BRIDGE FOUNDATION INVESTIGATION (LRFD)

PROJECT NUMBER , County
P.I. NUMBER
LOCATION (See Map) *Project Location, Bridge No.*

GENERAL INFORMATION

GEOLOGIC FORMATION _____Formation of the Georgia *Piedmont/Coastal Plain/Valley and Ridge* Region.

SUBSURFACE FEATURES *Groundwater/hard rock/dense soil was encountered from Elevations ____ to _____.*

SITE CLASSIFICATION We recommend a site class of *A,B,C,D,E,F* per AASHTO LRFD 3.10.3.1.

1.0 -- FOUNDATION RECOMMENDATIONS

Bents	Drilled Shaft	Spread Footing	Pile Footing (Type)	Pile Bent (Type)

***Note to the Engineer**: Only indicate 50 ksi steel loads for H-piles when a bridge only has end bents and pile footings. When recommending H-pile intermediate bents, the 36 ksi steel loads should be listed for ALL bents. Per the Bridge Design Manual 36 and 50 ksi steel loadings should not be mixed on the same bridge. For metal shell piles use grade 3 (Fy = 45 ksi).*

1.1 -- Pile Properties

Pile Type	Pile Size (in)	Nominal Compression Stress (ksi)	Nominal Tension Stress (ksi)	Maximum Factored Structural Resistance (kips)
HP (50 ksi)	*10 x 42*	*45.0*	*45.0*	*310*
HP (50 ksi)	*12 x 53*	*45.0*	*45.0*	*384*
HP (50 ksi)	*14 x 73*	*45.0*	*45.0*	*520*
HP (50 ksi)	*14 x 89*	*45.0*	*45.0*	*653*
HP (50 ksi)	*14 x 102*	*45.0*	*45.0*	*750*
HP (50 ksi)	*14 x 117*	*45.0*	*45.0*	*860*
HP (36 ksi)	*10 x 42*	*32.4*	*32.4*	*223*
HP (36 ksi)	*12 x 53*	*32.4*	*32.4*	*279*
HP (36 ksi)	*14 x 73*	*32.4*	*32.4*	*385*
HP (36 ksi)	*14 x 89*	*32.4*	*32.4*	*470*

HP (36 ksi)	*14 x 102*	*32.4*	*32.4*	*540*
HP (36 ksi)	*14 x 117*	*32.4*	*32.4*	*619*

Note to the Engineer: *The above values for compression and tension stresses refer to drivability stresses found in AASHTO LRFD 10.7.8. The compression stresses, tension stresses, and factored structural resistances have been provided by the Office of Bridge Design in a letter dated December 9, 2013.*

Pile Type	Pile Size (in)	Nominal Compression Stress (ksi)	Nominal Tension Stress (ksi)		Maximum Factored Structural Resistance (kips)
			Normal Env.	Severe Env.	
PSC	*12 x 12*	*3.310*	*1.152*	*0.940*	*352*
PSC	*14 x 14*	*3.214*	*1.248*	*1.036*	*473*
PSC	*16 x 16*	*3.457*	*1.005*	*0.793*	*636*
PSC	*18 x 18*	*3.623*	*0.839*	*0.627*	*820*
PSC	*20 x 20*	*3.573*	*0.889*	*0.677*	*1006*
PSC	*24 x 24*	*3.662*	*0.800*	*0.588*	*1464*
PSC	*24 x 24 (void)*	*3.519*	*0.943*	*0.731*	*1158*
PSC	*30 x 30 (void)*	*3.553*	*0.909*	*0.697*	*1706*
PSC	*36 x 36 (void)*	*3.561*	*0.901*	*0.689*	*2224*

Note to the Engineer: *The above values for compression and tension stresses refer to drivability stresses found in AASHTO LRFD 10.7.8 and in accordance with GDOT Standard 3215. The compression stresses, tension stresses, and factored structural resistances have been provided by the Office of Bridge Design in a letter dated December 9, 2013. Tension stresses should be controlled based on the severe environment for any bridges over waterways located fully or partially in the following coastal counties: Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden.*

Pile Type	Pile Size (in)		Nominal Compression Stress (ksi)	Nominal Tension Stress (ksi)	Maximum Factored Structural Resistance (kips)
	Diam.	Wall Thickness			
MS	*14*	*0.2500*	*40.5*	*40.5*	*-*
MS	*14*	*0.3125*	*40.5*	*40.5*	*-*
MS	*16*	*0.2500*	*40.5*	*40.5*	*-*
MS	*16*	*0.3125*	*40.5*	*40.5*	*-*
MS	*18*	*0.3125*	*40.5*	*40.5*	*-*
MS	*20*	*0.3125*	*40.5*	*40.5*	*-*

Note to the Engineer*: The above values for compression and tension stresses refer to drivability stresses found in AASHTO LRFD 10.7.8 and based on ASTM A252 Grade 3. The compression stresses, tension stresses, and factored structural resistances have been provided by the Office of Bridge Design in a letter dated December 9, 2013. Compression and tension stresses will control for MS piles since the factored structural resistance would include concrete and reinforcement which is not present during driving.*

1.2 -- DESIGN LOADS

Bents	Maximum Factored Foundation Load (kips)	Service Load (kips)

***Note to the Engineer**: List the loads provided by the Bridge Designer per column for spread footings/drilled shafts, and per pile for pile bents/footings.*

2.0 -- GEOTECHNICAL LOADS

2.1 -- PILE FOUNDATION LOADS

Bents	Pile Type	Size (in)	Down Drag (kips)	Scour (Kips)	Driving Resistance * (kips)

***Note to the Engineer**: Don't forget to include the factored down drag load, side resistance for down drag, and scour in the driving resistance. ***The selected pile was chosen due to an issue with the drivability analysis.*

2.2 -- SPREAD FOOTING FOUNDATION LOADS

Bents	Nominal Resistance (ksf)	Resistance Factor φ	Factored Resistance (ksf)	Effective Footing Size (in)

***Note to the Engineer**: Next to the bearing value for spread footings, note what material the foundation is bearing upon. (Example: 6 ksf on soil). Resistance should be controlled based on a maximum settlement of 1 inch.*

2.3 -- DRILLED SHAFT FOUNDATION LOADS

Bents	Diameter (ft)	Nominal Tip Resistance (ksf)	Factored Tip Resistance ** (ksf)	Base Area of Shaft (ft^2)	Factored Axial Resistance (kips)

***Note to the Engineer**: Next to the resistance values provide a note of what material the foundation is bearing upon. (Example: 2 ksf in dense soil, or 100 ksf on hard rock), Also, include a designation for side resistance or tip resistance in the heading. Minimum Diameter is for end bearing shafts. If the shaft will be designed for side resistance a specific diameter should listed instead of a minimum.*

Bents	Diameter (ft)	Nominal Side Resistance (ksf)	Factored Side Resistance ** (ksf)	Circumference of shaft (π*d) (ft^2)	Factored Axial Resistance (kips/lf)

***Note to the Engineer**: Next to the resistance values provide a note of what material the foundation is bearing in. (Example: 2 ksf in dense soil, or 6 ksf in lime rock)*

3.0 -- FOUNDATION ELEVATIONS

Bents	Bottom of Drilled Shaft	Bottom of Spread Footing	Minimum Tip	Estimated Tip

***Note to the Engineer**: Next to Bottom of Footing/Shaft Elevation, state "or below". (Example: 650 or below). Note that bottom of footing elevations are not given for pile footings. For size reference the type and dimensions of pile, dimensions of spread footing, or diameter for drilled shaft.*

4.0 -- GENERAL NOTES

Elevations All elevations are based on an Elevation of ___ at the *corner of the east endbent.*

Waiting Period None required.

***Note to the Engineer**: Waiting period recommendations within the BFI report are normally only applicable to the driving of piles at the endbents. However, waiting periods may also apply to bents immediately adjacent to endbents.*

Waiting Period A waiting period of *45/60/90* days will be required before the driving of piles at the endbents to allow for the settlement of the soft underlying soils.

Staged Construction Due to the presence of ___ feet of soft, compressible material beneath the embankment and endfills, staged construction will be required.

***Note to the Engineer**: If you recommend stage construction in this section, explain what the recommended construction sequence is, including*

allowable fill heights, waiting periods between each stage and if a surcharge is required. A detail may also be needed.

Theoretical Scour Appears feasible for the material encountered.

***Note to the Engineer**: The only time a recommendation to change the scour line is made is if hard or very dense partially weathered rock (PWR) is encountered above the 500-year theoretical scour line.*

Theoretical Scour The theoretical scour line may be raised to Elevation ____ at Bent ___ because of the presence of scour resistant rock that was encountered during our subsurface investigations.

Stream Migration By comparing the material encountered at *Borings* _____, it appears that the stream channel once ran closer to the *north* endbent. The main stream channel is now closer to the *south* endbent. This indicates a migration towards the *south*, and the extension of the bridge towards the *south* ____ feet should assist in handling this migration.

Voids Voids in the *limerock layers* were encountered from *Elevation* ____ to ___ at *Bents* ____ and may be encountered at other bents at this site. The Contractor should be made aware of this condition.

Obstructions Several of our borings in the area of the bridge indicate *bricks, old timber piles, etc.* within ____ feet of the ground surface. The Contractor should remove these prior to foundation construction.

Special Problems On-site inspection revealed severe erosion of the roadway embankment behind the *west* end abutment. We recommend extending the length of the bridge at least _____ feet to the *west* side for increased discharge capacity.

Artesian Flow Artesian flow is common in this area and can be very difficult to control and plug. Preparations to plug the flow should be on-site and readily available at all times.

As Built Foundation Information The as built foundation information should be forwarded to the Geotechnical Engineering Bureau upon completion of the foundation system.

Special Problems ***Note to the Engineer**: Make note of any special problems or conditions you encounter during your site visit that you feel need to be addressed during design or construction.*

4.1 -- PILE FOUNDATION NOTES

PDO Driving resistance after minimum tip elevations are achieved in conjunction with Special Provision 520 Piling for LRFD *and Special Provision 523 Dynamic Pile Testing. List bents and locations for PDA tests to be run.*

*** Nominal Bearing Resistance of Single Pile** Driving resistance is based on the following field verification method and resistance factor ϕ_{dyn} AASHTO LRFD 2010 (10.5.5.2.3-1):

Resistance Determination Method	Resistance Factor
Driving criteria established by successful static load test of at least one pile per site condition without dynamic testing.	*0.75*
Driving criteria established by dynamic testing of at least two piles per site condition, but no less than 2% of the production piles.	*0.65*
FHWA-modified Gates dynamic pile formula (End of Drive condition only)	*0.40*

Drivability

A drivability analysis has been completed on the above mentioned piles to their respective estimated tips with a *PILE HAMMMER USED*.

***Note to the Engineer**: If a pile was specifically chosen due to a drivability issue with either the compression and/or tension stress, then it should be stated here.*

Spudding/Jetting

Spudding and/or jetting *will/may* be required to achieve the Minimum Tip Elevations for *PSC / metal shell* piles at the proposed intermediate bents.

***Note to the Engineer**: Spudding and jetting should only be considered for pile intermediate bents at stream crossings. There is **not** a separate pay item for spudding, jetting, or predrilling and the Contractor may choose not to do any of the 3 options. If drilling for pile installation is required at the site, pilot holes must be set up. There is a pay item for pilot holes and they will be set up on the plans.*

Pre-drilling
(For PSC/ MS)
(Add SP 520)

The Contractor may choose pre-drilling as an option to spudding or jetting to assist in the installation of *PSC / metal shell* piles through dense soil layers at Bent(s) _____ as per Special Provision Section 520. If pre-drilling is used, it should be (*to 3 feet above the minimum tip elevation(s).) or (to the following elevation(s)), and may be adjusted by the Engineer during construction:*

Bent	**Elevation**

***Note to the Engineer**: Predrilling is used only as an option to spudding and jetting. Use either the standard note, "to 3 feet above the minimum tip elevation(s)" or specify the elevation that states how deep the pre-drilling must be. This information should not be included in SP520, however. Note that pre-drilling may only be needed to get through a dense layer and may not have to extend to within 3 feet of minimum tip.*

No separate payment will be made if the Contractor chooses to use pre-drilling. The maximum diameter of the pre-drilled hole should be determined from the following table:

Pile Size - PSC	Maximum Pre-Drill Hole Size - PSC
14“	12“
16”	18“
18“	18“
20“	24”
24“	24“
30“	30“
36“	36”

Pile Size - MS	Maximum Pre-Drill Hole Size - MS
14 “	12 “
16 “	12 “
18 “	12 “

Note: Delete the pile and pre-drill hole sizes for the pile type that is not selected.

Pilot Holes (for PSC/ MS piles)

Very dense *sand/ PWR/boulders* layers were encountered above the Minimum Tip Elevations at *Bents* _____. We recommend that pilot holes be set up to *Elevation* ___ to help advance piles through these layers. This elevation represents an embedment of ___ feet into *very* dense material and may be adjusted by the Engineer during construction. *Temporary casing will / may also be required to prevent the collapse of the pilot holes prior to driving the piles at Bents* ____.

Pile Size - PSC	Maximum Pilot Hole Size - PSC
14“	18“
16”	18“
18“	24“
20“	24”
24“	30“
30“	36“
36“	48”

Pile Size - MS	Maximum Pilot Hole Size - MS
14 “	18 “
16 “	18 “
18 “	18 “

***Note to the Engineer**: If necessary to maintain an open hole, set up temporary casing and specify type of backfill material to be used. In addition, the maximum size pilot hole will have to be modified. The aforementioned pilot hole sizes are for “loosening” of soils and do not produce clean, open holes.*

Pilot Holes *(for H- piles)*

Pilot Holes should be set up for H-piles due to the potential for hard driving. Use a maximum pilot hole diameter of 24”. *The holes should be filled with concrete to the top of the rock after the piles are driven. Pilot holes should be set up to the following elevations:*

***Notes to the Engineer**: Pilot holes should be used sparingly. They are very*

expensive per linear foot to install. If pilot holes in rock are being considered, look at drilled shafts as the primary foundation recommendation. If pilot holes in hard rock with concrete backfill are specified, Special Provision 520 (pilot holes) must also be used. Pilot holes may be used to either advance piles through a hard layer or to socket the piles into hard rock.

Points Pile points are recommended for each pile to be driven at *Bents* _____ to insure adequate penetration into very dense weathered rock.

Freeze Bearing Piles should not be overdriven at this site. If dynamic bearing has not been achieved by 2 feet above the Estimated Tip Elevation, pile driving should be stopped for a minimum of 24 hours and re-started with a warm hammer to check for "freeze" bearing.

***Note to the Engineer**: If Freeze Bearing is recommended, verify there is a 2 foot difference in Minimum and Estimated Tip Elevations so that pile driving will not be stopped 2 feet above the minimum tip elevation.*

Pile Protection All *exposed HP/MS piles and steel sway bracing* should be painted with a 2P epoxy coating as protection against corrosion.

The H-piles at intermediate *Bents* _____ should be encased in concrete, as per Standard Bridge Office Specifications.

Metal Shell Piles Metal Shell piles are recommended for use at this site due to the excessive pile length required for PSC piles. PSC piles that are too long are not easily handled or driven. In addition, hard driving is anticipated through dense soil layers and this presents potential problems of overstressing and cracking PSC piles.

Closure Plates Option *1/2* closure plates should be used on all metal shell piles.

***Note to the Engineer**: The options for closure plates are listed in the Standard Specifications Section 520.3.05.M.*

Down-drag Protection To avoid inducing down-drag loads into the piles from potential settlement of compressible layers during construction of the MSE wall, we recommend that piles at *Bents* _____ be protected from down-drag by using jackets or other approved materials.

***Note to the Engineer**: Yellow jackets only remove down-drag from the construction of the wall backfill, not from compressible layers below the wall.*

Test Piles We recommend that PSC test piles be set up at *Bents* ____ to help determine pile order lengths. They should be of sufficient length to reach a depth of 5 feet below the Estimated Tip Elevation.

***Note to the Engineer**: Test piles are used to determine order lengths for PSC Piles only. This is not the same as a load test. The Bent number and*

location (left or right) along the bent line should also be noted.

Cofferdams Cofferdams will be needed to construct the pile footings at *Bents* ____. Seal concrete *may / will* also be required. Dewatering of the excavations *may / will* also be required. *We recommend that the Construction Office evaluate the need for cofferdams at this site.*

***Note to the Engineer**: Cofferdams consist of sheet piling where footings fall within the main water channel. In the event the foundation system falls adjacent to the channel or along the bank, make a recommendation for the Construction Office to evaluate the need for cofferdams at this site.*

Temporary Shoring Shoring *may / will* be required to construct the pile footings at *Bents* _____if the excavations cannot be safely sloped back. *Because groundwater was encountered near or above the footing elevations, dewatering of the excavations will/may also be required.*

***Note to the Engineer**: Temporary shoring consists of sheet piling where footings fall outside of the main water channel, but cannot be stabilized due to the presence of high groundwater.*

In addition, temporary shoring may be used at intermediate bents at grade crossings for pile footing installation where the slopes cannot be safely laid back due to the presence of existing roads, railroads, etc.

Pile Footings Due to the high groundwater elevations near the footing elevations, we recommend that 12 inches of Type II Foundation Backfill Material be set up for use in the footing area. The use of this material should be at the direction of the Engineer and may be eliminated on construction if the footing area is dry.

***Note to the Engineer**: The use of Type II Foundation Material can be recommended at pile footings bearing on soil at grade or railroad crossings. In addition, it can also be recommended for use at pile footings at stream crossings.*

Special Problems Erratic pile lengths can be expected.

4.2 -- SPREAD FOOTING NOTES

Spread Footings Should be embedded (*2'-3' for PWR/1' for hard rock)* feet into *partially weathered / hard* rock to protect the footing from scour. The footing elevations reflect this embedment.

***Note to the Engineer**: Embedment in rock /PWR is normally only required for footings in stream crossings where scour may be an issue.*

Spread Footings The footing excavations should be protected from standing water and surface run-off. Footings should be poured as soon as practical after excavation.

Cofferdams Cofferdams will be needed to construct the spread footings at *Bents* ____.

Seal concrete *may / will* also be required. Dewatering of the excavations *may / will* also be required. *We recommend that the Construction Office evaluate the need for cofferdams at this site.*

***Note to the Engineer**: Cofferdams consist of sheet piling where footings fall within the main water channel. In the event the foundation system falls adjacent to the channel or along the bank, make a recommendation for the Construction Office to evaluate the need for cofferdams at this site.*

Temporary Shoring

Shoring *may / will* be required to construct the spread footings at *Bents* _____if the excavations cannot be safely sloped back. *Because groundwater was encountered near or above the footing elevations, dewatering of the excavations will/may also be required.*

***Note to the Engineer**: Temporary shoring consists of sheet piling where footings fall outside of the main water channel, but cannot be stabilized due to the presence of high groundwater.*

In addition, temporary shoring may be used at intermediate bents at grade crossings for spreading footing installation where the slopes cannot be safely laid back due to the presence of existing roads, railroads, etc.

Spread Footings

Due to the high groundwater elevations near the footing elevations, we recommend that 12 inches of Type II Foundation Backfill Material be set up for use in the footing area. The use of this material should be at the direction of the Engineer and may be eliminated on construction if the footing area is dry.

***Note to the Engineer**: The use of Type II Foundation Material can be recommended at spread bearing on soil at grade or railroad crossings. It is NOT to be used with spread footings at stream crossings due to scour concerns.*

Special Problems

***Note to the Engineer**: Make note of any special problems or conditions you encounter during your site visit that you feel need to be addressed during design or construction.*

4.3 -- DRILLED SHAFT NOTES

Drilled Shafts

The drilled shafts should be constructed as per Special Provision Section 524: Drilled Caisson Foundations. *Drilled shafts are recommended as the foundation type at this site because they will eliminate the need for pilot holes and/or cofferdams.* A minimum ___-foot socket into sound rock will be required for all drilled shafts at this site.

**** Nominal Axial Compressive Resistance of Single Drilled Shafts**

Factored *tip/side* resistance is based on the following method and resistance factor ϕ_{stat} AASHTO LRFD 2010 (10.5.5.2.4-1) :

Soil Condition	Method	Resistance Factor

Side resistance in sand	*β-method* *O'Neill and Reese (1999)*	*0.55*
Side resistance in IGMs	*O'Neill and Reese (1999)*	*0.60*
Tip resistance in IGMs	*O'Neill and Reese (1999)*	*0.55*
Side resistance in rock	*Horvath and Kenney (1979)* *O'Neill and Reese (1999)*	*0.55*
Tip resistance in rock	*O'Neill and Reese (1999)*	*0.50*

Permanent Casing Permanent casing will be required at *Bents* ____ to install the drilled shafts through the voids at this site. Casing will be required to at least *Elevation* ____.

Special Problems ***Note to the Engineer**: Make note of any special problems or conditions you encounter during your site visit that you feel need to be addressed during design or construction.*

5.0 – QA / QC

Prepared By ENGINEER NAME

Reviewed By _____, PE