDARD TEST METHOD. THE OBSERVED WATER LEVELS OR SOIL MOISTURE CONDITIONS INDICATED IN THE SUBSURFACE INVESTIGATIONS ARE AS RECORDED AT THE TIME OF THE INVESTIGATION. THESE WATER LEVELS OR SOIL MOISTURE CONDITIONS MAY VARY CONSIDERABLY WITH TIME ACCORDING TO CLIMATIC CONDITIONS INCLUDING TEMPERATURES, PRECIPITATION AND WIND, AS WELL AS OTHER NON-CLIMATIC FACTORS.

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NOTES:

1. THE INFORMATION CONTAINED HEREIN IS NOT IMPLIED OR GUARANTEED BY THE N. C. DEPARTMENT OF TRANSPORTATION AS ACCURATE NOR IS IT CONSIDERED PART OF THE PLANS, SPECIFICATIONS OR CONTRACT FOR THE PROJECT.
2. BY HAVING REQUESTED THIS INFORMATION, THE CONTRACTOR SPECIFICALLY WAIVES ANY CLAIMS FOR INCREASED COMPENSATION OR EXTENSION OF TIME BASED ON DIFFERENCES BETWEEN THE CONDITIONS INDICATED HEREIN AND THE ACTUAL CONDITIONS AT THE PROJECT SITE.

PERSONNEL

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F&R PERSONNEL

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8/20/2024

SIGNATURE DATE

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	2

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

SOIL DESCRIPTION

SOIL IS CONSIDERED UNCONSOLIDATED, SEMI-CONSOLIDATED, OR WEATHERED EARTH MATERIALS THAT CAN BE PENETRATED WITH A CONTINUOUS FLIGHT POWER AUGER AND YIELD LESS THAN 100 BLOWS PER FOOT ACCORDING TO THE STANDARD PENETRATION TEST (AASHTO T 206, ASTM D1586). SOIL CLASSIFICATION IS BASED ON THE AASHTO SYSTEM. BASIC DESCRIPTIONS GENERALLY INCLUDE THE FOLLOWING: CONSISTENCY, COLOR, TEXTURE, MOISTURE, AASHTO CLASSIFICATION, AND OTHER PERTINENT FACTORS SUCH AS MINERALOGICAL COMPOSITION, ANGULARITY, STRUCTURE, PLASTICITY, ETC. FOR EXAMPLE,

VERY STIFF, GRAY, SILTY CLAY, MOIST WITH INTERBEDDED FINE SAND LAYERS, HIGHLY PLASTIC, A-7-6

SOIL LEGEND AND AASHTO CLASSIFICATION

GENERAL CLASS.	GRANULAR MATERIALS (≤ 35% PASSING #200)							SILT-CLAY MATERIALS (> 35% PASSING #200)				ORGANIC MATERIALS		
GROUP CLASS.	A-1		A-3	A-2				A-4	A-5	A-6	A-7	A-1, A-2 A-3	A-4, A-5 A-6, A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6			
SYMBOL	○○○	○○○	∴	⁘	⁘	▧	▧	⁚	⁘	▰	▰	⟍⟍	☰	﹏
% PASSING #10 #40 #200	50 MX 30 MX 15 MX	50 MX 25 MX	51 MN 10 MX	35 MX	35 MX	35 MX	35 MX	36 MN	36 MN	36 MN	36 MN	GRANULAR SOILS	SILT-CLAY SOILS	MUCK, PEAT
MATERIAL PASSING #40 LL PI	— 6 MX		— NP	40 MX 10 MX	41 MN 10 MX	40 MX 11 MN	41 MN 11 MN	40 MX 10 MX	41 MN 10 MX	40 MX 11 MN	41 MN 11 MN	SOILS WITH LITTLE OR MODERATE AMOUNTS OF ORGANIC MATTER		HIGHLY ORGANIC SOILS
GROUP INDEX	0		0	0		4 MX		8 MX	12 MX	16 MX	NO MX			
USUAL TYPES OF MAJOR MATERIALS	STONE FRAGS. GRAVEL, AND SAND		FINE SAND	SILTY OR CLAYEY GRAVEL AND SAND				SILTY SOILS		CLAYEY SOILS				
GEN. RATING AS SUBGRADE	EXCELLENT TO GOOD							FAIR TO POOR				FAIR TO POOR	POOR	UNSUITABLE

PI OF A-7-5 SUBGROUP IS ≤ LL - 30 ; PI OF A-7-6 SUBGROUP IS > LL - 30

CONSISTENCY OR DENSENESS

PRIMARY SOIL TYPE	COMPACTNESS OR CONSISTENCY	RANGE OF STANDARD PENETRATION RESISTENCE (N-VALUE)	RANGE OF UNCONFINED COMPRESSIVE STRENGTH (TONS/FT^2)
GENERALLY GRANULAR MATERIAL (NON-COHESIVE)	VERY LOOSE	< 4	N/A
	LOOSE	4 TO 10	
	MEDIUM DENSE	10 TO 30	
	DENSE	30 TO 50	
	VERY DENSE	> 50	
GENERALLY SILT-CLAY MATERIAL (COHESIVE)	VERY SOFT	< 2	< 0.25
	SOFT	2 TO 4	0.25 TO 0.5
	MEDIUM STIFF	4 TO 8	0.5 TO 1.0
	STIFF	8 TO 15	1 TO 2
	VERY STIFF	15 TO 30	2 TO 4
	HARD	> 30	> 4

TEXTURE OR GRAIN SIZE

U.S. STD. SIEVE SIZE	4	10	40	60	200	270
OPENING (MM)	4.76	2.00	0.42	0.25	0.075	0.053

BOULDER (BLDR.)	COBBLE (COB.)	GRAVEL (GR.)	COARSE SAND (CSE. SD.)	FINE SAND (F SD.)	SILT (SL.)	CLAY (CL.)

GRAIN SIZE						
MM	305	75	2.0	0.25	0.05	0.005
IN.	12	3				

SOIL MOISTURE - CORRELATION OF TERMS

SOIL MOISTURE SCALE (ATTERBERG LIMITS)	FIELD MOISTURE DESCRIPTION	GUIDE FOR FIELD MOISTURE DESCRIPTION
	- SATURATED - (SAT.)	USUALLY LIQUID; VERY WET, USUALLY FROM BELOW THE GROUND WATER TABLE
LL — LIQUID LIMIT PLASTIC RANGE (PI) PL — PLASTIC LIMIT	- WET - (W)	SEMISOLID; REQUIRES DRYING TO ATTAIN OPTIMUM MOISTURE
OM — OPTIMUM MOISTURE SL — SHRINKAGE LIMIT	- MOIST - (M)	SOLID; AT OR NEAR OPTIMUM MOISTURE
	- DRY - (D)	REQUIRES ADDITIONAL WATER TO ATTAIN OPTIMUM MOISTURE

PLASTICITY

	PLASTICITY INDEX (PI)	DRY STRENGTH
NON PLASTIC	0-5	VERY LOW
SLIGHTLY PLASTIC	6-15	SLIGHT
MODERATELY PLASTIC	16-25	MEDIUM
HIGHLY PLASTIC	26 OR MORE	HIGH

COLOR

DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YELLOW-BROWN, BLUE-GRAY). MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.

GRADATION

WELL GRADED - INDICATES A GOOD REPRESENTATION OF PARTICLE SIZES FROM FINE TO COARSE.

UNIFORMLY GRADED - INDICATES THAT SOIL PARTICLES ARE ALL APPROXIMATELY THE SAME SIZE.

GAP-GRADED - INDICATES A MIXTURE OF UNIFORM PARTICLE SIZES OF TWO OR MORE SIZES.

ANGULARITY OF GRAINS

THE ANGULARITY OR ROUNDNESS OF SOIL GRAINS IS DESIGNATED BY THE TERMS: ANGULAR, SUBANGULAR, SUBROUNDED, OR ROUNDED.

MINERALOGICAL COMPOSITION

MINERAL NAMES SUCH AS QUARTZ, FELDSPAR, MICA, TALC, KAOLIN, ETC. ARE USED IN DESCRIPTIONS WHEN THEY ARE CONSIDERED OF SIGNIFICANCE.

COMPRESSIBILITY

SLIGHTLY COMPRESSIBLE	LL < 31
MODERATELY COMPRESSIBLE	LL = 31 - 50
HIGHLY COMPRESSIBLE	LL > 50

PERCENTAGE OF MATERIAL

ORGANIC MATERIAL	GRANULAR SOILS	SILT - CLAY SOILS	OTHER MATERIAL	
TRACE OF ORGANIC MATTER	2 - 3%	3 - 5%	TRACE	1 - 10%
LITTLE ORGANIC MATTER	3 - 5%	5 - 12%	LITTLE	10 - 20%
MODERATELY ORGANIC	5 - 10%	12 - 20%	SOME	20 - 35%
HIGHLY ORGANIC	> 10%	> 20%	HIGHLY	35% AND ABOVE

GROUND WATER

▽	WATER LEVEL IN BORE HOLE IMMEDIATELY AFTER DRILLING
▼	STATIC WATER LEVEL AFTER 24 HOURS
▽PW	PERCHED WATER, SATURATED ZONE, OR WATER BEARING STRATA
○∿→	SPRING OR SEEP

MISCELLANEOUS SYMBOLS

▯	ROADWAY EMBANKMENT (RE) WITH SOIL DESCRIPTION	25/025 →	DIP & DIP DIRECTION OF ROCK STRUCTURES		
↕	SOIL SYMBOL	◕ SPT DPT DMT VST PMT	TEST BORING	⬡	SLOPE INDICATOR INSTALLATION
⊠	ARTIFICIAL FILL (AF) OTHER THAN ROADWAY EMBANKMENT	⊕	AUGER BORING	◬	CONE PENETROMETER TEST
— — —	INFERRED SOIL BOUNDARY	⌖	CORE BORING	●	SOUNDING ROD
≡//≡	INFERRED ROCK LINE	MW ○	MONITORING WELL	◕	TEST BORING WITH CORE
┬┬┬	ALLUVIAL SOIL BOUNDARY	△	PIEZOMETER INSTALLATION	⬭	SPT N-VALUE

RECOMMENDATION SYMBOLS

⊠	UNDERCUT	▧	UNCLASSIFIED EXCAVATION - UNSUITABLE WASTE	✳	UNCLASSIFIED EXCAVATION - ACCEPTABLE, BUT NOT TO BE USED IN THE TOP 3 FEET OF EMBANKMENT OR BACKFILL
■	SHALLOW UNDERCUT	▨	UNCLASSIFIED EXCAVATION - ACCEPTABLE DEGRADABLE ROCK		

ABBREVIATIONS

AR - AUGER REFUSAL
BT - BORING TERMINATED
CL. - CLAY
CPT - CONE PENETRATION TEST
CSE. - COARSE
DMT - DILATOMETER TEST
DPT - DYNAMIC PENETRATION TEST
e - VOID RATIO
F - FINE
FOSS. - FOSSILIFEROUS
FRAC. - FRACTURED, FRACTURES
FRAGS. - FRAGMENTS
HI. - HIGHLY

MED. - MEDIUM
MICA. - MICACEOUS
MOD. - MODERATELY
NP - NON PLASTIC
ORG. - ORGANIC
PMT - PRESSUREMETER TEST
SAP. - SAPROLITIC
SD. - SAND, SANDY
SL. - SILT, SILTY
SLI. - SLIGHTLY
TCR - TRICONE REFUSAL
w - MOISTURE CONTENT
V - VERY

VST - VANE SHEAR TEST
WEA. - WEATHERED
γ - UNIT WEIGHT
γ_d - DRY UNIT WEIGHT

SAMPLE ABBREVIATIONS

S - BULK
SS - SPLIT SPOON
ST - SHELBY TUBE
RS - ROCK
RT - RECOMPACTED TRIAXIAL
CBR - CALIFORNIA BEARING RATIO

EQUIPMENT USED ON SUBJECT PROJECT

DRILL UNITS:
- ☐ CME-45C
- ☒ CME-55
- ☐ CME-550
- ☐ VANE SHEAR TEST
- ☐ PORTABLE HOIST
- ☐ ________
- ☐ ________

ADVANCING TOOLS:
- ☐ CLAY BITS
- ☐ 6" CONTINUOUS FLIGHT AUGER
- ☒ 8" HOLLOW AUGERS
- ☐ HARD FACED FINGER BITS
- ☐ TUNG.-CARBIDE INSERTS
- ☐ CASING ☐ W/ ADVANCER
- ☐ TRICONE ______" STEEL TEETH
- ☐ TRICONE ______" TUNG.-CARB.
- ☐ CORE BIT
- ☐ ________

HAMMER TYPE:
- ☒ AUTOMATIC ☐ MANUAL

CORE SIZE:
- ☐ -B ______ ☐ -H ______
- ☐ -N ______

HAND TOOLS:
- ☐ POST HOLE DIGGER
- ☒ HAND AUGER
- ☒ SOUNDING ROD
- ☐ VANE SHEAR TEST
- ☒ SOWERS DCP

ROCK DESCRIPTION

HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT REFUSAL IF TESTED. AN INFERRED ROCK LINE INDICATES THE LEVEL AT WHICH NON-COASTAL PLAIN MATERIAL WOULD YIELD SPT REFUSAL. SPT REFUSAL IS PENETRATION BY A SPLIT SPOON SAMPLER EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS IN NON-COASTAL PLAIN MATERIAL, THE TRANSITION BETWEEN SOIL AND ROCK IS OFTEN REPRESENTED BY A ZONE OF WEATHERED ROCK.

ROCK MATERIALS ARE TYPICALLY DIVIDED AS FOLLOWS:

WEATHERED ROCK (WR)	▨	NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT N VALUES > 100 BLOWS PER FOOT IF TESTED.
CRYSTALLINE ROCK (CR)	▧	FINE TO COARSE GRAIN IGNEOUS AND METAMORPHIC ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GRANITE, GNEISS, GABBRO, SCHIST, ETC.
NON-CRYSTALLINE ROCK (NCR)	☰	FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YEILD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.
COASTAL PLAIN SEDIMENTARY ROCK (CP)	▦	COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.

WEATHERING

FRESH	ROCK FRESH, CRYSTALS BRIGHT, FEW JOINTS MAY SHOW SLIGHT STAINING. ROCK RINGS UNDER HAMMER IF CRYSTALLINE.
VERY SLIGHT (V SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED, SOME JOINTS MAY SHOW THIN CLAY COATINGS IF OPEN, CRYSTALS ON A BROKEN SPECIMEN FACE SHINE BRIGHTLY. ROCK RINGS UNDER HAMMER BLOWS IF OF A CRYSTALLINE NATURE.
SLIGHT (SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED AND DISCOLORATION EXTENDS INTO ROCK UP TO 1 INCH. OPEN JOINTS MAY CONTAIN CLAY. IN GRANITOID ROCKS SOME OCCASIONAL FELDSPAR CRYSTALS ARE DULL AND DISCOLORED. CRYSTALLINE ROCKS RING UNDER HAMMER BLOWS.
MODERATE (MOD.)	SIGNIFICANT PORTIONS OF ROCK SHOW DISCOLORATION AND WEATHERING EFFECTS. IN GRANITOID ROCKS, MOST FELDSPARS ARE DULL AND DISCOLORED, SOME SHOW CLAY. ROCK HAS DULL SOUND UNDER HAMMER BLOWS AND SHOWS SIGNIFICANT LOSS OF STRENGTH AS COMPARED WITH FRESH ROCK.
MODERATELY SEVERE (MOD. SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. IN GRANITOID ROCKS, ALL FELDSPARS DULL AND DISCOLORED AND A MAJORITY SHOW KAOLINIZATION. ROCK SHOWS SEVERE LOSS OF STRENGTH AND CAN BE EXCAVATED WITH A GEOLOGIST'S PICK. ROCK GIVES "CLUNK" SOUND WHEN STRUCK. *IF TESTED, WOULD YIELD SPT REFUSAL*
SEVERE (SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC CLEAR AND EVIDENT BUT REDUCED IN STRENGTH TO STRONG SOIL. IN GRANITOID ROCKS ALL FELDSPARS ARE KAOLINIZED TO SOME EXTENT. SOME FRAGMENTS OF STRONG ROCK USUALLY REMAIN. *IF TESTED, WOULD YIELD SPT N VALUES > 100 BPF*
VERY SEVERE (V SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE THAT ONLY MINOR VESTIGES OF ORIGINAL ROCK FABRIC REMAIN. *IF TESTED, WOULD YIELD SPT N VALUES < 100 BPF*
COMPLETE	ROCK REDUCED TO SOIL. ROCK FABRIC NOT DISCERNIBLE, OR DISCERNIBLE ONLY IN SMALL AND SCATTERED CONCENTRATIONS. QUARTZ MAY BE PRESENT AS DIKES OR STRINGERS. SAPROLITE IS ALSO AN EXAMPLE.

ROCK HARDNESS

VERY HARD	CANNOT BE SCRATCHED BY KNIFE OR SHARP PICK. BREAKING OF HAND SPECIMENS REQUIRES SEVERAL HARD BLOWS OF THE GEOLOGIST'S PICK.
HARD	CAN BE SCRATCHED BY KNIFE OR PICK ONLY WITH DIFFICULTY. HARD HAMMER BLOWS REQUIRED TO DETACH HAND SPECIMEN.
MODERATELY HARD	CAN BE SCRATCHED BY KNIFE OR PICK. GOUGES OR GROOVES TO 0.25 INCHES DEEP CAN BE EXCAVATED BY HARD BLOW OF A GEOLOGIST'S PICK. HAND SPECIMENS CAN BE DETACHED BY MODERATE BLOWS.
MEDIUM HARD	CAN BE GROOVED OR GOUGED 0.05 INCHES DEEP BY FIRM PRESSURE OF KNIFE OR PICK POINT. CAN BE EXCAVATED IN SMALL CHIPS TO PEICES 1 INCH MAXIMUM SIZE BY HARD BLOWS OF THE POINT OF A GEOLOGIST'S PICK.
SOFT	CAN BE GROVED OR GOUGED READILY BY KNIFE OR PICK. CAN BE EXCAVATED IN FRAGMENTS FROM CHIPS TO SEVERAL INCHES IN SIZE BY MODERATE BLOWS OF A PICK POINT. SMALL, THIN PIECES CAN BE BROKEN BY FINGER PRESSURE.
VERY SOFT	CAN BE CARVED WITH KNIFE. CAN BE EXCAVATED READILY WITH POINT OF PICK. PIECES 1 INCH OR MORE IN THICKNESS CAN BE BROKEN BY FINGER PRESSURE. CAN BE SCRATCHED READILY BY FINGERNAIL.

FRACTURE SPACING

TERM	SPACING
VERY WIDE	MORE THAN 10 FEET
WIDE	3 TO 10 FEET
MODERATELY CLOSE	1 TO 3 FEET
CLOSE	0.16 TO 1 FOOT
VERY CLOSE	LESS THAN 0.16 FEET

BEDDING

TERM	THICKNESS
VERY THICKLY BEDDED	4 FEET
THICKLY BEDDED	1.5 - 4 FEET
THINLY BEDDED	0.16 - 1.5 FEET
VERY THINLY BEDDED	0.03 - 0.16 FEET
THICKLY LAMINATED	0.008 - 0.03 FEET
THINLY LAMINATED	< 0.008 FEET

INDURATION

FOR SEDIMENTARY ROCKS, INDURATION IS THE HARDENING OF MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.

FRIABLE	RUBBING WITH FINGER FREES NUMEROUS GRAINS; GENTLE BLOW BY HAMMER DISINTEGRATES SAMPLE.
MODERATELY INDURATED	GRAINS CAN BE SEPARATED FROM SAMPLE WITH STEEL PROBE; BREAKS EASILY WHEN HIT WITH HAMMER.
INDURATED	GRAINS ARE DIFFICULT TO SEPARATE WITH STEEL PROBE; DIFFICULT TO BREAK WITH HAMMER.
EXTREMELY INDURATED	SHARP HAMMER BLOWS REQUIRED TO BREAK SAMPLE; SAMPLE BREAKS ACROSS GRAINS.

TERMS AND DEFINITIONS

ALLUVIUM (ALLUV.) - SOILS THAT HAVE BEEN TRANSPORTED BY WATER.

AQUIFER - A WATER BEARING FORMATION OR STRATA.

ARENACEOUS - APPLIED TO ROCKS THAT HAVE BEEN DERIVED FROM SAND OR THAT CONTAIN SAND.

ARGILLACEOUS - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, SUCH AS SHALE, SLATE, ETC.

ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE.

CALCAREOUS (CALC.) - SOILS THAT CONTAIN APPRECIABLE AMOUNTS OF CALCIUM CARBONATE.

COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE.

CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.

DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK.

DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL.

DIP DIRECTION (DIP AZIMUTH) - THE DIRECTION OR BEARING OF THE HORIZONTAL TRACE OF THE LINE OF DIP, MEASURED CLOCKWISE FROM NORTH.

FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE.

FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES.

FLOAT - ROCK FRAGMENTS ON SURFACE NEAR THEIR ORIGINAL POSITION AND DISLODGED FROM PARENT MATERIAL.

FLOOD PLAIN (FP) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM.

FORMATION (FM.) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD.

JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED.

LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT.

LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS.

MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS. MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE.

PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM.

RESIDUAL (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK.

ROCK QUALITY DESIGNATION (RQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.

SAPROLITE (SAP.) - RESIDUAL SOIL THAT RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK.

SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, THAT HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS.

SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE.

STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS (N OR BPF) OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS PENETRATION EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS.

STRATA CORE RECOVERY (SREC.) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE.

STRATA ROCK QUALITY DESIGNATION (SRQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE.

TOPSOIL (TS.) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.

BENCH MARK: ____________

ELEVATION: ______ FEET

NOTES:

BOREHOLE ELEVATIONS DETERMINED FROM PROVIDED .TIN FILE
TIN FILE: u4015a_ls_tin.tin DATE: 1/7/2019

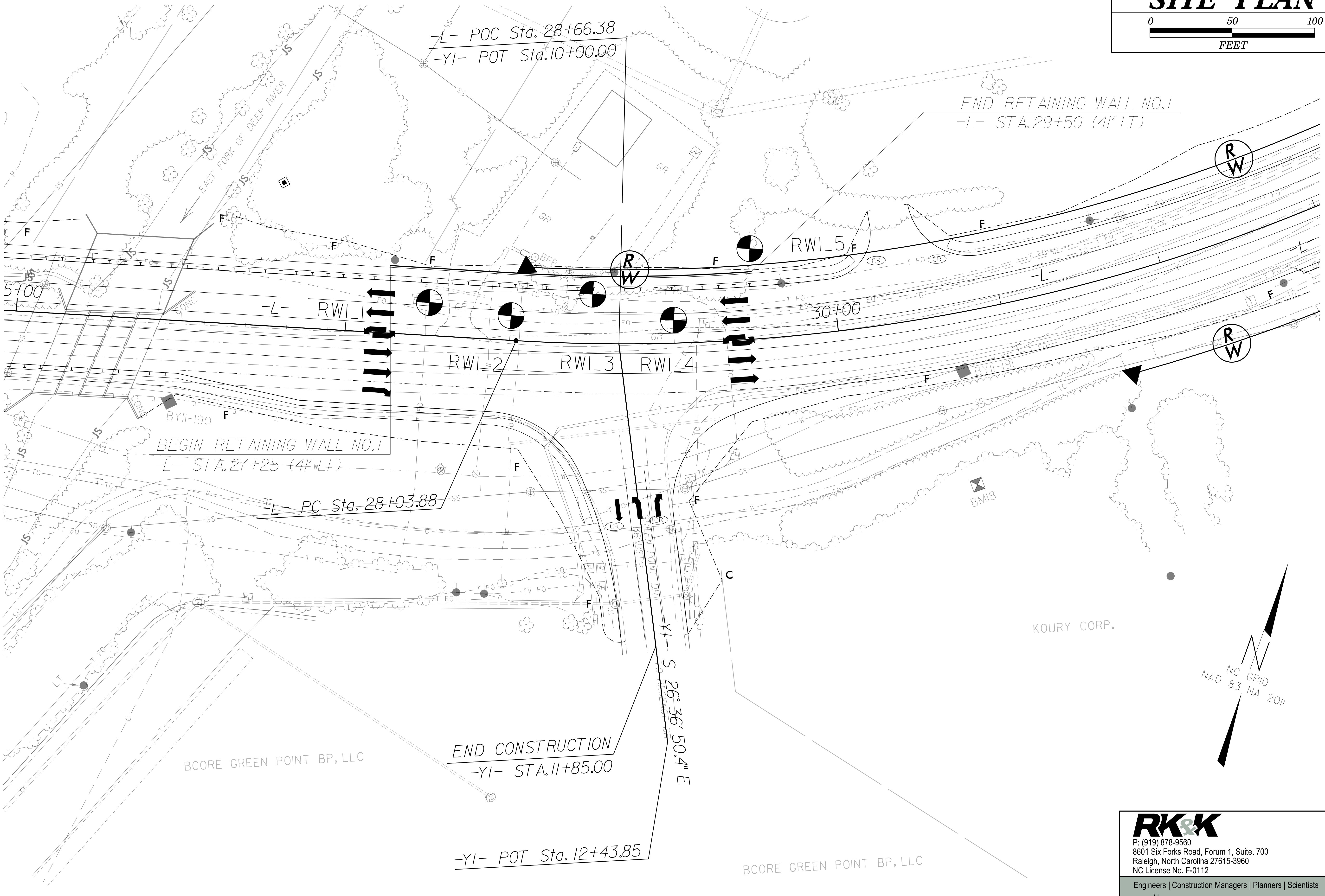
ABBREVIATIONS:

FIAD - FILLED IMMEDIATELY AFTER DRILLING
ND - NOT DETERMINED
SR - SOUNDING ROD
✳ - SOWERS DCP PERFORMED TO DETERMINE RELATIVE DENSITY
✳✳ - SOUNDING ROD PERFORMED TO DETERMINE RELATIVE DENSITY
⊙ HAND AUGER WITH SOUNDING ROD
⊡ HAND AUGER WITH SOWERS DCP

DATE: 10-10-19

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	3

SITE PLAN



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RETAINING WALL NO. I

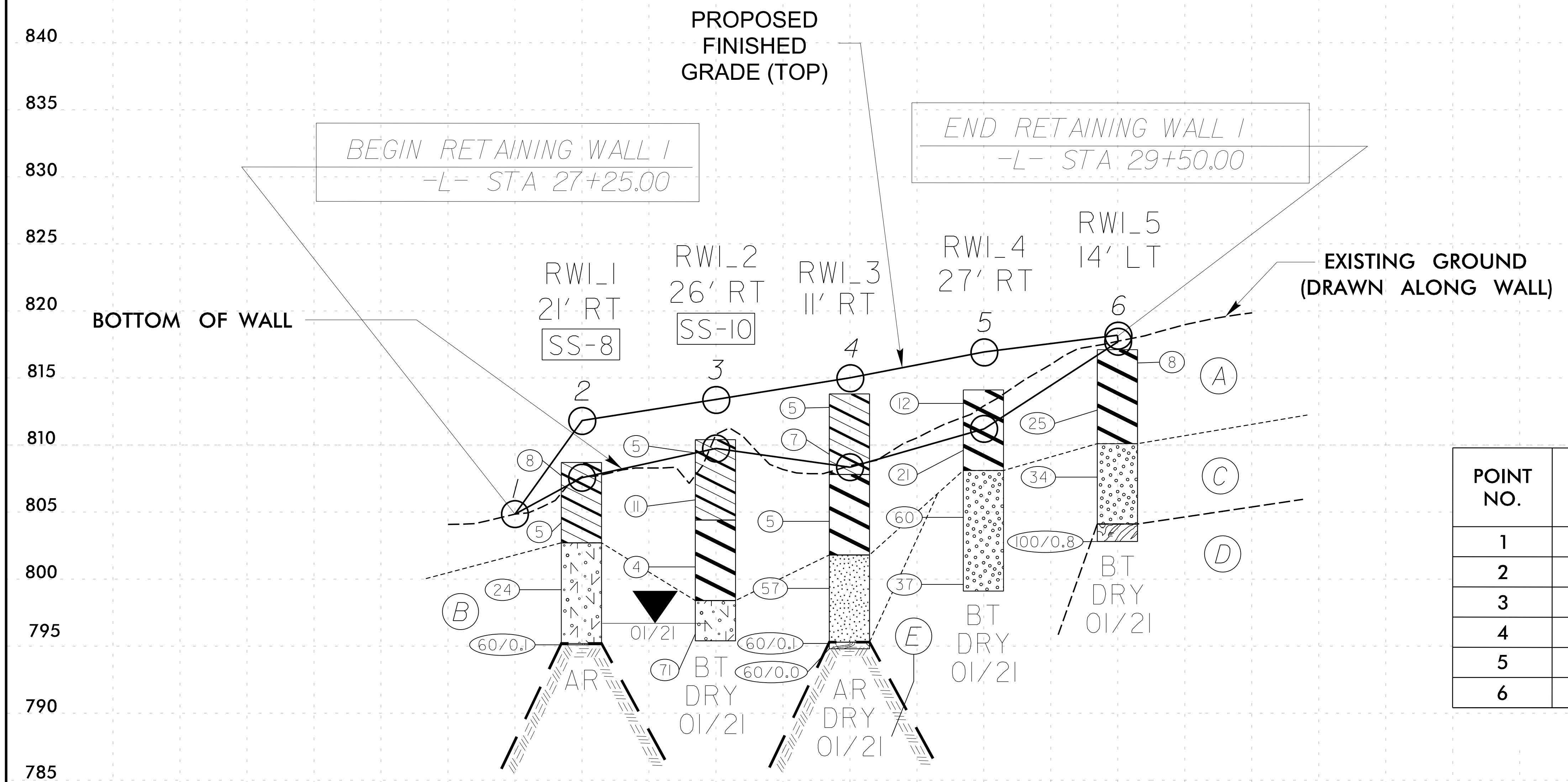
0 50 100
FEET
VE = 5

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	4

PROFILE ALONG -L-

SOIL TEST RESULTS

SAMPLE NO.	STATION	OFFSET	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
SS-8	27+50	20' LT	3.5-5.0'	A-6	37	17	23	23	17	38	99	84	59	23	ND
SS-10	28+00	15' LT	0.0-1.5'	A-6	32	14	ND	ND	ND	ND	44	0	56	18	ND



POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	27+25.00	804.85'	804.85'
2	27+50.00	811.84'	807.57'
3	28+00.00	813.41'	809.76'
4	28+50.00	815.04'	808.37'
5	29+00.00	816.98'	811.24'
6	29+50.00	818.24'	817.75'

Ⓐ RESIDUAL Brown to brown-orange to tan-brown, medium stiff to very stiff, sandy slightly to moderately plastic CLAY and silty CLAY (A-6, A-7-5, A-7-6), trace rock fragments, trace of organic matter, saprolitic, moist

Ⓑ Brown and gray-green to dark gray, very stiff to hard, sandy and clayey SILT (A-4, A-5), trace mica, trace rock fragments, saprolitic, moist

Ⓒ Brown-white-gray-black to brown-gray to brown, dense to very dense, silty fine to coarse SAND (A-2-4), trace rock fragments, moist

Ⓓ WEATHERED ROCK METAGRANITE

Ⓔ CRYSTALLINE ROCK METAGRANITE

-L-

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8/17/99
12/9/2021
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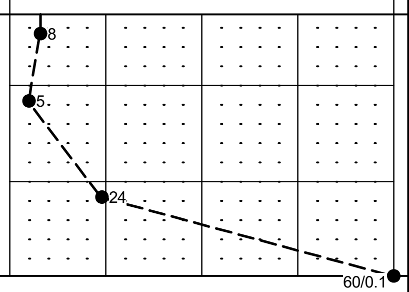
GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.	
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 1				**GROUND WTR (ft)**
BORING NO. RW1_1	**STATION** 27+50	**OFFSET** 20 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 808.7 ft	**TOTAL DEPTH** 13.6 ft	**NORTHING** 844,306	**EASTING** 1,717,795	**24 HR.** 12.0
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER Tignor, D.	**START DATE** 01/06/21	**COMP. DATE** 01/06/21	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	▼/MOI
810							
	808.7	0.0	4	4	4		M
805	805.2	3.5	1	2	3	SS-8	23%
800	800.2	8.5	3	12	12		M ▼
	795.2	13.5	60/0.1				



SOIL AND ROCK DESCRIPTION

ELEV. (ft) — DEPTH (ft)

808.7 GROUND SURFACE 0.0

RESIDUAL

Brown, medium stiff to stiff, silty sandy moderately plastic CLAY (A-6), trace rock fragments

802.7 — 6.0

Brown, very stiff, clayey SILT (A-5), trace mica

795.2 — 13.5

795.1 — 13.6

CRYSTALLINE ROCK

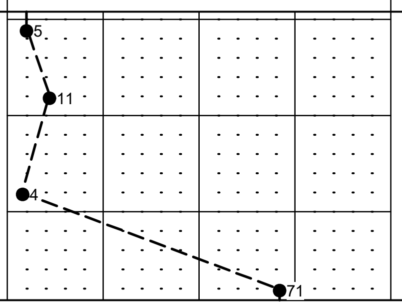
METAGRANITE

Boring Terminated with Standard Penetration Test Refusal at Elevation 795.1 ft In Crystalline Rock Metagranite

---

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.	
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 1				**GROUND WTR (ft)**
BORING NO. RW1_2	**STATION** 28+00	**OFFSET** 15 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 810.4 ft	**TOTAL DEPTH** 15.0 ft	**NORTHING** 844,315	**EASTING** 1,717,845	**24 HR.** Dry
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER Tignor, D.	**START DATE** 01/06/21	**COMP. DATE** 01/06/21	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI
815							
810	810.4	0.0	1	2	3	SS-10	18%
805	806.9	3.5	4	5	6		M
800	801.9	8.5	2	2	2		M
	796.9	13.5	5	24	47		M



SOIL AND ROCK DESCRIPTION

810.4 GROUND SURFACE 0.0

RESIDUAL

Brown to brown-orange, soft to stiff, sandy slightly plastic CLAY (A-6), trace rock fragments

804.4 — 6.0

Brown-orange, soft, silty CLAY (A-7-6), saprolitic

798.4 — 12.0

Brown and gray-green, hard, sandy clayey SILT (A-5), saprolitic

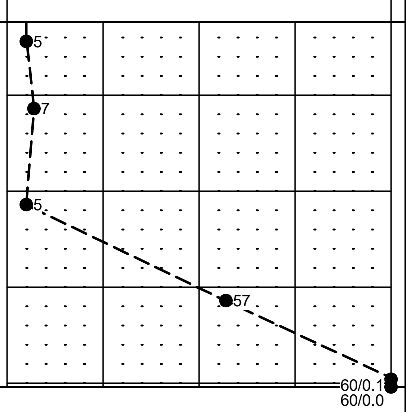
795.4 — 15.0

Boring Terminated at Elevation 795.4 ft In Residual sandy clayey SILT (A-5)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 1			**GROUND WTR (ft)**
BORING NO. RW1_3	**STATION** 28+50	**OFFSET** 30 ft LT	**ALIGNMENT** -L- **0 HR.** Dry
COLLAR ELEV. 813.8 ft	**TOTAL DEPTH** 19.0 ft	**NORTHING** 844,344	**EASTING** 1,717,887 **24 HR.** Dry
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021	**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER Tignor, D.	**START DATE** 01/06/21	**COMP. DATE** 01/06/21	**SURFACE WATER DEPTH** N/A

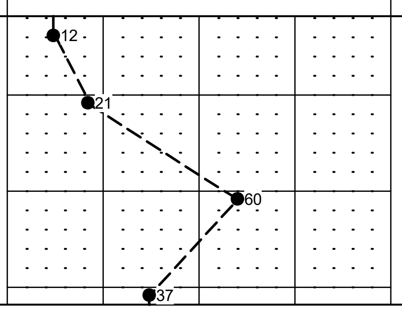
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
815								
	813.8	0.0	1	3	2	5		M
810	810.3	3.5	4	3	4	7		M
805	805.3	8.5	1	3	2	5		M
800	800.3	13.5	47	27	30	57		M
795	795.3	18.5	60/0.1			60/0.1		
	794.8	19.0	60/0.0			60/0.0		



ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
813.8	GROUND SURFACE	0.0
	RESIDUAL Brown, medium stiff, sandy CLAY (A-6), trace rock fragments	
807.8	Brown, medium stiff, sandy silty CLAY (A-7-5), trace rock fragments	6.0
801.8	Dark gray, hard, sandy SILT (A-4), trace rock fragments	12.0
795.3		18.5
794.8	**CRYSTALLINE ROCK** METAGRANITE	19.0
	Boring Terminated with Standard Penetration Test Refusal at Elevation 794.8 ft In Crystalline Rock Metagranite	

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 1			**GROUND WTR (ft)**
BORING NO. RW1_4	**STATION** 29+00	**OFFSET** 14 ft LT	**ALIGNMENT** -L- **0 HR.** Dry
COLLAR ELEV. 814.1 ft	**TOTAL DEPTH** 15.0 ft	**NORTHING** 844,346	**EASTING** 1,717,938 **24 HR.** Dry
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021	**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER Tignor, D.	**START DATE** 01/07/21	**COMP. DATE** 01/07/21	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
815								
	814.1	0.0	4	5	7	12		M
810	810.6	3.5	12	12	9	21		M
805	805.6	8.5	16	29	31	60		M
800	800.6	13.5	18	22	15	37		M



ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
814.1	GROUND SURFACE	0.0
	RESIDUAL Brown, stiff to very stiff, sandy silty CLAY (A-7-5), trace rock fragments	
808.1	Brown-white-gray-black to brown-gray, dense to very dense, silty fine to coarse SAND (A-2-4), trace rock fragments	6.0
799.1		15.0
	Boring Terminated at Elevation 799.1 ft In Residual silty SAND (A-2-4)	

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.

SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 1

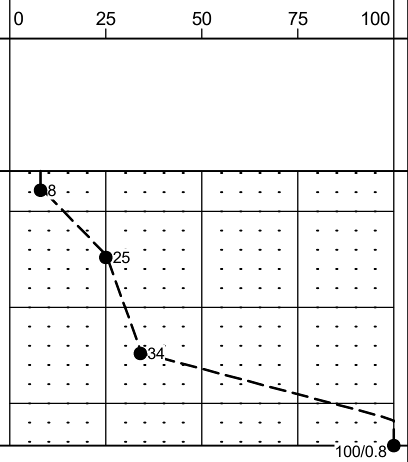
BORING NO. RW1_5	**STATION** 29+50	**OFFSET** 55 ft LT	**ALIGNMENT** -L-	**GROUND WTR (ft)**
				0 HR. Dry
COLLAR ELEV. 817.1 ft	**TOTAL DEPTH** 14.3 ft	**NORTHING** 844,402	**EASTING** 1,717,968	**24 HR.** Dry

DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021 **DRILL METHOD** H.S. Augers **HAMMER TYPE** Automatic

DRILLER Tignor, D. **START DATE** 01/06/21 **COMP. DATE** 01/06/21 **SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI
820							
	817.1	0.0	2	2	6		M
815							
	813.6	3.5	7	10	15		M
810							
	808.6	8.5	9	17	17		M
805							
	803.6	13.5	25	75/0.3			

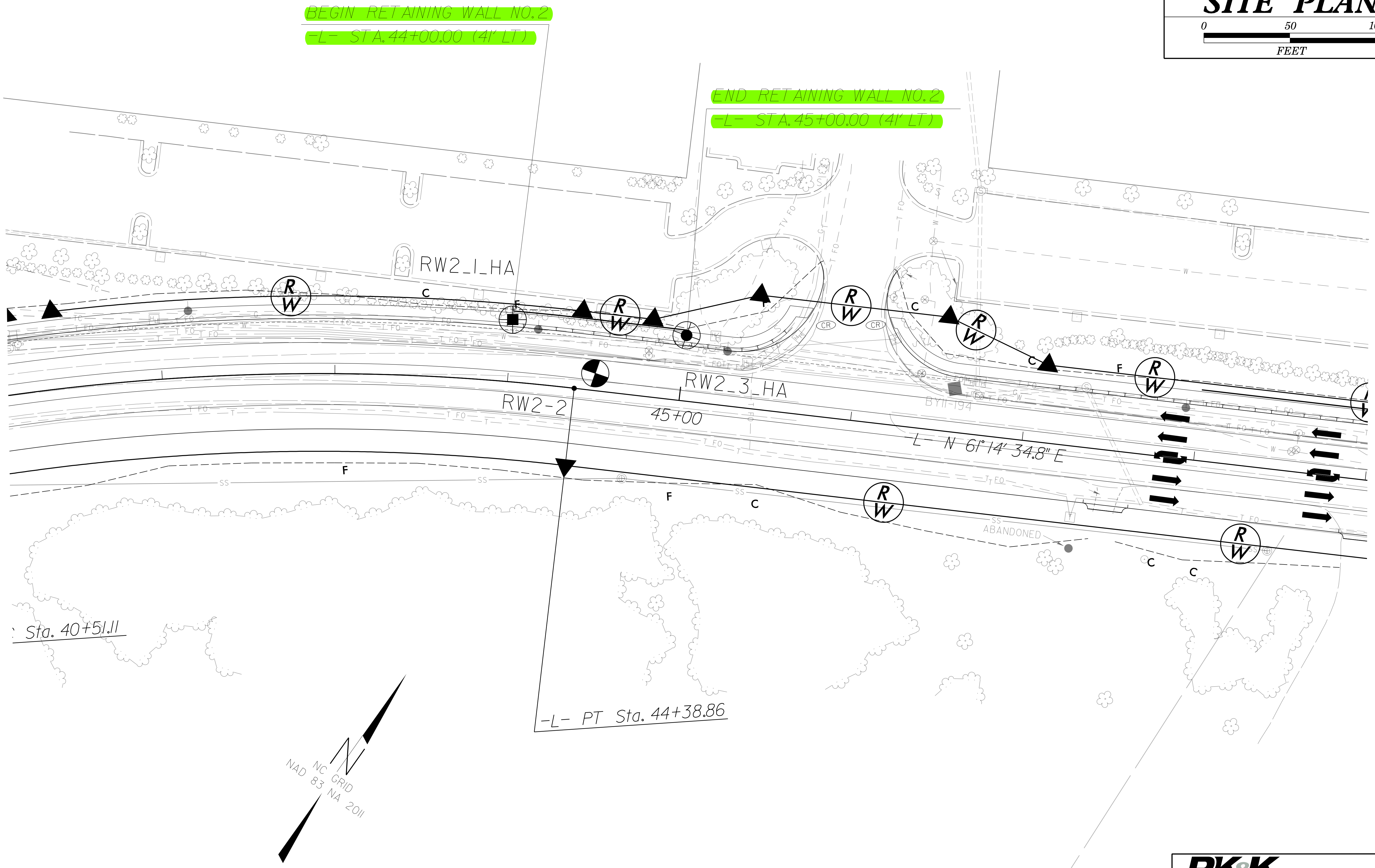
BLOWS PER FOOT



SOIL AND ROCK DESCRIPTION ELEV. (ft)		DEPTH (ft)
817.1	GROUND SURFACE	0.0
	RESIDUAL Orange-brown to tan-brown, stiff to very stiff, silty CLAY (A-7-6), trace rock fragments	
810.1	Brown, dense, silty fine to coarse SAND (A-2-4), trace rock fragments	7.0
804.1	**WEATHERED ROCK**	13.0
802.8	METAGRANITE	14.3
	Boring Terminated at Elevation 802.8 ft in Weathered Rock Metagranite	

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	8

SITE PLAN



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RETAINING WALL NO. 2

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	9
PROFILE ALONG -L-	

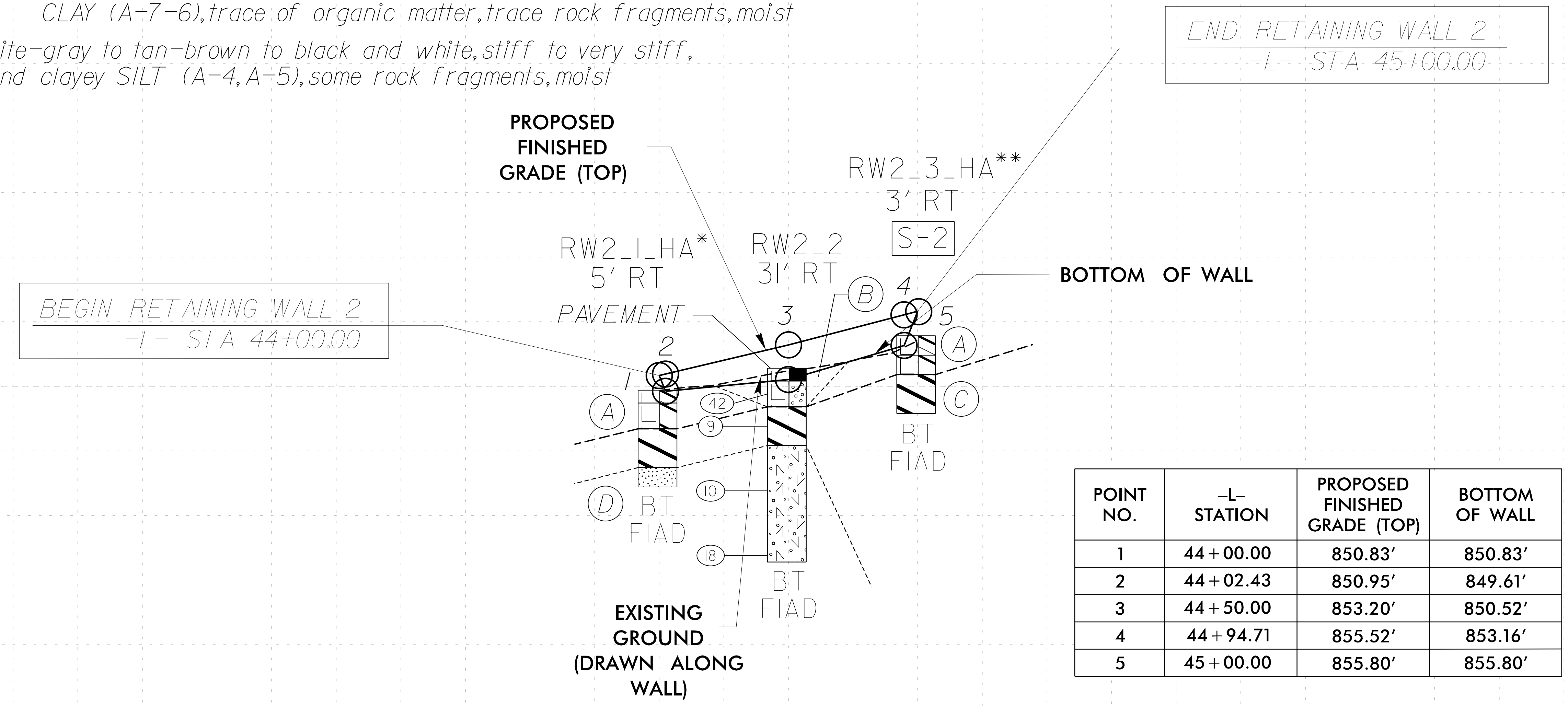
0 50 100
FEET
VE = 5

Ⓐ ROADWAY EMBANKMENT Brown to brown-orange, medium stiff to hard, sandy and silty highly plastic CLAY (A-6, A-7-6), trace of organic matter, moist

Ⓑ Tan-white, dense, silty fine to coarse SAND (A-2-4), little gravel, moist

Ⓒ RESIDUAL Brown-orange to dark gray and red-brown, medium stiff to very stiff, silty CLAY (A-7-6), trace of organic matter, trace rock fragments, moist

Ⓓ Tan-white-gray to tan-brown to black and white, stiff to very stiff, sandy and clayey SILT (A-4, A-5), some rock fragments, moist



POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	44+00.00	850.83′	850.83′
2	44+02.43	850.95′	849.61′
3	44+50.00	853.20′	850.52′
4	44+94.71	855.52′	853.16′
5	45+00.00	855.80′	855.80′

SOIL TEST RESULTS

SAMPLE NO.	STATION	OFFSET	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
S-2	45+00	38' LT	1.5-3.0'	A-7-6	55	28	1	6	34	60	100	99	96	28	ND

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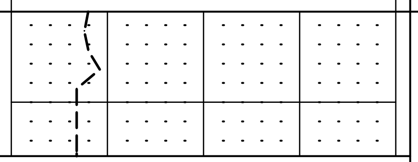
-L-

41+00 42+00 43+00 44+00 45+00 46+00 47+00

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.	
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 2				**GROUND WTR (ft)**
BORING NO. RW2_1_HA	**STATION** 44+00	**OFFSET** 36 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 849.7 ft	**TOTAL DEPTH** 7.5 ft	**NORTHING** 845,328	**EASTING** 1,719,059	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE N/A		**DRILL METHOD** Hand Auger		**HAMMER TYPE** Manual
DRILLER Kabra, S.	**START DATE** 01/19/21	**COMP. DATE** 01/19/21	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	BLOW COUNT 0.5ft	BLOW COUNT 0.5ft	SAMP. NO.	MOI
850							M
							M
							M
							M
845							M
							M



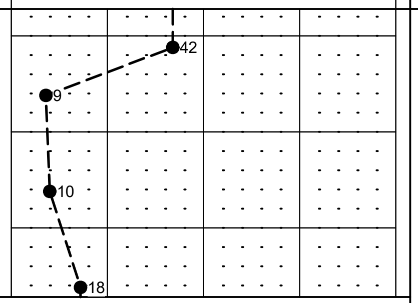
ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
849.7	GROUND SURFACE	0.0
849.2	**ROADWAY EMBANKMENT**	0.5
848.7	Brown, very stiff, sandy CLAY (A-6)	1.0
848.2	DCP blows - 3, 9, and 11	1.5
847.2	DCP blows - 5, 9, and 10	2.5
846.7		3.0
846.2	Brown, very stiff, silty CLAY (A-7-6)	3.5
845.2	DCP blows - 6, 10, and 10	4.5
843.7	DCP blows - 13, 11, and 12	6.0
842.2		7.5
	RESIDUAL	
	Brown-orange, very stiff, silty CLAY (A-7-6)	
	DCP blows - 12, 9, and 8	
	Tan-white-gray, very stiff, clayey fine sandy SILT (A-4)	
	DCP blows - 16 and 24	

Boring Terminated at Elevation 842.2 ft In Residual clayey sandy SILT (A-4)

DCP values converted to equivalent SPT blows/ft.

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.	
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 2				**GROUND WTR (ft)**
BORING NO. RW2_2	**STATION** 44+50	**OFFSET** 10 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 851.4 ft	**TOTAL DEPTH** 15.0 ft	**NORTHING** 845,330	**EASTING** 1,719,116	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER Tignor, D.	**START DATE** 01/12/21	**COMP. DATE** 01/12/21	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	BLOW COUNT 0.5ft	BLOW COUNT 0.5ft	SAMP. NO.	MOI
855							
850	850.4	1.0	24	26	16		M
	847.9	3.5	4	4	5		M
845							
	842.9	8.5	3	5	5		M
840							
	837.9	13.5	3	5	13		M



ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
851.4	GROUND SURFACE	0.0
850.4	**ROADWAY EMBANKMENT**	1.0
	0.6' Asphalt, 0.4' ABC	
848.4	Tan-white, dense, silty fine to coarse SAND (A-2-4), little gravel	3.0
	RESIDUAL	
845.4	Dark gray and red-brown, stiff, silty CLAY (A-7-6), trace rock fragments	6.0
	Black and white to tan-brown, stiff to very stiff, clayey SILT (A-5), some rock fragments	
836.4		15.0

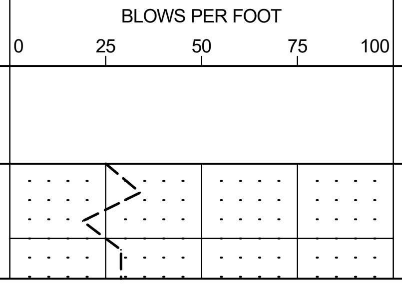
Boring Terminated at Elevation 836.4 ft In Residual clayey SILT (A-5)

NCDOT BORE DOUBLE U-4015A_RKK.GPJ NC_DOT.GDT 3/29/22

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 2			**GROUND WTR (ft)**
BORING NO. RW2_3_HA	**STATION** 45+00	**OFFSET** 38 ft LT	**ALIGNMENT** -L-
COLLAR ELEV. 853.9 ft	**TOTAL DEPTH** 6.0 ft	**NORTHING** 845,379	**EASTING** 1,719,147
DRILL RIG/HAMMER EFF./DATE N/A		**DRILL METHOD** Hand Auger	**HAMMER TYPE** Manual
DRILLER Kabra, S.	**START DATE** 01/19/21	**COMP. DATE** 01/19/21	**SURFACE WATER DEPTH** N/A

0 HR. Dry
24 HR. FIAD



ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI	LOG
855								
							M	
						S-2	28%	
850							M	
							M	

ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
853.9	GROUND SURFACE	0.0
	ROADWAY EMBANKMENT	
852.4	Brown-orange, very stiff, sandy CLAY (A-6)	1.5
850.9	SR blows - 1, 6, and 8	3.0
	Brown, hard, sandy silty highly plastic CLAY (A-7-6)	
847.9	SR blows - 4, 10, and 11	6.0
	RESIDUAL	
	Brown-orange, very stiff, silty CLAY (A-7-6) SR blows - 3, 4, and 5 SR blows - 10, 7, and 10	

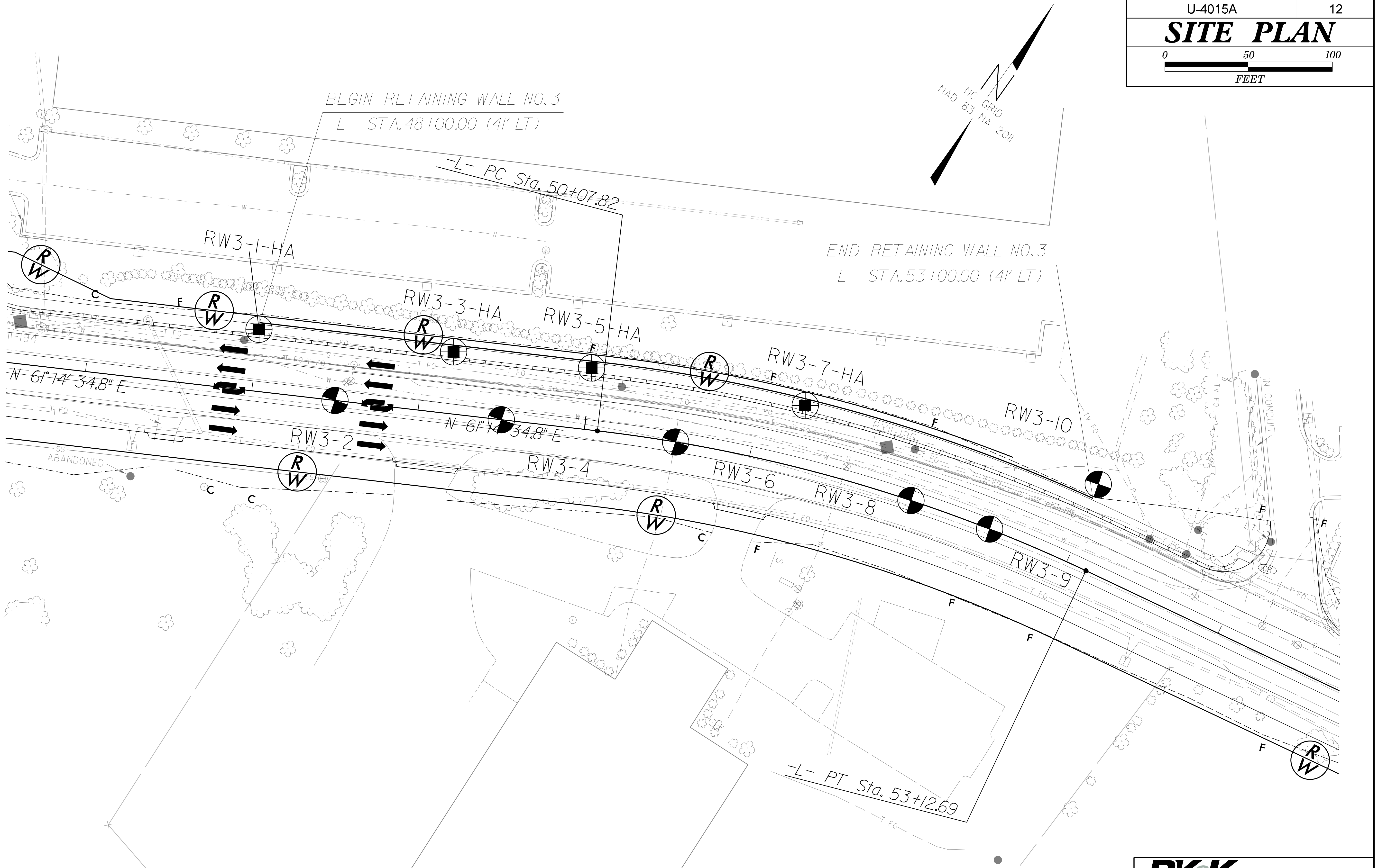
Boring Terminated at Elevation 847.9 ft In Residual silty CLAY (A-7-6)

Sounding Rod blows/ft values converted to equivalent SPT blows/ft

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	12

SITE PLAN

0 50 100
FEET



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RETAINING WALL NO. 3

0 50 100
FEET
VE = 5

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	13

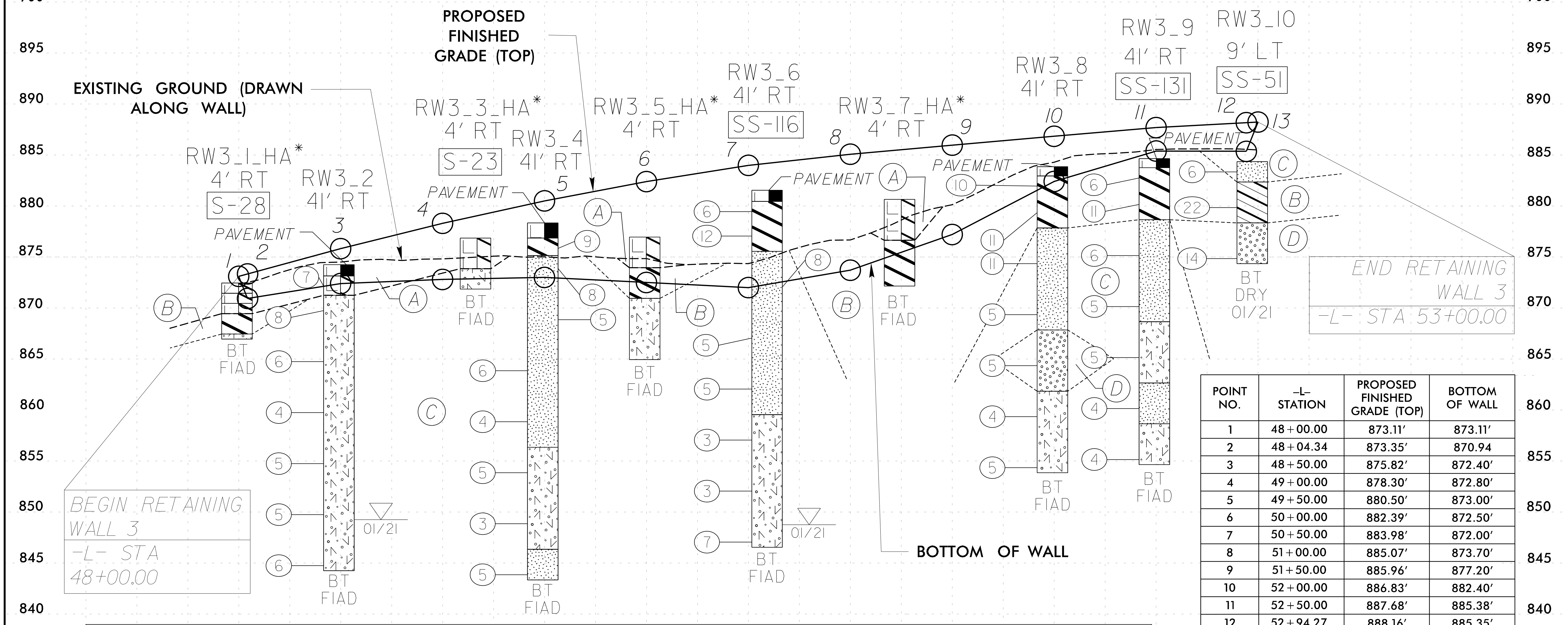
PROFILE ALONG -L-

Ⓐ ROADWAY EMBANKMENT Brown to brown-red-black to red-brown, medium stiff to very stiff, sandy and silty highly plastic CLAY (A-6, A-7-5, A-7-6), trace of organic matter, trace gravel, trace mica, moist

Ⓑ RESIDUAL Brown to brown-black to red-orange, medium stiff to very stiff, sandy and silty highly plastic CLAY (A-6, A-7-6), trace of organic matter, trace rock fragments, trace mica, moist

Ⓒ Tan-brown to red-orange-brown to orange-tan-black to orange-white, soft to stiff, sandy and clayey SILT (A-4, A-5), trace of organic matter, trace to little mica, saprolitic, moist to saturated

Ⓓ Tan-brown to red-orange, loose to medium dense, clayey silty fine to coarse SAND (A-2-5), trace mica, trace rock fragments, saprolitic, moist



POINT NO.	–L– STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	48+00.00	873.11′	873.11′
2	48+04.34	873.35′	870.94
3	48+50.00	875.82′	872.40′
4	49+00.00	878.30′	872.80′
5	49+50.00	880.50′	873.00′
6	50+00.00	882.39′	872.50′
7	50+50.00	883.98′	872.00′
8	51+00.00	885.07′	873.70′
9	51+50.00	885.96′	877.20′
10	52+00.00	886.83′	882.40′
11	52+50.00	887.68′	885.38′
12	52+94.27	888.16′	885.35′
13	53+00.00	888.22′	888.22′

SOIL TEST RESULTS

SAMPLE NO.	STATION	OFFSET	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
S-28	48+00	37' LT	0.0-1.0'	A-7-5	61	30	10	19	20	51	99	93	75	30	ND
S-23	49+17	37' LT	0.0-1.0'	A-7-5	58	28	ND	ND	ND	ND	36	0	64	25	ND
SS-116	50+60	0 CL	1.1-2.6'	A-7-6	58	31	11	15	16	59	100	94	78	26	ND
SS-131	52+50	0 CL	0.9-2.4'	A-7-6	56	28	13	17	22	48	97	89	72	31	ND
SS-51	52+98	50' LT	0.0-1.5'	A-4	18	3	ND	ND	ND	ND	ND	ND	43	12	ND

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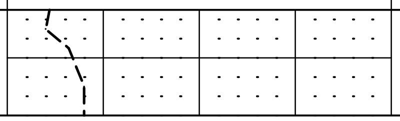
GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.	
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3				**GROUND WTR (ft)**
BORING NO. RW3_1_HA	**STATION** 48+00	**OFFSET** 37 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 872.5 ft	**TOTAL DEPTH** 5.5 ft	**NORTHING** 845,522	**EASTING** 1,719,410	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE N/A		**DRILL METHOD** Hand Auger	**HAMMER TYPE** Manual	
DRILLER Kabra, S.	**START DATE** 01/19/21	**COMP. DATE** 01/19/21	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI
875								
870							S-28	30% M M M M



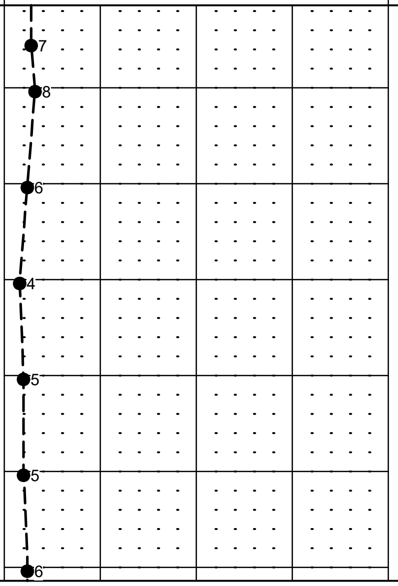
ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
872.5	GROUND SURFACE	0.0
872.0	**ROADWAY EMBANKMENT**	0.5
871.5	Brown-red, stiff, sandy silty highly plastic CLAY (A-7-5), trace gravel	1.0
871.0	DCP blows - 4, 5, and 6	1.5
870.5	DCP blows - 6, 5, and 5	2.0
870.0	Brown-red, stiff, silty CLAY (A-7-6), trace gravel	2.5
869.5	DCP blows - 10, 8, and 8	3.0
869.0	Brown-red, very stiff, sandy CLAY (A-6), trace gravel	3.5
868.0	DCP blows - 5, 9, and 9	4.5
867.5	**RESIDUAL** Brown, very stiff, sandy silty to silty CLAY (A-7-6) DCP blows - 8, 8, and 12	5.0
867.0	Tan-brown, stiff, clayey SILT (A-5)	5.5

Boring Terminated at Elevation 867.0 ft In Residual clayey SILT (A-5)

DCP values converted to equivalent SPT blows/ft.

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.	
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3				**GROUND WTR (ft)**
BORING NO. RW3_2	**STATION** 48+50	**OFFSET** CL	**ALIGNMENT** -L-	**0 HR.** 25.0
COLLAR ELEV. 874.3 ft	**TOTAL DEPTH** 30.0 ft	**NORTHING** 845,514	**EASTING** 1,719,472	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Tignor, D.	**START DATE** 01/12/21	**COMP. DATE** 01/12/21	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI
875								
	873.2	1.1	3	3	4	7		M
870	870.8	3.5	2	3	5	8		M
865	865.8	8.5	1	3	3	6		M
860	860.8	13.5	2	2	2	4		M
855	855.8	18.5	2	2	3	5		M
850	850.8	23.5	2	2	3	5		▽
845	845.8	28.5	2	2	4	6		W



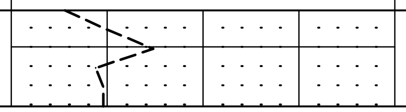
ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
874.3	GROUND SURFACE	0.0
873.2	**ROADWAY EMBANKMENT** 0.7' Asphalt, 0.4' ABC	1.1
871.3	Brown-red-black, medium stiff, sandy silty CLAY (A-7-5), trace mica **RESIDUAL** Red-orange-brown to orange-tan to brown-tan-orange, medium stiff to stiff, sandy clayey SILT (A-5), trace mica	3.0
844.3		30.0

Boring Terminated at Elevation 844.3 ft In Residual sandy clayey SILT (A-5)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Kabra, S.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3			**GROUND WTR (ft)**
BORING NO. RW3_3_HA	**STATION** 49+17	**OFFSET** 37 ft LT	**ALIGNMENT** -L-
COLLAR ELEV. 876.9 ft	**TOTAL DEPTH** 5.0 ft	**NORTHING** 845,578	**EASTING** 1,719,513
DRILL RIG/HAMMER EFF./DATE N/A	**DRILL METHOD** Hand Auger	**HAMMER TYPE** Manual	
DRILLER Goode, B.	**START DATE** 01/19/21	**COMP. DATE** 01/19/21	**SURFACE WATER DEPTH** N/A

GROUND WTR (ft)	
0 HR.	Dry
24 HR.	FIAD



SAMP. NO.	MOI	ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
		876.9	GROUND SURFACE	0.0
S-23	25%	876.4	**ROADWAY EMBANKMENT** Brown, stiff to very stiff, sandy silty highly plastic CLAY (A-7-5), trace gravel DCP blows - 4, 6, and 8 DCP blows - 12, 14, and 11 DCP blows - 8, 11, and 26 DCP blows - 9, 11, and 11	0.5
	M	875.4		1.5
	M	874.4		2.5
	M	873.9	**RESIDUAL** Brown-tan, stiff, clayey SILT (A-5), trace mica DCP blows - 9, 13, and 11	3.0
	M	873.4		3.5
		872.4		4.5
		871.9		5.0

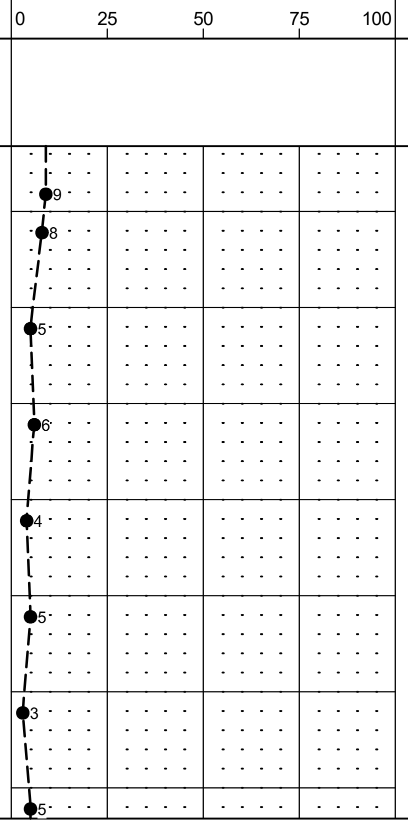
Boring Terminated at Elevation 871.9 ft In Residual clayey SILT (A-5)

DCP values converted to equivalent SPT blows/ft.

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3			
BORING NO. RW3_4	**STATION** 49+50	**OFFSET** CL	**ALIGNMENT** -L-
COLLAR ELEV. 878.4 ft	**TOTAL DEPTH** 35.0 ft	**NORTHING** 845,562	**EASTING** 1,719,560
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021	**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Tignor, D.	**START DATE** 01/14/21	**COMP. DATE** 01/14/21	**SURFACE WATER DEPTH** N/A

GROUND WTR (ft)	
0 HR.	Dry
24 HR.	FIAD

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	MOI
876.9	1.5	3	4	5	9	M
874.9	3.5	2	4	4	8	M
869.9	8.5	2	2	3	5	M
864.9	13.5	2	3	3	6	M
859.9	18.5	2	2	2	4	M
854.9	23.5	2	2	3	5	W
849.9	28.5	1	1	2	3	W
844.9	33.5	1	2	3	5	W

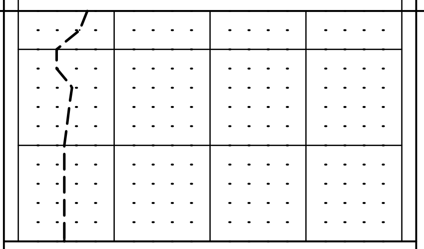


ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
878.4	GROUND SURFACE	0.0
876.9	**ROADWAY EMBANKMENT** 0.6' Asphalt, 0.9' ABC	1.5
875.2	Red-orange, stiff, silty CLAY (A-7-6), trace mica	3.2
	RESIDUAL Red-orange-black to orange-tan-black, medium stiff to stiff, sandy SILT (A-4), trace mica, saprolitic	
856.4	Orange-tan-black, soft to medium stiff, clayey SILT (A-5), trace mica, saprolitic	22.0
846.4	Tan-brown, medium stiff, sandy SILT (A-4), trace mica, saprolitic	32.0
843.4		35.0

Boring Terminated at Elevation 843.4 ft In Residual sandy SILT (A-4)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Kabra, S.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3			**GROUND WTR (ft)**
BORING NO. RW3_5_HA	**STATION** 50+00	**OFFSET** 37 ft LT	**ALIGNMENT** -L-
			0 HR. Dry
COLLAR ELEV. 877.0 ft	**TOTAL DEPTH** 12.0 ft	**NORTHING** 845,618	**EASTING** 1,719,586
			24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE N/A	**DRILL METHOD** Hand Auger	**HAMMER TYPE** Manual	
DRILLER Goode, B.	**START DATE** 01/19/21	**COMP. DATE** 01/19/21	**SURFACE WATER DEPTH** N/A

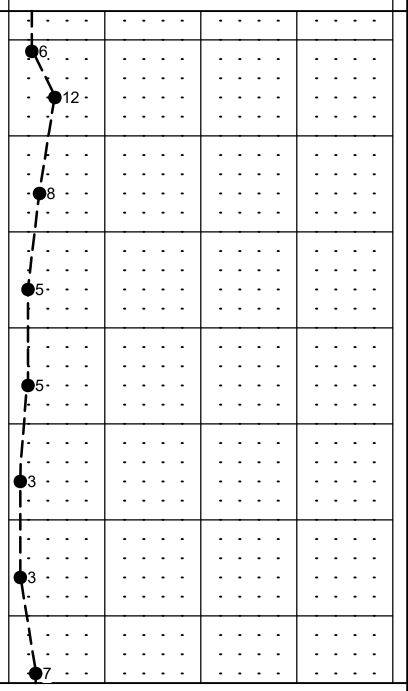


ELEV (ft)	MOI	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
877.0		GROUND SURFACE	0.0
876.5	M	**ROADWAY EMBANKMENT**	0.5
875.5	M	Red-brown, stiff to very stiff, sandy silty CLAY (A-7-6), trace gravel	1.5
874.5	M		2.5
874.0			3.0
873.5	M	DCP blows - 9, 9, and 9	3.5
872.5	M	DCP blows - 7, 8, and 8	4.5
871.0		DCP blows - 5, 5, and 5	6.0
869.5	M	DCP blows - 5, 5, and 5	7.5
		RESIDUAL Brown, stiff, silty CLAY (A-7-6), trace rock fragments DCP blows - 6, 7, and 7	
865.0		Brown, stiff, clayey SILT (A-5), trace mica DCP blows - 4, 5, and 7	12.0

Boring Terminated at Elevation 865.0 ft In Residual clayey SILT (A-5)

DCP values converted to equivalent SPT blows/ft.

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3			**GROUND WTR (ft)**
BORING NO. RW3_6	**STATION** 50+55	**OFFSET** CL	**ALIGNMENT** -L-
			0 HR. 32.8
COLLAR ELEV. 881.5 ft	**TOTAL DEPTH** 35.0 ft	**NORTHING** 845,611	**EASTING** 1,719,652
			24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021	**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Tignor, D.	**START DATE** 01/14/21	**COMP. DATE** 01/14/21	**SURFACE WATER DEPTH** N/A



DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
880.4	1.1	3	3	3	6	SS-116	26%
878.0	3.5	3	5	7	12		M
873.0	8.5	3	4	4	8		M
868.0	13.5	2	2	3	5		M
863.0	18.5	2	2	3	5		M
858.0	23.5	1	1	2	3		M
853.0	28.5	1	2	1	3		W
848.0	33.5	2	3	4	7		▽ Sat.

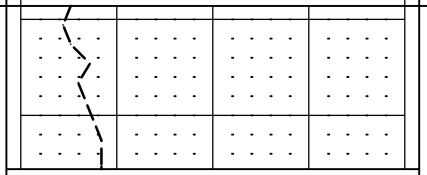
ELEV (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
881.5	GROUND SURFACE	0.0
880.4	**ROADWAY EMBANKMENT** 0.7' Asphalt, 0.4' ABC	1.1
878.5	Red-brown, medium stiff, silty highly plastic CLAY (A-7-6)	3.0
875.5	**RESIDUAL** Red-brown, stiff, silty highly plastic CLAY (A-7-6) Red-brown to brown-orange, medium stiff to stiff, sandy SILT (A-4), saprolitic, trace mica	6.0
859.5	Brown-orange-tan, soft to medium stiff, sandy clayey SILT (A-5), trace to little mica	22.0
846.5		35.0

Boring Terminated at Elevation 846.5 ft In Residual sandy clayey SILT (A-5)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3			**GROUND WTR (ft)**
BORING NO. RW3_7_HA	**STATION** 51+25	**OFFSET** 37 ft LT	**ALIGNMENT** -L- **0 HR.** Dry
COLLAR ELEV. 880.7 ft	**TOTAL DEPTH** 8.5 ft	**NORTHING** 845,674	**EASTING** 1,719,703 **24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE N/A		**DRILL METHOD** Hand Auger	**HAMMER TYPE** Manual
DRILLER Kabra, S.	**START DATE** 01/19/21	**COMP. DATE** 01/19/21	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI
885							
880							M
							M
							M
							M
							M
875							M
							M



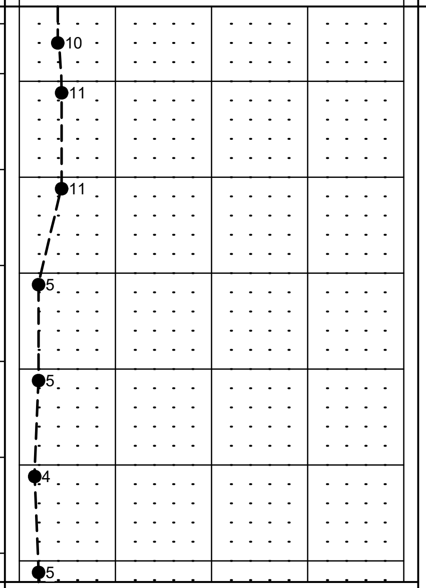
ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
880.7	GROUND SURFACE	0.0
880.2	**ROADWAY EMBANKMENT**	0.5
879.2	Red-brown to brown, stiff to very stiff, silty	1.5
878.2	CLAY (A-7-6), trace gravel	2.5
877.2	DCP blows - 4, 5, and 8	3.5
876.7	DCP blows - 4, 4, and 7	4.0
876.2	DCP blows - 4, 6, and 7	4.5
873.2	DCP blows - 9, 8, and 10	7.5
872.2	DCP blows - 5, 7, and 8	8.5
	RESIDUAL	
	Brown-black to brown-red, very stiff, silty CLAY (A-7-6)	
	DCP blows - 8, 11, and 10	

Boring Terminated at Elevation 872.2 ft In Residual silty CLAY (A-7-6)

DCP values converted to equivalent SPT blows/ft.

WBS 35013.1.1	**TIP** U-4015A	**COUNTY** GUILFORD	**GEOLOGIST** Goode, B.
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3			**GROUND WTR (ft)**
BORING NO. RW3_8	**STATION** 52+00	**OFFSET** CL	**ALIGNMENT** -L- **0 HR.** Dry
COLLAR ELEV. 883.9 ft	**TOTAL DEPTH** 30.0 ft	**NORTHING** 845,664	**EASTING** 1,719,787 **24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER Tignor, D.	**START DATE** 01/18/21	**COMP. DATE** 01/18/21	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
885								
	883.0	0.9	4	5	5	10		M
880	880.4	3.5	3	5	6	11		M
875	875.4	8.5	3	5	6	11		M
870	870.4	13.5	1	2	3	5		M
865	865.4	18.5	1	2	3	5		M
860	860.4	23.5	1	1	3	4		M
855	855.4	28.5	1	2	3	5		M



ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
883.9	GROUND SURFACE	0.0
883.0	**ROADWAY EMBANKMENT** 0.6' Asphalt, 0.3' ABC	0.9
880.9	Red-orange, stiff, silty CLAY (A-7-6), trace gravel	3.0
	RESIDUAL	
877.9	Red-orange, stiff, sandy silty CLAY (A-7-6), trace rock fragments Orange-red, medium stiff to stiff, sandy SILT (A-4), saprolitic	6.0
867.9	Tan-brown, loose, silty fine to coarse SAND (A-2-5), trace mica, saprolitic	16.0
861.9	Tan-orange to tan-orange-gray, medium stiff, sandy clayey SILT (A-5)	22.0
853.9		30.0

Boring Terminated at Elevation 853.9 ft In Residual sandy clayey SILT (A-5)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35013.1.1 | **TIP** U-4015A | **COUNTY** GUILFORD | **GEOLOGIST** Goode, B.

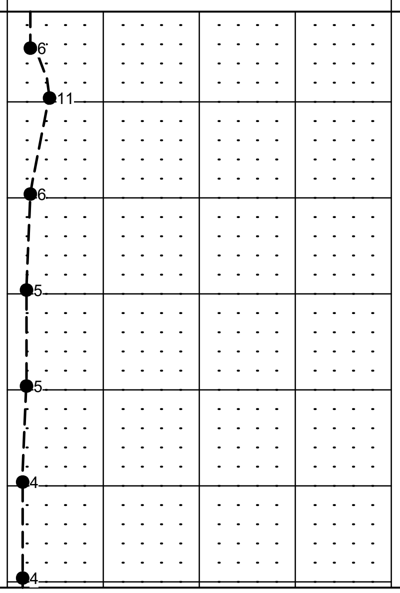
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3

				GROUND WTR (ft)
BORING NO. RW3_9	**STATION** 52+50	**OFFSET** CL	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 884.7 ft	**TOTAL DEPTH** 30.0 ft	**NORTHING** 845,678	**EASTING** 1,719,835	**24 HR.** FIAD

DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021 | **DRILL METHOD** H.S. Augers | **HAMMER TYPE** Automatic

DRILLER Tignor, D. | **START DATE** 01/18/21 | **COMP. DATE** 01/18/21 | **SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
885								
	883.8	0.9	4	3	3	6	SS-131	31%
880	881.2	3.5	3	4	7	11		M
875	876.2	8.5	2	3	3	6		M
870	871.2	13.5	1	2	3	5		M
865	866.2	18.5	1	2	3	5		M
860	861.2	23.5	1	2	2	4		M
855	856.2	28.5	1	2	2	4		W



ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
884.7	GROUND SURFACE	0.0
883.8	**ROADWAY EMBANKMENT** 0.6' Asphalt, 0.3' ABC	0.9
881.7	Red-orange, medium stiff, silty highly plastic CLAY (A-7-6)	3.0
	RESIDUAL	
878.7	Red-orange, stiff, silty highly plastic CLAY (A-7-6) Orange-red, medium stiff, sandy SILT (A-4), saprolitic	6.0
868.7	Orange-white, medium stiff, clayey SILT (A-5), saprolitic	16.0
862.7	Tan-brown-orange, medium stiff, sandy SILT (A-4), saprolitic	22.0
858.7	Tan-orange, medium stiff, clayey SILT (A-5), saprolitic	26.0
854.7	Boring Terminated at Elevation 854.7 ft In Residual clayey SILT (A-5)	30.0

WBS 35013.1.1 | **TIP** U-4015A | **COUNTY** GUILFORD | **GEOLOGIST** Goode, B.

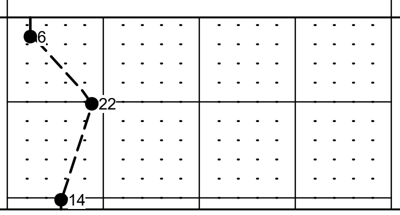
SITE DESCRIPTION Gallimore Dairy Rd. Widening: Retaining Wall No. 3

				GROUND WTR (ft)
BORING NO. RW3_10	**STATION** 52+98	**OFFSET** 50 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 884.4 ft	**TOTAL DEPTH** 10.0 ft	**NORTHING** 845,737	**EASTING** 1,719,873	**24 HR.** Dry

DRILL RIG/HAMMER EFF./DATE F&R2245 CME-55 92% 04/30/2021 | **DRILL METHOD** H.S. Augers | **HAMMER TYPE** Automatic

DRILLER Tignor, D. | **START DATE** 01/11/21 | **COMP. DATE** 01/11/21 | **SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
885								
	884.4	0.0	WOH	3	3	6	SS-51	12%
880	880.9	3.5	4	10	12	22		M
875	875.9	8.5	3	6	8	14		M



ELEV. (ft)	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
884.4	GROUND SURFACE	0.0
883.9	**ROADWAY EMBANKMENT** Brown, medium stiff, sandy SILT (A-4)	0.5
882.4	**RESIDUAL** Brown, medium stiff, sandy SILT (A-4)	2.0
	Red-orange, very stiff, sandy CLAY (A-6), trace rock fragments	
878.4	Red-orange, medium dense, clayey silty fine to coarse SAND (A-2-5), trace rock fragments	6.0
874.4	Boring Terminated at Elevation 874.4 ft In Residual clayey silty SAND (A-2-5)	10.0

RK&K

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April 6, 2022

Memorandum to:	Mr. Brian Ketner, PE Project Manager NCDOT – Division 7 1584 Yanceyville Street Greensboro, NC 27415
From:	Atefeh Asoudeh, P.E. Project Manager, Geotechnical
WBS Number:	35013.1.1
TIP Number:	U-4015A
County:	Guilford
Description:	SR 1556 (Gallimore Dairy Road) Widening from NC 68 (Lynwood Smith Expressway) to Airport Road in Greensboro
Subject:	**Retaining Wall Recommendations, Wall No. 1 through Wall No. 3 - Revision 2**

RK&K is pleased to submit the following revised recommendations for the proposed retaining walls. The revision to this letter includes removing the recommendation for previously named Retaining Wall No. 2 located at -L- Sta. 36+50.00 to -L- Sta. 39+50.00. The wall was removed due to the right of way conflicts. The previously named Retaining Wall No.3 and Retaining Wall No.4 were revised to Retaining Wall No. 2 and Retaining Wall No.3, respectively.

The recommendations are based on soil test borings performed by RK&K and roadway plans. This report includes recommendations for the following retaining walls:

Retaining Wall No. 1: -L- Sta. 27+25.00 to -L- Sta. 29+50.00
Retaining Wall No. 2: -L- Sta. 44+00.00 to -L- Sta. 45+00.00
Retaining Wall No. 3: -L- Sta. 48+00.00 to -L- Sta. 53+00.00

It is recommended that Retaining Wall No. 1 through No. 3 be designed and constructed as a Mechanically Stabilized Earth (MSE) Wall with a level backslope and traffic surcharge. Wall No. 2 designed as MSE Wall not as Standard Segmental Gravity Wall due to the presence of handrail and traffic surcharge.

The attached MSE Retaining Wall (W-1 through W-5) plan sheets should be included in the Roadway Plans.

Prepared by,

DocuSigned by:
Atefeh Asoudeh
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SEAL
043747
ATEFEH ASOUDEH
8/20/2024

Atefeh Asoudeh, P.E.	Saket N. Kabra, P.E
Project Manager, Geotechnical	Project Engineer, Geotechnical
Registered, North Carolina 043747	Registered, North Carolina 053059

Attachments:
- MSE Retaining Wall Plan Sheets (W-1 through W-5)
- MSE Wall Standard Provision
- Architectural Concrete Surface Treatment Special Provision
- Provided Information

MSE RETAINING WALL PLAN SHEETS

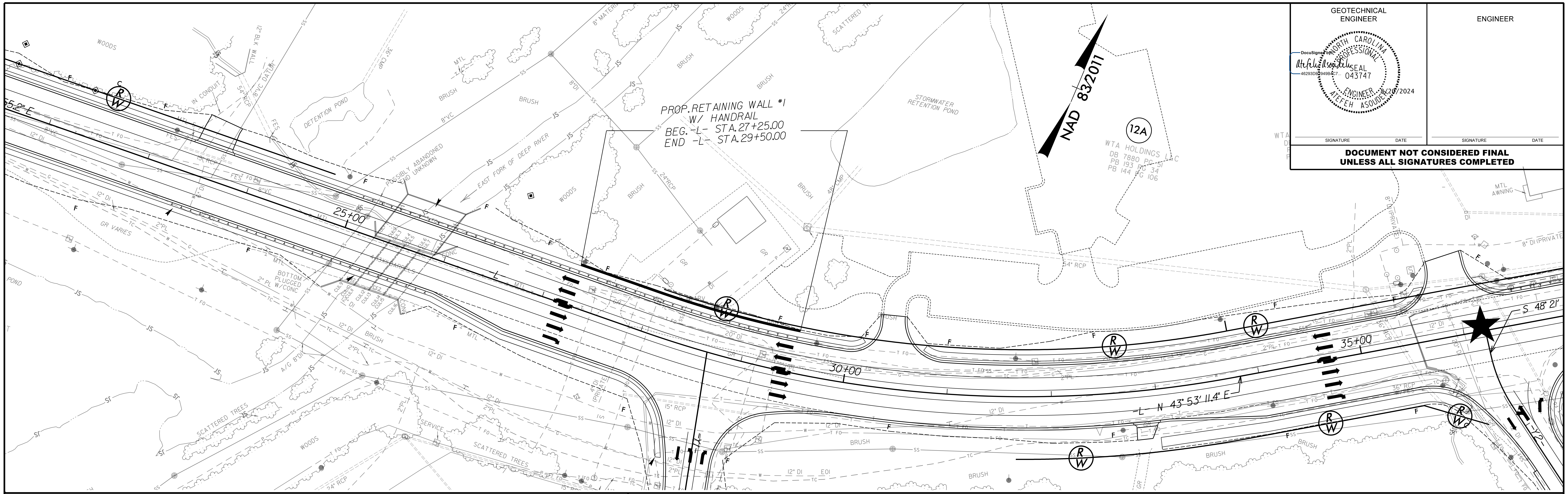
SHEET W1: RETAINING WALL NO. 1 - PLAN AND PROFILE

SHEET W2: RETAINING WALL NO. 2 - PLAN AND PROFILE

SHEET W3: RETAINING WALL NO. 3 - PLAN AND PROFILE

SHEET W4: MSE RETAINING WALL NO. 1 THROUGH NO.3 – DETAILS

SHEET W5: MSE RETAINING WALL NO. 1 THROUGH NO.3 – NOTES & LEVELING PAD DETAILS



GEOTECHNICAL ENGINEER

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Atefeh Asoudeh
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SEAL 043747
8/20/2024

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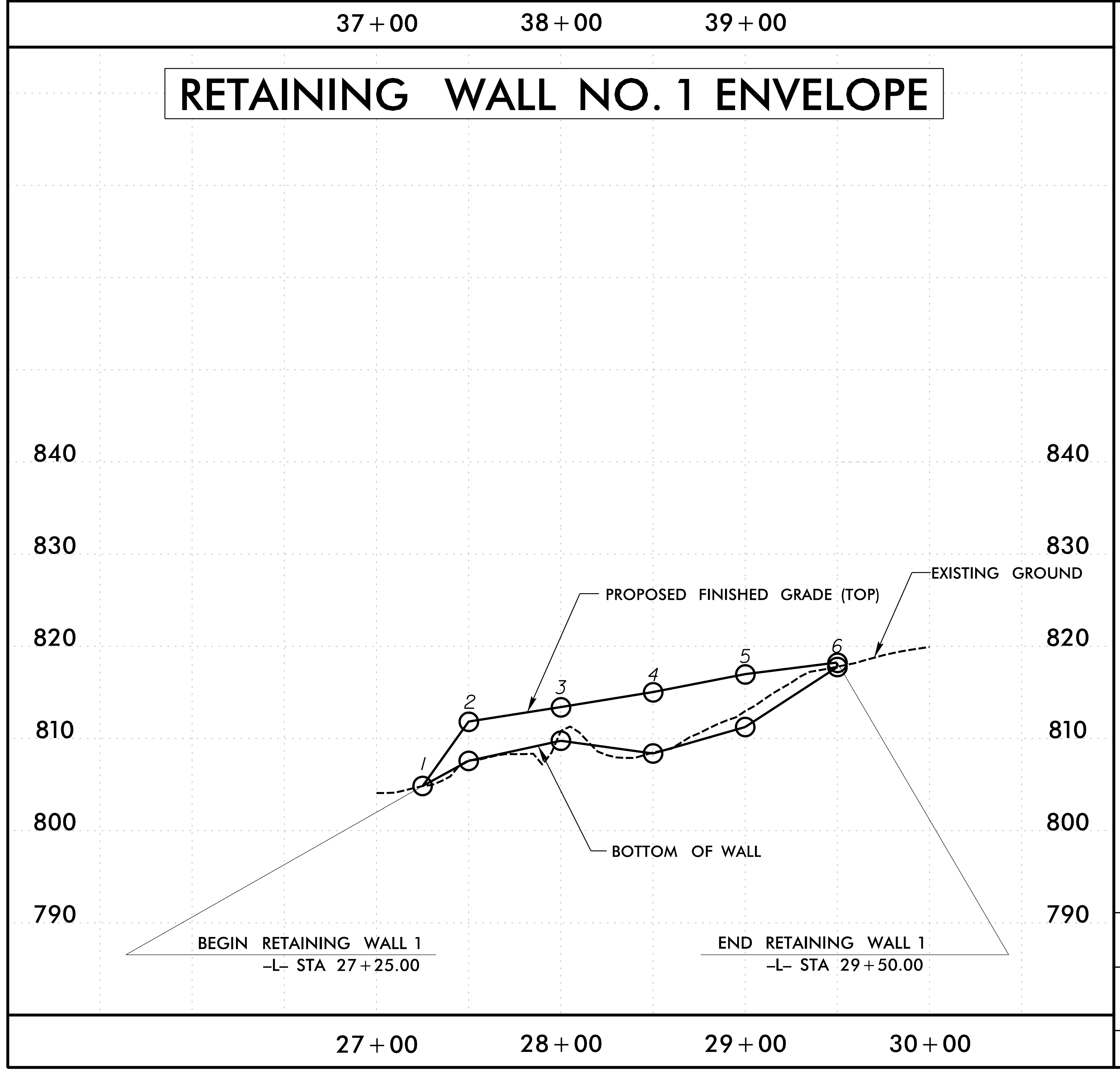

RETAINING WALL NO. 1 ENVELOPE

POINT NO.	–L– STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	27+25.00	804.85′	804.85′
2	27+50.00	811.84′	807.57′
3	28+00.00	813.41′	809.76′
4	28+50.00	815.04′	808.37′
5	29+00.00	816.98′	811.24′
6	29+50.00	818.24′	817.75′

ESTIMATED QUANTITIES

RETAINING WALL NO.	MSE RETAINING WALL (SQUARE FOOT)
1	1540

PROJECT NO.: U-4015A
GUILFORD COUNTY
STATION: RW-1: -L- 27+25.00 TO -L- 29+50.00
SHEET 1 OF 5

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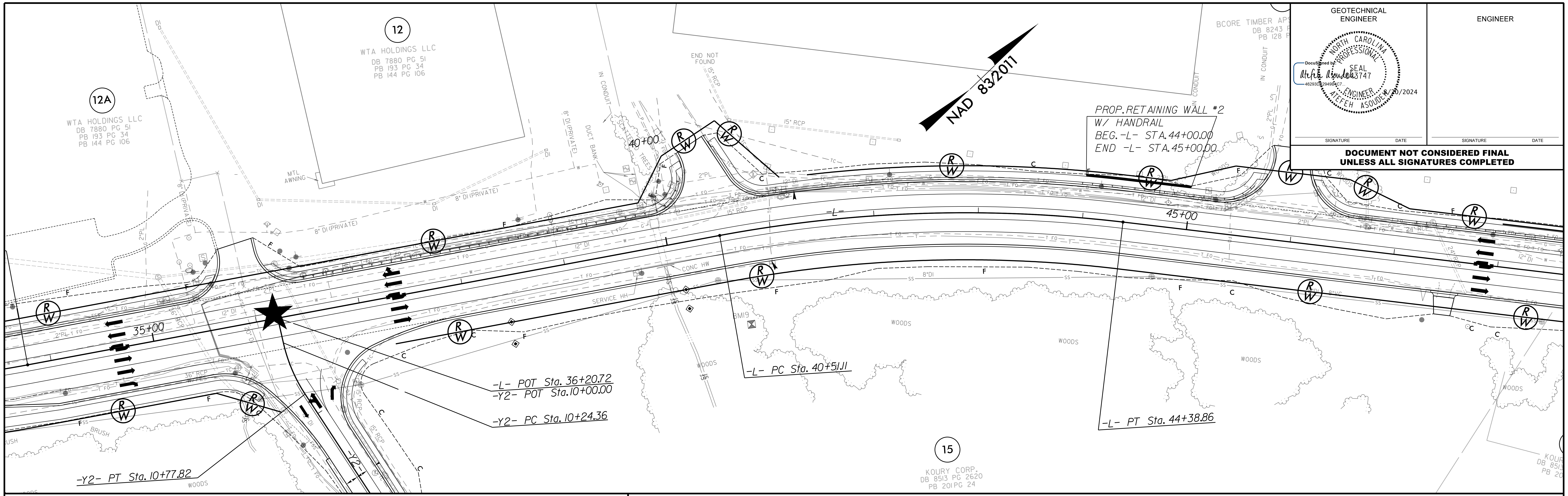
RETAINING WALL NO. 1
PLAN AND PROFILE

REVISIONS

NO.	BY	DATE	NO.	BY	DATE
1	S. KABRA	12/20/21	3		
2	S. KABRA	03/25/22	4		

SHEET NO.
W-1



GEOTECHNICAL ENGINEER

Atefeh Asoudeh
8/20/2024
SEAL 043747
ATEFEH ASOUDEH

SIGNATURE DATE

ENGINEER

SIGNATURE DATE

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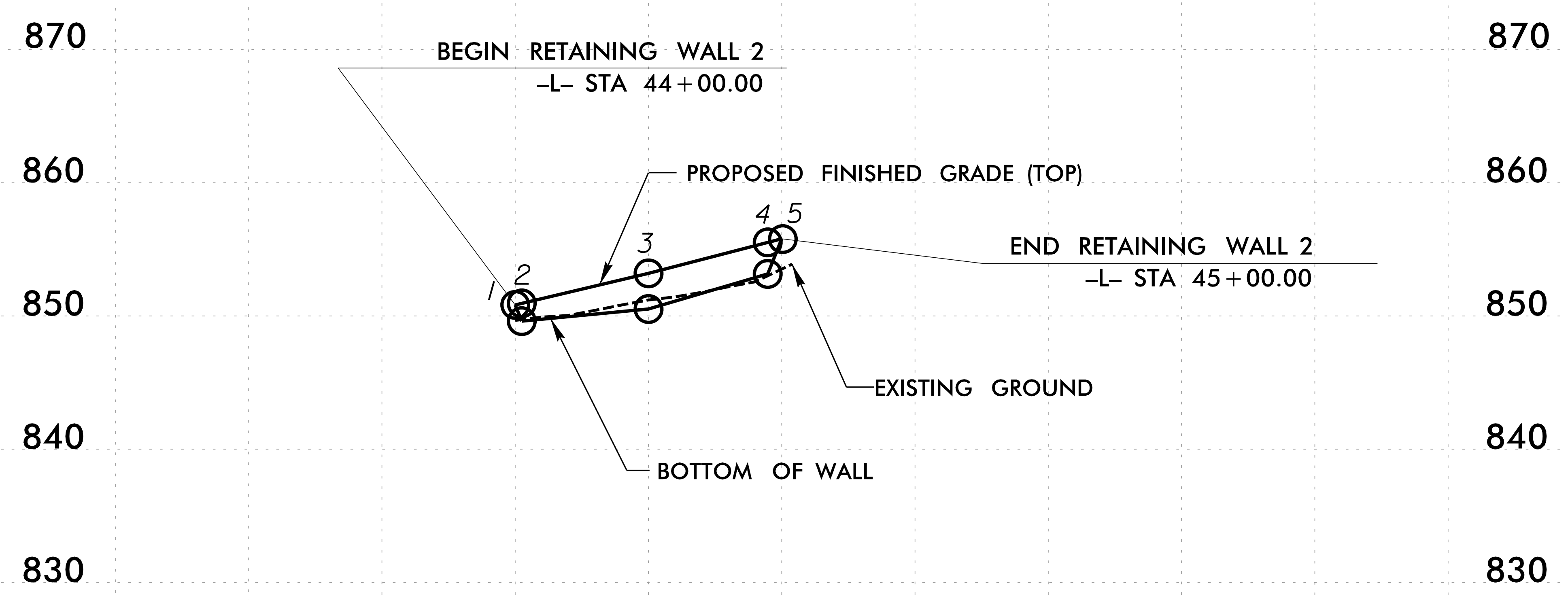
44+00 45+00 46+00

RETAINING WALL NO. 2 ENVELOPE

POINT NO.	–L– STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	44+00.00	850.83′	850.83′
2	44+02.43	850.95′	849.61′
3	44+50.00	853.20′	850.52′
4	44+94.71	855.52′	853.16′
5	45+00.00	855.80′	855.80′



44+00 45+00 46+00

ESTIMATED QUANTITIES

RETAINING WALL NO.	MSE RETAINING WALL (SQUARE FOOT)
2	470

PROJECT NO.: U-4015A
GUILFORD COUNTY
STATION: RW-2: -L- 44+00.00 TO -L- 45+00.00
SHEET 2 OF 5

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RETAINING WALL NO. 2 PLAN AND PROFILE

REVISIONS

NO.	BY	DATE	NO.	BY	DATE	SHEET NO.
1	S. KABRA	12/20/21	3			W-2
2	S. KABRA	03/25/22	4			

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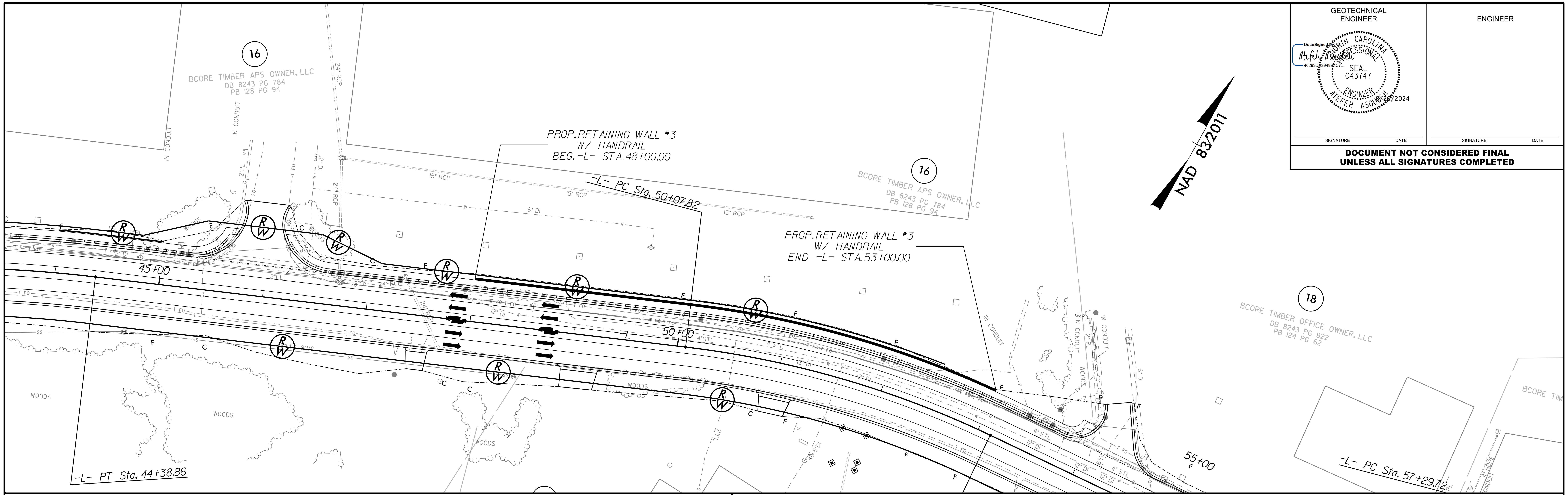

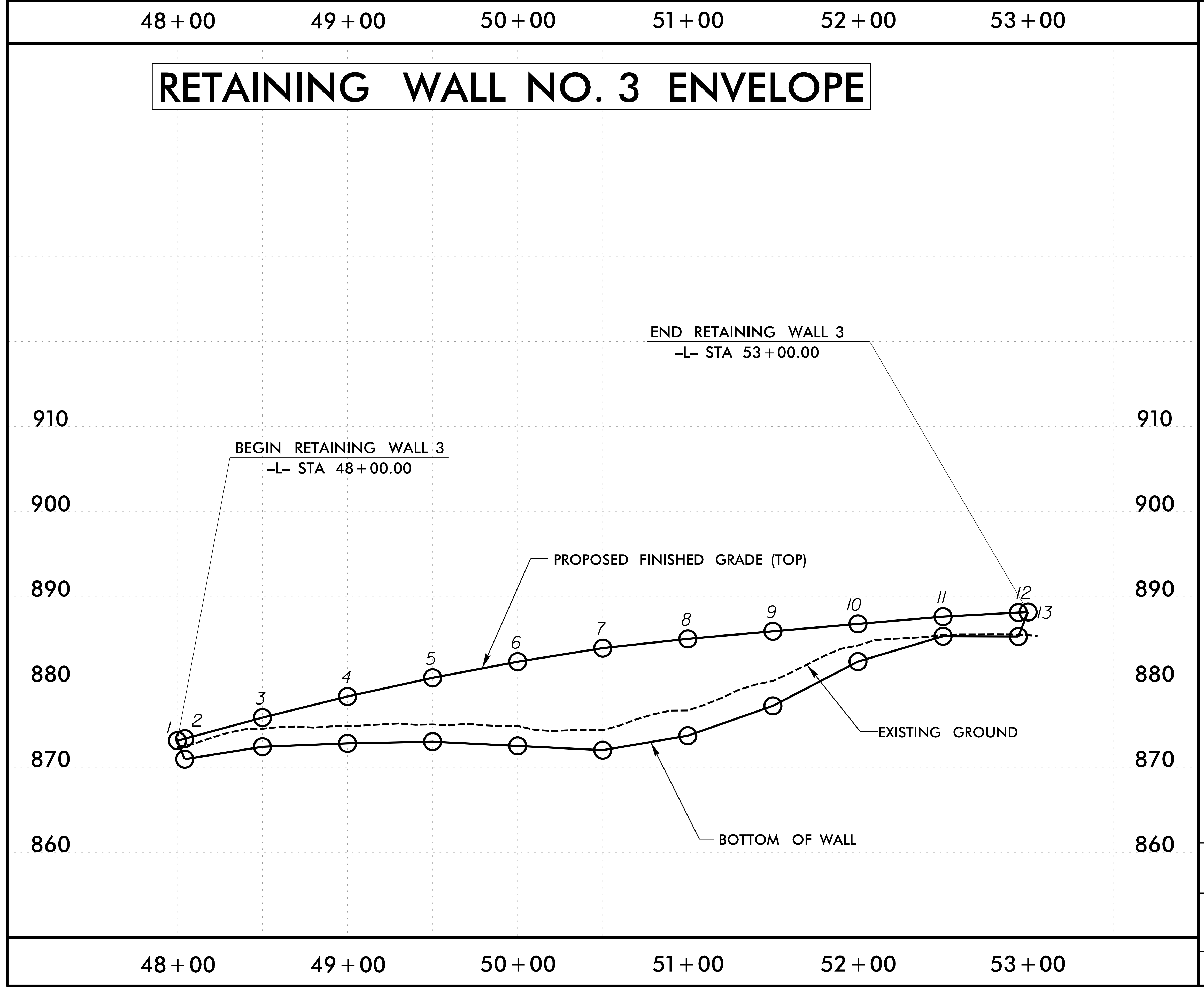

POINT NO.	–L– STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	48+00.00	873.11′	873.11′
2	48+04.34	873.35′	870.94
3	48+50.00	875.82′	872.40′
4	49+00.00	878.30′	872.80′
5	49+50.00	880.50′	873.00′
6	50+00.00	882.39′	872.50′
7	50+50.00	883.98′	872.00′
8	51+00.00	885.07′	873.70′
9	51+50.00	885.96′	877.20′
10	52+00.00	886.83′	882.40′
11	52+50.00	887.68′	885.38′
12	52+94.27	888.16′	885.35′
13	53+00.00	888.22′	888.22′

PROJECT NO.: U-4015A
GUILFORD COUNTY
STATION: RW-3: -L- 48+00.00 TO -L- 53+00.00
SHEET 3 OF 5

ESTIMATED QUANTITIES

RETAINING WALL NO.	MSE RETAINING WALL (SQUARE FOOT)
3	4,630

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RETAINING WALL NO. 3
PLAN AND PROFILE

REVISIONS

NO.	BY	DATE	NO.	BY	DATE
1	S. KABRA	12/20/21	3		
2	S. KABRA	03/25/22	4		

SHEET NO.
W-3

GEOTECHNICAL ENGINEER

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043747
ATEFEH ASOUDEH
8/20/2024

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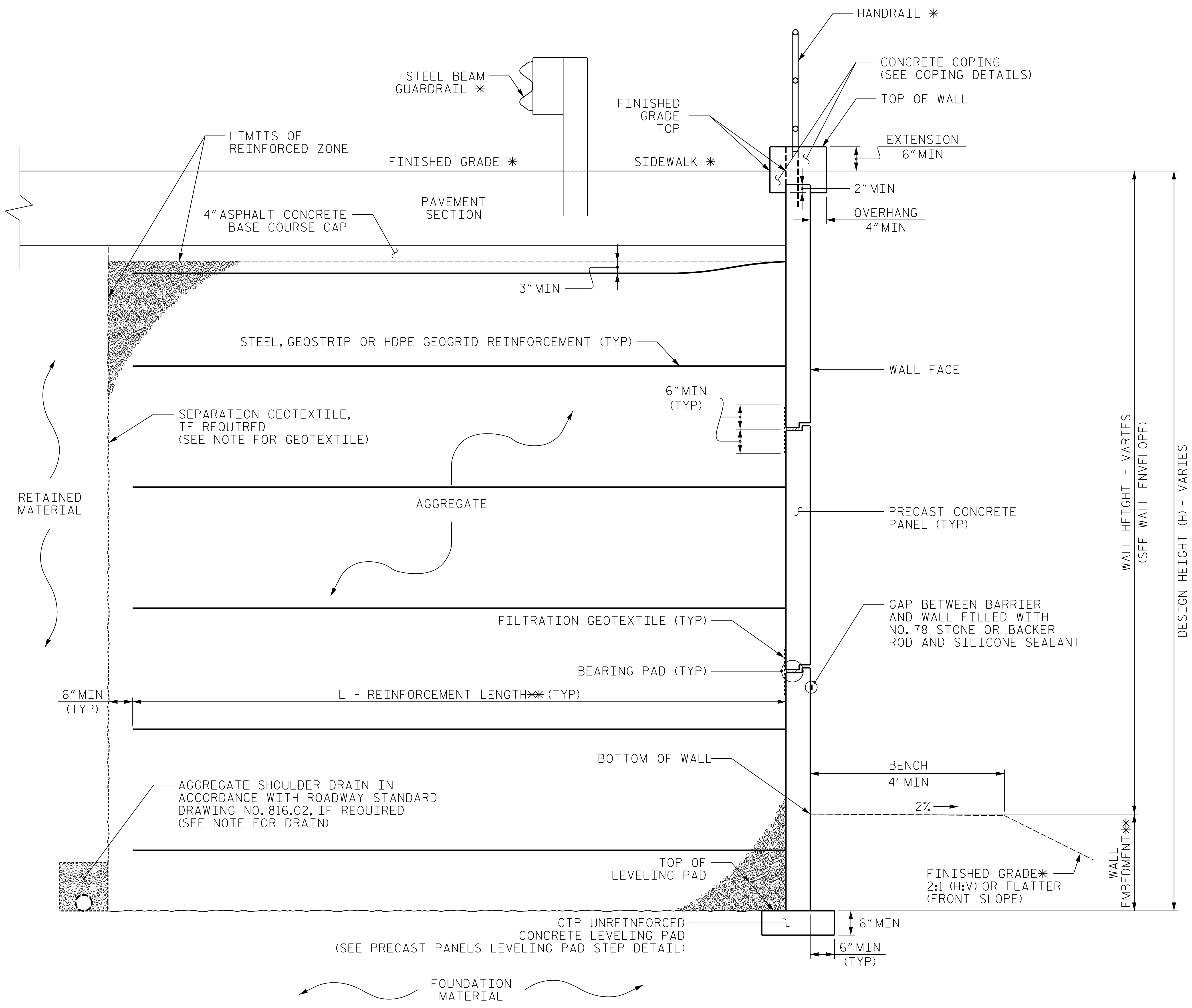
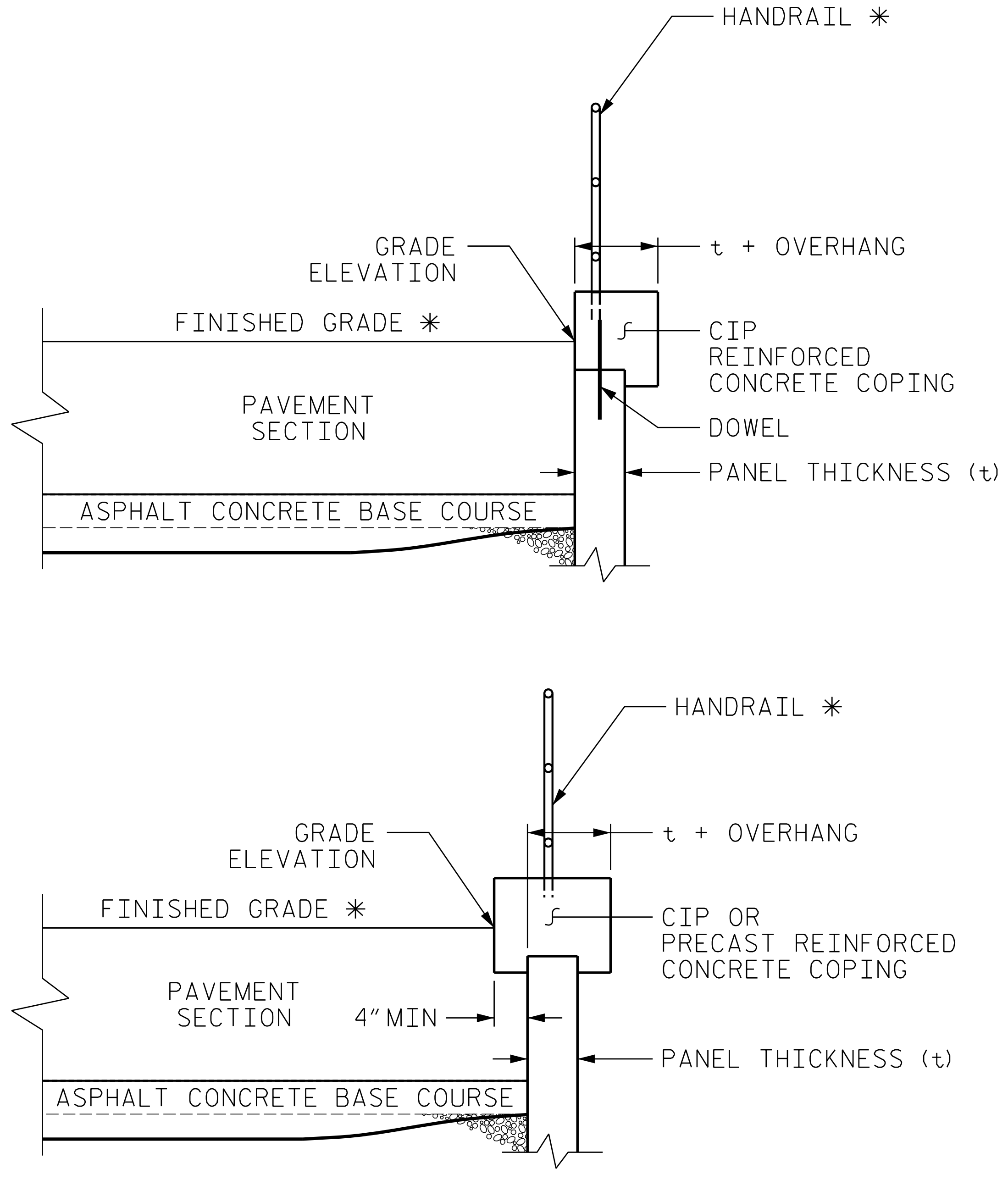


MSE WALL WITH PRECAST PANELS - TYPICAL SECTION

✳ SEE ROADWAY PLANS FOR FINISHED GRADE, SIDEWALK, GUARDRAIL AND HANDRAILS DETAILS.
✳✳ SEE MSE RETAINING WALLS PROVISION AND IF APPLICABLE, MSE WALL NOTES FOR WALL EMBEDMENT AND REINFORCEMENT LENGTH REQUIREMENTS.



COPING DETAILS

AT THE CONTRACTOR'S OPTION, CONNECT COPING TO PANELS WITH DOWELS OR EXTEND COPING DOWN BACK OF PANELS.
✳ SEE ROADWAY PLANS FOR FINISHED GRADE DETAILS.

PROJECT NO.: U-4015A
GUILFORD COUNTY
STATION: RW1: -L- 27+25.00 TO -L- 29+50.00
RW2: -L- 44+00.00 TO -L- 45+00.00
RW3: -L- 48+00.00 TO -L- 53+00.00

SHEET 4 OF 5
WALL ID RW-1 TO 3

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DIVISION OF HIGHWAYS

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MSE RETAINING WALL NO. 1 THROUGH NO. 3 DETAILS

REVISIONS

NO.	BY	DATE	NO.	BY	DATE
1	S. KABRA	12/20/21	3		
2	S. KABRA	03/25/22	4		

SHEET NO. W-4

PREPARED BY: S. KABRA	DATE: 03/25/22
REVIEWED BY: M. METRY	DATE: 03/28/22

GEOTECHNICAL ENGINEER	ENGINEER
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NOTES:

FOR MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALLS, SEE MECHANICALLY STABILIZED EARTH RETAINING WALLS PROVISION.

FOR STEEL BEAM GUARDRAIL, SEE ROADWAY PLANS AND SECTION 862 OF THE STANDARD SPECIFICATIONS.

USE AN MSE WALL SYSTEM WITH PRECAST CONCRETE PANELS THAT MEET SECTION 1077 OF THE STANDARD SPECIFICATIONS FOR RETAINING WALL NO. 1 THROUGH NO. 3.

AN ASHLAR STONE ARCHITECTURAL FINISH IS REQUIRED FOR CONCRETE FOR RETAINING WALLS NO. 1 THROUGH NO. 3. SEE ARCHITECTURAL CONCRETE SURFACE TREATMENT SPECIAL PROVISION.

CIP REINFORCED CONCRETE COPING IS REQUIRED FOR RETAINING WALL NO. 1 THROUGH NO. 3.

AT THE CONTRACTOR'S OPTION, USE FINE AGGREGATE IN THE REINFORCED ZONE OF RETAINING WALL NO. 1 THROUGH NO. 3.

A SEPARATION GEOTEXTILE IS NOT REQUIRED AT THE BACK OF THE REINFORCED ZONE FOR RETAINING WALL NO. 1 THROUGH NO. 3, PROVIDED FINE AGGREGATE IS USED IN THE REINFORCED ZONE.

A DRAIN IS REQUIRED FOR RETAINING WALL NO. 1 THROUGH NO. 3.

BEFORE BEGINNING MSE WALL DESIGN FOR RETAINING WALL NO. 1 THROUGH NO. 3, SURVEY WALL LOCATION AND SUBMIT A REVISED WALL PROFILE VIEW (WALL ENVELOPE) FOR REVIEW. DO NOT START WALL DESIGN OR CONSTRUCTION UNTIL THE REVISED WALL ENVELOPE IS ACCEPTED.

DESIGN RETAINING WALL NO. 1 THROUGH NO. 3 FOR THE FOLLOWING:
1) DESIGN HEIGHT (H) = WALL HEIGHT + WALL EMBEDMENT
2) DESIGN LIFE = 75 YEARS
3) MINIMUM EMBEDMENT DEPTH = 2 FT
4) MAXIMUM FACTORED VERTICAL PRESSURE ON FOUNDATION MATERIAL SHALL BE AS SHOWN BELOW.
5) MINIMUM REINFORCEMENT LENGTH (L) SHALL BE AS SHOWN BELOW OR 6 FT, WHICHEVER IS LONGER

WALL NO.	-L- STATION	REINFORCEMENT LENGTH RATIO	MAXIMUM FACTORED VERTICAL PRESSURE ON FOUNDATION MATERIAL (KSF)
1	27+25.00 TO 29+50.00	0.8H	2.5
2	44+00.00 TO 45+00.00	1.2H	1.4
3	48+00.00 TO 49+00.00	0.8H	2.2
3	49+00.00 TO 52+00.00	0.7H	3.9
3	52+00.00 TO 53+00.00	0.8H	2.2

6) REINFORCED ZONE AGGREGATE PARAMETERS:

AGGREGATE TYPE✱	UNIT WEIGHT (γ) PCF	FRICTION ANGLE (ϕ) DEGREES	COHESION (c) PSF
COARSE	110	38	0
FINE	115	34	0

✱SEE MSE RETAINING WALLS PROVISION FOR COARSE AND FINE AGGREGATE MATERIAL REQUIREMENTS.

7) IN-SITU ASSUMED MATERIAL PARAMETERS:

MATERIAL TYPE	UNIT WEIGHT (γ) PCF	FRICTION ANGLE (ϕ) DEGREES	COHESION (c) PSF
RETAINED	120	30	0
FOUNDATION AT RW NO. 1	120	28	0
FOUNDATION AT RW NO. 2	120	28	0
FOUNDATION AT RW NO. 3	120	28	0

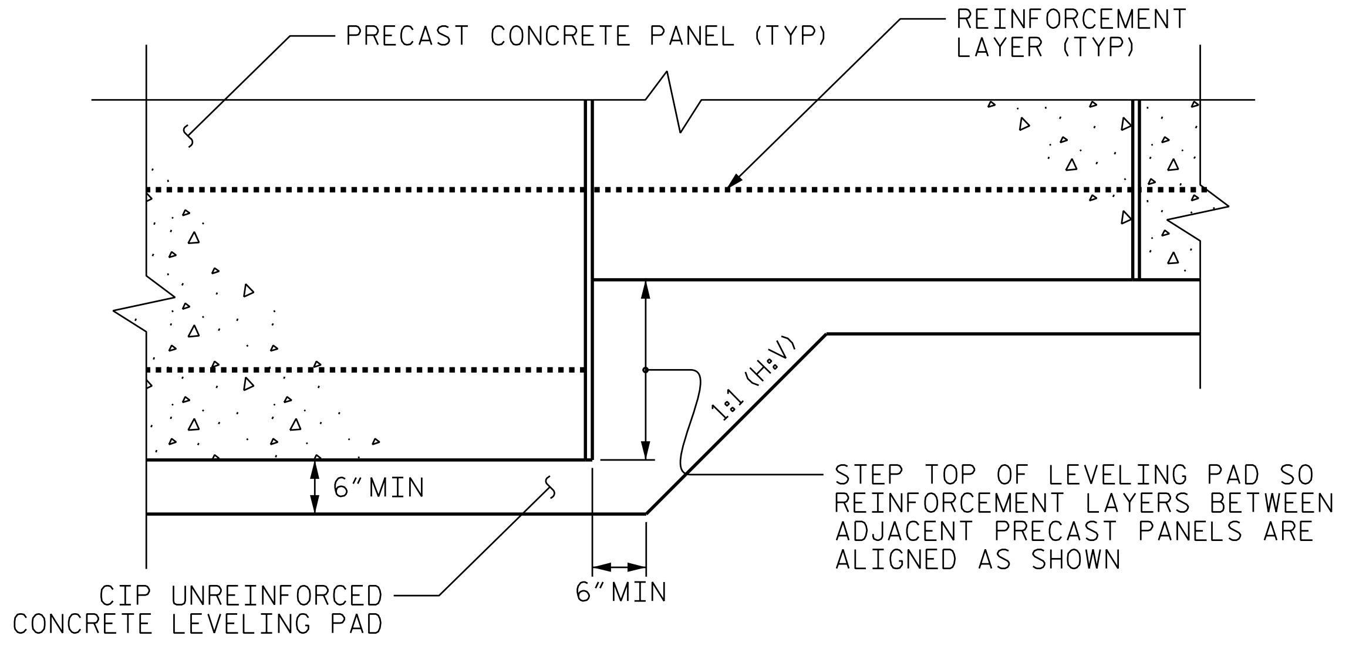
DESIGN RETAINING WALL NO. 1 THROUGH NO.3 FOR A LIVE LOAD (TRAFFIC) SURCHARGE.

FOUNDATIONS FOR SIGNS, LIGHTING or SIGNALS MAY BE LOCATED BEHIND RETAINING WALL NO. 1 THROUGH NO. 3, AND MAY INTERFERE WITH REINFORCEMENT. BEFORE BEGINNING MSE WALL CONSTRUCTION, SUBMIT PROPOSED CONSTRUCTION METHODS FOR THESE FOUNDATIONS FOR APPROVAL.

EXISTING OR FUTURE OBSTRUCTIONS SUCH AS FOUNDATIONS, GUARDRAIL, FENCE OR HANDRAIL POSTS, PAVEMENTS, PIPES, INLETS OR UTILITIES MAY INTERFERE WITH REINFORCEMENT FOR RETAINING WALL NO. 1 THROUGH NO. 3.

DO NOT PLACE LEVELING PAD CONCRETE, AGGREGATE OR REINFORCEMENT FOR RETAINING WALL NO. 1 AND NO. 3, UNTIL EXCAVATION DIMENSIONS AND FOUNDATION MATERIAL ARE APPROVED.

"TEMPORARY SHORING" MAY BE REQUIRED FOR RETAINING WALL NO. 1 THROUGH NO. 3, IN ACCORDANCE WITH THE TEMPORARY SHORING PROVISION. SEE ROADWAY or TRAFFIC CONTROL PLANS.



PRECAST PANELS
LEVELING PAD STEP DETAIL

PROJECT NO.: U-4015A
GUILFORD COUNTY
STATION: RW1: -L- 27+25.00 TO -L- 29+50.00
RW2: -L- 44+00.00 TO -L- 45+00.00
RW3: -L- 48+00.00 TO -L- 53+00.00

SHEET 5 OF 5
WALL ID RW-1 TO 3

PREPARED BY: S. KABRA	DATE: 03/25/22
REVIEWED BY: M. METRY	DATE: 03/28/22

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MSE RETAINING WALL NO. 1 THROUGH NO. 3 NOTES AND LEVELING PAD DETAILS

REVISIONS

NO.	BY	DATE	NO.	BY	DATE	SHEET NO.
1	S. KABRA	12/20/21	3			W-5
2	S. KABRA	03/25/22	4			

STANDARD PROVISIONS
FOR MSE WALLS

MECHANICALLY STABILIZED EARTH RETAINING WALLS (10-19-21)

1.0 GENERAL

Construct mechanically stabilized earth (MSE) retaining walls consisting of steel or geosynthetic reinforcement in the reinforced zone connected to vertical facing elements. Use precast concrete panels for vertical facing elements and coarse aggregate in the reinforced zone unless noted otherwise in the plans. Provide reinforced concrete coping and pile sleeves as required. Design and construct MSE retaining walls based on actual elevations and wall dimensions in accordance with the contract and accepted submittals. Use a prequalified MSE Wall Installer to construct MSE retaining walls.

Define MSE wall terms as follows:
Geosynthetic Reinforcement – Polyester Type (PET), HDPE or Polypropylene (PP) geosynthetic grids, i.e., geogrid reinforcement or polymer straps, i.e., geostrip reinforcement,
Geogrid – PET, HDPE or PP geogrid,
Reinforcement – Steel or geosynthetic reinforcement,
Aggregate – Coarse or fine aggregate,
Panel – Precast concrete panel,
Coping – Precast or CIP concrete coping,
Design Height (H) – Wall height + wall embedment as shown in the plans,
MSE Wall – Mechanically stabilized earth retaining wall,
MSE Wall Vendor – Vendor supplying the chosen MSE wall system,
MSE Panel Wall – MSE wall with panels,
MSE Segmental Wall – MSE wall with segmental retaining wall (SRW) units and
Abutment Wall – MSE wall with bridge foundations in any portion of the reinforced zone or an MSE wall connected to an abutment wall (even if bridge foundations only penetrate a small part of the reinforced zone, the entire MSE wall is considered an abutment wall).

For bridge approach fills behind end bents with MSE abutment walls, design reinforcement connected to end bent caps in accordance with the plans and this provision. Construct Type III Reinforced Bridge Approach Fills in accordance with the *Bridge Approach Fills* provision and Roadway Detail Drawing No. 422D10.

Use an approved MSE wall system in accordance with the plans and any NCDOT restrictions or exceptions for the chosen system. Value engineering proposals for other MSE wall systems will not be considered. Do not use MSE wall systems with an "approved for provisional use" status for MSE walls with design heights greater than 35 ft or walls supporting or adjacent to railroads or interstate highways. The list of approved MSE wall systems with approval status is available from:
connect.ncdot.gov/resources/Geological/Pages/Products.aspx

2.0 MATERIALS

Refer to the *Standard Specifications*.

Item	**Section**
Aggregate	1014

Asphalt Concrete Base Course, Type B25.0C	620
Corrugated Steel Pipe	1032-3
Epoxy, Type 3A	1081
Geosynthetics	1056
Grout, Type 3	1003
Joint Materials	1028
Portland Cement Concrete, Class A	1000
Precast Retaining Wall Coping	1077
Reinforcing Steel	1070
Retaining Wall Panels	1077
Segmental Retaining Wall Units	1040-4
Select Material, Class V	1016
Shoulder Drain Materials	816-2
Steel Pipe	1036-4(A)

Use galvanized corrugated steel pipe with a zinc coating weight of 2 oz/sf (G200) for pile sleeves. Provide Type 2 geotextile for filtration and separation geotextiles. Use Class A concrete for CIP coping, leveling concrete and pads. Use galvanized steel pipe, threaded rods and nuts for the PET geogrid reinforcement vertical obstruction detail. Provide galvanized Grade 36 anchor rods and Grade A hex nuts that meet AASHTO M 314 for threaded rods and nuts.

Use panels and SRW units from producers approved by the Department and licensed by the MSE Wall Vendor. Provide steel strip connectors embedded in panels fabricated from structural steel that meets the requirements for steel strip reinforcement. Unless required otherwise in the contract, produce panels with a smooth flat final finish that meets Article 1077-11 of the *Standard Specifications*. Accurately locate and secure reinforcement connectors in panels and maintain required concrete cover. Produce panels within 1/4" of the panel dimensions shown in the accepted submittals.

Damaged panels or SRW units with excessive discoloration, chips or cracks as determined by the Engineer will be rejected. Do not damage reinforcement connection devices or mechanisms in handling or storing panels and SRW units.

Store steel materials on blocking at least 12" above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. Handle and store geosynthetics in accordance with Article 1056-2 of the *Standard Specifications*. Load, transport, unload and store MSE wall materials so materials are kept clean and free of damage. Bent, damaged or defective materials will be rejected.

A. Aggregate

Use standard size No. 57, 57M, 67 or 78M that meets Table 1005-1 of the *Standard Specifications* for coarse aggregate and the following for fine aggregate:

1. Standard size No. 1S, 2S, 2MS or 4S that meets Table 1005-2 of the *Standard Specifications* or

2. Gradation that meets Class III, Type 3 select material in accordance with Article 1016-3 of the *Standard Specifications*.

Fine aggregate is exempt from mortar strength in Subarticle 1014-1(E) of the *Standard Specifications*. Use fine aggregate with a maximum organic content of 1.0%. Provide aggregate with chemical properties that meet the following requirements:

AGGREGATE pH REQUIREMENTS

Aggregate Type (in reinforced zone)	**Reinforcement or Connector Material**	**pH**
Coarse or Fine	Steel	5 – 10
Coarse or Fine	Geosynthetic	4.5 – 9

AGGREGATE ELECTROCHEMICAL REQUIREMENTS
(Steel Reinforcement/Connector Materials Only)

Aggregate Type (in reinforced zone)	**Resistivity**	**Chlorides**	**Sulfates**
Coarse	≥ 5,000 Ω · cm	≤ 100 ppm	≤ 200 ppm
Fine	≥ 3,000 Ω · cm		

Use aggregate from sources participating in the Department's Aggregate QC/QA Program as described in Section 1006 of the *Standard Specifications*. Sample and test aggregate in accordance with the *Mechanically Stabilized Earth Wall Aggregate Sampling and Testing Procedures*.

B. Reinforcement

Provide steel or geosynthetic reinforcement supplied by the MSE Wall Vendor or a manufacturer approved or licensed by the vendor. Use reinforcement approved for the chosen MSE wall system. The list of approved reinforcement for each MSE wall system is available from the website shown elsewhere in this provision.

1. Steel Reinforcement

   Provide Type 1 material certifications in accordance with Article 106-3 of the *Standard Specifications* for steel reinforcement. Use welded wire grid reinforcement ("mesh", "mats" and "ladders") that meet Article 1070-3 of the *Standard Specifications* and steel strip reinforcement ("straps") that meet ASTM A572, A1011 or A463. Use 10 gauge or heavier structural steel Grade 50 or higher for steel strip reinforcement. Galvanize steel reinforcement in accordance with Section 1076 of the *Standard Specifications* or provide aluminized steel strip reinforcement that meet ASTM A463, Type 2-100.

2. Geosynthetic Reinforcement

   Provide Type 1 material certifications and identify geosynthetic reinforcement in accordance with Article 1056-3 of the *Standard Specifications*. Define machine direction (MD) and cross-machine direction (CD) for geogrids per Article 1056-3 of the *Standard Specifications*.

Use HDPE or PP geogrid for geogrid reinforcement cast into backwalls of end bent caps. Use PET or HDPE geogrid for geogrid reinforcement connected directly to SRW units and only HDPE geogrid for geogrid reinforcement cast into panels.

Provide extruded geogrids produced in the United States and manufactured from punched and drawn polypropylene sheets for PP geogrids that meet the following:

PP GEOGRID REQUIREMENTS		
Property	**Requirement[1]**	**Test Method**
Aperture Dimensions[2]	1" x 1.2"	N/A
Minimum Rib Thickness[2]	0.07" x 0.07"	N/A
Tensile Strength @ 2% Strain[2]	580 lb/ft x 690 lb/ft	ASTM D6637, Method B
Tensile Strength @ 5% Strain[2]	1,200 lb/ft x 1,370 lb/ft	
Ultimate Tensile Strength[2]	1,850 lb/ft x 2,050 lb/ft	
Junction Efficiency[3] (MD)	93%	ASTM D7737
Flexural Rigidity[4]	2,000,000 mg–cm	ASTM D7748
Aperture Stability Modulus[5]	0.55 lb–ft/degrees	ASTM D7864
UV Stability (Retained Strength)	100% (after 500 hr of exposure)	ASTM D4355

1. MARV per Article 1056-3 of the *Standard Specifications* except dimensions and thickness are nominal.
2. Requirement for MD x CD.
3. Junction Efficiency (%) = (Average Junction Strength ($X_{j_{ave}}$) / Ultimate Tensile Strength in the MD from ASTM D6637, Method A) × 100.
4. Test specimens two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs, and sufficiently long to enable measurement of the overhang dimension.
5. Applied moment of 17.7 lb–inch (torque increment).

C. Bearing Pads

For MSE panel walls, use preformed ethylene propylene diene monomer rubber bearing pads that meet ASTM D2000 Grade 2, Type A, Class A with a durometer hardness of 60 or 80 ± 5. Provide bearing pads with thicknesses that meet the following:

BEARING PAD THICKNESS	
Facing Area per Panel (A)	**Minimum Pad Thickness After Compression (based on 2 times panel weight above pads)**
A ≤ 30 sf	1/2"
30 sf < A ≤ 75 sf	3/4"

D. Miscellaneous Components

Miscellaneous components may include connectors (e.g., anchors, bars, clamps, pins, plates, ties, etc.), fasteners (e.g., bolts, nuts, washers, etc.) and any other MSE wall components not included above. Use 10 gauge or heavier structural steel Grade 50 or higher for steel strip panel anchors and connectors. Galvanize steel components in accordance with Section 1076 of the *Standard Specifications*. Provide miscellaneous components approved for the chosen MSE wall system. The list of approved miscellaneous components for each MSE wall system is available from the website shown elsewhere in this provision.

3.0 PRECONSTRUCTION REQUIREMENTS

A. MSE Wall Surveys

The Retaining Wall Plans show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for each MSE wall. Before beginning MSE wall design, survey existing ground elevations shown in the plans and other elevations in the vicinity of MSE wall locations as needed. For proposed slopes above or below MSE walls, survey existing ground elevations to at least 10 ft beyond slope stake points. Based on these elevations, finished grades and actual MSE wall dimensions and details, submit revised wall envelopes for acceptance. Use accepted wall envelopes for design.

B. MSE Wall Designs

For MSE wall designs, submit PDF files of working drawings and design calculations at least 30 days before the preconstruction meeting. Note name and NCDOT ID number of the panel or SRW unit production facility on working drawings. Do not begin MSE wall construction until a design submittal is accepted.

Use a prequalified MSE Segmental Wall Design Consultant to design MSE segmental walls. Provide MSE segmental wall designs sealed by a Design Engineer approved as a Geotechnical Engineer (key person) for the MSE Segmental Wall Design Consultant. Provide MSE panel wall designs sealed by a Design Engineer licensed in the state of North Carolina and employed or contracted by the MSE Wall Vendor.

Design MSE walls in accordance with the plans, *AASHTO LRFD Bridge Design Specifications* and any NCDOT restrictions for the chosen MSE wall system unless otherwise required. For abutment walls only, design MSE walls for seismic if wall sites meet either or both of the following:

- Wall site is in seismic zone 2 based on Figure 2-1 of the *Structure Design Manual*,
- Wall site is classified as AASHTO Site Class E, as noted in the plans, and is in or west of Pender, Duplin, Wayne, Johnston, Wake, Durham or Person County.

Connect reinforcement to panels or SRW units with methods or devices approved for the chosen system. Use a uniform reinforcement length throughout the height of the wall of at least 0.7H or 6 ft, whichever is longer, unless noted otherwise in the plans. Extend the reinforced zone at least 6" beyond end of reinforcement. Do not locate drains, the reinforced zone or leveling pads outside right-of-way or easement limits.

Use the simplified method for determining maximum reinforcement loads and design parameters approved for the chosen MSE wall system or default values in accordance with the AASHTO LRFD specifications. Design steel components including reinforcement and connectors for the design life noted in the plans and aggregate type in the reinforced zone. If an MSE wall system with geosynthetic reinforcement includes any steel parts for obstructions, bin walls, connections or other components, design steel exposed to aggregate for the design life noted in the plans and aggregate type in the reinforced zone. Use “loss of galvanizing” metal loss rates for nonaggressive backfill in accordance with the AASHTO LRFD specifications for galvanized and aluminized steel and metal loss rates for carbon steel in accordance with the following:

CARBON STEEL CORROSION RATES

Aggregate Type (in reinforced zone)	Carbon Steel Loss Rate (after coating depletion)
Coarse	0.47 mil/year
Fine (except abutment walls)	0.58 mil/year
Fine (abutment walls)	0.70 mil/year

For PET or HDPE geogrid and geostrip reinforcement and geosynthetic connectors, use approved geosynthetic properties for the design life noted in the plans and aggregate type in the reinforced zone. For geogrid reinforcement connected to end bent caps, embed reinforcement or connectors in caps as shown in the plans. For PP geogrid reinforcement connected to end bent caps, use the following design parameters for the aggregate type in the reinforced approach fill.

PP GEOGRID REINFORCEMENT DESIGN PARAMETERS

Aggregate Type (in reinforced zone)	T_{al} (MD)	F*	α	ρ
Coarse	400 lb/ft	0.70	0.8	32.0°
Fine	428 lb/ft	0.54	0.8	28.35°

Where,

T_{al} = long-term design strength (LTDS),
F* = pullout resistance factor,
α = scale effect correction factor and
ρ = soil-geogrid friction angle.

When noted in the plans, design MSE walls for a live load (traffic) surcharge of 250 psf in accordance with Figure C11.5.6-3(b) of the AASHTO LRFD specifications. For steel beam guardrail with 8 ft posts or concrete barrier rail above MSE walls, analyze top 2 reinforcement layers for traffic impact loads in accordance with Section 7.2 of *FHWA Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I* (Publication No. FHWA-NHI-10-024) except use the following for geosynthetic reinforcement rupture:

$$\phi\ T_{al}\ R_c \geq T_{max} + (T_I\ /\ RF_{CR})$$

Where,

ϕ = resistance factor for tensile resistance in accordance with Section 7.2.1 of the FHWA MSE wall manual,
T_{al} = long-term geosynthetic design strength approved for chosen MSE wall system,
R_c = reinforcement coverage ratio = 1 for continuous geosynthetic reinforcement,
T_{max} = factored static load in accordance with Section 7.2 of the FHWA MSE wall manual,
T_I = factored impact load in accordance with Section 7.2 of the FHWA MSE wall manual and
RF_{CR} = creep reduction factor approved for chosen MSE wall system.

When shown in the plans for abutment walls, use pile sleeves to segregate piles from aggregate in the reinforced zone. If existing or future obstructions such as foundations, guardrail, fence or handrail posts, moment slabs, pavements, pipes, inlets or utilities will interfere with reinforcement, maintain a clearance of at least 3" between obstructions and reinforcement unless otherwise approved. Design reinforcement for obstructions and locate reinforcement layers so all of reinforcement length is within 3" of corresponding connection elevations. Modify PET geogrid reinforcement for obstructions as shown in the plans.

Use 6" thick CIP unreinforced concrete leveling pads beneath panels and SRW units that are continuous at steps and extend at least 6" in front of and behind bottom row of panels or SRW units. Unless required otherwise in the plans, embed top of leveling pads in accordance with the following requirements:

WALL EMBEDMENT REQUIREMENTS		
Front Slope[1] (H:V)	**Minimum Embedment Depth[2] (whichever is greater)**	
6:1 or flatter (except abutment walls)	H/20	1 ft for H ≤ 10 ft 2 ft for H > 10 ft
6:1 or flatter (abutment walls)	H/10	2 ft
> 6:1 to < 3:1	H/10	2 ft
3:1 to 2:1	H/7	2 ft

1. Front slope is as shown in the plans.
2. H is the maximum design height per wall.

When noted in the plans, locate a continuous aggregate shoulder drain along the base of the reinforced zone behind the aggregate. Provide wall drainage systems consisting of drains and outlet components in accordance with Roadway Standard Drawing No. 816.02.

For MSE panel walls, cover joints at back of panels with filtration geotextiles at least 12" wide. If the approval of the chosen MSE wall system does not require a minimum number of bearing pads, provide the number of pads in accordance with the following:

NUMBER OF BEARING PADS

Facing Area per Panel (A)	**Maximum Height of Wall Above Horizontal Panel Joint**	**Minimum Number of Pads per Horizontal Panel Joint**
A ≤ 30 sf	25 ft	2
	35 ft[1]	3
30 sf < A ≤ 75 sf	25 ft	3
	35 ft[1]	4

1. Additional bearing pads per horizontal panel joint may be required for wall heights above joints greater than 35 ft.

For MSE segmental walls, coarse aggregate is required in any SRW unit core spaces and between and behind SRW units for a horizontal distance of at least 18".

Separation geotextiles are required between the aggregate and overlying fill sections. When noted in the plans, separation geotextiles are also required at the back of the reinforced zone between the aggregate and backfill or natural ground. When placing pavement sections directly on the reinforced zone, cap aggregate with 4" of asphalt concrete base course. Unless required otherwise in the plans, use reinforced concrete coping at top of walls that meets the following requirements:

1. Coping dimensions as shown in the plans,
2. At the Contractor’s option, coping that is precast or CIP concrete for MSE panel walls unless CIP coping is required as shown in the plans,
3. CIP concrete coping for MSE segmental walls and
4. At the Contractor’s option and when shown in the plans, CIP concrete coping that extends down back of panels or SRW units or connects to panels or SRW units with dowels.

For MSE segmental walls with dowels, attach dowels to top courses of SRW units in accordance with the following:

1. Set dowels in core spaces of SRW units filled with grout instead of coarse aggregate or
2. Embed adhesively anchored dowels in holes of solid SRW units with epoxy.

For MSE panel walls with coping, connect CIP concrete coping or leveling concrete for precast concrete coping to top row of panels with dowels cast into panels. When concrete barrier rail is required above MSE walls, use concrete barrier rail with moment slab as shown in the plans.

Submit working drawings and design calculations for acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, wall profiles with foundation pressures, typical sections with reinforcement and connection details, aggregate locations and types, geotextile locations and details of leveling pads, panels or SRW units, coping, bin walls, slip joints, pile sleeves, etc. If necessary, include details on working drawings for concrete barrier rail with moment slab, reinforcement splices if allowed for the chosen MSE wall system, reinforcement connected to end bent caps, curved MSE walls with tight (short) radii and obstructions extending through walls or interfering with reinforcement, leveling pads, barriers or moment slabs. Submit design calculations for each wall section with different surcharge loads, geometry or material parameters. At least one analysis is required for each wall section with different reinforcement lengths. When designing MSE walls with computer software other than MSEW, use MSEW manufactured by ADAMA Engineering, Inc. to verify the design. At least one MSEW analysis is required per 100 ft of wall length with at least one analysis for the wall section with the longest reinforcement. Submit electronic MSEW input files and PDF output files with design calculations.

C. Preconstruction Meeting

Before starting MSE wall construction, hold a preconstruction meeting to discuss the construction and inspection of the MSE walls. If this meeting occurs before all MSE wall submittals have been accepted, additional preconstruction meetings may be required before beginning construction of MSE walls without accepted submittals. The Resident or Bridge Maintenance Engineer, Area Construction Engineer, Geotechnical Operations Engineer, Contractor and MSE Wall Installer Superintendent will attend preconstruction meetings.

4.0 CORROSION MONITORING

Corrosion monitoring is required for MSE walls with steel reinforcement. The Engineer will determine the number of monitoring locations and where to install the instrumentation. Contact M&T before beginning wall construction. M&T will provide the corrosion monitoring instrumentation kits and if necessary, assistance with installation.

5.0 SITE ASSISTANCE

Unless otherwise approved, an MSE Wall Vendor representative is required to assist and guide the MSE Wall Installer on-site for at least 8 hours when the first panels or SRW units and reinforcement layer are placed. If problems are encountered during construction, the Engineer may require the vendor representative to return to the site for a time period determined by the Engineer.

6.0 CONSTRUCTION METHODS

Control drainage during construction in the vicinity of MSE walls. Direct run off away from MSE walls, aggregate and backfill. Contain and maintain aggregate and backfill and protect material from erosion.

Excavate as necessary for MSE walls in accordance with the accepted submittals. If applicable and at the Contractor’s option, use temporary shoring for wall construction instead of temporary slopes to construct MSE walls. Define “temporary shoring for wall construction” as temporary shoring not shown in the plans or required by the Engineer including shoring for OSHA reasons or the Contractor’s convenience.

Unless required otherwise in the plans, install foundations and if required, pile sleeves located in the reinforced zone before placing aggregate or reinforcement. Brace piles in the reinforced zone to maintain alignment when placing and compacting aggregate. Secure piles together with steel members near top of piles. Clamp members to piles instead of welding if bracing is at or below pile cut-off elevations.

Notify the Engineer when foundation excavation is complete. Do not place leveling pad concrete, aggregate or reinforcement until excavation dimensions and foundation material are approved.

Construct CIP concrete leveling pads at elevations and with dimensions shown in the accepted submittals and in accordance with Section 420 of the *Standard Specifications*. Cure leveling pads at least 24 hours before placing panels or SRW units.

Erect and support panels and stack SRW units so the final wall position is as shown in the accepted submittals. Stagger SRW units to create a running bond by centering SRW units over joints in the row below as shown in the accepted submittals. Space bearing pads in horizontal panel joints as shown in the accepted submittals and cover all panel joints with filtration geotextiles as shown in the accepted submittals. Attach filtration geotextiles to back of panels with adhesives, tapes or other approved methods.

Construct MSE walls with the following tolerances:

A. SRW units are level from front to back and between units when checked with a 4 ft long level,

B. Vertical joint widths are 1/4" maximum for SRW units and 3/4", ±1/4" for panels,

C. Final wall face is within 3/4" of horizontal and vertical alignment shown in the accepted submittals when measured along a 10 ft straightedge and

D. Final wall plumbness (batter) is not negative (wall face leaning forward) and within 0.5° of vertical unless otherwise approved.

Place reinforcement at locations and elevations shown in the accepted submittals and within 3" of corresponding connection elevations. Install reinforcement with the direction shown in the accepted submittals. Before placing aggregate, pull geosynthetic reinforcement taut so it is in tension and free of kinks, folds, wrinkles or creases. Reinforcement may be spliced once per reinforcement length if shown in the accepted submittals. Use reinforcement pieces at least 6 ft long. Contact the Engineer when unanticipated existing or future obstructions such as foundations, guardrail, fence or handrail posts, pavements, pipes, inlets or utilities will interfere with reinforcement. To avoid obstructions, deflect, skew or modify reinforcement as shown in the accepted submittals.

Place aggregate in the reinforced zone in 8" to 10" thick lifts. Compact fine aggregate in accordance with Subarticle 235-3(C) of the *Standard Specifications*. Use only hand operated compaction equipment to compact aggregate within 3 ft of panels or SRW units. At a distance greater than 3 ft, compact aggregate with at least 4 passes of an 8 ton to 10 ton vibratory roller in a direction parallel to the wall face. Smooth wheeled or rubber tired rollers are also acceptable for compacting aggregate. Do not use sheepsfoot, grid rollers or other types of compaction equipment with feet. Do not displace or damage reinforcement when placing and compacting aggregate. End dumping directly on geosynthetics is not permitted. Do not operate heavy equipment on reinforcement until it is covered with at least 8" of aggregate. Replace any damaged reinforcement to the satisfaction of the Engineer.

Backfill for MSE walls outside the reinforced zone in accordance with Article 410-8 of the *Standard Specifications*. If a drain is required, install wall drainage systems as shown in the accepted submittals and in accordance with Section 816 of the *Standard Specifications*. If pile sleeves are required, fill sleeves with loose uncompacted sand before constructing end bent caps.

Install dowels as necessary for SRW units and place and construct coping and leveling concrete as shown in the accepted submittals. Construct leveling concrete in accordance with Section 420 of the *Standard Specifications*. Construct CIP concrete coping in accordance with Subarticle 452-4(B) of the *Standard Specifications*. When single faced precast concrete barrier is required in front of and against MSE walls, stop coping just above barrier so coping does not interfere with placing barrier up against wall faces. If the gap between a single faced barrier and wall face is wider than 2", fill gap with Class V select material (standard size No. 78M stone). Otherwise, fill gap with backer rod and seal joint between barrier and MSE wall with silicone sealant.

When separation geotextiles are required, overlap adjacent geotextiles at least 18" and hold geotextiles in place with wire staples or anchor pins as needed. Seal joints above and behind MSE walls between coping and concrete slope protection with silicone sealant.

7.0 MEASUREMENT AND PAYMENT

MSE Retaining Wall No. 1 through No. 3 will be measured and paid in square feet. MSE walls will be measured as the square feet of wall face area with the pay height equal to the difference between top of wall and top of leveling pad elevations. Define "top of wall" as top of coping or top of panels or SRW units for MSE walls without coping.

The contract unit price for *MSE Retaining Wall No. 1 through No. 3* will be full compensation for providing designs, submittals, labor, tools, equipment and MSE wall materials, excavating, hauling and removing excavated materials, placing and compacting aggregate and backfill material and supplying site assistance, leveling pads, panels, SRW units, reinforcement, aggregate, wall drainage systems, geotextiles, aggregate concrete base course, bearing pads, coping, miscellaneous components and any incidentals necessary to construct MSE walls. The contract unit price for *MSE Retaining Wall No. 1 through No. 3* will also be full compensation for reinforcement and connector design for reinforcement connected to end bent caps, wall modifications for obstructions, pile sleeves filled with sand, joints sealed with silicone sealant and gaps between barriers and MSE walls filled with backer rod or No. 78M stone, if required.

No separate payment will be made for temporary shoring for wall construction. Temporary shoring for wall construction will be incidental to the contract unit price for *MSE Retaining Wall No. 1 through No. 3*.

The contract unit price for *MSE Retaining Wall No. 1 through No. 3* does not include the cost for ditches, fences, handrails, barrier, or guardrail associated with MSE walls as these items will be paid for elsewhere in the contract. The contract unit price for *MSE Retaining Wall No. 1 through No. 3* also does not include the cost for constructing bridge approach fills behind end bents with MSE abutment walls. See *Bridge Approach Fills* provision for measurement and payment of Type III Reinforced Bridge Approach Fills.

Where it is necessary to provide backfill material behind the reinforced zone from sources other than excavated areas or borrow sources used in connection with other work in the contract, payment for furnishing and hauling such backfill material will be paid as extra work in accordance with Article 104-7 of the *Standard Specifications*. Placing and compacting such backfill material is not considered extra work but is incidental to the work being performed.

Payment will be made under:

Pay Item	**Pay Unit**
MSE Retaining Wall No. 1	Square Foot
MSE Retaining Wall No. 2	Square Foot
MSE Retaining Wall No. 3	Square Foot

DocuSigned by:
Atefeh Asoudeh
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NORTH CAROLINA PROFESSIONAL ENGINEER
SEAL
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ATEFEH ASOUDEH

ARCHITECTURAL CONCRETE SURFACE TREATMENT SPECIAL PROVISIONS

ARCHITECTURAL CONCRETE SURFACE TREATMENT (SPECIAL)

1.0 GENERAL

The work covered by this special provision consists of constructing textured surfaces on formed reinforced concrete surfaces as indicated on the Plans and in this Special Provision. The Contractor shall furnish all materials, labor, equipment, and incidentals necessary for the construction of architectural concrete surface treatment using simulated stone masonry form liners (molds) and a compatible concrete coloring system.

The architectural concrete surface treatment should match the appearance (stone size and shape, stone color, and stone texture, pattern, and relief) of natural stone and rock as directed by the Engineer. Grout pattern joints (mortar joints) and bed thickness should re-create the appearance and color of precast concrete surfaces as indicated in the Plans, this Special Provision, or as directed by the Engineer.

2.0 SUBMITTALS

Shop Drawings - Submit for review and acceptance, a PDF file for plan and elevation views and details showing overall simulated stone pattern, joint locations and end, edge or other special conditions. The drawings should include typical cross sections of applicable surfaces, joints, corners, stone relief, stone size, pitch/working line, mortar joint and bed depths. If necessary, revise the shop drawings until the proposed form liner patterns and arrangement have been accepted by the Engineer. The PDF file of shop drawings should be 22-inch x 34-inch in size and have enough resolution to show the details of all stone and joints patterns as well as overall appearance.

The form liner shall be patterned such that long continuous horizontal or vertical lines do not occur on the finished exposed surface. The line pattern shall be random in nature and shall minimize construction joint lines. The top of wall must have untreated, non-textured, and uncolored areas within the distance from the top of wall to the bottom of the coping.

Shop drawings shall be reviewed and accepted prior to fabrication of form liners.

Sample Panels – After the shop drawings have been reviewed and accepted by the Engineer, submit a precast sample panel to the project site. The sample panel shall be transportable and minimum 4 foot x 4 foot in size. The materials used in construction of the sample panel shall comply with section 420 of the Standard Specifications. The sample panel shall be constructed using approved form liners and color system/stains. The sample panel can be colored on the project site in accordance with this provision. Any sample panel that is not accepted by the Engineer is to be removed from the project site and a new sample panel produced at no additional expense to the Department.

After the color, texture, and uniformity of the furnished samples are approved, produce a full scale unit meeting the design requirements. This mock-up and the furnished samples establish the standard quality for determining the acceptance of the panels.

Architectural surface treatments and patterns of the finished work shall achieve the same final effect as demonstrated on the accepted sample panels. Upon acceptance by the Engineer, the sample panels shall be used as the quality standard for the project. After the acceptance of the completed structure, dispose of the sample panels as directed by the Engineer.

3.0 MATERIALS REQUIREMENTS

Form Liner – The form liner shall be a high quality, re-useable product manufactured of high strength urethane rubber or other approved material which attaches easily to the form work system, and shall not compress more than ¼ inch when concrete is poured at a rate of 10 vertical feet per hour. The form liners shall be removable without causing deterioration of the surface or underlying concrete.

The architectural concrete surface treatment shall match the appearance (stone size and shape, stone texture, pattern, relief and joint) of natural stone to resemble an ashlar stone pattern or approved equal. All texture shall be in addition to the nominal thickness of the wall panels of four inches ±¼ inch. The maximum relief of the textured surface shall be 1.5 inch or less. The top 1'-0" of the top panel within each sound barrier wall segment shall have a smooth, non-textured and non-stained finish to resemble faux coping. For information purposes only, sources of form liners in the ashlar stone pattern include, but are not limited to:

Custom Rock Formliner
2020 West 7th Street
St. Paul, MN 55116
http://www.customrock.com
Pattern: Ashlar Stone # 12021

Architectural Polymers, Inc.
1220 Little Gap Road
Palmerton, PA 18071
http://www.apformliner.com/
Pattern: Ashlar Stone #904

Fitzgerald Form Liners
1500 East Chestnut Avenue
Santa Ana, CA 92701
http://formliners.com/
Pattern: Georgia Ashlar # 16999

The contractor has the option of supplying an alternative pattern of simulated stone form liner, as long as the pattern selected is approved, in writing, as an equal or approved alternative by the Engineer.

Form Release Agent – Form release agent shall be a non-staining petroleum distillate free from water, asphaltic, and other insoluble residue, or an equivalent product. Form release agents shall be compatible with the color system applied and any special surface finish.

Concrete color system/stain – The final coloration of the wall is to match the Grey Palette Color # FS 36270 found in the *Federal Standard 595B - Colors Used in Government Procurement*. Stain the sample panel using the proposed colors and the approved sample panel shall be the basis for determining the appropriate color/stain application.

The concrete color stains shall create a surface finish that is breathable (allowing water vapor transmission), and that resists deterioration from water, acid, alkali, fungi, sunlight, or weathering. Stain mix shall meet the requirements for mildew resistance of Federal Test Method Standard 144, Method 6271, and requirements for weathering resistance of 1,000 hours accelerated exposure measures by Weatherometer in accordance with ASTM G 26. Color samples must be submitted for approval.

Anti-Graffiti Coating Application – Apply the anti-graffiti coating that is compatible with the concrete color system/stain. After application, the anti-graffiti coating shall be dry to touch within one hour and shall achieve a final cure within three hours. The color of the anti-graffiti shall be clear after full cure. The contractor shall provide one gallon of graffiti remover, thinners, dryers and all necessary components recommended by the manufacturer to the North Carolina Department of Transportation Materials and Test Unit, Chemical Testing Engineer.

Quality Standards - Manufacturer of simulated stone masonry form liners and custom coloring system shall have at least five years of experience making stone masonry molds and color stains to create formed concrete surfaces to match natural stone shapes, surface textures and colors.

After the Engineer has reviewed and approved the shop drawings, schedule a preconstruction conference with manufacturer representative and the Engineer to assure understanding of simulated stone masonry form liner use, color application, requirements for construction of sample panels, and to coordinate the work. Disclose the source of simulated stone masonry manufacturer and final coloration contractor at the Preconstruction Conference.

4.0 CONSTRUCTION METHODS

Form Liner Preparation – Before each concrete pour, the form liners shall be clean and free of build-up. Each liner shall be visually inspected for blemishes and tears. Repairs shall be made in accordance with the manufacturer's recommendations. Repairs shall be accepted by the Engineer before being used. Form liner panels that do not perform as intended or are no longer repairable shall be replaced. Use a technical representative from the form liner manufacturer for technical supervision during the installation and removal of form liners.

Form Release Agent – Form release agent shall be applied in accordance with the manufacturer's recommendations. The material shall be compatible with the form liner material and the concrete coloring system and in accordance with this Special Provision. Form release agent should be worked into all areas, especially pattern recesses.

Patching – All form tie holes and other defects in finished uncolored surface shall be filled or repaired within 48 hours of form removal. Use patching materials and procedures in accordance with the manufacturer's recommendations.

Surface Finish – All surfaces that are to receive coloring agent application shall be free of all laitance, dirt, dust, grease, efflorescence, paint or any other foreign material prior to the application of coloring agent. Pressure washing with water is the preferred method of removing laitances. Sandblasting will not be permitted.

Final surface shall be free of blemishes, discolorations, surface voids, and other irregularities. All patterns should be continuous without visual disruption.

Reinforced concrete shall be finished in accordance with the Standard Specifications, except that curing of concrete should be done to accommodate the application of coloring and surface finish treatment.

Grout Pattern Joints – Grout pattern joints shall be constructed to simulate the appearance of mortared joints produced in laid up masonry work. Grout pattern joints shall be produced in accordance with the form liner / concrete color system manufacturer.

Color/Stain Application – Maintain the concrete temperature between 40°F and 85°F during color/stain application and for 48 hours after color/stain application. Consult the manufacturer's recommendations for preparation, application, curing, and storage of coloring agents/stains. Treated surfaces located adjacent to exposed soil or pavement shall be temporarily covered to prevent dirt or soil splatter from rain.

Anti-Graffiti Coating Application – The anti-graffiti coating shall be applied by brush, roller or airless spray when the ambient temperature is between 40°F and 90°F, and the surface temperature is between 50° F and 100° F. Ensure the surface is clean and dry before applying the anti-graffiti coating. The minimum dry film thickness of the anti-graffiti coating shall be 2.0 mils.

Following the completion of all work, repairs of any damage made by other construction operations shall be made to the form lined and colored surfaces as directed by the Engineer.

Experience and Qualifications - The Contractor shall have a minimum of three consecutive years of experience in architectural concrete surface treatment construction on similar types of projects. A minimum of 10 days prior to the submission of shop drawings, furnish to the Engineer 5 references who were responsible for supervision of similar projects and will testify to the successful completion of these projects. Include name, address, telephone number, and specific type of application.

5.0 MEASUREMENT AND PAYMENT

The quantity of architectural concrete surface treatment to be paid for will be the actual number of square feet of architectural concrete surface treatment that has been incorporated into the completed and accepted work.

The area of architectural concrete surface treatment will be measured by the area of front facing in-place treated concrete. Do not include the top surfaces and the end wall surfaces in the measurement. Area of sample panels shall not be included in the measurement of architectural concrete surface treatment.

6.0 BASIS OF PAYMENT

Architectural concrete surface treatment as described on the plans and in this Special Provision will be paid for at the contract unit price bid for “Architectural Concrete Surface Treatment”. The above price and payment will be full compensation for all work covered by this Special Provision, the plans and applicable parts of the Standard Specifications and shall include, but not be limited to, furnishing all labor, materials, equipment, and other incidentals, including sample panels, necessary to complete this work.

Payment will be made under:

Pay Item	**Pay Unit**
Architectural Concrete Surface Treatment	Square Foot

NORTH CAROLINA PROFESSIONAL
SEAL
043747
ENGINEER
ATEFEH ASOUDEH

DocuSigned by:
Atefeh Asoudeh
46293DE2949B4C7...

PROVIDED INFORMATION

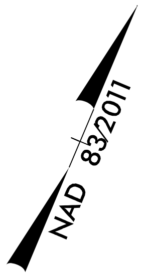
RETAINING WALL ENVELOPES

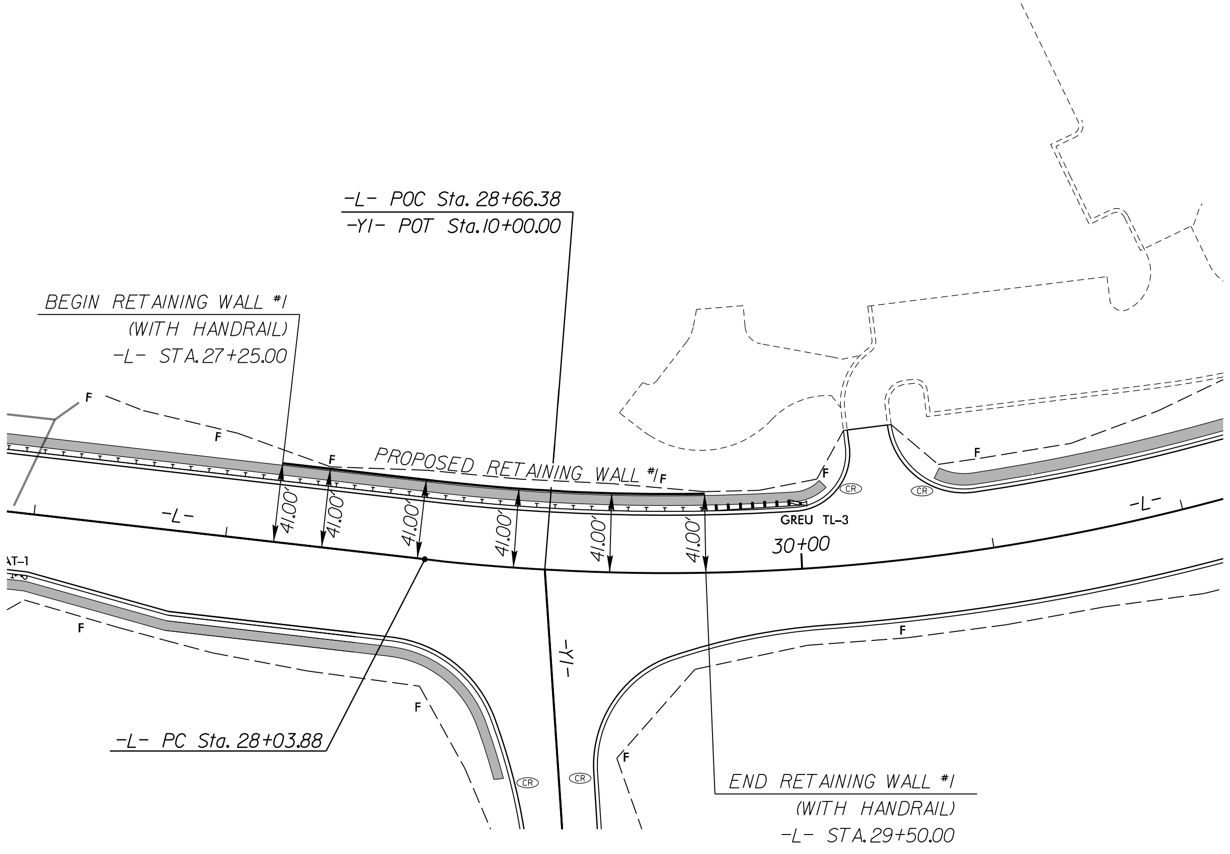
SITE PLAN

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	2N-1
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

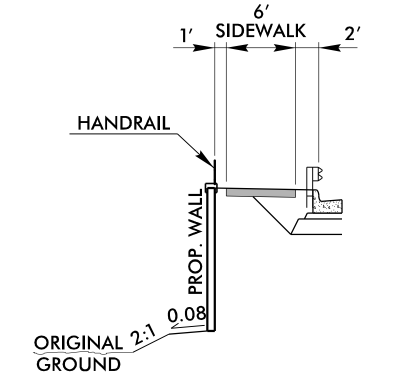
RETAINING WALL #1 DETAIL





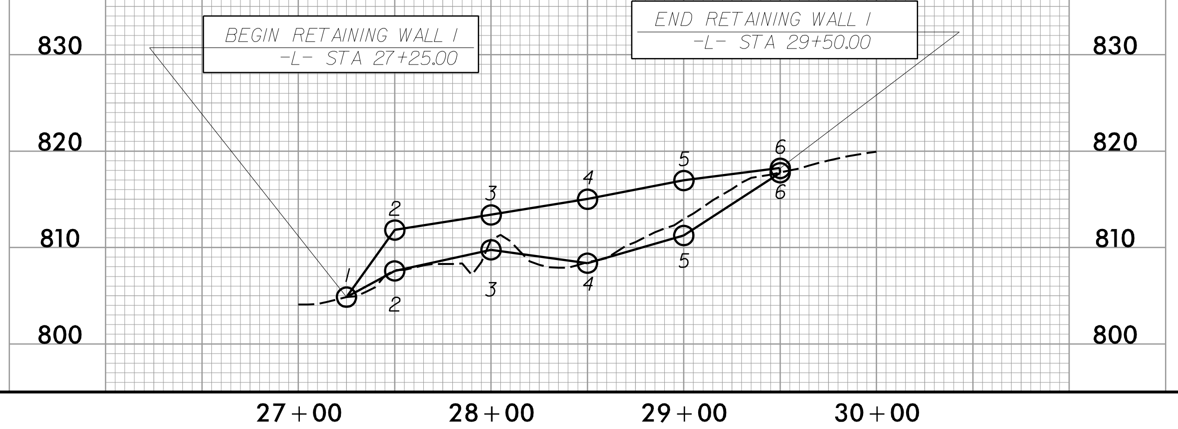
SEE SHEET 5
FOR PLAN VIEW

RETAINING WALL TYPICAL SECTION



USE IN THE FOLLOWING LOCATION:
-L- STA. 27+25.00 LT TO STA. 29+50.00 LT

POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	PROPOSED FINISHED GRADE (BOT.)
1	27+25.00	804.85'	804.85'
2	27+50.00	811.84'	807.57'
3	28+00.00	813.41'	809.76'
4	28+50.00	815.04'	808.37'
5	29+00.00	816.98'	811.24'
6	29+50.00	818.24'	817.75'

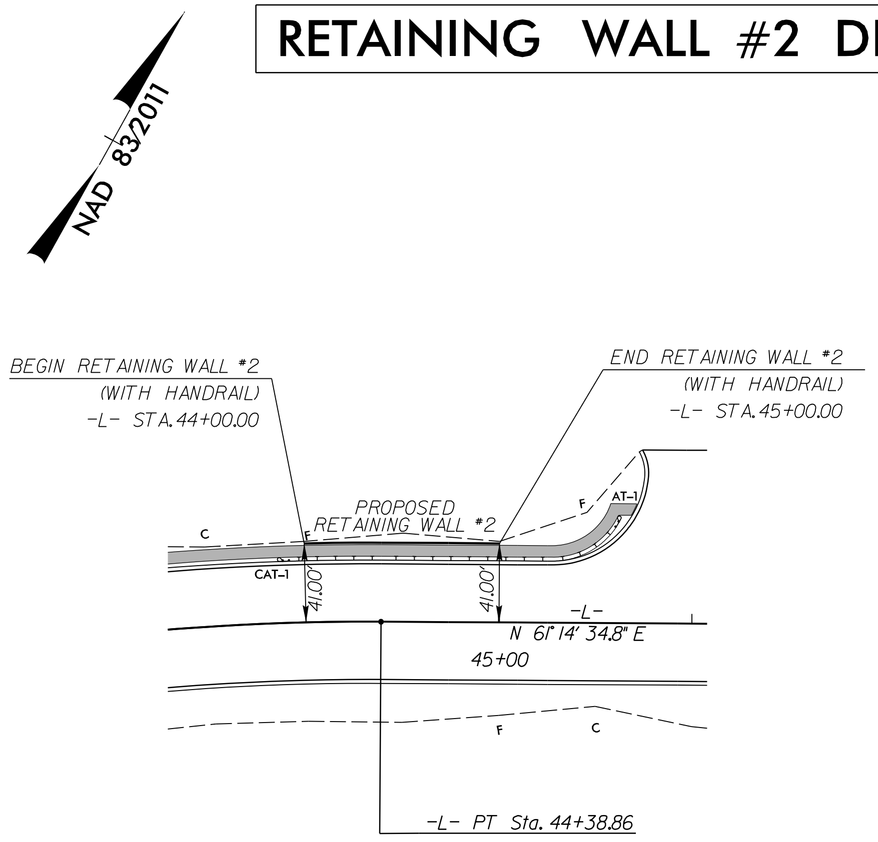


3/28/2022
R:\Roadway\Proj\u4015a_rdy_PSH_RET_WALL_02N-1.dgn
skabra

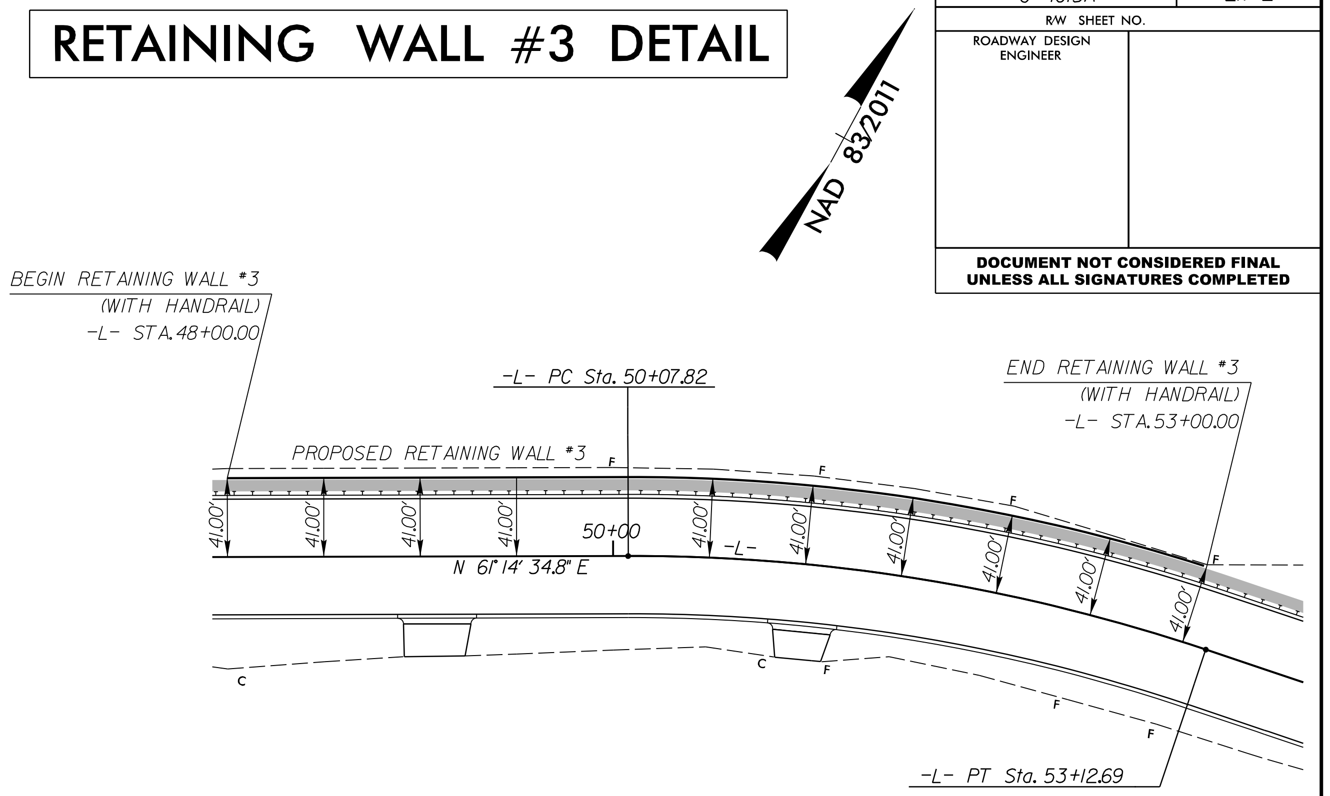
PROJECT REFERENCE NO.	SHEET NO.
U-4015A	2N-2
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

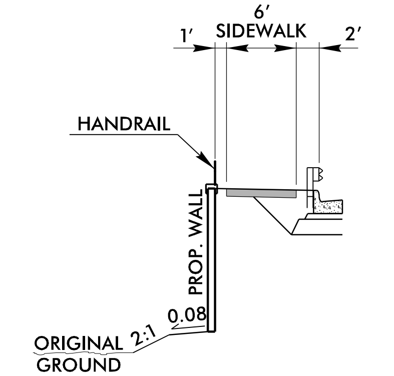
RETAINING WALL #2 DETAIL



RETAINING WALL #3 DETAIL



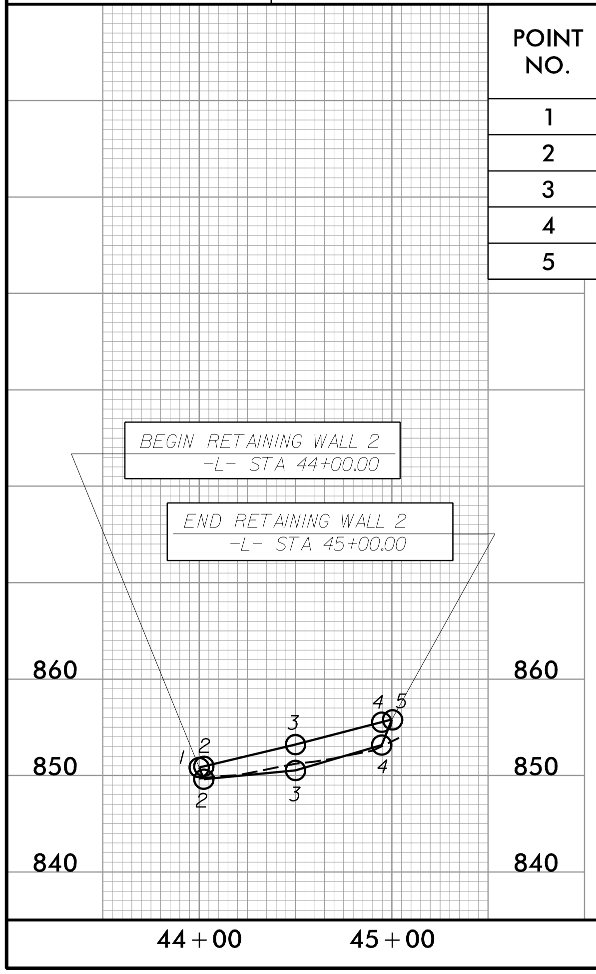
RETAINING WALL TYPICAL SECTION



USE IN THE FOLLOWING LOCATIONS:
-L- STA. 44+00.00 LT TO STA. 45+00.00 LT
-L- STA. 48+00.00 LT TO STA. 53+00.00 LT

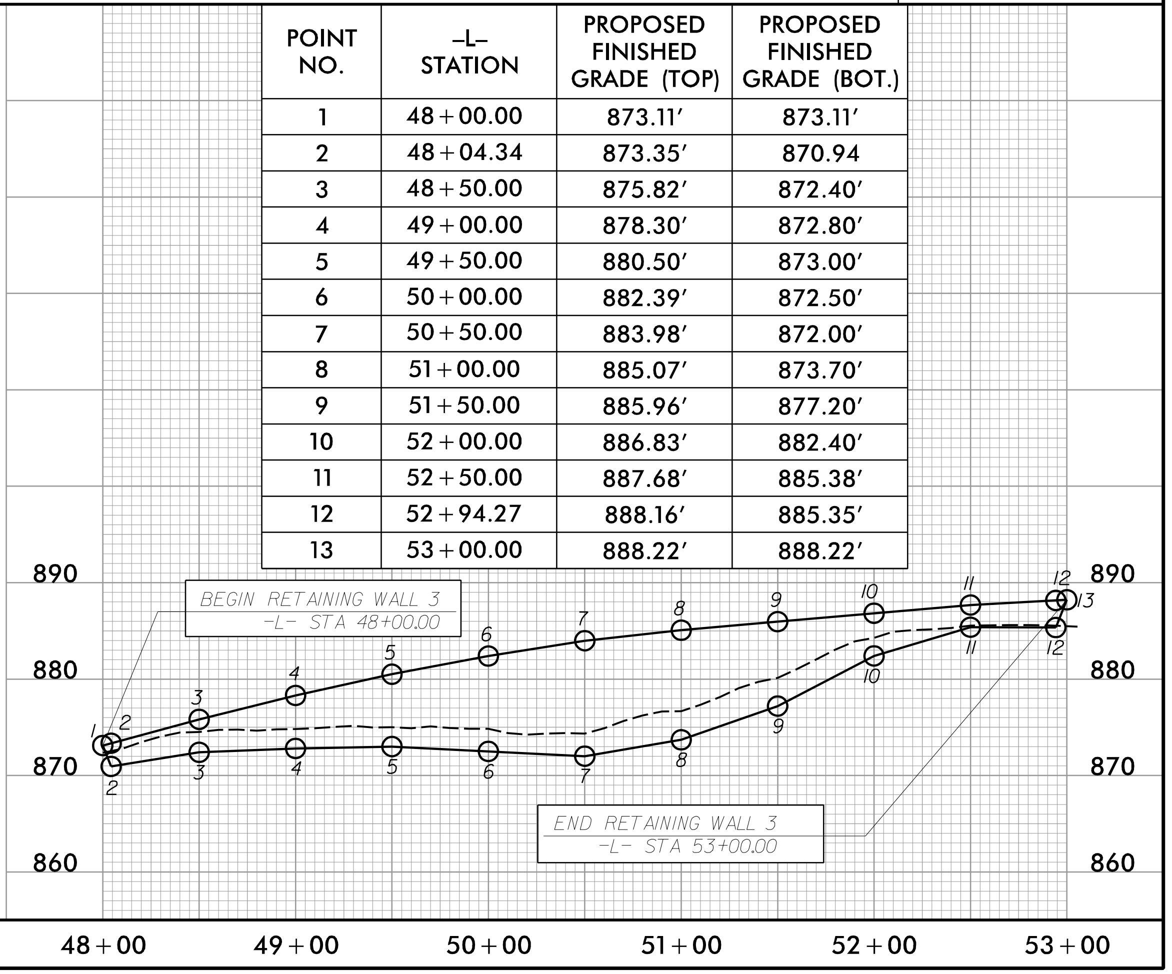
SEE SHEET 6
FOR PLAN VIEW

POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	PROPOSED FINISHED GRADE (BOT.)
1	44+00.00	850.83'	850.83'
2	44+02.43	850.95'	849.61'
3	44+50.00	853.20'	850.52'
4	44+94.71	855.52'	853.16'
5	45+00.00	855.80'	855.80'



SEE SHEET 7
FOR PLAN VIEW

POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	PROPOSED FINISHED GRADE (BOT.)
1	48+00.00	873.11'	873.11'
2	48+04.34	873.35'	870.94
3	48+50.00	875.82'	872.40'
4	49+00.00	878.30'	872.80'
5	49+50.00	880.50'	873.00'
6	50+00.00	882.39'	872.50'
7	50+50.00	883.98'	872.00'
8	51+00.00	885.07'	873.70'
9	51+50.00	885.96'	877.20'
10	52+00.00	886.83'	882.40'
11	52+50.00	887.68'	885.38'
12	52+94.27	888.16'	885.35'
13	53+00.00	888.22'	888.22'



3/29/2022
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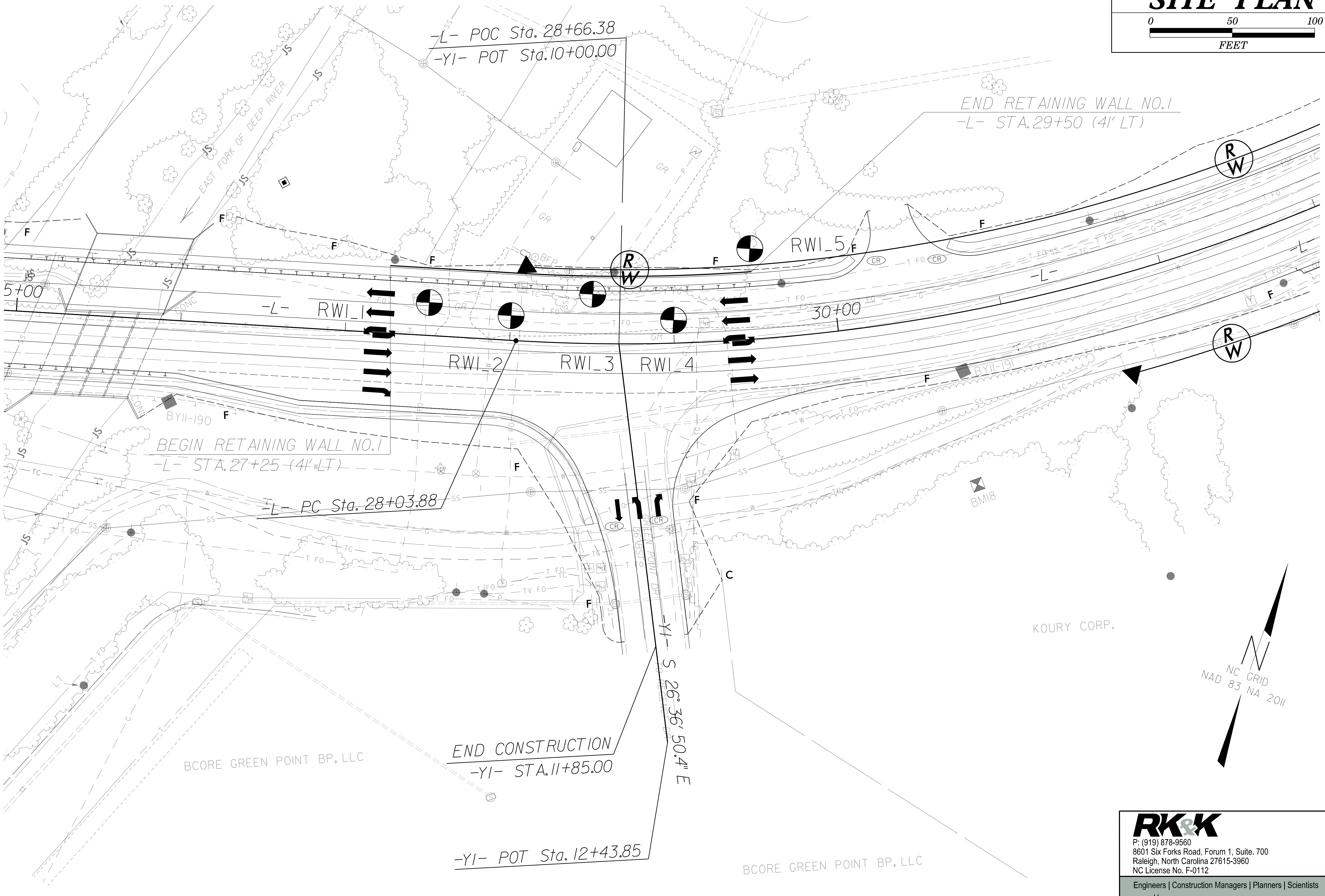
skabra

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	3

SITE PLAN

0 50 100
FEET



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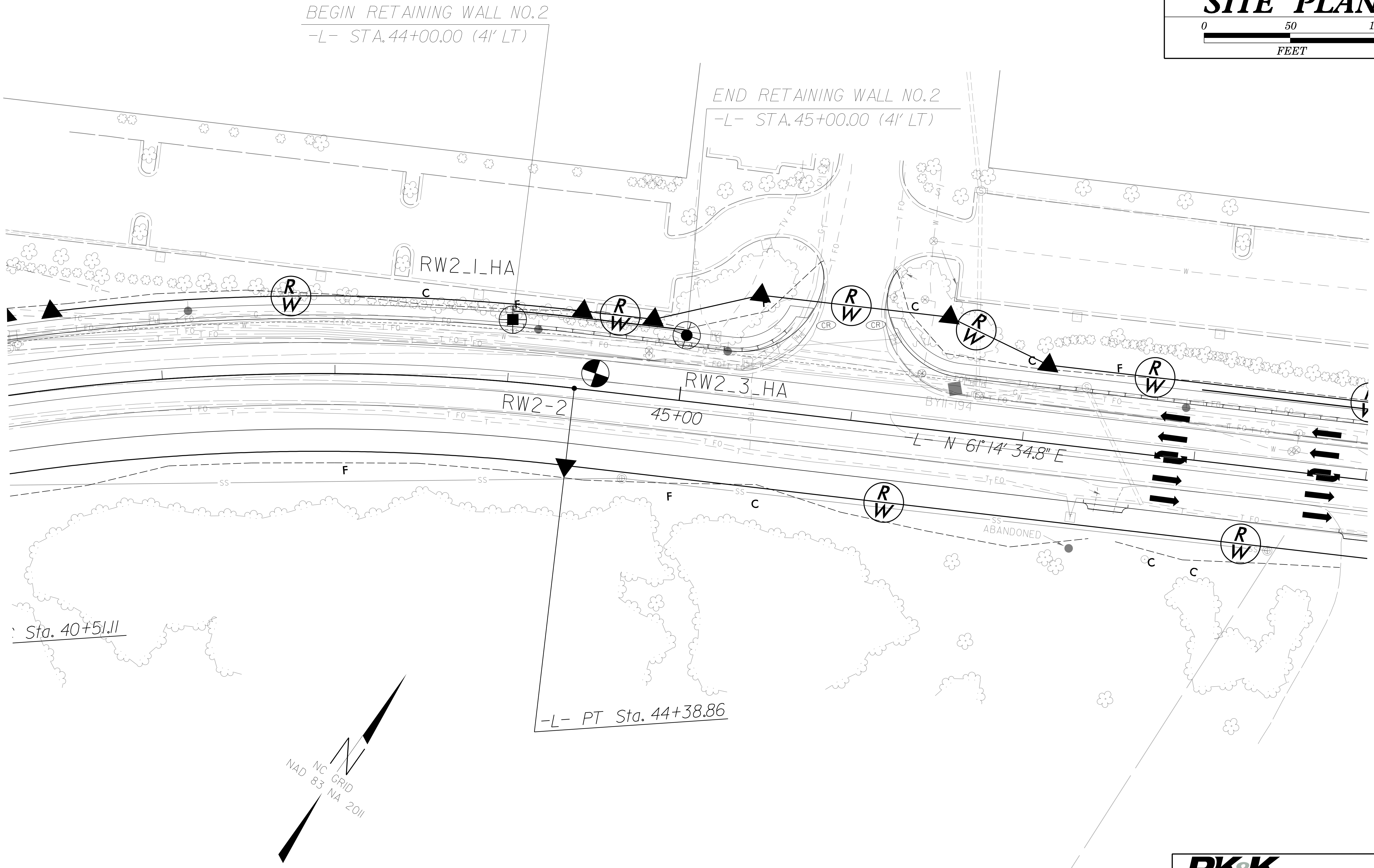
PROJECT REFERENCE NO.	SHEET NO.
U-4015A	8

SITE PLAN

0 50 100

FEET



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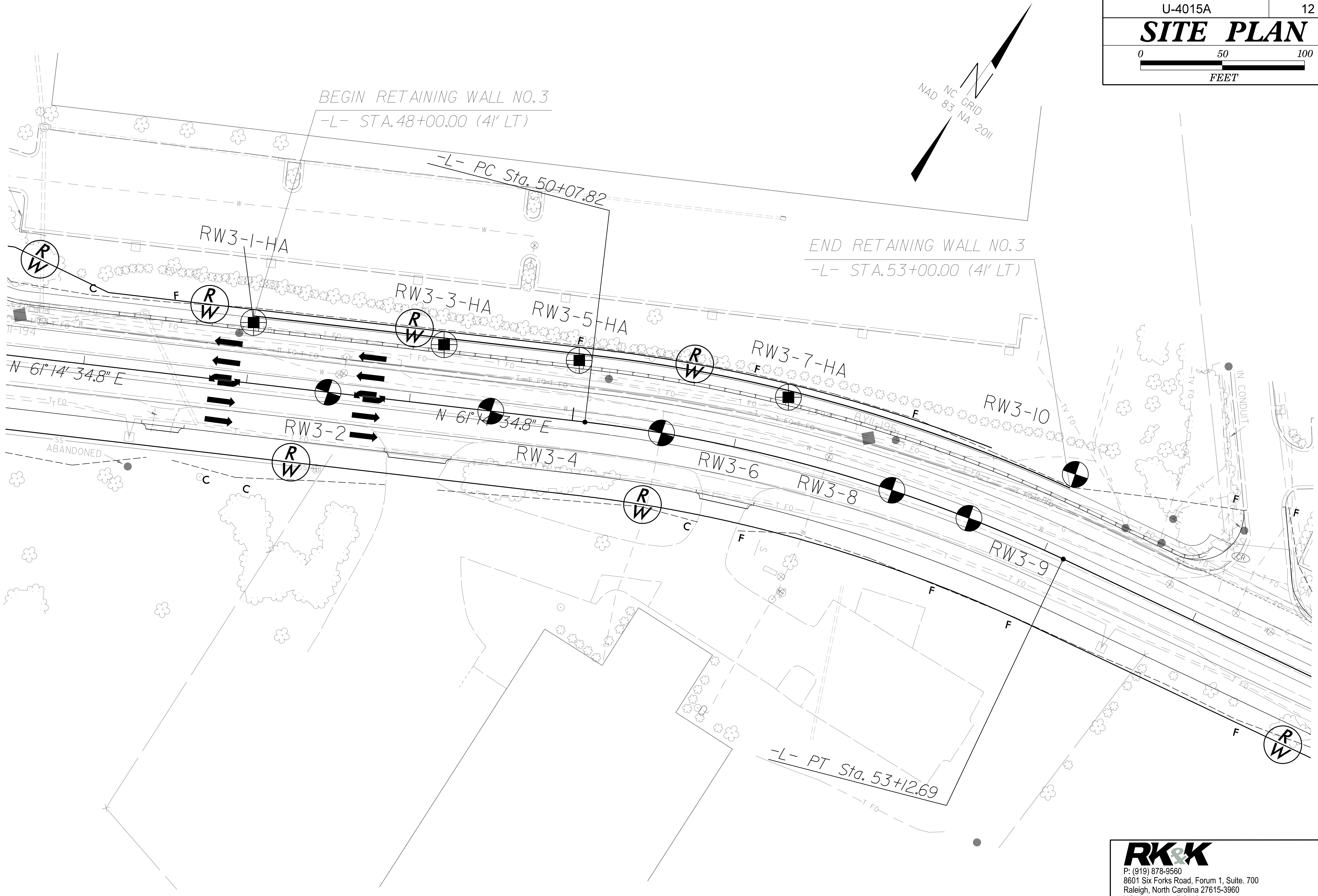
PROJECT REFERENCE NO.	SHEET NO.
U-4015A	12

SITE PLAN

0 50 100
FEET



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MSE WALL CALCULATIONS FOR RETAINING WALL NO. 1

CALCULATIONS SUMMARY
CROSS SECTION INVENTORY
MSE WALL EXTERNAL STABILITY SPREADSHEETS
GLOBAL SLOPE STABILITY – SLOPE/W RESULTS
SETTLEMENT ANALYSIS SPREADSHEET

U-4015 A: RW 1 - MSE WALL

Input Data from Wall Envelope

STATION	Point	Proposed Finished Grade (Bottom)	Proposed Finished Grade (Top)	Wall Height (ft)	Min. Embedment (ft)	Top of the Leveling Pad EL	Design Height (H) (ft)
-L- 27+25	1	804.9	804.9	0.0	2.0	802.9	2.0
-L- 27+50	2	807.6	811.8	4.3	2.0	805.6	6.3
-L- 28+00	3	809.8	813.4	3.6	2.0	807.8	5.6
-L- 28+50	4	808.4	815.0	6.7	2.0	806.4	8.7
-L- 29+00	5	811.2	817.0	5.7	2.0	809.2	7.7
-L- 29+50	6	817.8	818.2	0.5	2.0	815.8	2.5

Assumptions Used for Calculations

Design Section	LOCATION	Design Height (H) (ft)	Backslope Ratio	Backslope Length (ft)	Traffic Load (psf)	MSE Wall Type	Foundation Material			Backfill Material		
							φ (deg.)	C (psf)	γ (pcf)	φ (deg.)	C (psf)	γ (pcf)
1	POINT 1 TO 6	9.0	-	-	240.0	A	28	0	120	30	0	120

Wall Height (h) (ft) = Top of the Wall EL - Bottom of the Wall EL

Min. Embedment (ft) = h/7 or , 2-ft, whichever is greater

Top of the Leveling Pad EL = Bottom of the Wall EL - Min. Embedment (ft)

Design Height (H) (ft) = Top of the Wall EL - Top of the Leveling Pad EL

**MSE Wall Type in External Stability Analysis (See NCDOT Spreadsheet):

A) MSE Wall with Level Backslope
B) MSE Wall with Broken Backslope
C) MSE Wall with Infinite Backslope
D) MSE Wall with Bridge Abutment with Pile Foundation

Calculations Results

Design Section	Design Height (H) (ft)	External stability (1)			Global Stabiltiy (2)		Global Stability Controls
		Reinforcement Length Ratio	Strap Length = H x Reinforcement Ratio (ft)	Bearing Pressure (ksf)	Factor of Safety		
					Undrained, Short Term Condition	Drained, Long Term Condition	
1	9.0	0.8H	7.2	2.5	1.81	1.43	No

Notes:

1- See external stabiltiy calculations based on NCDOT MSE Wall External Stability Spreadsheet

2-See Global Stability calculations based on SLOPE/W analyses. Global Stability was checked for both short-term condition (using undrained strength propoeties of CLAY) and long-term condition (using drained strength properties of CLAY).

3-The total settlement of the RW No. 1 is anticipated to be 0.5 - inches.

R:\Geotech\InvestigationDesign\NON_CADD\Retaining Walls\Wall Nos. 1-4\Working\Recs\Analysis\WALL_Summary.xlsx

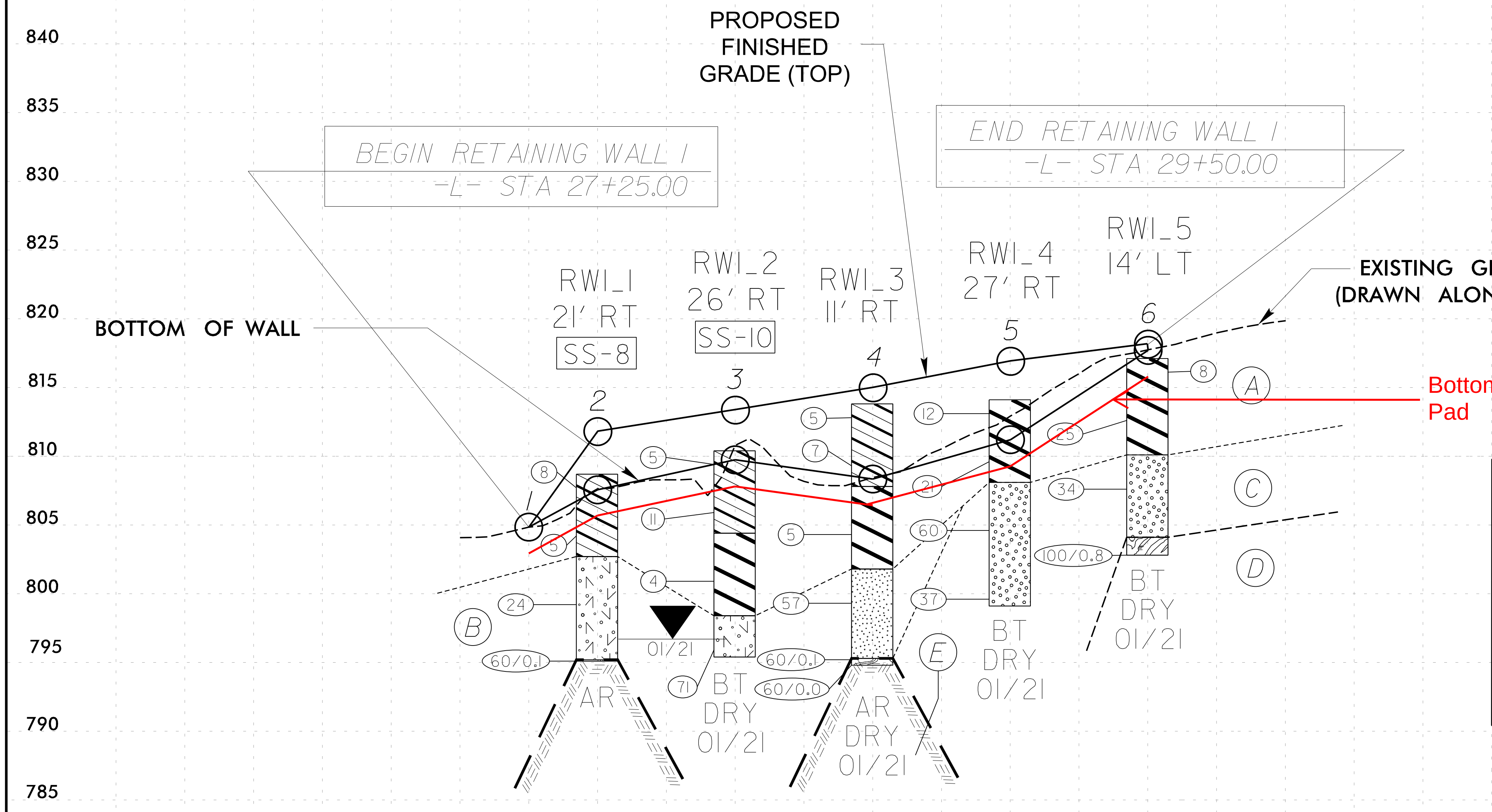
RETAINING WALL NO. I

0 50 100
FEET
VE = 5

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	4

PROFILE ALONG -L-

SOIL TEST RESULTS															
SAMPLE NO.	STATION	OFFSET	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
SS-8	27+50	20' LT	3.5-5.0'	A-6	37	17	23	23	17	38	99	84	59	23	ND
SS-10	28+00	15' LT	0.0-1.5'	A-6	32	14	ND	ND	ND	ND	44	0	56	18	ND



POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	27+25.00	804.85'	804.85'
2	27+50.00	811.84'	807.57'
3	28+00.00	813.41'	809.76'
4	28+50.00	815.04'	808.37'
5	29+00.00	816.98'	811.24'
6	29+50.00	818.24'	817.75'

Ⓐ RESIDUAL Brown to brown-orange to tan-brown, medium stiff to very stiff, sandy slightly to moderately plastic CLAY and silty CLAY (A-6, A-7-5, A-7-6), trace rock fragments, trace of organic matter, saprolitic, moist

Ⓑ Brown and gray-green to dark gray, very stiff to hard, sandy and clayey SILT (A-4, A-5), trace mica, trace rock fragments, saprolitic, moist

Ⓒ Brown-white-gray-black to brown-gray to brown, dense to very dense, silty fine to coarse SAND (A-2-4), trace rock fragments, moist

Ⓓ WEATHERED ROCK METAGRANITE

Ⓔ CRYSTALLINE ROCK METAGRANITE

-L-

26+00 27+00 28+00 29+00 30+00 31+00 32+00

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RETAINING WALL NO. 1

MSE WALL EXTERNAL STABILITY SPREADSHEETS

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 1 - Design Section 2- Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 27+25 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 1 OF 8

MSE Wall Type (See Figures on right)

MSE Wall with Level Backslope and Traffic Surcharg

Traffic Surcharge and Wall Geometry

q = 240 psf *live load traffic surcharge (AASHTO Tables 3.11.6.4-1 & 2)*

H = 9.00 ft *wall design height*
L/H = 0.800 *ratio of reinforcement length to wall height*
L = 7.2 ft *reinforcement length (L = H x L/H)*
(L/H ≥ 0.7 and L ≥ 6 ft per NCDOT MSE Wall Provision)
s = 1.00 ft *distance from bottom of wall to lowest reinforcement layer*
Slope = N/A : 1 (H_{slope} : V_{Slope}) *slope behind wall*
d = N/A ft *distance from back of wall face to top of backslope*
z = N/A ft *height of soil behind cap for MSE abutment wall*
w = N/A ft *distance from back of wall face to back of cap*
h = N/A ft *height of wall & slope at the back of reinforced zone*

Soil Parameters for Reinforced Zone

Type of aggregate used: ○ Coarse ● Fine

ϕ_r = 34 deg *friction angle (38 deg for coarse, 34 deg for fine)*
γ_r = 115 pcf *unit weight (110 psf for coarse, 115 psf for fine)*

Soil Parameters for Retained Backfill

ϕ_b = 30 deg *friction angle*
γ_b = 120 pcf *unit weight*

Soil Parameters for Foundation Material

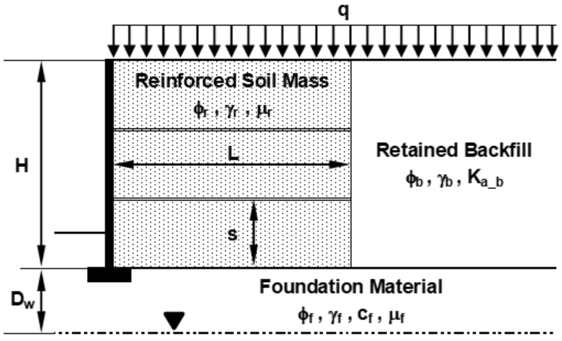
ϕ_f = 28 deg *friction angle*
γ_f = 120 pcf *unit weight*
c_f = 0 psf *undrained shear strength of the foundation material*
D_w = 7.50 ft *distance of water table below bottom of the wall*

Load Factors (AASHTO Table 3.4.1-1 and 2)

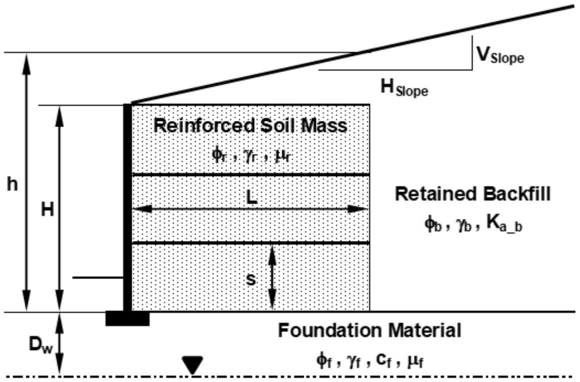
Ψ_{LS} = 1.75 *live load surcharge*
$\Psi_{EH(A)}$ = 1.50 *horizontal (active) earth pressure*
Ψ_{EV} = 1.00 min, 1.35 max *vertical dead load generated from earth fill*

Resistance Factors (AASHTO Table 11.5.7-1)

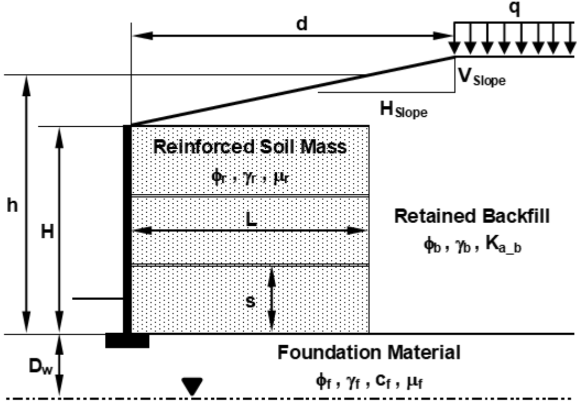
φ_b = 0.65 *bearing resistance for MSE walls*
φ_t = 1.00 *sliding resistance for MSE walls*



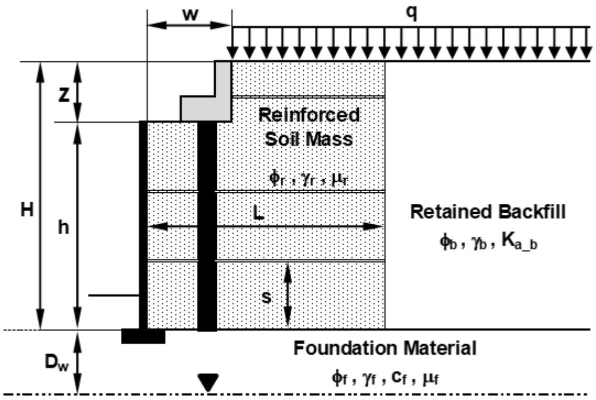
MSE Wall with Level Backslope and Traffic Surcharge



MSE Wall with Infinite Backslope



MSE Wall with Broken Backslope



MSE Wall Bridge Abutment with Pile Foundation

(MSE WALL FIGURES ARE NOT TO SCALE)

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. Thereare no expressed or implied warrantie*

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 1 - Design Section 2- Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 27+25 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 2 OF 8

Summary of External Stability Analysis - MSE Wall with Level Backslope and Traffic Surcharge

Geometry of Reinforced Soil Mass

H = wall height	9.00 ft
L/H = ratio of reinforcement length to wall height (must be greater than or equal to 0.700)	0.800
L = reinforcement length (must be greater than or equal to 6 ft)	7.20 ft

Forces Acting on Wall - Vertical Direction

$V_{1(LLR)}$ = vertical force from reinforced soil mass acting at the lowest level of reinforcement	6,624 lbs
$V_{1(BW)}$ = vertical force from reinforced soil mass acting at the base of the wall	7,452 lbs
V_2 = vertical force from the retained fill above the reinforced soil mass	0 lbs
$F_{V(LLR)}$ = vertical force generated from lateral earth pressure at the lowest level of reinforcement	0 lbs
$F_{V(BW)}$ = vertical force generated from lateral earth pressure at the base of the wall	0 lbs

Forces Acting on Wall - Horizontal Direction

$F_{H(LLR)}$ = horizontal force generated from lateral earth pressure at the lowest level of reinforcement	1,279 lbs
$F_{H(BW)}$ = horizontal force generated from lateral earth pressure at the base of the wall	1,618 lbs
$F_{2(LLR)}$ = horizontal force generated from traffic surcharge, acting at the lowest level of reinforcement	639 lbs
$F_{2(BW)}$ = horizontal force generated from traffic surcharge, acting at the base of the wall	719 lbs

F_P = total horizontal force acting on the back of the MSE wall (wall contact pressure under service loads)	2,337 lbs

Sliding Stability - at the interface between the soil and reinforcement for the lowest reinforcement layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer	3,577 lbs
$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer	3,037 lbs
$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$	OK

Sliding Stability - at the base of the bottom of the wall facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing	3,964 lbs
$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing	3,686 lbs
$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$	OK

Overturning / Limiting Eccentricity

e = eccentricity	1.74 ft
L / 3	2.40 ft
e must be less than or equal to L / 3	OK

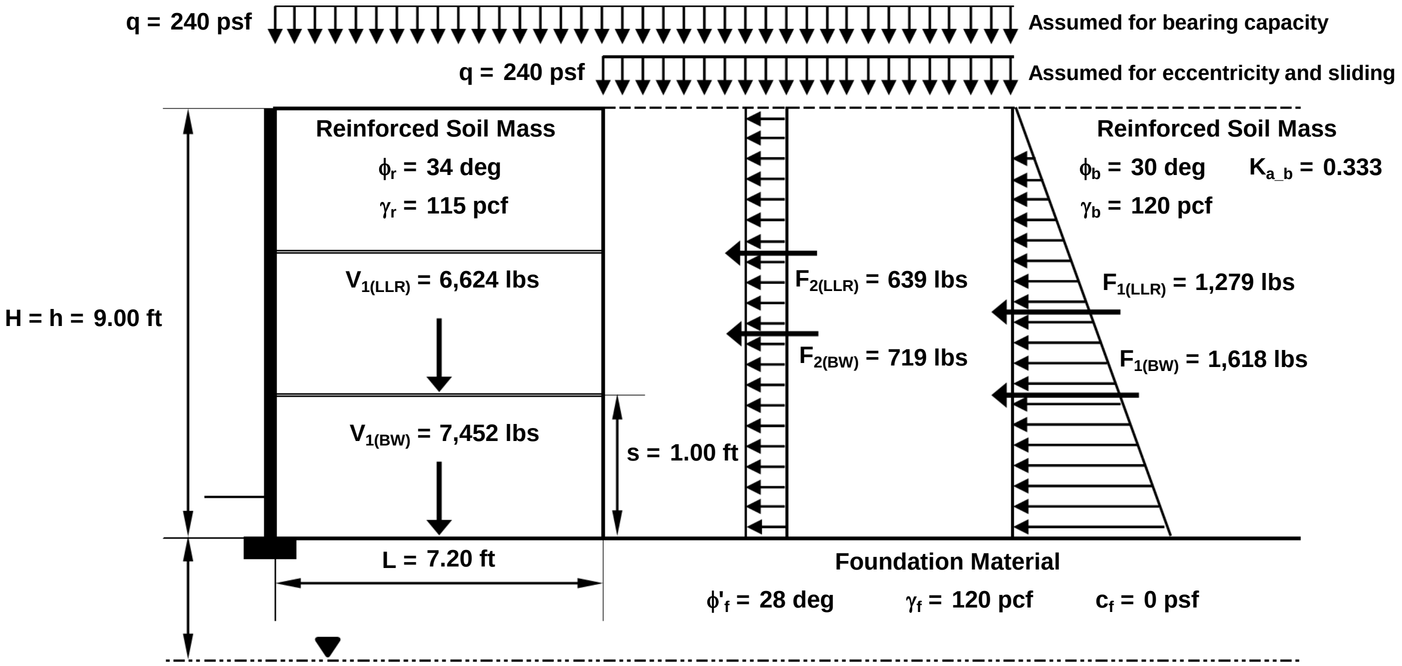
Bearing Resistance - General Shear

q_r = factored bearing resistance	2,720 lbs
$q_{uniform}$ = factored bearing pressure at the base of the wall	2,507 lbs
q_R must be greater than or equal to $q_{uniform}$	OK

Bearing Resistance - Local / Punching Shear (only applicable to soils with cohesion)

q_r = reduced factored bearing resistance	N/A
$q_{uniform}$ = factored bearing pressure at the base of the wall	N/A
q_R must be greater than or equal to $q_{uniform}$	N/A

Forces Acting on Wall



External Stability for MSE Walls: Forces acting on Wall - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO Figure 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Vertical Forces from Earth Loads

$V_{1(LLR)}$ = total vertical force from reinforced soil mass, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(\gamma_r)(H - s)(L)$

$V_{1(BW)}$ = total vertical force from reinforced soil mass, acting at the base of the bottom of the wall facing

= $(\gamma_r)(H)(L)$

γ'_r (pcf)	H (ft)	s (ft)	L (ft)	$V_{1(LLR)}$ (lbs)	$V_{1(BW)}$ (lbs)
115	9.00	1.00	7.20	6,624	7,452

Forces Generated from Lateral (Active) Earth Pressure

K_{a_b} = coefficient of active earth pressure

$$= \frac{\sin^2(\theta+\phi'_f)}{\Gamma[\sin^2\theta\sin(\theta-\delta)]} \quad \text{where} \quad \left[1+\sqrt{\frac{\sin(\phi'_f+\delta)\sin(\phi'_f-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}\right]^2$$

AASHTO Equations 3.11.5.3-1 and 2

$\phi_f = \phi_b$

δ = friction angle between fill and wall = β per AASHTO Article 11.10.5.2

β = inclination angle of backslope = 0 for level backslope

θ = angle of back face of wall to the horizontal = 0 degrees for vertical wall face

ϕ_b (deg)	δ (deg)	β (deg)	K_{a_b} (lbs)
120	0	0	0.333

Forces Acting on Wall - continued

Forces Generated from Lateral (Active) Earth Pressure - continued

$F_{1(LLR)}$ = total force generated from lateral earth pressure, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $0.5(\gamma_b)(H\text{-}s)^2(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5 (modified)*

$F_{1(BW)}$ = total force generated from lateral earth pressure, acting at the base of the bottom of the wall facing

= $0.5(\gamma_b)(H^2)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5*

γ'_b (psf)	H (ft)	s (ft)	K_{a_b}	$F_{1(LLR)}$ (lbs)	$F_{1(BW)}$ (lbs)
120	9.00	1.00	0.333	1,279	1,618

Horizontal Forces Generated from Traffic Surcharge

$F_{2(LLR)}$ = total horizontal force generated from traffic surcharge, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(q)(H\text{ -}s\text{ })(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6 (modified)*

$F_{2(BW)}$ = total horizontal force generated from traffic surcharge, acting at the base of the bottom of the wall facing

= $(q)(H)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6*

q (psf)	H (ft)	s (ft)	K_{a_b}	$F_{2(LLR)}$ (lbs)	$F_{2(BW)}$ (lbs)
240	9.00	1.00	0.333	639	719

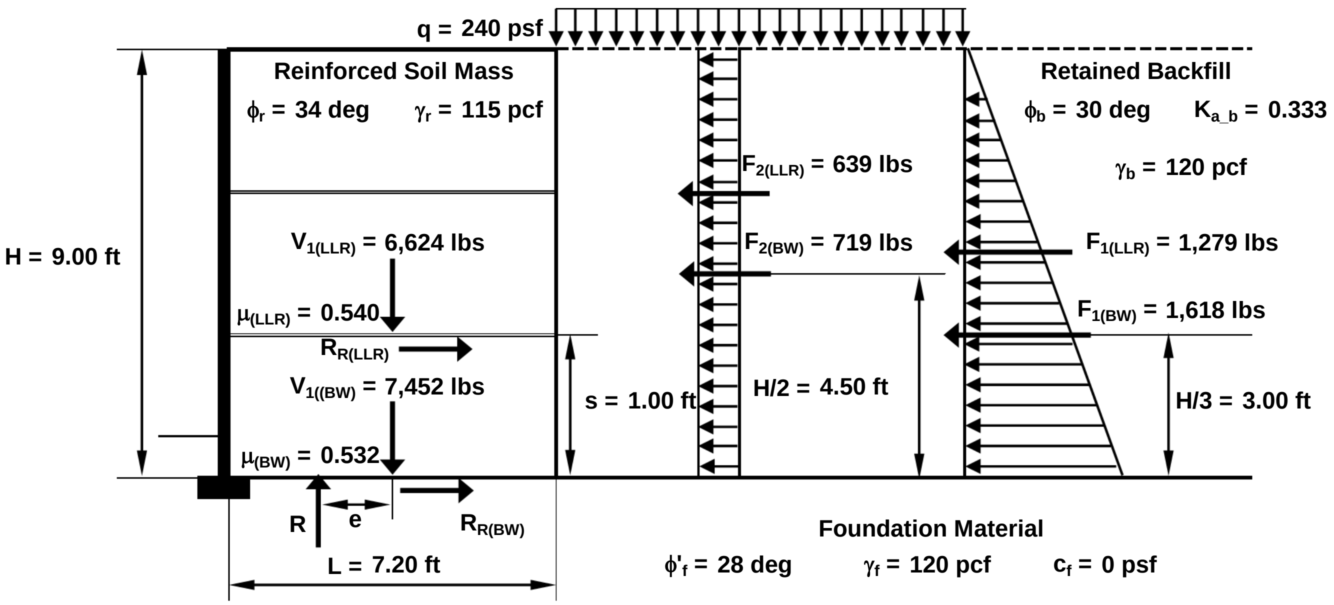
Wall Contact Pressure Under Service Loads

The wall contact pressure under service loads is equal to the total horizontal force acting on the back of the wall

Wall Contact Pressure, $F_P = F_{1(BW)} + F_{2(BW)}$

$F_{1(BW)}$ (lbs)	$F_{2(BW)}$ (lbs)	F_P (lbs)
1,618	719	2,337

Sliding Stability and Eccentricity (Overturning)



External Stability for MSE Walls: Sliding Stability and Eccentricity - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer
= $\varphi R_N = \varphi_\tau R_{\tau(LLR)}$ *AASHTO Eqn. 10.6.3.4-1*

$R_{t(LLR)}$ = nominal sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer
= $\Psi_{EV}(V_{1(LLR)})\mu_{(LLR)}$ *FHWA GEC 011 Eqn. 4-12*

$\mu_{(LLR)}$ = coefficient of friction at interface between the soil and reinforcement for the lowest reinforcement layer *AASHTO 11.10.5.3*

Because the type of reinforcement, continous (e.g., grids) or discontinous (e.g, strips), is not determined at the time of the analysis, the coefficent of friction is taken as the lesser of ϕ_r and ρ, where ρ is the soil-reinforcement interface friciton angle. The value of ρ is taken as the lowest value for all NCDOT approved MSE wall geogrids based on the use of either fine or coarse aggregate in the reinforced zone.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(LLR)}$ (lbs)	ϕ_r (deg)	ρ (deg)	$\mu_{(LLR)}$	$R_{\tau(LLR)}$ (lbs)	$R_{R(LLR)}$ (lbs)
1.00	1.00	6,624	34.00	28.35	0.540	3,577	3,577

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer
= $(\Psi_{EHA})(F_{1(LLR)}) + (\Psi_{LS})(F_{2(LLR)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(LLR)}$ (lbs)	Ψ_{LS}	$F_{2(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)
1.50	639	1.75	1,279	3,037

Sliding Stability and Eccentricity (Overturning) - continued

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer - continued

$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$

$R_{R(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)	$R_{R(LLR)} \geq P_{d(LLR)}$
3,577	3,037	**OK**

Sliding Resistance at the Base of the Bottom of the Wall Facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing *AASHTO Eqn. 10.6.3.4-1*

$= \varphi R_N = \varphi_\tau R_{\tau(BW)}$

$R_{t(BW)}$ = nominal sliding resistance at the base of the bottom of the wall facing

$= \Psi_{EV}(V_{1(BW)})\mu_{(BW)} + (c_f)(L)$ *FHWA GEC 011 Eqn. 4-12 and AASHTO 10.6.3.4*

$\mu_{(BW)}$ = coefficient of friction at the base of the bottom of the wall facing *AASHTO 11.10.5.3*

If the lowest reinforcement layer is above the bottom of the wall facing, to check sliding at the base of the wall, the friction angle of the foundation soil, ϕ_f, or reinforced fill soil, ϕ_r, whichever is less, shall be used to assess sliding resistance.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	ϕ_r (deg)	$\mu_{(BW)}$	c_f (psf)	L (ft)	$R_{\tau(BW)}$ (lbs)	$R_{R(BW)}$ (lbs)
1.00	1.00	7,452	34.00	0.532	0	7.20	3,964	3,964

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing

$= (\Psi_{EHA})(F_{1(BW)}) + (\Psi_{LS})(F_{2(BW)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)
1.50	719	1.75	1,618	3,686

$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$

$R_{R(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)	$R_{R(BW)} \geq P_{d(BW)}$
3,964	3,686	**OK**

Eccentricity (Overturning)

$$e = \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)}} \text{ must be} \leq L/3$$

FHWA GEC 011 Eqn. 4-15 and AASHTO 10.6.3.3

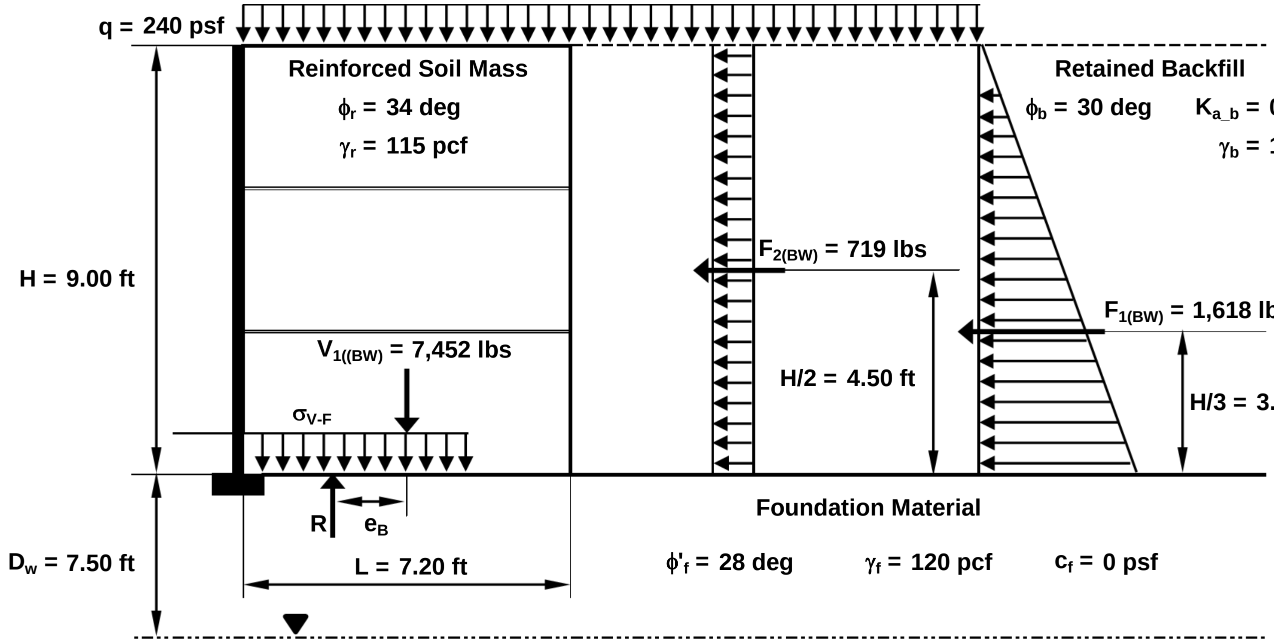
Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e (ft)	L/3 (ft)	e ≤ L/3
1.50	1,618	3.00	1.75	719	4.50	1.00	7,452	1.74	2.40	**OK**

***Note - Use minimum value of Ψ_{EV} for eccentricity per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY: Guilford
DESCRIPTION: RW 1 - Design Section 2- Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 27+25 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 7 OF 8

Bearing Resistance



External Stability for MSE Walls: Bearing Resistance - Level Backslope with Surcharge Case
(Based on FHWA Figure 4-7, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Bearing Resistance for General Shear Failure

e_B = eccentricity for bearing

$$= \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}$$ *FHWA GEC 011 Eqn. 4-19*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e_B (ft)
1.50	1,618	3.00	1.75	1,618	4.50	1.00	7,452	0.99

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

q_r = factored bearing resistance

$= \varphi_b q_n$ *AASHTO Eqn. 10.6.3.1.1-1*

q_n = nominal bearing resistance

$= c_f N_c + 0.5\gamma_f B' N_\gamma C_{w\gamma}$ *AASHTO Eqn. 10.6.3.1.2a-1*

N_c = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*
N_γ = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*
B' = effective foundation width = L - $2e_B$ *AASHTO C11.10.5.4*
$C_{w\gamma}$ = correction factor to account for location of groundwater table *AASHTO Table 10.6.3.1.2a-2*

All other variables have previously been defined

φ_b	c_f (psf)	N_c	γ_f (psf)	N_γ	B' (ft)	$C_{w\gamma}$	q_n (psf)	q_r (psf)
0.65	0	25.80	120	16.70	5.22	0.80	4,184	2,720

Bearing Resistance - continued

Bearing Resistance for General Shear Failure - continued

$q_{uniform} = \sigma_{V\text{-}F}$ = factored bearing pressure at the base of the wall

$$= \frac{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}{L - 2e_B}$$

FHWA GEC 011 Eqn. 4-20

Ψ_{EV}*	$V_{1(BW)}$ (lbs)	Ψ_{LS}	q (psf)	L (ft)	e_B (ft)	$q_{uniform}$ (psf)
1.35	7,452	1.75	240	7.20	0.99	2,507

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.c, AASHTO C3.4.1, and AASHTO C11.5.5**

q_R must be greater than or equal to $q_{uniform}$

FHWA GEC 011 Eqn. 4-17

q_r (psf)	$q_{uniform}$ (psf)	$q_r \geq q_{uniform}$
2,720	2,507	**OK**

Bearing Resistance for Local Shear Failure

Local and Punching shear failure occurs in loose or compressible soils and in weak soils under slow (drained) loading. This mode of failure will only be considered for foundation material that is cohesive.

To prevent Local/Punching Shear on weak cohesive soils, $(\gamma_r)(H) \leq 3c_f$

FHWA GEC 011 Eqn. 4-24

The foundation material for this project is not cohesive

RETAINING WALL NO. 1

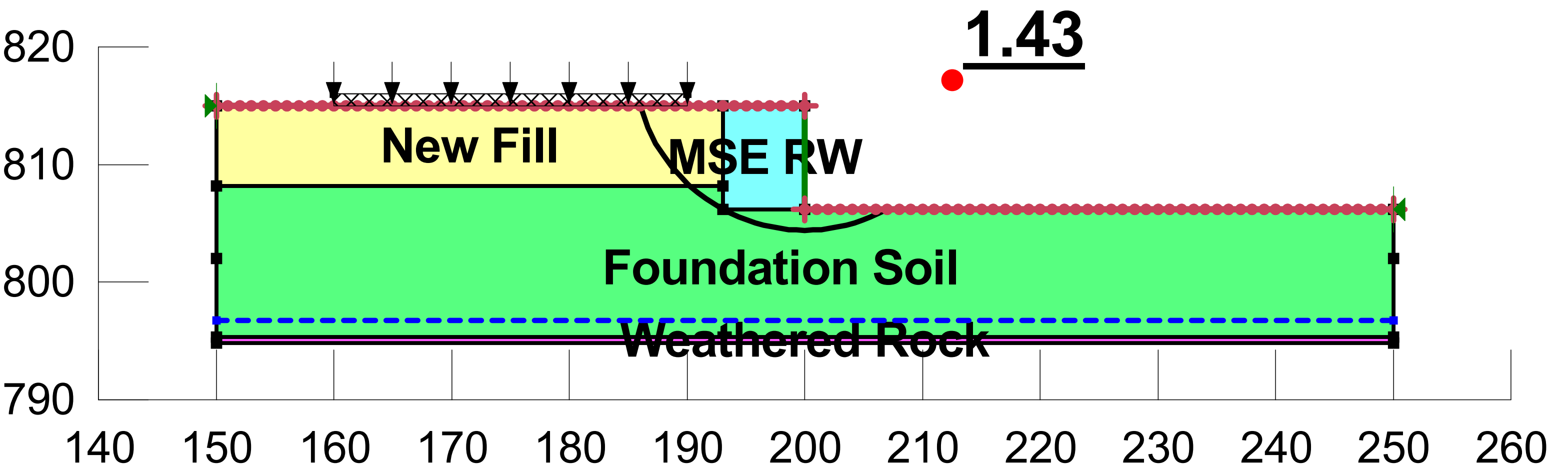
GLOBAL SLOPE STABILITY – SLOPE/W RESULTS

Project Name: U-4015A Gallimore Dairy
Analysis: RW1_Section1_Global Stability Analysis_Circular Failure

H = 9 ft
Reinforcement Length (L) = 7 ft
L/H = 0.8

Borings Used: RW1_3

Color	Name	Model	Unit Weight	Cohesion'	Phi'	Piezometric Line
🟩	Foundation Soil	Mohr-Coulomb	120	0	28	1
🟦	MSE RW	High Strength	120			1
🟨	New Fill	Mohr-Coulomb	120	0	30	1
🟪	Weathered Rock	Mohr-Coulomb	135	0	40	1



RK&K

Project Name:	U-4015A Gallimore Dairy
Task Title:	RW1_Section1_Global Stability Analysis_Circular Failure

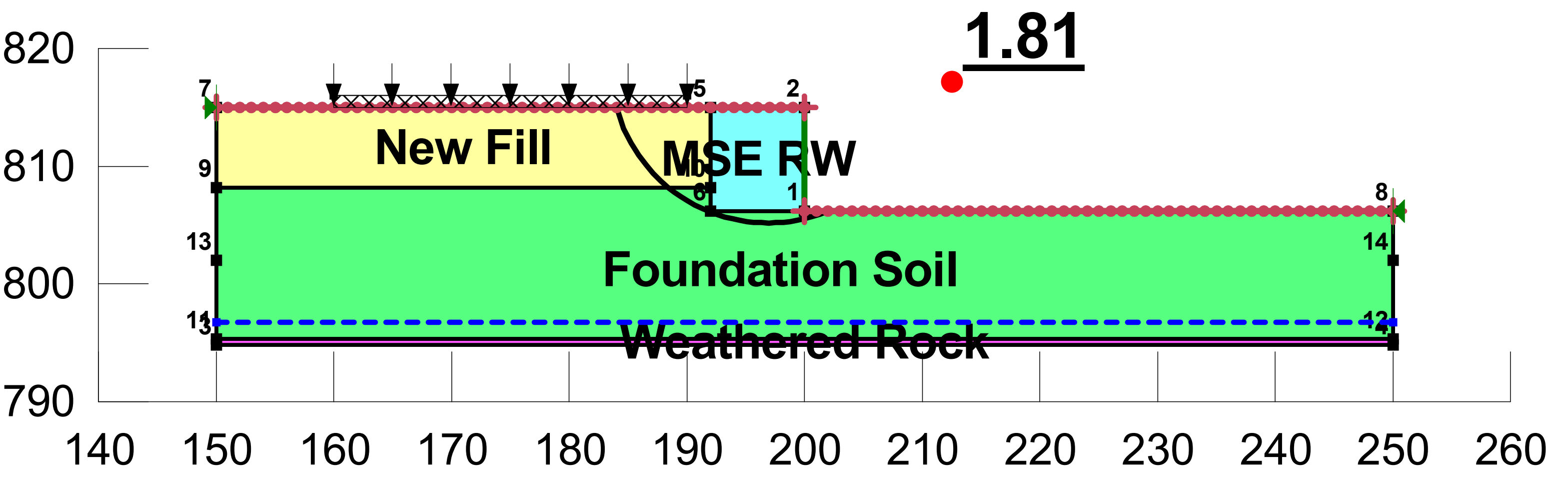
Design by: S Kabra | **Date:** 08/27/2021 | **Job No.** U-4015A

Project Name: U-4015A Gallimore Dairy
Analysis: RW1_Section1_Global Stability Analysis_Circular Failure_Undrained

H = 9 ft
Reinforcement Length (L) = 7 ft
L/H = 0.8

Borings Used: RW1_3

Color	Name	Model	Unit Weight	Phi'	Cohesion	Piezometric Line
🟩	Foundation Soil	Undrained (Phi=0)	120		500	1
🟦	MSE RW	High Strength	120			1
🟨	New Fill	Mohr-Coulomb	120	30		1
🟪	Weathered Rock	Mohr-Coulomb	135	40		1



RK&K

Project Name:	U-4015A Gallimore Dairy
Task Title:	RW1_Section1_Global Stability Analysis_Circular Failure_Undrained

Design by: S Kabra **Date:** 08/27/2021 **Job No.** U-4015A

RETAINING WALL NO. 1

SETTLEMENT ANALYSIS SPREADSHEET

NORTH CAROLINA DEPARTMEN
OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UN
Settlement Calcs for Spread Footings

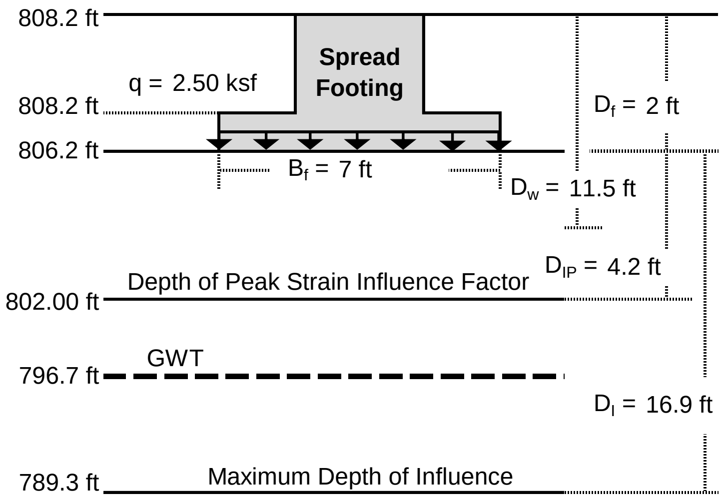
PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro
DESIGNED BY: SK DATE: 07/14/21 STATION: -L-28+50
CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW- PAGE: 1 OF 3

Settlement Calculations for Spread Footings (Schmertmann Method)

Loading Information

Gross bearing pressure, p = q = 2.5 ksf
Time passed since loading applied, t = 0.1 years

t = 0.1 years for immediate settlement.



(Typical Footing Profile - Not To Scale)

Unit Weight Information

Unit Weight of Concrete, γ_c = 0.150 kcf
Unit Weight of Water, γ_w = 0.0624 kcf
Unit Weight of Overburden Soil, γ_s = 0.120 kcf

Elevations and Footing Dimensions

Finished Grade Elevation = 808.2 ft
Natural Ground Elevation = 808.2 ft
Top of Footing Elevation = 808.2 ft
Bottom of Footing Elevation = 806.2 ft
Groundwater Table Elevation = 796.7 ft

Footing Thickness, t_f = 2.0 ft
Width of Footing, B_f = 7.0 ft — *Taken as the shorter dimension of the footing*
Length of Footing, L_f = 20.0 ft — *Taken as the longer dimension of the footing*
L_f / B_f = 2.86 — *Footing Shape = Rectangle*

Footing Embedment Depth, D_f = 2.0 ft
Maximum depth of influence below footing base (D_I) = 4.2 ft — *D_I = 2.41 B_f (See FHWA Figure 8-21a)*
Depth from footing base to peak strain influence factor (D_{IP}) = 16.9 ft — *D_{IP} = 0.60 B_f (See FHWA Figure 8-21a)*

Soil Information

Layer No.	Soil Type (pick the type that best describes the soil layer)	Top of Layer Elev (ft)	Bottom of Layer Elev (ft)	Total Unit Weight (kcf)	SPT $N1_{60}$	CPT q_c (ksf)	F_s	*E_s (ksf)
1	Medium Stiff to Stiff Clay	806.2	798.4	0.120	---	---	0	650
2	Silt	798.4	789.3	0.120	---	---	0	220
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Modulus values are based on Average Es value based on soil type (AASHTO Table C10.4.6.3.1)

Strain Influence Diagram using FHWA Figure 8-21

Strain Influence Factor at the Footing Base, (I_{ZB}) = 0.121 *for L_f/B_f = 2.86 (See FHWA Figure 8-21a)*

Peak Influence Factor (I_{ZP})

$$I_{zp} = 0.5 + 0.1\sqrt{\frac{\Delta p}{p_{op}}}$$

FHWA-NHI-06-089 Page 8-46

Δp = *net bearing pressure at the foundation depth = p - p_o*

p = q = gross bearing pressure at the foundation depth

2.5 p_o = effective in-situ overburden stress at the foundation depth

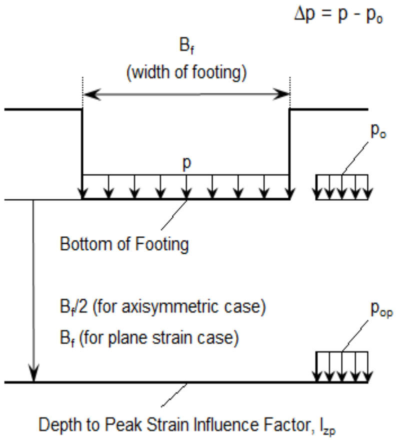
= 2.6 ksf - 0.24 ksf = 2.36 ksf

p_{op} = vertical eff 0.504 ksf - 0 ksf = 0.504 ksf

influence factor (Elevation = 802.00)

= $\sigma_v - \mu$ = 0.81 ksf - 0 ksf = 0.81 ksf

I_{zp} = 0.712



Adapted from FHWA NHI-06-089 Figure 8-21(b)
(Explanation of pressure terms in equation for I_{ZP})

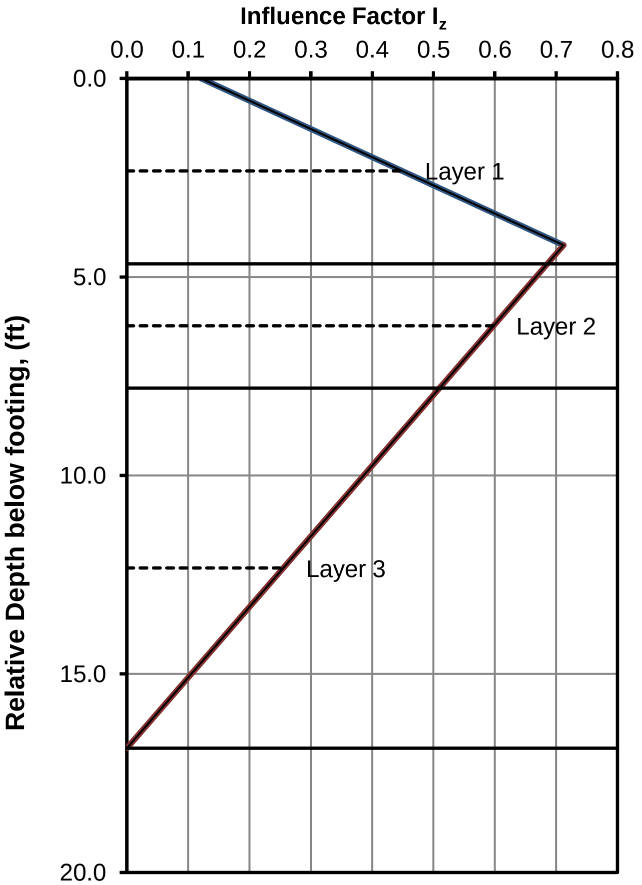
Average Influence Factors (I_{asi}) for each soil layer

Soil layers are divided according to FHWA NHI-06-089, Step 5 (page 8-50)

z_i = depth to center of layer i from the base of the footing

Average Influence Factors for each soil layer

Layer No.	Elevations		Depth		z_i (ft)	I_{azi}
	Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)		
1	806.2	801.5	0.0	4.7	2.3	0.449
2	801.5	798.4	4.7	7.8	6.2	0.598
3	798.4	789.3	7.8	16.9	12.3	0.255



Adapted from FHWA NHI-06-089 Figure 8-21(a)

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
Settlement Calcs for Spread Footings

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro
DESIGNED BY: SK DATE: 07/14/21 STATION: -L-28+50
CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW- PAGE: 3 OF 3

Calculate Settlement using Schmertmann Method

$$S_t = Total\ Settlement = C_1 C_2 \Delta p \sum_{i=1}^{n} \left(H_c \frac{I_z}{X E_{si}} \right)$$

FHWA-NHI-06-089 Equation 8-16

C_1 = Depth Correction Factor

$$= 1 - 0.5\left(\frac{p_o}{\Delta p}\right) \geq 0.5 = \underline{0.947}$$

FHWA-NHI-06-089 Equation 8-17

where, p_0 = 0.240 ksf *effective in-situ overburden stress at the foundation depth*

Δp = 2.260 ksf *net foundation pressure as shown in FHWA Figure 8-21b*

C_2 = Creep Correction Factor

$$= 1 + 0.2 log_{10}\left(\frac{t}{0.1}\right) = \underline{1.000}$$

FHWA-NHI-06-089 Equation 8-18

where, t = 0.1 years *t = time in years (for immediate settlement, t = 0.1 years)*

H_C = Layer Thickness

X = factor to convert cone tip penetration resistance to elastic modulus when using AASHTO Table C10.4.6.3.1

= 1.25 for square footing, (L_f/B_f = 1) and 1.75 for strip footing, ($L_f/B_f \geq 10$)

Use linear interpolation for rectangle footings (1 < L_f/B_f < 10)

FHWA-NHI-06-089 Page 8-45

= 1.00 *X = 1.00 when modulus values are not based on AASHTO Table C10.4.6.3.1*

Layer No.	Soil Type	Elevations		H_c	E_s	I_Z	S_i
		Top (ft)	Bottom (ft)	(in)	(ksf)		(inches)
1	Medium Stiff to Stiff Clay	806.2	801.5	56.0	650	0.449	0.083
2	Medium Stiff to Stiff Clay	801.5	798.4	37.6	650	0.598	0.074
3	Silt	798.4	789.3	108.8	220	0.255	0.270

Total Settlement, S_t = 0.427 inches

MSE WALL CALCULATIONS FOR RETAINING WALL NO. 2

CALCULATIONS SUMMARY
CROSS SECTION INVENTORY
MSE WALL EXTERNAL STABILITY SPREADSHEETS
GLOBAL SLOPE STABILITY – SLOPE/W RESULTS
SETTLEMENT ANALYSIS SPREADSHEET

U-4015 A: RW 2 - MSE WALL

Input Data from Wall Envelope

STATION	Point	Proposed Finished Grade (Bottom)	Proposed Finished Grade (Top)	Wall Height (ft)	Min. Embedment (ft)	Top of the Leveling Pad EL	Design Height (H) (ft)
-L- 44+00.00	1	850.8	850.8	0.0	2.0	848.8	2.0
-L- 44+02.43	2	849.6	850.9	1.3	2.0	847.6	3.3
-L- 44+50.00	3	850.5	853.2	2.7	2.0	848.5	4.7
-L- 44+94.71	4	853.2	855.5	2.3	2.0	851.2	4.3
-L- 45+00.00	5	855.8	855.8	0.0	2.0	853.8	2.0

Assumptions Used for Calculations

Design Section	LOCATION	Design Height (H) (ft)	Backslope Ratio	Backslope Length (ft)	Traffic Load (psf)	MSE Wall Type	Foundation Material			Backfill Material		
							ϕ (deg.)	C (psf)	γ (pcf)	ϕ (deg.)	C (psf)	γ (pcf)
1	POINT 1 TO 5	5.0	-	-	240.0	A	28	0	120	30	0	120

Wall Height (h) (ft) = Top of the Wall EL - Bottom of the Wall EL
Min. Embedment (ft) = h/7 or , 2-ft, whichever is greater
Top of the Leveling Pad EL = Bottom of the Wall EL - Min. Embedment (ft)
Design Height (H) (ft) = Top of the Wall EL - Top of the Leveling Pad EL

**MSE Wall Type in External Stability Analysis (See NCDOT Spreadsheet):
A) MSE Wall with Level Backslope
B) MSE Wall with Broken Backslope
C) MSE Wall with Infinite Backslope
D) MSE Wall with Bridge Abutment with Pile Foundation

Calculations Results

Design Section	Design Height (H) (ft)	External stability (1)			Global Stabiltiy (2)		Global Stability Controls
					Factor of Safety		
		Reinforcement Length Ratio	Strap Length = H x Reinforcement Ratio (ft)	Bearing Pressure (ksf)	Undrained, Short Term Condition	Drained, Long Term Condition	
1	5.0	1.2H	6	1.4	3.40	1.97	No

Notes:

1- See external stabiltiy calculations based on NCDOT MSE Wall External Stability Spreadsheet

2-See Global Stability calculations based on SLOPE/W analyses.

3-The total settlement of the RW No. 2 is anticipated to be 0.2 - inches.

RETAINING WALL NO. 2

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	9

PROFILE ALONG -L-

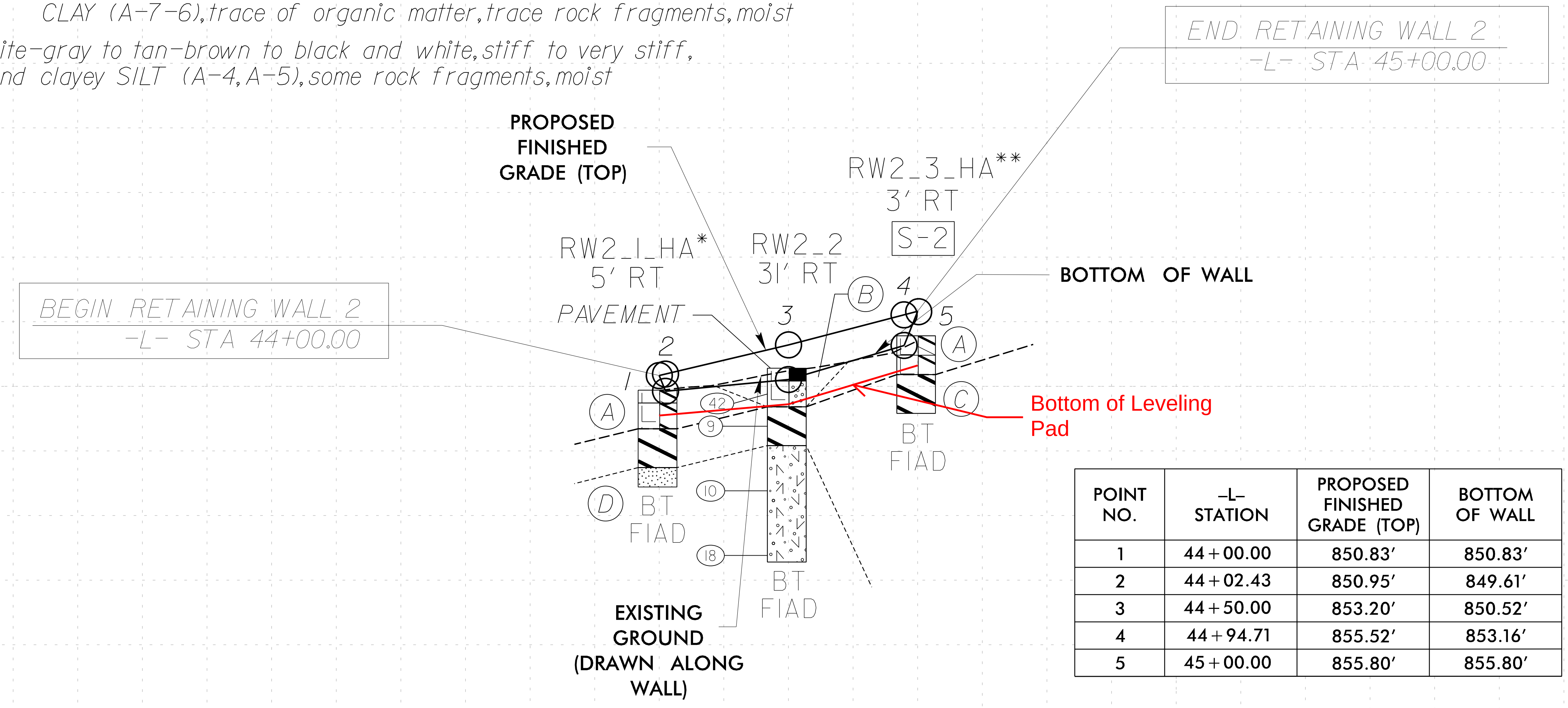
0 50 100
FEET
VE = 5

Ⓐ *ROADWAY EMBANKMENT* Brown to brown-orange, medium stiff to hard, sandy and silty highly plastic CLAY (A-6, A-7-6), trace of organic matter, moist

Ⓑ Tan-white, dense, silty fine to coarse SAND (A-2-4), little gravel, moist

Ⓒ *RESIDUAL* Brown-orange to dark gray and red-brown, medium stiff to very stiff, silty CLAY (A-7-6), trace of organic matter, trace rock fragments, moist

Ⓓ Tan-white-gray to tan-brown to black and white, stiff to very stiff, sandy and clayey SILT (A-4, A-5), some rock fragments, moist



POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	44+00.00	850.83'	850.83'
2	44+02.43	850.95'	849.61'
3	44+50.00	853.20'	850.52'
4	44+94.71	855.52'	853.16'
5	45+00.00	855.80'	855.80'

SOIL TEST RESULTS

SAMPLE NO.	STATION	OFFSET	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
S-2	45+00	38' LT	1.5-3.0'	A-7-6	55	28	1	6	34	60	100	99	96	28	ND

-L-

41+00 42+00 43+00 44+00 45+00 46+00 47+00

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skabra

RETAINING WALL NO. 2

MSE WALL EXTERNAL STABILITY SPREADSHEETS

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 2 - Design Section 1
DESIGNED BY: SK DATE: 07/14/21 STATION: 44+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 1 OF 8

MSE Wall Type (See Figures on right)

MSE Wall with Level Backslope and Traffic Surcharg

Traffic Surcharge and Wall Geometry

q = 240 psf *live load traffic surcharge (AASHTO Tables 3.11.6.4-1 & 2)*

H = 5.00 ft *wall design height*
L/H = 1.200 *ratio of reinforcement length to wall height*
L = 6.00 ft *reinforcement length (L = H x L/H)*
(L/H ≥ 0.7 and L ≥ 6 ft per NCDOT MSE Wall Provision)

s = 1.00 ft *distance from bottom of wall to lowest reinforcement layer*
Slope = N/A : 1 (H_{slope} : V_{Slope}) *slope behind wall*
d = N/A ft *distance from back of wall face to top of backslope*
z = N/A ft *height of soil behind cap for MSE abutment wall*
w = N/A ft *distance from back of wall face to back of cap*
h = N/A ft *height of wall & slope at the back of reinforced zone*

Soil Parameters for Reinforced Zone

Type of aggregate used: ○ Coarse ● Fine

ϕ_r = 34 deg *friction angle (38 deg for coarse, 34 deg for fine)*
γ_r = 115 pcf *unit weight (110 psf for coarse, 115 psf for fine)*

Soil Parameters for Retained Backfill

ϕ_b = 30 deg *friction angle*
γ_b = 120 pcf *unit weight*

Soil Parameters for Foundation Material

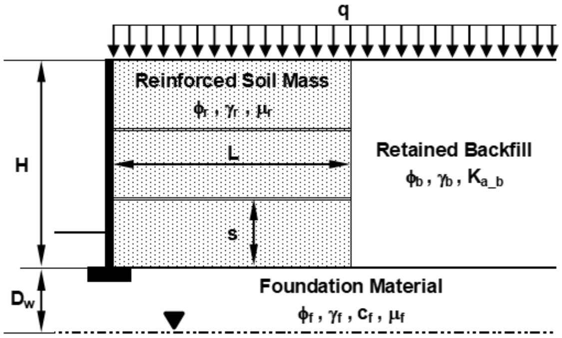
ϕ_f = 28 deg *friction angle*
γ_f = 120 pcf *unit weight*
c_f = 0 psf *undrained shear strength of the foundation material*
D_w = 15.00 ft *distance of water table below bottom of the wall*

Load Factors (AASHTO Table 3.4.1-1 and 2)

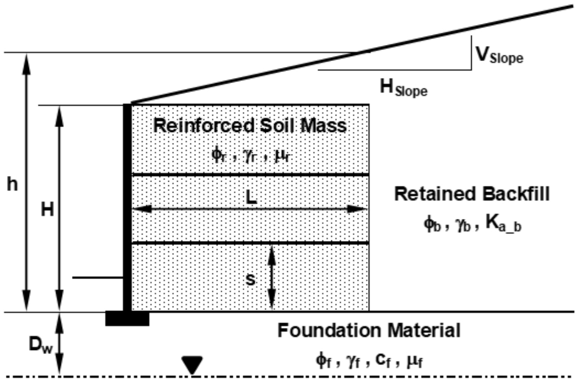
Ψ_{LS} = 1.75 *live load surcharge*
$\Psi_{EH(A)}$ = 1.50 *horizontal (active) earth pressure*
Ψ_{EV} = 1.00 min / 1.35 max *vertical dead load generated from earth fill*

Resistance Factors (AASHTO Table 11.5.7-1)

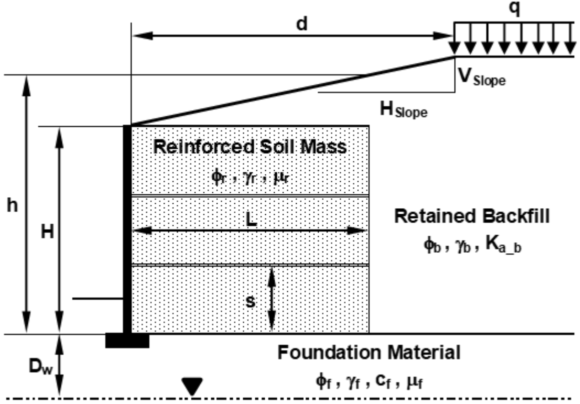
φ_b = 0.65 *bearing resistance for MSE walls*
φ_t = 1.00 *sliding resistance for MSE walls*



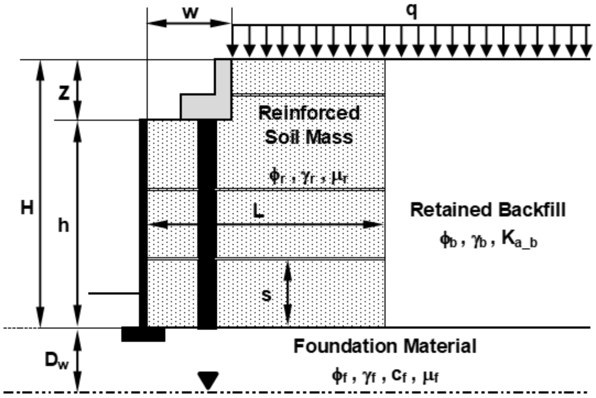
MSE Wall with Level Backslope and Traffic Surcharge



MSE Wall with Infinite Backslope



MSE Wall with Broken Backslope



MSE Wall Bridge Abutment with Pile Foundation

(MSE WALL FIGURES ARE NOT TO SCALE)

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. Thereare no expressed or implied warrantie*

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 2 - Design Section 1
DESIGNED BY: SK DATE: 07/14/21 STATION: 44+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 2 OF 8

Summary of External Stability Analysis - MSE Wall with Level Backslope and Traffic Surcharge

Geometry of Reinforced Soil Mass

H = wall height	5.00 ft
L/H = ratio of reinforcement length to wall height (must be greater than or equal to 0.700)	1.200
L = reinforcement length (must be greater than or equal to 6 ft)	6.00 ft

Forces Acting on Wall - Vertical Direction

$V_{1(LLR)}$ = vertical force from reinforced soil mass acting at the lowest level of reinforcement	2,760 lbs
$V_{1(BW)}$ = vertical force from reinforced soil mass acting at the base of the wall	3,450 lbs
V_2 = vertical force from the retained fill above the reinforced soil mass	0 lbs
$F_{V(LLR)}$ = vertical force generated from lateral earth pressure at the lowest level of reinforcement	0 lbs
$F_{V(BW)}$ = vertical force generated from lateral earth pressure at the base of the wall	0 lbs

Forces Acting on Wall - Horizontal Direction

$F_{H(LLR)}$ = horizontal force generated from lateral earth pressure at the lowest level of reinforcement	320 lbs
$F_{H(BW)}$ = horizontal force generated from lateral earth pressure at the base of the wall	500 lbs
$F_{2(LLR)}$ = horizontal force generated from traffic surcharge, acting at the lowest level of reinforcement	320 lbs
$F_{2(BW)}$ = horizontal force generated from traffic surcharge, acting at the base of the wall	400 lbs

F_P = total horizontal force acting on the back of the MSE wall (wall contact pressure under service loads)	900 lbs

Sliding Stability - at the interface between the soil and reinforcement for the lowest reinforcement layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer	1,490 lbs
$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer	1,039 lbs
$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$	OK

Sliding Stability - at the base of the bottom of the wall facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing	1,835 lbs
$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing	1,449 lbs
$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$	OK

Overturning / Limiting Eccentricity

e = eccentricity	0.87 ft
L / 3	2.00 ft
e must be less than or equal to L / 3	OK

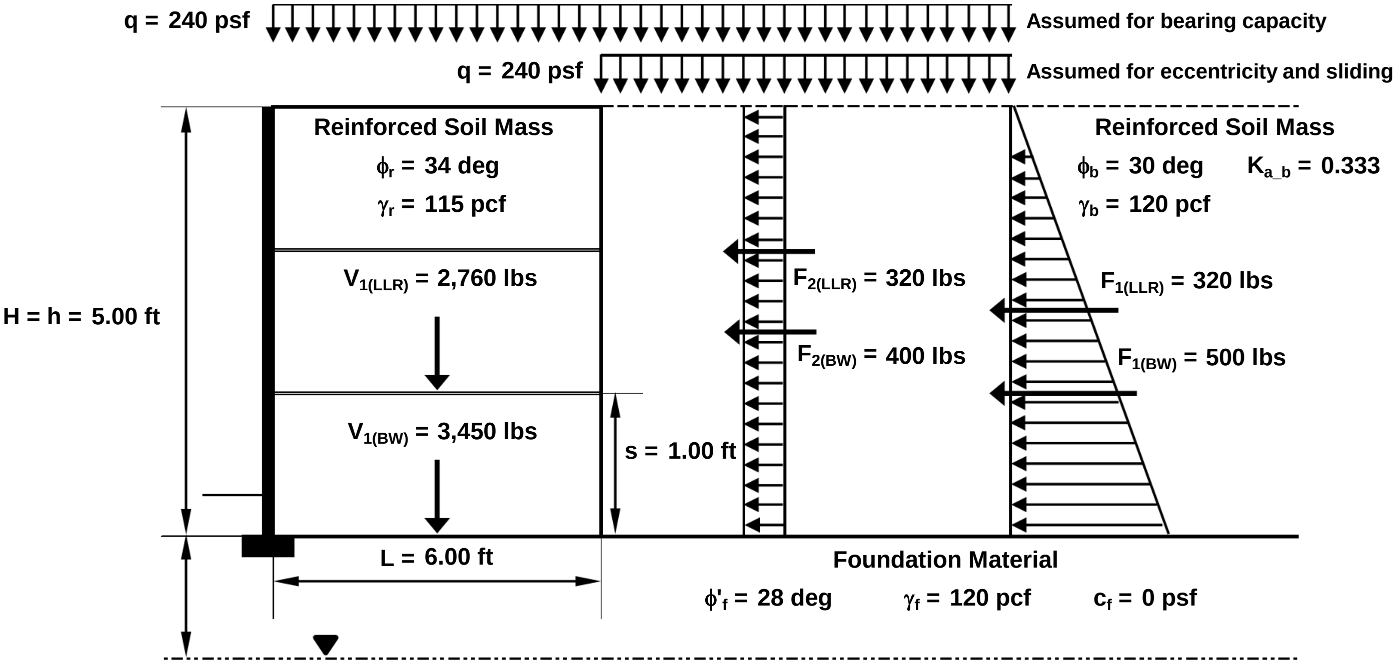
Bearing Resistance - General Shear

q_r = factored bearing resistance	3,361 lbs
$q_{uniform}$ = factored bearing pressure at the base of the wall	1,391 lbs
q_R must be greater than or equal to $q_{uniform}$	OK

Bearing Resistance - Local / Punching Shear (only applicable to soils with cohesion)

q_r = reduced factored bearing resistance	N/A
$q_{uniform}$ = factored bearing pressure at the base of the wall	N/A
q_R must be greater than or equal to $q_{uniform}$	N/A

Forces Acting on Wall



External Stability for MSE Walls: Forces acting on Wall - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO Figure 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Vertical Forces from Earth Loads

$V_{1(LLR)}$ = total vertical force from reinforced soil mass, acting at the interface between the soil and reinforcement for the lowest reinforcement layer
= $(\gamma_r)(H - s)(L)$

$V_{1(BW)}$ = total vertical force from reinforced soil mass, acting at the base of the bottom of the wall facing
= $(\gamma_r)(H)(L)$

γ'_r (pcf)	H (ft)	s (ft)	L (ft)	$V_{1(LLR)}$ (lbs)	$V_{1(BW)}$ (lbs)
115	5.00	1.00	6.00	2,760	3,450

Forces Generated from Lateral (Active) Earth Pressure

K_{a_b} = coefficient of active earth pressure

$$= \frac{\sin^2(\theta+\phi'_f)}{\Gamma\,[\sin^2\theta\,\sin(\theta-\delta)]} \quad \text{where} \quad \left[1+\sqrt{\frac{\sin(\phi'_f+\delta)\sin(\phi'_f-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}\right]^2$$

AASHTO Equations 3.11.5.3-1 and 2

$\phi_f = \phi_b$
δ = friction angle between fill and wall = β per AASHTO Article 11.10.5.2
β = inclination angle of backslope = 0 for level backslope
θ = angle of back face of wall to the horizontal = 0 degrees for vertical wall face

ϕ_b (deg)	δ (deg)	β (deg)	K_{a_b} (lbs)
120	0	0	0.333

Forces Acting on Wall - continued

Forces Generated from Lateral (Active) Earth Pressure - continued

$F_{1(LLR)}$ = total force generated from lateral earth pressure, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $0.5(\gamma_b)(H\text{-}s)^2(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5 (modified)*

$F_{1(BW)}$ = total force generated from lateral earth pressure, acting at the base of the bottom of the wall facing

= $0.5(\gamma_b)(H^2)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5*

γ'_b (psf)	H (ft)	s (ft)	K_{a_b}	$F_{1(LLR)}$ (lbs)	$F_{1(BW)}$ (lbs)
120	5.00	1.00	0.333	320	500

Horizontal Forces Generated from Traffic Surcharge

$F_{2(LLR)}$ = total horizontal force generated from traffic surcharge, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(q)(H\ \text{-}s\ )(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6 (modified)*

$F_{2(BW)}$ = total horizontal force generated from traffic surcharge, acting at the base of the bottom of the wall facing

= $(q)(H)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6*

q (psf)	H (ft)	s (ft)	K_{a_b}	$F_{2(LLR)}$ (lbs)	$F_{2(BW)}$ (lbs)
240	5.00	1.00	0.333	320	400

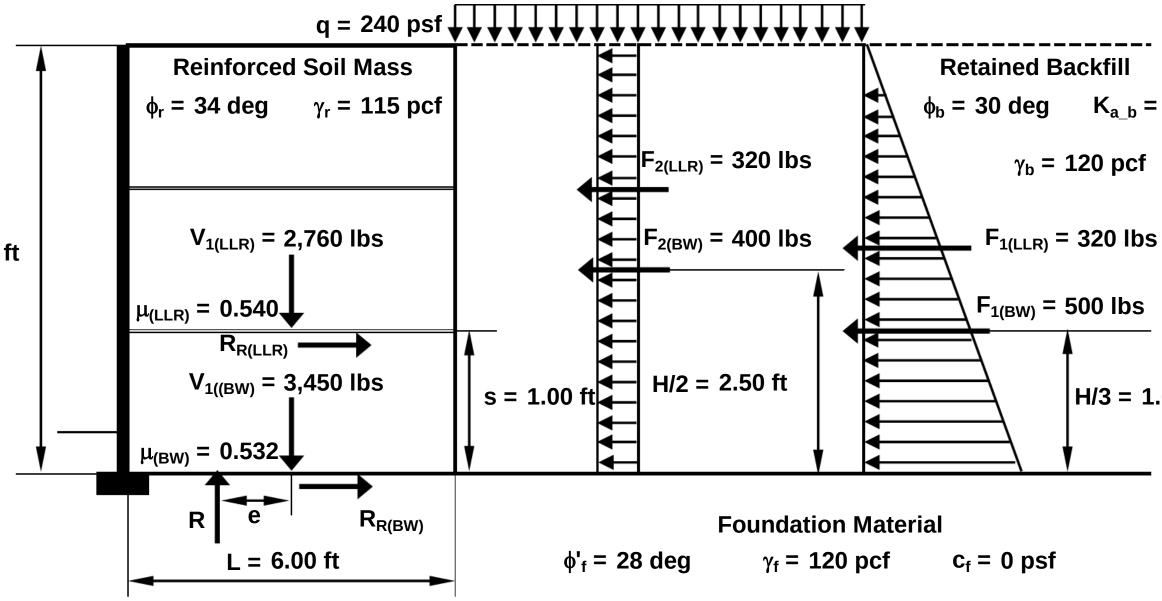
Wall Contact Pressure Under Service Loads

The wall contact pressure under service loads is equal to the total horizontal force acting on the back of the wall

Wall Contact Pressure, $F_P = F_{1(BW)} + F_{2(BW)}$

$F_{1(BW)}$ (lbs)	$F_{2(BW)}$ (lbs)	F_P (lbs)
500	400	900

Sliding Stability and Eccentricity (Overturning)



External Stability for MSE Walls: Sliding Stability and Eccentricity - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer

= $\varphi R_N = \varphi_\tau R_{\tau(LLR)}$ *AASHTO Eqn. 10.6.3.4-1*

$R_{t(LLR)}$ = nominal sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer

= $\Psi_{EV}(V_{1(LLR)})\mu_{(LLR)}$ *FHWA GEC 011 Eqn. 4-12*

$\mu_{(LLR)}$ = coefficient of friction at interface between the soil and reinforcement for the lowest reinforcement layer *AASHTO 11.10.5.3*

Because the type of reinforcement, continous (e.g., grids) or discontinous (e.g, strips), is not determined at the time of the analysis, the coefficent of friction is taken as the lesser of ϕ_r and ρ, where ρ is the soil-reinforcement interface friciton angle. The value of ρ is taken as the lowest value for all NCDOT approved MSE wall geogrids based on the use of either fine or coarse aggregate in the reinforced zone.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(LLR)}$ (lbs)	ϕ_r (deg)	ρ (deg)	$\mu_{(LLR)}$	$R_{\tau(LLR)}$ (lbs)	$R_{R(LLR)}$ (lbs)
1.00	1.00	2,760	34.00	28.35	0.540	1,490	1,490

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(\Psi_{EHA})(F_{1(LLR)}) + (\Psi_{LS})(F_{2(LLR)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(LLR)}$ (lbs)	Ψ_{LS}	$F_{2(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)
1.50	320	1.75	320	1,039

Sliding Stability and Eccentricity (Overturning) - continued

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer - continued

$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$

$R_{R(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)	$R_{R(LLR)} \geq P_{d(LLR)}$
1,490	1,039	**OK**

Sliding Resistance at the Base of the Bottom of the Wall Facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing *AASHTO Eqn. 10.6.3.4-1*

$= \varphi R_N = \varphi_\tau R_{\tau(BW)}$

$R_{t(BW)}$ = nominal sliding resistance at the base of the bottom of the wall facing

$= \Psi_{EV}(V_{1(BW)})\mu_{(BW)} + (c_f)(L)$ *FHWA GEC 011 Eqn. 4-12 and AASHTO 10.6.3.4*

$\mu_{(BW)}$ = coefficient of friction at the base of the bottom of the wall facing *AASHTO 11.10.5.3*

If the lowest reinforcement layer is above the bottom of the wall facing, to check sliding at the base of the wall, the friction angle of the foundation soil, ϕ_f, or reinforced fill soil, ϕ_r, whichever is less, shall be used to assess sliding resistance.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	ϕ_r (deg)	$\mu_{(BW)}$	c_f (psf)	L (ft)	$R_{\tau(BW)}$ (lbs)	$R_{R(BW)}$ (lbs)
1.00	1.00	3,450	34.00	0.532	0	6.00	1,835	1,835

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing

$= (\Psi_{EHA})(F_{1(BW)}) + (\Psi_{LS})(F_{2(BW)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)
1.50	400	1.75	500	1,449

$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$

$R_{R(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)	$R_{R(BW)} \geq P_{d(BW)}$
1,835	1,449	**OK**

Eccentricity (Overturning)

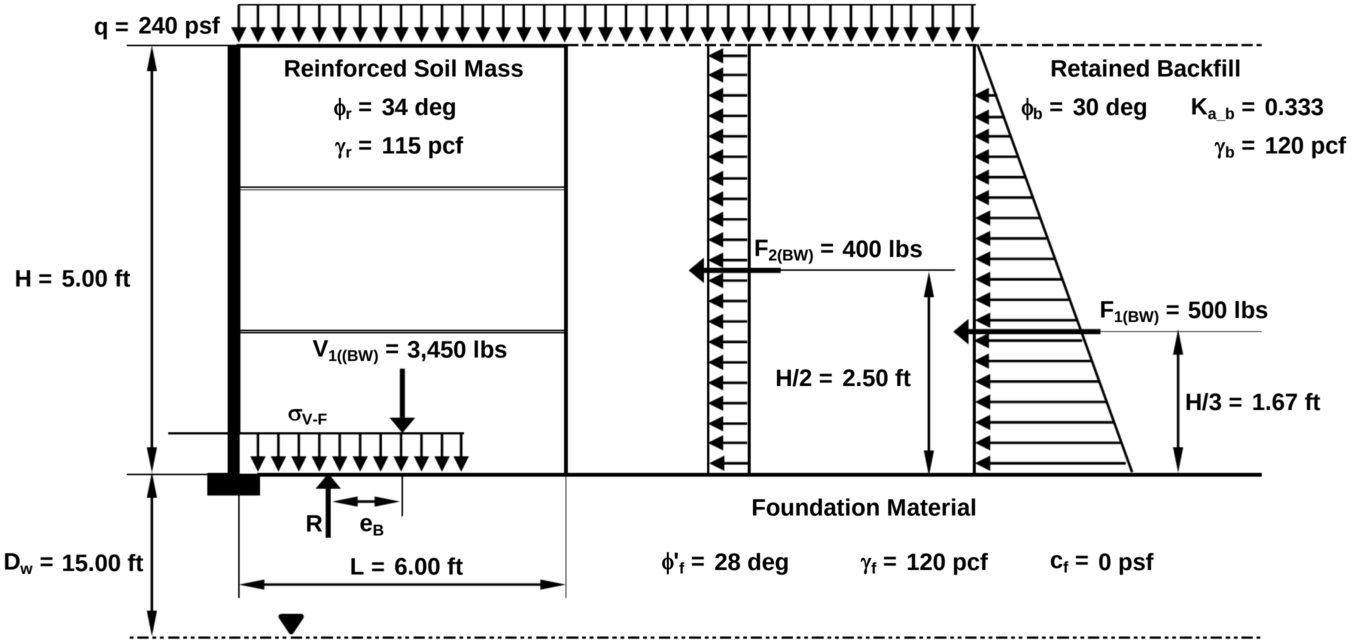
$$e = \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)}} \text{ must be} \leq L/3$$

FHWA GEC 011 Eqn. 4-15 and AASHTO 10.6.3.3

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e (ft)	L/3 (ft)	$e \leq L/3$
1.50	500	1.67	1.75	400	2.50	1.00	3,450	0.87	2.00	**OK**

***Note - Use minimum value of Ψ_{EV} for eccentricity per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

Bearing Resistance



External Stability for MSE Walls: Bearing Resistance - Level Backslope with Surcharge Case
(Based on FHWA Figure 4-7, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Bearing Resistance for General Shear Failure

e_B = eccentricity for bearing

$$= \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}$$ *FHWA GEC 011 Eqn. 4-19*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e_B (ft)
1.50	500	1.67	1.75	500	2.50	1.00	3,450	0.42

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

q_r = factored bearing resistance

$= \varphi_b q_n$ *AASHTO Eqn. 10.6.3.1.1-1*

q_n = nominal bearing resistance

$= c_f N_c + 0.5\gamma_f B' N_\gamma C_{w\gamma}$ *AASHTO Eqn. 10.6.3.1.2a-1*

N_c = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*
N_γ = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*
B' = effective foundation width = L - $2e_B$ *AASHTO C11.10.5.4*
$C_{w\gamma}$ = correction factor to account for location of groundwater table *AASHTO Table 10.6.3.1.2a-2*

All other variables have previously been defined

φ_b	c_f (psf)	N_c	γ_f (psf)	N_γ	B' (ft)	$C_{w\gamma}$	q_n (psf)	q_r (psf)
0.65	0	25.80	120	16.70	5.16	1.00	5,170	3,361

Bearing Resistance - continued

Bearing Resistance for General Shear Failure - continued

$q_{uniform} = \sigma_{V\text{-}F}$ = factored bearing pressure at the base of the wall

$$= \frac{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}{L - 2e_B}$$

FHWA GEC 011 Eqn. 4-20

Ψ_{EV}*	$V_{1(BW)}$ (lbs)	Ψ_{LS}	q (psf)	L (ft)	e_B (ft)	$q_{uniform}$ (psf)
1.35	3,450	1.75	240	6.00	0.42	1,391

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.c, AASHTO C3.4.1, and AASHTO C11.5.5**

q_R must be greater than or equal to $q_{uniform}$

FHWA GEC 011 Eqn. 4-17

q_r (psf)	$q_{uniform}$ (psf)	$q_r \geq q_{uniform}$
3,361	1,391	**OK**

Bearing Resistance for Local Shear Failure

Local and Punching shear failure occurs in loose or compressible soils and in weak soils under slow (drained) loading. This mode of failure will only be considered for foundation material that is cohesive.

To prevent Local/Punching Shear on weak cohesive soils, $(\gamma_r)(H) \leq 3c_f$

FHWA GEC 011 Eqn. 4-24

The foundation material for this project is not cohesive

RETAINING WALL NO. 2

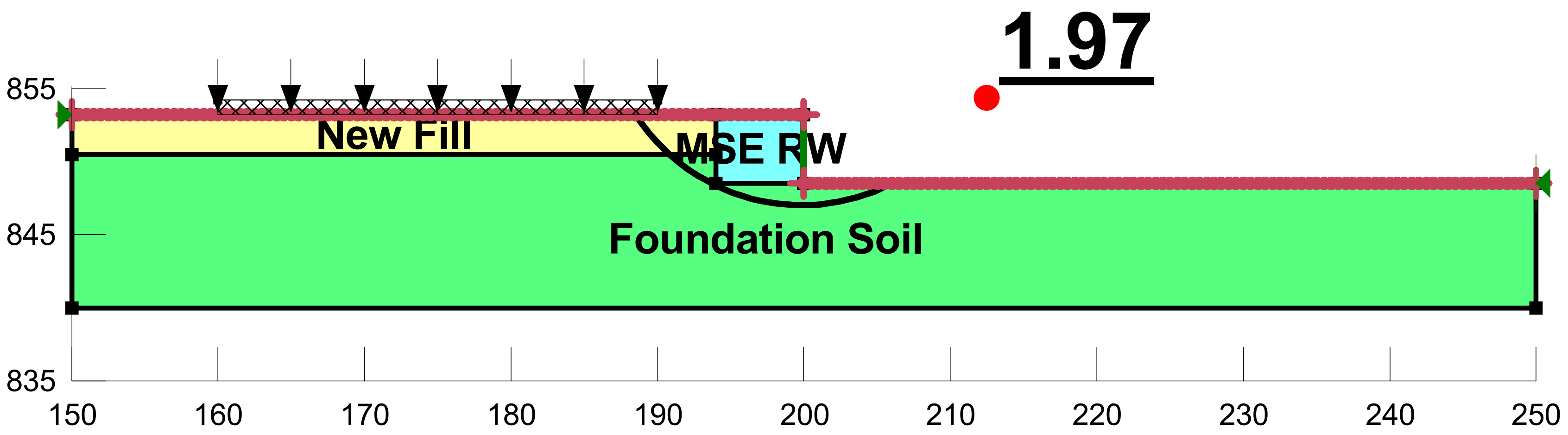
GLOBAL SLOPE STABILITY – SLOPE/W RESULTS

Project Name: U-4015A Gallimore Dairy
Analysis: RW2_Global Stability Analysis_Circular Failure_Drained

H = 5 ft
Reinforcement Length (L) = 6 ft
L/H = 1.2

Borings Used: RW2_1_HA, RW2_2, & RW2_3_HA

Color	Name	Model	Unit Weight	Phi'
🟩	Foundation Soil	Mohr-Coulomb	120	30
🟦	MSE RW	High Strength	120	
🟨	New Fill	Mohr-Coulomb	120	30



RK&K

Project Name:	U-4015A Gallimore Dairy
Task Title:	RW2_Global Stability Analysis_Circular Failure_Drained

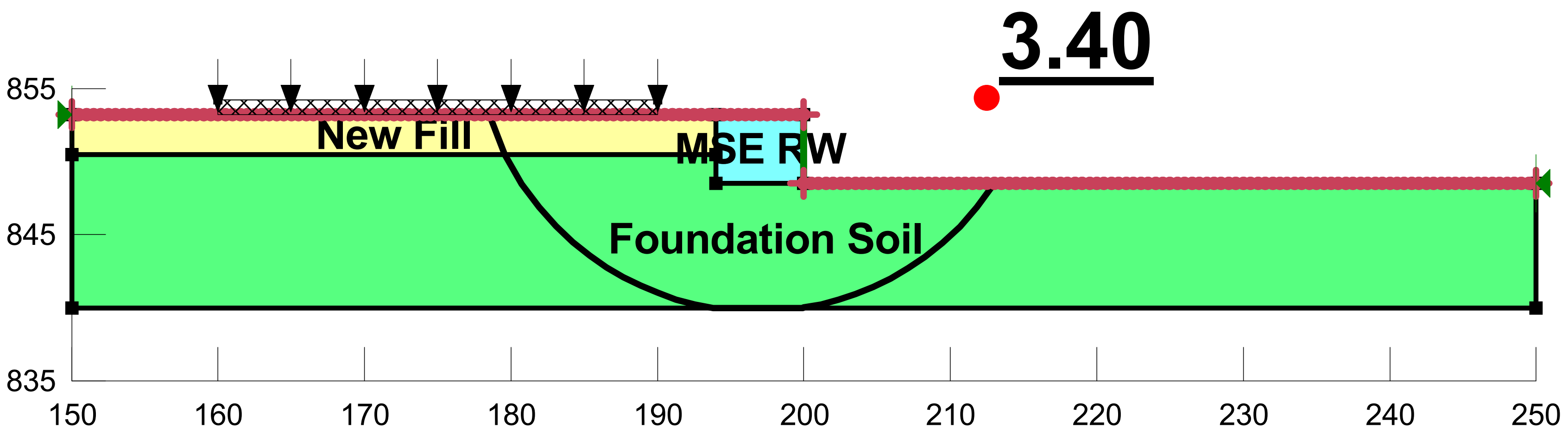
Design by: S Kabra
Date: 03/28/2022
Job No. U-4015A

Project Name: U-4015A Gallimore Dairy
Analysis: RW2_Global Stability Analysis_Circular Failure_Undrained

H = 5 ft
Reinforcement Length (L) = 6 ft
L/H = 1.2

Borings Used: RW2_1_HA, RW2_2, & RW2_3_HA

Color	Name	Model	Unit Weight	Phi'	Cohesion
🟩	Foundation Soil	Undrained (Phi=0)	120		500
🟦	MSE RW	High Strength	120		
🟨	New Fill	Mohr-Coulomb	120	30	



RK&K	**Project Name:**	U-4015A Gallimore Dairy	
	Task Title:	RW2_Global Stability Analysis_Circular Failure_Undrained	
	Design by: S Kabra	**Date:** 03/28/2022	**Job No.** U-4015A

RETAINING WALL NO. 2

SETTLEMENT ANALYSIS SPREADSHEET

NORTH CAROLINA DEPARTMENT
OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UN
Settlement Calcs for Spread Footings

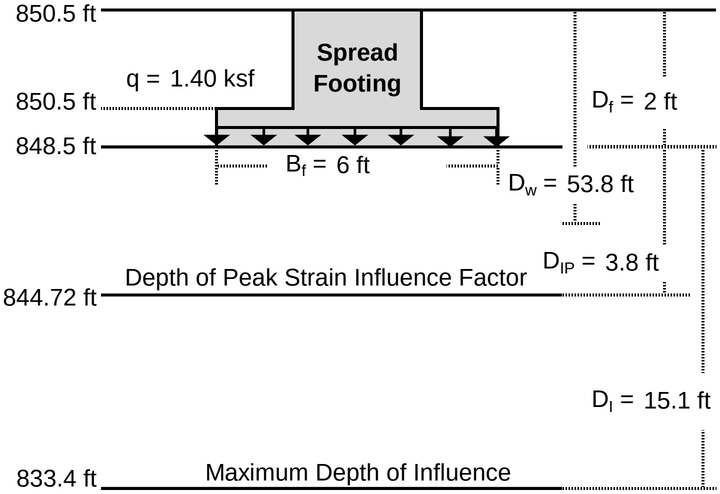
PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro
DESIGNED BY: SK DATE: 07/14/21 STATION: -L-44+50
CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW- PAGE: 1 OF 3

Settlement Calculations for Spread Footings (Schmertmann Method)

Loading Information

Gross bearing pressure, p = q = 1.4 ksf
Time passed since loading applied, t = 0.1 years

t = 0.1 years for immediate settlement.



(Typical Footing Profile - Not To Scale)

Unit Weight Information

Unit Weight of Concrete, γ_c = 0.150 kcf
Unit Weight of Water, γ_w = 0.0624 kcf
Unit Weight of Overburden Soil, γ_s = 0.120 kcf

Elevations and Footing Dimensions

Finished Grade Elevation = 850.5 ft
Natural Ground Elevation = 850.5 ft
Top of Footing Elevation = 850.5 ft
Bottom of Footing Elevation = 848.5 ft
Groundwater Table Elevation = 796.7 ft

Footing Thickness, t_f = 2.0 ft
Width of Footing, B_f = 6.0 ft — *Taken as the shorter dimension of the footing*
Length of Footing, L_f = 20.0 ft — *Taken as the longer dimension of the footing*
L_f / B_f = 3.33 — *Footing Shape = Rectangle*

Footing Embedment Depth, D_f = 2.0 ft
Maximum depth of influence below footing base (D_I) = 3.8 ft — D_I = 2.52 B_f *(See FHWA Figure 8-21a)*
Depth from footing base to peak strain influence factor (D_{IP}) = 15.1 ft — D_{IP} = 0.63 B_f *(See FHWA Figure 8-21a)*

Soil Information

Layer No.	Soil Type (pick the type that best describes the soil layer)	Top of Layer Elev (ft)	Bottom of Layer Elev (ft)	Total Unit Weight (kcf)	SPT $N1_{60}$	CPT q_c (ksf)	F_s	*E_s (ksf)
1	Medium Stiff to Stiff Clay	848.5	845.0	0.120	---	---	0	650
2	Silt	845.0	833.0	0.120	---	---	0	220
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Modulus values are based on Average Es value based on soil type (AASHTO Table C10.4.6.3.1)

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
Settlement Calcs for Spread Footings

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro
DESIGNED BY: SK DATE: 07/14/21 STATION: -L-44+50
CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW-2 PAGE: 2 OF 3

Strain Influence Diagram using FHWA Figure 8-21

Strain Influence Factor at the Footing Base, (I_{ZB}) = 0.126 *for L_f/B_f = 3.33 (See FHWA Figure 8-21a)*

Peak Influence Factor (I_{ZP})

$$I_{zp} = 0.5 + 0.1\sqrt{\frac{\Delta p}{p_{op}}}$$

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Δp = *net bearing pressure at the foundation depth = p - p_o*

p = q = gross bearing pressure at the foundation depth

1_o4= effective in-situ overburden stress at the foundation depth

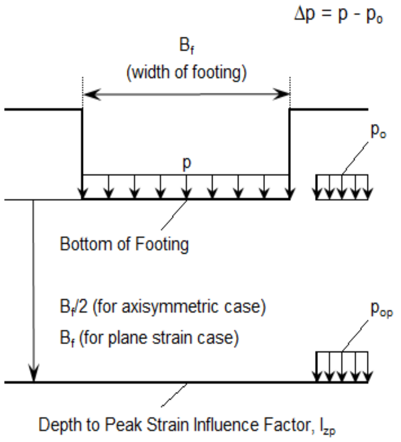
= 2.6 ksf - 0.24 ksf = 2.36 ksf

p_{op} = vertical eff 0.694 ksf - 0 ksf = 0.694 ksf

influence factor (Elevation = 844.72)

= $\sigma_v - \mu$ = 0.81 ksf - 0 ksf = 0.81 ksf

I_{zp} = 0.629



Adapted from FHWA NHI-06-089 Figure 8-21(b)
(Explanation of pressure terms in equation for I_{ZP})

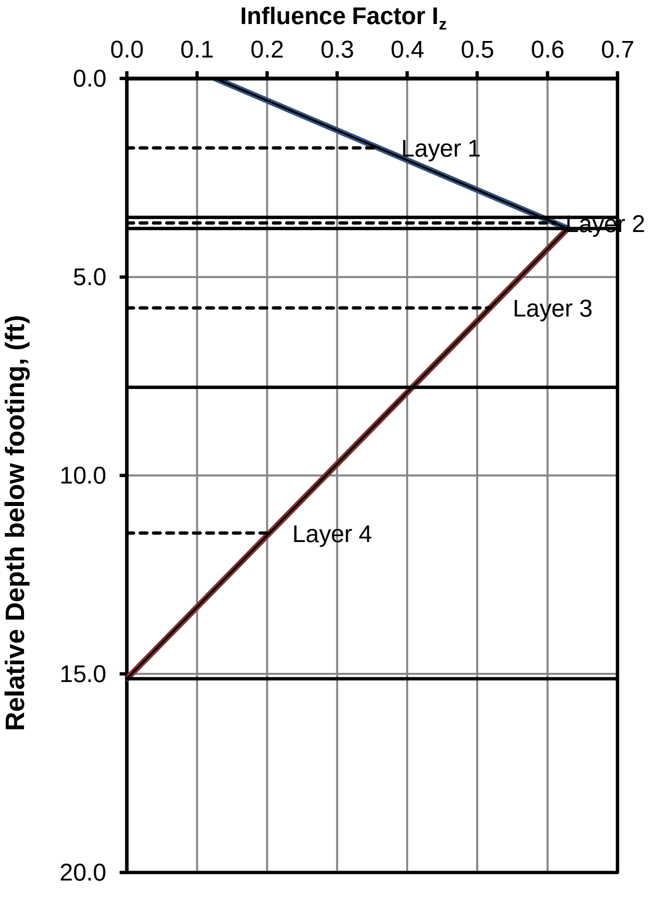
Average Influence Factors (I_{asi}) for each soil layer

Soil layers are divided according to FHWA NHI-06-089, Step 5 (page 8-50)

z_i = depth to center of layer i from the base of the footing

Average Influence Factors for each soil layer

Layer No.	Elevations		Depth		z_i (ft)	I_{azi}
	Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)		
1	848.5	845.0	0.0	3.5	1.8	0.359
2	845.0	844.7	3.5	3.8	3.6	0.610
3	844.7	840.7	3.8	7.8	5.8	0.518
4	840.7	833.4	7.8	15.1	11.5	0.204



Adapted from FHWA NHI-06-089 Figure 8-21(a)

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
Settlement Calcs for Spread Footings

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro
DESIGNED BY: SK DATE: 07/14/21 STATION: -L-44+50
CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW-2 PAGE: 3 OF 3

Calculate Settlement using Schmertmann Method

$$S_t = Total\ Settlement = C_1 C_2 \Delta p \sum_{i=1}^{n} \left(H_c \frac{I_z}{XE_{si}} \right)$$

FHWA-NHI-06-089 Equation 8-16

C_1 = Depth Correction Factor

$$= 1 - 0.5\left(\frac{p_o}{\Delta p}\right) \geq 0.5 = \underline{0.897}$$

FHWA-NHI-06-089 Equation 8-17

where, p_0 = 0.240 ksf — *effective in-situ overburden stress at the foundation depth*

Δp = 1.160 ksf — *net foundation pressure as shown in FHWA Figure 8-21b*

C_2 = Creep Correction Factor

$$= 1 + 0.2log_{10}\left(\frac{t}{0.1}\right) = \underline{1.000}$$

FHWA-NHI-06-089 Equation 8-18

where, t = 0.1 years — *t = time in years (for immediate settlement, t = 0.1 years)*

H_C = Layer Thickness

X = factor to convert cone tip penetration resistance to elastic modulus when using AASHTO Table C10.4.6.3.1

= 1.25 for square footing, (L_f/B_f = 1) and 1.75 for strip footing, (L_f/B_f ≥ 10)

Use linear interpolation for rectangle footings (1 < L_f/B_f < 10)

FHWA-NHI-06-089 Page 8-45

= 1.00 — *X = 1.00 when modulus values are not based on AASHTO Table C10.4.6.3.1*

Layer No.	Soil Type	Elevations		H_c	E_s	I_Z	S_i
		Top (ft)	Bottom (ft)	(in)	(ksf)		(inches)
1	Medium Stiff to Stiff Clay	848.5	845.0	42.0	650	0.359	0.024
2	Silt	845.0	844.7	3.4	220	0.610	0.010
3	Silt	844.7	840.7	48.0	220	0.518	0.118
4	Silt	840.7	833.4	88.1	220	0.204	0.085

Total Settlement, S_t = 0.236 inches

MSE WALL CALCULATIONS FOR RETAINING WALL NO. 3

CALCULATIONS SUMMARY
CROSS SECTION INVENTORY
MSE WALL EXTERNAL STABILITY SPREADSHEETS
GLOBAL SLOPE STABILITY – SLOPE/W RESULTS
SETTLEMENT ANALYSIS SPREADSHEET

U-4015 A: RW 3 - MSE WALL

Input Data from Wall Envelope							
STATION	**Point**	**Proposed Finished Grade (Bottom)**	**Proposed Finished Grade (Top)**	**Wall Height (ft)**	**Min. Embedment (ft)**	**Top of the Leveling Pad EL**	**Design Height (H) (ft)**
-L- 48+00.00	1	873.1	873.1	0.0	2.0	871.1	2.0
-L- 48+04.34	2	870.9	873.4	2.5	2.0	868.9	4.5
-L- 48+50.00	3	872.4	875.8	3.4	2.0	870.4	5.4
-L- 49+00.00	4	872.8	878.3	5.5	2.0	870.8	7.5
-L- 49+50.00	5	873.0	880.5	7.5	2.0	871.0	9.5
-L- 50+00.00	6	872.5	882.4	9.9	2.0	870.5	11.9
-L- 50+50.00	7	872.0	884.0	12.0	2.0	870.0	14.0
-L- 51+00.00	8	873.7	885.1	11.4	2.0	871.7	13.4
-L- 51+50.00	9	877.2	886.0	8.8	2.0	875.2	10.8
-L- 52+00.00	10	882.4	886.8	4.4	2.0	880.4	6.4
-L- 52+50.00	11	885.4	887.7	2.3	2.0	883.4	4.3
-L- 52+94.27	12	885.4	888.2	2.8	2.0	883.4	4.8
-L- 53+00.00	13	888.2	888.2	0.0	2.0	886.2	2.0

Wall Height (ft) = Top of the Wall EL - Bottom of the Wall EL

Min. Embedment (ft) = h/7 or , 2-ft, whichever is greater

Top of the Leveling Pad EL = Bottom of the Wall EL - Min. Embedment (ft)

Design Height (H) (ft) = Top of the Wall EL - Top of the Leveling Pad EL

Assumptions Used for Calculations												
Design Section	**LOCATION**	**Design Height (H) (ft)**	**Backslope Ratio**	**Backslope Length (ft)**	**Traffic Load (psf)**	**MSE Wall Type**	**Foundation Material**			**Backfill Material**		
							ϕ (deg.)	**C (psf)**	**γ (pcf)**	**ϕ (deg.)**	**C (psf)**	**γ (pcf)**
1	POINT 1 TO 4	7.5	-	-	240.0	A	28	0	120	30	0	120
2	POINT 4 TO 10	14.0	-	-	240.0	A						
1	POINT 10 TO 13	6.5	-	-	240.0	A						

**MSE Wall Type in External Stability Analysis (See NCDOT Spreadsheet):

A) MSE Wall with Level Backslope

B) MSE Wall with Broken Backslope

C) MSE Wall with Infinite Backslope

D) MSE Wall with Bridge Abutment with Pile Foundation

Calculations Results							
Design Section	**Design Height (H) (ft)**	**External stability (1)(3)**			**Global Stabiltiy (2)**		**Global Stability Controls**
					Factor of Safety		
		Reinforcement Length Ratio	**Strap Length = H x Reinforcement Ratio (ft)**	**Bearing Pressure (ksf)**	**Undrained, Short Term Condition**	**Drained, Long Term Condition**	
1	7.5	0.8H	6	2.2	2.96	1.46	No
2	14.0	0.7H	10	3.9	1.65	1.36	No

Notes:

1- See external stabiltiy calculations based on NCDOT MSE Wall External Stability Spreadsheet

2-See Global Stability calculations based on SLOPE/W analyses. Global Stability was checked for both short-term condition (using undrained strength propoeties of CLAY) and long-term condition (using drained strength properties of CLAY).

3-The total settlement of the RW No. 3 is anticipated to be 1.8 - inches.

RETAINING WALL NO. 3

PROJECT REFERENCE NO.	SHEET NO.
U-4015A	13

PROFILE ALONG -L-

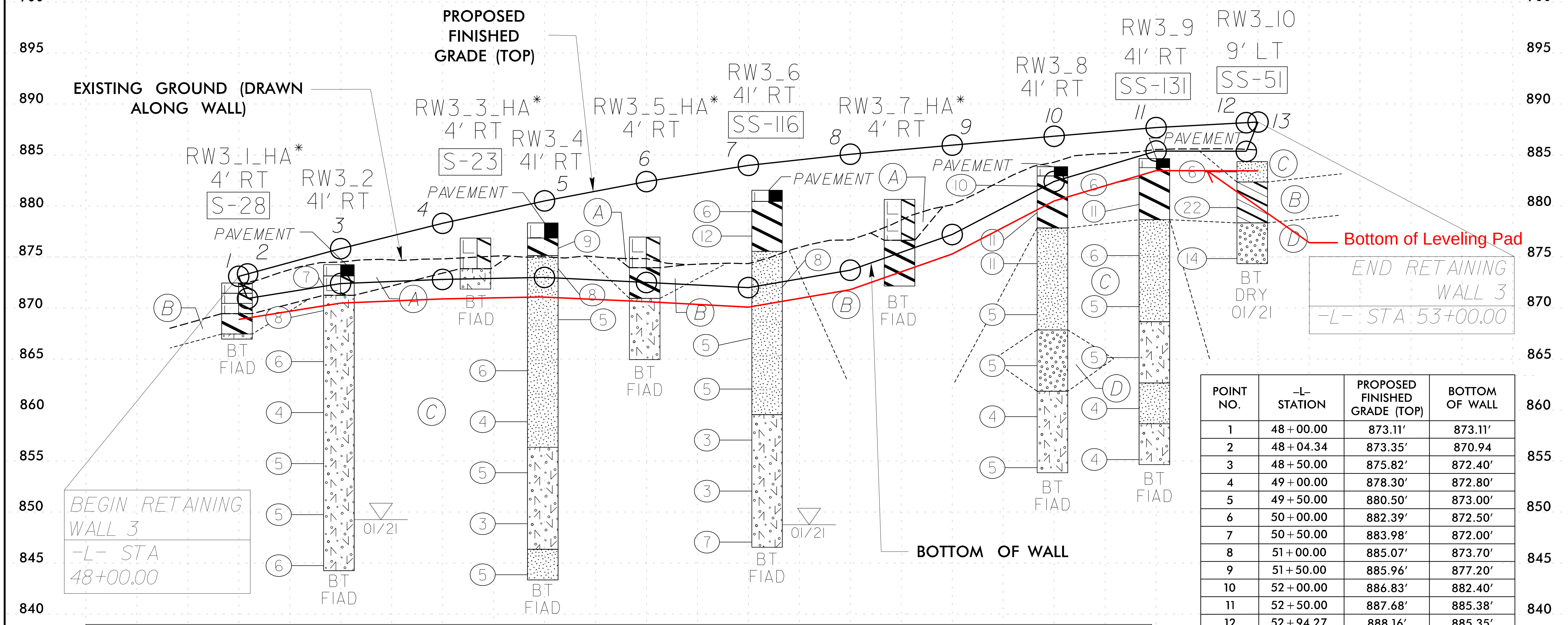
0 50 100
FEET
VE = 5

(A) *ROADWAY EMBANKMENT* Brown to brown-red-black to red-brown, medium stiff to very stiff, sandy and silty highly plastic CLAY (A-6, A-7-5, A-7-6), trace of organic matter, trace gravel, trace mica, moist

(B) *RESIDUAL* Brown to brown-black to red-orange, medium stiff to very stiff, sandy and silty highly plastic CLAY (A-6, A-7-6), trace of organic matter, trace rock fragments, trace mica, moist

(C) Tan-brown to red-orange-brown to orange-tan-black to orange-white, soft to stiff, sandy and clayey SILT (A-4, A-5), trace of organic matter, trace to little mica, saprolitic, moist to saturated

(D) Tan-brown to red-orange, loose to medium dense, clayey silty fine to coarse SAND (A-2-5), trace mica, trace rock fragments, saprolitic, moist



POINT NO.	-L- STATION	PROPOSED FINISHED GRADE (TOP)	BOTTOM OF WALL
1	48+00.00	873.11′	873.11′
2	48+04.34	873.35′	870.94
3	48+50.00	875.82′	872.40′
4	49+00.00	878.30′	872.80′
5	49+50.00	880.50′	873.00′
6	50+00.00	882.39′	872.50′
7	50+50.00	883.98′	872.00′
8	51+00.00	885.07′	873.70′
9	51+50.00	885.96′	877.20′
10	52+00.00	886.83′	882.40′
11	52+50.00	887.68′	885.38′
12	52+94.27	888.16′	885.35′
13	53+00.00	888.22′	888.22′

SOIL TEST RESULTS

SAMPLE NO.	STATION	OFFSET	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
S-28	48+00	37' LT	0.0-1.0'	A-7-5	61	30	10	19	20	51	99	93	75	30	ND
S-23	49+17	37' LT	0.0-1.0'	A-7-5	58	28	ND	ND	ND	ND	36	0	64	25	ND
SS-116	50+60	0 CL	1.1-2.6'	A-7-6	58	31	11	15	16	59	100	94	78	26	ND
SS-131	52+50	0 CL	0.9-2.4'	A-7-6	56	28	13	17	22	48	97	89	72	31	ND
SS-51	52+98	50' LT	0.0-1.5'	A-4	18	3	ND	ND	ND	ND	ND	ND	43	12	ND

-L-

47+50 48+50 49+50 50+50 51+50 52+50 53+50

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3/25/2022
skabra

RETAINING WALL NO. 3

MSE WALL EXTERNAL STABILITY SPREADSHEETS

DESIGN SECTION 1

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 3 - Design Section 1 - Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 48+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 1 OF 8

MSE Wall Type (See Figures on right)

MSE Wall with Level Backslope and Traffic Surcharg

Traffic Surcharge and Wall Geometry

q = 240 psf *live load traffic surcharge (AASHTO Tables 3.11.6.4-1 & 2)*

H = 7.50 ft *wall design height*
L/H = 0.800 *ratio of reinforcement length to wall height*
L = 6.0 ft *reinforcement length (L = H x L/H)*
(L/H ≥ 0.7 and L ≥ 6 ft per NCDOT MSE Wall Provision)
s = 1.00 ft *distance from bottom of wall to lowest reinforcement layer*
Slope = N/A : 1 (H_{slope} : V_{Slope}) *slope behind wall*
d = N/A ft *distance from back of wall face to top of backslope*
z = N/A ft *height of soil behind cap for MSE abutment wall*
w = N/A ft *distance from back of wall face to back of cap*
h = N/A ft *height of wall & slope at the back of reinforced zone*

Soil Parameters for Reinforced Zone

Type of aggregate used: ○ Coarse ● Fine

ϕ_r = 34 deg *friction angle (38 deg for coarse, 34 deg for fine)*
γ_r = 115 pcf *unit weight (110 psf for coarse, 115 psf for fine)*

Soil Parameters for Retained Backfill

ϕ_b = 30 deg *friction angle*
γ_b = 120 pcf *unit weight*

Soil Parameters for Foundation Material

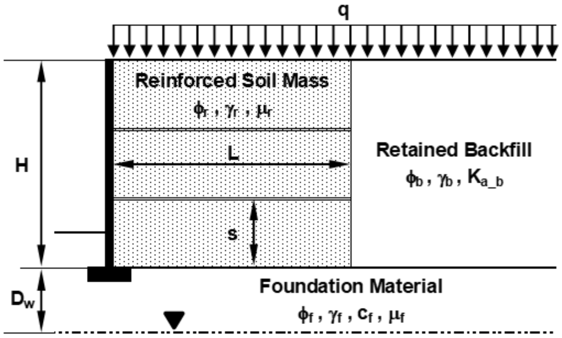
ϕ_f = 28 deg *friction angle*
γ_f = 120 pcf *unit weight*
c_f = 0 psf *undrained shear strength of the foundation material*
D_w = 23.00 ft *distance of water table below bottom of the wall*

Load Factors (AASHTO Table 3.4.1-1 and 2)

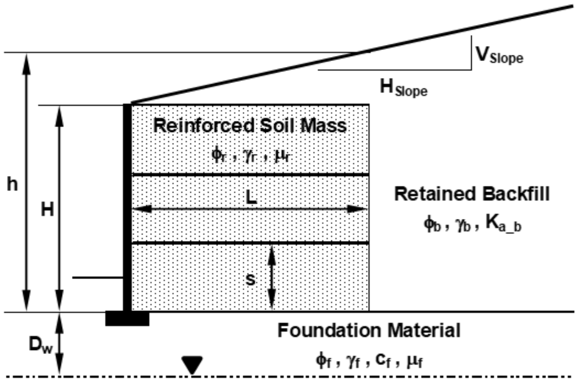
Ψ_{LS} = 1.75 *live load surcharge*
$\Psi_{EH(A)}$ = 1.50 *horizontal (active) earth pressure*
Ψ_{EV} = 1.00 min / 1.35 max *vertical dead load generated from earth fill*

Resistance Factors (AASHTO Table 11.5.7-1)

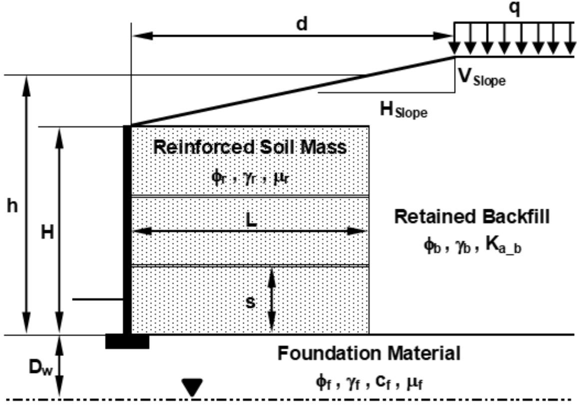
φ_b = 0.65 *bearing resistance for MSE walls*
φ_t = 1.00 *sliding resistance for MSE walls*



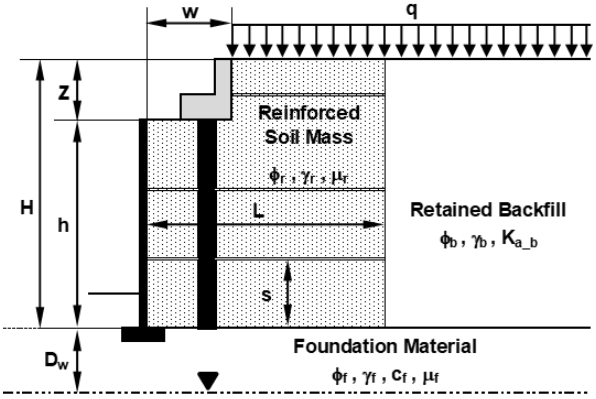
MSE Wall with Level Backslope and Traffic Surcharge



MSE Wall with Infinite Backslope



MSE Wall with Broken Backslope



MSE Wall Bridge Abutment with Pile Foundation

(MSE WALL FIGURES ARE NOT TO SCALE)

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. Thereare no expressed or implied warrantie*

NORTH CAROLINA DEPARTMENT
OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 3 - Design Section 1 - Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 48+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 2 OF 8

Summary of External Stability Analysis - MSE Wall with Level Backslope and Traffic Surcharge

Geometry of Reinforced Soil Mass

H = wall height	7.50 ft
L/H = ratio of reinforcement length to wall height (must be greater than or equal to 0.700)	0.800
L = reinforcement length (must be greater than or equal to 6 ft)	6.00 ft

Forces Acting on Wall - Vertical Direction

$V_{1(LLR)}$ = vertical force from reinforced soil mass acting at the lowest level of reinforcement	4,485 lbs
$V_{1(BW)}$ = vertical force from reinforced soil mass acting at the base of the wall	5,175 lbs
V_2 = vertical force from the retained fill above the reinforced soil mass	0 lbs
$F_{V(LLR)}$ = vertical force generated from lateral earth pressure at the lowest level of reinforcement	0 lbs
$F_{V(BW)}$ = vertical force generated from lateral earth pressure at the base of the wall	0 lbs

Forces Acting on Wall - Horizontal Direction

$F_{H(LLR)}$ = horizontal force generated from lateral earth pressure at the lowest level of reinforcement	844 lbs
$F_{H(BW)}$ = horizontal force generated from lateral earth pressure at the base of the wall	1,124 lbs
$F_{2(LLR)}$ = horizontal force generated from traffic surcharge, acting at the lowest level of reinforcement	519 lbs
$F_{2(BW)}$ = horizontal force generated from traffic surcharge, acting at the base of the wall	599 lbs

F_P = total horizontal force acting on the back of the MSE wall (wall contact pressure under service loads)	1,723 lbs

Sliding Stability - at the interface between the soil and reinforcement for the lowest reinforcement layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer	2,422 lbs
$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer	2,175 lbs
$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$	OK

Sliding Stability - at the base of the bottom of the wall facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing	2,753 lbs
$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing	2,735 lbs
$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$	OK

Overturning / Limiting Eccentricity

e = eccentricity	1.57 ft
L / 3	2.00 ft
e must be less than or equal to L / 3	OK

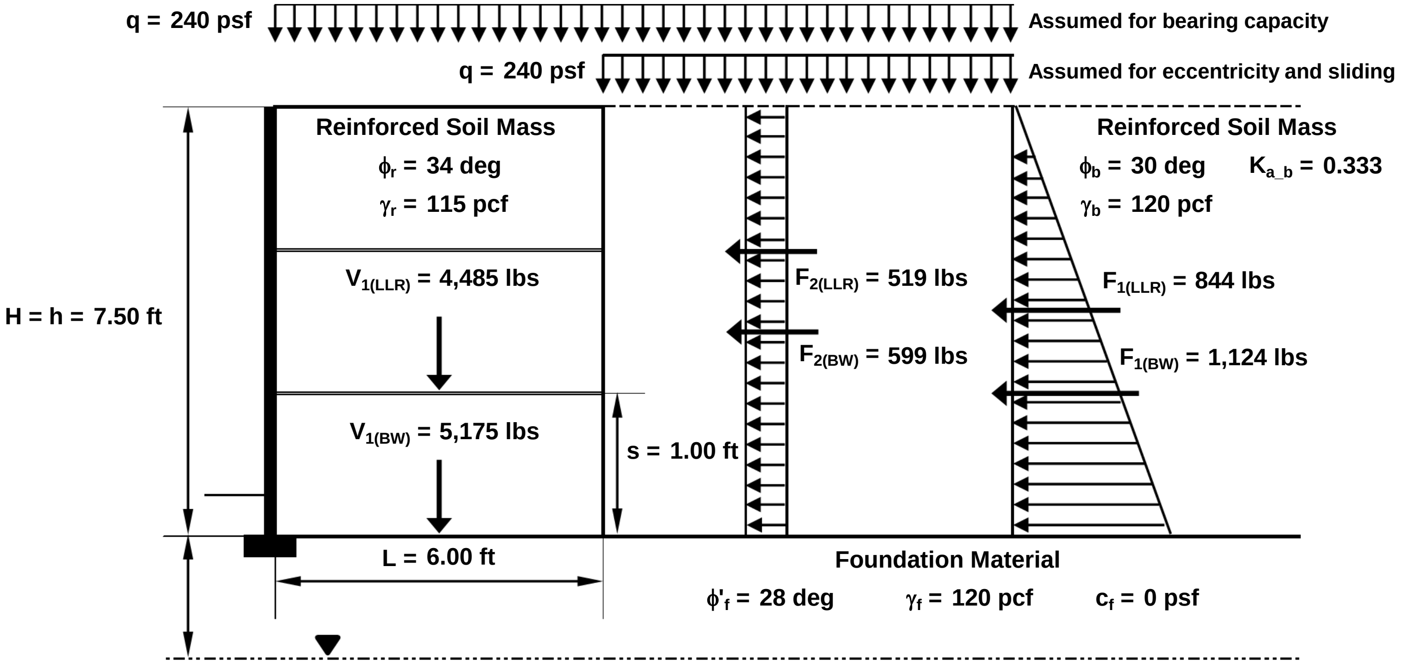
Bearing Resistance - General Shear

q_r = factored bearing resistance	2,788 lbs
$q_{uniform}$ = factored bearing pressure at the base of the wall	2,221 lbs
q_R must be greater than or equal to $q_{uniform}$	OK

Bearing Resistance - Local / Punching Shear (only applicable to soils with cohesion)

q_r = reduced factored bearing resistance	N/A
$q_{uniform}$ = factored bearing pressure at the base of the wall	N/A
q_R must be greater than or equal to $q_{uniform}$	N/A

Forces Acting on Wall



External Stability for MSE Walls: Forces acting on Wall - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO Figure 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Vertical Forces from Earth Loads

$V_{1(LLR)}$ = total vertical force from reinforced soil mass, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(\gamma_r)(H - s)(L)$

$V_{1(BW)}$ = total vertical force from reinforced soil mass, acting at the base of the bottom of the wall facing

= $(\gamma_r)(H)(L)$

γ'_r (pcf)	H (ft)	s (ft)	L (ft)	$V_{1(LLR)}$ (lbs)	$V_{1(BW)}$ (lbs)
115	7.50	1.00	6.00	4,485	5,175

Forces Generated from Lateral (Active) Earth Pressure

K_{a_b} = coefficient of active earth pressure

$$= \frac{\sin^2(\theta+\phi'_f)}{\Gamma\,[\sin^2\theta\sin(\theta-\delta)]} \quad \text{where} \quad \left[1+\sqrt{\frac{\sin(\phi'_f+\delta)\sin(\phi'_f-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}\right]^2$$

AASHTO Equations 3.11.5.3-1 and 2

$\phi_f = \phi_b$

δ = friction angle between fill and wall = β per AASHTO Article 11.10.5.2

β = inclination angle of backslope = 0 for level backslope

θ = angle of back face of wall to the horizontal = 0 degrees for vertical wall face

ϕ_b (deg)	δ (deg)	β (deg)	K_{a_b} (lbs)
120	0	0	0.333

Forces Acting on Wall - continued

Forces Generated from Lateral (Active) Earth Pressure - continued

$F_{1(LLR)}$ = total force generated from lateral earth pressure, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $0.5(\gamma_b)(H\text{-}s)^2(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5 (modified)*

$F_{1(BW)}$ = total force generated from lateral earth pressure, acting at the base of the bottom of the wall facing

= $0.5(\gamma_b)(H^2)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5*

γ'_b (psf)	H (ft)	s (ft)	K_{a_b}	$F_{1(LLR)}$ (lbs)	$F_{1(BW)}$ (lbs)
120	7.50	1.00	0.333	844	1,124

Horizontal Forces Generated from Traffic Surcharge

$F_{2(LLR)}$ = total horizontal force generated from traffic surcharge, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(q)(H\text{ -}s\text{ })(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6 (modified)*

$F_{2(BW)}$ = total horizontal force generated from traffic surcharge, acting at the base of the bottom of the wall facing

= $(q)(H)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6*

q (psf)	H (ft)	s (ft)	K_{a_b}	$F_{2(LLR)}$ (lbs)	$F_{2(BW)}$ (lbs)
240	7.50	1.00	0.333	519	599

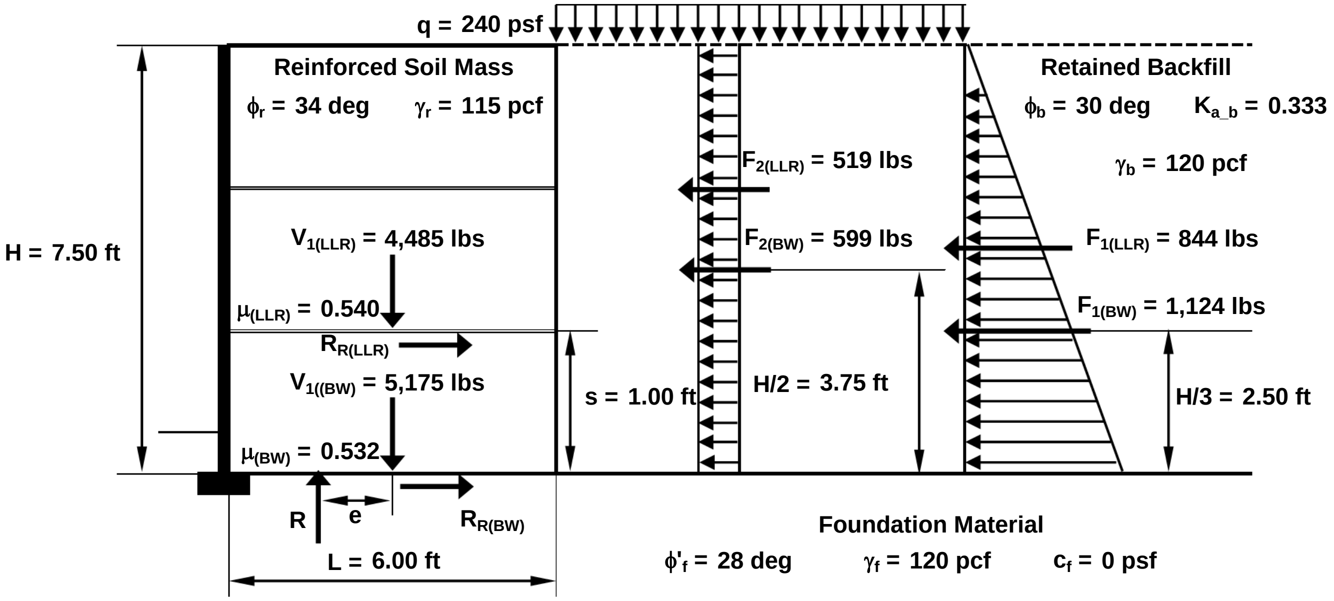
Wall Contact Pressure Under Service Loads

The wall contact pressure under service loads is equal to the total horizontal force acting on the back of the wall

Wall Contact Pressure, $F_P = F_{1(BW)} + F_{2(BW)}$

$F_{1(BW)}$ (lbs)	$F_{2(BW)}$ (lbs)	F_P (lbs)
1,124	599	1,723

Sliding Stability and Eccentricity (Overturning)



External Stability for MSE Walls: Sliding Stability and Eccentricity - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer
= $\varphi R_N = \varphi_\tau R_{\tau(LLR)}$ *AASHTO Eqn. 10.6.3.4-1*

$R_{t(LLR)}$ = nominal sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer
= $\Psi_{EV}(V_{1(LLR)})\mu_{(LLR)}$ *FHWA GEC 011 Eqn. 4-12*

$\mu_{(LLR)}$ = coefficient of friction at interface between the soil and reinforcement for the lowest reinforcement layer *AASHTO 11.10.5.3*

Because the type of reinforcement, continous (e.g., grids) or discontinous (e.g, strips), is not determined at the time of the analysis, the coefficent of friction is taken as the lesser of ϕ_r and ρ, where ρ is the soil-reinforcement interface friciton angle. The value of ρ is taken as the lowest value for all NCDOT approved MSE wall geogrids based on the use of either fine or coarse aggregate in the reinforced zone.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(LLR)}$ (lbs)	ϕ_r (deg)	ρ (deg)	$\mu_{(LLR)}$	$R_{\tau(LLR)}$ (lbs)	$R_{R(LLR)}$ (lbs)
1.00	1.00	4,485	34.00	28.35	0.540	2,422	2,422

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer
= $(\Psi_{EHA})(F_{1(LLR)}) + (\Psi_{LS})(F_{2(LLR)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(LLR)}$ (lbs)	Ψ_{LS}	$F_{2(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)
1.50	519	1.75	844	2,175

Sliding Stability and Eccentricity (Overturning) - continued

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer - continued

$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$

$R_{R(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)	$R_{R(LLR)} \geq P_{d(LLR)}$
2,422	2,175	**OK**

Sliding Resistance at the Base of the Bottom of the Wall Facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing *AASHTO Eqn. 10.6.3.4-1*

$= \varphi R_N = \varphi_\tau R_{\tau(BW)}$

$R_{t(BW)}$ = nominal sliding resistance at the base of the bottom of the wall facing

$= \Psi_{EV}(V_{1(BW)})\mu_{(BW)} + (c_f)(L)$ *FHWA GEC 011 Eqn. 4-12 and AASHTO 10.6.3.4*

$\mu_{(BW)}$ = coefficient of friction at the base of the bottom of the wall facing *AASHTO 11.10.5.3*

If the lowest reinforcement layer is above the bottom of the wall facing, to check sliding at the base of the wall, the friction angle of the foundation soil, ϕ_f, or reinforced fill soil, ϕ_r, whichever is less, shall be used to assess sliding resistance.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	ϕ_r (deg)	$\mu_{(BW)}$	c_f (psf)	L (ft)	$R_{\tau(BW)}$ (lbs)	$R_{R(BW)}$ (lbs)
1.00	1.00	5,175	34.00	0.532	0	6.00	2,753	2,753

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing

$= (\Psi_{EHA})(F_{1(BW)}) + (\Psi_{LS})(F_{2(BW)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)
1.50	599	1.75	1,124	2,735

$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$

$R_{R(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)	$R_{R(BW)} \geq P_{d(BW)}$
2,753	2,735	**OK**

Eccentricity (Overturning)

$$e = \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)}} \text{ must be} \leq L/3$$

FHWA GEC 011 Eqn. 4-15 and AASHTO 10.6.3.3

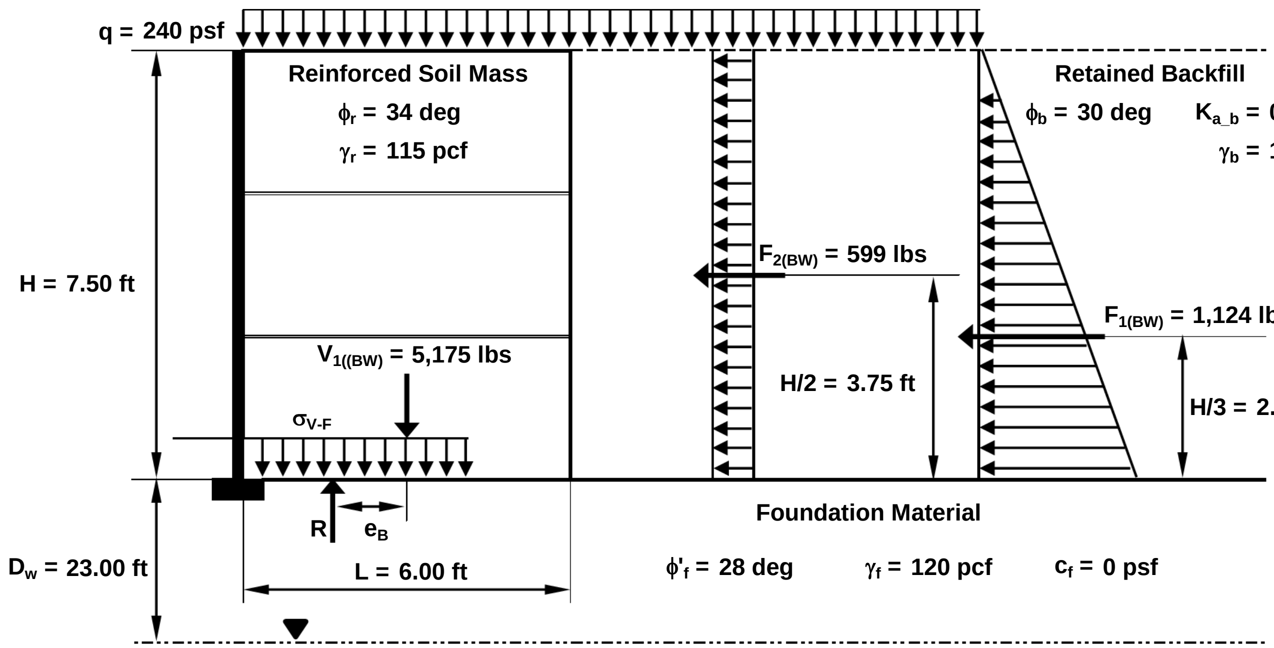
Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e (ft)	L/3 (ft)	e ≤ L/3
1.50	1,124	2.50	1.75	599	3.75	1.00	5,175	1.57	2.00	**OK**

***Note - Use minimum value of Ψ_{EV} for eccentricity per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 3 - Design Section 1 - Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 48+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 7 OF 8

Bearing Resistance



External Stability for MSE Walls: Bearing Resistance - Level Backslope with Surcharge Case
(Based on FHWA Figure 4-7, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Bearing Resistance for General Shear Failure

e_B = eccentricity for bearing

$$= \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}$$ *FHWA GEC 011 Eqn. 4-19*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e_B (ft)
1.50	1,124	2.50	1.75	1,124	3.75	1.00	5,175	0.86

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

q_r = factored bearing resistance

$= \varphi_b q_n$ *AASHTO Eqn. 10.6.3.1.1-1*

q_n = nominal bearing resistance

$= c_f N_c + 0.5\gamma_f B' N_\gamma C_{w\gamma}$ *AASHTO Eqn. 10.6.3.1.2a-1*

N_c = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*

N_γ = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*

B' = effective foundation width = L - $2e_B$ *AASHTO C11.10.5.4*

$C_{w\gamma}$ = correction factor to account for location of groundwater table *AASHTO Table 10.6.3.1.2a-2*

All other variables have previously been defined

φ_b	c_f (psf)	N_c	γ_f (psf)	N_γ	B' (ft)	$C_{w\gamma}$	q_n (psf)	q_r (psf)
0.65	0	25.80	120	16.70	4.28	1.00	4,289	2,788

Bearing Resistance - continued

Bearing Resistance for General Shear Failure - continued

$q_{uniform} = \sigma_{V\text{-}F}$ = factored bearing pressure at the base of the wall

$$= \frac{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}{L - 2e_B}$$

FHWA GEC 011 Eqn. 4-20

Ψ_{EV}*	$V_{1(BW)}$ (lbs)	Ψ_{LS}	q (psf)	L (ft)	e_B (ft)	$q_{uniform}$ (psf)
1.35	5,175	1.75	240	6.00	0.86	2,221

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.c, AASHTO C3.4.1, and AASHTO C11.5.5**

q_R must be greater than or equal to $q_{uniform}$

FHWA GEC 011 Eqn. 4-17

q_r (psf)	$q_{uniform}$ (psf)	$q_r \geq q_{uniform}$
2,788	2,221	**OK**

Bearing Resistance for Local Shear Failure

Local and Punching shear failure occurs in loose or compressible soils and in weak soils under slow (drained) loading. This mode of failure will only be considered for foundation material that is cohesive.

To prevent Local/Punching Shear on weak cohesive soils, $(\gamma_r)(H) \leq 3c_f$

FHWA GEC 011 Eqn. 4-24

The foundation material for this project is not cohesive

DESIGN SECTION 2

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 3 - Design Section 2 - Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 48+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 1 OF 8

MSE Wall Type (See Figures on right)

MSE Wall with Level Backslope and Traffic Surcharg

Traffic Surcharge and Wall Geometry

$q =$	240	psf	*live load traffic surcharge (AASHTO Tables 3.11.6.4-1 & 2)*
$H =$	14.00	ft	*wall design height*
$L/H =$	0.700		*ratio of reinforcement length to wall height*
$L =$	9.8	ft	*reinforcement length (L = H x L/H)*
			(L/H ≥ 0.7 and L ≥ 6 ft per NCDOT MSE Wall Provision)
$s =$	1.00	ft	*distance from bottom of wall to lowest reinforcement layer*
Slope =	N/A	: 1 (H_{slope} : V_{Slope})	*slope behind wall*
$d =$	N/A	ft	*distance from back of wall face to top of backslope*
$z =$	N/A	ft	*height of soil behind cap for MSE abutment wall*
$w =$	N/A	ft	*distance from back of wall face to back of cap*
$h =$	N/A	ft	*height of wall & slope at the back of reinforced zone*

Soil Parameters for Reinforced Zone

Type of aggregate used: ○ Coarse ● Fine

$\phi_r =$	34	deg	*friction angle (38 deg for coarse, 34 deg for fine)*
$\gamma_r =$	115	pcf	*unit weight (110 psf for coarse, 115 psf for fine)*

Soil Parameters for Retained Backfill

$\phi_b =$	30	deg	*friction angle*
$\gamma_b =$	120	pcf	*unit weight*

Soil Parameters for Foundation Material

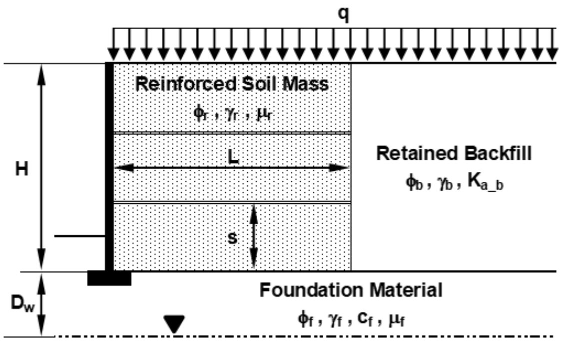
$\phi_f =$	28	deg	*friction angle*
$\gamma_f =$	120	pcf	*unit weight*
$c_f =$	0	psf	*undrained shear strength of the foundation material*
$D_w =$	23.00	ft	*distance of water table below bottom of the wall*

Load Factors (AASHTO Table 3.4.1-1 and 2)

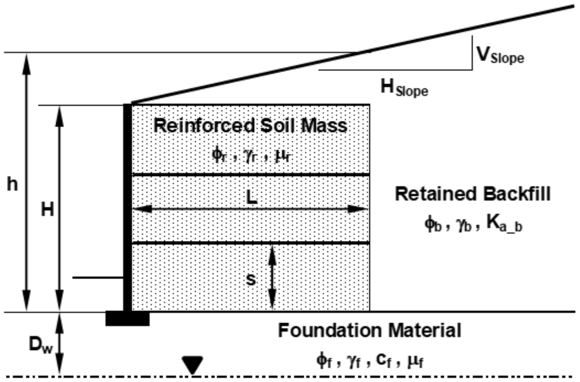
$\Psi_{LS} =$	1.75		*live load surcharge*
$\Psi_{EH(A)} =$	1.50		*horizontal (active) earth pressure*
$\Psi_{EV} =$	1.00	min	*vertical dead load generated from earth fill*
	1.35	max	

Resistance Factors (AASHTO Table 11.5.7-1)

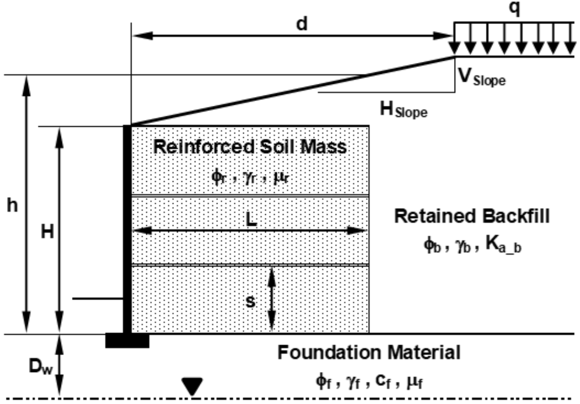
$\varphi_b =$	0.65		*bearing resistance for MSE walls*
$\varphi_t =$	1.00		*sliding resistance for MSE walls*



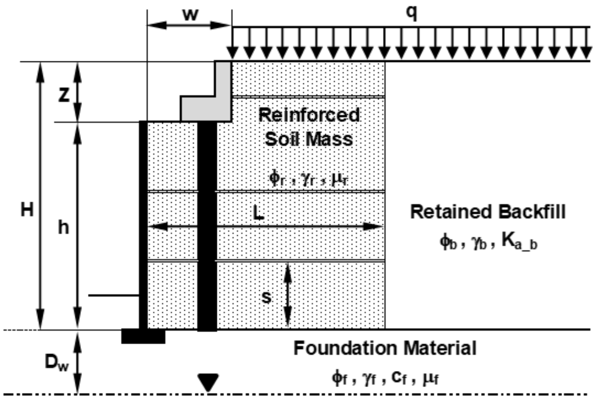
MSE Wall with Level Backslope and Traffic Surcharge



MSE Wall with Infinite Backslope



MSE Wall with Broken Backslope



MSE Wall Bridge Abutment with Pile Foundation

(MSE WALL FIGURES ARE NOT TO SCALE)

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 3 - Design Section 2 - Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 48+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 2 OF 8

Summary of External Stability Analysis - MSE Wall with Level Backslope and Traffic Surcharge

Geometry of Reinforced Soil Mass

H = wall height	14.00 ft
L/H = ratio of reinforcement length to wall height (must be greater than or equal to 0.700)	0.700
L = reinforcement length (must be greater than or equal to 6 ft)	9.80 ft

Forces Acting on Wall - Vertical Direction

$V_{1(LLR)}$ = vertical force from reinforced soil mass acting at the lowest level of reinforcement	14,651 lbs
$V_{1(BW)}$ = vertical force from reinforced soil mass acting at the base of the wall	15,778 lbs
V_2 = vertical force from the retained fill above the reinforced soil mass	0 lbs
$F_{V(LLR)}$ = vertical force generated from lateral earth pressure at the lowest level of reinforcement	0 lbs
$F_{V(BW)}$ = vertical force generated from lateral earth pressure at the base of the wall	0 lbs

Forces Acting on Wall - Horizontal Direction

$F_{H(LLR)}$ = horizontal force generated from lateral earth pressure at the lowest level of reinforcement	3,377 lbs
$F_{H(BW)}$ = horizontal force generated from lateral earth pressure at the base of the wall	3,916 lbs
$F_{2(LLR)}$ = horizontal force generated from traffic surcharge, acting at the lowest level of reinforcement	1,039 lbs
$F_{2(BW)}$ = horizontal force generated from traffic surcharge, acting at the base of the wall	1,119 lbs

F_P = total horizontal force acting on the back of the MSE wall (wall contact pressure under service loads)	5,035 lbs

Sliding Stability - at the interface between the soil and reinforcement for the lowest reinforcement layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer	7,912 lbs
$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer	6,884 lbs
$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$	OK

Sliding Stability - at the base of the bottom of the wall facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing	8,394 lbs
$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing	7,832 lbs
$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$	OK

Overturning / Limiting Eccentricity

e = eccentricity	2.61 ft
L / 3	3.27 ft
e must be less than or equal to L / 3	OK

Bearing Resistance - General Shear

q_r = factored bearing resistance	4,272 lbs
$q_{uniform}$ = factored bearing pressure at the base of the wall	3,874 lbs
q_R must be greater than or equal to $q_{uniform}$	OK

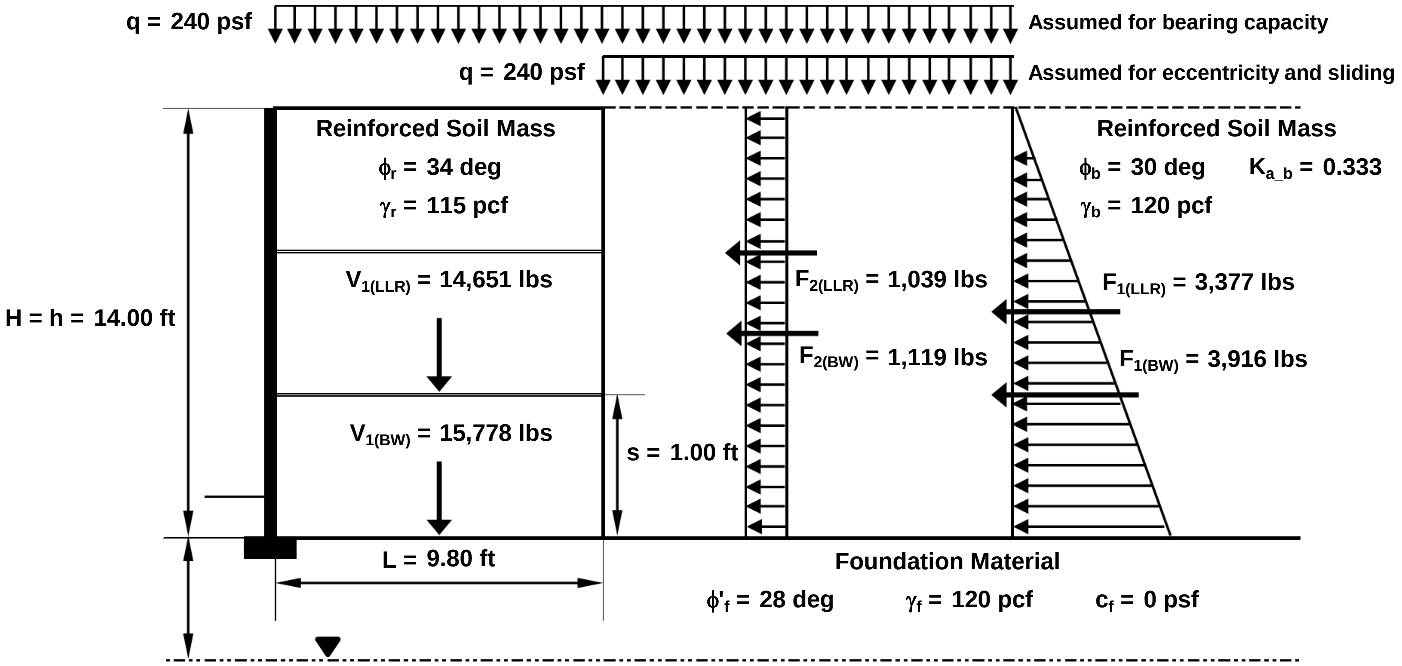
Bearing Resistance - Local / Punching Shear (only applicable to soils with cohesion)

q_r = reduced factored bearing resistance	N/A
$q_{uniform}$ = factored bearing pressure at the base of the wall	N/A
q_R must be greater than or equal to $q_{uniform}$	N/A

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
MSE Wall External Stability Spreadsheet

PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: RW 3 - Design Section 2 - Drained Analysis
DESIGNED BY: SK DATE: 07/14/21 STATION: 48+00 -L-
CHECKED BY: MM DATE: 07/21/21 STR. NO.: 1 PAGE: 3 OF 8

Forces Acting on Wall



External Stability for MSE Walls: Forces acting on Wall - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO Figure 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Vertical Forces from Earth Loads

$V_{1(LLR)}$ = total vertical force from reinforced soil mass, acting at the interface between the soil and reinforcement for the lowest reinforcement layer
= $(\gamma_r)(H - s)(L)$

$V_{1(BW)}$ = total vertical force from reinforced soil mass, acting at the base of the bottom of the wall facing
= $(\gamma_r)(H)(L)$

γ'_r (pcf)	H (ft)	s (ft)	L (ft)	$V_{1(LLR)}$ (lbs)	$V_{1(BW)}$ (lbs)
115	14.00	1.00	9.80	14,651	15,778

Forces Generated from Lateral (Active) Earth Pressure

K_{a_b} = coefficient of active earth pressure

$$= \frac{\sin^2(\theta+\phi'_f)}{\Gamma\,[\sin^2\theta\,\sin(\theta-\delta)]} \quad \text{where} \quad \left[1+\sqrt{\frac{\sin(\phi'_f+\delta)\sin(\phi'_f-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}\right]^2$$

AASHTO Equations 3.11.5.3-1 and 2

$\phi_f = \phi_b$
δ = friction angle between fill and wall = β per AASHTO Article 11.10.5.2
β = inclination angle of backslope = 0 for level backslope
θ = angle of back face of wall to the horizontal = 0 degrees for vertical wall face

ϕ_b (deg)	δ (deg)	β (deg)	K_{a_b} (lbs)
120	0	0	0.333

Forces Acting on Wall - continued

Forces Generated from Lateral (Active) Earth Pressure - continued

$F_{1(LLR)}$ = total force generated from lateral earth pressure, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $0.5(\gamma_b)(H\text{-}s)^2(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5 (modified)*

$F_{1(BW)}$ = total force generated from lateral earth pressure, acting at the base of the bottom of the wall facing

= $0.5(\gamma_b)(H^2)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-5*

γ'_b (psf)	H (ft)	s (ft)	K_{a_b}	$F_{1(LLR)}$ (lbs)	$F_{1(BW)}$ (lbs)
120	14.00	1.00	0.333	3,377	3,916

Horizontal Forces Generated from Traffic Surcharge

$F_{2(LLR)}$ = total horizontal force generated from traffic surcharge, acting at the interface between the soil and reinforcement for the lowest reinforcement layer

= $(q)(H\ \text{-}s\ )(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6 (modified)*

$F_{2(BW)}$ = total horizontal force generated from traffic surcharge, acting at the base of the bottom of the wall facing

= $(q)(H)(K_{a\_b})$ *FHWA GEC 011 Eqn. 4-6*

q (psf)	H (ft)	s (ft)	K_{a_b}	$F_{2(LLR)}$ (lbs)	$F_{2(BW)}$ (lbs)
240	14.00	1.00	0.333	1,039	1,119

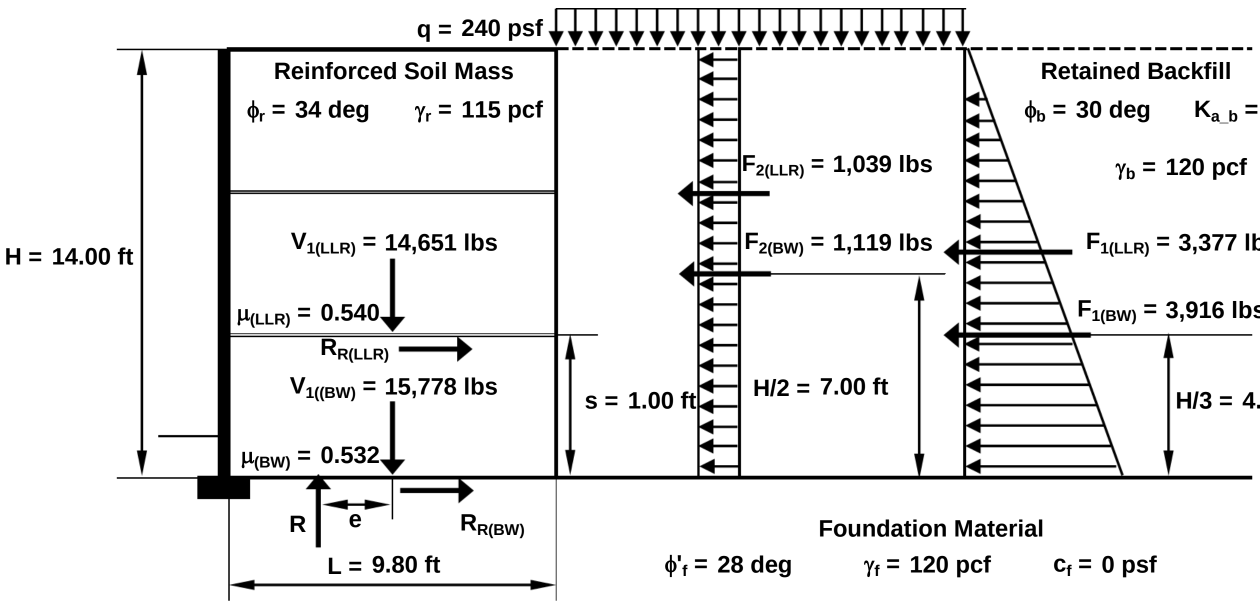
Wall Contact Pressure Under Service Loads

The wall contact pressure under service loads is equal to the total horizontal force acting on the back of the wall

Wall Contact Pressure, $F_P = F_{1(BW)} + F_{2(BW)}$

$F_{1(BW)}$ (lbs)	$F_{2(BW)}$ (lbs)	F_P (lbs)
3,916	1,119	5,035

Sliding Stability and Eccentricity (Overturning)



External Stability for MSE Walls: Sliding Stability and Eccentricity - Level Backslope with Surcharge Case
(Based on FHWA GEC 011 Figure 4-2, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer

$R_{R(LLR)}$ = sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer
$= \varphi R_N = \varphi_\tau R_{\tau(LLR)}$ *AASHTO Eqn. 10.6.3.4-1*

$R_{t(LLR)}$ = nominal sliding resistance at the interface between the soil and reinforcement for the lowest reinforcement layer
$= \Psi_{EV}(V_{1(LLR)})\mu_{(LLR)}$ *FHWA GEC 011 Eqn. 4-12*

$\mu_{(LLR)}$ = coefficient of friction at interface between the soil and reinforcement for the lowest reinforcement layer *AASHTO 11.10.5.3*

Because the type of reinforcement, continous (e.g., grids) or discontinous (e.g, strips), is not determined at the time of the analysis, the coefficent of friction is taken as the lesser of ϕ_r and ρ, where ρ is the soil-reinforcement interface friciton angle. The value of ρ is taken as the lowest value for all NCDOT approved MSE wall geogrids based on the use of either fine or coarse aggregate in the reinforced zone.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(LLR)}$ (lbs)	ϕ_r (deg)	ρ (deg)	$\mu_{(LLR)}$	$R_{\tau(LLR)}$ (lbs)	$R_{R(LLR)}$ (lbs)
1.00	1.00	14,651	34.00	28.35	0.540	7,912	7,912

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(LLR)}$ = horizontal driving force at the interface between the soil and reinforcement for the lowest reinforcement layer
$= (\Psi_{EHA})(F_{1(LLR)}) + (\Psi_{LS})(F_{2(LLR)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(LLR)}$ (lbs)	Ψ_{LS}	$F_{2(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)
1.50	1,039	1.75	3,377	6,884

Sliding Stability and Eccentricity (Overturning) - continued

Sliding Stability at the Interface between the Soil and Reinforcement for the Lowest Reinforcement Layer - continued

$R_{R(LLR)}$ must be greater than or equal to $P_{d(LLR)}$

$R_{R(LLR)}$ (lbs)	$P_{d(LLR)}$ (lbs)	$R_{R(LLR)} \geq P_{d(LLR)}$
7,912	6,884	**OK**

Sliding Resistance at the Base of the Bottom of the Wall Facing

$R_{R(BW)}$ = sliding resistance at the base of the bottom of the wall facing *AASHTO Eqn. 10.6.3.4-1*

$= \varphi R_N = \varphi_\tau R_{\tau(BW)}$

$R_{t(BW)}$ = nominal sliding resistance at the base of the bottom of the wall facing

$= \Psi_{EV}(V_{1(BW)})\mu_{(BW)} + (c_f)(L)$ *FHWA GEC 011 Eqn. 4-12 and AASHTO 10.6.3.4*

$\mu_{(BW)}$ = coefficient of friction at the base of the bottom of the wall facing *AASHTO 11.10.5.3*

If the lowest reinforcement layer is above the bottom of the wall facing, to check sliding at the base of the wall, the friction angle of the foundation soil, ϕ_f, or reinforced fill soil, ϕ_r, whichever is less, shall be used to assess sliding resistance.

All other variables have previously been defined

φ_t	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	ϕ_r (deg)	$\mu_{(BW)}$	c_f (psf)	L (ft)	$R_{\tau(BW)}$ (lbs)	$R_{R(BW)}$ (lbs)
1.00	1.00	15,778	34.00	0.532	0	9.80	8,394	8,394

***Note - Use minimum value of Ψ_{EV} for sliding resistance per FHWA GEC 011 4.4.6.a, AASHTO C3.4.1, and AASHTO C11.5.5**

$P_{d(BW)}$ = horizontal driving force at the base of the bottom of the wall facing

$= (\Psi_{EHA})(F_{1(BW)}) + (\Psi_{LS})(F_{2(BW)})$ *FHWA GEC 011 Eqn. 4-9*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)
1.50	1,119	1.75	3,916	7,832

$R_{R(BW)}$ must be greater than or equal to $P_{d(BW)}$

$R_{R(BW)}$ (lbs)	$P_{d(BW)}$ (lbs)	$R_{R(BW)} \geq P_{d(BW)}$
8,394	7,832	**OK**

Eccentricity (Overturning)

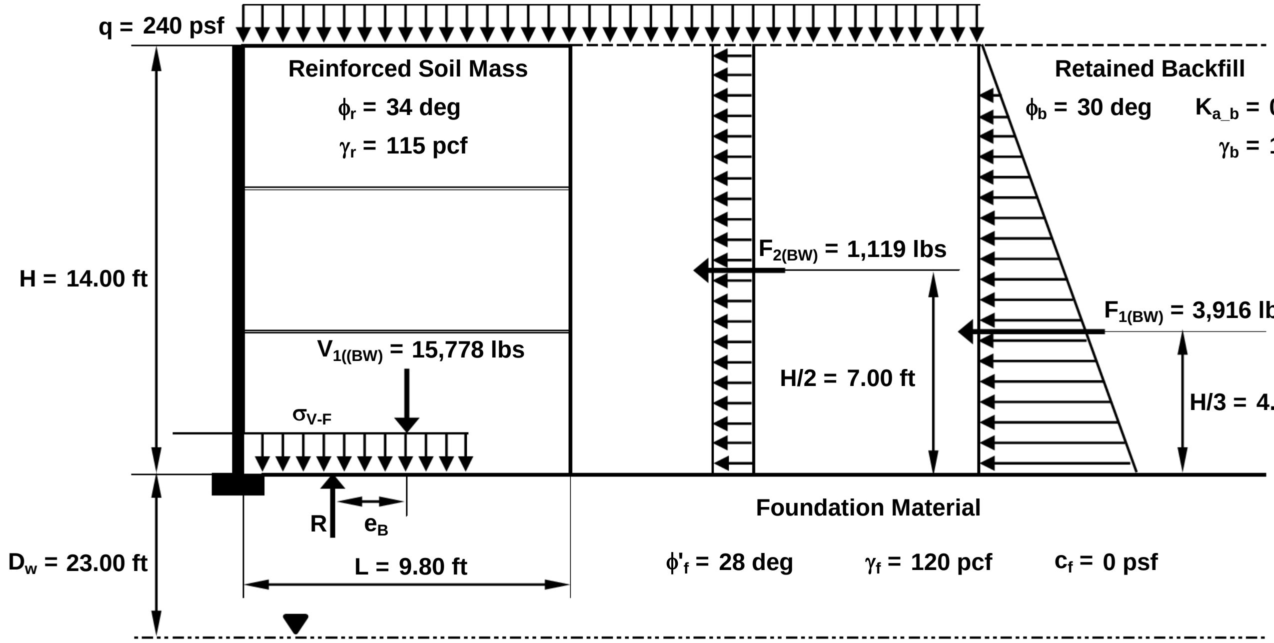
$$e = \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)}} \text{ must be } \leq L/3$$

FHWA GEC 011 Eqn. 4-15 and AASHTO 10.6.3.3

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e (ft)	L/3 (ft)	$e \leq L/3$
1.50	3,916	4.67	1.75	1,119	7.00	1.00	15,778	2.61	3.27	**OK**

***Note - Use minimum value of Ψ_{EV} for eccentricity per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

Bearing Resistance



External Stability for MSE Walls: Bearing Resistance - Level Backslope with Surcharge Case
(Based on FHWA Figure 4-7, AASHTO 3.11.5.8.1-1, and AASHTO Figure 11.10.5.2-1)
All Forces Are Calculated per Unit Length of Wall (Figure Not Drawn to Scale)

Bearing Resistance for General Shear Failure

e_B = eccentricity for bearing

$$= \frac{\Psi_{EHA}F_{1(BW)}(H/3) + \Psi_{LS}F_{2(BW)}(H/2)}{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}$$ *FHWA GEC 011 Eqn. 4-19*

Ψ_{EHA}	$F_{1(BW)}$ (lbs)	H/3 (ft)	Ψ_{LS}	$F_{2(BW)}$ (lbs)	H/2 (ft)	Ψ_{EV}*	$V_{1(BW)}$ (lbs)	e_B (ft)
1.50	3,916	4.67	1.75	3,916	7.00	1.00	15,778	1.62

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.b, AASHTO C3.4.1, and AASHTO C11.5.5**

q_r = factored bearing resistance

$= \varphi_b q_n$ *AASHTO Eqn. 10.6.3.1.1-1*

q_n = nominal bearing resistance

$= c_f N_c + 0.5\gamma_f B' N_\gamma C_{w\gamma}$ *AASHTO Eqn. 10.6.3.1.2a-1*

N_c = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*
N_γ = bearing capacity factor (based on ϕ_f) *AASHTO Table 10.6.3.1.2a-1*
B' = effective foundation width = L - $2e_B$ *AASHTO C11.10.5.4*
$C_{w\gamma}$ = correction factor to account for location of groundwater table *AASHTO Table 10.6.3.1.2a-2*

All other variables have previously been defined

φ_b	c_f (psf)	N_c	γ_f (psf)	N_γ	B' (ft)	$C_{w\gamma}$	q_n (psf)	q_r (psf)
0.65	0	25.80	120	16.70	6.56	1.00	6,573	4,272

Bearing Resistance - continued

Bearing Resistance for General Shear Failure - continued

$q_{uniform}$ = $\sigma_{V\text{-}F}$ = factored bearing pressure at the base of the wall

$$= \frac{\Psi_{EV}V_{1(BW)} + \Psi_{LS}qL}{L - 2e_B}$$

FHWA GEC 011 Eqn. 4-20

Ψ_{EV}*	$V_{1(BW)}$ (lbs)	Ψ_{LS}	q (psf)	L (ft)	e_B (ft)	$q_{uniform}$ (psf)
1.35	15,778	1.75	240	9.80	1.62	3,874

***Note - Use the maximum value of Ψ_{EV} per FHWA GEC 011 4.4.6.c, AASHTO C3.4.1, and AASHTO C11.5.5**

q_R must be greater than or equal to $q_{uniform}$

FHWA GEC 011 Eqn. 4-17

q_r (psf)	$q_{uniform}$ (psf)	$q_r \geq q_{uniform}$
4,272	3,874	**OK**

Bearing Resistance for Local Shear Failure

Local and Punching shear failure occurs in loose or compressible soils and in weak soils under slow (drained) loading. This mode of failure will only be considered for foundation material that is cohesive.

To prevent Local/Punching Shear on weak cohesive soils, $(\gamma_r)(H) \leq 3c_f$

FHWA GEC 011 Eqn. 4-24

The foundation material for this project is not cohesive

RETAINING WALL NO. 3

GLOBAL SLOPE STABILITY – SLOPE/W RESULTS

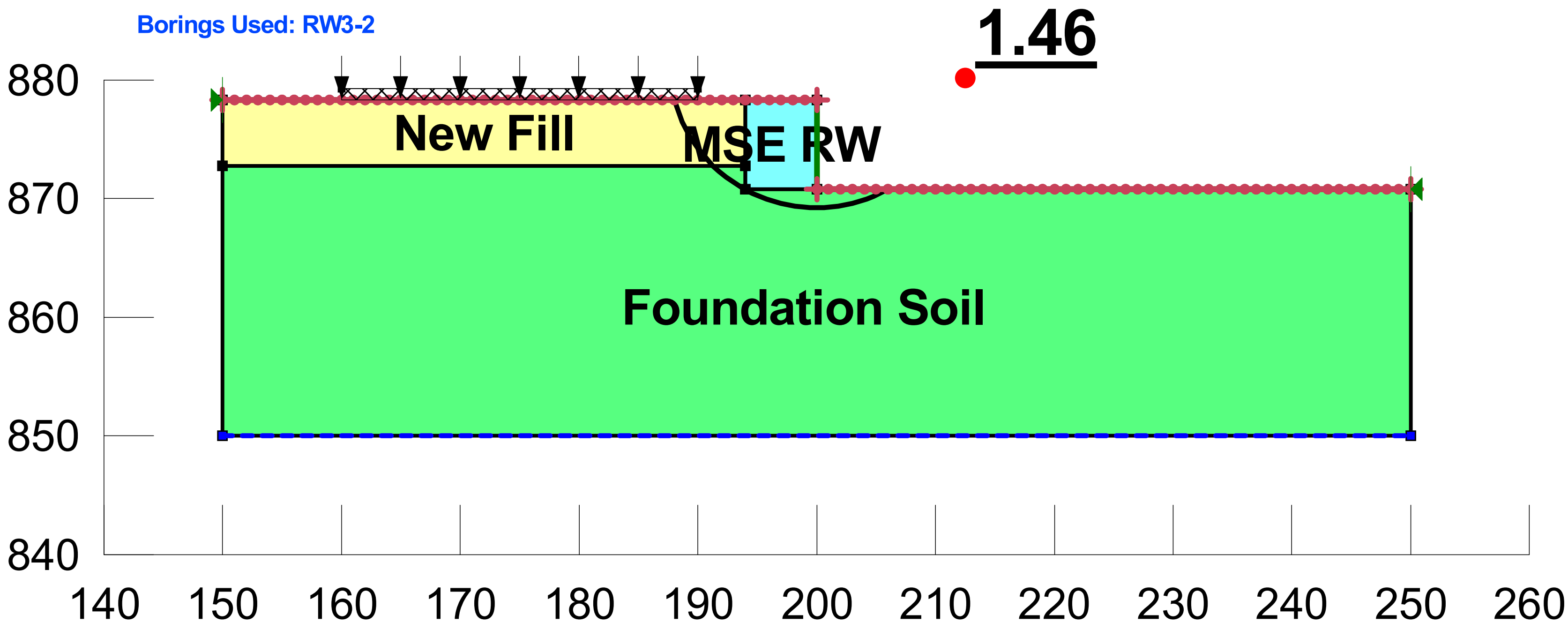
Project Name: U-4015A Gallimore Dairy

Analysis: RW3_Section1_Global Stability Analysis_Circular Failure_Drained

H = 7.5 ft
Reinforcement Length (L) = 6 ft
L/H = 0.8

Borings Used: RW3-2

Color	Name	Model	Unit Weight	Cohesion'	Phi'	Piezometric Line
🟩	Foundation Soil	Mohr-Coulomb	120	0	28	1
🟦	MSE RW	High Strength	120			1
🟨	New Fill	Mohr-Coulomb	120	0	30	1



RK&K

Project Name: U-4015A Gallimore Dairy

Task Title: RW3_Section1_Global Stability Analysis_Circular Failure_Drained

Design by: S Kabra

Date: 03/28/2022

Job No. U-4015A

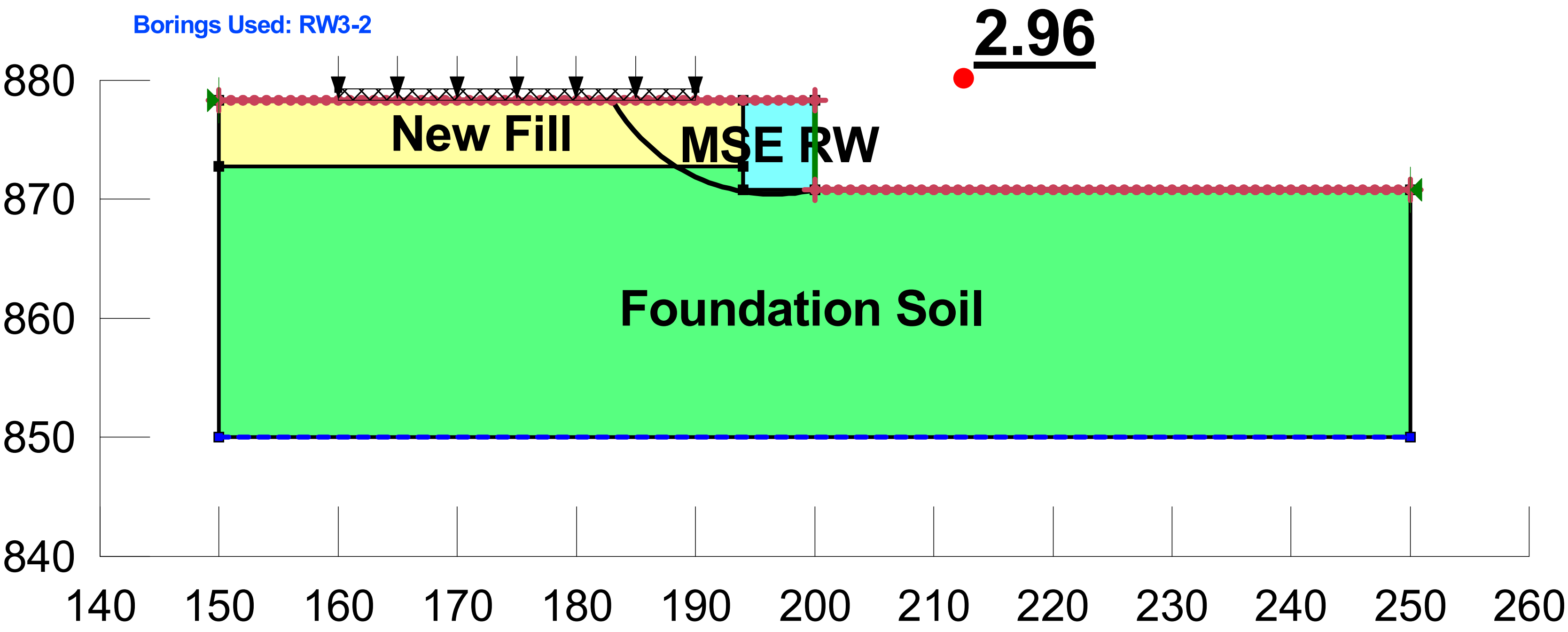
Project Name: U-4015A Gallimore Dairy

Analysis: RW3_Section1_Global Stability Analysis_Circular Failure_Undrained

H = 7.5 ft
Reinforcement Length (L) = 6 ft
L/H = 0.8

Borings Used: RW3-2

Color	Name	Model	Unit Weight	Phi'	Cohesion
🟩	Foundation Soil	Undrained (Phi=0)	120		800
🟦	MSE RW	High Strength	120		
🟨	New Fill	Mohr-Coulomb	120	30	



Project Name:	U-4015A Gallimore Dairy
Task Title:	RW3_Section1_Global Stability Analysis_Circular Failure_Undrained

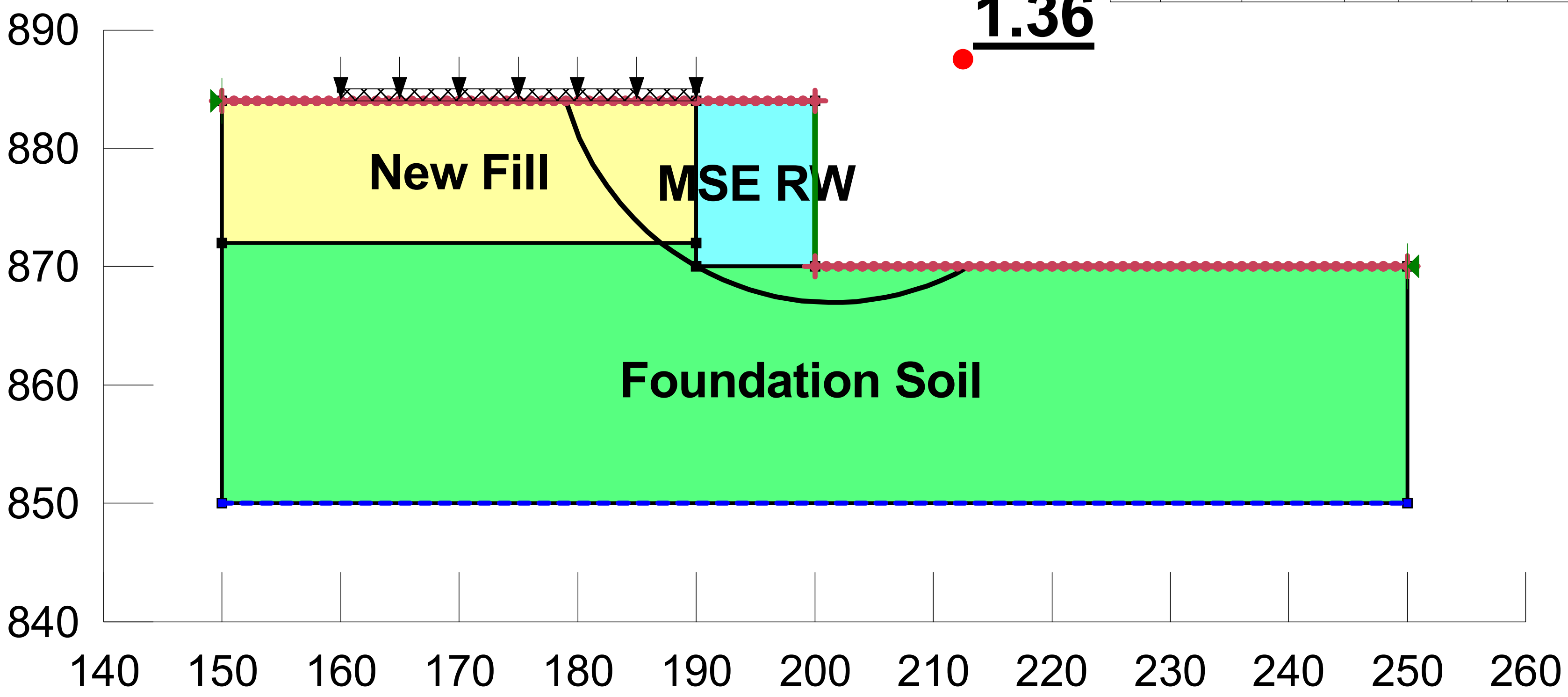
Design by: S Kabra **Date:** 03/28/2022 **Job No.** U-4015A

Project Name: U-4015A Gallimore Dairy
Analysis: RW3_Section2_Global Stability Analysis_Circular Failure- Drained

H = 14.0 ft
Reinforcement Length (L) = 10 ft
L/H = 0.7

Borings Used: RW3-6

Color	Name	Model	Unit Weight	Cohesion'	Phi'	Piezometric Line
🟩	Foundation Soil	Mohr-Coulomb	120	0	28	1
🟦	MSE RW	High Strength	120			1
🟨	New Fill	Mohr-Coulomb	120	0	30	1



Project Name: U-4015A Gallimore Dairy	
Task Title: RW3_Section2_Global Stability Analysis_Circular Failure- Drained	

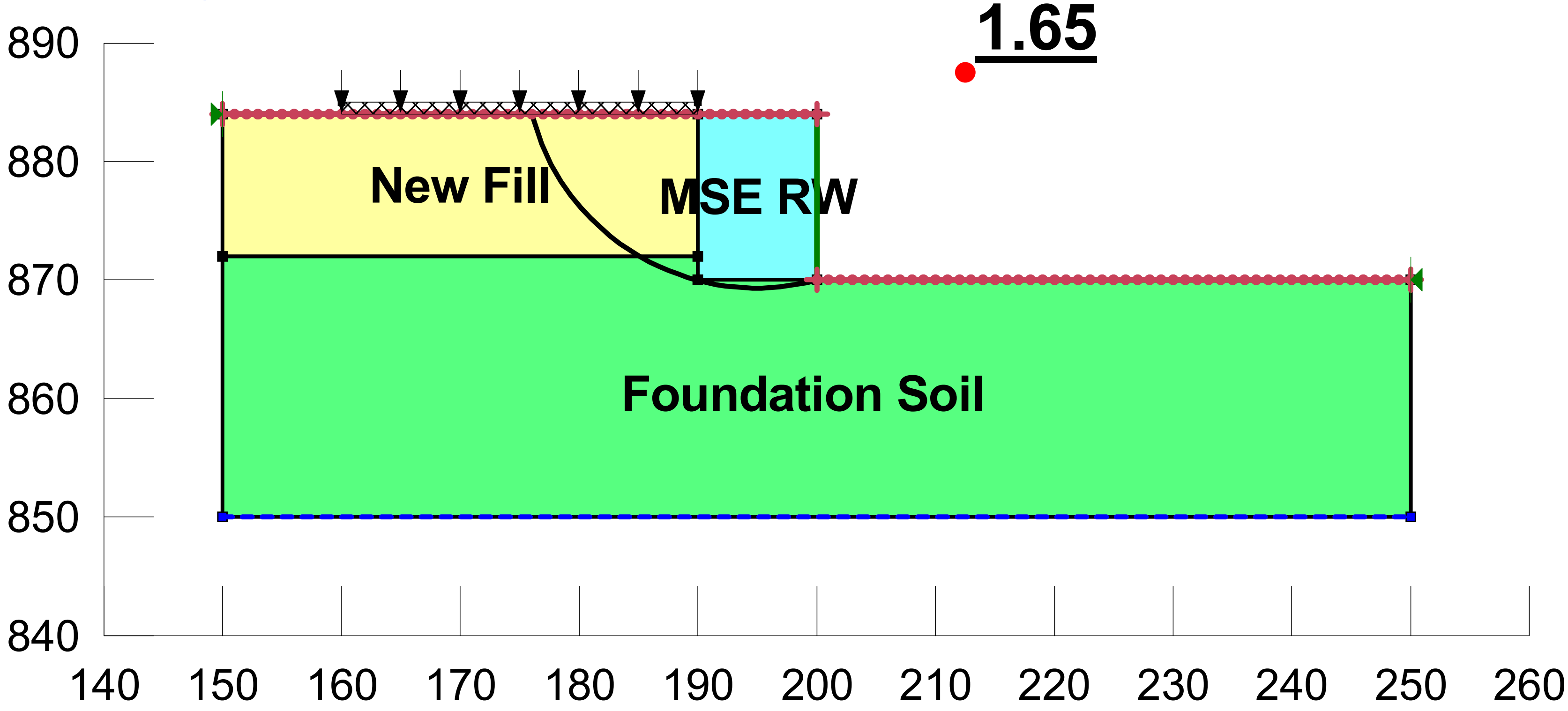
Design by: S Kabra | **Date:** 03/28/2022 | **Job No.** U-4015A

Project Name: U-4015A Gallimore Dairy
Analysis: RW3_Section2_Global Stability Analysis_Circular Failure- Undrained

H = 14.0 ft
Reinforcement Length (L) = 10 ft
L/H = 0.7

Borings Used: RW3-6

Color	Name	Model	Unit Weight	Phi'	Cohesion
🟩	Foundation Soil	Undrained (Phi=0)	120		800
🟦	MSE RW	High Strength	120		
🟨	New Fill	Mohr-Coulomb	120	30	



RK&K

Project Name: U-4015A Gallimore Dairy

Task Title: RW3_Section2_Global Stability Analysis_Circular Failure- Undrained

Design by: S Kabra **Date:** 03/28/2022 **Job No.** U-4015A

RETAINING WALL NO. 4

SETTLEMENT ANALYSIS SPREADSHEET

NORTH CAROLINA DEPARTMEN
OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UN
Settlement Calcs for Spread Footings

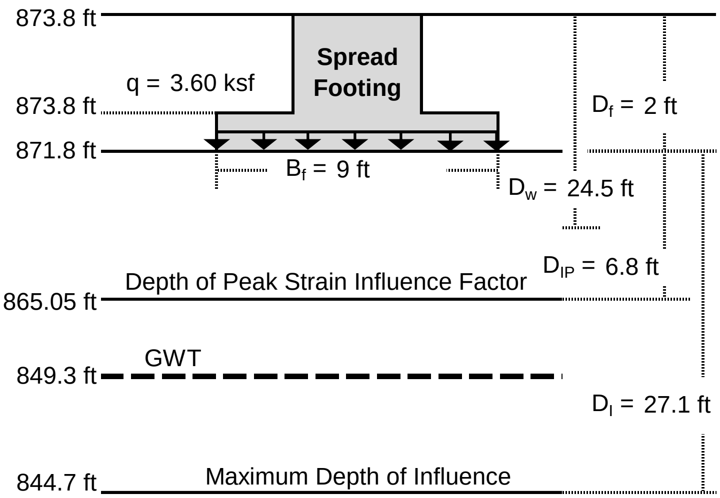
PROJECT: U-4015A COUNTY Guilford
DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro
DESIGNED BY: SK DATE: 07/14/21 STATION: -L-48+00
CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW- 3 PAGE: 1 OF 3

Settlement Calculations for Spread Footings (Schmertmann Method)

Loading Information

Gross bearing pressure, p = q = 3.6 ksf
Time passed since loading applied, t = 0.1 years

t = 0.1 years for immediate settlement.



(Typical Footing Profile - Not To Scale)

Unit Weight Information

Unit Weight of Concrete, γ_c = 0.150 kcf
Unit Weight of Water, γ_w = 0.0624 kcf
Unit Weight of Overburden Soil, γ_s = 0.120 kcf

Elevations and Footing Dimensions

Finished Grade Elevation = 873.8 ft
Natural Ground Elevation = 873.8 ft
Top of Footing Elevation = 873.8 ft
Bottom of Footing Elevation = 871.8 ft
Groundwater Table Elevation = 849.3 ft

Footing Thickness, t_f = 2.0 ft
Width of Footing, B_f = 9.0 ft — *Taken as the shorter dimension of the footing*
Length of Footing, L_f = 50.0 ft — *Taken as the longer dimension of the footing*
L_f / B_f = 5.56 — *Footing Shape = Rectangle*

Footing Embedment Depth, D_f = 2.0 ft
Maximum depth of influence below footing base (D_I) = 6.8 ft — *D_I = 3.01 B_f (See FHWA Figure 8-21a)*
Depth from footing base to peak strain influence factor (D_{IP}) = 27.1 ft — *D_{IP} = 0.75 B_f (See FHWA Figure 8-21a)*

Soil Information

Layer No.	Soil Type (pick the type that best describes the soil layer)	Top of Layer Elev (ft)	Bottom of Layer Elev (ft)	Total Unit Weight (kcf)	SPT $N1_{60}$	CPT q_c (ksf)	F_s	*E_s (ksf)
1	Silt	871.8	844.7	0.120	---	---	0	220
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Modulus values are based on Average Es value based on soil type (AASHTO Table C10.4.6.3.1)

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNI
Settlement Calcs for Spread Footings

PROJECT:	U-4015A	COUNTY	Guilford		
DESCRIPTION:	SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro				
DESIGNED BY:	SK	DATE:	07/14/21	STATION:	-L-48+00
CHECKED BY:	MM	DATE:	07/21/21	STR. NO.:	RW-3
				PAGE:	2 OF 3

Strain Influence Diagram using FHWA Figure 8-21

Strain Influence Factor at the Footing Base, (I_{ZB}) = 0.151 *for L_f/B_f = 5.56 (See FHWA Figure 8-21a)*

Peak Influence Factor (I_{ZP})

$$I_{zp} = 0.5 + 0.1\sqrt{\frac{\Delta p}{p_{op}}}$$

FHWA-NHI-06-089 Page 8-46

Δp = *net bearing pressure at the foundation depth = p - p_o*

p = q = gross bearing pressure at the foundation depth

3_o6= effective in-situ overburden stress at the foundation depth

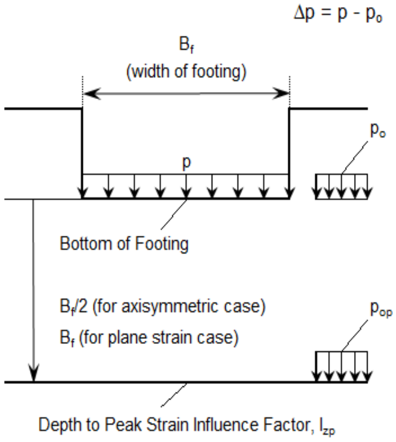
= 2.6 ksf - 0.24 ksf = 2.36 ksf

p_{op} = vertical eff 0.81 ksf - 0 ksf = 0.81 ksf

influence factor (Elevation = 865.05)

= σ_v - μ = 0.81 ksf - 0 ksf = 0.81 ksf

I_{zp} = 0.704



Adapted from FHWA NHI-06-089 Figure 8-21(b)
(Explanation of pressure terms in equation for I_{ZP})

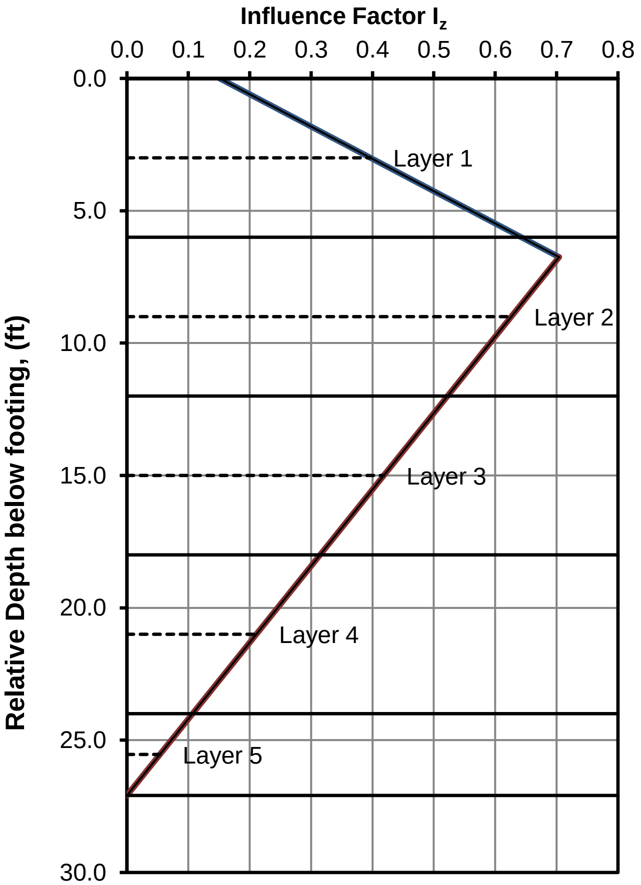
Average Influence Factors (I_{asi}) for each soil layer

Soil layers are divided according to FHWA NHI-06-089, Step 5 (page 8-50)

z_i = depth to center of layer i from the base of the footing

Average Influence Factors for each soil layer

Layer No.	Elevations		Depth		z_i (ft)	I_{azi}
	Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)		
1	871.8	865.8	0.0	6.0	3.0	0.397
2	865.8	859.8	6.0	12.0	9.0	0.626
3	859.8	853.8	12.0	18.0	15.0	0.418
4	853.8	847.8	18.0	24.0	21.0	0.211
5	847.8	844.7	24.0	27.1	25.5	0.054



Adapted from FHWA NHI-06-089 Figure 8-21(a)

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL ENGINEERING UNI

Settlement Calcs for Spread Footings

PROJECT: U-4015A COUNTY Guilford

DESCRIPTION: SR 1556 (Gallimore Dairy Rd.) Widening in Greensboro

DESIGNED BY: SK DATE: 07/14/21 STATION: -L-48+00

CHECKED BY: MM DATE: 07/21/21 STR. NO.: RW- 3 PAGE: 3 OF 3

Calculate Settlement using Schmertmann Method

$$S_t = Total\ Settlement = C_1 C_2 \Delta p \sum_{i=1}^{n} \left(H_c \frac{I_z}{X E_{si}} \right)$$

FHWA-NHI-06-089 Equation 8-16

C_1 = Depth Correction Factor

$= 1 - 0.5\left(\frac{p_o}{\Delta p}\right) \geq 0.5 =$ 0.964

FHWA-NHI-06-089 Equation 8-17

where, p_0 = 0.240 ksf *effective in-situ overburden stress at the foundation depth*

Δp = 3.360 ksf *net foundation pressure as shown in FHWA Figure 8-21b*

C_2 = Creep Correction Factor

$= 1 + 0.2 log_{10}\left(\frac{t}{0.1}\right) =$ 1.000

FHWA-NHI-06-089 Equation 8-18

where, t = 0.1 years *t = time in years (for immediate settlement, t = 0.1 years)*

H_C = Layer Thickness

X = factor to convert cone tip penetration resistance to elastic modulus when using AASHTO Table C10.4.6.3.1

= 1.25 for square footing, (L_f/B_f = 1) and 1.75 for strip footing, ($L_f/B_f \geq$ 10)

Use linear interpolation for rectangle footings (1 < L_f/B_f < 10)

FHWA-NHI-06-089 Page 8-45

= 1.00 *X = 1.00 when modulus values are not based on AASHTO Table C10.4.6.3.1*

Layer No.	Soil Type	Elevations		H_c (in)	E_s (ksf)	I_Z	S_i (inches)
		Top (ft)	Bottom (ft)				
1	Silt	871.8	865.8	72.0	220	0.397	0.421
2	Silt	865.8	859.8	72.0	220	0.626	0.664
3	Silt	859.8	853.8	72.0	220	0.418	0.444
4	Silt	853.8	847.8	72.0	220	0.211	0.223
5	Silt	847.8	844.7	37.1	220	0.054	0.029

Total Settlement, S_t = 1.781 inches