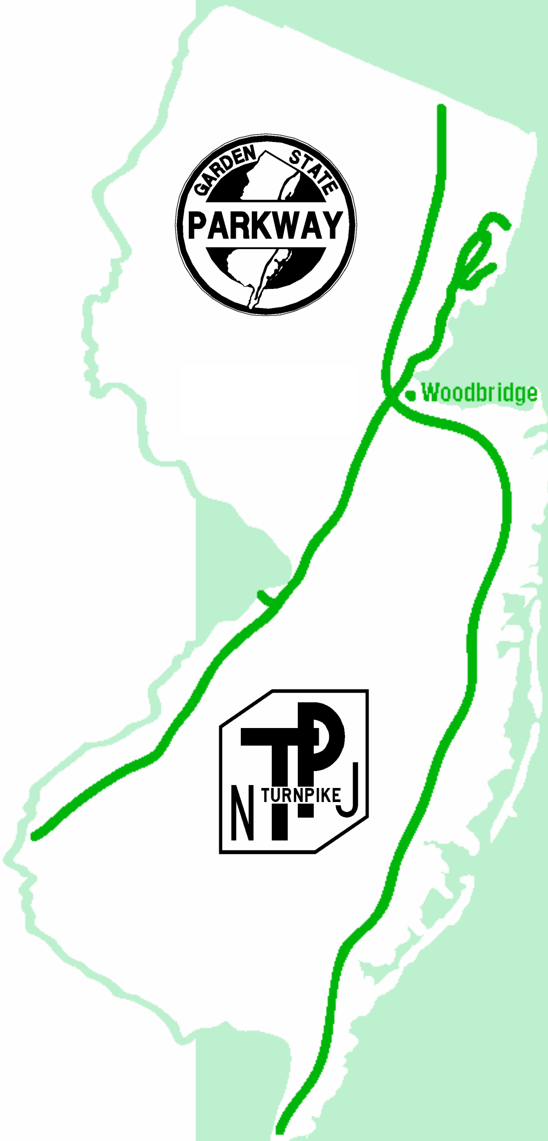
NEW JERSEY TURNPIKE AUTHORITY

GARDEN STATE PARKWAY

NEW JERSEY TURNPIKE



DESIGN MANUAL

INTRODUCTION

This document (hereinafter referred to as the “Manual”) supersedes the previously published 1987 Design Manual including subsequent updates and has been prepared to provide its users with current, uniform procedures and guidelines for the application and design of safe, convenient and efficient roadways that satisfy optimally the needs of the roadway users while maintaining the integrity of the environment and aesthetics for New Jersey Turnpike Authority engineering projects on the Garden State Parkway and New Jersey Turnpike. The Manual contains current, uniform criteria and guidelines to be used in the performance of work on Authority projects. **Please be aware that this Manual is intended only as an aid and not as a textbook.** Each project is unique and has particular needs and requirements. This Manual does not attempt to encompass the total scope of important, published information and literature relative to the formulation of highway design criteria, policies and procedures. Furthermore during the course of a project, Authority regulations and applicable statutes may change; different information may be required or different methods may need to be followed.

When design criteria presented in this Manual differs from criteria presented in other sources, this Manual shall take precedence. The design criteria and text presented herein provide guidance to the designer by referencing a recommended range of values for critical dimensions. Initiative should be exercised to utilize larger values within the given ranges whenever practicable and within reasonable economic limitations and sound engineering judgment.

The inclusion of specified design criteria in this Manual does not imply that existing roadways, which were designed and constructed using different criteria, are either substandard or must be reconstructed to meet the criteria contained herein. Many existing facilities which met the design criteria at the time of their construction are adequate to safely and efficiently accommodate current traffic demands.

Variations from the design criteria may be required for special or unusual conditions where deviations from a particular criteria may be desirable due to structural restrictions, especially bridge, roadway and shoulder widths. When the design criteria presented in this Manual cannot be achieved for new construction or reconstruction, a Design Element Modification request, discussed in Section 3 of the Procedures Manual, shall be prepared with a full explanation provided for the retention of these features. The determination to approve a project design not conforming to the minimum criteria should be made only after due consideration is given to all conditions such as maximum service and safety benefits, compatibility with adjacent sections of unimproved roadways and the probable time before reconstruction of the section due to increased traffic demand or changed conditions.

The Authority has prepared Standard Drawings to provide engineering personnel, designers and contractors with a catalog of specific design conditions for use in the development of the design of highways. The Standard Drawings shall be used in conjunction with the Standard Specifications, Special Provisions and construction plans to provide a uniform design and construction practice for all projects.

The word “Authority” as it appears in this Manual is intended to be the New Jersey Turnpike Authority, with its principal office at 1 Turnpike Plaza, Woodbridge, New Jersey, or its duly authorized representative in cases of projects entrusted to the Authority’s General

Consultant or Program Manager, acting on behalf of the Authority and should be given the requisite respect and deference.

The word “Engineer” as it appears in this Manual is intended to be the Consulting Engineer that has been issued an Order for Professional Services to complete the design of a project for the Authority. This term can be further extended for any subconsultants to the prime consultant that are engaged in certain tasks for the project.

The words “Resident Engineer” as they appear in this Manual are intended to be the field representative of the Authority, having direct supervision of the administration of the construction contract.

Updates and revisions to this Manual may occur and will be posted on the Authority’s website, http://www.njta.com/doing-business/professional-services .

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Section 1 - NEW JERSEY TURNPIKE GEOMETRIC DESIGN

1.1. GENERAL

The geometric design criteria contained herein were developed by the Authority for its own particular needs. They are intended to equal or exceed standards currently being used for limited access highways and should be considered minimum criteria and increased wherever economically feasible. The use of substandard criteria, including absolute minimum / maximum values listed in this manual, shall require a Design Element Modification Request subject to approval by the Authority's Engineering Department. For any items not adequately outlined in this section, the Engineer should refer to the latest edition of *AASHTO A Policy on Geometric Design of Highways and Streets* and *AASHTO Roadside Design Guide*.

The design criteria presented is intended to be used as an aid toward sound engineering design. When individual circumstances arise that are not specifically covered, engineering judgment is to be exercised that represents the intent of the criteria shown. The overall objective should be an aesthetically pleasing and safe design that is geometrically compatible in all respects.

1.1.1. Design Controls

The following design controls shall be applicable on all Turnpike roadways:

1. Design Vehicle
   Design Vehicle WB – 67 (Interstate Semi-trailer) shall control geometric design. See Exhibit 1-1.

2. Clearances

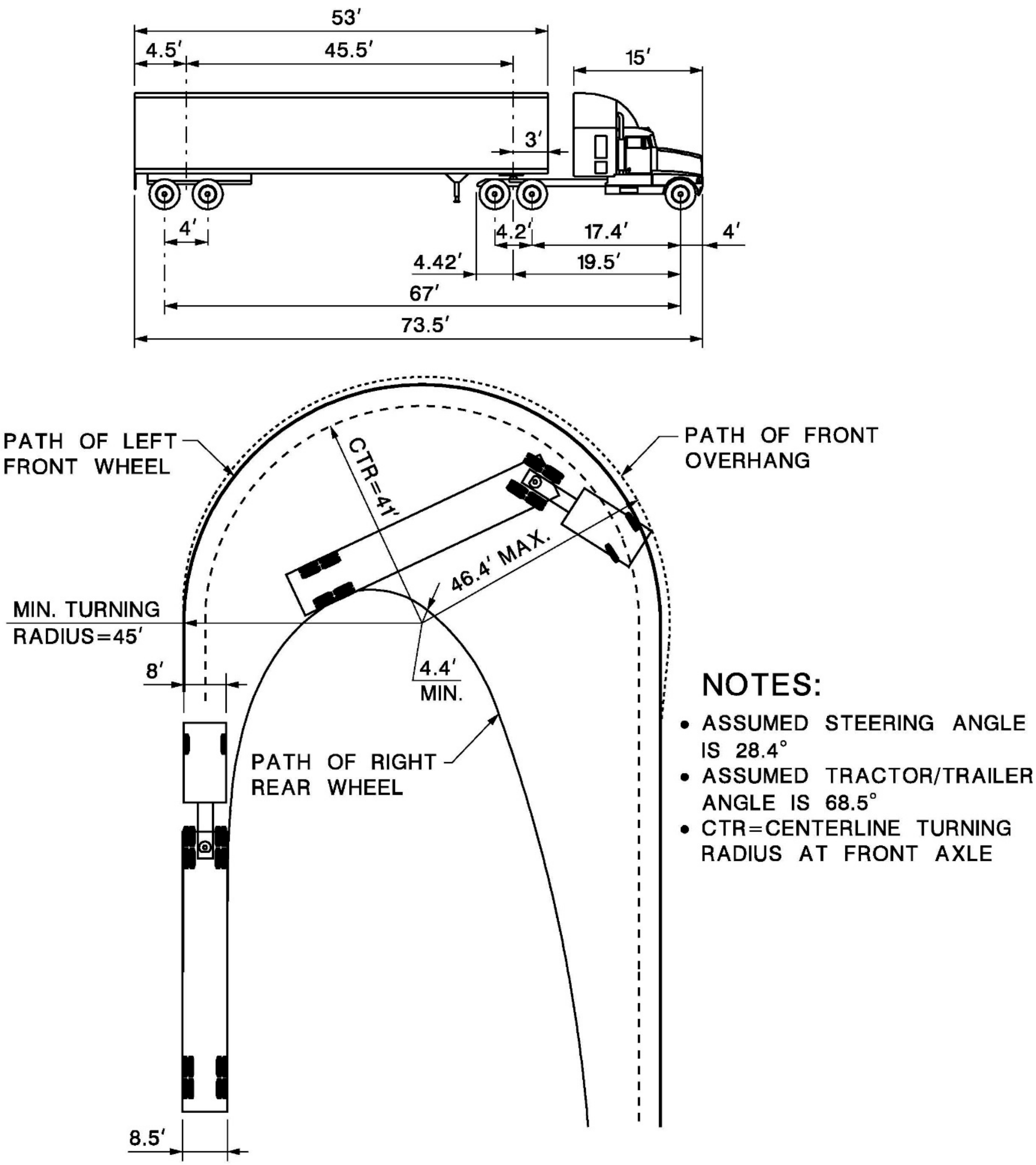
   a. Horizontal - Minimum clear zone width or less with appropriate roadside or median protection as directed by Section 4 - of this Manual, and as further directed by Section 3 of this Manual for protection of structures.

   b. Vertical - Minimum vertical clearances shall be maintained over all roadways, including shoulders. Verification of all clearances shall be made with the controlling agency.

      i. Minimum clearance above Turnpike roadways - As directed by Section 3 of this Manual or existing vertical clearance, whichever is greater. When resurfacing or widening a Turnpike roadway under an existing crossing whose vertical clearance is less than the required minimum, the resulting vertical clearance must not be less than the existing condition.

      ii. Minimum clearance below Turnpike roadways - As required by the agency having jurisdiction, but not less than the required minimum as directed by Section 3 of this Manual. When resurfacing or widening a roadway under an existing Turnpike crossing whose existing vertical clearance is less than the required minimum, the resulting vertical clearance must not be less than the existing condition.

Exhibit 1-1 WB-67 (Interstate Semi-Trailer) Design Vehicle



3. Sight Distances

   Horizontal and vertical sight distance shall be investigated to ensure that the minimum stopping sight distances as shown in Exhibit 1-3 and Exhibit 1-22 (horizontal) and Exhibit 1-8 and Exhibit 1-16 (vertical) are met or exceeded.

   a. Horizontal - Sight distance shall be investigated using one or both of the methods listed below.

i. Where obstruction and vehicle are located within the limits of a simple curve:

$$HSO = R - \sqrt{R^2 - (S/2)^2}$$

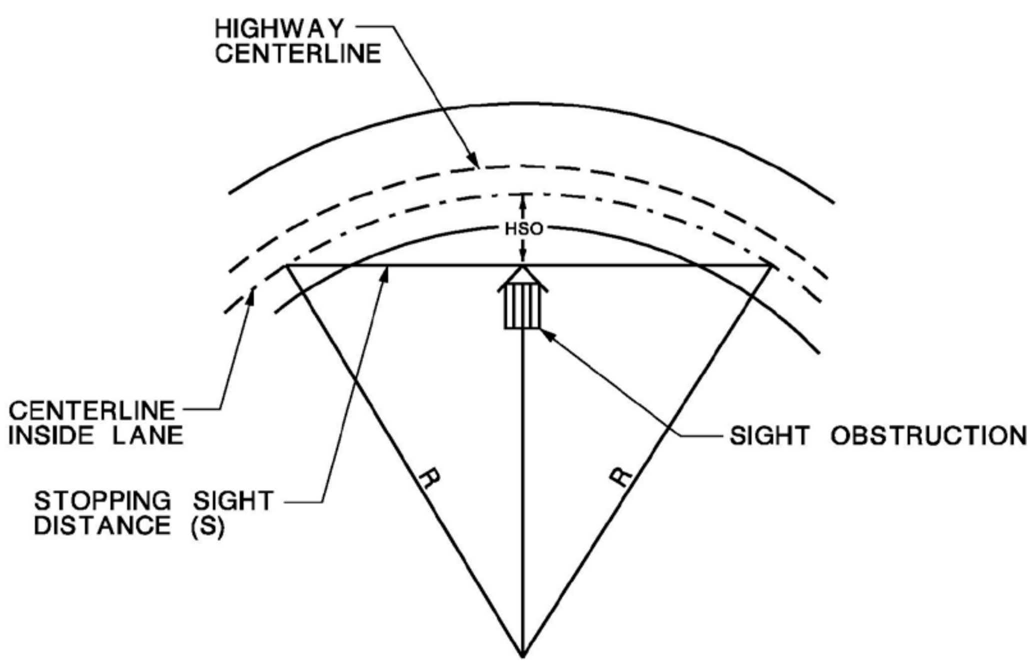
Where:

s	=	Stopping sight distance, ft
R	=	Radius of curve, ft
HSO	=	Horizontal sightline offset, ft

ii. Where the vehicle, the obstruction, or both are situated beyond the limits of a simple curve or within the limits of a compound curve, the design should be checked by utilizing graphical procedures.

b. Vertical - The sight distance for crest curves shall be based on a height of eye of 3.5 feet to an object 6 inches high. The sight distance for sag curves shall be based on headlight sight distance using a headlight height of 2.0 feet and a 1-degree upward divergence of the light beam from the longitudinal axis of the vehicle.

Exhibit 1-2 Components for Determining Horizontal Sight Distance



1.2. MAINLINE ROADWAYS

1.2.1. Roadway Designations

All mainline roadways shall be designated such that the origin and then the destination of that roadway are given in order, (from the north to the south - NS roadway, or from the south to the north, inner roadway - SNI). See Subsection 1.4.1 of the Procedures Manual for a complete listing.

1.2.2. Design Speed

The design speed for mainline roadways shall be 70 mph south of Milepost 97.0 and 60 mph north of Milepost 97.0. In areas south of Milepost 97.0 where the vertical alignment is controlled by the existing Turnpike profile or other restrictions, the absolute minimum allowable design speed is 60 mph.

1.2.3. Stopping Sight Distance

The minimum stopping sight distance is the distance required by the driver of a vehicle, traveling at a given speed, to bring his vehicle to a stop after an object on the road becomes visible. Stopping sight distance is measured from the driver's eyes, which is 3.5 feet above the pavement surface, to an object 6 inches high on the road. An object height of 2 feet may be used with Authority approval. The minimum stopping sight distance for mainline design speeds shall be as shown in Exhibit 1-3, and Exhibit 1-8 for minimum K values.

Exhibit 1-3 Minimum Stopping Sight Distance for Mainline Roadways

Design Speed (mph)	Minimum Stopping Sight Distance (ft)
60	570
70	730

1.2.4. Horizontal Alignment

1. Radii
   The minimum radius curve shall be 3,500 feet for 70 mph design speed and 3,000 feet for 60 mph. It is desirable to use as large a radius as geometric controls reasonably permit.

2. Compound Curves
   The ratio of the flatter radius to the sharper radius shall not exceed 1.5:1.

3. The desirable minimum length of curve shall be 1,050 feet for 70 mph design speed, and 900 feet for 60 mph design speed. Absolute minimum length of curve shall be 600 feet.

4. The minimum tangent distance between reversed curves shall be 1,000 feet. The absolute minimum tangent length shall be sufficient to accommodate the superelevation transitions between the reversing curves.
5. The desirable minimum tangent distance between broken back (same direction) curves shall be 2,500 feet. Absolute minimum shall be 1,500 feet.
6. A standard taper rate of 1:100 shall be used for all lane width reductions and lane drops.

1.2.5. Superelevation

1. Mainline superelevation rate shall be determined from Exhibit 1-4 based on a maximum superelevation rate of 5 percent.
   a. For mainline profile grades less than 0.5 percent, the minimum roadway cross slope shall be increased from 1.5 to 2 percent. Where median barrier is present in this situation, the normal median cross slope as shown in Exhibit 1-11 shall be transitioned between 2 and 5 percent to direct drainage flow along the barrier and into storm drains at localized low points along the median. Where profile grades less than 0.5 percent occur in a superelevated section of the mainline with median barrier, the median cross slope transition shall be limited by the maximum rollover values indicated in **Exhibit 1-10**.
   b. If a design assignment involves modification or resurfacing of an existing roadway, the rate of superelevation to be used shall normally follow the current standard, as described in this section. However, if a bridge deck falls within the horizontal curve and the deck superelevation is not being upgraded, the rate of superelevation for the entire length of the horizontal curve shall not exceed that on the existing bridge deck.

Exhibit 1-4 Minimum Mainline Roadway Radii for Design Superelevation Rates, E_{MAX} = 5%

e_d (%)	V_d = 60 mph $R_{(ft)}$	V_d = 70 mph $R_{(ft)}$
1.5	11100	14100
2.0	8060	10300
2.2	7230	9240
2.4	6540	8380
2.6	5950	7660
2.8	5440	7030
3.0	4990	6490
3.2	4600	6010
3.4	4250	5580
3.6	3940	5210

e_d (%)	V_d = 60 mph $R_{(ft)}$	V_d = 70 mph $R_{(ft)}$
3.8	3650	4860
4.0	3390	4550
4.2	3140	4270
4.4	R_{MIN} = 3000	4010
4.6		3770
4.8		3550
5.0		R_{MIN} = 3500

2. Tangent to Curve Transition

   a. The minimum length of superelevation runoff (length of roadway needed to accomplish the change in outside-lane cross slope from zero to full superelevation or vice versa) shall be determined from the following equation:

$$L_r = \frac{(wn_1)e_d}{\Delta}(b_w)$$

Where:

L_r = Minimum Length of superelevation runoff (ft)

Δ = Maximum relative gradient (%). See Exhibit 1-5.

n_1 = Number of lanes rotated

b_w = Adjustment factor for number of lanes rotated. See Exhibit 1-6.

w = width of one traffic lane (ft)

e_d = design superelevation rate (%)

   b. The minimum tangent runout length (length of roadway needed to accomplish the change in outside-lane cross slope from the normal cross slope to zero or vice versa) required to remove adverse crown shall be determined from the following equation:

$$L_t = \frac{e_{NC}}{e_d} L_r$$

Where:

L_t = Minimum length of tangent runout (ft)

e_{NC} = Normal cross slope rate (%)

e_d = Design superelevation rate (%)

L_r = Minimum length of superelevation runoff (ft)

c. The location of the superelevation runoff length with respect to the point of curvature (PC) shall be as shown in Exhibit 1-7 when conditions allow:

Exhibit 1-5 Maximum Relative Gradient (Mainline)

Design Speed (mph)	Maximum Relative Gradient %
60	0.45
70	0.40

Exhibit 1-6 Adjustment Factor for Number of Lanes Rotated

Number of Lanes Rotated n_1	Adjustment Factor b_w	Length Increase Relative to One Lane Rotated ($=n_1 b_w$)
1	1.00	1.0
1.5	0.83	1.25
2	0.75	1.5
2.5	0.70	1.75
3	0.67	2.0
3.5	0.64	2.25
4	0.63	2.50

Exhibit 1-7 Location of Superelevation Runoff (Mainline)

Design Speed (mph)	Portion of Runoff Located Prior to the Curve			
	No. of Lanes Rotated			
	1.0	**1.5**	**2.0 – 2.5**	**3.0 – 3.5**
60 – 70	0.70	0.75	0.80	0.85
If the specific values listed above are not attainable for a given location, then the portion of superelevation runoff prior to the PC shall fall within the range of 0.60 to 0.90.				

1.2.6. Vertical Alignment

1. Grades

a. Desirable maximum profile grade shall be 3 percent. Absolute maximum profile grade shall be 5 percent. Desirable minimum profile grade shall be

0.5 percent. Absolute minimum profile grade shall be 0.3 percent. See Subsection 1.2.5 for superelevation with less than 0.5 percent profile grade.

b. Desirable minimum length of profile tangent shall be 1,000 feet. Absolute maximum length of vertical tangent shall be dictated by a maximum permissible loss in truck speed of 10 mph.

2. Vertical Curves

a. The minimum length of vertical curve shall be determined as follows:

L = AK

Where:

L = Length of vertical curve, in increments of 25 feet where feasible.

A = Algebraic difference in grades entering and leaving vertical curve.

K = Horizontal distance in feet required to effect a 1 percent change in gradient. See Exhibit 1-8. The minimum value of K shall accommodate the minimum stopping sight distance along the vertical curve based on the criteria for investigating vertical sight distance established in Subsection 1.1.1

b. The PVI (point of vertical intersection of two grades) station shall be located at an even 25-foot station increment where feasible.

c. For an "A" less than or equal to 0.25 percent, an angle point shall be established, and no vertical curve used.

Exhibit 1-8 Design Controls for Mainline Roadway Vertical Curves

Design Speed (mph)	Stopping Sight Distance (ft)	Crest K	Sag K
	Minimum		
60	570	245	136
70	730	400	181

1.2.7. Pavement

Pavement design shall be in accordance with Subsection 6.7.4 of this Manual.

1.2.8. **Typical Section**

1. For typical mainline roadway dimensions and cross slopes for normal and superelevated sections see Exhibit 1-9 and Exhibit 1-10.
2. Rumble Strips

Rumble strips shall be constructed on all mainline roadway outside shoulders and on all median shoulders that are 5 feet or greater in width. Placement of rumble strips along mainline roadways shall be limited as follows:

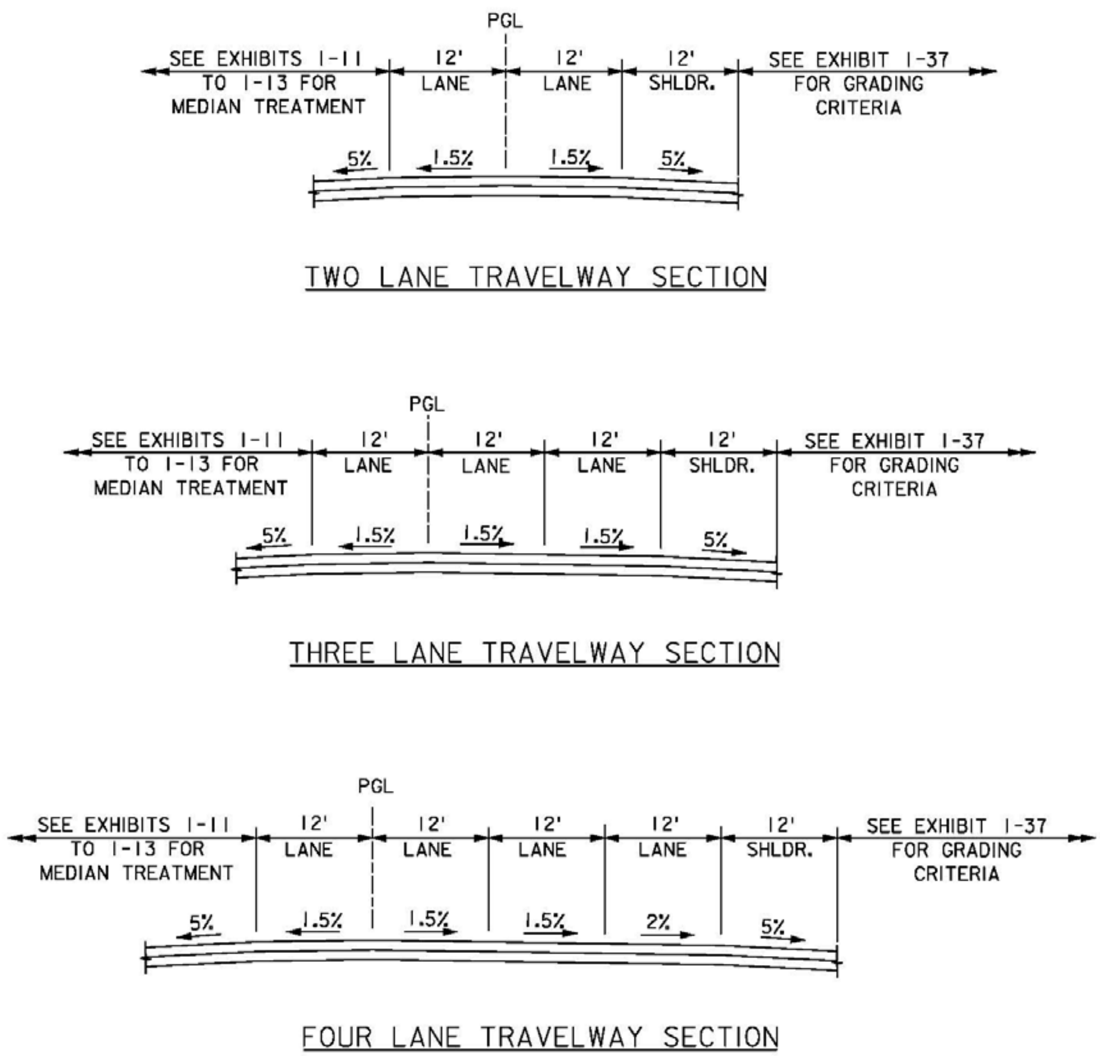
   a. On approach to mainline toll plazas, the rumble strips shall terminate at the end of the mainline normal section.
   b. At entrance ramp terminals, rumble strips on outside shoulders shall terminate at the point of the physical gore and resume at the end of the acceleration lane taper.
   c. At exit ramp terminals, rumble strips on outside shoulders shall terminate at the start of the deceleration lane taper and resume at the point of the physical gore.
   d. On approach to bridges, the rumble strips shall terminate at the abutment joint.
   e. For rumble strip limitations at U-Turns and Z-Turns, refer to Subsection 1.5.4 and Subsection 1.5.4, respectively.
   f. Rumble strips may be eliminated at other locations at the direction of the Authority's Engineering Department.

3. Median Treatment
   a. The median type to be used shall be dictated by the overall design considerations of a specific situation. The various median types are shown on Exhibit 1-11 to Exhibit 1-13. Medians other than the standards shown shall require approval from the Authority's Engineering Department.
   b. The standard centerline median width (edge of travel way to edge of travel way) shall be 26 feet. The absolute minimum width shall be 13 feet or 7 feet, depending on the specific situation, to match the existing roadway section design.
   c. The standard inner-outer median width (edge of travel way to edge of travel way) shall be 26 feet. Where the outer roadway is 4 lanes, the standard width shall be 33 feet between same direction roadways. The absolute minimum width shall be 20 feet or 15 feet, depending on the specific situation, to match the existing roadway section design.
4. Lateral Bridge Clearances

For mainline roadways, clearances shall be provided as shown on Exhibit 1-14.

5. For deviations to left shoulder widths on approach roadways to structures, refer to Subsection 3.2.1.3. Shoulder width shall be tapered at a rate of 1:100.

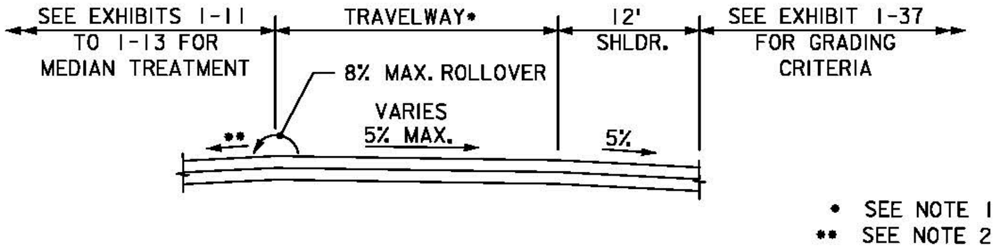
Exhibit 1-9 Mainline Roadway Typical Sections (Normal Sections)



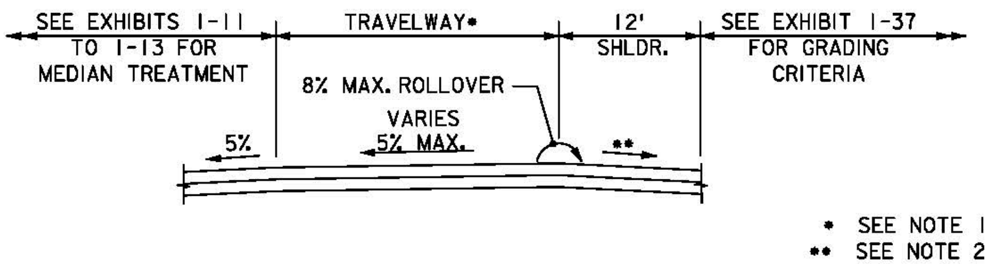
NOTES:

1. ROADWAY CROSS SLOPES SHALL BE ADJUSTED AS NEEDED AS PER SECTION 1.2.5.
2. ABSOLUTE MINIMUM SHOULDER WIDTH SHALL BE 10 FEET.

Exhibit 1-10 Mainline Roadway Typical Sections (Superelevated Sections)



SUPERELEVATED SECTION - CURVE RIGHT



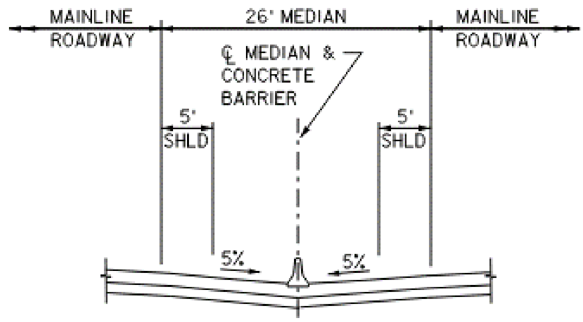
SUPERELEVATED SECTION - CURVE LEFT

NOTES:

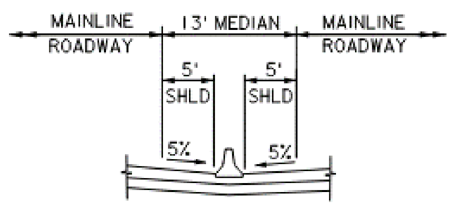
1. LANE WIDTHS AND PGL LOCATION ARE THE SAME AS SHOWN FOR THE NORMAL SECTIONS IN EXHIBIT 1-9.

2. FOR SUPERELEVATED CROSS SLOPE ≤ 3%, THE SHOULDER CROSS SLOPE SHALL BE 5% MAXIMUM. FOR SUPERELEVATED CROSS SLOPE > 3% TO 5% MAXIMUM, THE SHOULDER CROSS SLOPE SHALL VARY FROM 5% MAXIMUM TO 3% MINIMUM. ROLLOVER FROM THE ADJACENT LANE TO SHOULDER SHALL NOT EXCEED 8% MAXIMUM.

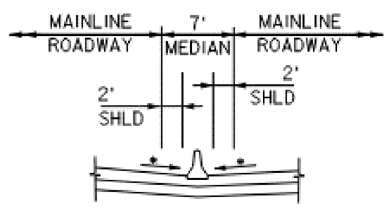
Exhibit 1-11 Center Median Typical Sections



STANDARD



DESIRABLE MINIMUM



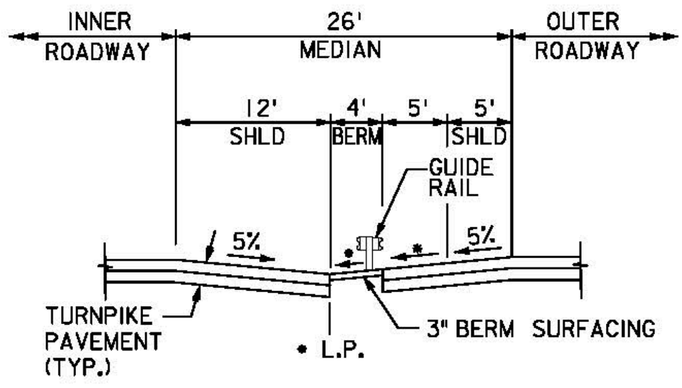
* SEE NOTE 2

ABSOLUTE MINIMUM

NOTES:

1. TURNPIKE PAVEMENT SHALL BE USED ACROSS ENTIRE CENTER MEDIAN.
2. MATCH ADJACENT LANE CROSS SLOPE, MIN. 1.5%.
3. NORMAL SHOULDER CROSS SLOPE = 5%. SEE EXHIBIT 1-10 FOR CROSS SLOPE ADJUSTMENTS IN SUPERELEVATED SECTIONS.
4. SEE STANDARD DRAWINGS FOR UNDERDRAIN DETAILS.

Exhibit 1-12 Inner-Outer Median Typical Sections (10-12 Lanes)



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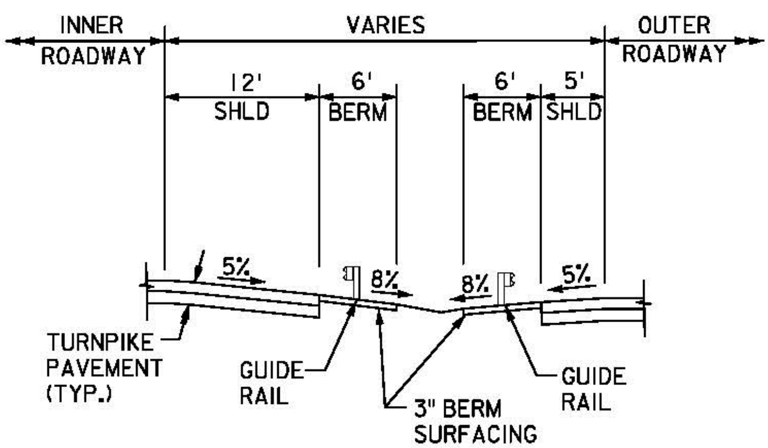


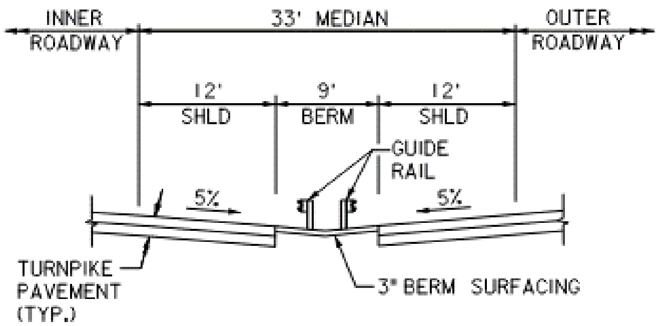
WIDE MEDIAN

NOTES:

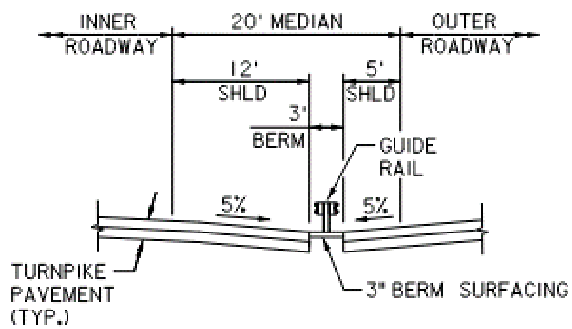
1. NORMAL SHOULDER CROSS SLOPE = 5%. SEE EXHIBIT 1-10 FOR CROSS SLOPE ADJUSTMENTS IN SUPERELEVATED SECTIONS.

2. MATCH SHOULDER CROSS SLOPE OR 10% MAX. AS NEEDED TO MEET THE GRADE OF THE INNER ROADWAY. THE MEDIAN AREA BETWEEN SHOULDERS SHALL BE GRADED TO LOCATE THE LOW POINT OF THE SECTION AT THE BACK OF THE INNER ROADWAY SHOULDER AND 2' OFFSET FROM THE FACE OF GUIDE RAIL AS SHOWN.

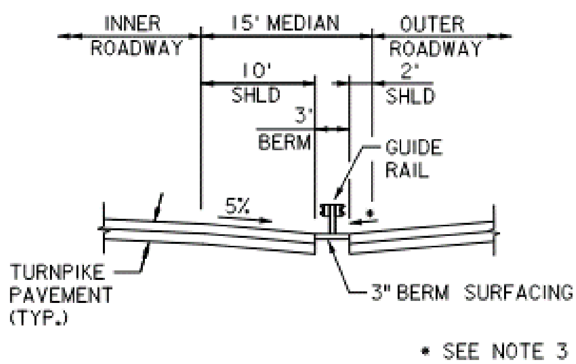
Exhibit 1-13 Inner-Outer Typical Sections (14 Lanes)



STANDARD



DESIRABLE MINIMUM

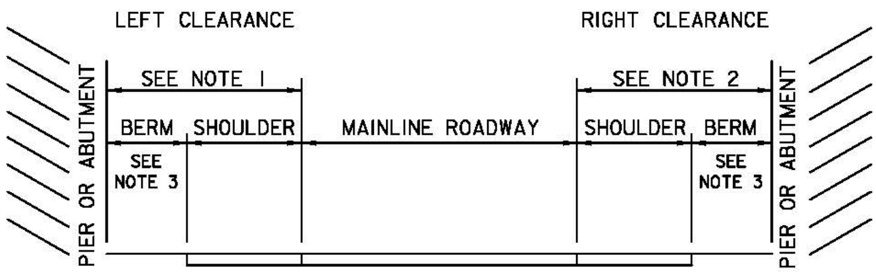


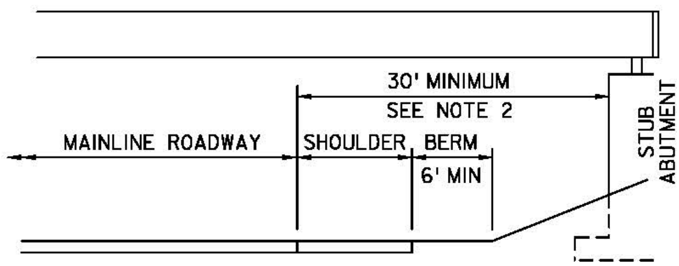
ABSOLUTE MINIMUM

NOTES:

1. NORMAL SHOULDER CROSS SLOPE = 5%. SEE EXHIBIT 1-10 FOR CROSS SLOPE ADJUSTMENTS IN SUPERELEVATED SECTIONS.
2. FOR UNDERDRAIN DETAILS, REFER TO THE STANDARD DRAWINGS.
3. MATCH ADJACENT LANE CROSS SLOPE, MIN. 1.5%.

Exhibit 1-14 Lateral Bridge Clearances - Mainline





TURNPIKE UNDERPASS

NOTES:

1. PIERS LOCATED IN THE CENTER MEDIAN OF THE TURNPIKE MAINLINE SHALL BE PLACED AT THE CENTERLINE OF THE MEDIAN. FOR PIERS LOCATED WITHIN THE INNER / OUTER MEDIAN OF DUALIZED ROADWAYS, THE PIER SHALL BE PLACED SUCH THAT THE MINIMUM SHOULDER DIMENSIONS AS SHOWN IN EXHIBITS 1-12 AND 1-13 FOR BOTH INNER AND OUTER ROADWAYS ARE MAINTAINED AT ALL TIMES.
2. PROVISION FOR ADDITIONAL LANES SHOULD BE CONSIDERED WHEN DETERMINING THE PIER OR ABUTMENT LOCATION ALONG THE OUTSIDE OF THE TURNPIKE MAINLINE.
3. ROADSIDE PROTECTION OF PIERS AND ABUTMENTS SHALL BE DESIGNED IN ACCORDANCE WITH SECTION 4 OF THIS MANUAL.

1.2.9. **Detours**

1. The minimum design speed shall be 5 mph over regulatory speed limit with no reduction in the posted speed limit. Absolute minimum reduction in design speed shall be 10 mph.
2. Horizontal Alignment
   a. Desirable minimum radius curve shall be 3,000 feet. Absolute minimum radius curve shall be 1,800 feet. When back-to-back reverse curves are necessary, a sufficient tangent distance to effect the superelevation transitions is to be provided.

b. Superelevation rates and transition lengths are to be consistent with the horizontal alignment and shall be reviewed on a case-by-case basis with the objective of attaining the smoothest ride possible.

3. Vertical Alignment

   Maximum profile grade shall be 3 percent. Minimum profile grade shall be sufficient to keep pavement free of ponding water.

4. Detour pavement shall be the same as mainline pavement. Any use of a substandard pavement section for a short period of time is subject to Authority's Engineering Department approval.

5. Typical detour section shall consist of normal 12-foot lanes and normal left and right shoulders throughout. Variations to this shall be treated with standard maintenance and protection of traffic practices.

6. Clearances shall be the same as for mainline roadways and interchange ramps. Refer to Subsection 1.1.1.

7. Refer to Section 10 - of this manual for detour signing.

8. All detours must be striped as if they were a permanent roadway. Where necessary, temporary pavement stripes may be used.

9. Temporary construction measures necessary for the protection of the environment (e.g. area of construction detours or temporary stream crossings) shall be adequately shown on plans and permits, and the payment therefore covered in the plans and specifications.

1.3. INTERCHANGE RAMPS

1.3.1. Roadway Designation

Ramps shall be designated such that the origin and then the destination of that roadway are given in order (i.e. from the toll plaza to the north – TN Ramp or from the north inner roadway to the toll plaza – NIT). See Subsection 1.4.1 of the Procedures Manual for a complete listing.

1.3.2. Design Speed

The design speed for interchange ramps shall vary from 25 mph minimum to 50 mph maximum, with 40 mph desirable minimum for intermediate portions of long ramps. The central radius of the ramp shall be used for design speed control. Refer to Exhibit 1-15.

Exhibit 1-15 Minimum Curve Radii for Ramp Design Speed

Ramp Central Radius in Feet for Maximum Superelevation (E_{max}=6%)	Recommended Design Speed (mph)
150	25
235	30
340	35
485	40
650	45
840	50

1.3.3. Stopping Sight Distance

The minimum stopping sight distance for the various interchange ramp design speeds shall be as shown in Exhibit 1-16.

Exhibit 1-16 Minimum Stopping Sight Distance for Interchange Ramps

Design Speed (mph)	Minimum Stopping Sight Distance (ft)
25	155
30	200
35	250
40	305
45	360
50	425

1.3.4. Horizontal Alignment

1. Ramp Geometry

   a. The desirable minimum radius shall be 235 feet. The absolute minimum radius shall be 150 feet (waiver required from Chief Engineer). It is desirable to use as large a radius as project conditions will allow.

   b. Ramp configuration and transition curves shall be as indicated on Exhibit 1-17.

   c. The minimum lengths of curves shall be as indicated on Exhibit 1-17.

d. The minimum length of tangent between reverse curves shall be sufficient to accommodate the superelevation transitions between the reversing curves.

e. For typical acceleration and deceleration lane treatment, see Subsection 1.4.

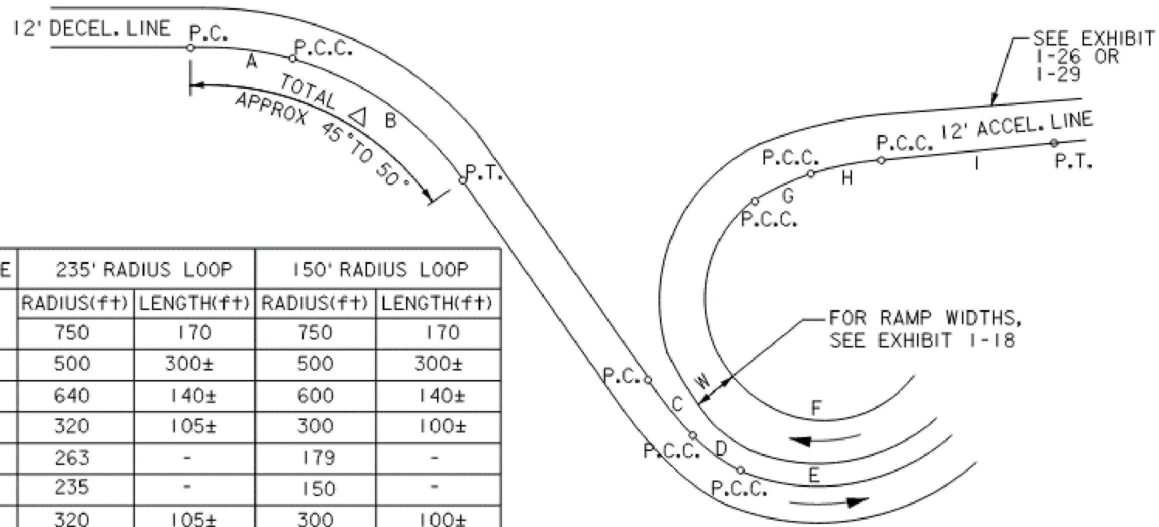
2. Ramp Lane Width

   a. Ramp lane width shall vary with horizontal radii as per Exhibit 1-18. Verify horizontal sight distance in accordance with Subsection 1.1.1.3 .

   b. In the area of horizontal transition curves, it is intended that smooth lane width transitions, controlled by the central radius, be used.

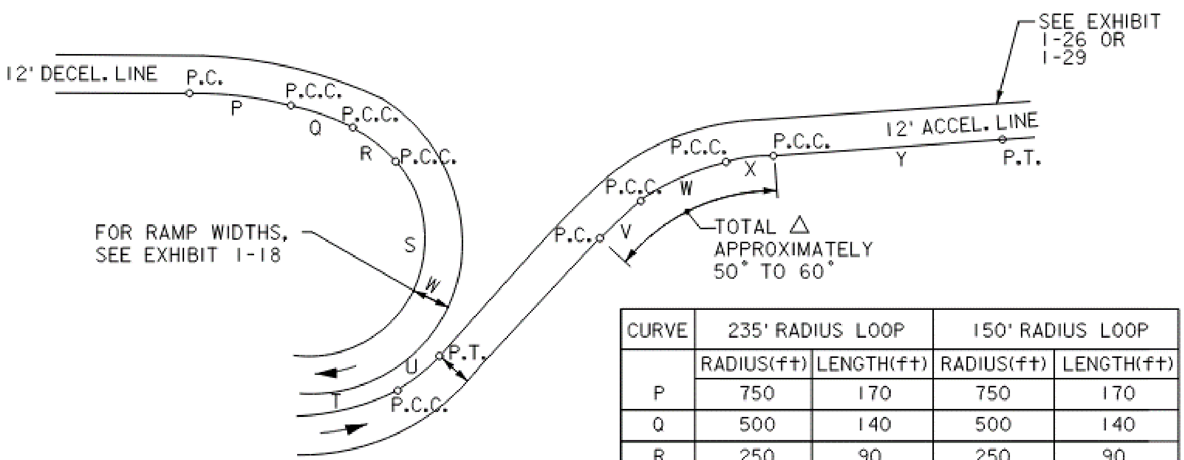
Exhibit 1-17 Interchange Ramp Geometry

INTERCHANGE RAMP GEOMETRY



CURVE	235' RADIUS LOOP		150' RADIUS LOOP	
	RADIUS(ft)	LENGTH(ft)	RADIUS(ft)	LENGTH(ft)
A	750	170	750	170
B	500	300±	500	300±
C	640	140±	600	140±
D	320	105±	300	100±
E*	263	-	179	-
F	235	-	150	-
G	320	105±	300	100±
H	640	140±	600	140±
I	1,000 MIN.	200±	1,000 MIN.	200±

TURNOUTS TO AND FROM ENTRANCE LOOP



CURVE	235' RADIUS LOOP		150' RADIUS LOOP	
	RADIUS(ft)	LENGTH(ft)	RADIUS(ft)	LENGTH(ft)
P	750	170	750	170
Q	500	140	500	140
R	250	90	250	90
S	235	-	150	-
T*	263	-	179	-
U	350±	110±	300±	100+
V	640±	140±	640	140±
W	320±	200±	320	200±
X	640	140±	640	140±
Y	1,000 MIN.	200±	1,000 MIN.	200±

* INCREASE RADII AS NECESSARY FOR TWO LANE INNER LOOP RAMP.

TURNOUTS TO AND FROM EXIT LOOP

Exhibit 1-18 Minimum Interchange Ramp Lane Widths by Radii

Radius at Lane Edge of Inside Curve	Lane Width for One Lane Ramp		Width of Two Lane Ramp
	Des. Min.	Abs. Min.	
150’	22’	18’	33’
200’	20’	17’	30’
235’	20’	16.5’	30’
250’	19’	16’	28.5’
300’	18’	15.5	27’
400’	18’	15’	26’
500’	18’	15’	26’
Tangent	12’	12’	24’

1.3.5. Superelevation

1. Interchange ramp superelevation rates shall be determined from Exhibit 1-19 based on a maximum superelevation rate of 6 percent.

   a. For a ramp profile grades less than 0.5 percent, the minimum ramp cross slope is to be increased from 1.5 to 2 percent. When the section is curbed, the shoulder cross slope is transitioned between 2 and 5 percent to control drainage flow along the curb.

   b. If a design assignment involves modification or resurfacing of an existing interchange ramp, the rate of superelevation to be used shall normally follow the current standard, as described in this section. However, if a bridge deck falls within the horizontal curve and the deck superelevation is not being upgraded, the rate of superelevation for the entire length of the horizontal curve shall not exceed that on the existing bridge deck.

Exhibit 1-19 Minimum Interchange Ramp Radii for Design Superelevation Rates E_{max}=6%

e_d (%)	V_d= 25 mph R(ft)	V_d= 30 mph R(ft)	V_d= 35 mph R(ft)	V_d= 40 mph R(ft)	V_d= 45 mph R(ft)	V_d= 50 mph R(ft)
1.5	2290	3130	4100	5230	6480	7870
2.0	1630	2240	2950	3770	4680	5700
2.2	1450	2000	2630	3370	4190	5100
2.4	1300	1790	2360	3030	3770	4600

e_d (%)	V_d= 25 mph R(ft)	V_d= 30 mph R(ft)	V_d= 35 mph R(ft)	V_d= 40 mph R(ft)	V_d= 45 mph R(ft)	V_d= 50 mph R(ft)
2.6	1170	1610	2130	2740	3420	4170
2.8	1050	1460	1930	2490	3110	3800
3.0	944	1320	1760	2270	2840	3480
3.2	850	1200	1600	2080	2600	3200
3.4	761	1080	1460	1900	2390	2940
3.6	673	972	1320	1740	2190	2710
3.8	583	864	1190	1590	2010	2490
4.0	511	766	1070	1440	1840	2300
4.2	452	684	960	1310	1680	2110
4.4	402	615	868	1190	1540	1940
4.6	360	555	788	1090	1410	1780
4.8	324	502	718	995	1300	1640
5.0	292	456	654	911	1190	1510
5.2	264	413	595	833	1090	1390
5.4	237	373	540	759	995	1280
5.6	212	335	487	687	903	1160
5.8	186	296	431	611	806	1040
6.0	150	235	340	485	650	840

1. Tangent to Curve Transition

   a. Ramp superelevation shall be controlled by the central radius of the ramp. Full superelevation as indicated by the central radius of a ramp shall not be attained before that radius is reached. A smooth superelevation transition shall be provided over the length of the corresponding horizontal transition.

   b. The minimum length of superelevation runoff on interchange ramps shall be determined from the same methods used on mainline roadways. See Subsection 1.2.5. The values for maximum relative gradient shall be determined from Exhibit 1-20 for the various interchange ramp design speeds.

   c. The minimum tangent runout length required to remove adverse crown on interchange ramps shall be determined from the same methods used on mainline roadways. See Subsection 1.2.5.

d. The location of the superelevation runoff length with respect of the point of curvature (PC) shall be as shown in Exhibit 1-21.

Exhibit 1-20 Maximum Relative Gradient (Interchange Ramp)

Design Speed (mph)	Maximum Relative Gradient percent
25	0.70
30	0.66
35	0.62
40	0.58
45	0.54
50	0.50

Exhibit 1-21 Location of Superelevation Runoff (Interchange Ramps)

Design Speed (mph)	Portion of Runoff Located Prior to the Curve			
	No. of Lanes Rotated			
	1.0	1.5	2.0 – 2.5	3.0 – 3.5
25 – 45	0.80	0.85	0.90	0.90
50	0.70	0.75	0.80	0.85

If the specific values listed above are not attainable for a given location, then the portion of superelevation runoff prior to the PC shall fall within the range of 0.60 to 0.90.

1.3.6. Vertical Alignment

1. Grades
   a. Desirable maximum profile upgrade shall be 5 percent. Absolute maximum profile upgrade shall be 7 percent.
   b. Maximum profile downgrade shall be 5 percent.
   c. Desirable minimum profile grade shall be 0.5 percent. Absolute minimum profile grade shall be 0.3 percent. See Subsection 1.3.5 for ramp superelevation with less than 0.5 percent profile grade.
   d. Short tangents (less than 100 ft) between vertical curves should be avoided if possible. In this case, it is preferable for the location of the PVT and PVC of successive curves to coincide.
2. Vertical Curves
   a. The minimum length of vertical curve shall be determined from the same methods used on mainline roadways. See Subsection 1.2.6. The minimum value of K shall be determined from Exhibit 1-22 for the various interchange ramp design speeds.
   b. The PVI (point of vertical intersection of two grades) station shall be located at an even 25-foot station increment where feasible.
   c. For an "A" less than or equal to 0.25 percent, an angle point shall be established, and no vertical curve used.

Exhibit 1-22 Design Controls for Interchange Ramp Vertical Curves

Design Speed (mph)	Stopping Sight Distance (ft)	Crest K	Sag K
	Minimum		
25	155	20	30
30	200	30	40
35	250	47	50
40	305	70	64
45	360	98	79
50	425	136	96

1.3.7. Pavement

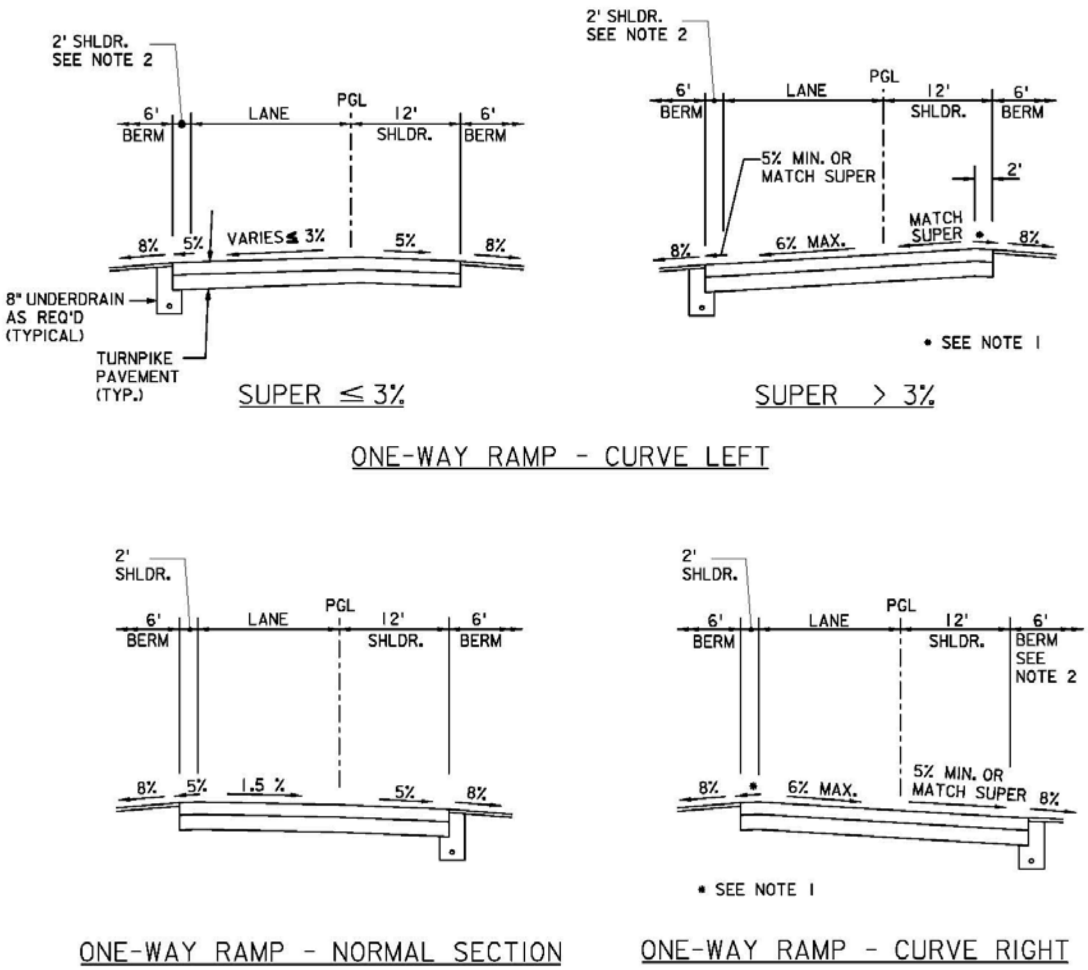
The interchange ramp pavement section shall be similar to the mainline section. See Subsection 1.2.7

1.3.8. Typical Section

1. For typical interchange ramp dimensions and cross slopes for normal and superelevated sections, see Exhibit 1-23.
2. Rumble Strips shall not be constructed on interchange ramps. Refer to Subsection 1.2.8 for the limits of rumble strip construction at interchange areas.
3. Median treatment between ramps is shown on Exhibit 1-24.
4. For placement of asphalt lip curb with guide rail, see Section 4.
5. Lateral Bridge Clearances

   For ramps, clearances shall be provided as shown on Exhibit 1-25.

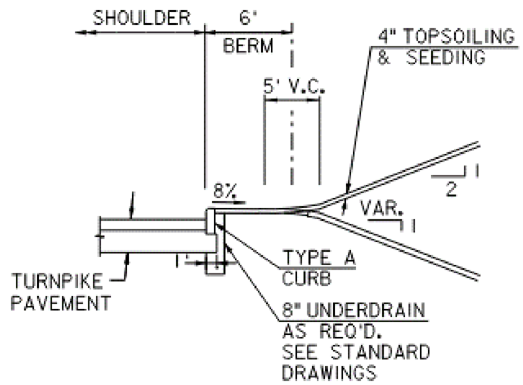
Exhibit 1-23 Interchange Ramp Typical Sections



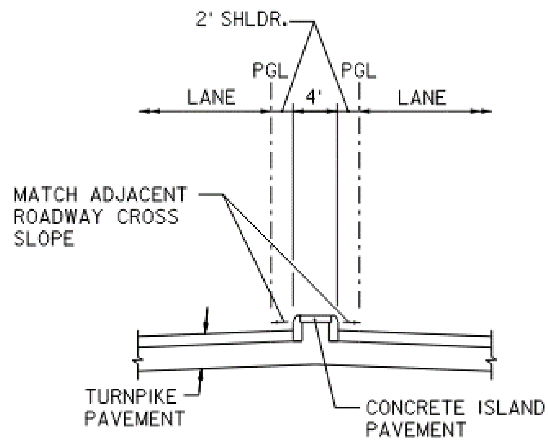
NOTES:

1. FOR SUPERELEVATED ROADWAY CROSS SLOPE ≤ 3%, SHOULDER CROSS SLOPE = 5%. FOR SUPERELEVATED ROADWAY CROSS SLOPE >3% TO 6% MAXIMUM, SHOULDER CROSS SLOPE SHALL VARY FROM <5% MAXIMUM TO 2% MINIMUM. (i.e. 8% MAXIMUM ROLLOVER).
2. WIDEN, IF REQUIRED, FOR HORIZONTAL SIGHT DISTANCE AS NEEDED.
3. BERM AND GRADING CRITERIA FOR RAMPS SHALL BE SIMILAR TO THE MAINLINE AS SHOWN ON EXHIBIT 1-24 AND 1-37.

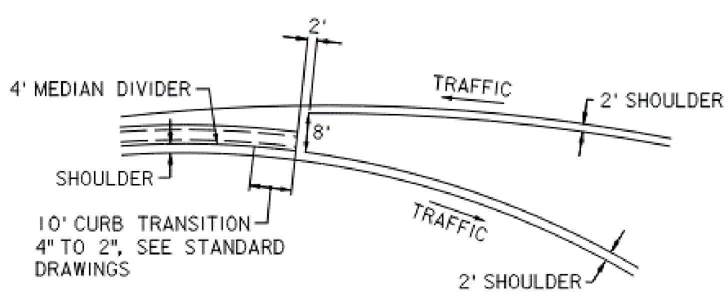
Exhibit 1-24 Interchange Ramp Curb Sections and Details



TYPICAL CURB SECTION

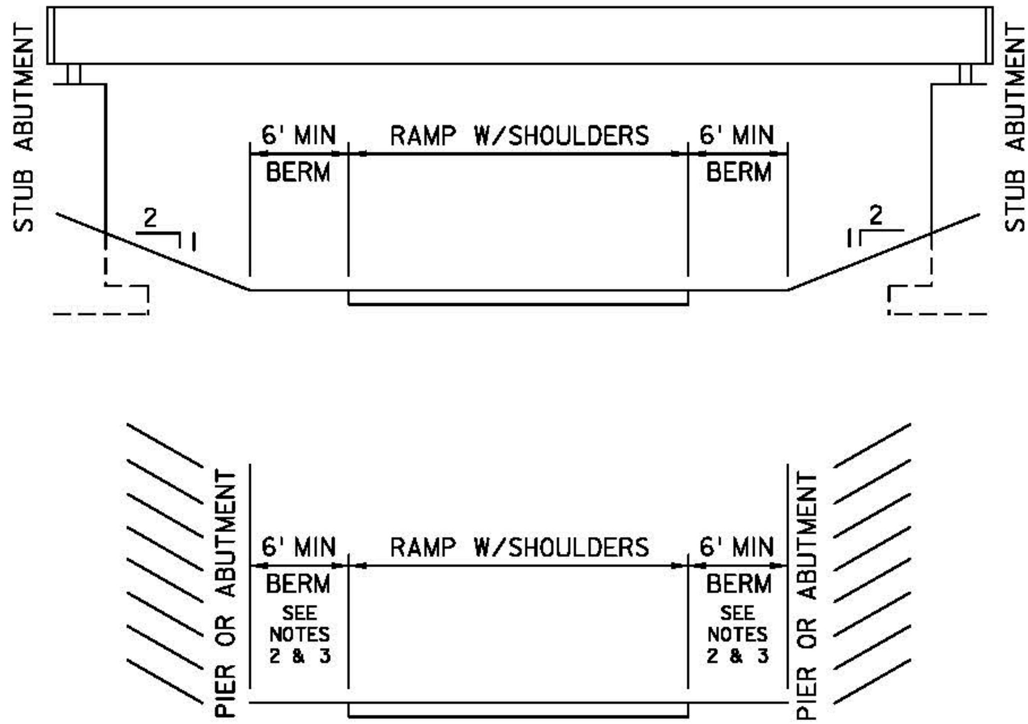


TWO-WAY RAMP DIVIDER

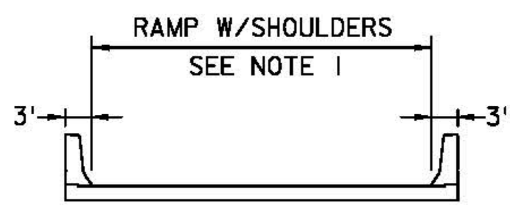


TWO-WAY RAMP CURB TRANSITION

Exhibit 1-25 Lateral Bridge Clearances - Ramps



RAMP UNDERPASS



RAMP OVERPASS

NOTES:

1. RAMP SHOULDER WIDTH ON STRUCTURE TO BE WIDENED AS NEEDED TO PROVIDE MINIMUM STOPPING SIGHT DISTANCES AS PER EXHIBIT 1-16.
2. STOPPING SIGHT DISTANCE ON HORIZONTAL CURVES GOVERNS OFFSET TO PIER OR ABUTMENT (SEE EXHIBIT 1-16).
3. ROADSIDE PROTECTION OF PIERS AND ABUTMENTS SHALL BE DESIGNED IN ACCORDANCE WITH SECTION 4.

1.3.9. **Detours**

1. The design speed shall be 25 mph minimum.
2. Horizontal Alignment
   a. Minimum radius curve shall be 150 feet.
   b. Superelevation rates and transition lengths are to be consistent with the horizontal alignment and shall be reviewed on a case-by-case basis with objective of attaining the smoothest ride possible.
3. Vertical Alignment

   Maximum profile grade shall be 7 percent. Minimum profile grade shall be sufficient to keep pavement free of ponding water.
4. Detour pavement shall be the same as mainline pavement. Any use of a substandard pavement section for a short period of time is subject to Authority's Engineering Department approval.
5. Typical detour section shall be similar to the normal ramp section. Variations to this shall be treated with standard maintenance and protection of traffic procedures.
6. Clearances shall be the same as for mainline roadways and interchange ramps. Refer to Subsection 1.1.1.
7. Refer to Section 10 of this manual for detour signing on ramps.
8. All detours must be striped as if they were a permanent ramp. Where necessary, temporary pavement stripes may be used.
9. All ramp detours shall be lighted; see Section 8 of this manual.
10. Temporary construction measures necessary for the protection of the environment (e.g. area of construction detours or temporary stream crossings) shall be adequately shown on plans and permit applications, and the payment therefore covered in the plans and specifications.

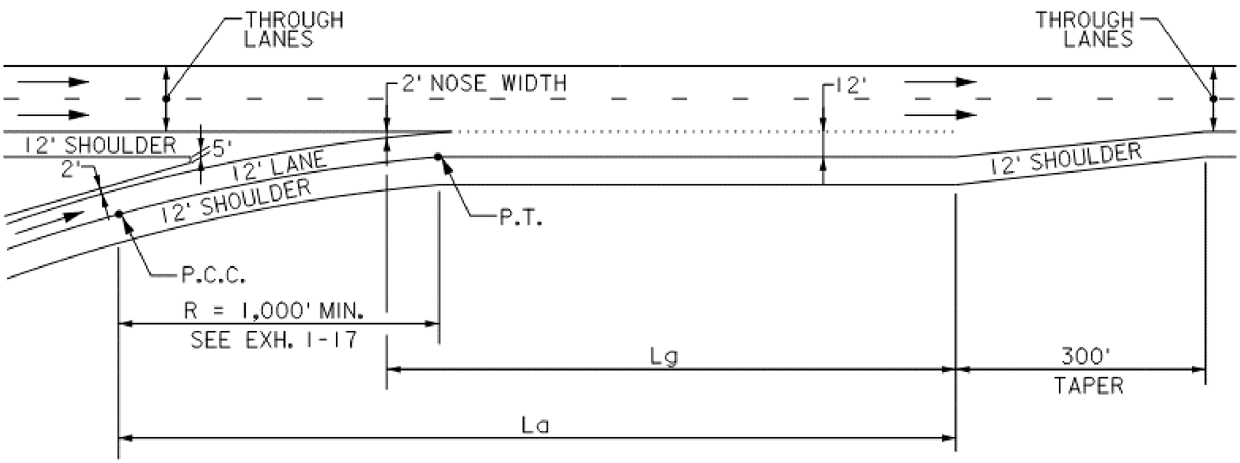
1.4. AUXILIARY LANES

1.4.1. **Entrance Ramp Acceleration Lanes**

1. Single Lane and Two-Lane Entrance ramps:
   a. A typical acceleration lane for a single lane entrance ramp is shown in Exhibit 1-26.
   b. A two-lane entrance ramp shall consist of the typical ramp acceleration geometry followed by a single lane drop. A typical two-lane entrance ramp is shown in Exhibit 1-29.

2. If the mainline is curved, the acceleration lane shall be curved to fit the required lengths and dimensions shown.
3. Where the acceleration lane falls within a section of roadway with 3 percent or greater profile (upgrade or downgrade), the acceleration lengths from Exhibit 1-27 shall be adjusted by the ratios indicated in Exhibit 1-28 to determine minimum acceleration lane lengths.
4. See PM Standard Drawings for entrance ramp pavement markings.
5. The continuity of the through (mainline) roadway shall be maintained at all times.

Exhibit 1-26 Single Lane Entrance Ramp



NOTES:
1. "La" SHALL BE OBTAINED FROM EXHIBITS 1-27 AND 1-28 FOR ACCELERATION LENGTH AND GRADE ADJUSTMENT FACTORS.
2. "Lg" SHALL BE 300' MINIMUM, MEASURED FROM 2' NOSE WIDTH TO START OF TAPER.
3. THE VALUE OF "La" OR "Lg", WHICHEVER RESULTS IN THE GREATER DISTANCE DOWNSTREAM FROM WHERE THE NOSE WIDTH EQUALS 2' SHALL DETERMINE THE LENGTH OF THE RAMP ACCELERATION LANE.

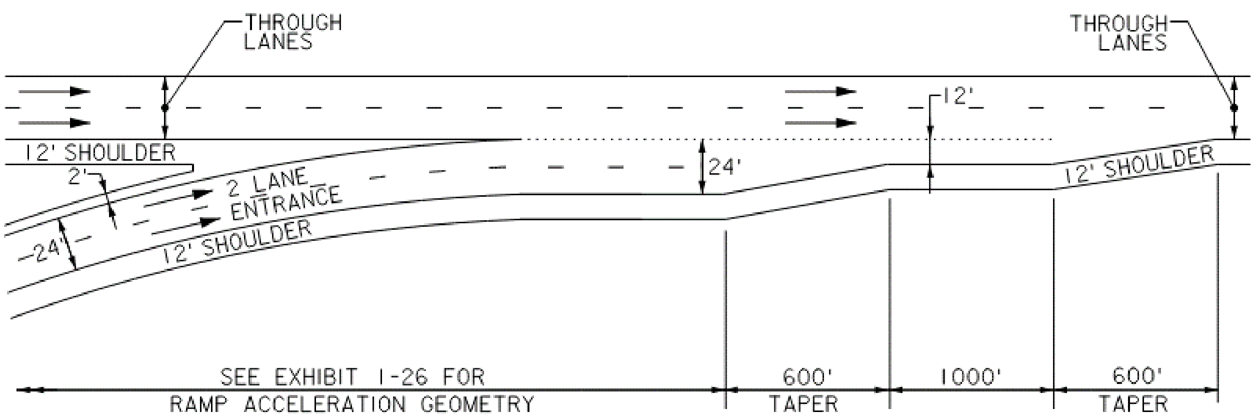
Exhibit 1-27 Minimum Length of Acceleration Lane

Highway Design Speed, *V* (mph)	Acceleration Length, *La* (ft) for Entrance Curve Design Speed (mph)					
	25	**30**	**35**	**40**	**45**	**50**
60	1020	910	800	550	420	180
70	1420	1350	1230	1000	820	580

Exhibit 1-28 Acceleration Lane Grade Adjustment Factors

Highway Design Speed (mph)	Acceleration Lanes Ratio of Length on Grade to Length of Level for Design Speed of Turning Curve (mph)				
	25	**30**	**40**	**50**	**All Speeds**
	3 to 4 percent upgrade				3 to 4 percent downgrade
60	1.4	1.5	1.5	1.6	0.6
70	1.5	1.6	1.7	1.8	0.6
	5 percent upgrade				5 percent downgrade
60	1.7	1.9	2.2	2.5	0.5
70	2.0	2.2	2.6	3.0	0.5

Exhibit 1-29 Two-Lane Entrance Ramp

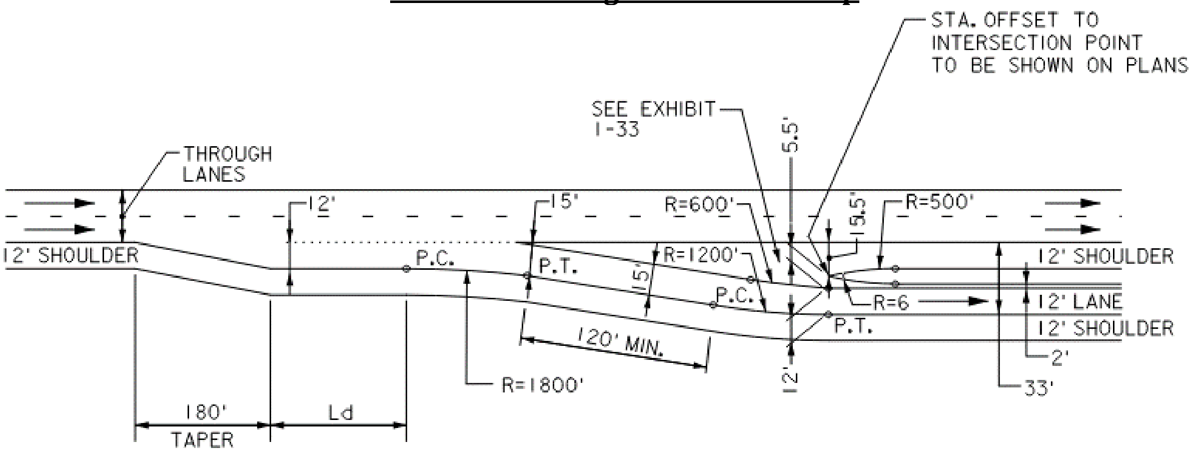


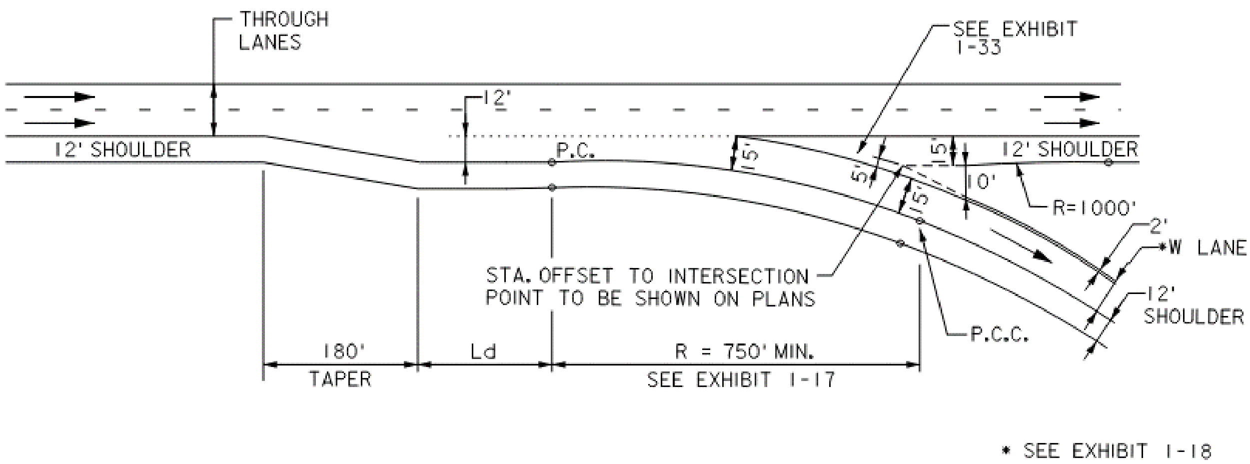
1.4.2. Exit Ramp Deceleration Lanes

1. Single Lane and Two-Lane Exit Ramps
   a. For Single Lane exit ramps there are two types of deceleration lanes as shown in Exhibit 1-30. The application of these two types is dependent upon the overall geometry of the situation. The “Parallel Ramp Configuration” is generally used in conjunction with a dual-dual roadway for exit from the inner roadway.
   b. A two-lane exit ramp shall consist of a single lane widening followed by the typical ramp deceleration. A typical two lane exit ramp is shown in Exhibit 1-33.
2. If the mainline is curved, the deceleration lane shall be curved to fit the required lengths and dimensions shown.

3. Where the deceleration lane falls within a section of roadway with 3 percent or greater profile (upgrade or downgrade), the deceleration lengths from Exhibit 1-31 shall be adjusted by the ratios indicated in Exhibit 1-32 to determine minimum deceleration lane lengths.
4. See PM Standard Drawings for exit ramp pavement markings.
5. The continuity of the through (mainline) roadway shall be maintained at all times. Where directed by the Authority, the mainline through lanes may be reduced with a lane drop that maintains through lanes for 900 feet beyond the exit ramp followed by a 300-foot taper.

Exhibit 1-30 Single Lane Exit Ramp





NOTES:

1. "Ld" SHALL BE DETERMINED FROM EXHIBITS 1-31 AND 1-32 FOR DECELERATION LANE LENGTH AND GRADE ADJUSTMENT FACTORS.

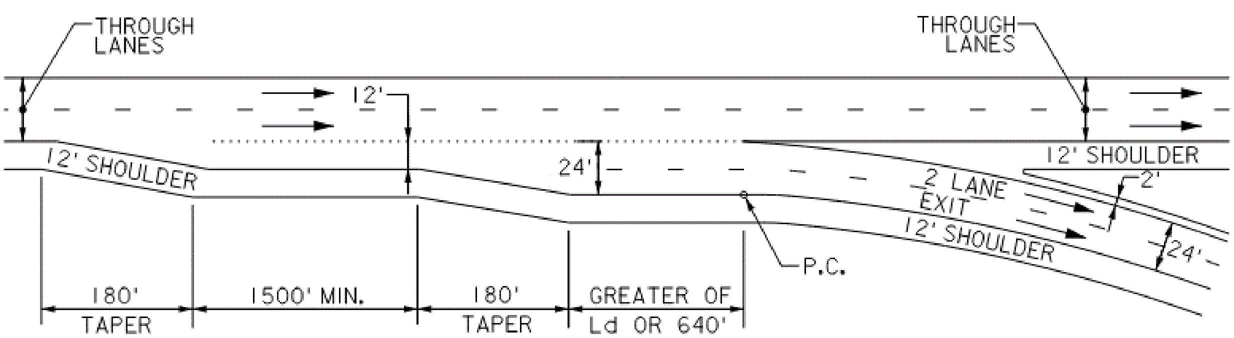
Exhibit 1-31 Minimum Length of Deceleration Lane

Highway Design Speed, *V* (mph)	Deceleration Length, *Ld* (ft) for Exit Curve Design Speed (mph)					
	25	**30**	**35**	**40**	**45**	**50**
60	460	430	405	350	300	240
70	550	520	490	440	390	340

Exhibit 1-32 Deceleration Lane Grade Adjustment Factors

Highway Design Speed (mph)	Deceleration Lanes Ratio of Length on Grade to Length of Level for Design Speed of Turning Curve (mph)	
	All Speeds	
	3 to 4 percent upgrade	3 to 4 percent downgrade
All Speeds	0.9	1.2
	5 percent upgrade	5 percent downgrade
All Speeds	0.8	1.35

Exhibit 1-33 Two-Lane Exit Ramp



1.4.3. Major Roadway Merge and Diverge

A merge of two major roadways of three lanes into one major roadway of three lanes shall require a total minimum length of 3,600 feet for three consecutive lane drops (each lane drop consisting of a 900-foot continued lane followed by a 300-foot taper), with the roadway lanes on the left having mainline priority.

A diverge of a major roadway of three lanes into two separate major roadways of three lanes each shall require a total minimum length of 3,600 feet from the beginning of the diverge start to the nose of the separated roadways, with the left, right, and then center lane each expanding consecutively. The expansion of the left and right lane are each developed by a 180-foot taper followed by a 1,020-foot continued lane and the expansion of the center lane is developed by a continuous lane widening over 1,200 feet).

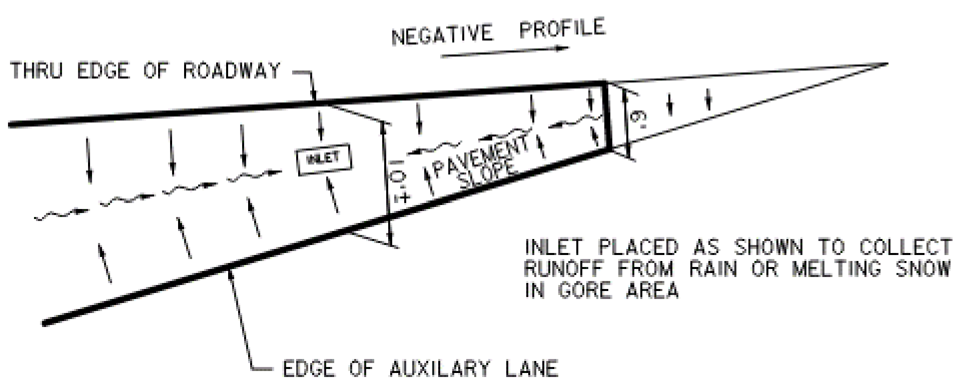
1.4.4. Climbing Lanes

With a maximum of 3 percent grades, the Authority does not use truck climbing lanes. As indicated in Subsection 1.2.6, the absolute minimum length of vertical tangent shall be limited by a maximum permissible loss in truck speed of 10 mph.

1.4.5. Nose Grading

Typical nose grading between a mainline roadway and an auxiliary lane(s) is shown in Exhibit 1-34.

Exhibit 1-34 Typical Nose Grading



1.5. OTHER ROADWAYS

1.5.1. Crossroads

Where local roads are being replaced, the intent of the Authority with respect to any work under the jurisdiction of the state, county, municipality, or any other agency is “replacement in kind”, according to the present standards of that agency. All such work is subject to the approval of the Authority’s Engineering Department and must be previously agreed to in writing by the concerned agency, as noted elsewhere in this manual and the Procedures Manual.

Similarly, all detouring and/or closing of local roads during construction must be approved by the appropriate agencies in accordance with the Procedures Manual.

1.5.2. Access and Service Roads

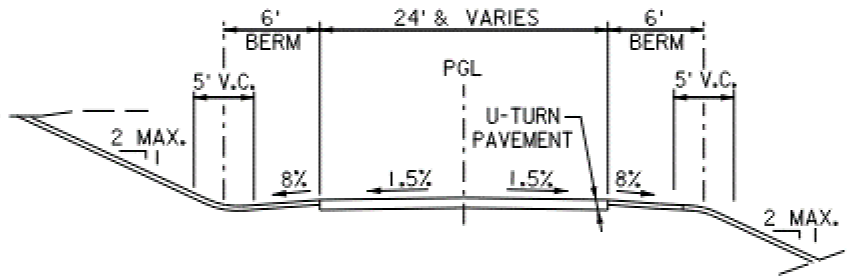
Treatment shall be similar to Subsection 1.5.1. Where the Authority has jurisdiction, the pavement design shall be in accordance with Subsection 6.7.4 of this Manual U-Turns

1.5.3. U-Turns

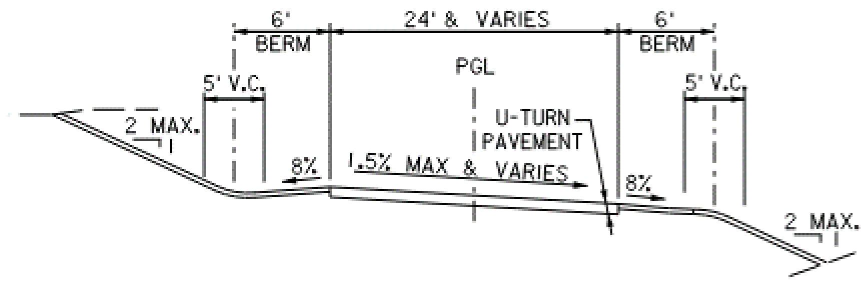
1. U-Turns shall be designated by milepost location. Refer to Section 7 for U-Turn signing.
2. Location
    a. Within one mile of and on each side of an interchange.
    b. No more than five miles apart between interchanges.
3. Configuration and Alignment
    a. All U-Turns shall be grade separated through the end span of a structure when the mainline passes over a crossroad etc., or on a separate overhead structure when necessary.
    b. Maximum profile grade shall be 5 percent.
    c. Rumble strips shall not be placed in the mainline shoulder within 300 feet on either side of the U-Turn entrance / exit.
    d. For all other information, see Exhibit 1-35 and Exhibit 1-36.
4. Pavement design shall be in accordance with Subsection 6.7.4 of this Manual.

Exhibit 1-35 U-Turn Geometric Criteria

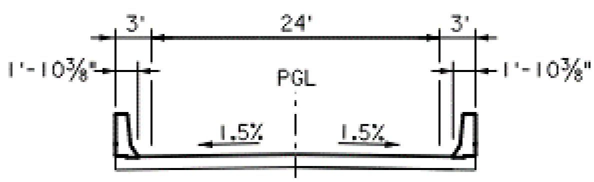
Exhibit 1-36 U-Turn Typical Sections



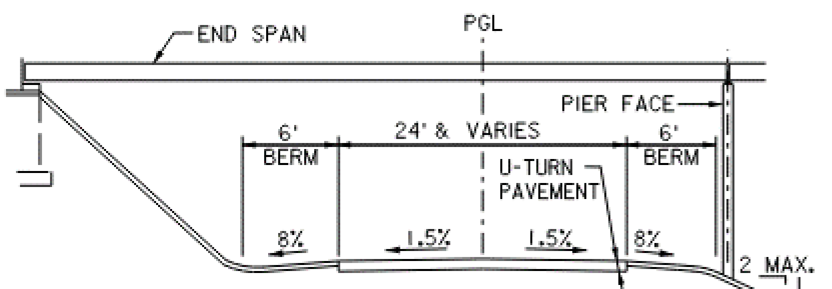
U-TURN NORMAL SECTION



U-TURN SUPERELEVATED SECTION



U-TURN STRUCTURAL SECTION



U-TURN SECTION UNDER STRUCTURE

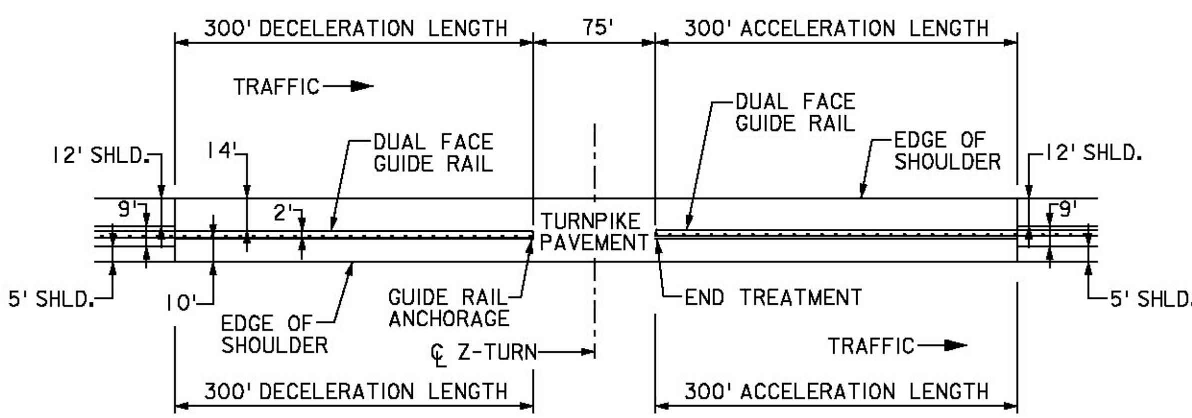
NOTE:

1. SEE EXHIBIT 1-35 FOR U-TURN GEOMETRY AND RAMP WIDENING.

1.5.4. Z-Turns

1. Z-Turns shall be designated by milepost location.
2. Use and Location
   a. Z-Turns shall be used on dual-dual roadway between same direction roadways as a connection between those roadways.
   b. Z-Turns shall be used in conjunction with grade separated U-turns and shall be approximately 2,500 feet on each side of the U-Turns for 70 mph design speed and approximately 2,000 feet for 60 mph design speeds. The absolute minimum distance shall be 1,500 feet.
   c. Drainage within Z-Turn median shall be maintained.
   d. Refer to Section 7 for signing.
3. Configuration
   a. Z-Turns shall be at-grade crossovers as shown on Exhibit 1-37.
   b. Rumble strips shall not be placed within 300 feet of the Z-Turn opening on either side of the median.
4. Pavement design shall be in accordance with Subsection 6.7.4 of this Manual.
5. See GR Standard Drawings for further details concerning Z-Turn configuration.

Exhibit 1-37 Z-Turn Geometric Criteria



Z-TURN GEOMETRIC CRITERIA

1.6. Grading Criteria

The general grading criteria set forth in this section are intended to be used as guidelines to achieve an economically feasible, safe and aesthetically pleasing design. Variations to the specified criteria are permissible as long as the design adequately complies with the intent of the guidelines. Design side slopes based on slope stability as determined according to Subsection 6.7. Variations in side slopes should be investigated in order to obtain a favorable earthwork balance. Every effort is to be made to limit the use of critical slopes where feasible so as to eliminate the need for guide rail. Consideration shall be given to the impact on right of way, earthwork, aesthetics, existing trees, utilities, regulated areas, etc.

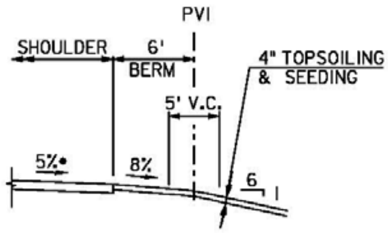
1.6.1. Grading in Fill Areas

1. Variable side slopes, depending on the height of fill at the PVI of berm, shall be used for all ramps and for existing Turnpike roadways. See Exhibit 1-38.
   a. 0 - 5 feet fills – 6H:1V slope
   b. 5-10 feet fills – 4H:1V slope
   c. 10 feet and greater fills – 2H:1V slope maximum
2. Refer to Section 4 (Guide Rail/Median Barrier/Attenuator Design) of this Manual for guide rail requirements related to height of fill. Safety grading criteria may be utilized on mainline roadways as directed by the Authority's Engineering Department in order to eliminate guide rail warrants.
3. Mainline and ramp sections shall have a berm width of 6 feet minimum sloping away from the roadway at an 8 percent grade.
4. All roundings shall have 5-foot vertical curves.

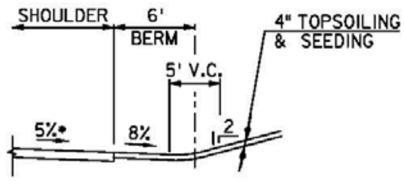
1.6.2. Grading in Cut Areas

1. 2:1 maximum side slopes are recommended throughout. See Exhibit 1-38.
2. Berm widths are the same as for fill sections.
3. All roundings shall have 5-foot vertical curves.
4. Cut sections in rock will be subject to Authority's Engineering Department approval of the Engineer's soils recommendations.
5. In borrow projects, the Engineer shall investigate the possibility of using flatter cut slopes in an attempt to achieve a more favorable earthwork balance.

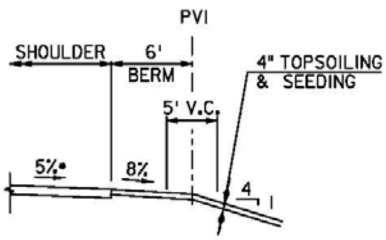
Exhibit 1-38 Turnpike Grading Criteria



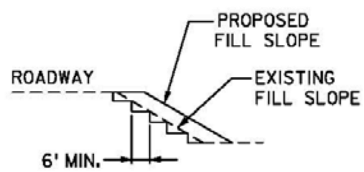
FILLS LESS THAN 5'



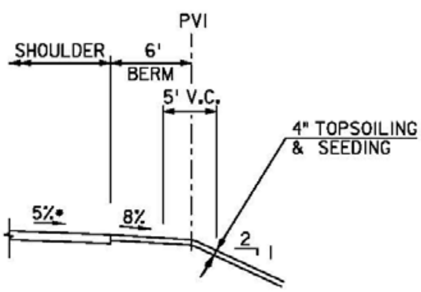
TYPICAL CUT SECTION



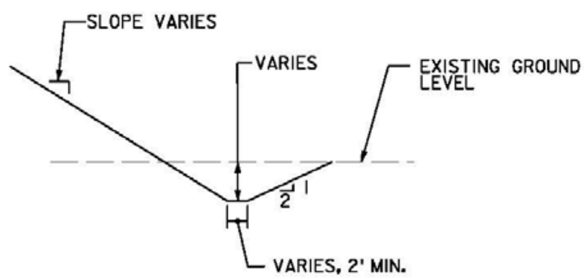
FILLS 5' TO 10'



BENCHING DETAIL



FILLS GREATER THAN 10'
(SEE NOTE #3)



TOE OF SLOPE DITCH

NOTES:

1. HEIGHT OF FILL IS MEASURED FROM PVI OF BERM.

*2. NORMAL SHOULDER CROSS SLOPE IS 5%. SEE MAINLINE AND RAMP TYPICAL SECTIONS FOR CROSS SLOPE ADJUSTMENT IN SUPERELEVATED SECTIONS.

3. REFER TO SECTION 4 OF THIS MANUAL FOR GUIDE RAIL WARRANTS AND PLACEMENT.

1.7. FENCING

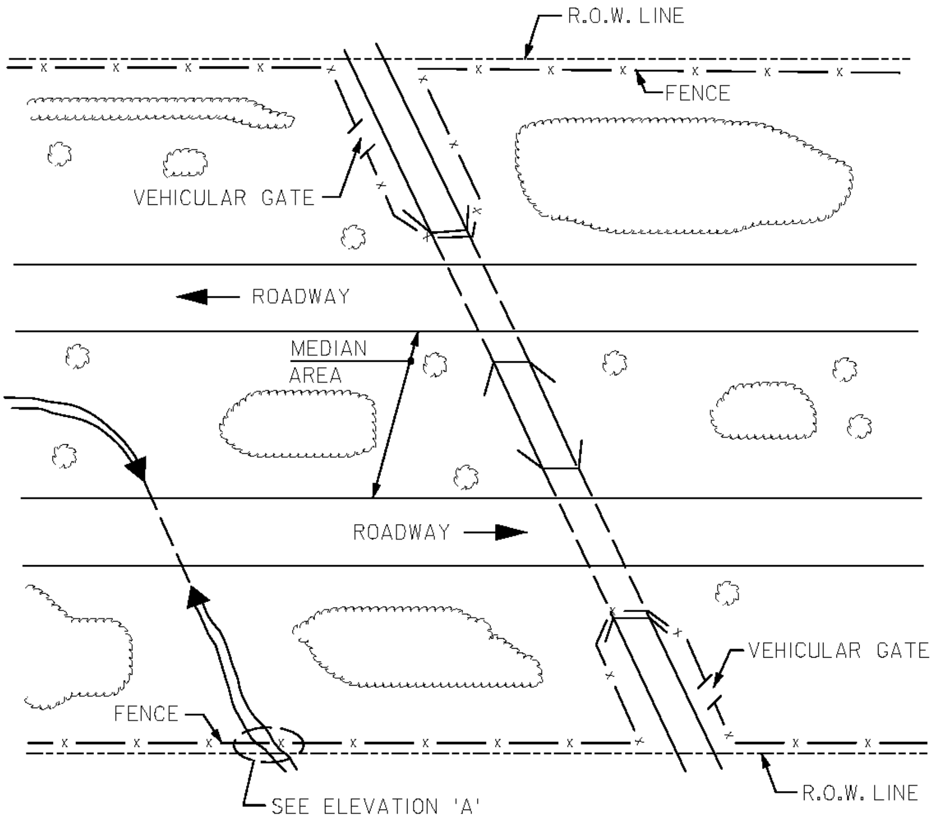
1.7.1. General

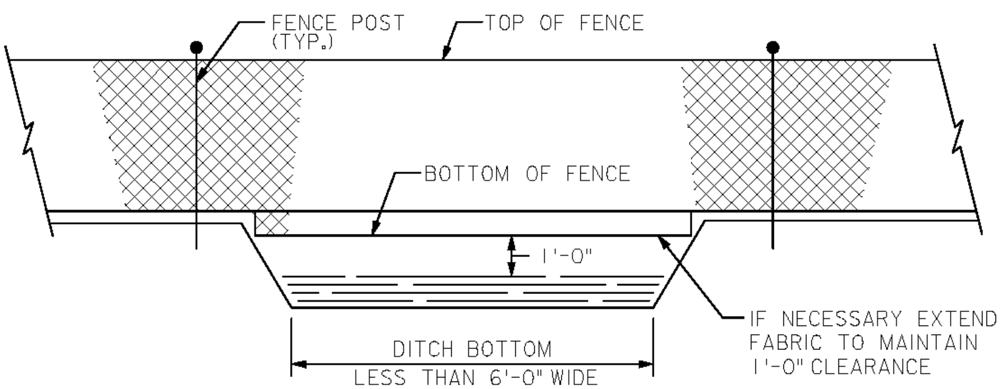
1. The policy of the Authority is to fence all Turnpike right of way.
2. Chain Link fence shall be used around interchanges, service areas and maintenance areas; along the right of way adjacent to existing commercial or residential areas or areas zoned for future commercial or residential development and 1,000 feet either side of the limits of these areas; along local roads and 500 feet either side of local roads along the Authority's right of way; and at all other locations at the direction of the Authority's Engineering Department.
3. Chain link fence shall be as per the Standard Drawings.

1.7.2. Configuration

1. Placement of fence with respect to the right of way line shall be as per the Standard Drawings.
2. Fence intersecting waterways which have a bottom width of 6 feet or greater will be turned and run parallel to the stream, along the top of bank, to the culvert headwall through the roadway embankment. Fencing will then be carried up behind the wingwall, across behind the headblock and back out to the right of way along the far side of the waterway. The median area crossed by the waterway will not be fenced. On one selected side of that portion of the fence running perpendicular between the ROW and roadway embankment, the engineer shall consider placing a single vehicular gate.
3. Vehicular gate dimensions shall be as shown on the Standard Drawings. These gates shall be placed on that side of each water course which affords best access for maintenance. Consideration is to be given to proximity of local road access, the extent of trees, vegetation and ground contour to determine if a gate is required and if so where it is to be placed.
4. A right of way fence is to be carried across streams and ditches having less than a 6-foot bottom width. Line posts are to be spaced so that no post is erected in the bed or slopes of the ditch. The bottom of the fence shall provide for one foot freeboard above the ditch high water elevation. When the profile line of the fence bottom is greater than one foot above the high water elevation, the fence fabric shall be extended lower as necessary to maintain the specified freeboard across the width of the ditch. See Exhibit 1-39 for general fence placement criteria at streams and ditches.

Exhibit 1-39 Stream Fencing Criteria





ELEVATION "A"

Section 2 - GARDEN STATE PARKWAY GEOMETRIC DESIGN

2.1. GENERAL

The geometric design criteria contained herein were developed by the Authority for its own particular needs. They are intended to equal or exceed standards currently being used for limited access highways and should be considered minimum criteria and increased wherever economically feasible. The use of substandard criteria, including absolute minimum / maximum values listed in this manual, shall require a Design Element Modification Request subject to approval by the Authority's Engineering Department. For any items not adequately outlined in this section, the Engineer should refer to the latest edition of AASHTO A Policy on Geometric Design of Highways and Streets and AASHTO Roadside Design Guide.

The design criteria are intended to be used as an aid toward sound engineering design. When individual circumstances arise that are not specifically covered, engineering judgment is to be exercised that represents the intent of the criteria shown. The overall objective should be an aesthetically pleasing and safe design that is geometrically compatible in all respects.

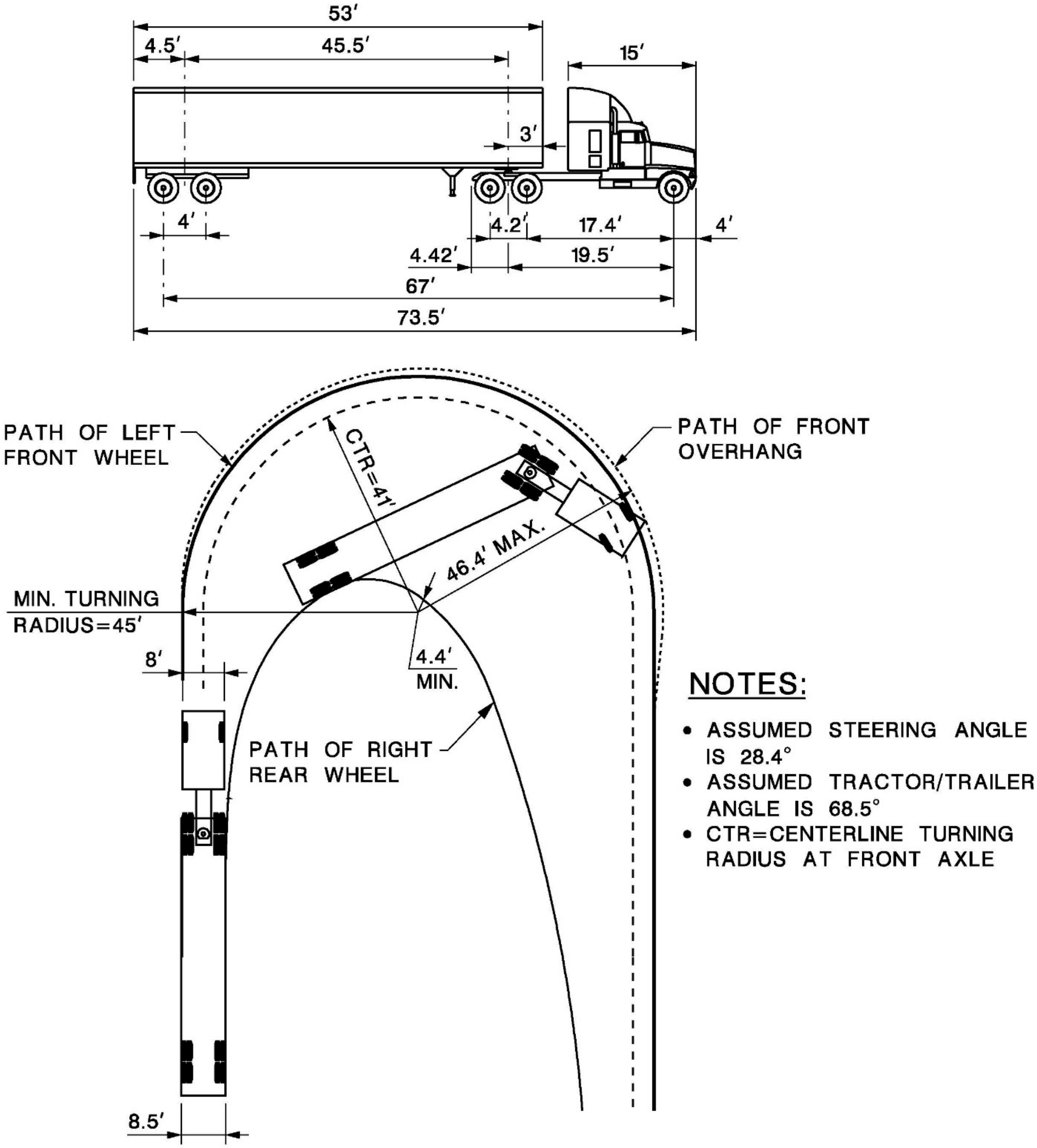
2.1.1. Design Controls

The following design controls shall be applicable on all Parkway roadways:

1. All types of design vehicles are permitted on the Parkway south of Interchange 105 at Milepost 106.4, while North of Interchange 105, trucks with a gross weight exceeding 6,999 pounds are prohibited. To be conservative the Design Vehicle WB-67 will be used to control geometric design for the entire roadway, see Exhibit 2-1.
2. Clearances
    a. Horizontal – Minimum clear zone width or less with appropriate roadside or median protection as directed by Section 4 of this Manual, and as further directed by Section 3 of this Manual for protection of structures.
    b. Vertical – Maintained over all roadways, including shoulders. Verification of all clearances shall be made with the controlling agency.
        i. Minimum clearance above Parkway roadways - As directed by Section 3 of this Manual or existing vertical clearance, whichever is greater. When resurfacing or widening a Parkway roadway under an existing crossing whose vertical clearance is less than the required minimum, the resulting vertical clearance must not be less than the existing condition.
        ii. Minimum clearance below Parkway roadways - As required by the agency having jurisdiction, but not less than the required minimum as directed by Section 3 of this Manual. When resurfacing or widening a roadway under an existing Parkway crossing whose existing vertical

clearance is less than the required minimum, the resulting vertical clearance must not be less than the existing condition.

Exhibit 2-1 Minimum Turning Path for Interstate Semi-Trailer (WB-67) Design Vehicle



2.2. Basic Geometric Design Elements

2.2.1. Sight Distances

1. Stopping Sight Distances

The minimum stopping sight distance is the distance required by the driver of a vehicle, traveling at a given speed, to bring his vehicle to a stop after an object on the road becomes visible. Stopping sight distance is measured from the driver's eyes, which is 3.5 feet above the pavement surface, to an object 6 inches high on the road. An object height of 2 feet may be used with Authority approval. See Exhibit 2-2 for minimum stopping sight distances for a given design speed, and Subsection 2.2.3 and Exhibit 2-12 for minimum and desirable K values.

Exhibit 2-2 Minimum Stopping Sight Distances

Design Speed (MPH)	Stopping Sight Distance in Feet, Minimum
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
70	730

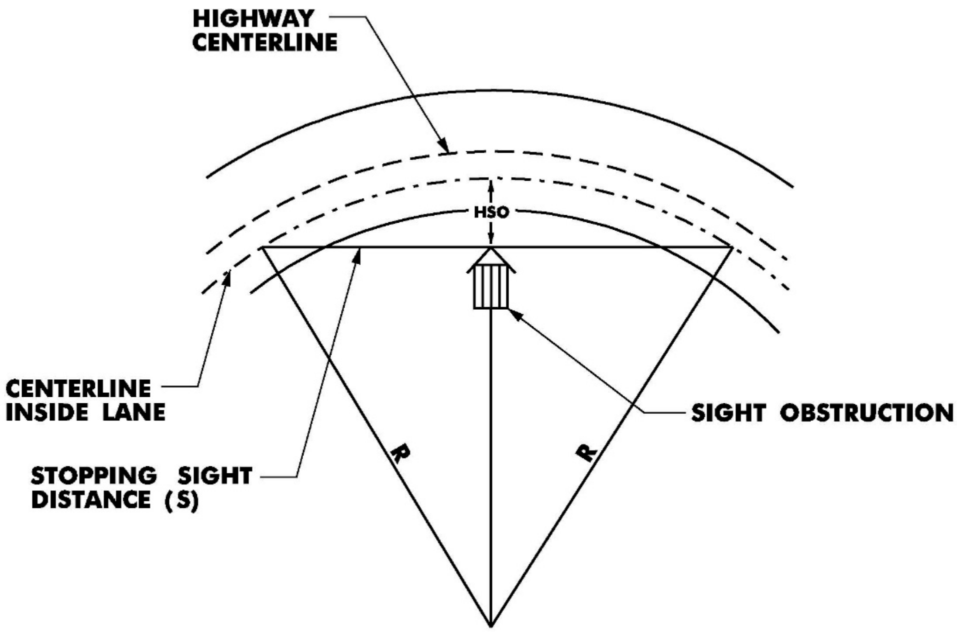
2. Stopping Sight Distance on Horizontal Curves

The horizontal sightline offsets needed for clear sight areas that satisfy the stopping sight distance criteria presented in Exhibit 2-2 shall be investigated using one or both of the methods listed below:

a. Where obstruction and vehicle are located within the limits of a vertical curve, use Exhibit 2-3.

b. Where the vehicle, the obstruction, or both are situated beyond the limits of a simple curve or within the limits of a compound curve, the design should be checked by utilizing graphical procedures.

Exhibit 2-3 Illustrates Components for Determining Horizontal Sight Distance



US Customary

$$HSO = R - \sqrt{R^2 - (S/2)^2}$$

Where:

s	=	Stopping sight distance, feet
R	=	Radius of curve, feet
HSO	=	Horizontal sightline offset, feet

2.2.2. Horizontal Alignment

2.2.2.1. Superelevation

If a design assignment involves modification or resurfacing of an existing roadway, the rate of superelevation to be used shall normally follow the current standard, as described in this section. However, if a bridge deck falls within the horizontal curve and the deck superelevation is not being upgraded, the rate of superelevation for the entire length of the horizontal curve shall not exceed that on the bridge deck.

A 6 percent maximum superelevation rate shall be used (see Exhibit 2-4), for the entire length of the Parkway mainline and all interchange ramps.

The superelevation tables included in this section are based on AASHTO distribution of "e" Method 5. Superelevation rates based on other AASHTO methods will be considered in certain cases with written approval from the Authority.

Exhibit 2-4 Minimum Radii for Design Superelevation Rates, Design Speeds, and E_{max}=6%

e (%)	V_d= 25 mph R(ft)	V_d= 30 mph R(ft)	V_d= 35 mph R(ft)	V_d= 40 mph R(ft)	V_d= 45 mph R(ft)	V_d= 50 mph R(ft)	V_d= 55 mph R(ft)	V_d= 60 mph R(ft)	V_d= 65 mph R(ft)	V_d= 70 mph R(ft)
1.5	2290	3130	4100	5230	6480	7870	9410	11100	12600	14100
2	1630	2240	2950	3770	4680	5700	6820	8060	9130	10300
2.2	1450	2000	2630	3370	4190	5100	6110	7230	8200	9240
2.4	1300	1790	2360	3030	3770	4600	5520	6540	7430	8380
2.6	1170	1610	2130	2740	3420	4170	5020	5950	6770	7660
2.8	1050	1460	1930	2490	3110	3800	4580	5440	6200	7030
3	944	1320	1760	2270	2840	3480	4200	4990	5710	6490
3.2	850	1200	1600	2080	2600	3200	3860	4600	5280	6010
3.4	761	1080	1460	1900	2390	2940	3560	4250	4890	5580
3.6	673	972	1320	1740	2190	2710	3290	3940	4540	5210
3.8	583	864	1190	1590	2010	2490	3040	3650	4230	4860
4	511	766	1070	1440	1840	2300	2810	3390	3950	4550
4.2	452	684	960	1310	1680	2110	2590	3140	3680	4270
4.4	402	615	868	1190	1540	1940	2400	2920	3440	4010
4.6	360	555	788	1090	1410	1780	2210	2710	3220	3770
4.8	324	502	718	995	1300	1640	2050	2510	3000	3550
5	292	456	654	911	1190	1510	1890	2330	2800	3330
5.2	264	413	595	833	1090	1390	1750	2160	2610	3120
5.4	237	373	540	759	995	1280	1610	1990	2420	2910
5.6	212	335	487	687	903	1160	1470	1830	2230	2700
5.8	186	296	431	611	806	1040	1320	1650	2020	2460
6	150	235	340	485	650	840	1060	1330	1660	2040

2.2.2.2. **Superelevation Transition**

The superelevation transition consists of the superelevation runoff (length of roadway needed to accomplish the change in outside-lane cross slope from zero to full superelevation or vice versa) and tangent runout (length of roadway needed to accomplish the change in outside-lane cross slope from the normal cross slope to zero or vice versa).

With respect to the beginning or ending of a curve, the amount of runoff on the tangent should desirably be based on Exhibit 2-7. However, runoff lengths on the tangent ranging from 60 to 90 percent are acceptable.

Superelevation Runoff

L_r = minimum length of superelevation runoff (feet)

Δ = maximum relative gradient, percent (Exhibit 2-5)

n = number of lanes rotated

b = adjustment factor for number of lanes rotated (**Exhibit 2-6**)

w = width of one traffic lane (feet), (typically 12 feet)

e = design superelevation rate (%)

Tangent Runout

$L_t = (L_r)(e_{NC})/e$

Where:

Lt = minimum length of tangent runout (feet)

Lr = minimum length of superelevation runoff (feet)

eNC = normal cross slope rate (%)

e = design superelevation rate

Exhibit 2-5 Maximum Relative Gradient

Design Speed (mph)	25	30	35	40	45	50	55	60	65	70
Maximum Relative Gradient	0.70	0.66	0.62	0.58	0.54	0.50	0.47	0.45	0.43	0.40

Exhibit 2-6 Adjustment Factor for Number of Lanes Rotated

Number of Lanes Rotated (n)	Adjustment Factor (b)
1	1.00
1.5	0.83
2	0.75
2.5	0.70
3	0.67
3.5	0.64

Exhibit 2-7 Percent Runoff on Tangent

Design Speed (mph)	Portion of Runoff Located Prior to the Curve			
	Number of Lanes Rotated			
	1.0	**1.5**	**2.0-2.5**	**3.0-3.5**
25-45	0.80	0.85	0.90	0.90
50-80	0.70	0.75	0.80	0.85

2.2.2.3. General Controls for Horizontal Alignment

1. Curves should be at least 500 feet long for a central angle of 5 degrees, and the minimum length should be increased 100 feet for each 1-degree decrease in the central angle.
2. For compound curves, the ratio of the flatter radius to the sharper radius should not exceed 1.5 for mainline roadways.
3. The tangent distance between reverse curves should, as a minimum, be sufficient to accommodate the superelevation transition as specified in Subsection 2.2.2. The desirable tangent lengths are as shown in Exhibit 2-8.

Exhibit 2-8 Desirable Tangent Length Between Reverse Curves

Design Speed (mph)	Desirable Tangent (ft)
50	500
60	600
70	800

4. The "broken back" arrangement of curves (short tangent between two curves in the same direction) should be avoided except where very unusual topographical or right of way conditions make other alternatives impractical. Exhibit 2-9 indicates the desirable and absolute minimum tangent lengths between same direction curves.

Exhibit 2-9 Desirable Tangent Length Between Same Direction Curves

Design Speed (mph)	Desirable Tangent (ft)	Absolute Minimum Tangent(ft)
50	1000	600
60	1500	900
70	2500	1500

5. Transitions in roadway width should be made on tangent sections whenever possible and should avoid locations with horizontal and/or vertical sight distance restrictions. The desirable taper length for the Parkway mainline is 1,000 feet per lane.

6. The minimum required taper length when reducing the roadway width is shown in Exhibit 2-10 In general, when a lane is dropped by tapering, the transition should be on the right so that traffic merges to the left.

Exhibit 2-10 Minimum Taper Length when Reducing Roadway Width

2.2.3. Vertical Alignment

1. Grades for Mainline Roadway

   a. Desirable minimum profile grade shall be 0.5 percent. Absolute minimum profile grade shall be 0.3 percent.

   b. Desirable maximum profile grade shall be 3.0 percent. Absolute maximum profile grade shall be 5.0 percent.

2. Vertical Curves

   a. Minimum vertical curve length determined by L = AK, see Exhibit 2-12 for desirable and minimum K values.

   Where:

   L = Length of Curve

   A = Algebraic difference in tangent grades, percent.

   K = Length of vertical curve per percent change in A.

   b. Special attention to drainage should be exercised where values in excess of K=167 are used.

   c. The PVI station should be located at even 5 or 10-foot station increments, or 25 feet where feasible.

   d. Length of vertical curves to be in 10-foot increments where feasible.

e. Short tangents (less than 100 feet) between vertical curves should be avoided if possible. In this case, it is preferable for the location of the PVT and PVC of successive curves to coincide.

f. No vertical curve is necessary and angle points can be used in accordance with Exhibit 2-11.

g. Refer to Exhibit 2-2 for minimum stopping sight distances for a given speed.

Exhibit 2-11 Use of a Profile Angle Point

Design Speed (mph)	A_{max} %
25	.70
30	.55
35	.50
40	.40
45	.40
50	.35
55	.30
60	.30
65	.25
70	.25

Exhibit 2-12 Design Controls for Vertical Curves

Design Speed (mph)	Desirable (6-inch Object Height)		Minimum (2-foot Object Height)	
	Crest K (minimum)	Sag K (minimum)	Crest K (minimum)	Sag K (minimum)
25	20	30	12	26
30	30	40	19	37
35	47	50	29	49
40	70	64	44	64
45	98	79	61	79
50	136	96	84	96
55	185	114	114	115
60	245	136	151	136
65	313	157	193	157
70	400	181	247	181

2.3. MAINLINE ROADWAY

2.3.1. Design Speed

A design speed of 70 miles per hour is to be used on the Parkway mainline, except where existing alignment and sight distance restrictions occur or restrictions are caused by existing physical constraints. Design speeds of less than 70 MPH will require written approval from the Authority and in any case shall be a minimum of 5 MPH greater than the posted speed limit.

2.3.2. Pavement

Pavement design shall be in accordance with Subsection 6.7.4 of this Manual.

2.3.3. Typical Sections

Refer to Exhibit 2-13 for typical shoulder and lane widths and cross slopes. Also refer to the following notes.

1. All lane widths shall be 12 feet with an absolute minimum of 11 feet.

2. Shoulders on the high side of a superelevated section should drain away from the adjacent traffic lanes with a desirable rollover of 7 percent (max rollover 8 percent) and a minimum shoulder cross slope of 2 percent. See Exhibit 2-14.

3. Rumble strips shall be constructed on all mainline roadway outside shoulders and on all median shoulders that are 5 feet or greater in width. Placement of rumble strips along mainline roadways shall be limited as follows:

    a. On approach to mainline toll plazas, the rumble strips shall terminate at the end of the mainline normal section.

    b. At entrance ramp terminals, rumble strips on outside shoulders shall terminate at the point of the physical gore and resume at the end of the acceleration lane taper.

    c. At exit ramp terminals, rumble strips on outside shoulders shall terminate at the start of the deceleration lane taper and resume at the point of the physical gore.

    d. Rumble strips may be eliminated at other locations at the direction of the Authority's Engineering Department.

    e. On approaches to bridges, rumble strips shall terminate at the abutment joint.

    f. Rumble strips shall not be placed within 400 feet of Z-Turn and U-Turn openings on either side of the median.

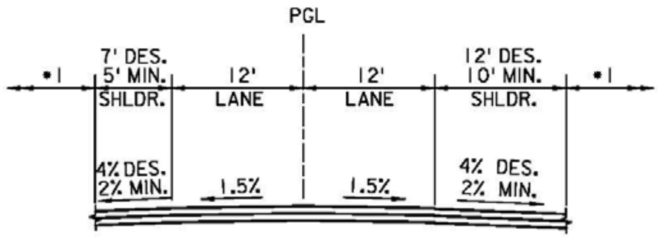
4. New installations of concrete vertical curb shall not be constructed on mainline roadway. However, if surface drainage control is required, asphalt lip curb shall be provided under the face of guide rail.

5. Medians must have barrier or guide rail as warranted by Section 4.3.1.2 of this Manual.

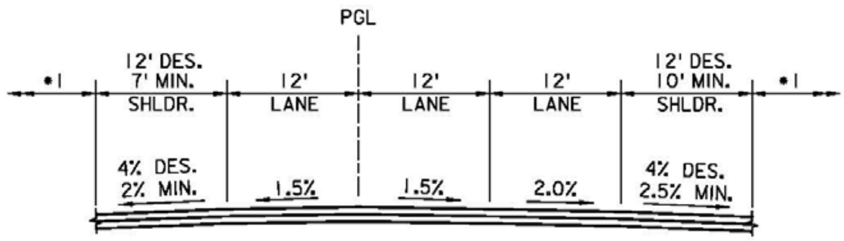
6. Lateral bridge clearances for ramps and mainline roadways shall be provided as shown on Exhibit 2-16 and Exhibit 2-17.

7. For deviations to left shoulder widths on approach roadways to structures, refer to Subsection 3.2.1.3. Shoulder width shall be reduced in accordance with Subsection 3.2.2.

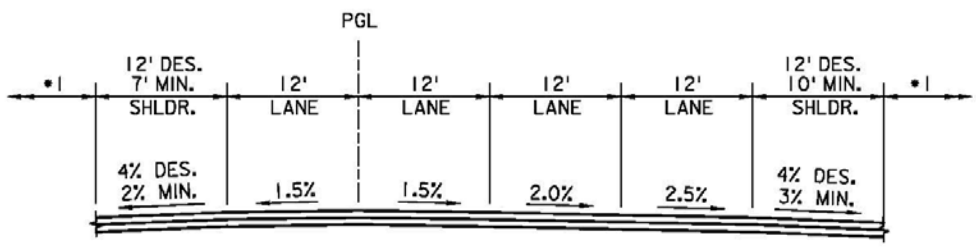
Exhibit 2-13 Typical Normal Sections



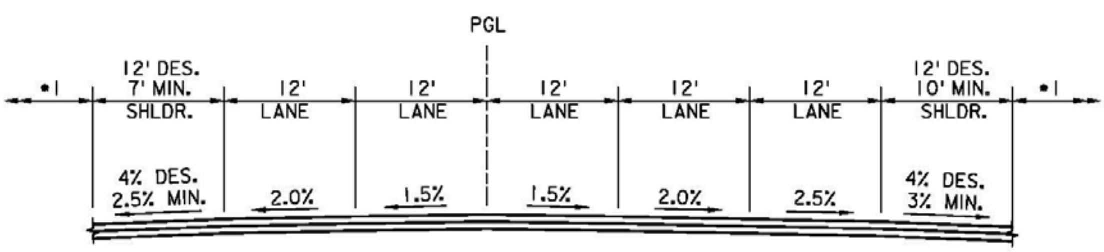
TWO LANE TRAVELWAY (ONE DIRECTION) - SECTION



THREE LANE TRAVELWAY (ONE DIRECTION) - SECTION



FOUR LANE TRAVELWAY (ONE DIRECTION) - SECTION



FIVE LANE TRAVELWAY (ONE DIRECTION) - SECTION

• 1. SEE EXHIBIT 2-15 FOR GRADING CRITERIA.

2. PGL AND CROWN LINE CAN BE ADJUSTED TO MATCH SPECIFIC SIGHT CONDITIONS.

Exhibit 2-14 Typical Superelevated Section

Exhibit 2-15 Desirable Grading Criteria - Mainline and Ramps

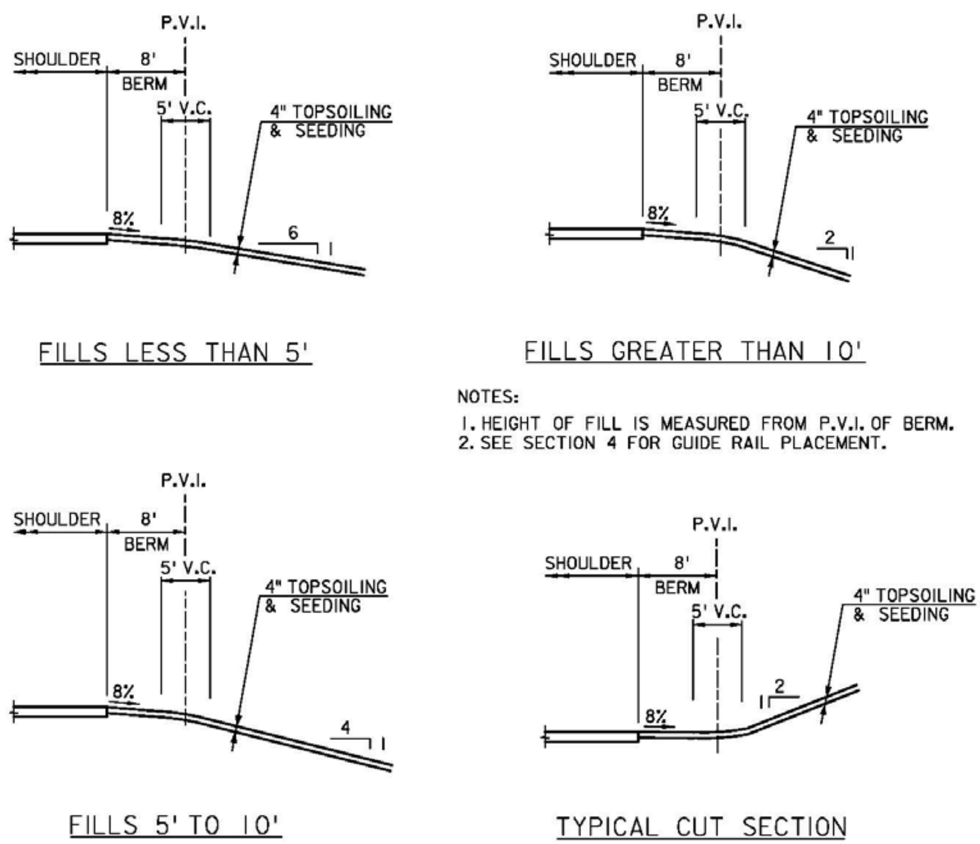
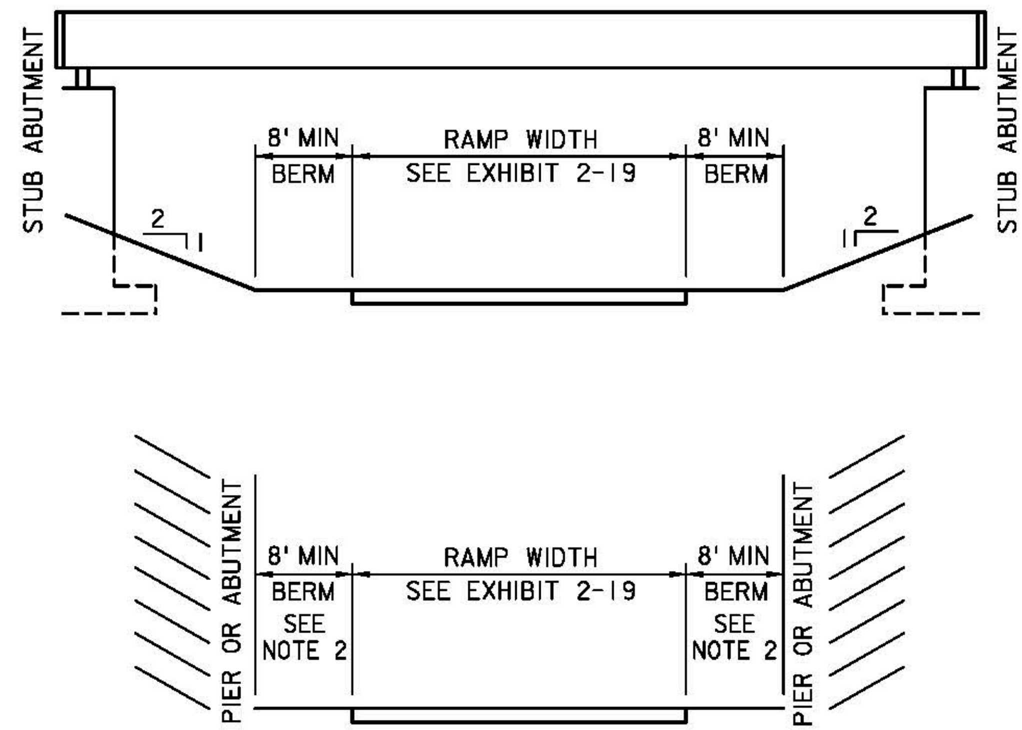
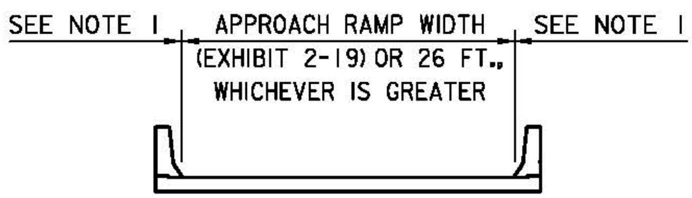


Exhibit 2-16 Lateral Bridge Clearances - Ramps



RAMP UNDERPASS

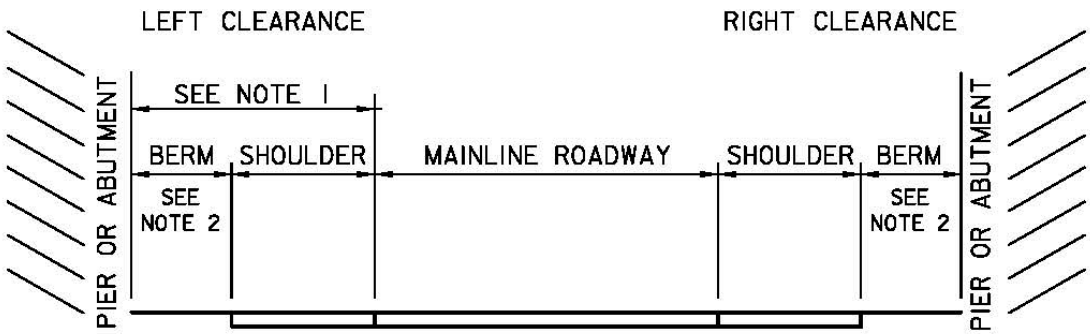


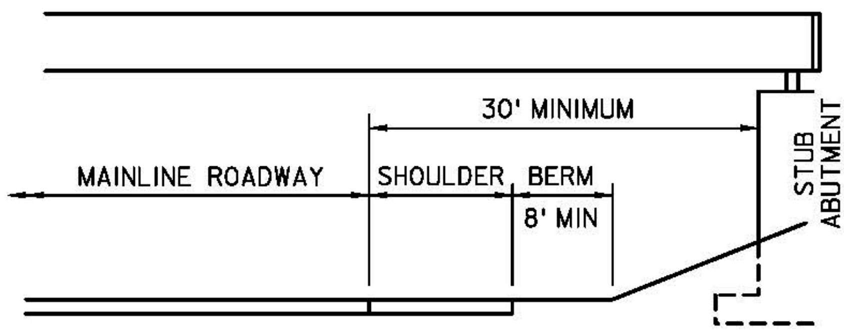
RAMP OVERPASS

NOTES:

1. STOPPING SIGHT DISTANCE ON HORIZONTAL CURVES GOVERNS WIDTH OF RAMP (SEE EXHIBIT 2-3)
2. STOPPING SIGHT DISTANCE ON HORIZONTAL CURVES GOVERNS OFFSET TO PIER OR ABUTMENT.
3. THE CONTROLLING WIDTH OF 26 FEET ON THE RAMP OVERPASS IS TO ALLOW FOR FUTURE LANE CLOSINGS FOR MAINTENANCE SUCH AS DECK PATCHING OR REPLACEMENT.

Exhibit 2-17 Lateral Bridge Clearances - Mainline





PARKWAY UNDERPASS

NOTES:

1. WHEN PRACTICAL, PLACE PIER AT CENTERLINE OF MEDIAN. PROVISION FOR ADDITIONAL LANES SHOULD BE CONSIDERED WHEN DETERMINING PIER OR ABUTMENT LOCATION. IF THERE IS A CONTINUOUS MEDIAN BARRIER THE OFFSET SHOULD BE SUFFICIENT TO CONSTRUCT THE BARRIER IN FRONT OF THE PIER WITHOUT REDUCING THE SHOULDER WIDTH.

2. ROADSIDE PROTECTION OF PIERS AND ABUTMENTS SHALL BE DESIGNED IN ACCORDANCE WITH SECTION 4 OF THIS MANUAL.

2.4. INTERCHANGE RAMPS

2.4.1. Roadway Designation

See Section 1 of the Procedures Manual for ramp naming convention.

2.4.2. Design Speed

1. Loop ramps = 30 MPH; Absolute minimum = 25 MPH

2. Semi-direct connections = 30 MPH
3. Outer cloverleaf connections = 35 MPH
4. Direct connections = 40 MPH

2.4.3. Horizontal Alignment

1. For minimum radii see For minimum radii see Exhibit 2-18.
    a. The desirable minimum radius shall be 235 feet. The absolute minimum radius shall be 150 feet (waiver required from Chief Engineer). It is desirable to use as large a radius as project conditions will allow.
    b. For compound curves, the ratio of the flatter radius to the sharper radius should not exceed 2.0.
2. For pavement widths, see Exhibit 2-19.
3. Loop ramp configuration and transition curves shall be as indicated on Exhibit 2-20.
4. The minimum length of tangent between reverse curves shall be sufficient to accommodate the superelevation transition.
5. For typical Exit and Entrance Terminal treatments, see Subsection 2.5.

Exhibit 2-18 Minimum Curve Radii for Ramp Design Speeds

Ramp Central Radius in feet (minimum)	Recommended Design Speed (mph)
150	25
235	30
340	35
485	40
650	45
840	50

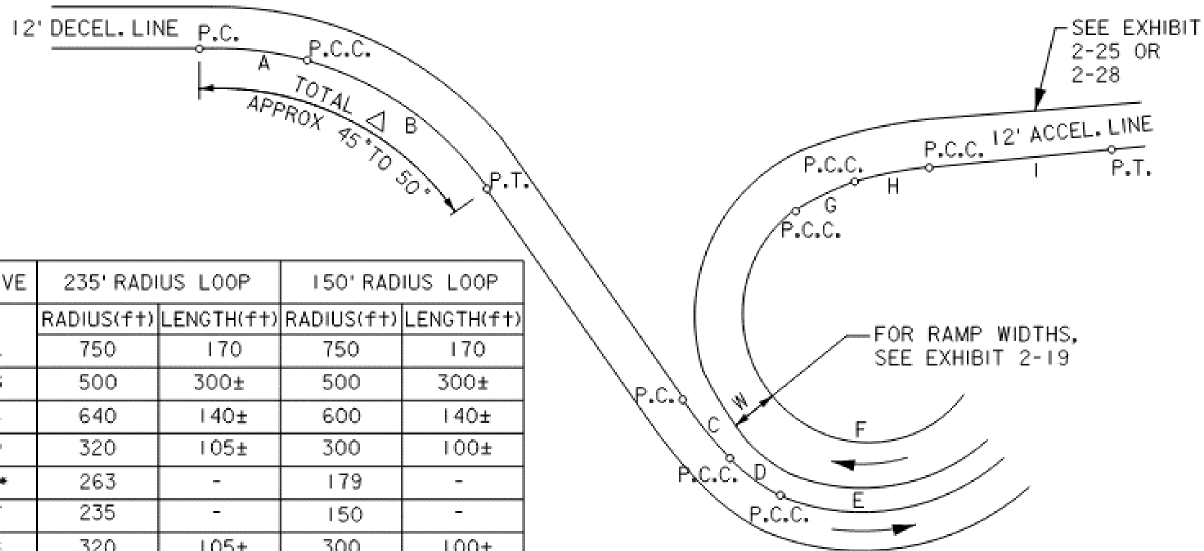
Exhibit 2-19 Design Width of Pavement for Ramps

Radius at Lane edge of Inside Curve	One Lane Entrance Terminal Width (W1)	Ramp Proper Width for One Lane Ramp (W)	Ramp Proper Width for Two Lane Ramp (W)
150’	18’	22’	32’
235’	18’	22’	31’
300’	17’	22’	30’

400’	17’	22’	30’
500’	17’	22’	30’
Tangent	17’	22’	29’

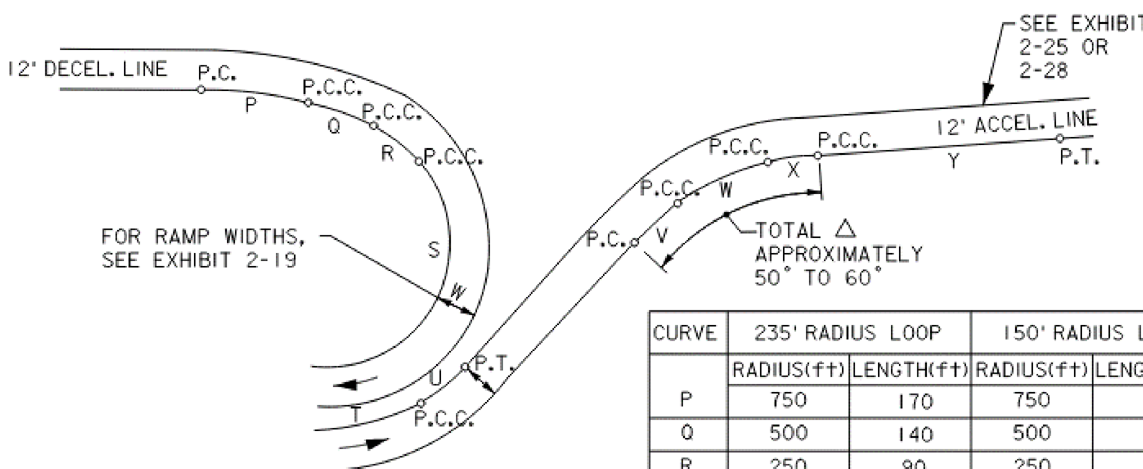
Exhibit 2-20 Typical Loop Ramp Geometry

INTERCHANGE RAMP GEOMETRY



CURVE	235' RADIUS LOOP		150' RADIUS LOOP	
	RADIUS(ft)	LENGTH(ft)	RADIUS(ft)	LENGTH(ft)
A	750	170	750	170
B	500	300±	500	300±
C	640	140±	600	140±
D	320	105±	300	100±
E*	263	-	179	-
F	235	-	150	-
G	320	105±	300	100±
H	640	140±	600	140±
I	1,000 MIN.	200±	1,000 MIN.	200±

TURNOUTS TO AND FROM ENTRANCE LOOP



CURVE	235' RADIUS LOOP		150' RADIUS LOOP	
	RADIUS(ft)	LENGTH(ft)	RADIUS(ft)	LENGTH(ft)
P	750	170	750	170
Q	500	140	500	140
R	250	90	250	90
S	235	-	150	-
T*	263	-	179	-
U	350±	110±	300±	100+
V	640±	140±	640	140±
W	320±	200±	320	200±
X	640	140±	640	140±
Y	1,000 MIN.	200±	1,000 MIN.	200±

* INCREASE RADII AS NECESSARY FOR TWO LANE INNER LOOP RAMP.

TURNOUTS TO AND FROM EXIT LOOP

2.4.4. **Superelevation**

1. Cross slope on tangent sections are typically sloped one-way at 2.0 percent.
2. Minimum cross slope of 1.5 percent.
3. Maximum cross slope of 6.0 percent.
4. The desirable length of superelevation transition should be in accordance with Subsection 2.2.2 and in no case should be less than the rate of two percent per second of time for the associated design speed.
5. Exhibit 2-21 provides a suggested range of superelevation rates from minimum to desirable for various interchange ramp radii.
6. Exhibit 2-22 indicates the maximum algebraic difference between ramp and mainline pavement.

Exhibit 2-21 Interchange Ramp Superelevation

Design Speed (mph)	Radius (ft)								
	150	230	340	485	650	1000	1500	2000	3000
25	4 – 6	3 – 6	3 – 6	3 – 5	2 – 4	2 – 3	2	2	2
30	--	6	5 - 6	4 - 6	3 – 5	3 – 4	2 – 3	2	2
35	--	--	6	6	5 – 6	4 – 5	3 – 4	2 – 3	2
40	--	--	--	6	6	5 – 6	4 – 5	3 – 4	2 - 3

Exhibit 2-22 Maximum Difference in Cross Slope Rates at Crossover Crown Line

Ramp Design Speed (mph)	Max. Δ in Cross Slope at Crossover Line (%)
V ≤ 35 mph	6
V > 35 mph	5

2.4.5. Vertical Alignment

1. Desirable maximum profile upgrade shall be 5.0 percent. Absolute maximum profile upgrade shall be 7.0 percent.
2. Maximum profile downgrade shall be 5.0 percent.
3. Desirable minimum profile grade shall be 0.5 percent. Absolute minimum profile grade shall be 0.3 percent.
4. See Subsection 2.2.3 for Vertical Curve requirements.

2.4.6. Pavement Sections and Details

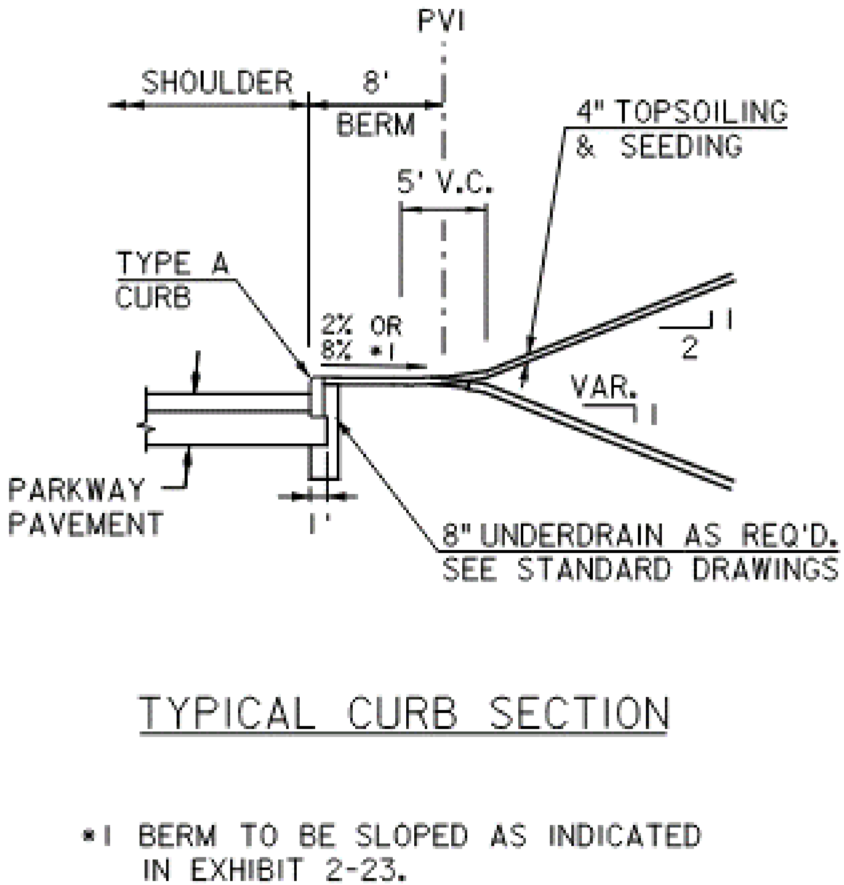
The interchange ramp pavement section shall be the same as the mainline section. See Subsection 2.3.2.

2.4.7. Typical Sections

1. Refer to Exhibit 2-19 and Exhibit 2-23 for typical interchange ramp and berm widths and cross slopes.
2. Ramps should be designed without curbs whenever possible. However, if surface drainage control is required, curb can be specified as shown in Exhibit 2-24.

Exhibit 2-23 Typical Section - Ramps

Exhibit 2-24 Interchange Ramps - Curb Section Detail



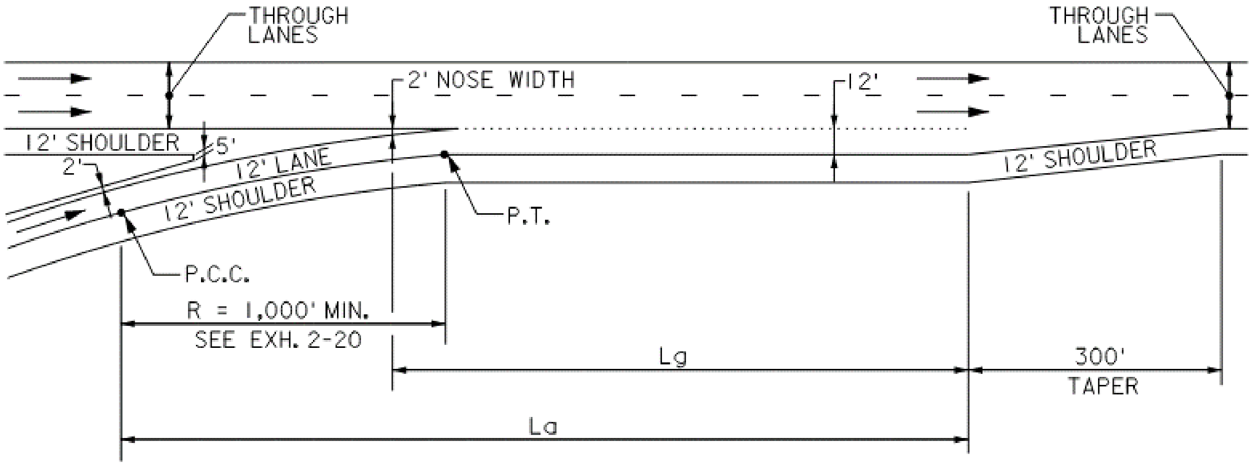
2.5. Auxiliary Lanes

2.5.1. Entrance Ramp Acceleration Lanes

1. Single Lane and Two-Lane Entrance ramps:
    a. A typical acceleration lane for a single lane entrance ramp is shown in Exhibit 2-25.
    b. A two-lane entrance ramp shall consist of the typical ramp acceleration geometry followed by a single lane drop. A typical two-lane entrance ramp is shown in Exhibit 2-28.
2. If the mainline is curved, the acceleration lane shall be curved to fit the required lengths and dimensions shown.
3. Where the acceleration lane falls within a section of roadway with 3 percent or greater profile (upgrade or downgrade), the acceleration lengths from Exhibit 2-26 shall be adjusted by the ratios indicated in Exhibit 2-27 to determine minimum acceleration lane lengths.

4. See PM Standard Drawings for entrance ramp pavement markings.
5. The continuity of the through (mainline) roadway shall be maintained at all times.

Exhibit 2-25 Single Lane Entrance Ramp



NOTES:

1. "La" SHALL BE OBTAINED FROM EXHIBITS 2-26 AND 2-27 FOR ACCELERATION LENGTH AND GRADE ADJUSTMENT FACTORS.
2. "Lg" SHALL BE 300' MINIMUM, MEASURED FROM 2' NOSE WIDTH TO START OF TAPER.
3. THE VALUE OF "La" OR "Lg", WHICHEVER RESULTS IN THE GREATER DISTANCE DOWNSTREAM FROM WHERE THE NOSE WIDTH EQUALS 2' SHALL DETERMINE THE LENGTH OF THE RAMP ACCELERATION LANE.

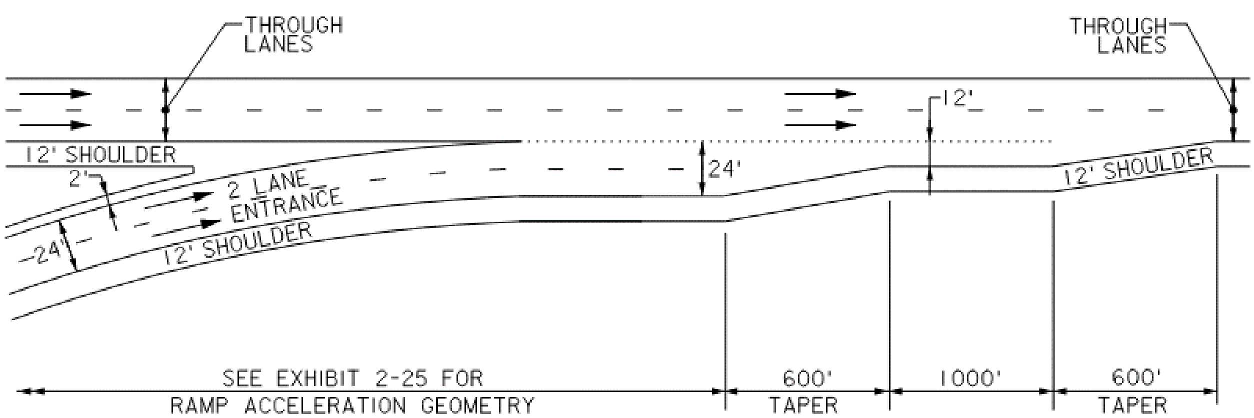
Exhibit 2-26 Minimum Length of Acceleration Lane

Highway Design Speed, *V* (mph)	Acceleration Length, *La* (ft) for Entrance Curve Design Speed (mph)					
	25	**30**	**35**	**40**	**45**	**50**
60	1020	910	800	550	420	180
70	1420	1350	1230	1000	820	580

Exhibit 2-27 Acceleration Lane Grade Adjustment Factors

Highway Design Speed (mph)	Acceleration Lanes Ratio of Length on Grade to Length of Level for Design Speed of Turning Curve (mph)				
	25	**30**	**40**	**50**	**All Speeds**
	3 to 4 percent upgrade				3 to 4 percent downgrade
60	1.4	1.5	1.5	1.6	0.6
70	1.5	1.6	1.7	1.8	0.6
	5 percent upgrade				5 percent downgrade
60	1.7	1.9	2.2	2.5	0.5
70	2.0	2.2	2.6	3.0	0.5

Exhibit 2-28 Two-Lane Entrance Ramp



2.5.2. Exit Ramp Deceleration Lanes

1. Single Lane and Two-Lane Exit Ramps

a. For Single Lane exit ramps there are two types of deceleration lanes as shown in Exhibit 2-29. The application of these two types is dependent upon the overall geometry of the situation. The "Parallel Ramp Configuration" is generally used in conjunction with a dual-dual roadway for exit from the inner roadway.

b. A two-lane exit ramp shall consist of a single lane widening followed by the typical ramp deceleration. A typical two lane exit ramp is shown in **Exhibit 2-32**.

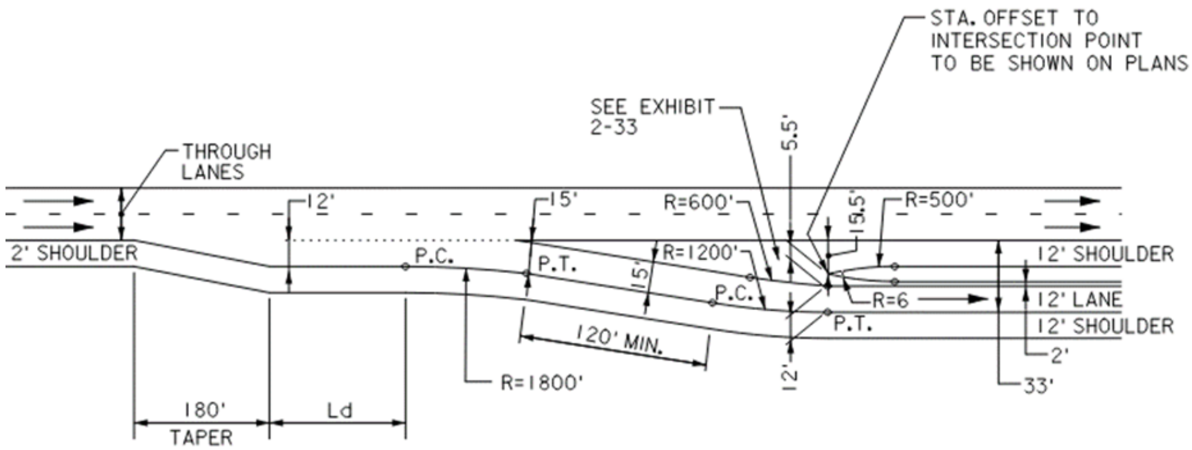
2. If the mainline is curved, the deceleration lane shall be curved to fit the required lengths and dimensions shown.

3. Where the deceleration lane falls within a section of roadway with 3 percent or greater profile (upgrade or downgrade), the deceleration lengths from Exhibit 2-30 shall be adjusted by the ratios indicated in Exhibit 2-31 to determine minimum deceleration lane lengths.

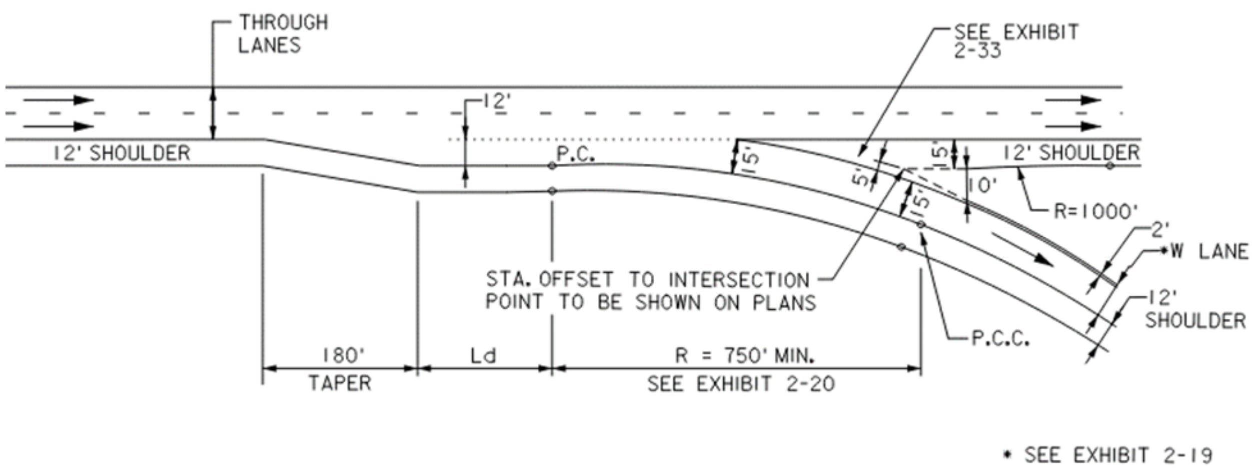
4. See PM Standard Drawings for exit ramp pavement markings.

5. The continuity of the through (mainline) roadway shall be maintained at all times. Where directed by the Authority, the mainline through lanes may be reduced with a lane drop that maintains through lanes for 900 feet beyond the exit ramp followed by a 300-foot taper.

Exhibit 2-29 - Single Lane Exit Ramp



PARALLEL RAMP CONFIGURATION



LOOP RAMP CONFIGURATION

NOTES:

1. "Ld" SHALL BE DETERMINED FROM EXHIBITS 2-30 AND 2-31 FOR DECELERATION LANE LENGTH AND GRADE ADJUSTMENT FACTORS.

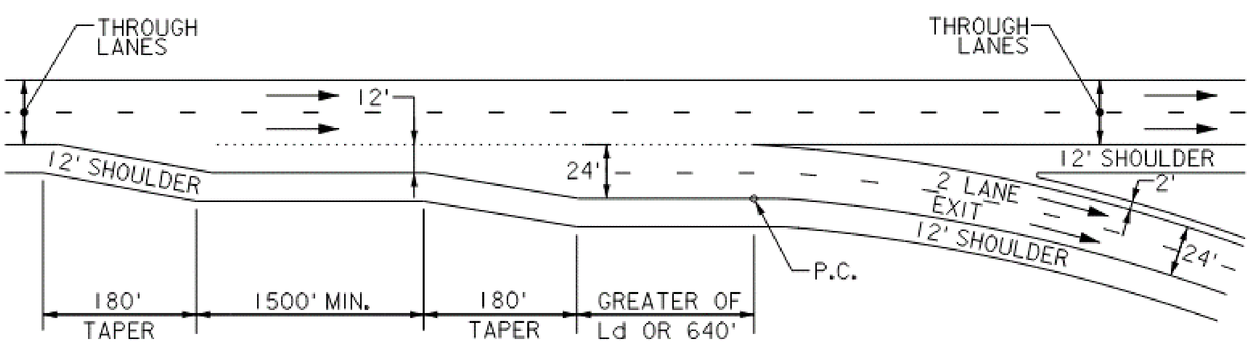
Exhibit 2-30 Minimum Length of Deceleration Lane

Highway Design Speed, *V* (mph)	Deceleration Length, *Ld* (ft) for Exit Curve Design Speed (mph)					
	25	**30**	**35**	**40**	**45**	**50**
60	460	430	405	350	300	240
70	550	520	490	440	390	340

Exhibit 2-31 Deceleration Lane Grade Adjustment Factors

Highway Design Speed (mph)	Deceleration Lanes Ratio of Length on Grade to Length of Level for Design Speed of Turning Curve (mph)	
	All Speeds	
	3 to 4 percent upgrade	3 to 4 percent downgrade
All Speeds	0.9	1.2
	5 percent upgrade	5 percent downgrade
All Speeds	0.8	1.35

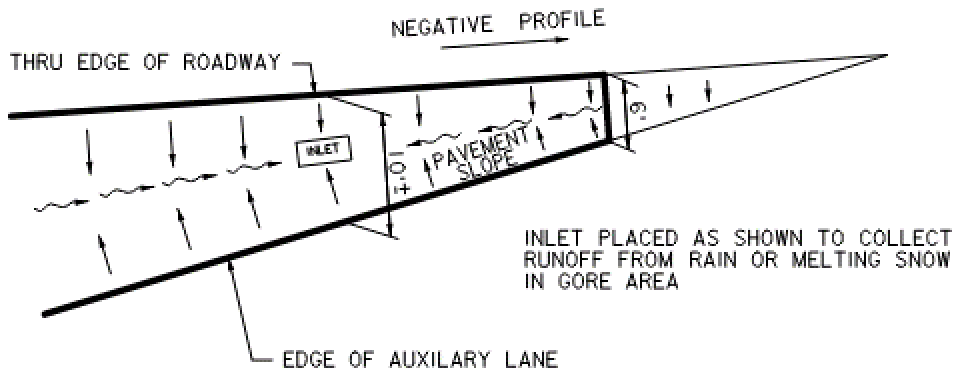
Exhibit 2-32 Two-Lane Exit Ramp



2.5.3. Nose Grading

Typical nose grading between a mainline roadway and an auxiliary lane(s) is shown in Exhibit 2-33.

Exhibit 2-33 Typical Nose Grading



2.6. Other Roadways

2.6.1. Crossroads

Where local roads are being replaced, the intent of the Authority with respect to any work under the jurisdiction of the state, county, municipality, or any other agency is "replacement in kind", according to present standards of that agency. All such work is subject to the approval of the Authority's Engineering Department and must be previously agreed to in writing by the concerned agency, as noted elsewhere in this manual and the Procedures Manual.

Similarly, all detouring and / or closing of local roads during construction must be approved by the appropriate agencies in accordance with the Procedures Manual.

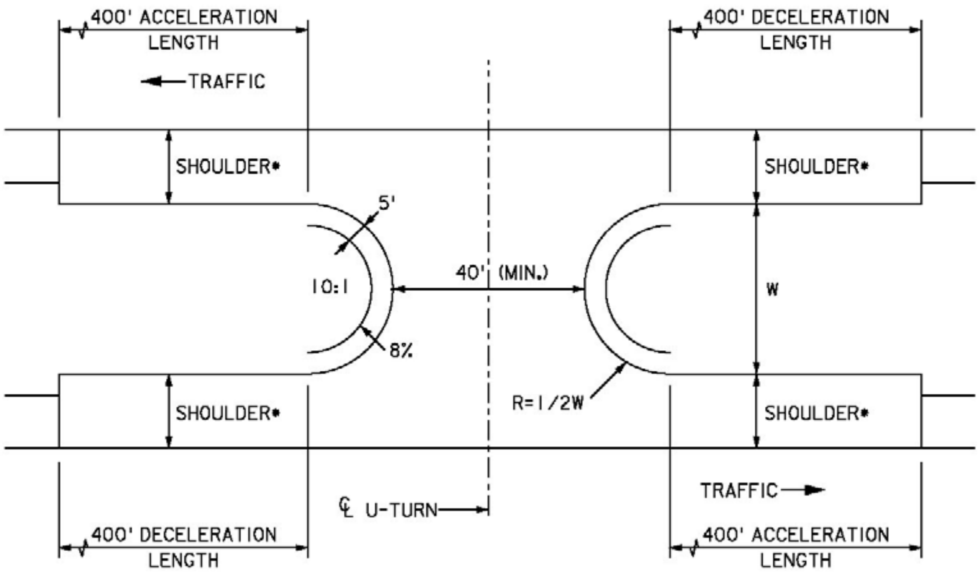
2.6.2. Access and Service Roads

Treatment similar to "Crossroads" above.

2.6.3. U-Turns and Z-Turns

1. U-Turns and Z-Turns shall be designated by milepost location. Refer to Section 7 for signing.
2. Use and Location - Consult the Authority for location criteria.

Exhibit 2-34 U-Turn Geometric Criteria



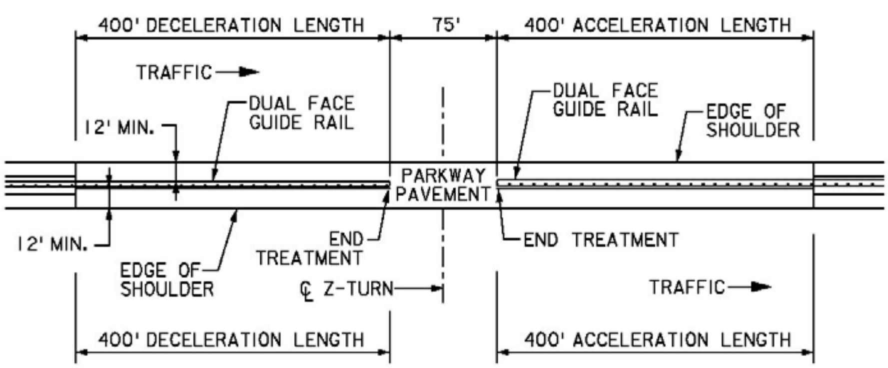
U-TURN GEOMETRIC CRITERIA

NOTES:

1. MAINTAIN DRAINAGE WITHIN U-TURN MEDIAN.
2. RUMBLE STRIPS SHALL NOT BE PLACED WITHIN 400 FEET OF ACCELERATION/DECELERATION LENGTH.

* 10' MINIMUM
12' DESIRABLE
14' WHEN GUIDE RAIL IS PRESENT OR CONSTRAINING GEOMETRY DICTATES

Exhibit 2-35 Z-Turn Geometric Criteria



Z-TURN GEOMETRIC CRITERIA

NOTES:

1. MAINTAIN DRAINAGE WITHIN Z-TURN MEDIAN.
2. RUMBLE STRIPS SHALL NOT BE PLACED WITHIN ACCELERATION/DECELERATION LANES.

2.7. GRADING CRITERIA

The general grading criteria set forth in this section are intended to be used as guidelines to achieve an economically feasible, safe, and aesthetically pleasing design. Variations to the specified criteria are permissible as long as the design adequately complies with the intent of the guidelines. Design side slopes based on slope stability as determined according to Subsection 6.7. Variations in side slopes should be investigated in order to obtain a favorable earthwork balance. Every effort is to be made to limit the use of critical slopes where feasible so as to eliminate the need for guide rail. Consideration shall be given to the impact on right of way, earthwork, aesthetics, existing trees, utilities, regulated areas, etc.

2.7.1. Grading in Fill Areas

1. Variable side slopes, depending on the height of fill at the PVI of berm, shall be used for all ramps and for existing Parkway roadways. See Exhibit 2-15.
    a. 0 - 5 feet fills – 6H:1V slope
    b. 5-10 feet fills – 4H:1V slope
    c. 10 feet and greater fills – 2H:1V slope maximum
2. Refer to Section 4 (Guide Rail/Median Barrier/Attenuator Design) of this Manual for guide rail requirements related to height of fill. Safety grading criteria may be utilized on mainline roadways as directed by the Authority's Engineering Department in order to eliminate guide rail warrants.
3. Mainline and ramp sections shall have a berm width of 8 feet minimum sloping away from the roadway at an 8 percent grade with the exception of the berm on the high side of a superelevated ramp which will slope away at a 2 percent grade as indicated on Exhibit 2-23.
4. All roundings shall have 5-foot vertical curves.

2.7.2. Grading in Cut Areas

1. 2:1 maximum side slopes are recommended throughout. See Exhibit 2-15.
2. Berm widths are the same as for fill sections.
3. All roundings shall have 5-foot vertical curves.
4. Cut sections in rock will be subject to Authority's Engineering Department approval of the Engineer's soils recommendations.
5. In borrow projects, the Engineer shall investigate the possibility of using flatter cut slopes in an attempt to achieve a more favorable earthwork balance.

2.8. FENCING

2.8.1. General Policy

1. The policy of the Authority is to fence all of their right of way.
2. Chain Link fence shall be used around interchanges, service areas and maintenance areas; along the right of way adjacent to existing commercial or residential areas or areas zoned for future commercial or residential development and 1,000 feet either side of the limits of these areas; along local roads and 500 feet either side of local roads along the Authority's right of way; and at all other locations at the direction of the Authority.
3. Chain link fence shall be as per the Standard Details.

2.8.2. Configuration

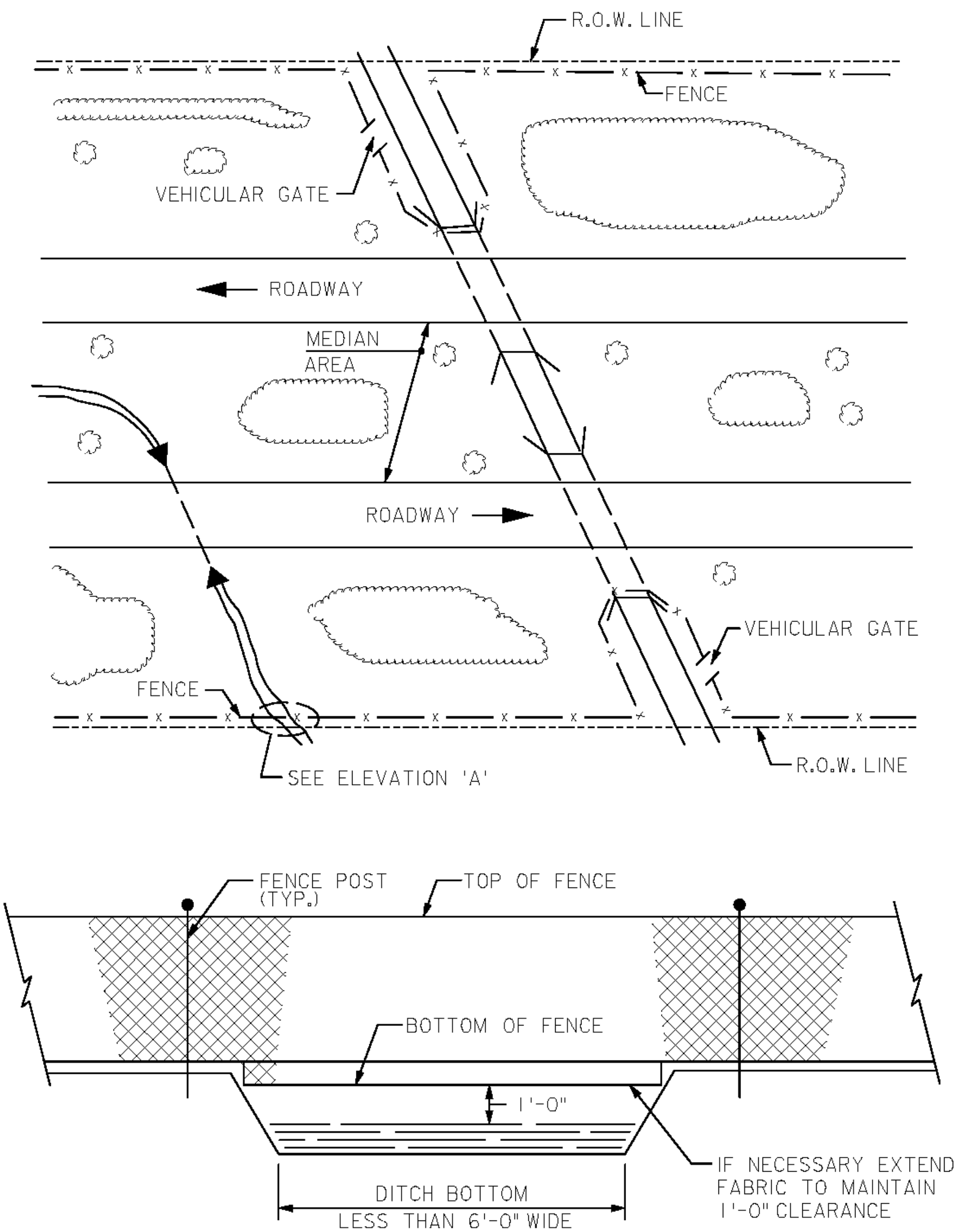
The following criteria will be followed in placing ROW fence at or across waterway openings:

Fence intersecting waterways which have a bottom width of 6 feet or greater will be turned and run parallel to the stream, and along the top of bank, to the culvert headwall through the roadway embankment. Fencing will then be carried up behind the wingwall, across behind the headblock and back out to the right of way along the far side of the waterway. The median area crossed by the waterway will not be fenced. On one selected side of that portion of the fence running perpendicular between the ROW and roadway embankment, the engineer shall consider placing a single vehicular gate.

Vehicular gate dimensions shall be as shown on the Standard Details. These gates shall be placed on that side of each water course which affords best access for maintenance. Consideration is to be given to proximity of local road access, the extent of trees, vegetation and ground contour to determine if a gate is required and if so where it is to be placed.

A right of way fence is to be carried across streams and ditches having less than a 6-foot bottom width. Line posts are to be spaced so that no post is erected in the bed or slopes of the ditch. The bottom of the fence shall provide for one foot freeboard above the ditch high water elevation. When the profile line of the fence bottom is greater than one foot above the high-water elevation, the fence fabric shall be extended lower as necessary to maintain the specified freeboard across the width of the ditch. See Exhibit 2-36 for general fence placement criteria at streams and ditches.

Exhibit 2-36 Stream Fencing Criteria



ELEVATION "A"

Section 3 - STRUCTURES DESIGN

3.0. DEFINITIONS

Definitions as provided below supersede definitions located elsewhere within the NJTA document library and are for the purpose of this Section only. Defined terms where shown in this Section, will have only the first letter capitalized. Where capitalized terms are noted throughout the text but not below, the reader is implicitly directed to either the NJTA Procedures Manual or the NJTA Standard Specifications for the definition of those terms. Terms that are defined below but are not shown with the first letter capitalized in this Section, are provided for general information and for the purposes of enabling uniform nomenclature.

AUTHORITY: The New Jersey Turnpike Authority (NJTA), with its principal office in Woodbridge, New Jersey, or its duly authorized representative in cases of Projects entrusted to the Authority's General Consultant or Program Manager, acting on behalf of the Authority.

BRIDGE MAINTENANCE WORK: Work intended to preserve a structure, which typically includes local area repairs to the concrete deck and / or riding surface (or overlay), resetting of bearings, joint repair, drainage cleaning, bridge seat cleaning, crack sealing, and miscellaneous repairs to the superstructure and substructure with spot painting, as required. Also included is select/localized concrete deck panel replacement.

BRIDGE REHABILITATION: Rehabilitation of any existing bridge which generally includes replacement of a large portion or all of the concrete deck and joints, zone painting of the bridge superstructure, and/or miscellaneous superstructure and substructure repairs. Bridge Rehabilitation Projects are generally intended to extend the service life of a bridge for 25 to 35 years. In special instances, a Bridge Rehabilitation may include repair of designated critical items to extend the useful service life of bridges which are considered in poor condition and are scheduled for replacement within 10 to 15 years.

COMPREHENSIVE BRIDGE REHABILITATION: Rehabilitation of any existing bridge (Major or Routine) which generally includes, but is not limited to, complete replacement of the concrete deck and joints, extensive superstructure repairs (including strengthening), full/zone repainting, bearing replacement, seismic retrofit, bridge widening, and/or miscellaneous substructure repairs. Complete/ or partial superstructure replacement may also be considered. Comprehensive Bridge Rehabilitation projects generally are intended to extend the service life of a bridge for an additional 60 to 75 years.

CONTRACT DOCUMENTS: Advertisement for Proposal, Proposal Guarantee, Contract Agreement, Contract Bond, Power of Execution, Standard Specifications, Supplementary Specifications, Plans, Addenda, and other transmitted documents to the prospective bidders prior to the receipt of bids, Change Orders, Field Orders, and Supplementary Agreements, all of which are to be treated as one instrument whether or not set forth at length in the written Contract Agreement.

CONSULTANT: An engineering consulting firm retained by the Authority to perform engineering and plan preparation work.

CONTRACT PLANS: The standard drawings, the official approved drawings specially prepared for the Project, profiles, cross-sections, and any supplemental drawings, or exact reproductions thereof, and that are current on the date the bids are received, and were furnished by the Authority, that indicate the location, character, dimensions, and details of the Work to be done.

CROSS-BEAM: A Closed-box or open-shape steel pier cap, either free spanning or cantilevering out, for the purposes of supporting Girders or Stringers. Cross-Beams are always considered Fracture Critical Members.

CROSS-FRAME: A Fabricated open truss member that acts as bracing that spans between deeper Stringers of a bridge and assists in the distribution of loads. Cross-Frames shall be considered as primary members in curved structures.

CULVERT: A structure including supports erected over a depression, drainage path, or waterway having an opening measured perpendicular to the flow of water (or equivalent measure) of 5’ to 20’ between faces of abutments or spring lines of arches, or extreme ends of openings for multiple boxes. It may also include multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening.

DESIGN ENGINEER: The Design Engineer is an authorized representative of the Engineer of Record, with at least 10 years of direct bridge structural engineering design experience and at least 5 years working as a structural engineer in New Jersey, who is licensed to practice in New Jersey. Design Engineers shall have practical experience with all the design and construction issues required for the Project including, but not limited to, steel fabrication including welding and field erection, basic metallurgical understanding of common construction materials, basic concrete mix design and chemistry, and an understanding of current trends in construction methods and materials related to heavy bridge work. The Design Engineer may or may not be the Engineer of Record. However, the Design Engineer’s initials shall always be the Supervisor in the “supervised box” lower left-hand corner of the Plans related to the structural design aspects of the Project.

DIAPHRAGM: A solid body member such as a C-channel, W-shape, fabricated welded plate, or concrete beam element that acts as bracing and assists in load distribution spans between the Stringers of a bridge. Diaphragms shall be considered as primary members in curved structures and heavily skewed structures.

ENGINEER: The Chief Engineer of the Authority or his/her duly authorized representative acting within the scope of the authority vested in him/her.

ENGINEER OF RECORD (EOR): Professional Engineer licensed to practice in New Jersey, responsible for the preparation of the Contract Documents. All communications with the Authority shall be through the EOR.

FAILURE CRITICAL MEMBER: A bridge member whose failure would be expected to result in a partial or full collapse of the bridge. Failure Critical Members may be constructed of any material designed to withstand loads including non-tensile loads. An example of a Failure Critical Member is a truss chord compression member or non-redundant pier column. This definition is meant to identify bridge members which may not be subjected to significant tension or flexure (such as pier columns), but their loss would still adversely affect the functionality and safe use of the structure. Non-redundant pier columns meeting the impact provisions of Subsection 3.2.2 of this Manual are exempt from this definition.

FLOORBEAM: Horizontal members that span transversely to, and are supported on, Girders or trusses and are used to support the Stringers or deck.

FRACTURE CRITICAL MEMBER: A bridge member subjected to tension or flexure that lacks redundancy. i.e., in the event of failure of just that element, the collapse of an entire span or bridge is likely to occur. Fracture critical members are noted as (FCM) for the purposes of identifying Fracture Critical Members in the Contract Plans. This definition is expanded beyond current FHWA guidance to include members other than steel components, such as non-redundant free spanning pier caps under direct flexure load from the superstructure. Two column concrete pier bents are exempted from this provision where they meet the impact resistance design provisions of Subsection 3.2.2

GIRDER: A horizontal structural member carrying vertical loads by resisting bending. A Girder is comprised of multiple plates and/or angles which are riveted or welded together and is usually interconnected by a system of Floorbeams, which in turn support a floor system that is typically comprised of Stringers, that directly supports a concrete bridge deck. In certain rare instances within the Authority, some Girder bridges may have decks supported solely on the Floorbeams or the deck may be supported directly on the Girder. These details are not to be reproduced in New Bridges. Girder ends are supported directly on abutments and/or piers. Girders may simply be referred to as “beams” in this section.

MAJOR BRIDGE: A bridge carrying Turnpike or Parkway roadways which merits additional consideration for design, maintenance, or rehabilitation effort. The minimum criteria for qualifying as a Major Bridge is that the bridge must support mainline traffic, must feature at least one span longer than 180 feet, or is designated by the Authority to be considered a Major Bridge.

NEW BRIDGE: A complete replacement of an existing bridge or an additional bridge added to the inventory. For the purposes of this Section, the limits of this work include all aspects of the construction from the level of the light standard mounts on the parapet to the bottom of the substructure components (piles / drilled shafts), and the full length of the bridge from the outer limits of the bridge approach slabs (or abutment back walls), including the wingwalls. Also included is the design of all permanent materials left in place and consideration of all temporary works and staging required to construct the New Bridge.

PROJECT: The entire Work to be performed under the Contract, including the furnishing and execution of all things necessary or proper therefore or incidental thereto for completion of the Work.

REFERENCE DRAWING: Any Plan sheet from a previous contract, a concurrent contract, or a future contract, included with the Contract Documents which will aid the Contractor in performing the work of the Project. Absolutely no changes are to be made to any Reference Drawings.

ROUTINE BRIDGE: Any bridge which is not a Major Bridge that is 20' or longer. A Culvert with a clear span of 20 feet or longer is also considered to be a Routine Bridge.

SPECIFICATIONS: The Standard Specifications, the Supplementary Specifications and Addenda, if issued, pertaining to the method or manner of performing the Project and to the qualities of the materials to be furnished for the Project.

STRINGER: A horizontal structural member carrying the vertical loads which supports the bridge deck by resisting bending. Stringer ends may be supported directly on abutments and piers, or may be supported only by a Floorbeam system of a Girder or truss bridge. Stringers may simply be referred to as "beams" in this section.

SUBSTANTIAL MODIFICATION: A Substantial Modification shall be defined as the alteration of any primary load carrying member within a bridge superstructure, including, but not limited to, Girders, Floorbeams, or Stringers, where the incurred load upon, or load capacity of, these members is changed by more than 10% of the existing condition.

3.1. PURPOSE AND INTENT

Section 3 of the Authority's Design Manual provides guidance, policies, standard practice and procedures for the development of bridge and/or structure Projects. The primary goal of this Section is to provide direction to Design Engineers to ensure that bridges constructed for the Authority are, in descending order of priority: (1) highly durable, (2) constructible, and (3) economical.

The instructions found within Section 3 constitute the minimum required level of effort on the part of the EOR. The EOR is encouraged to exceed the minimum required level of effort when best practices dictate. The Authority desires the "best value" structural solution, not the "lowest cost" structural solution, in cases when these two conditions conflict.

Section 3 of the Design Manual shall be used with other Design Manual sections (e.g. Geotechnical-Section 6) and shall be supplemented by current versions of the Authority's Procedures Manual, Load Rating Manual, Construction Manual, Manual for Traffic Control in Work Zones, Standard Specifications, and Standard Supplementary Specifications.

Although this Section provides guidance on design and analysis procedures, it does not preclude the need for additional engineering analysis and design procedures to produce a safe, economical and maintainable structure. Often special conditions will require engineering judgment to be applied and shall be assessed by the EOR and approved by the Authority on a Project specific basis.

3.2. BRIDGES

3.2.1. Design Specifications

3.2.1.1. Design

Standard Design Criteria

Except as modified within this Section, the design of all New Bridges and superstructures shall be governed by the latest edition of the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design Bridge Design Specifications (LRFD BDS), with current Interims and as modified by Subsection 3.2.2 of this Manual at the time the design contract is awarded.

Project Specific Design Criteria

The Design Engineer is responsible for preparing a Project Specific Design Criteria outlining the date and version of the LRFD BDS used for the design of the Project at the time of Notice to Proceed. Project specific criteria may differ from the guidance within this section of the Manual, where warranted. Large design projects often require multi-year design durations which may span multiple interims to the LRFD BDS. Some of these interims may contain specific items that are relevant and necessary to complete the design. Where changes to the Design Criteria occur either through recommendation of the Design Engineer or at the direction of the Authority, these changes should be documented in the Project Specific Design Criteria throughout the design process.

In addition, the Design Engineer shall also include in this document all design assumptions, external referenced research, and accepted third party design guidance used to progress the design. No design guidance document is all-encompassing and the Design Engineer is ultimately responsible for interpreting guidance documents and exercising good engineering judgment in the execution of the work. Where these interpretations and judgments may affect the ability of future Design Engineers to review the Project work, they shall be published in the Project Specific Design Criteria.

The Project Specific Design Criteria shall be published and submitted as a part of the Phase A submission as described in the Procedures Manual. The Design Engineer is encouraged to consult the Authority Engineer for concurrence when changes or additions are made to this document as the project progresses. Updates made during the course of design of the Project

Specific Design Criteria shall again be submitted as a part of the Phase C submission and as a part of the final calculations package submitted with the Phase D submission.

Foundation Design

The Authority does not permit the use of shallow bridge foundations without prior approval of the Supervising Engineer, Structures. Driven pile or drilled shaft foundations are the Authority's preferred foundation for all bridge piers, abutments and wingwalls. Deep foundation supported bridge elements need not consider differential settlement. Refer to Section 6 of this Manual for additional guidance.

3.2.1.2. **Load Rating**

As-designed load ratings shall be performed by the Design Engineer in parallel with all designs for New Bridges, or where an existing bridge is subjected to a Substantial Modification.

Load ratings of new structures or structures subject to substantial rehabilitation or modification shall be performed and published in accordance with the Authority's Load Rating Manual Subsection 4.4.

In addition, the Design Engineer shall review and update the load rating analysis when changes are made during construction that may affect the previously calculated As-Designed load ratings. The updated load rating analysis shall be considered an As-Built load rating and it shall be published and submitted within the specified timeline as per the Authority's Load Rating Manual Subsection 4.4 following the bridge being fully opened to public traffic. When updated load ratings are required, the Design Engineer shall modify the General Notes sheet of the Contract Plans as part of the relevant Change of Plan submission to include the updated (As-Built) load ratings. When updated load ratings are not required, the load rating report shall be updated in accordance with the Authority's Load Rating Manual Subsection 4.4 to indicate that the As-Designed and As-Built load ratings are identical.

3.2.1.3. **Geometry**

Shoulder Widths

Shoulder widths shall be established as shown in the following Exhibits at the end of this Section:

- Turnpike Bridges: Exhibits 3-100 to 3-107
- Parkway Bridges: Exhibits 3-108 to 3-111

It is desirable for the shoulder widths on a structure to match the shoulder widths of the approaching roadway for Turnpike and Parkway bridges. However, under certain conditions, it may be acceptable for shoulder widths on a structure to differ from the approach roadways. For bridges carrying local roadways over Turnpike or Parkway roadways, shoulder widths shall be as required by that roadway owner.

Shoulder widths for New Bridges which are less than the shoulder widths of the approach roadways may be permissible in situations where a physical or environmental obstruction beyond the fascias of the bridge prevents widening of the bridge. Approval of substandard shoulder widths shall be only via accepted Design Element Modification Request. Consult with the Authority Engineer where it is anticipated that reduced shoulder widths may be warranted.

The use of a reduced width shoulder will not exempt the Design Engineer from considering future bridge re-decking efforts per Subsection 3.2.4.1 of this Design Manual. Consideration of future re-decking of the structure may still require the use of over-wide shoulders in order to maintain all lanes of traffic during deck replacement or rehabilitation operations.

In the event that the shoulder widths on the structure are less than the shoulder widths on the approach roadway, the approach roadway shall be tapered such that it is tangent a minimum of 100’ from the begin / end bridge stations. This will allow the structure cross-section to be considered as matching the approach roadway section, effectively preventing the structure from being categorized as “functionally obsolete” in the NBIS bridge rating system. Refer to Sections 1 and 2 (Turnpike and Parkway Geometric Design) of this Manual for guidelines on tapering the approach roadway.

For bridge replacement Projects, Consultants shall be required to ensure bridge cross sections meet or exceed the NBIS requirements, effectively preventing the structure from being categorized as “functionally obsolete”.

For Major Bridge Rehabilitation Projects, the existing bridge geometry shall be evaluated per the NBIS requirements. The Consultant shall make recommendations to the Authority for improving the bridge geometrics to prevent “functionally obsolete” NBIS categorization as a part of the Phase A submission. No geometric improvements shall proceed without approval from the Authority.

For Bridge Replacement Projects, Consultants shall be required to confirm that new substructure locations meet the applicable sight distance and lateral clearance requirements for roadways passing under the New Bridge.

For bridge replacement Projects and for Major Bridge Rehabilitation Projects, the bridge cross section and the substructure locations shall be assessed for future roadway capacity requirements of the roadways below the structure and above, as dictated by the Authority's current accepted Capital Plan. Consult with the Authority Engineer for guidance.

3.2.1.4. **Railroad Bridges**

Bridges constructed to carry railways shall conform to the latest edition of the Manual for Railway Engineering published by the American Railway Engineering and Maintenance-of-Way Association (AREMA), subject to the requirements of the railroad agency concerned. Where railroad bridges are constructed for separate governing entities (New Jersey Transit, Norfolk-Southern, Conrail, etc.) those bridges shall be designed in accordance with their respective design standards. The New Jersey Turnpike Authority does not assume ownership of or maintenance for rail structures except as determined through an executed agreement. Refer to Subsection 3.2.2 of this Manual regarding modifications to AASHTO Subsection 3.6.5 for railroad impact loading. Consultants are advised that new rail bridges will become the property of the carried rail owner after completion of construction. Consult with the Authority Engineer prior to engaging with rail entities for bridge rehabilitation work.

3.2.1.5. **Local and State Highway Bridges**

For bridges carrying local roads and State highways over Authority roadways that fall under the Authority's maintenance jurisdiction, this Design Manual shall be followed for the bridge's structural design. However, the above roadway geometric requirements as well as the details for sidewalks, parapets, fencing, etc. shall conform to the requirements of the applicable agencies (i.e. NJDOT, local counties).

3.2.1.6. **Accelerated Bridge Construction (ABC)**

ABC is an emerging form of bridge construction which uses alternative methods of Project planning, design and construction. These alternative methods are geared towards reducing the onsite construction, reducing traffic delays for the duration of a bridge replacement or rehabilitation Project and reducing lane closures and impacts to traffic and local communities. This can be accomplished through use of prefabricated bridge elements to drastically reduce or eliminate time-consuming field operations such as forming and curing of structural concrete. Innovative construction methods such as utilizing slide-out/slide-in techniques which allow a bridge to be built off-line and then quickly moved into place are also effective ABC methods to minimize traffic impacts.

All New Bridge, bridge replacement, superstructure replacement, and bridge deck replacement Projects shall consider the use of ABC.

It is generally understood that ABC Projects will be of a higher initial construction cost than traditionally built Projects. This additional cost may be acceptable when compared to the advantages provided by ABC, including shortened disruptions to traffic, shortened on-site construction duration, reduction or elimination of winter cessation of concrete placement via use of precast elements, and increased quality control for complex aspects of bridge construction. ABC can also be beneficial where extremely tight construction work zones may preclude or complicate the use of traditional construction operations.

In addition, intangible benefits such as increased worker and public safety, decreased environmental impact, and reduced disruption to densely populated areas should be weighed, where appropriate.

The use of ABC is strongly encouraged for bridge work on the Garden State Parkway between Milepost 120 and Milepost 163 where limited shoulder widths, high traffic congestion, and limited work staging areas complicate construction operations.

The Authority has evaluated ABC techniques and details utilized by various agencies and has prepared a reference document titled ‘Policy and Guidelines for Accelerated Bridge Construction, Final Report’, summarizing preferred methodology and tools to evaluate ABC feasibility for a project. The ABC Screening Spreadsheet tool in this reference document shall be utilized in the Phase A investigation to determine if ABC is to be evaluated further for the bridges in the project.

The following ABC candidate evaluation categories were identified as a part of the report. The categories shown below are considered the most critical for the purposes of using the ABC Screening Spreadsheet tool. These categories are discussed in greater depth in the above referenced report.

- Initial Construction Cost
- Road User Cost
- Toll Revenue Impact
- Project Type
- Bridge Type

- Complexity of Geometry
- Maximum Span Dimensions
- Anticipated Detour Route
- Repetition / Economy of Scale
- Public / Road Worker Safety
- Durability / Life Cycle Costs
- Constructability
- Ease of Inspection
- Adherence to the Authority's Standards
- Environmental Impacts
- Utility and Railroad Impacts
- Right-of-Way Impacts

Where Project specific category considerations in addition to the above are identified during the screening process, they shall be brought to the attention of the Authority via the Phase A report.

ABC candidate bridges shall be identified and investigated as a part of the Phase A evaluation. At a minimum, the Phase A report will include:

- A narrative describing how the above considerations affect the recommendation to use ABC for a bridge Project.
- General Plan, Elevation, Bridge Section, and staging sketches for both the traditional and ABC options.
- Cost estimate for both the traditional and ABC options including toll revenue impacts, where relevant.
- Preliminary simplified Gantt style construction schedule in Excel for both the traditional and ABC options.

Certain high cost / high construction duration elements of all bridges, regardless of location, shall consider precast construction methods. These elements include items such as cap beams for bent concrete piers and open bent pier columns for very tall piers.

When considering ABC superstructure replacements, the Design Engineer shall investigate substructure elements for remaining life span per guidance given in Section 6 of the Design Manual prior to recommending them for extended service.

Precast deck panels shall not be used on roadways subject to heavy truck traffic including the Turnpike roadways north of Interchange 15E and the entirety of the Newark Bay Hudson County Extension without the express permission of the Chief Engineer.

The Authority will determine whether a candidate bridge is to be advanced with traditional or ABC type construction as a part of the Phase A review process.

3.2.1.7. **Utilities on Structures**

Utilities on structures are strongly discouraged. It is the policy of the Authority to prevent the placement of utilities on structures. The Design Engineer shall make every effort to provide alternate roadway crossing options for utilities that would otherwise be supported on a bridge. The alternate options may include directional boring under the roadway or aerial wires spanning over the road. New Bridges are prohibited from having utilities placed upon them without express written permission from the Authority. Comprehensive Bridge Rehabilitation Projects shall investigate the possibility of removing utilities from subject bridges where practical. Refer to Section 8 of the Procedures Manual for additional utility guidance.

3.2.2. **Modifications to Current Codes**

The following modifications to the current AASHTO LRFD Bridge Design Specifications shall apply:

1.3.5 Operational Importance (AASHTO)

The Operational Importance strength limit state shall classify all Turnpike and Parkway mainline and ramp bridges as "important", therefore: $\eta_I = 1.05$.

2.3.3 Clearances (AASHTO)

The minimum vertical clearances for new or replacement bridges shall be limited to 16'-0" to the lowest projection of the underside of the bridge where it crosses over a roadway or roadway shoulder.

The minimum vertical clearance for widened or rehabilitated bridges shall be equal to or greater than the existing bridge clearance. Where existing bridge clearance is less than 14'-6", consideration shall be given to the following to achieve the minimum bridge replacement clearance noted above.

- Replacing the superstructure
- Raising the superstructure
- Lowering the roadway below.

In instances where this is not practical, the Authority may approve a reduced minimum under clearance of 15'-0". Consult with the Authority Engineer should this occur.

2.5.2.4 Rideability (AASHTO)

For design purposes, the top 1/2" of the concrete deck slab thickness shall be considered as dead load only and shall not be considered effective in carrying secondary dead loads, live load or impact.

Also note that corrective grinding or micro-milling of the concrete deck has become standard practice for the Authority's bridge Projects to improve rideability and overall deck durability. An additional 1/4" of concrete shall be provided in the Contract Plans for construction, but shall not be considered for dead load as it is assumed that it will be removed during the micro-milling work. Direction should be given in the Contract Plans for the Contractor to set drainage inlets lower to allow for the final micro-milling. Joints should be set in specific end-of-deck and headblock closure pours after the completion of micro-milling to allow for best possible flush fit. However, in instances where this is not practicable, the joint armor may be set to account for the final micro-milling. The Design Engineer is referred to the NJTA Standard and/or Supplementary Specifications for guidance.

2.5.2.6.2 Criteria for Deflection (AASHTO)

Traditionally, bridges have been designed for stress limits using allowable stress design (ASD) or load factor design (LFD) provisions published in the AASHO or AASHTO codes from the first to seventeenth editions. These publications included language limiting deflections due to live load via the limit relationship of span length 'L' divided by a factor of 800 for pure vehicular traffic, or 'L' divided by 1000 for vehicular plus pedestrian traffic. The anecdotal history of these provisions was ostensibly to mitigate driver and pedestrian discomfort with additional concerns noted for durability of bridges and decks subjected to "excessive" flexure. Many bridge owners still maintain this criterion in their own design guidelines, often without a complete understanding of the need of this provision or its effects on their bridges.

In evaluating the validity of the provision, both the above noted concerns were researched and no conclusive documentation was found to support either supposition. If anything, it is worth pointing out that the inverse may in actuality be true for driver and pedestrian discomfort; consider that no physical sense in the human range is capable of easily detecting so slight a movement as 1/800th of even a relatively modest span length of 100' (1½") simply by standing on that span. That being said, the human inner ear does have the ability to detect changes in the ambient rate of acceleration, which is actually how one senses the vertical motion of a bridge while standing on it. Higher rate of acceleration therefore may cause more discomfort than lower rates of acceleration. High rates of acceleration stemming from higher bridge first resonant frequencies with small deflections are more likely to cause more discomfort than lower rates of acceleration stemming from lower bridge first resonant frequencies with large deflections. Regardless, it is often difficult to calculate the first resonant frequency of even a Routine Bridge.

In actual design, deflection can still be a concern. Beams with large cambers can be difficult to erect and correctly align where field splices are concerned, as the erecting contractor must 'follow the curve' of the Girder and cannot rely on a straight line view of the side profile of the girder. Shallow Girders may have large cambers that approach or even exceed the depth of the Girder web, creating concerns regarding stability, particularly during plastic concrete deck placement.

After factoring these constructability restrictions, it was determined that minimum practical limits on at least dead load deflection camber must be observed. To that end, the following principles shall apply to deflections:

- When investigating the maximum absolute deflection in tangent (straight beams) bridges, all design lanes should be loaded and all supporting components should be assumed to deflect equally.
- When investigating the maximum absolute deflection in bridges with horizontally curved stringers, all design lanes should be loaded and supporting components should be assumed to deflect unequally. The deflection limit is applied to each individual beam.
- When investigating maximum absolute deflection in transverse members such as closed steel box Cross-Beam pier caps, design lane positions should be loaded as appropriate to create the maximum deflection.
- The live load shall be taken from Article 3.6.1.3.2 and shall not be increased to reflect TP-16 live loading as described in NJTA Design Manual Subsection 3.2.2 (modifications to AASHTO Section 3.6).
- The live load multiple presence provisions of Article 3.6.1.1.2 shall apply.

Deflections of all Turnpike and Parkway bridges shall use the following values as general performance goals. Achieving the actual deflection goals shown below is not required, but encouraged.

- Vehicular load (longitudinal and transverse members) ....Span / 800
- Vehicular load on cantilever arms..Span / 400

The following additional criteria shall also be followed:

- The gross composite section properties in both the negative and positive moment regions of the span shall be used when calculating live load deflections (i.e. uncracked deck slab in negative moment region).
- The span length shall be defined as the distance between the centerlines of supports.

3.5.1 Dead Loads: DC, DW and EV (AASHTO)

Future Wearing Surface

An additional 25 psf of dead load allowance for a future wearing surface shall be applied to New Bridges or replacement bridge deck Projects with one course construction. The 25 psf provision accounts for the difference in weight due to the additional thickness of overlay.

Stay in Place Forms

The dead load for bridges with new or replacement reinforced concrete deck slabs supported by Stringers shall include a provisional 5 psf applied over the deck slab between Stringers to provide for the weight of corrugated metal stay in place (SIP) deck forms. All SIPs shall have their corrugations filled with foam and be oriented such that the minimum clearance to the reinforcing bar is maintained.

3.6 Live Loads (AASHTO) (Except for the design of Modular Bridge Expansion Joints)

3.6.1.2 Design Vehicular Live Load (Except for the design of Modular Bridge Expansion Joints)

Turnpike Bridges

Design vehicular live load (Strength I) to be used for all new Turnpike mainline and ramp bridges shall be TP-16 design live load unless otherwise directed by the Authority. Design live load on New Bridges carrying non-Turnpike traffic or U-Turns shall be HL-93 unless otherwise directed by the Authority.

TP-16 design vehicular live load shall be in accordance with HL-93 loading except as modified below:

- The first sentence of Article 3.6.1.2.3 is changed to:
    - The design tandem shall consist of a pair of 50 kip axles spaced 4' apart.
- The first sentence of Article 3.6.1.2.4 is changed to:
    - The design lane load shall consist of a load of 0.700 klf uniformly distributed in the longitudinal direction.
- The first sentence of Article 3.6.1.3.1, third bullet item, is changed to:
    - For negative moment between points of contraflexure, the uniform load specified above shall be considered with the tandem load above.
    - Wherever a wheel load is specified, a 25 kip load shall be used.

The generation of TP-16 loading is based on review of Weigh In Motion (WIM) studies performed at critical points along the Hudson County Extension and the Westerly Alignment. Results have shown that heavy and frequent traffic are common on the Turnpike roadway, which serves as an industrial / commercial / shipping artery for the region. TP-16 was derived to capture the increasingly frequent heavy trucks with tightly spaced axles while also simplifying the design effort on the part of the Design Engineer. Strength based live load modelling for New Bridges has now been functionally reduced to a static lane load and a single moving load of two tightly spaced fixed axles.

Generally speaking, for positive moment regions, TP-16 generates live loads that are approximately 80% higher for spans under 60' in length and decreases in variance down to approximately 30% at spans lengths up to 200', based on parametric analysis.

For negative moment regions TP-16 generates peak live loads that are approximately 10% higher for spans under 60' in length and decreases in variance down to parity at spans lengths up to 200', based on parametric analysis.

Parkway Bridges

The design vehicular live load to be used for all new Parkway mainline and ramp bridges shall be TP-16 as described above, unless otherwise directed by the Authority. However, the design live load to be used for all new members in Substantial Modifications to existing Parkway bridges shall be HL-93. Wherever a wheel load is specified, a 20 kip load shall be used.

3.6.1.4 Fatigue Load

3.6.1.4.1 Magnitude and Configuration

The first and second paragraphs are changed to:

- The fatigue load shall be one design truck or axles thereof specified in Article 3.6.1.2.2. The weights of the axle loads shown in Figure 3.6.1.2.2-1 shall be increased by multiplying by a Dynamic Load Allowance factor of 1.33. A constant spacing of 30.0 ft. shall be used between the 32 kip axles.

3.6.1.4.2 Frequency

The following is added to the first paragraph of Article 3.6.1.4.2:

- For computation of fatigue resistance in accordance with Article 6.6.1.2.5, one way ADTT traffic counts may be taken from Section 3.1.3 of the NJTA Load Rating Manual, current edition.

3.6.5 Vehicular Collision Force: CT (AASHTO)

3.6.5.1 Protection of Structures

The following is added:

Superstructure Impact

Review of historical collision damage at spans of Authority owned structures has shown that the majority of impacts have occurred at the fascia Stringer of the bridge and have been almost exclusively due to over-height vehicles with variable reach features, such as lifted dump bodies, or improperly secured bucket arms of excavators loaded on trailers.

These incidents are difficult to prevent due to the transient height nature of the vehicles. The resulting impact energy of the collision is likewise difficult to evaluate as it varies with vehicle weight, speed, and concentration of the impact area.

Therefore, in lieu of a more refined analysis, spans of Authority owned structures that have less than a 20' clearance over any roadway shall include fascia Stringers that have a minimum bottom flange thickness of 2" with a web plate of minimum 3/4" thickness. Diaphragms or Cross Frames for fascia beams (if present) shall be of a depth that is as close to the full-height of the web plate as is practicable and shall include stiffeners / connection plates with bolted connections to the bottom flange.

This provision may be waived for bridge superstructures built using ABC methods due to prefabricated element weight lifting concerns, as approved by the Authority.

Substructure Impact

Vehicular collision at traditional solid concrete abutments is not anticipated to be a controlling design load, given the consideration of the following:

- Embankments at stub abutments
- Passive pressure resistance of soil behind the full-height abutment walls

Abutments and piers located within a distance of 25' to the centerline of a railroad track shall be designed for an equivalent static force of 600 kips or shall be protected by a structurally independent crash wall or embankment that extends not less than 7' above the top of rail. This provides an allowance of 1' for future ballasting of the railroad tracks and for potential encroachment during construction or maintenance operations.

Regardless of ADT, all bridges shall consider collision load.

Individual pier columns and wall stems with more than 42 sf of cross-sectional area at the impact height are exempt from impact consideration.

3.10 Earthquake Effects: EQ (AASHTO)

This section shall not be considered in the design of new structures or the rehabilitation of existing structures. Refer to Subsection 3.2.6 of this Design Manual for seismic design and retrofit criteria.

3.11 Earth Pressure: EH, ES, LS and DD (AASHTO)

Geotechnical force effects for walls and abutments including lateral earth pressures shall be computed in accordance with Subsection 6.6.2 of this Design Manual.

3.12 Force Effects Due to Superimposed Deformations: TU, TG, SH, CR, SE, PS (AASHTO)

Design thermal force effects, deformations, and displacements shall be determined per the AASHTO LRFD Bridge Design Specifications, current ed., Article 3.12.2 using Procedure A for Moderate Climate conditions. The load factor for all thermal force effects, deformations, and displacements shall be 1.20 for all applicable limit states. When considering thermal force effects between substructures and superstructures, only the gross moment of inertia of concrete columns or piers shall be considered unless a more detailed analysis is performed, as described below, to verify that the partially cracked moment of inertia can be mobilized.

Forces from thermal effects, such as superstructure expansion between adjacent fixed piers, can cause large moments on pier elements. These moments are carried by the un-cracked gross moment of inertia of the concrete element until internal stress in the bare concrete exceeds the modulus of rupture (fr). After the stresses exceed this limit, the cracked moment of inertia may be used for stiffness and thermal force effect computation. The cracked moment of inertia may be conservatively assumed at 50% of the gross moment of inertia unless a more detailed analysis is performed. Before a partially cracked moment of inertia may be utilized for design, the Design Engineer shall verify that thermal force effects are adequate to exceed the modulus of rupture in the gross moment of inertia of the pier or column and will not cause failures in the bearing mechanisms.

3.15 Blast Loading: BL (AASHTO)

Blast loading shall only be considered for design as directed by the Authority. All design loading required shall be provided to the Design Engineer by the Authority.

4.6.2.2 Beam-Slab Bridges (AASHTO)

Replace the 11th paragraph of Article 4.6.2.2.1-Application (Where bridges

meet the conditions specified) with the following:

The dead load considered as supported by the outside roadway Stringer shall be that portion of the floor slab from the fascia to the centerline between the outside Stringer and the first interior Stringer. Parapets, railings, and safety walks, if placed after the slab has cured, shall be assumed to be carried entirely by the fascia Stringer. Sidewalks shall be assumed to be carried proportionally by the Stringers under and directly adjacent to the sidewalk curb using simple span distribution between the Stringers. This distribution ratio is not applicable to noise barriers mounted to superstructures and reference is made to Subsection 3.7 for further guidance for noise barrier loading. Where there is an open joint in a split median barrier, the dead load of the median barrier or raised median shall be distributed in the same manner as for fascia Stringers. Where the deck slab is continuous through the median, the dead load of median dividers or barriers shall be apportioned between the Stringers assuming the slab to act as a simple span between Stringers. Wearing surfaces shall be considered to be carried by the Stringer carrying the slab upon which it is placed.

These provisions are not applicable to bridges where the fascia Stringers are to be reused. Refer to the Authority's Load Rating Manual for dead load distribution for existing bridges.

5.4.2.3.2 Creep (AASHTO)
The average annual ambient relative humidity shall be taken as 70%.

5.9.2.3.2b Tensile Stresses (AASHTO)
Article 5.9.2.3.2b shall be replaced by the following:

For service load combinations that involve traffic loading, tension stresses in members with bonded or unbonded pre-stressing tendons should be investigated using Load Combination Service III and the tension in the pre-compressed tensile zone shall be zero. Stress Limit limitations stated in AASHTO LRFD Specification Table 5.9.2.3.2b-1 shall be accounted for in the NJDOT permit vehicle check, where applicable.

5.10.1 Concrete Cover (AASHTO)
Article 5.10.1 shall be replaced by the following:

The minimum clear cover for all reinforcement shall be two inches except as given below:

1. Concrete permanently in contact with earth: 3 inches

2. Concrete exposed to salt or brackish water:
   Piers and abutments: 4 inches
   Walls and culverts: 3 inches

3. Concrete in piers and abutments exposed to flowing water other than the above: 3 inches

4. Concrete deck slabs:
   Top Reinforcement: See Section 3.2.4.2
   Bottom Reinforcement: 1 inch

Splash zones noted above shall be any pier or abutment surface within 15” of an active roadway lane. This provision does not apply to MSE precast wall facing panels.

In piled foundations, reinforcement or supports for reinforcement shall be positioned a minimum of three inches clear from the piles.

6.4.1 Structural Steels (AASHTO)

See Subsection 3.2.3.1 of this Design Manual for additional information.

6.7.2 Dead Load Camber (AASHTO)

In computing cambers, the weight of the concrete deck slab shall include the permanent metal deck forms and the concrete contained in the forms, where present. Refer to Subsection 3.2.4.2 for new decks with foam filled deck forms.

In determining cambers in bridges with overlays, the weight of the overlay shall be taken as a superimposed dead load in computing deflections of the steel section acting compositely with the concrete slab. New Bridges need not consider a dead load provision for future asphaltic overlays for the purposes of establishing camber. Should need arise to install an asphaltic overlay in the future, the top 1/2” of the concrete deck will be milled away and replaced with the new asphaltic riding surface, thus negligible additional weight will be added to the bridge.

Steelwork shall be cambered to compensate for the weight of utilities where those utility weights incur deflections of 0.1 inches or more. The utility dead load shall be considered as supported by the steel section only.

Simple span bridges shall have a residual architectural camber equal to the length of the span / 1000 or 1”, whichever is greater.

These instructions shall apply unless it is known that the construction method will be such as to make them impractical. Consult with the Project Engineer where these deviations are anticipated or warranted.

3.2.3. Materials

3.2.3.1. Structural Steel

Turnpike Bridges

Structural steel for Turnpike bridges shall comply with AASHTO M270, Grade 50W (ASTM A709, Grade 50W) unless otherwise approved by the Authority’s Engineering Department. Members classified as FCM’s shall be fabricated from ASTM A709 Grade HPS50W.

All structural steel within a distance of 1.5 times the beam depth from a bridge joint shall be metallized in accordance with the NJTA Standard and Supplementary Specifications. The top flanges of Stringers shall be specified as furnished coated in zinc compatible weld-through primer. The exterior metalized surfaces of the fascia stringers shall be painted brown in accordance with the NJTA Standard and Supplementary Specifications. The exterior uncoated surfaces of fascia stringers, including the underside of the bottom flange, shall be blast cleaned in accordance with SSPC-SP-10 to ensure a uniform patina formation.

Parkway Bridges
Structural steel for Parkway bridges shall comply with AASHTO M270, Grade 50 (ASTM A709, Grade 50) unless otherwise approved by the Authority's Engineering Department. Members classified as FCM's shall be fabricated from ASTM A709 Grade HPS50W.

All structural steel for bridges shall be painted contrasting shades of green in accordance with the NJTA Supplementary Specifications and per Exhibit 3-304.

High Strength Steel (HPS70W or higher)
Use of High Strength Steel (Grade 70W or higher) should only be considered on a case-by-case basis and where permitted by the below provisions. Hybrid girder design, where appropriate, will preferably incorporate High Strength Steel in the bottom flanges of girder positive moment regions, and in both the bottom and top flanges of girder negative moment regions. Conventional Grade 50W Steel should be retained in girder positive moment top flanges and all web elements.

Typical design conditions where the Authority may allow High Strength Steel may include but are not limited to:

- Significant anticipated cost savings (10%, min) related to the total Structural Steel bid item.
- Shallow depth girders which may otherwise require overly thick and difficult to fabricate Gr. 50W flanges.
- Negative moment region flanges where drastic changes in flange plate thicknesses (greater than 50%) would otherwise create fabrication or erection complications.

The Design Engineer should be aware that due to the volatile availability of high strength steel, economy of materials should not be used as the sole determining factor for its use. The possibility of mill delivery delays should be investigated by the Design Engineer via direct contact with local steel fabricators prior to specifying its use.

Notch Toughness and Tensile Requirements
All flanges and webs in tension shall be noted as (T) on the plans for supplementary notch toughness testing required in accordance with ASTM A709 Section 10.

All components which are defined as Fracture Critical shall be noted as (FCM) on the plans for supplementary notch toughness testing required in accordance with ASTM A709 Section 10.

For the purposes of testing, Charpy V-Notch (CVN) toughness testing shall be performed for Zone 2 requirements per the ASTM A709 specification.

3.2.3.2. **Concrete**

The Authority does not allow the use of prestressed concrete for structural beams or piles except at the express written permission of the Supervising Engineer, Structures.

Wherever precast elements are specified for use, they shall be Concrete Class P with a minimum compressive strength at 28 days of 5,500 psi. The Design Engineer shall use a value of 5,000 psi for design.

Concrete for use in deck slabs, headblocks, cast-in-place parapets, and unsurfaced approach slabs for New Bridges, widenings and major deck reconstruction shall be High Performance Concrete (HPC) with a minimum compressive strength at 28 days of 4,400 psi. The Design Engineer shall use a value of 4,000 psi for design.

In situations where small concrete quantities are required for barrier parapet, Class A concrete with concrete penetrating sealer may be used in lieu of High Performance Concrete with the approval of the Engineer.

Concrete Class A, with a minimum compressive strength at 28 days of 4,500 psi, shall be used where Class P and Class HPC are not specified. The Design Engineer shall use a value of 4,000 psi for design.

Concrete Class SCC, with a minimum compressive strength equal to Concrete Class A, shall be considered for drilled shaft foundations when the following conditions exist:

- Very long and / or large diameter shafts.
- Reinforcing requirements dictate congested reinforcement configurations where flow of 3/4” diameter aggregate will be challenging.
- Concrete hold times are excessive due to difficult access or long duration pours.
- Other conditions that, in the opinion of the Engineer, may necessitate the use of Concrete Class SCC.

Concrete Class SCC may also be specified where congested reinforcement is present in above ground concrete members. The Design Engineer is advised that additional notations shall be provided on plans where SCC is used above ground, alerting the contractor to the possible necessity of more robust formwork to resist the higher fluid pressures exerted by the free-flowing nature of the Concrete Class SCC.

3.2.3.3. Reinforcement Steel

Reinforcement steel shall conform to the requirements of ASTM Designation A615, Grade 60 deformed carbon steel. Low-alloy, low-carbon steel conforming to the requirements of ASTM Designation A706, Grade 60, may be substituted in situations where welding is employed to expedite the assembly of reinforcement cages.

Reinforcement steel conforming to the requirements of ASTM Designation A615 shall not be welded. Additionally, welding of intersecting bars shall not be permitted in deck slabs.

All reinforcement steel, regardless of where it is placed within a structure, except for bridge decks, shall be specified as galvanized. For reinforcement within bridge decks, refer to Subsection 3.2.4.2. The designer is advised that for complete protection and to avoid unwanted galvanic response between dissimilar metals, all reinforcement steel accessories and support bars shall be galvanized. All galvanized coatings damaged during installation shall be repaired in accordance with ASTM A780.

3.2.4. Superstructure Design

3.2.4.1. Stringers and Beams

1. General
The preferred superstructure type shall be steel for both Turnpike and Parkway Bridges. Prestressed concrete superstructure types are not permitted unless approved by the Authority. This is due to poor durability of precast concrete stringer ends in the northeast region as compared to steel stringers. Prestressed Stringers traditionally feature uncoated strands which are both susceptible to corrosion and difficult to monitor when encased in concrete. In addition, prestressed concrete Stringers are not repairable after sustaining damage or decay and exhibit poor vehicular impact resistance. Furthermore, they have been subject to procurement difficulty, and raise concerns associated with repairing or replacing prestressed Stringers damaged during shipping or construction. For these reasons, the use of prestressed concrete has been discontinued. The Authority may allow exceptions on a case by case basis.

   Continuous superstructures should be used where practical and/or required for structural efficiency considerations such as achieving longer or shallower spans. Bridges with multiple simple span arrangements are no longer discouraged. Simple span arrangements, particularly where two span superstructures are considered, generally offer similar materials efficiency against continuous structures and also may offer the additional benefit of eliminating costly and time consuming field splices.

The spacing of Stringers shall be set so that future deck replacements may be made while traffic is maintained for the full number of active lanes on the bridge. The deck replacement shall be assumed to be in any single bay between Stringer centerlines, and provisions shall be made for construction barrier to protect the work area from traffic. In this condition, the full shoulder areas may be used for traffic and no shoulders need to be maintained through the work zone.

Refer to the provisions of Subsection 3.2.2 of this Manual for additional sizing guidelines relating to fascia beams which may be subjected to impact loading.

b. Composite Construction

Stringers with a concrete deck slab shall normally be designed as composite structures, assuming that no temporary supports will be provided for the beam during the placement of the permanent dead load. Girders should not be made composite with the above Stringer/deck system.

Preferred shear connectors for standard steel stringer construction shall be end-welded, 7/8” diameter stud. However, 3/4” diameter studs may be advantageous to use on original steel work (pre-1970 build) to effect better penetration of the stud end weld. In addition, 1” diameter studs may be advantageous for use in precast deck panel work where reduction in the number of studs lessens the number of perforations in the new deck and speeds the end stud welding work.

For straight beam bridges, the Design Engineer shall ignore the concrete deck in computing the shear range in regions of negative flexure. The deck and its reinforcement shall not be considered effective in resisting longitudinal stress.

In continuous spans, shear connectors shall be provided through the negative moment areas at a nominal pitch not to exceed 48”. The AASHTO LRFD BDS limit of 24” in Section 6.10.10.1.2 is waived.

Under no circumstances shall transverse steel members be made composite with the deck, including, but not limited to, framed-in steel Cross-Beams and end Diaphragm top members. Provisions shall be made in the design to prevent composite action at these members either by providing a physical gap between the deck and transverse members or by furnishing a primer coat only on the steel. Cross-Beams shall only be designed with a physical gap between the steel work and the deck. This provision has been added to reduce shrinkage confinement within the deck created by the shear connectors and therefore reduce early age deck cracking in these regions.

a. Curved Stringers

In general, fascia Stringers shall be curved in plan to match the curvature of the bridge fascia unless the mid-ordinate of the curve is so small that the curvature can be accommodated within a consistent slab overhang and the resulting appearance of the fascia is not aesthetically objectionable.

b. Intermediate Stiffeners and Connection Plates

Transverse intermediate stiffeners for welded plate Girders and Stringers, where required, shall be placed on both sides of the web with a tight fit at the top and bottom of the stiffener. Where stiffeners are used as connection plates for Diaphragms or Cross-Frames, they shall be welded at both the tension and compression flanges. Additionally, connection plates for Diaphragms or Cross-Frames for fascia Stringers shall be bolted to the bottom flange.

c. Welded Details

Field welding of steel is strongly discouraged. Its use should be limited to regions of no or negligible tensile stress only, such as welding of bottom flanges to bearing sole plates and welding of formwork accessories to the top flange of Girders in regions of non-reversing positive flexure. The Design Engineer shall clearly designate limits of exclusion for welding to the top flange of the Girders on the Contract Plans. Field automatic end welding of shear studs is permitted in all regions of the top flange.

Fillet weld sizes as required by design shall be shown on the plans. Refer to AWS A2.4 for proper weld call out geometry and nomenclature.

d. Splices

Beam elements of up to 120’ have been successfully transported to the site on Authority Projects. Congested regions with tight clearances, such as the Garden State Parkway between Mileposts 120 and 163, will likely require shorter shipping lengths. The Design Engineer is responsible for determining practical shipping lengths for site delivery as a part of their constructability review. Refer to Subsection 3.5 of the Procedures Manual for guidance in preparing the Constructability Report.

For continuous spans, splices shall be placed at locations of dead load contraflexure. For simple spans, splices shall preferably be placed at the outer 1/4 span points.

When a field splice is shown on the plans, provisions for it shall be made in the design by increasing the haunch and underclearance to accommodate the splice plates and bolt heads. Additionally, splice locations should be co-located with flange thickness changes to minimize butt weld requirements.

All field splice locations shall be shown as ‘optional’. The Contractor should be given freedom to omit a splice and transport the member in fewer pieces.

Design Engineers shall locate field splice locations with care. Field splices shall preferably not be made over active lanes as the corresponding bridge construction can be time consuming and disruptive to the operation of the roadway. Erection sequencing of the Girders should also be considered to minimize the use of temporary support towers.

Splices and connections shall be designed and the details and locations shown on the plans. Field splices shall be designed and detailed with ASTM F3125 high-strength bolts. 7/8” diameter bolts are traditionally employed for field splices, however, the consideration of 1” diameter bolts is encouraged as they may provide a substantial reduction in fastener usage. Bolt strengths in excess of 120 ksi may only be used in shear applications and may not be used in direct tension.

Field splicing of flanges shall preferably be performed by matching the capacity of the smaller flange plate to the capacity of the bolted connection. The net cross-sectional area of the flange splice plates shall equal or exceed the cross-sectional area of the smaller flange.

Web splices shall be proportioned to resist the shear capacity of the lesser web plate, accounting for the eccentricity of the bolted connection on either side of the splice.

For the purposes of design, the bolted connections for splices should be proportioned to resist strength loads using only slip critical resistance with the Class B friction coefficient. Where direct shear design is required for the connection, bolts shall be clearly specified in the Plans to have threads excluded from the shear plane of the connection.

The above design criteria will somewhat increase the number of fasteners used for splices. The rationale for this is based both on cost and pragmatism. Overweight loads have been increasingly prevalent on Authority roadways. The nominal cost increase of additional fasteners is outweighed by the benefit of having a capacity matched splice detail. In addition, conversations with contractors have indicated that the cost of field splices lies almost entirely in the initial fit-up of the connection. Once a few initial fasteners are installed to locate the connection plates, the labor cost to fill the remaining holes with fasteners, is negligible as well as the cost of the hardware.

e. Diaphragms and Cross-Frames

End Diaphragms or Cross-Frames shall be provided at all bearing lines regardless of skew. End Diaphragms or Cross-Frames and their connections shall be designed as simple spans between supporting longitudinal members for the effect of dead loads and wheel loads. They shall also be designed with provisions for future bearing replacement jacking loads including full dead and live loads. The End Diaphragms or Cross-Frames and their connections shall be designed to resist the forces listed above in appropriate combinations and shall include an impact factor for live load forces of 1.75. Detailing consideration for jack placement(s) shall be made in the End Diaphragm or Cross-Frame designs.

Diaphragms situated directly adjacent to abutment backwalls or other obstructions shall be designed with provisions for inspection of the back side of the diaphragm and future painting access. At a minimum, the following criteria shall be met for end Diaphragms:

- Open frame configurations should be considered
- At plate girder end diaphragms, reinforced access openings (port holes) shall be provided in the Diaphragm webs. The port hole shall be minimum 18” wide x 24” high and be proportioned so that no portion of the Diaphragm or connected Girders are more than 36” beyond the rim of the port hole opening.
- Plate girder end diaphragms, including flanges and stiffeners, shall provide a minimum clearance of 12” between abutment backwalls or adjacent end diaphragms.
- Where the aforementioned access opening (port hole) is not possible due to design or geometric considerations, minimum clearances of 18” and 24” shall be maintained to the abutment backwalls and adjacent end diaphragms, respectively; and a preferred 30” wide x 24” high (minimum 24” wide x 18” high) opening shall be provided between the bottoms of the Diaphragms and bearing seat areas for inspection access. This may be accomplished by providing a ‘painter’s notch’ block-out in the abutment seat or pier cap.

Intermediate Diaphragms or Cross-Frames shall be provided at spacing not to exceed 25’ along the length of any Stringer/Girder. Floor beam spacing shall not exceed 25’. In addition, intermediate Diaphragms or Cross-Frames shall be provided at or adjacent to all changes in Stringer/Girder flange thickness. Where Stringers/Girders are skewed, intermediate Diaphragms or

Cross-Frames may be placed continuously or dis-continuously (staggered) along the cross section of the superstructure at skews up to and including 20 degrees. At skews over 20 degrees, intermediate Diaphragms or Cross-Frames may only be staggered Refer to Section 3.2.2 of this Manual regarding modifications to AASHTO Subsection 3.6.5, for additional intermediate Diaphragm and stiffener/connection plate requirements to resist vehicular impact.

Intermediate Diaphragms may be rolled MC18x42.7 or C15x33.9 and shall be used for Stringers/Girders of less than 36" in overall depth.

Intermediate Cross-Frames shall be used for Stringers/Girders greater than 36" in overall depth and shall be either solid rolled or fabricated "I" or "C" shape members, or shall be X type Cross-Frames with top and bottom horizontal members provided. The minimum intermediate Cross-Frame member size shall be L5x5x1/2" angles.

. This provision has been added to simplify field erection of Diaphragms and Cross-Frames across differently cambered Stringer/Girder.

f. Depth of Stringers and Girders

Stringers and Girders shall generally be of uniform depth for the full length of the structure, except where changes in depth are absolutely necessary to meet underclearance requirements. Changes in depth shall not normally be made in structures with varying span lengths. Interior Stringers shall be made the same depth as the fascia Stringer(s). The fascia Stringer(s) should be the lowest projecting superstructure elements.

g. Economics of Girder and Stringer Design

Recent research and economic analysis has shown that the material cost of fabricated and erected structural steel only represents about 20% to 30% of the overall per-pound fabricated and erected steel cost included in the Engineer's estimates. Where the Design Engineer can take measures to reduce fabrication and erection complexity, these measures should be given higher priority than attempting to achieve savings by minimizing material usage.

In the design of welded plate Stringers and Girders, consideration shall be given to minimizing fabrication cost by eliminating flange plate cutoffs. In the case of a flange plate cutoff, the fabrication cost of the butt-welded splice must be compared to the material cost of the steel being saved, and also with the consideration that the ends of the Stringers/Girders are where future corrosion is most likely to occur.

h. Flange Plate Welded Butt Splices and Thicknesses

Where a change in thickness of a flange plate is made at a welded splice, the thicker plate will be tapered down to the thickness of the thinner plate.

Generally, the change in plate area made at a welded splice should be such that the area of the smaller plate is approximately 50% to 75% of the area of the larger plate. Small changes in plate area at a welded butt splice should be avoided, as the expense of the weldment often exceeds any savings in material. Flange plates at joints and abutments should be proportioned such that an overall thickness loss of 1/4” due to corrosion can be tolerated without reducing the live load capacity of the superstructure.

Regardless of flange plate thickness transitions, it is preferable that the width of flanges be constant within a single field section.

i. Fracture and Failure Critical Members

Fracture Critical Members (FCMs) are sometimes necessary to meet geometric needs or traverse over immovable facilities such as roads, railways, or critical utilities. Many bridges within the Authority inventory have FCMs and have served without incident for the duration of their service life. Use of Fracture Critical Members solely for the sake of material economy, however, is strongly discouraged.

Where the Design Engineer has recommended the use of FCMs, the following considerations shall be made during the design and shall be addressed as a part of the Phase A design submission:

- FCMs shall be designed to have a minimum un-factored capacity/demand ratio of 1.5 with the full design live load placed for maximum effect on the FCM. Please note that this is not to be evaluated as a load rating of 2.0, but a fully loaded total capacity divided by total demand calculation assuming Strength 1 load combination load factors.
- FCMs will require full hands-on inspection of all elements per current NBIS requirements. Design Engineers shall consider and provide inspection access facilities on all FCMs that will allow for unencumbered access for inspection staff to physically touch with bare hands all elements and surfaces of FCM components. This may be accomplished via inclusion of walking platforms, tie-off cables for harness climbing, or other methods as approved by the Authority. Closing of lanes of Authority roadways or crossed major roadways should not be required to inspect FCMs.
- Hollow shape FCMs such as framed-in closed steel box Cross-Beam pier caps shall have their interiors painted with an

approved 3 coat system in the SAE-AMS-STD-595C color 27925, including members which are externally left as weathering steel patina. This has been specified to promote visibility of nascent cracks and defects within the member. Where practicable, interiors of hollow shape FCMs shall be provided with lighting.

- Failure Critical Members such as non-redundant pier columns shall be designed to have a minimum un-factored capacity/demand ratio of 1.5 with the full design live load placed for maximum effect on the Failure Critical Member. Please note that this is not a load rating of 2.0, but a fully loaded total capacity divided by total demand calculation assuming Strength 1 load combination load factors.

3.2.4.2. **Deck Slabs**

1. General

Deck slabs shall be designed on the assumption that permanent stay-in-place (SIP) steel bridge deck forms shall be used with all corrugations filled with foam. Foam filled SIP forms shall be assumed to weigh 5 psf.

The wheel load for calculating slab bending moments shall be as outlined in Subsection 3.2.2 of this Manual, except for deck joints, which may be 16 kips.

Longitudinal expansion joints shall only be provided where necessary to accommodate transverse expansion on wide structures (e.g. wider than 90') and between parallel bridges. Joints shall preferably be located at the median barrier and shall be no greater than 1" where vehicles are expected to cross over the joint. Open joints between parallel structures shall preferably be 12" to allow adequate room for seismic excitation and access for future maintenance/repair of the parapets. Where open joints between parallel structures are required, adequate clearance for inspecting the fascia of both structures shall be considered. This may be accomplished either by allowing locations for climbing down and viewing the steel work, or verifying that these areas are inspectable via under bridge inspection vehicle.

Corrective deck grinding or micro-milling of the concrete deck has become common practice for the Authority's bridge Projects to improve rideability, and shall be used on all Projects where the bridge deck is new or replaced in its entirety. Refer to Subsection 3.2.2 for additional guidance on this requirement.

Concrete decks shall be sawcut grooved in the longitudinal direction. Sawcut grooving may be chorded in the longitudinal direction where the horizontal radius of curved bridges does not permit continuous longitudinal sawcutting operations. Transverse sawcutting may be permitted in certain instances as directed by the Authority. Design Engineers shall reference the latest Specifications.

The following deck designs shall be used for all bridges that are owned and/or maintained by the Authority, as noted in Subsection 3.2.1:

a. New Bridges (Mandatory) and Deck Reconstruction (Preferred):

For all New Bridges and complete deck reconstruction of existing bridges, one course construction shall be used, consisting of a 10" reinforced HPC slab (10 1/4" with sacrificial surface). Concrete cover for the top reinforcing bars shall be 2 1/2" measured from the top of the slab, not including the 1/4" sacrificial thickness for micro-milling. Galvanized bars shall be used for the top and bottom reinforcement steel mats. The standard reinforcement for the 10" slab shall be #5 bars at 10" minimum spacing for top and bottom bars, in both directions. This design is based on the premise of the Empirical Design methodology in AASHTO LRFD BDS Section 9.7.2. The use of this design inherently requires that the conditions expressed in AASHTO LRFD BDS Section 9.7.2.4 which are not explicitly specified above (i.e. deck slab thickness, concrete cover, reinforcement size/spacing) are strictly followed with the exception that the minimum overhang provision is reduced to 3.0 times the thickness of the slab for all cases. The reinforcement spacing was selected to conform with the typical bridge parapet reinforcement spacing shown in the Authority's Standard Drawings.

Deck overhang widths detailed on bridges shall consider the installation of scuppers and drain pipes/downspouts and shall ideally be proportioned such that drainage appurtenances do not interfere with the Stringer top flanges. The prior guidance to not place drainage appurtenances outside of the fascia Stringer top flanges has been eliminated.

Deck overhangs have traditionally been designed as small as possible to reduce the expense of formwork and additional reinforcement typically required. Deck overhangs should be of adequate size to offer weather protection to the outside face of the fascia Stringers and ideally should be proportioned to be 50% of the adjacent center to center Stringer spacing. This is offered as guidance to the Design

Engineer and not a strict mandate. Regardless, all deck overhangs shall be fully designed by the Design Engineer to resist TL-5 level impact loading per the provisions of AASHTO LRFD BDS Section A13.1.

Where the above empirical deck design is found to be impractical for full deck replacement work for existing bridges, the Design Engineer shall reduce the sectional thickness as necessary to carry the above design wheel loading and preserve the load carrying capacity of the superstructure.

2. Reinforcement
For new deck slab designs for Routine Bridges, galvanized reinforcing steel shall be used throughout. The Design Engineer is advised that for complete protection and to avoid unwanted galvanic response between dissimilar metals, all reinforcement steel accessories as well as all top surfaces of top flanges shall be coated with an inorganic zinc rich primer. Support bars shall be galvanized. All galvanized coatings damaged during installation shall be specified on the plans to be repaired after installation of shear connectors in accordance with ASTM A780.

- For New Bridges and total replacement of bridge decks, stainless steel reinforcement is recommended for use when any of the following apply. Its cost impact on the total Project cost is 5% or less.

- The redecking Project for Major Bridges that are expected to serve for 75 years or more beyond the completion of the redecking Project.

- Anticipated complex future staging or non-practicable access to a bridge deck for future repairs warrants its use to avoid correspondingly difficult lane closures.

Stainless steel reinforcing bar shall not be used for redecking projects without the express written consent of the Authority.

All reinforcement steel accessories and support bars shall be either stainless steel or non-ferrous in construction where stainless steel reinforcing is specified for decks.

Solid stainless steel reinforcement where specified shall conform to ASTM A955/A955M – UNS Designations S24000, S24100, S30400, S31603, S31653, S31803, S32101.

Reinforcement type and protective coating for parapets, medians, and overhangs shall match the deck slab.

For the purposes of a new deck designed on existing superstructures to remain, additional longitudinal deck reinforcement may be used to increase the negative moment bending capacity of the Stringers.

3. Concrete Haunches
   Haunches shall be provided for all cast in place concrete decks. The haunch shall be made deep enough to ensure that the concrete slab can be constructed to the nominal depth shown on the plans and with its top surface at the required profile, without any decrease in slab depth over the Stringer due to construction tolerances, variation in Stringer depth, variation in camber, deflection of the Stringer or other causes. The dimension from the top surface of the slab to the top of the Stringer shall not be less than the nominal slab plus 1" (minimum 1" haunch). The top of the Stringer shall normally be set so as to provide the minimum haunch depth over the thickest flange plate and at the most restrictive side of the Stringer when a cross slope is present. Where field splices in the Stringers are shown on the plans, or permitted by the Specifications, the haunch shall be a minimum depth of 1" over the splice plate. Bolt heads may project into the haunch, but 1" minimum of clear cover shall be maintained between the main steel reinforcement and the bolts.

   Haunches that are over 4" high shall be reinforced. Shear studs in reinforced haunches shall penetrate at least 2" above the top of the haunch reinforcement stirrup. Haunch reinforcement shall be designed as shear reinforcement and shall, in combination with the shear capacity of the unreinforced concrete, meet or exceed the fatigue resistance of the shear connectors as defined in Section 6.10.10.2 of the AASHTO LRFD BDS.

4. Stay in Place Permanent Steel Bridge Deck Forms (SIP forms)
   For New Bridges, complete deck replacement work, and Rehabilitation work, the main reinforcement in the lower mat shall be placed a minimum of 1" above the top surface of the Styrofoam filled SIP forms. The permanent steel bridge deck form corrugations shall be arranged parallel to the direction of transverse reinforcement, except where it is impractical such as in acute corners of the deck at fascia Stringers or in curved bridges where the reinforcement steel may be fanned in a radial arrangement regardless of the SIP corrugation orientation. The concrete cover around the main bars shall not be less than 1" clear in any direction to the surface of the form, see Exhibit 3-301.

5. Slab Corners
   The reinforcing of the acute corners of skewed slabs at a fascia Stringer shall be given special consideration. In these areas, it may be necessary to place additional reinforcement in a fanned arrangement extending into the corner as shown in Exhibit 3-302.

6. Expansion Joints
   Strip seal expansion joints are preferred and shall be used wherever practical. The maximum movement rating permissible for strip seal deck joints shall be 4”. Regardless of calculated thermal movements of less than 4”, all strip seal joints shall be configured to support 4” movement ratings. Strip seal glands shall also support a minimum 4” movement rating and be of the self-cleaning type. Where strip seal expansion joints are not practical for use and analysis indicates joint movements greater than 4“, modular type deck joints shall be used. Modular joints are generally 5 to 8 times as expensive as a strip seal expansion dam and they are generally more expensive to maintain. It is the preference of the Authority for Design Engineers to limit continuous span superstructure unit lengths such that modular joints will be either minimized or not needed.

   Where widening adjacent to an existing bridge joint that has been retrofitted with an asphaltic type “1P” style joint, it may be acceptable to use a different joint system with a longer service life. Consult with the Authority Engineer.

   All deck joints, regardless of type shall be shown in the Contract Documents as being installed after the placement of the majority of the bridge deck. Beam end rotations and translations during construction may complicate the installation and support of the deck joint assemblies. Block-outs shall be utilized to install the deck joint assemblies in their intended alignment for all bridges. The Design Engineer shall provide appropriate details, including all pertinent dimensioning of the closure pours, on the Contract Plans. Closure pours shall be clearly shown on all deck pour sequence diagrams. The Design Engineer shall calculate end rotations and translations for a bridge to determine if the requirements for this construction joint can be relieved.

3.2.4.3. **Bearings**

1. Standard Drawings**:**
   Standard bearing designs are available for Elastomeric Bearings and High Load Multi Rotational (HLMR) Bearings and are detailed on Standard Drawing Nos. BR-10 to BR-12.

   Steel reinforced Elastomeric Bearings shall be designed in accordance with Method B as outlined in the AASHTO LRFD BDS. Designs shall be coordinated with the notes and Specifications provided both in the NJTA Standard Drawings noted above, and in the Standard Specifications, when analyzing material properties and accounting for fabrication tolerances.

2. New Designs, Widening and Retrofits:
   Bearings shall be designed in accordance with the appropriate provisions of Section 14 of the AASHTO LRFD BDS.

   Elastomeric Bearings which are fully vulcanized to a masonry plate and a sole plate are preferred where their use is practical and cost effective. Elastomeric Bearings with a sliding surface will be permitted on a case by case basis.

   HLMR Bearings shall be specified for all bridges that qualify as curved in accordance with Article 4.6.1.2.4 of the AASHTO LRFD BDS. HLMR Bearings should be considered and are encouraged for use in situations where skewed, shallow, highly cambered, or unconventional structure framing may induce torsion or transverse rotations at the bearing points.

   Seismic Isolation Bearings shall be specified for use as dictated by seismic analysis. Adequacy of Seismic Isolation Bearings shall be evaluated in accordance with the appropriate provisions of the current edition of the AASHTO Guide Specifications for Seismic Isolation Design. Performance metrics for the bearings shall be presented on the Contract Plans.

   Regardless of bearing type chosen, the Design Engineer shall evaluate the anticipated construction sequence and alert the Contractor via contract plan notations if temporary bracing, preload jacking for thermal displacement, or other special procedures are required to install the bearings without overstress.

3. Provisions for Substructure Movement:
   Appreciable displacement of bearings can result from settlement of fill under and behind flexible type abutments causing horizontal movement at the top of abutments, as well as small rotations of tall piers. In these circumstances, and others where movements or settlements may take place, provisions shall be made in the design for resetting the bearings. The end Diaphragm or Cross-Frame shall be positioned and designed to provide for jacking the end of the span. Sufficient additional expansion capacity shall be provided in the bearings to accommodate any anticipated substructure movement, and to minimize the need to reset them.

4. Provisions for Bearing Replacement:
   All bearing designs and details shall provide a means for ready removal of the bearing for the purpose of inspection, maintenance and replacement. As an example, the bearing may be placed between steel load plates so that removal does not entail the demolition of reinforced concrete substructures. Substructures shall be designed to

allow adequate space for jacks or other devices for temporarily supporting the superstructure. Superstructures shall be designed to accommodate the loads imposed by these devices.

5. Provisions for Anchor Bolts:
   Anchor bolts shall be fully designed for Elastomeric Bearings. Force effects on anchor bolts to be designed by the bearing fabricator shall be considered where specifying HLMR or Seismic Isolation Bearings for use. Where large horizontal or longitudinal forces are anticipated due to multiple lines of fixed bearings at a single superstructure unit and/or where impact/thrust against guided expansion bearing guides or keeper plates is likely, these forces shall be accounted for in the design of the anchor bolts for Elastomeric Bearings, or included in the Bearing Design Tables provided for HLMR/Seismic Isolation Bearings.

   Pedestals, rather than stepped bearing seats, shall be used to support bearings. A nominal height of 6" is preferred. The Design Engineer shall verify by design that a minimum 1'-6" depth of embedment for the anchor bolt is sufficient to secure the bolt into the reinforced concrete mass of the abutment stem or pier cap. Additional pedestal reinforcement, in addition to, or in lieu of extending the anchor bolt embedment, may also be considered where appropriate or required by design. See Exhibit 3-213 for Pedestal Reinforcement Details.

   Anchor bolts may be installed by the Contractor via direct casting into the substructure unit concrete, drilling and grouting the bolts in place, or by casting-in oversize holes or preformed holes in the substructure concrete. Drilling and grouting of bars must be explicitly eliminated from use in the Contract Documents if the possibility of damaging the structural integrity of the substructure elements is anticipated. If net uplift or tension is anticipated at the anchor bolts, the casting of oversize holes or use of preformed holes in the substructure concrete shall be explicitly eliminated from use in the Contract Plans.

3.2.5. Substructure Design

3.2.5.1. Piers

1. See Exhibits 3-214 to 3-216 for general guidelines on Turnpike pier details. For all New Bridges, hammerhead style wall piers will be specified. Current market trends as of 2016 for labor versus concrete indicate that typical low level open bent pier construction is not cost-efficient. The cost to furnish and install the elaborate steel reinforcing bar arrangements present in the columns of multi-column bents can be considerable. This cost, combined with similar costs to reinforce, form, and place the

concrete cap for an open bent pier, have rendered this type of pier uneconomical for low and midlevel structures.

Open bent piers may be considered on a case-by-case basis where high level structures make this form of construction economical, or where obstructions within the footprint of the pier preclude the use of a solid-wall pier and footing.

Open bent pier caps, where used, shall be designed such that they are structurally capable of functioning as simple spans between adjacent pier columns to allow for future staged bridge reconstruction. Cover to main reinforcement for pier caps of open bent piers under deck joints shall be 3” minimum.

For existing bridges requiring rehabilitation, reconstruction or widening, Design Engineers shall utilize the pier type that matches that of the existing bridge.

All new and reconstructed or widened piers shall conform to the impact requirements of Subsection 3.2.2 of this Design Manual.

All reinforcement in all piers shall be galvanized.

2. Footings

Piers shall generally be designed with a continuous footing supporting all walls and /or columns, except where footings must be discontinuous to avoid features such as utilities or roadways. All piers, regardless of type, shall be founded on piles, drilled shafts, or competent rock. Soil bearing piers are not permitted.

All reinforcement in footing shall be galvanized.

3.2.5.2. **Abutments**

1. Design Criteria

Design guidance for Abutments has been separated between Section 3 and Section 6 of this Design Manual. Refer to Subsection 6.6.2 for additional guidance on retaining wall type selection and design. Unless noted otherwise, the AASHTO LRFD BDS as modified herein shall govern the design of the abutment’s structural concrete and foundation.

For clarity, it is repeated in this Section of the Design Manual that the preferred abutment and wingwall type for both the Turnpike and Parkway bridges shall be conventional cast-in-place concrete cantilever semi-gravity retaining walls. Alternate abutment wall types addressed in this Section and Subsection 3.3 shall be considered and approved by the Authority on a case by case basis.

The preferred foundation type for conventional abutment and wingwalls is driven piles, selected and designed in accordance with Section 6 of the Design Manual. Alternate foundation types (spread footings, drilled shafts, etc.) shall be considered and approved by the Authority on a case by case basis.

Foundation and global stability of abutments shall be analyzed in accordance with Sections 10 and 11 of the AASHTO LRFD BDS and Section 6 of this Manual. The Design Engineer is advised that abutment design relies heavily on the input and coordination of the Geotechnical Engineer. Refer to Section 6 of this Manual for definition of, and responsibilities for the Geotechnical Engineer pertaining to the design of abutments.

Abutments shall be designed to resist all vertical and horizontal forces from the bridge superstructure and the bridge approach slab. The use of fixed bearings upon abutments should be avoided where practicable in multi span bridges. Abutments shall be specified to be backfilled to the underside of the new approach slab prior to the placement of the superstructure or bearings. Abutments shall be designed for this sequencing as a temporary construction condition where the earth fill is fully placed before the superstructure is erected. The design for this condition shall include a surcharge load for construction equipment. For this condition, the resistance factors may be increased by 25%.

For the purposes of standardizing limits, wingwalls for abutments shall be included as the portion of the retaining wall originating from the abutment stem and cast integrally with the abutment up to the joint with the adjoining retaining wall (if present). Where no such clear definition exists, the wingwall shall be defined as the portion of the wall extending 25’ from the corner at the abutment. This definition has been provided to establish uniformity with the Authority’s inspection inventory practices.

2. Approach Slabs
   Approach slabs shall be provided for all abutments and shall be constructed for the full width of the roadway including shoulders. Approach slabs shall be designed assuming they act as simple spans between the abutment backwall and the end of the approach slab for a distance of not less than 25’.

3. Alternate Abutments Walls

   On a case-by-case basis, the Authority may approve the use of alternate abutment configurations which deviate from the preferred configuration described previously in this Section. Where approved by the Authority, Alternate type abutments, such as Mechanically Stabilized Earth (MSE) or Prefabricated Modular (PM) Wall proprietary type systems, may be considered. Where approved by the Authority, analysis and recommendations justifying the deviation shall be included in the Phase A Report. Initial cost shall not be considered as a metric in this analysis.

a. Proprietary type abutment systems shall be designed based on a 100 year service life.

b. Refer to 2.3.3 for MSE and PM wall system requirements. Criteria stated therein shall be applied in such Abutment designs.

c. The design of proprietary type wall systems supporting abutment caps shall take into account the anticipated movements and loads transmitted from the abutment caps. Plans and/or specifications for the wall system shall clearly state the additional loads and/or movements that will be imposed on the wall system. On a Project specific basis, Design Engineers may need to consider certain design options, such as adding soil reinforcement straps to the abutment backwall cap, isolating the deep foundation from the wall face, requiring the proprietary system to be designed for higher pressures, etc.

d. Design Engineers shall contact the approved wall system manufacturers during the design process to discuss Project specific design requirements and details to ensure there will be no conflicts during construction phasing.

e. Under no circumstances may abutment caps on proprietary walls be designed as soil bearing. All abutment caps shall bear directly on piles or drilled shafts assuming no vertical contribution from the proprietary wall system.

4. Integral and Semi-Integral Abutments

Integral abutment design shall conform to the provisions of the 6th Edition of the NJDOT Bridges and Structures Design Manual, Section 15, and the associated NJDOT Standard Drawing Plates 2.5-1 through 2.5-6, except as supplemented/modified by the following:

a. Integral abutment design will only be permitted for non-skewed single span bridges.

b. The joints between abutment stems and independent wingwalls shall always be oriented longitudinally, parallel to the bridge center line.

c. Loose or compressible fill shall be used behind and beneath any wingwall not independent from the abutment stem.

d. Provisions shall be made for expansion at the end of relief slabs by installation of sleeper slabs and joints, regardless of the bridge length.

e. Single span bridges shall have a span length not exceeding 80'.

f. The minimum reveal between the bottom of the superstructure and the top of the fore slope embankment (if present) shall be 1'-6".

g. If Mechanically Stabilized Earth (MSE) wall systems are utilized at integral abutment locations, the following provisions shall apply:

   i. The minimum clear distance between the back of the wall facing and the front edge of the abutment stem foundation piles or pile casings shall be 1'-6".

   ii. Soil reinforcing straps shall be designed considering the additional loads transmitted from the piles to the reinforced soil backfill.

h. Manholes, utility valve covers and drainage inlets shall be located beyond the limits of relief and sleeper slabs.

3.2.5.3. **Scour Design**

1. Bridge substructures and foundations shall be evaluated for scour conditions in accordance with the AASHTO LRFD BDS. Hydraulic and scour analysis shall be performed in accordance with Section 5 of this Manual.

2. In accordance with the AASHTO LRFD BDS, new and replacement bridges shall be designed for the scour condition for a recurrence interval that is expected to produce the most severe adverse condition, up to 100 years maximum. Other existing bridges scheduled to be significantly rehabilitated or widened will be identified by the Authority on a Project by Project basis. Scour evaluations of existing bridges shall also take into account past history of floods in the Project area. The use of flood criteria greater than 100 years may be necessary and shall be evaluated on an individual bridge basis.

3. In accordance with the AASHTO LRFD BDS, new, replacement and widened bridges shall be checked for the scour condition for a 500-year flood.

4. In accordance with Section 5 of this Manual, a Scour Report shall be submitted which shall include scour countermeasure and resistance recommendations.
5. Scour considerations and / or countermeasures shall be selected and designed as directed in Section 5 of this Manual.

3.2.6. Design for Seismic Events

3.2.6.1. Design Specifications

Except as modified below, the seismic evaluation of all bridges shall be governed by the current editions of the following design codes:

- AASHTO LRFD Bridge Design Specifications, with current interims. (AASHTO LRFD BDS)
- AASHTO Guide Specifications for LRFD Seismic Bridge Design, with current interims. (AASHTO LRFD SBD)
- FHWA Seismic Retrofitting Manual for Highway Structures, Publication No. FHWA-HRT-06-032, January 2006. (FHWA Manual)
- AASHTO Guide Specifications for Seismic Isolation Design (AASHTO GSSID)

The AASHTO Guide Specifications for LRFD Seismic Bridge Design offers a displacement-based design alternative to the force-based design methodology presented in the AASHTO LRFD Bridge Design Specifications. Displacement-based seismic design has the potential to offer a more economical bridge design, especially in regions of high seismic activity. However, the Turnpike and Parkway facilities are contained within a region of relatively low seismic activity where displacement-based designs have generally proven to offer minimal savings as compared to force-based designs. While the Design Engineer is not explicitly discouraged from using a displacement-based seismic design, it should be noted that the potential benefits of such a design may be negligible. However, where site specific spectra in problematic soils may arrive at high peak accelerations, a displacement-based approach to New Bridge design may be warranted.

3.2.6.2. General Considerations

The most common and significant hazard causing earthquake damage is ground shaking. Additional seismic hazards can also include ground failure, liquefaction, lateral spreading, differential settlement and land sliding. All New Bridges shall be designed to resist such hazards in accordance with the AASHTO LRFD BDS. All existing bridges which meet the criteria of Subsection 3.2.6.8 or are otherwise designated by the Authority shall be subjected to a vulnerability analysis and subsequent retrofit design (as required) which considers the above hazards.

3.2.6.3. **Seismic Ground Shaking Hazards**

For the purposes of both existing bridge vulnerability analysis and new bridge design, the following criteria shall be used when defining the seismic ground shaking hazard. The seismic ground shaking hazard is defined by the design response spectrum.

For the 1,000-year mean return period earthquake, bedrock ground motion parameters shall be taken from the AASHTO LRFD BDS seismic hazard maps and procedures. For the 2,500-year mean return period earthquake, bedrock ground motion parameters for the site shall be taken from the most recent USGS National Seismic Hazard Maps.

For both the 1,000-year and 2,500-year mean return period earthquakes, the design response spectrum shall be computed following the provisions of AASHTO LRFD BDS Article 3.10.4.

The Site Specific Procedure may be used for any bridge, but shall be mandatory for the following situations:

- Bridges 1000’ or greater in length.
- Bridges with a deck area exceeding 50,000 sf
- Bridges designated by the Authority as “Critical”.
- Anywhere a time history response analysis will be performed as part of the overall design / retrofit scheme.

3.2.6.4. **Bridge Importance Classification**

For the seismic design of New Bridges as well as the seismic vulnerability assessment and retrofit design of existing bridges, all bridges shall be classified as “Essential” bridges unless designated otherwise by the Authority. If the Authority elects to assign “Critical” importance classification to a bridge, the designation will be clearly stated in the project scope of work.

3.2.6.5. **Siesmic Performance Criteria**

The following seismic performance criteria shall apply for the design of New Bridges as well as for seismic vulnerability assessment and retrofit design of existing bridges. These criteria expand upon and supersede definitions in the AASHTO LRFD BDS and the FHWA Manual.

Bridge Classification	Considered Seismic	Mean Return	Probability of Exceedance	Acceptable Damage	Access Level

	Event	Period		Level	
Essential	Single Level	1000 years	7% in 75 years	Minimal	Immediate
Critical	Upper Level	2500 years	3% in 75 years	Repairable	Limited
	Lower Level	1000 years	7% in 75 years	Minimal	Immediate

Post-seismic event acceptable damage levels are defined as follows:

- "Minimal" damage means that the bridge should have "essentially elastic" response, meaning minor inelastic response could take place. In reinforced concrete elements, post-earthquake damage should be limited to light flexural cracking. Permanent deformations are not allowed for primary structural members. Minor damage and permanent deformations are permitted in secondary members. No damage to expansion joints is permitted, except for the sealing gland, which may be considered sacrificial for the purposes of seismic performance evaluation.
- "Repairable" damage means that the bridge can be restored to its pre-earthquake condition without replacement of primary structural members. Inelastic response is permitted and may result in concrete cracking, concrete cover spalling, and yielding of reinforcement in concrete members. Where spalling or loss of concrete cover is anticipated, consideration shall be given to where loosened concrete may fall. Falling concrete over active roadways or populated areas will not be considered acceptable. Loosened concrete which may fall over median areas or in roadway shoulders will be considered acceptable. Limited damage will be considered acceptable in secondary members and non-structural components, including expansion joints, provided that such damage will not significantly damage attached primary members or allow the secondary members to fall free of the bridge. Permanent post-event deformations shall be small and no collapse will be permitted. Repairs, where required, shall be possible without completely closing the bridge to traffic, i.e., repairs can be performed with limited lane and shoulder closures. As a part of the Phase A report, the Consultant shall present their detailed seismic design criteria including an inventory of bridge members which are anticipated to receive damage, the anticipated extent of the damage with a conceptual repair scheme, a preliminary estimate of repair costs, and an anticipated construction schedule or time frame in which the repairs can be completed to the point that all active traffic lanes on the bridge can be restored to full service.

Post-earthquake access levels are defined as follows:

- Immediate access means that full service for all vehicles will be available within 72 hours following a design seismic event allowing for inspection and clearance of debris.
- Limited access means that service for emergency vehicles will be available within 72 hours following a design seismic event allowing for inspection and clearance of debris, i.e. steel plates may be required to span over failed joint areas or damaged deck areas. Full service to general traffic for all lanes shall be able to be restored within a matter of three months unless longer timeframes are permitted by the Authority.

3.2.6.6. **Analysis for Earthquake Loads**

Analysis requirements for earthquake loads presented herein apply to New Bridge design as well as existing bridge seismic vulnerability assessment/retrofit design.

Single Mode or Uniform Load analyses are permitted for all Essential bridges which will not be classified as “Irregular bridges”. Multi-mode analyses shall be used for all Irregular bridges. In addition to the provisions noted in the AASHTO LRFD BDS Article 4.7.4.3, the following bridge types shall be considered to be “Irregular bridges”:

- Bridges with any span curved in plan, where the definition of curvature is as described in Section 4.6.1.2.4b of the AASHTO LRFD BDS.
- Bridges designed with transverse Cross-Beam pier cap elements.
- All bridges designated as “Critical” by the Authority.

Note: seismic analysis does not apply to single span bridges, which are exempt from seismic analysis, with the exception of checking bridge seat length, in accordance with Section 4.7.4.4 of the AASHTO LRFD BDS. This exception does not apply to viaduct bridges composed of a series of single span superstructures.

Extreme Event I Load Combination in Table 3.4.1-1 of the AASHTO LRFD BDS shall consider a Live Load Factor (gEQ) of 0.50. Similarly, 50% of live load lane forces shall be considered simultaneously with dead load and seismic effects when the design and/or analysis is performed in accordance with AASHTO LRFD SBD or the FHWA Manual. The notional truck or tandem portion of the HL-93 or TP-16 live load model shall not be considered. Note that the inertial effects of the live load shall not be included in the dynamic analysis.

3.2.6.7. **Design of New Bridges**

All New Bridges shall be designed to incorporate minimum support bridge seat lengths, connection designs, and column design / ductility details required for Zone 2 criteria, per the provisions of the AASHTO LRFD BDS. New Bridges designed using AASHTO LRFD SBD shall follow, at a minimum, the design and detailing requirements of Seismic Design Category B. Single-span bridges shall be designed in accordance with Article 3.10.9.1 of the AASHTO LRFD BDS. Forces used in the design of connections between the superstructure and the substructure need not be considered in the design of the substructure for bridges located in Zone 1.

New Bridges designated as "Critical" shall be designed to resist both the lower level and upper level events while maintaining the post-earthquake acceptable damage levels and access levels as defined in Subsection 3.2.6.5.

These general considerations provide for a rational approach to bridge designs that allows the use of simplified analysis methods for the majority of bridges in the Turnpike and Parkway inventories, but requires the inclusion of code mandatory detailing, which offers significant increases in seismic performance, ductility, and redundancy at a relatively incidental increase to the bridge construction cost.

3.2.6.8. **Vulnerability Assessment and Retrofit Design**

The FHWA Manual shall be used as a guide regarding evaluation procedures and upgrade measures for retrofitting existing seismically deficient highway bridges.

Unless directed otherwise by the Authority, a seismic retrofit shall be considered for all existing Bridge Rehabilitation projects which meet the following criteria:

- Anticipated Project work includes increasing the bridge deck area by more than 25% and / or replacing the entire bridge deck.
- Anticipated Project work includes replacing or repairing more than 25% of the superstructure bearings.

When the estimated cost of the proposed seismic retrofit strategy exceeds 25% of the estimated replacement cost of the bridge, replacement of the bridge shall be considered.

In addition to the above criteria, the Design Engineer is responsible for rational consideration of all existing bridges within a Project for seismic retrofit eligibility. Development of a retrofit scheme should be considered where the anticipated scale and type of work to an existing bridge offers the opportunity to include cost effective seismic retrofitting measures in the Project.

When an existing bridge has been determined to be a candidate for seismic retrofitting, a conceptual retrofit strategy shall be included as part of the Phase A submission. When the estimated cost of the proposed retrofit strategy indicates that a full bridge replacement may be warranted, the Authority shall be contacted prior to the Phase A submission.

When existing bridges designated by the Authority as “Critical” are investigated for retrofit design, they shall be analyzed to resist both the lower level event and upper level events for maintaining the post-earthquake acceptable damage levels and access levels as defined in Subsection 3.2.6.5. Retrofit strategies shall be prepared for both the lower level event and the upper level event, including a cost estimate for each strategy. Both strategies and their corresponding cost estimates shall be presented as part of the Phase A report and shall include a recommendation to retrofit the structure to either the lower level or the higher-level event.

The Authority reserves the right to reduce the design seismic event to 500 years where the candidate bridge is anticipated to have a remaining service life of 35 years or less.

The majority of existing bridges should not be expected to meet the force and ductile detailing requirements set forth in the AASHTO LRFD codes noted above, as many of these existing bridges were designed with little or no provision for resistance to seismic hazards. The inventory of the Authority’s existing bridges generally has limited ductility and are incapable of sustaining stable inelastic cyclic response, which is the basis of current seismic design provisions for New Bridges.

For existing bridge seismic retrofit evaluation, Method C: Component Capacity/Demand Method, as described in Subsection 5.4 for Seismic Retrofit Category C and D, and Appendix D of the Retrofitting Manual shall be used, at a minimum.

Nonlinear static and / or dynamic analyses are recommended, but not required, where bridges with ductile details are to be evaluated, or where member strengthening and/or ductility enhancement are considered as part of the retrofitting concept.

Seismic retrofitting of existing bridges constitutes a substantial structural alteration. The Design Engineer shall perform a complete LRFR load rating analysis of the as-retrofitted bridge in accordance with the NJTA Load Rating Manual unless directed otherwise by the Engineer.

Isolation strategies, if employed, shall be designed in accordance with the AASHTO GSSID. This document is explicitly intended to function in concert with the AASHTO LRFD BDS and the AASHTO LRFD SBD. The use of Load Factor Design or Allowable Stress Design methodologies in concert with these Specifications is not permitted.

3.2.7. **Computer Software**

(For Design Purposes Only – See Section 2.3 of the NJTA Load Rating Manual for Load Rating Computer Software Requirements)

3.2.7.1. **Guidelines on Use**

The use of computer software has become a valuable tool to the Design Engineer. However, even the best computer software cannot replace good engineering judgment and design practice. In addition to the guidelines noted below, it is recommended that the checked results be reviewed by senior structural engineers or technical managers as part of the Engineer's QA/QC process.

Design software, with version number and date of release, shall be clearly indicated in the general notes on the Contract Plans. The Authority's Engineering Department approval will not relieve the Design Engineer of the responsibility for the use of the program. The Design Engineer assumes full responsibility for the logic and results of the program.

The following guidelines shall be followed when using any design software:

1. Program input and output shall always be checked by a second Design Engineer. All input and results shall be furnished as .pdf documents and placed in the design calculations. Design Engineers shall be responsible for verifying that the results of the computer software are correct. Verification shall be in the form of a second computer program or sufficient hand calculations to verify results.

2. All computer analysis and design shall be performed under the direct supervision of a structural engineer familiar with the computer software program who has direct experience designing at least two (2) bridges of similar scale and complexity with the software.

3. When utilizing spreadsheets, Mathcad, or software written by or obtained from external sources, the Design Engineer and checking Engineer shall thoroughly check the language and/or formulas to assure the integrity of the structural analysis and/or design.

4. Design calculations shall include as much program documentation as required to ensure that the program input and output can be interpreted by the Authority and future Engineers.

5. Software generated design calculations shall always be validated by hand calculations. At a minimum, the Design Engineer is required to prepare and submit the following hand calculations to validate the software as a part of the overall design calculations submission:

   - Proof calculations for section properties for all Stringer, Girder, Floorbeam, Cross-Frames for curved bridges, and Cross-Beam elements. Calculations shall be provided for non-composite, short-term composite, and long-term composite properties, as applicable.
   - Proof calculations for live load distribution for shear and moment, as applicable.
   - Proof calculations for unfactored live load moments and shears at controlling locations.
   - Proof calculations for field splice and bolted connections where design is performed via software.

Where Finite Element Modeling (FEA) analysis makes the above hand-calculation verification not practicable, the Authority may allow the use of an independent FEA analysis using separate software as sufficient validation.

3.2.8. Permits

For permit requirements to be considered during design, reference is made to the NJTA Procedures Manual.

3.3. Retaining Walls

3.3.1. General

Design guidance for retaining walls has been separated between Section 3 and Section 6 of this Design Manual. Refer to Subsection 6.6.2 for additional guidance on retaining wall type selection and design.

For clarity, it is repeated in this Section of the Design Manual that the preferred retaining wall type shall be conventional cast in place concrete semi-gravity retaining walls for both the Turnpike and Parkway roadways. Alternate retaining wall types may be considered and approved by the Authority on a case by case basis.

The preferred foundation type for the conventional retaining walls is driven piles. Alternate foundation types (spread footings, drilled shafts, etc.) may be considered and approved by the Authority on a case by case basis.

3.3.2. Conventional Retaining Structures

1. Foundation and Stability Design
   Foundation and global stability of the retaining structures shall be analyzed in accordance with Sections 10 and 11 of the AASHTO LRFD BDS and Section 6 of this Manual. The Design Engineer is advised that retaining wall design relies heavily on the input and coordination of the Geotechnical Engineer. Refer to Section 6 of this Manual for definition of, and responsibilities for the Geotechnical Engineer pertaining to the design of conventional retaining structures.

2. Conventional Cast in Place Wall Minimum Dimensions
   The minimum thickness at the base of any cast in place concrete wall shall be 12” for walls up to 10’ high, 15” for walls up to 14’ high, and 18” thick for walls higher than 14’. Low walls should be designed with a vertical rear face and higher walls should be battered or stepped, with a rear face batter of not less than 1 in 12. Battered faces shall (where possible) be plane, and changes in batter shall be avoided. Tops of walls shall be no less than 12” in thickness.

   Footings for conventional cast in place concrete walls shall be no less than 24” thick for soil bearing foundations and 36” for pile bearing foundations with a minimum embedment of 12” for all pile types.

3. Refer to Section 6 of this Manual for the design of driven cantilever walls, such as sheet pile and soldier pile and lagging type walls. These types of walls should only be used in ‘cut’ situations where the intent of the work is to install the wall and then remove the material in front of the wall to expose down to the finished grade.

3.3.3. Alternate / Proprietary Retaining Walls

1. As approved by the Authority, Design Engineers may consider the use of proprietary retaining wall systems. Proprietary retaining wall systems, Mechanically Stabilized Earth (MSE) Walls and Prefabricated Modular (PM) Walls, generally are more cost effective in specific situations and often provide a shorter construction time than conventional cast-in-place reinforced concrete cantilever retaining wall systems.

   MSE walls are generally not desirable where large excavations are required to construct the wall (cut wall), as the additional cost of temporary walls to support the cut outweighs the cost of other wall types.

2. The current NJTA Standard Specifications provide a list of Wall systems and design and construction criteria that shall be used as guidance when developing the Project Specific Specifications.

3. The Design Engineer shall compare retaining wall types and listed systems to determine which wall configurations best meet Project objectives, i.e., structure cost, functionality, construction time, aesthetics, durability, and other Project specific parameters. Analysis summary and recommendations should be included in the Phase A Report.

4. Alternate retaining walls shall be generically presented in the Contract Documents using the Common Structure Volume (CSV) concept. The CSV is the volume into which all potential wall systems can be placed. All work items required to construct the wall and all appurtenances, ancillary items and all work to complete the Project located within the CSV are not measured but are included in the pay item for the retaining wall. The CSV concept allows the quantification of pay items outside the CSV, such as excavations, embankments, etc., such that those quantities will not vary due to the proprietary wall system selection.

3.3.4. Proprietary Wall Design Guidelines

Except as modified by the current New Jersey Turnpike Authority Standard Specifications and the current New Jersey Turnpike Authority Design Manual, Section 3, designs of MSE and Prefabricated Modular Wall retaining wall systems shall conform to the standards noted in Section 6 of this Manual, with the exception of moment slabs supporting barriers, which shall be designed in accordance with the below document:

2002 AASHTO Standard Specifications for Highway Bridges, 17th Edition and as Modified by the 2007 New Jersey Turnpike Authority Design Manual, Section 3, through Current Updates, for Modifications Appropriate to Load Factor Design (LFD).

a. Design Method
   Load Factor Design (LFD):

   Internal Strength and Stability for Barrier Parapet and Moment Slab System

   Allowable Stress Design (ASD): External Stability for Moment Slab

   <u>IMPACT LOAD</u>

   Load Factor Design (LFD) and Allowable Stress Design (ASD): Vehicular Impact Load applied to the Barrier Parapet and the Moment Slab System shall be per AASHTO Standard Specification, Article 2.7.1.3.

Load and Resistance Factor Design (LRFD): Vehicular Impact Load applied from the barrier parapet and moment slab system to the proprietary wall shall be per AASHTO LRFD Bridge Design Specifications, Article 11.10.10.2.

The impact requirements of AASHTO LRFD Article 3.6.5 are waived for MSE or PM abutment walls which envelop pile supported abutment seat beams and for full height cast in place conventional abutments.

b. Design Engineers shall be responsible for developing preliminary design and Contract Documents for MSE Walls including all geometry and loading conditions. Generally speaking, it is the responsibility of the Design Engineer to define the alignment of the retaining wall, indicate anticipated leveling pad steps below the grade, establish Common Structure Volume criteria, and establish elevations of the grade and top of wall at regular stations along its length. Constructability and coordinating with external conflicts such as utilities and adjacent structures is also the responsibility of the Design Engineer. Establishing internal wall design parameters, backfilling requirements, and internal material Specifications is the responsibility of the Geotechnical Engineer. Evaluating external and internal stability (where appropriate) and any associated ground improvements is also the responsibility of the Geotechnical Engineer.

c. Contractors, material suppliers and/or wall vendors will be responsible for developing the final design for MSE Walls including but not limited to, the following:

- Evaluate Internal Stability for Strength limit state and extreme event, and Confirm External Stability
- Select type of soil reinforcement
- Define critical failure surface (for selected soil reinforcement type)
- Define unfactored loads
- Establish vertical layout of soil reinforcements
- Calculate factored horizontal stress and maximum tension at each reinforcement level
- Calculate nominal and factored long-term tensile resistance of soil reinforcements
- Select grade (strength) of soil reinforcement and/or number of soil reinforcement elements at each level

- Calculate nominal and factored pullout resistance of soil reinforcements, and check established layout
- Check connection resistance requirement at facing
- Estimate lateral wall movements (at service limit state)
- Check vertical movement and compression pads
- Design of Facing Elements
- Confirm Overall Global Stability
- Confirm Compound Stability
- Confirm Wall Drainage System – working drawings
- Subsurface drainage
- Surface drainage
- Where design parameters are modified by the Contractor, material supplier and/or vendor, they shall also evaluate the external stability for revised wall configurations.

Review of shop drawings and designs as provided by the Contractor is the shared responsibility of the Design Engineer and the Geotechnical Engineer.

d. For additional guidance and information, the Design Engineer is referred to the following resources:

- Section 6 of this Design Manual
- Standard Specifications
- NJTA Sample Plans and Exhibits 3-500 Series of the Manual

e. For MSE wall systems that are located under roadways, a high density polyethylene geo-membrane shall be placed below the pavement and just above the first row of reinforcements to intercept any flows that may contain deicing chemicals. The membrane shall be sloped to drain away from the wall facing. Reference is made to NJTA Standard Specifications for type of material to be used. Refer to the Exhibits at the end of this Section for further details.

Drainage considerations for MSE Walls are discussed in Subsection 6.6.2.3 of this Design Manual.

Where MSE Walls will be constructed in or adjacent to salt or brackish water, refer to Subsection 6.6.2.9 of this Manual for guidance regarding corrosion life estimation or use of stainless / nonmetallic reinforcement.

f. The metallic elements within an MSE wall system are subject to a higher potential for corrosion than other wall types due to the nature of their construction and susceptible to both microcell and macrocell (galvanic) corrosion. The Design Engineer shall consider the effects that the electrochemical environment has on these elements before recommending the use of an MSE wall on a project. When MSE wall systems are recommended, the Contract Documents shall include language that all ferrous component materials, including the mild reinforcement in the concrete facing panels, connection elements, soil reinforcement, and all related hardware, have sufficient corrosion protection. The Contract Documents shall also stipulate there is to be no steel-to-steel contact between soil reinforcement connections and the concrete facing reinforcement and the proper backfill materials must be specified in accordance with the current NJTA Standard Specifications, regardless of whether the wall is built using single-stage or two-stage construction methods.

   During working drawing review, the Design Engineer shall ensure the MSE wall fabricator / supplier has included appropriate notes and language for the required material specifications so that the above noted items are properly addressed.

3.4. CULVERTS

The design of cast-in-place concrete Culverts, precast concrete box Culverts, precast concrete arch structures and precast concrete three-sided rigid frame structures shall conform to Subsection 5.12 of this Manual and Section 12 of the AASHTO LRFD BDS.

Culverts shall be constructed as box Culverts or three-sided rigid frames with Class “A” reinforced concrete. Corrugated metal Culverts are not permitted. At a minimum, Culverts shall be of sufficient length so that the full roadway section, including shoulders and berms, can be maintained, including an additional 12’ of available space for Authority Maintenance forces to traverse the waterway when landscaping.

Precast culverts are permitted. Design Engineers shall contact precast manufacturers during the design to discuss Project specific requirements and details to ensure there will be no conflicts during the construction phase. Precast Culverts shall not be used when the top slab is to be used as a riding surface.

3.5. SIGN SUPPORTS

The various types of signs described in this section are either ground mounted or on overhead sign structures. Each of these general categories is sub-divided into various support methods:

1. Ground Mounted
    - Small Highway Signs (<50 sf)
    - Large Highway Signs (≥50 sf)

2. Overhead Type Structures
    - Span Type Structures
    - Cantilever Type Structures
    - Butterfly Type Structures
    - Bridge Mounted Structures

3.5.1. General Design Criteria

All Sign Support Structure designs shall be completed in accordance with the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 6th Edition, with 2015 Interim Revisions (AASHTO LTS), except as noted below. For sign placement layout guidelines and sign panel requirements, see Section 6 of this Manual.

1. Ground Mounted
    a. Small Highway Signs (<50 sf)

    U-Channel Post
    U-Channel (flanged) posts are only to be used for mile markers and delineators on the Turnpike and Parkway. Refer to the DE Standard Drawings for design details.

    Turnpike – Timber Post
    See Standard Drawings SL-1 to SL-7 and SI-43 to SI-46.

    Parkway - Timber Post
    See Standard Drawings SL-1 to SL-7 and SI-43 to SI-46.

    Turnpike – Single Aluminum Post
    Use of timber posts is preferred. Many signed are of sizes which may be too large for a single timber post support, but are impractically sized for multi column support. These signs shall be installed on a single extruded aluminum tube having an outside diameter of 4" and a wall thickness of 0.250" following the details as shown in Standard Drawing SI-13. Post sizing shall be validated by design computations.

    b. Large Highway Signs (≥50 sf)

    Turnpike - Multi-Timber Post

See Standard Drawings SL-1 to SL-7 and SI-43 to SI-47.

All timber post sign structures included in Standard Drawings SI-43 and SI-44 are designed for breakaway in a vehicular collision and do not require roadside protection.

<u>Turnpike - Multi-Aluminum Post</u>
Timber posts are preferred. Aluminum post supports shall only be used as directed or approved by the Authority.

Post spacing and limiting panel sizes are shown on Standard Drawing SI-26. Foundation details are shown on Standard Drawing SI-22.

Where large diameter posts and/or heavy wall thicknesses are required for an atypical installation, it is encouraged to add an additional post, whereby a smaller tube of more commonly available diameter and thickness of wall may be utilized.

<u>Parkway - Multi-Timber Post / Pole</u>

See Standard Drawings SL-1 to SL-7 and SI-43 to SI-47.

Timber double post sign structures included in Standard Drawing SI-44 are breakaway designs and are required when sign structures are to be placed within the roadway clear zone and lack roadside protection measures.

Timber double and triple post sign structures included in Standard Drawing SI-45 are non-breakaway designs and shall be provided with roadside protection measures or shall be located outside of the clear zone.

It is not necessary to perform design computations for sign panel and post configurations shown on the Standard Drawings. Where custom designs are required for configurations not shown on the Standard Drawings, the following wind loading criteria shall be followed when computing loads per AASHTO LTS Section 3:

- Wind Speed of 110 mph
- $K_z = 0.87$
- 10 year anticipated design life
- Note 'a' below Table 3.8.3-1 is waived

The decision to use a breakaway or non-breakaway sign structure shall be made during design. The Design Engineer shall consider using a breakaway sign structure when reasonable with regards to sign location and message. Non-breakaway signs requiring additional roadside protection may only be installed within the roadway clear zone if directed by the Authority.

2. Overhead Type Structures

   a. <u>Span Type Sign Structures</u>

Sign structure type and design varies between the Authority's Turnpike and Parkway roadways. Strictly for reference, Turnpike sign structure design is driven by economy of materials and cost, hence the use of uncoated weathering steel structures composed of commonly available pipe sections. Parkway sign structure design is driven by the need to conform to the historical appearance requirements for the roadway, which does explicitly cite the square weathering steel HSS Vierendeel structures as essential to the character of the roadway.

The Authority exclusively uses weathering steel for all sign structures, regardless of the roadway. This is done as much for economy as it is for aesthetic appearances. Specific permitted grades and Specifications for various weathering steels are published on the relevant Standard Drawings.

Uncoated weathering steel is generally more cost effective than paint or galvanized coatings. Furthermore, where other owners may specify hot dip galvanizing, their component sizes are limited by commonly available galvanizer dipping kettle sizes. Weathering steel structures are not limited by kettle size and can be made as large as structural efficiency dictates, hence why Authority structure trusses are 6' wide and larger, and adjacent agency structures are limited to 5' wide or less. This information is provided both as historical background and as an explanation why weathering steel structures cannot be substituted with galvanized structures in the event that weathering steel shapes or plates are difficult to procure for fabricators. Authority structures are simply too large to fit in commonly available galvanizer dipping kettles.

Sign structure placement shall generally locate the centerline of one end frame and foundation in the median between any adjacent roadways whenever possible and practical. The use of single span sign structures that span over multiple mainline roadways is prohibited, unless directed by the Authority Engineer. Additionally, sign structures located in any adjacent roadways shall be spaced apart, or staggered, a minimum of 35' as measured centerline to centerline of end frames in a direction parallel to traffic.

A minimum underclearance to the lowest obstruction (sign panel or structure member) of 17'-0" over the high point of the roadway shall be provided for all static sign structures and 18'-0" for Variable Message Sign (VMS) or Changeable Message Sign (CMS) structures.

Sign structures with static messages generally shall not be lit unless shown to require it as outlined below. Where lighting is not required, lighting brackets, handrail, and walkway shall be omitted. Turnpike sign structures shall be fabricated with wiring provisions for lighting, should it ever be required, or should the sign structure be re-used at a different location in the future.

Static sign panels on sign structures without lighting shall be placed such that the physical sign panels (not the text) are bottom edge justified with the bottom edge of all sign panels meeting the 17’-0” minimum clearance to the highpoint of the roadway limit. Sign structure end frame heights shall be chosen such that the truss is located as nearly as practical to the mid-height of the largest sign on the structure.

Static sign panels on sign structures with lighting shall be placed such that the physical sign panels (not the text) are vertically centered on the truss. Centerline elevation of the truss shall be placed assuming an 18” additional roadway clearance (total of 18’-6” from sign edge) to allow for the sign lighting support brackets. Where signs are to be provided with lighting, the tallest available standard end frame shall be used. Where it is not possible to use the standard end frames, the Design Engineer shall design a special end frame of the required height.

Turnpike Sign Structures General Criteria

Turnpike sign structure layout shall conform to Exhibits 3-401 to 3-404 shown in this Section of the Design Manual and Standard Drawings SI-13 through SI-25. The Standard Drawings for the span-type sign structures provide three (3) standard heights of end frames and six (6) standard lengths for box truss sections. Span lengths from 45’ to 135’, in increments of 5’ can be obtained by using the standard box truss sections in appropriate combinations, as indicated on the Standard Drawings. Sign structure spans shall be set in increments of 5’ wherever possible. Where this is not possible, the standard truss sections shall be combined with a minimum number of special sections to obtain the necessary length.

Parkway Sign Structures General Criteria

Parkway sign structure layout shall be in accordance with Exhibits 3-405 to 3-408 and Standard Drawings SI-28 through SI-34, SI-39, SI-40 and SI-42. Standard Drawings are organized into two ranges of standard spans with 60’ to 90’ span structures being of single plane Vierendeel truss design, and 91’ to 156’ span designs being of two plane (box) Vierendeel truss design. Parkway sign structures are typically custom fabricated for each location and are not similar to the modular construction typical of Turnpike signs.

The Design Engineer is made aware that large signs spanning Parkway roadways can potentially create oversize / overweight sign structure component shipping issues. Field splices for the trusses shall be located to accommodate shipping to site on the Parkway with the understanding that portions of the Parkway roadway, particularly above Milepost 105, have tight radius access ramps and low vertical clearances.

b. Cantilever Type Sign Structures General Criteria (Turnpike and Parkway)

This type of sign structure is used to support guide signs adjacent to deceleration lanes in the vicinity of ramp gore areas and may also be used to support overhead signing on narrow roadways and ramps. The sign panel should be located over the lane to which the message applies. The length of cantilever arms shall be detailed to suit the width of the sign proposed to be mounted on the arm. The sign panel shall extend to 6" beyond the outer edge of the arm. The provisions noted above for overhead span sign structures shall also be maintained for cantilever sign structures, as applicable, and in addition to the provisions noted below.

The layout of Turnpike Sign Structures shall be in accordance with Exhibit 3-404. Standard Drawings for Turnpike cantilever sign structures are available as Standard Drawing SI-18A and SI-18B.

The layout of Parkway Sign Structures shall be in accordance with Exhibit 3-408. Standard Drawings for Parkway cantilever sign structures are available as Standard Drawings SI-35 to 38, and SI-41.

c. Butterfly Type Sign Structures General Criteria (Turnpike and Parkway)

This type of sign structure is used to support signed on the Turnpike and Parkway between a pair of adjacent roadways carrying traffic in the same direction. With the approval of the Authority's Engineering Department, a butterfly type structure may be used at the nose of a ramp split and other locations required by design where the use of a span-type structure is not feasible. Structural details of this type of sign structure are similar to cantilever-type sign structures except that cantilever arms are provided on each side of the support post. The layout of the sign structure shall be in accordance with Exhibits 3-404 and 3-408. Standard Drawing for Turnpike butterfly sign structure is available as Standard Drawings SI-18C.

3.5.2. Sign Structure Design

In the event that the standard sign structure configurations do not meet the specific needs of the Project, a custom design will be required. The Design Engineer will follow the provisions of the AASHTO LTS with the following provisions:

Wind Load

Basic Wind Speed as defined in Section 3.8.2 of the AASHTO LTS shall be defined as a minimum of 100 mph for all Turnpike and Parkway sign structures.

Wind Drag Coefficients, Cd, shall be determined in accordance with Table 3.8.6-1 of the AASHTO LTS. Where the exact dimensions of a sign panel or sign structure element cannot be determined, the Design Engineer shall select the most conservative Drag Coefficient available for the most appropriate element type denoted in Table 3.8.6-1 of the AASHTO LTS. When determining the Wind Drag Coefficient for square shaped tubular truss members, the radius (r) denoted in Table 3.8.6-1 of the AASHTO LTS may be assumed as twice the thickness of the square shaped tubular member. VMS/CMS panels may use a drag coefficient of 1.2 for design.

The Height and Exposure Factor, KZ, shall be no less than 0.94 for all parts of the sign structure under normal exposure. Higher values of KZ shall be considered, in accordance with Table 3.8.4-1 of the AASHTO LTS, when structures are situated in abnormally exposed conditions on high embankments or on bridge piers or superstructures. The standard designs have been prepared using a value of KZ of 1.0. The Design Engineer shall check the design of the standard sign structures for the particular use intended wherever it is determined that a higher value of the KZ is appropriate.

The Wind Importance Factor and Velocity Conversion Factors defined in Tables 3.8.3-1 and 3.8.3-3 of the AASHTO LTS shall consider a 50 year design life, unless otherwise directed by the Authority.

<u>Ice Load</u>
Ice Load shall be considered as 3.0 psf and shall be applied as directed in Section 3.7 of the AASHTO LTS.

<u>Fatigue Loading</u>
Fatigue loading shall be considered for all span type, cantilever and butterfly sign structures. Dead loads and Ice loads shall not be considered to act in addition to the specific event fatigue loading. The Importance Factor for all fatigue wind loads shall be taken as 1.0.

<u>Foundation Design</u>
Foundations for sign structures shall be fully designed by the Design Engineer. Spread footing and pile foundations shall generally conform to the details shown on Standard Drawing SI-22. Differences in Parkway sign structure pedestal dimensions shall be accommodated in the design of spread footings and pile foundations. Drilled Shaft foundations shall conform to the details shown on Standard Drawings SI-22A, SI-22B and SI-39 through SI-41.

In accordance with the Authority's Procedures Manual and the Design Manual, a soils investigation shall be conducted for all foundations in existing ground and a Geotechnical Engineering Report shall be submitted. The foundation shall be supported on a spread footing, driven piles, or drilled shafts of 30" minimum diameter, with the required analysis and recommendations included in the Geotechnical Engineering Report.

All foundations for sign structures shall have the bottom of the base plate, shown as “Elevation A, AL or AR” on Exhibit 3-401 to 3-408 and “Elevation A” on Standard Drawings SI-14 through SI-41, set at 4’ higher than the highest point of the roadway cross section at the transverse centerline of the structure. This elevation shall be the same for both pedestals. Sign structure pedestals may be constructed on three types of foundations; spread footing, driven pile supported footing, or drilled shafts. Drilled shaft foundations have gained popularity with Contractors in recent years and are the preferred foundation type.

Where foundations are to be constructed adjacent to existing Turnpike or Parkway pavement, including shoulders, the width of the foundation shall preferably be that which will not require the removal of paved shoulders for its construction. When excavation for a spread footing or pile bearing footing is required adjacent to Turnpike or Parkway pavement, these excavations shall be protected by steel sheet piling which shall be left in place. When determining the most cost-effective foundation type, the cost of the sheet piling to remain, if required, shall be considered by the Design Engineer.

Where spread footings or driven pile supported footings are to be used, the elevation of sign structure foundations shall be set so that the soil cover over the top of the footing at the centerline of the stem shall be at least 4’. Where these footings are located in embankment slopes, the minimum cover at the outside of the footings shall be 2’. Where it is deemed appropriate to found sign structure pedestals on drilled shafts, the bottom of the pedestal shall be a minimum of 2’ below grade.

Where footings carry eccentric gravity loads, as will be the case for cantilever or butterfly signs, the net vertical force and overturning moment at the centerline of the footing shall be considered. The effects of torsion shall also be considered in the foundation design of all butterfly and cantilever structures.

1. Loadings for Design

   The foundations of span-type sign structures shall be designed for a band of signs having a length extending over the entire width of the roadway plus shoulders and having a height equal to the maximum height of sign that can be accommodated by the end frame of the sign structure. The maximum area of sign that need be used for design of structures shall be as specified on the Standard Drawings. Where the actual sign panel(s) width x length is unknown, the most conservative Wind Drag Coefficient (Cd) for sign panels shall be selected from Table 3.8.6-1 of the AASHTO LTS.

The foundations for standard cantilever-type sign structures shall be designed for a band of signs having a length of 18’-9” and a height equal to the maximum height that can be accommodated on the sign structure.

All Contract Plans prepared for Sign Structures shall have the design sign area clearly published on the General Plan and Elevation Plan sheet.

The following dead loads may be used for the components of standard Turnpike specific static sign structures:

Truss spans up to 100’	125 plf
Truss span greater than 100’	145 plf
Cantilever/Butterfly Arms	190 plf
End frames and posts	5,000 lbs
Flat sign panels w/stringers	3 psf
Hangers, luminaires, and supports	40 plf

Due to the simplified and more variable nature of Parkway sign structures, individual weight computations will be required for each Parkway structure.

Foundation design loads for VMS and CMS style structures are shown on the Standard Drawings pertaining to those structures.

3.6. LIGHTING

Sign Lighting

Sign structures with static messages generally shall not be lit unless required via lighting warrant analysis performed in accordance with Subsection 8.2.1 of this Design Manual. Guidance associated with the illumination of sign panels is discussed in Section 8 of this Manual.

Roadway Lighting on Bridges

Standard Drawing E-02 includes details for fatigue resistant steel lighting standards, which are to be used exclusively on bridges.

Lighting standards placed on structures shall be located at or near piers and abutments. When locating the lighting features at piers or abutments is not practical, the maximum offset from a pier or abutment bearing line shall be 25% of the length of the span in which the lighting features is to be located. Refer to Section 8 of this Manual to determine bridge lighting requirements.

3.7. NOISE BARRIERS

Noise barriers are only to be provided on new construction (new roads) or on widening projects unless otherwise directed by the Authority. Refer to the Authority’s *Policy for Construction of Noise Barriers in Residential Areas* for further guidance.

3.7.1. Preliminary Considerations

1. As part of the Phase A work for a Project where a Noise barrier is being considered, the following items shall be addressed:

    - Identification of limits of noise barriers.
    - Identification of buried utilities, drainage facilities, and overhead utilities impacted.
    - Protection of the noise barrier when located within the roadway clear zone.

In general, a noise study shall either be performed by the Consultant or will be provided to the Consultant by the Authority in order to determine the height of the noise barrier and recommend noise abatement coatings and/or construction materials. This study will be performed prior to commencement of structural design work.

Where utilities may conflict with the proposed noise barrier alignment, efforts shall be made to realign the barrier or consider revised foundation installation methods (for buried features) prior to investigating relocation of the utilities. The Design Engineer is made aware that drainage facilities or utilities that run parallel to the noise barrier may require access by maintenance forces or utility owners at a future point. Design of the noise barrier shall take this into account by the creation of access points as necessary.

3.7.2. Design Criteria

1. Ground Mounted Noise Barriers - AASHTO LRFD BDS Section 15 shall be used for structural design. Foundation design shall be in accordance with AASHTO LRFD BDS Subsection 15.9 and Section 6 of this Design Manual.

3.7.3. Functional Requirements

1. Guide rail or concrete barrier curb shall be installed when the noise barrier is located within the clear zone (see Section 1 of this Manual for more information).

2. Stopping sight distance criteria shall apply in determining the location of a noise barrier. Horizontal clearances which reduce the stopping sight distance shall be avoided. In extreme cases where reduced stopping sight distances may be warranted, justification shall be provided and a Design Element Modification Request approval will be required from the Authority’s Engineering Department.

3. Noise barrier heights shall be established based on the approved noise study.

4. When the tops of Noise barriers must be stepped, the maximum height of step should not exceed 2’.

5. Noise barriers obstruct light as well as noise. Consideration shall be given to possible roadway icing and other induced environmental conditions caused by shade from the Noise Barrier.

6. Provisions may be necessary to allow access to fire hydrants on the opposite side of the noise barrier. The Consultant shall confer with local fire and emergency officials regarding their specific needs.

7. Noise barriers shall be designed to retain all anticipated differential fills plus an additional 2’ of soil as a minimum.

8. Noise Barrier coatings and surfaces are designed primarily to abate sound. They are not designed to be resistant to de-icing salts or be subjected to accumulated plow spoils. Where it may be operationally impractical to place Noise Barriers where they will not be subjected to these conditions, consideration should be given to detailing the bottom 4’ of the noise barrier as a solid concrete parapet or wall.

3.7.4. **Maintenance Considerations**

1. In some urban areas, noise barriers may be subjected to graffiti being placed on their surfaces. In these locations, the surface texture selected should be such that it is difficult to place the graffiti or such that the graffiti is easily removed. Noise barriers with rough textures and dark colors tend to discourage graffiti, but final texture and colors should be coordinated with the community or stakeholders protected by the barrier. In the absence of external preference, noise wall panels shall be textured using a ‘fractured fin’ style form liner similar to Greenstreek form liner number 367. Noise Barrier panels shall be tinted to match color 30045 of the SAE AMS-STD-595C. Noise Barrier surfaces shall be detailed with a silicone based anti-graffiti coating such as recommended by the Qualified Products List (QPL).

2. Access to back side of the noise barrier should be provided for inspection, litter control, soil erosion monitoring, grass mowing, drainage repairs, maintenance, etc. In subdivision or residential areas, access may be via local streets, where available. If access is not available via local streets, openings in the noise barriers shall be provided as follows:

    - Openings shall be provided at a spacing of 1,000’ measured along the roadway; maintenance openings are not required for noise barriers with lengths shorter than 1,000’ that can provide access to the residential side from one of the ends.

    - Location of the access openings should be coordinated with the appropriate agency or landowner.

- Offset barriers concealing the access opening must be overlapped a minimum of 2 1/2 times the offset distance in order to maintain the integrity of the noise attenuation of the main barrier.
- The offset of the barriers shall allow for a 12'-0" wide vehicular gate.
- This gate or the barrier end shall be accessible from the right shoulder and not be obstructed by beam guide rail or barrier parapet.
- The ground leading to the gate or noise barrier end, as well as the ground behind the noise barrier, shall be graded to allow for maintenance vehicle access.

3.7.5. **Noise Barriers on Bridges**

1. Provisions for expansion shall be placed in the noise barrier at locations of bridge deck expansion joints and at parapet deflection joints.
2. When a noise barrier is designed to be supported by a New Bridge superstructure, the attachment to the superstructure shall be made to the concrete parapet or directly to the superstructure framing. When designing for wall attachments to the concrete parapet, the behaviors of the bridge superstructure framing and the deck slab overhang shall be analyzed, including the effects of the torsional moments and twist caused by the weight of the noise barrier and wind load. The distribution of the superimposed noise barrier dead load shall be placed entirely on the parapet and distributed to the interior Stringers assuming that the parapet is a cantilever load on a continuous deck beam acting from the fulcrum point of the fascia Stringer bearing. Design Engineers shall be aware that net uplift is possible at the 1st interior Stringer and greater than 100% weight distribution is possible at the fascia Stringer due to the eccentricity created by the Noise Barrier load placed on the outer edge of the deck overhang. A three dimensional analysis of the bridge superstructure shall be performed in order to determine the effective superimposed dead load and wind load distribution to the superstructure elements. Regardless of analysis results, full-depth Diaphragms shall be placed at all noise barrier post locations between the fascia, 1st interior and 2nd interior Stringers. The Diaphragm bottom flanges shall be framed into the Stringer bottom flanges via gusset plate connection. The use of light weight noise barrier panel systems is strongly encouraged.
3. Noise barrier retrofit is not permitted on existing bridges, except in the case of bridge widening. Where bridge widening is to be performed, the above provisions shall apply to the fascia, 1st interior and 2nd interior Stringers, all

of which shall be of new construction and explicitly designed to carry the noise barrier loads.

3.7.6. Types of Noise Barriers

1. Precast reinforced concrete post and panel systems are preferred to be used, except on bridge structures.
2. A number of proprietary noise barrier systems are available for use on bridges or where unusual site conditions prohibit the use of a precast reinforced concrete post and panel system. The materials, load carrying mechanisms and capabilities vary with each system; however, these systems shall conform to the criteria outlined in Subsection 3.7.1 and applicable Project Supplementary Specifications. Proprietary wall systems shall be approved prior to the design of the barrier.

3.7.7. Materials

For ground mounted noise barriers, concrete for cast-in-place foundations and precast/prestressed posts and panels shall conform to the Standard Specifications. Concrete Class P shall be used for precast elements. Concrete class B shall be used for pedestals. Concrete class C shall be used for foundations other than drilled shafts. Concrete class A or SCC shall be used for drilled shaft foundations. All other materials shall conform to the requirements of the Standard Specifications.

3.8. BRIDGE REPAIR AND REHABILITATION

The majority of Authority bridges were built between 1954 and 1971. Their age combined with constant traffic loading have made preservation of the aging infrastructure through regular maintenance and periodic rehabilitation a dominant priority. To that end, the majority of Authority bridge work contracts are rehabilitation or repair driven in nature. The intent of this section is to standardize an approach to the work for Design Engineers and clearly define the performance goals for the bridges, as based on their anticipated remaining life span.

This approach fundamentally differs from prior versions of this section as it implicitly recognizes that few, if any, structures can be practically built for an 'infinite' life span and repairing a bridge for an infinite life span is functionally and economically impractical. Furthermore, certain components of any bridge, regardless of design life, should be viewed as 'wear items' in need of periodic replacement, including, but not limited to, concrete decks, deck joints, paint, bearings, and the cover layer of concrete for substructures.

In addition, other work is often required on Authority structures due to exceptional circumstances such as repairs from vehicular impact or fire, repairs due to load or distortion derived fatigue damage to structural steel members, and strengthening of superstructure or substructure components to enable them to carry the heavier loading of modern truck traffic. This work is often bundled within larger rehabilitation contracts.

Repair or rehabilitation designs shall be prepared with an understanding of the bridge's Anticipated Service Life (ASL) after the work is performed and to achieve that life span performance goal before the bridge is to be replaced. There are five classifications of ASL which will be assigned to the structure for the design of repair or rehabilitation work:

1. Routine Maintenance Work – This work assumes that the bridge will remain in service for the foreseeable future and generally consists of simple repairs including patching of decks, repairs to safety walks and barriers/parapets, asphaltic and latex modified concrete overlay replacement, minor repairs to steel work, resetting of bearings, spall repairs on substructures, resealing or replacement of deck joints, and localized painting. General 'best practices' cleaning work shall also be incorporated including clearing of scuppers and drainage systems, pressure wash cleaning of joints and bearing seat areas, and application of a sealer coat on bare concrete decks.
2. 15 Year ASL Rehabilitation – This work assumes that the bridge will be replaced within the next 10 to 15 years. The intent of this work is to stabilize structures in poor to fair condition so that they will require minimal additional maintenance until their replacement is planned and constructed. Only advanced deterioration and those areas which are at-risk for a 15-year performance goal are to be repaired. Where bridge decks are in poor to fair condition and heavily patched, isolated or grouped bridge deck panel replacements along with a placement of an asphaltic overlay with membrane waterproofing may be required to extend the service life of the deck until its demolition.
3. Bridge Painting – Bridge coating systems have an ASL of 20 years. Bridge painting is sometimes bundled with larger rehabilitation work or performed as individual contract work. For all bridges which are scheduled for repainting, the Design Engineer is responsible for reviewing the latest Bridge Inspection Report and preparing appropriate repair details for areas of damage or deterioration. The Design Engineer is also to be aware that media blasting of superstructure steel often reveals more extensive deterioration than the hands-on inspection effort prior to blasting operations indicates. Additional allowances should be given during design for additional quantities of repair items. The Design Engineer is directed to physically inspect the steelwork after media blasting and spraying of the prime coat. All defects shall be noted and addressed through original contract "If-And-Where" directed items, or through additional repairs added via Change Order. The Design Engineer, not the Contractor or the Construction Manager, will be responsible for identification of additional areas of deterioration after prime coat application.
4. 35 Year ASL Rehabilitation – This work includes decks/seismic/moderate strengthening, and if practicable, bearing replacement, replacement of heavily deteriorated members, possible superstructure replacement.
5. 75 Year ASL Rehabilitation – Only for NJTA "Major Complex" (Major) bridges. Major Bridges are designed for a 150-year overall service life. A half-life major retrofit of these structures is commonly required to achieve this goal. This type of work typically includes

seismic rehabilitation, paint, deck replacement, superstructure replacement, pier modification/replacement, security hardening, fender work and inspection accessibility improvements.

Expected Life Span of Bridge Components

1. Major Bridges – 150 years
2. Routine Bridges and Culverts over 20' in Span– 75 years
3. Concrete Culverts – 50 years
4. Routine Bridge Decks – 35 years to 40 years
5. Major Bridge Decks – 50 to 75 years
6. Superstructure Steel - 75 years, except Stringers in GFS Bridges – 35 to 60 years (replace with the deck unless in good condition)
7. Latex Modified Concrete Overlay – 20 years
8. Asphaltic Overlay – 10 years
9. Joint Sealers – 10 years
10. Deck/Concrete Seal Coats – 5 years
11. Substructure Elements – Routine Bridges at 75 years, Major Bridges at 150 years
12. Bearings – 35 years to 60 years
13. Light standards – 15 years to 20 years
14. Sign Structures – 50 years

General Considerations for Repair or Rehabilitation Contract

1. Priority of Repair
2. Significance of Asset/Route
3. Utilities
4. Staging and Operational Limitations and Restrictions
5. External Stakeholders
6. Best Value of Work

The Design Engineer shall compile and assess deficiencies and required repairs, and their priority, and provide estimated construction costs within the Phase A report. Prioritization shall be used to select work areas suitable for the Authority's specific budget, and to establish milestones in the contract so high priority repairs are constructed in a timely manner.

Consideration should be given to oversizing repair quantities and details for structural elements. The deterioration at the time of the defect identification during inspection often progresses over the time required to produce the final Contract Drawings. Anticipation of larger repair areas should be incorporated in the contract details and the contract quantities.

3.8.1. **Access**

The Design Engineer shall consider Contractor Access when preparing Contract Documents for Bridge Rehabilitation work. The contract documents shall include potential access to work areas and staging areas, as determined and coordinated by the Design Engineer prior to completing final design.

3.8.2. **Permits**

The Design Engineer shall consider NJDEP and US Coast Guard, etc. permit requirements when preparing Contract Documents for Bridge Rehabilitation work. Permits may be required for the construction work activities to be performed or for the Contractors' access requirements. Final design documents shall include permit provisions or restrictions required for the Project.

3.8.3. **Other Agency and Railroad Coordination**

It is required that, when arranging traffic protection on or over facilities owned by other agencies, including railroads, the Authority's Engineering Department be provided with written statements attesting that all responsible agencies have been informed of the work and have reviewed and concur with the planned schemes for maintaining and protecting traffic on or over their facilities. The Authority's Engineering Department shall also be provided with written statements attesting that all affected utilities have been informed of the work and have reviewed and concur with the planned schemes for protecting their facilities. In scheduling plan preparation, time must be allotted for review by these agencies. The concurrence of these agencies must be obtained in writing.

3.8.4. **Structural Inspection Requirements for Rehabilitation and Repair Contracts**

The primary sources of deficiencies requiring repairs or rehabilitation required for a bridge Project are the Biennial Inspection Report and the Authority's Bridge Management system (InspectTech, by Bentley Systems, Incorporated). While these resources provide important information, they do not typically provide the details required to prepare detailed repair/rehabilitation plans.

The following guidelines shall be followed regarding when a separate hands-on bridge inspection shall be performed solely for the preparation of bridge repair/rehabilitation drawings:

<u>15 Year ASL Rehabilitation:</u> A separate hands-on bridge inspection shall be performed. The site visit may utilize binoculars, to locate and confirm the limits for repair work, supplemented by local hands-on inspection as required. If catwalks are present on the bridge, access may be available at the permission of the Authority. Challenging terrain may require the use of over-the-side bridge access equipment. Hands-on inspection to determine limits for repair of deficient concrete at splash zones, safety walks, barriers/parapets, substructures, walls, and Stringers, is strongly suggested as deficiencies likely extend beyond the limits observed through visual inspection.

<u>34 Year ASL Rehabilitation:</u> A separate hands-on bridge inspection shall be performed at the critical locations identified in the Biennial Bridge Inspection Report. If catwalks are present on the bridge, access may be available at the request

of the Authority. Challenging terrain may require the use of over-the-side bridge access equipment. Bearing replacements, deck joint reconstruction, and structural steel repairs shall require hands-on inspection to collect detailed measurements and identify conflicts with jacking and repair schemes. The Engineer shall inspect/sound all areas of apparent deterioration on all Routine Bridges, and 10% of all piers for Major Bridges with a minimum of two piers fully sounded. Concrete cores and laboratory analyses may be required to confirm the properties of existing bridge decks and other concrete elements.

75 Years ASL Rehabilitation: A separate hands-on bridge inspection shall be performed on the entire bridge. If catwalks are present on the bridge, access may be available at the request of the Authority. The intent of this level of rehabilitation is to extend the life of a Major Bridge for the same anticipated remaining life of an all-new routine structure. The Engineer shall inspect/sound all areas of apparent deterioration, and all piers for Major Bridges shall be fully sounded. All defects of any significance shall be fully inspected so that they may be restored to the as-built or better condition.

3.8.5. **Traffic Protection**

Bridge repair contracts are unique in that they often include short duration, high intensity maintenance level work to limit disruptions to the flow of traffic. In the preparation of repair contracts, all work and repairs must be designed to respect maintenance and protection of traffic (MPT) at, over, under and adjacent to work sites. Closures of the Authority's lanes and shoulders for the purpose of construction shall be planned in accordance with the lane and shoulder closure tables in the Manual for Traffic Control in Work Zones. Special considerations for lane closures occurring during peak travel periods for weekend days are reviewed by the Authority's Operations Department to permit High Intensity Construction Cycles. All MPT provisions in the Contract Documents for traffic and construction staging, including permissible work times, lane closing, and type of protection devices, shall be coordinated with the Authority's Operations Department. Reference is made to the NJTA Standard Specifications and Standard Supplementary Specifications, Standard Drawings, and Manual for Traffic Control in Work Zones for the Authority's general guidelines and construction requirements. Design Engineers shall revise the Specifications on a Project by Project basis as required.

In general, intensive work such as complete or panelized deck replacement shall be sequenced such that on existing bridges carrying mainline roadways of the Turnpike or Parkway, lanes may be closed for construction but typically a minimum of two traffic lanes must be available in every stage in each direction, pending approval from the Authority's Operations Department. For heavier traffic regions of the roadway, it may not be practical to remove any lanes from service for deck replacement work. This is generally accomplished by shifting traffic and using a shoulder as a temporary traffic lane during construction, where a shoulder is available and its condition permits its use as a travel lane. As previously discussed, New Bridges shall be designed such that future deck replacements may be made while traffic is maintained for the full number of active lanes on the bridge.

The Engineer of Record is responsible for reviewing and improving the shoulders, the underlying bridge deck, and protective features where shoulders across the bridge(s) are used as temporary travel lanes. Furthermore, the on-grade approach roadways must be considered when placing traffic in the shoulder.

Authority roadway shoulder pavement is generally designed only to accommodate break-down room for vehicles and emergency use as a travel lane. Shoulder pavement will generally require repaving or reconstruction based on its thickness and condition. While on-grade pavement reconstruction typically is the responsibility of the project highway engineer, this information is published here as it often affects the scope of bridge work.

The following shall be used as a guideline for evaluating and determining replacement for shoulder pavement for traffic staging; however, the Project Highway Engineer shall determine the level of pavement analysis required as it relates to AASHTO guidelines especially if long-term pavement performance is required.

- All shoulder pavement to be used for traffic staging shall be evaluated visually. Ground Penetrating Radar (GPR) shall be used to verify pavement thickness. Falling weight deflectometer testing may be warranted if long-term pavement performance is required.
- Existing shoulder pavement that is 5” thick and in fair or better condition may support traffic for up to two days without improvement.
- Existing shoulder pavement that is less than 5” thick or in poor condition shall be fully reconstructed with full depth pavement.
- Existing shoulder pavement that is 5” thick and in fair or better condition may support traffic for 14 days or less; however, removal and replacement of the surface course (the top 1.5”) may be necessary to maintain vehicle drivability.
- Shoulders which are to support traffic for more than 14 days shall be fully reconstructed with full depth pavement, regardless of condition, unless all of the following apply: the pavement is 5 years old or newer, is at least 5” thick, and has a suitable cross slope for use as a travel lane.
- Portions of shoulders adjacent to drainage inlets, and drainage inlets and chambers shall be carefully evaluated. They may warrant full depth reconstruction, regardless of condition visible at the roadway surface.

The Engineer of Record is also responsible for reviewing and improving shoulder cross slopes and drainage areas to maintain vehicle drivability and proper drainage where shoulder areas are intended for use as temporary lanes during the staged construction (including the approaches to and from), and for reviewing with assistance of the Project Highway Engineer, the clear zone distances and safe recovering areas along adjacent berms and slopes.

It is noted that the Parkway has areas where there are no shoulders and other provisions may be necessary for staged construction based on coordination with the Authority's Operations Department. Traffic protection within these areas requiring slab replacements may require reduction of the number of lanes over short durations/weekends and (High Intensity Construction Cycles) shall be reviewed on a project by project basis.

Lane and shoulder closings for deck slab replacement work along Authority owned roadways and ramps will be done in accordance with standard procedures as outlined in the "TP" series of Standard Drawings and the Manual for Traffic Control in Work Zones. Lane and shoulder closings in interchange areas, ramps and mixing bowl areas may require special details and arrangements of traffic protection devices which must be provided on the Plans.

For the purposes of staging deck replacement and reconstruction work, lanes through staged areas should be 12' wide where practicable. When lane width reductions are necessary, an 11' minimum travel lane is desirable with 10'-6" being the absolute minimum width allowed. Use of a 10'-6" wide travel lane should be limited to an isolated location. Reduced widths of lanes require the approval of the Authority's Operations Department. The minimum travel-way width along curved ramps may be greater than the above values based on the Project Highway Engineer review.

In addition to the above lane width requirements, a minimum 1' buffer shall be provided between the lane line and the face of any barrier where practicable, with 6" being the absolute minimum buffer allowed. Additional guidance is provided in the Authority's Manual for Traffic Control in Work Zones and the TP Standard Drawings.

3.8.6. Repair and Replacement of Decks

The use of temporary shielding for repairs and catches for replacement may be required to prevent debris from falling below. Any deck repair work, including milling of pavement over Authority roadways and partial depth repairs, within a span over or adjacent to live traffic or other public use shall be assumed to require shielding/ catches below the deck, especially where existing stay in place formwork is not present. The Design Engineer shall distinguish (and call out in the plans) the locations of the bridge, or spall repairs, that require temporary shielding or catches.

3.8.6.1. Installation of Replacement Wearing Surfaces

Bridge deck shielding for repairs and catches for replacement may be required to prevent debris from falling below. Any deck repair work, including milling of pavement over Authority roadways and partial depth repairs, within a span over or adjacent to live traffic or other public use shall be assumed to require shielding/ catches below the deck, especially where existing stay in place formwork is not present. The Design Engineer shall distinguish (and call out in the plans) the locations of the bridge, or spall repairs, that require temporary shielding or catches.

3.8.6.2. **Partial Depth Deck Replacement (Spall Repair)**

Bridge deck spall repair, which is the partial depth replacement of the deck, is performed on bridge decks to improve the riding surface and arrest decay. Spall repair generally does not require removal and replacement of reinforcing bars in the deck, except to replace reinforcement that exhibits 25% or more loss in cross-sectional area. Refer to the Standard Drawings for additional guidance on deck spall repair detailing and procedures.

3.8.6.3. **Full Depth Deck Repair and Replacement**

Complete deck slab replacements shall be designed to meet existing capacity. Isolated deck slab replacements should span between Stringer centerlines. Where this is not practical or possible, a supplemental Stringer shall be installed between the primary Stringers. A supplemental Stringer is typically supported on strengthened existing or new Diaphragms. It need not be made composite with the deck, but shall be left in place after completion of the deck replacement work.

3.8.6.4. **Bridges with Existing Surfacing**

The new portion of the deck shall be surfaced to match the existing construction. The surfacing shall incorporate membrane waterproofing on the new concrete deck prior to reapplying the overlay surfacing in the case of an asphalt concrete overlay. No membrane waterproofing shall be used in the case of an asphalt concrete overlay with 'Rosphalt' additive.

Concrete cover for the top reinforcing bars shall be 1 1/2" minimum. Epoxy-coated reinforcement steel shall be used for both the top and bottom reinforcement bar mats. No allowance shall be made for future wearing surface in the design of these slabs. Original deck slabs for Authority bridges vary in thickness from 7" to 10 1/2". Replacement bridge deck portions shall be preferably designed to match the existing reinforcing bar spacing of the adjacent deck panels that remain wherever possible to facilitate splicing of bars. Instances may exist where matching of the existing deck thickness and maintaining adequate structural design of the deck would be practical. Local thickening of the deck and / or increasing the main reinforcing bar size shall be permitted on a case-by-case basis. Reduction of the design wheel live load to 16 kips per wheel may be permitted on a case-by-case basis.

The design of the permanent metal bridge deck forms shall be the Contractor's responsibility. Requirements governing the selection, design and fastening of the forms shall be set forth in the Contract Specifications.

The design of catches and shielding shall be the Contractor's responsibility. Requirements governing the design, installation, maintenance and removal of catches and shielding systems shall be set forth in the Contract Specifications.

3.8.7. Repair of Spalls

Concrete spall repairs are typically performed for substructure elements such as piers and abutments. Spall repairs are performed to eliminate loose or falling concrete, restore environmental protection to exposed steel reinforcement, and to correct aesthetic blemishes. Spall repairs should not be considered structurally significant to the structure as it does not restore strength or structural capacity to the concrete member. Refer to the Standard Drawings for details and procedures regarding general spall repairs for concrete.

3.8.8. Repair of Headblocks, Headers, and Deck Joints

Headblock repairs consist of the reconstruction with concrete of existing abutment headblocks that are spalled or deteriorated or have been surfaced over with asphalt or elastomeric concrete. Generally, at locations where the existing bridge surfacing has been removed adjacent to deck joints, the headers are reconstructed using concrete. Care must be taken during the removal of existing concrete to not displace or damage the joint armoring, reinforcement and other embedded steelwork, where present.

Use of elastomeric concrete at headblocks and headers is no longer an acceptable practice on Authority owned bridges. Remaining elastomeric headblocks and headers that fall within the limits of work zones should be reconstructed with concrete.

All existing steelwork and reinforcement to remain that becomes exposed by the repair work shall be cleaned (by sandblasting) and coated with field anti-corrosion coating when possible.

Steel armored strip seal joints are preferred for retrofit work where full depth headblock repair is justified or where otherwise practical and / or where decks adjacent to a deck joint spanning several Stringer bays are scheduled for replacement. These joints are the only type approved for use on the Authority's Major Bridges.

Compression style epoxy bonded sealers are preferred where the deck edge and abutment headlock (and / or existing joint angle or bulb armor) are still in serviceable condition and do not require reconstruction. Compression style epoxy bonded sealers should be avoided along existing joints retrofit with riser bars, which are typically 1 1/2” to 2” high and present an irregular joint surface.

Asphaltic plug style joints are only permitted on Parkway and local roadway bridges that experience low average daily truck traffic and that currently have or are to receive an asphalt overlay as part of the contract. Any deficient headblock and header concrete underlying the proposed asphaltic plug joint shall be repaired prior to constructing the joint so as to achieve the ASL for the joint. Should the adjacent approach or bridge roadway pavement be scheduled for repair or replacement, the section of the asphaltic plug joint adjacent to that work shall also be replaced regardless of condition.

3.8.9. **Drainage on Bridges**

The original design philosophy for drainage on bridges was to place inlets in the gutters uphill of a (typically) open joint to eliminate run off through the joint and onto the bridge steel work and substructure elements below. This arrangement is still preferable and should be used in concert with sealing of any open bridge deck joints.

Since the original construction of Turnpike and Parkway roadways, much of the area underlying the bridge has been developed. Thus, existing inlets that are of the air-drop style may now require piping of the runoff to the ground or nearby roadway inlet below.

Open joints may require the installation of drainage troughs to collect the runoff that would otherwise splash on traffic or pedestrians below and funnel it to a remote discharge point. An elastomeric membrane or sheet should be used in the construction of troughs under open joints. This material offers a smooth surface to prevent snagging and is flexible enough, that under the vibration of the bridge due to traffic, it provides a constant flushing action to remove debris.

Drainage features should be designed to be ‘self-cleaning’ with smooth surfaces and edges to prevent snagging of debris. Sharp bends in the piping often causes larger debris such as beverage containers to catch and clog the pipe. All changes in direction of piping should be furnished with a clean-out plug and flat in-span piping should be avoided.

3.8.10. **Superstructure Repairs**

Superstructure repairs shall be evaluated for:

- Localized deterioration (holes, cracks, severe section loss).
- Members with LFR Inventory rating factor less than 1.0 for the AASHTO Type 3, 3S2 and 3-3 truck legal and Emergency Vehicle (EV) loads.
- Steel members with fatigue cracks.

Superstructure repairs shall consider the bridge's remaining ASL.

Steel superstructure repairs for section losses may be repaired via welded cover plate only at simply supported ends of Stringers, and only within a distance of 'D' from the centerline of bearing. The value 'D' is defined as the depth of the stringer's web. Repairs made outside of the 'D' limit shall only be made by bolted connection cover plating.

Vehicular impact damage repair shall be performed in accordance with the above provisions except where the damage is limited to deformation in the steel with no cracking or gouges over 1/4" in depth. Where damage is limited to deformation alone, heat straightening of the steel should be considered as an option. Contact the Authority for guidance on design of heat straightening work where considered.

Prestressed concrete Stringers cannot be repaired when damaged or deteriorated to restore their structural capacity. Spall repair for these members is intended only for restoration of protection from the elements and to arrest corrosion of exposed mild steel reinforcing and prestressing strands. While these repairs are still expected to be performed, the Design Engineer is cautioned that structural capacity and condition rating of these 'repairs' should not be noted as improved or restored.

Bearing devices should be replaced when more than 50% of an existing bridge deck is also replaced, or when the bridge superstructure is replaced. The Authority prefers the use of laminated Elastomeric Bearings for straight Routine Bridges with minimal skew where practical. Refer to Subsection 3.2.4.3 for additional design and selection criteria for new bearings. Bearing replacement shall be performed in accordance with the Standard Drawings pertaining to field measurement of existing bearings and fabrication of new bearings.

3.8.11. Superstructure Strengthening

At a minimum, all Bridge Rehabilitation Projects which include replacing the bridge deck shall include consideration for strengthening of the superstructure to carry modern live loads commensurate with the ASL performance goals below (based on load and resistance factor rating methodology):

- HL-93 Inventory Rating for ASL of greater than 35 years
- HL-93 Operating Rating for ASL of greater than 15 years to 35 years
- Legal Truck and EV Rating for ASL of 15 years or less

Strengthening to TP-16 loading is not considered practical for superstructure rehabilitation Projects except for Turnpike Roadway Projects where superstructure replacement is to be performed. The option of full superstructure replacement is typically considered in situations where a rehabilitation Project would otherwise include deck replacement, repairs to the superstructure, in combination with repainting the existing steel work. Where these or similar conditions are encountered, the Consultant shall provide a cost/benefit analysis of both superstructure replacement and rehabilitation options, with recommendations, as a part of the Phase A submission.

Substructure elements generally need not be considered for the increased live load, unless where directed by the Authority, where the Bridge Inspection Report indicates poor condition, or, where flexural elements in the pier, such as free spanning or cantilever pier caps, are subjected to a more than 10% increase in overall service loading due to the increased live load. It is the responsibility of the Design Engineer to compare the substructure conditions noted in the Bridge Inspection Report to the actual field conditions, which shall include a visit to the site and physically viewing the substructure elements.

3.9. STRUCTURES PLAN PREPARATION

The following are guidelines for the preparation of Contract Plans for new, reconstructed or repaired and other structures (not including sign bridges). These instructions are provided so that a uniform level of engineering (design) information is presented and arranged in a consistent format. Plans will be reviewed by the Authority's Engineering Department at various interim stages of completion as discussed below.

Structure Numbers for new or replacement bridges, sign structures, and Culverts shall be assigned by the Authority's Engineering Department.

3.9.1. Title Sheet

The Authority's standard templates for title sheets are provided at the Authority's website to achieve uniformity of title sheets.

The annual maintenance repair contracts have a consistent presentation between the contracts. The index of drawings on the Title Sheet shall be sufficiently detailed so as to identify and locate each rehabilitation plan, MPT plans, which are organized by Zones and follow the rehabilitation plans and structure/zone specific details of which the zone is associated, and general details.

3.9.2. General Plan and Elevation

As a minimum, a general plan of every structure affected shall be included in the Contract. The scale shall be no less than 1" = 50', preferably 1" = 30' or 1" = 20'. Where applicable, the following data is to be furnished:

- Abutment bearing lines and pier centerlines
- Turnpike/ Parkway continuous stationing at each substructure element.
- North Arrow.
- Lane lines, edge of pavement, roadway protective feature, direction of travel, milepost markers, and roadway designation(s).
- Proposed work areas.

- Drainage facilities.
- Utilities.
- Roadways above and below and right of way lines.
- Railroads tracks and right of way lines; each track shall be identified by the railroad line and branch number, and structure number where applicable, and be identified as active or inactive as determined through coordination with the owner.
- Pertinent existing topographic and planimetric features which may have an effect on the proposed work.
- Vehicular detector loops/pavement sensors for weather and traffic systems and be identified as active or inactive as determined through coordination with the owner.

Maintenance and protection of traffic plans shall also show Mileposts, and a lane closing summary table shall be provided for each plan for each stage of construction.

For the maintenance repair contracts, the Rehabilitation Plan shall act as the General Plan. In addition to the above noted data, structural framing of the superstructure elements shall be depicted on the Rehabilitation Plan for spans and structures that have proposed structural steel repairs, bearing replacements, and/or deck panel replacements. Rehabilitation Plans shall also include designations for each abutment's and pier's existing joint type(s) and joint hardware, the bearing or bearing line designations (as expansion or fixed), and a pilot hole layout and stage designation for each isolated and/or group of deck panel replacements. Depictions of deck panel replacements shall show presence of catches where required.

Also for maintenance repair contracts, in addition to the Estimate of Quantities plan sheets which are organized at the front of the Plans, each Rehabilitation Plan shall be provided with a table summarizing the estimated quantities for the repair pay items separated by stages of construction. Rows for "If and Where Directed by the Engineer" quantities and columns for the insertion of "As-Built" quantities are omitted from these tables.

As a minimum for all Projects, an elevation of every structure affected should depict the general features below the bridge, including those that may affect access such as waterways, ditches, chain link fences, roadway protective features, and other permanent features. Tidal waterways should have mean high and low tide water elevations, and freeboard depicted. Clearances below the structure, including at infield areas, should be shown where they may have an effect on the proposed work.

3.9.3. **Plan Content and Format**

Minimum expected Plans are defined in this Section. The Contract Plans are the central document for any bridge focused work. Contract Plans are in essence, little more than ‘assembly instructions’ and should be viewed as such when preparing them. Plans shall be prepared such that they contain adequate information for the Contractor to accurately bid and build all features shown in the plans. How a bridge is constructed is the domain and sole responsibility of the Contractor. It is the responsibility of the Engineer of Record and Design Engineer to investigate and provide adequate information to prove that the Work shown on the Plans is possible to construct. This is typically done through provided staging plans. A Contractor is not required to adhere strictly to the staging shown in the plans, however a plausible way of completing the work must be provided to substantiate that the design of the Project is definitively constructible.

Specifications work in concert with the Plans and are intended to supplement the plans with written descriptions of material requirements, specific methods of work, adherence to testing standards, methods of measuring the work for level of completion and basis of payment.

Specifications for fabricated or furnished materials often require the Contractor to prepare and submit complete shop drawings and details for review before proceeding with fabrication. This will require the Contractor to graphically describe the interpretation of the Plans through more finely detailed drawings which are then utilized during fabrication, erection and construction. The shop drawing and details are reviewed by the Engineer of Record and Construction Supervisor for conformance to the Contract Plans.

Other working drawings will also be required from the Contractor for temporary construction and facilities which are not the responsibility of the Engineer of Record or the Design Engineer during the design and preparation of the Contract Documents (jacking operations, cofferdams, bracing for excavations, forms, catches and shielding etc.). Any permanent features which are the responsibility of the Contractor (MSE Walls, HLMR Bearings, Modular Joint Assemblies, etc.) are to be fully designed, detailed and submitted for review by the Contractor as well. It is the responsibility of the Design Engineer to show these facilities on the plans and provide adequate information to allow the Contractor to design, quantify, bid, and detail them. For the purposes of the Plans, additional information above this level should only be shown where absolutely required for the Contractor to fully understand and execute the work.

3.9.4. New Bridges and Comprehensive Bridge Rehabilitation Projects

New Bridges and Comprehensive Bridge Rehabilitation contracts generally address either new construction or repair of most significant components of a bridge. Thus, the plan set organization for these two types of Projects are usually of similar scale and content. They have therefore been grouped together in this subsection for brevity. Where Comprehensive Rehabilitation Projects differ from New Bridge construction, they are as noted below:

3.9.4.1. **Key Plan to Structures**

A Key Plan is required upon which each structure site is located and identified within the Contract limits. Ordinarily drawn to a scale of 1” = 200’, the Key Plan is similar to the Plan Reference Drawing typically given in the roadway design plans. Information shown shall include all existing and new construction, stationing at intervals of 500’, and NJ Coordinate Plane grid references. If space permits, the index of drawings for all included structures should be given on this sheet, as well.

3.9.4.2. **Estimate of Quantities**

For consistent presentation of the maintenance repair contracts, a unique legend of special symbols and general notes shall be used consistently between Projects. It will be the Design Engineer’s responsibility to coordinate with the Authority’s Engineering Department to receive the most current version of the legend and general notes for the repair contracts. For some contracts, this may require a specific separate sheet.

For all Projects, the Estimate of Quantities is an item-by-item tabulation of pay items for each structure site and includes rows for “If and Where Directed by the Engineer” quantities and a column for the insertion of “As-Built” quantities. Separate tabulation of items concerning Maintenance and Protection of Traffic and other general items, for example mobilization, construction layout, and progress schedule, for the overall contract will also be included. The Estimate of Quantities shall include an item number specific to the contract for each pay item, in addition to the Authority’s assigned Unit Code, Description, and Unit.

3.9.4.3. **General Plan and Elevation and Bridge Sections**

This drawing should be prepared using the approved Preliminary Design Plan as a base (see Sample Plans). The scale shall preferably not be less than 1” = 16’, but in no case less than 1” = 30’. Additional General Plan and Elevation sheets may be required for large bridges. The typical section of the bridge superstructure shall be shown on the Bridge Section Sheet directly after the General Plan and Elevation sheet(s).

For Comprehensive Bridge Rehabilitation Projects, the General Plan and Elevation sheets in combination with the typical bridge section should also be used as work location plan sheets for the repair work. For Major Bridges where Girders and Floor-Beams may be very difficult to reach, the Design Engineer should show the repair work locations both on the plan and section sheets so that the Contractor can have a better understanding of the required effort to access the repair areas. Comprehensive Bridge Rehabilitation Projects should also be furnished with a specific Repair Type Description sheet narratively defining the various repair types and providing them with specific symbol call-outs for easy reference within the Plans.

General Notes are also typically shown in the General Plan and Elevation sheet. Checklists for features to be shown is attached as Appendix A.

3.9.4.4. **Demolition and Staging Details**

The demolition and staging details shall clearly describe the depth and breadth of the work required so that Contractors may understand and accurately bid the work. These plans shall include at a minimum the following:

- Demolition plan(s) and temporary sheeting / wall details
- Staging of demolition work
- Utilities on bridge staging or relocation

3.9.4.5. **Substructure Details**

Typically, Typically, and at a minimum, substructure plans are arranged as follows:

- Foundation Layout Plan(s) with pile or drilled shaft locations and notes
- Foundation Details with pile or drilled shaft details and notes
- Plan and Elevation Views of Abutments
- Detail Views and Sections of Abutments
- Plan and Elevation Views of Piers
- Special Details, Views and Sections of Piers
- Substructure Repair Details*
- Bearing Seat Reconstruction*

*Comprehensive Bridge Rehabilitation Projects only.

Marking and listing of reinforcement bars is not required for Authority Projects. It is generally sufficient to show reinforcement patterns, bends and shapes in elevation views and sectional views. However, special supplementary sections are often necessary to clearly indicate reinforcement shape and placement in corners and other obscure areas. Dimensions for positioning reinforcement beneath bearing areas shall be coordinated in the Plans to avoid conflicts with anchor bolt placement. Bearing pedestal reinforcement details must be shown.

Plan and Elevation views should generally be drawn to a 1/4” scale; preferably, the scale should not be less than 3/16”. The scale of sectional views shall be large enough to show a clear representation of reinforcement placement and shape. These views are commonly drawn to 1/2” or 3/4" scale. General substructure detailing criteria of note is described below.

3.9.4.6. **Joints**

Typical details for contraction and expansion joints are illustrated in Exhibit 305 to 307 of this Manual.

3.9.4.7. **Bearing Surfaces**

Tops of piers and abutments shall be sloped along their length to minimize the height of concrete bearing pedestals. Pedestals shall be reinforced using the details presented in Exhibit 3-213 to 3-216 of this Design Manual. Bridge seats shall be sloped longitudinally towards their front face, and pier tops crowned to provide for runoff. Substructure waterproofing membrane shall be applied to the tops of all piers, abutments, and bridge seats, including all sides of pedestals.

3.9.4.8. **Damp Proofing**

The rear face of all earth retaining structures shall be damp proofed from the top of footing to ground level.

3.9.4.9. **Under Bridge Slope Protection**

For bridges crossing over the Turnpike or Parkway roadways, under bridge slope protection consists of concrete slope protection or stone slope protection. Construction details are shown in Standard Drawings BR-5 and BR-8. Where the Turnpike or Parkway roadway section approaching the crossing is in cut, the slope normal to the abutment face shall be 2:1, otherwise a slope of 1.5:1 shall be used to determine the structure length and abutment heights.

Where the Turnpike or Parkway crosses local roads or State highways, the type of under bridge slope protection will be specified by the agency having jurisdiction. Usually, a concrete pavement slope protection will be required for these locations, and details will be those of, or approved by, that agency.

3.9.4.10. **Drainage Behind Walls and Abutments**

Earth retained by walls and abutments shall be drained by the use of porous fill, perforated corrugated metal pipe underdrains, and in some cases, weep holes. Generally, underdrains should connect or discharge into the roadway drainage system. Refer to the details presented in the Exhibits of this Section of the Design Manual.

3.9.4.11. Utility Supports

Utilities shall be supported by steelwork which frames into main members. Supports, which rely on deck inserts or drilled in expansion anchors, shall not be used. Support materials shall be fire resistant and offer secondary measure of restraint against collapse in the event of severe fire damage. Refer to Subsection 3.2.1.7 for further discussion regarding utilities on bridges.

3.9.4.12. Superstructure Details

Typically, and at a minimum, superstructure plans are arranged as follows:

- Framing Plans
- Beam Elevations
- Diaphragm and/or Cross Frame Details
- Field Splice Details
- Steel Details
- Camber Table(s)
- Superstructure Repair Details*
- Bearing Details
- Structural Jacking Details*
- Deck Plans
- Deck Sections
- Parapets
- Deck Joints
- Miscellaneous Details (as required)
- Bridge Painting Details*

*Comprehensive Bridge Rehabilitation Projects only.

No hard and fast rule can be set for determining the amount of information which can be presented on any one sheet, since this depends on the complexity of the structure’s framing. However, checklists for information typically required have been provided in Appendix A.

The scale of framing plans should generally be not less than 1” = 20’; Cross section scales should be either 3/8” or 1/2”. The scale of detail views will depend on the actual size of the detail and the degree to which that the view would be cluttered by dimensions, material notes, welding symbols, etc. General superstructure detailing criteria of note is described below.

3.9.4.13. Welded Joints Design and Detailing

Welded joint design and detailing shall comply with the latest edition of the AASHTO/AWS D1.5 Bridge Welding Code. Information provided on Contract Plans shall conform to Clause 4.1 of the same text. Weld call-outs and symbols shall conform to AWS A2.4. Finish grinding, where required, shall be shown on the welding symbol in the Contract Plans. Contract Plans shall show PJP or CJP requirements for all groove welds. It is not necessary for the Contract Plans to detail the specific joint designation for the welding procedure, however, the specific joint designation proposed by the Contractor is required for all welding symbols placed on working or shop drawings.

Specific reference is made within this section to the definition of Fracture Critical Members and guidelines related to member identification. A note shall be added to the structural steel plans that Fracture Critical Members and/or member components shall be subject to the provisions of the current Edition of the AASHTO/AWS D1.5 Bridge Welding Code, Clause 12.

As a last note, Fatigue of welded connections is a concern for Authority structures. Satisfactory performance of these details has been limited due to the heavy and frequent truck traffic present on the roadways. The Design Engineer is strongly encouraged to consider this when detailing weldments. Weldments of categories below Category D are strongly discouraged, except for cross frame gusset plate weldments and for sign structures where such details may be unavoidable.

3.9.4.14. Splices

Permissible locations of field and shop splices should be given on the Framing Plan or Stringer Elevations. Splices should be fully detailed.

3.9.4.15. Cambers

For simple spans, cambers shall be provided at Stringer quarter points and field splice locations for short spans where the camber is 4” or less, otherwise, camber shall be shown at tenth points and field splice locations. For continuous spans, Cambers shall be provided at 10th point ordinates along each span and at field splice locations. The individual cambers comprising the total value shall be given (i.e., camber for deflection due to steel dead load, camber for deflection due to concrete dead load, camber required for vertical curve), for the correct setting of forms and reinforcement. Ordinarily, beams shall not be cambered for sag vertical curves; the slab haunch shall be varied and the Stringer flange maintained on a vertical tangent, under full dead loads. Rolled section Stringers shall be placed with mill camber up, where practical.

3.9.4.16. Temperature

All details affected by thermal movements shall be designed for a reference temperature of 68°F.

3.9.4.17. Clearances

Unless a greater distance is required by consideration of expansion and live load movements, the ends of fascia Stringers should be set at 6" apart at piers (for simple spans) and within 6" from back walls at abutments. It is customary to detail beams so that ends will be vertical under full dead load.

3.9.4.18. Deck Joints

Bridge deck rehabilitation Projects shall typically consist of replacing failed preformed seals, like compression seals. Strip seal joint systems are preferred for New Bridges. Construction details are shown on Standard Drawings BR-13 and BR-14.

For combinations of span and skew outside the range of applicability of the compression seal or a strip seal, a modular system of multiple elastic sealers may be appropriate. Modular joints may be permitted for use on long continuous superstructure units, but prior approval should be obtained from the Authority before proceeding. The Design Engineer is alerted to the fact that special details must be included in the Plans for these joint systems. Consult with joint system manufacturers.

The type and size of each joint proposed for use shall be indicated on the Preliminary Design Plan.

3.9.4.19. Bridge Drainage

Storm sewer inlet and scupper details, shown on Standard Drawings BR-2A and BR-2B, shall be typically utilized. For bridge Projects where these details cannot be utilized due to superstructure type or other conflicts, the required modifications and/or additional details shall be shown on the Contract Plans.

3.9.5. Bridge Rehabilitation Contracts

Bridge Rehabilitation Contracts generally address limited work on bridges meant to extend their ASL. Their plan set is usually focused on repair of deck, superstructure, and substructure repair, rather than replacement, and often feature limited detailing of existing features intended only to inform the Contractor of the location of work and the expected scale of work at the repair location. Bridge Rehabilitation Project Plans typically have new deck work detailing similar to New Bridge Projects with additional provisions added for work to the Stringer top flanges for removal of existing shear lugs and weldments and staged installations of new shear studs, with top flange lead primer remediation, as appropriate.

3.9.6. Bridge Maintenance Work

Bridge Maintenance Work is organized into four yearly maintenance design and construction contracts.

The Project limits are:

- Garden State Parkway South (Mileposts 0-126)
- Garden State Parkway North (Mileposts 126-172)
- New Jersey Turnpike South (Including the Pearl Harbor Memorial Turnpike Extension)
- New Jersey Turnpike North (Including the Newark Bay-Hudson County Extension)

Bridge maintenance level of work is generally prepared with a minimal level of detailing as the work in these contracts is intended to be simple and repetitive “routine” tasks. Plan preparation is focused on locating the work over a large geographic area with basic standardized detailing provided throughout.

3.9.7. Retaining Walls

Recent retaining wall construction for Authority roadways has predominantly been of Mechanically Stabilized Earth (MSE) construction. However, the Authority has a stated preference for conventional cast-in-place semi-gravity Walls, which generally require more detailing effort on the part of the Design Engineer than MSE walls. This additional detailing effort should always be assumed on the part of the Engineer of Record when planning the design and plan preparation effort for retaining walls. Plan preparation effort for retaining wall types is as noted below.

3.9.8. Cast-in-Place Walls

Cast-in-place concrete walls generally will require the same level of detailing as bridge substructure units:

- General Plan and Elevation with general notes
- Construction or staging details
- Foundation layout with pile layout (if required)
- Typical sections of the retaining walls
- Reinforcement plans, elevations, and sections
- Fencing, handrail, drainage, architectural details

For contracts with long cast-in-place walls or many walls, design information may be conveniently presented in a panel-by-panel tabulation. Panels should be identified numerically on the General Plan and Elevation and referred to in the tabulation. Similarly, various types of wall sections, reinforcement patterns, pile plans, etc. should be detailed once and identified for use in the tabulation. The tabulation should also indicate footing dimensions for each panel, panel end point elevations and footing elevations.

Details such as the placement and arrangement of non-stress reinforcement on wall stems, key construction, porous fill placement, and joint construction are common to all panels and should be presented once in a contract set of plans.

3.9.9. Alternate Walls

Alternate walls are defined as walls, often proprietary, such as Mechanically Stabilized Earth (MSE) Walls and Prefabricated Modular (PM) Walls or any other proprietarily designed wall system other than Cast-in-Place Concrete walls as discussed above.

Design Engineers shall consider the use of alternate retaining wall systems at select Project locations. Proprietary retaining wall systems, MSE Walls and PM Walls, are generally considered to provide a reduced time for construction over standard cast-in-place reinforced concrete cantilever retaining wall system.

Alternate walls shall be presented in the Common Structure Volume (CSV) format. Common Structure Volume is defined in Subsection 3.3.3. Design Engineers shall develop the CSV to encompass all proprietary alternate wall systems applicable to each site and list those systems in the contract specifications. Only wall systems participating in design consultation may be included in the contract Specifications.

The Design Engineer shall develop the General Plan and Elevation to include the CSV, right-of-way, utilities, noise walls, lighting, drainage, staged construction, and other pertinent information. Elevations should show existing and proposed ground lines, minimum foundation elevations and mean high and low water, where appropriate. Cross sections should show limits of CSV, wall batters, pay limits and all pertinent information.

Magnitudes, locations and directions of external loads due to bridges, overhead signs and lighting, noise walls, traffic and other surcharges should be shown on the plans.

Architectural requirements should be identified.

3.9.10. Culverts

Because of their limited plan area, Culvert General Plans should be drawn to as large a scale as may be practical, preferably 1/8” =1’; scale shall not be less than 1” =20’.

3.9.11. Standard Drawings

The Standard Drawings required for each contract will be furnished by the Authority. Absolutely no changes or additions of any kind are to be made to the Standard Drawings. Should changes be required, the Design Engineer shall present the changed drawing on a Project specific border to be signed and sealed by the Engineer of Record for the Project.

3.9.12. Reference Drawings

Design Engineers shall be required to visit the Authority's office as required to obtain and review existing available as-built plans and shop drawings. These existing drawings are defined as Reference Drawings. Inasmuch as repair plans require details of existing construction of many bridges, a considerable number of Reference Drawings may be involved. It has been the practice not to include all Reference Drawings of affected structures as part of the plans, but to include only those specific Reference Drawings necessary to determine the extent of work for the bidding process.

Following the list of Standard Drawings, a separate listing is to be shown on the title sheet as Reference Drawings. An exception to this requirement is made for the annual maintenance repair contracts due to the number of Reference Drawings required for the various repairs in the contract. Direction for annual maintenance repair contracts is provided below.

For contracts listing Reference Drawings on the title sheet, these Reference Drawings will also receive a sheet number and become part of the contract. They will receive sheet numbers after the last Standard Drawing number has been assigned. All boring logs are to be included as Reference Drawings and are to appear in the contract at the end of the "Reference Drawings" division. All Reference Drawings are to have the words "Reference Drawing" placed immediately adjacent to the title box. In the margin below the title box, the contract number, individual sheet number and total number of sheets in the contract are to be added.

If Reference Drawings are required from another contract prepared by the same Consultant, it will be their responsibility to furnish reproduced original copies of such drawings for all contracts to which they apply.

Should the Reference Drawings be from a contract prepared by another Consultant, the Authority's Engineering Department will furnish reproduced original copies of such drawings, provided the Consultant has advised the contract number(s) and sheet description(s) that are required. It will be the Consultant's responsibility to give the Authority's Engineering Department ample notification of which Reference Drawings will be required for each contract so that the Authority's Engineering Department will have time to prepare copies of such sheets.

For the annual maintenance repair contracts, those Projects listed in Subsection 3.9.4, the Design Engineer shall tabularize the Reference Drawings required for each structure in the NJTA Supplementary Specifications Subsection 102.04. These Reference Drawings will not be provided sheet numbers or marked with the words "Reference Drawing".

It is the responsibility of the Design Engineer to acquire each Reference Drawing and to compile an electronic PDF file by individual contract for the Reference Drawings associated with an individual structure. The files by contract shall be organized in subfolders by structure. The Design Engineer shall submit to the Authority the Reference Drawings listed in the NJTA Supplementary Specifications, along with the Standard Drawings listed on the title sheet, for interim submissions of completion and for advertisement.

APPENDIX A

NJTA BRIDGE PLAN CHECKLIST

TITLE SHEET		
	1.	See standard template for title sheets provided on the Authority's website.

KEY PLAN TO STRUCTURES		
	2.	Identify location of each structure site that is to be built, altered, or demolished within the contract limits.
	3.	Scale is no less than 1" = 200'
	4.	Include all existing and new construction with stationing at intervals of 500' and NJ Coordinate Plane grid references.
	5.	Show north arrow.
	6.	Provide index of drawings.

ESTIMATE OF QUANTITIES		
	7.	For repair contracts, coordinate with the Authority's Engineering Department to receive the most current version of the legend and general notes.
	8.	Provide a tabulation of pay items for each structure site.
	9.	Ensure pay item numbers is in numerical order and each row contains the Authority's assigned Unit Code, Description, and Unit.
	10.	Columns for "If and Where Directed" quantities and "As-Built" quantities.
	11.	Separate quantities per each stage of construction
	12.	Include separate tabulation of items concerning Maintenance and Protection of Traffic and other general items (e.g., mobilization, construction layout, progress schedule, etc.).

GENERAL PLAN AND ELEVATION		
GENERAL PLAN		
	13.	Provide general notes, including: - design specifications - welding specifications - construction specifications - design live load - design thermal forces - design material properties - future wearing course weight assumed in design - cleaning and painting specifications - seismic design information (performance zone or design category, site class, PGA, S_S, S_1)
	14.	Label plan view as "PLAN".
	15.	Scale of general plan is no less than 1" = 50' (preferably 1" = 30' or 1" = 20').
	16.	Show north arrow.
	17.	Show and label all working points, working lines, and centerlines (including abutment bearing lines and pier centerlines).
	18.	Show skew angle of bearing lines
	19.	Provide Turnpike/Parkway continuous stationing at intervals of 100'. Provide stations and

		elevations along centerline of survey at beginning and ends of bridge and centerline of all substructures.
	20.	Provide azimuth of roadway centerline or working line.
	21.	Show and label horizontal PC, PCC, and PT points that affect the structure.
	22.	Label radius and/or degree of curve for all horizontal curves.
	23.	Show lane lines, edge of pavement, roadway protective features, direction of travel, milepost markers, and roadway designation(s).
	24.	Show location of bridge and substructures. Provide type of structure, length, and width of bridge.
	25.	Tie bridge dimensions to working points.
	26.	Define bridge length along centerline. (End of deck to centerline of abutment bearing to centerline of pier to centerline of abutment bearing to end of deck and overall length)
	27.	Show approach slab limits.
	28.	Dimension roadway, barrier/parapet, sidewalk, and median widths.
	29.	Show and label abutment wingwalls.
	30.	Show location of deck drains and centerline and station of electrical and lighting facilities.
	31.	Show all applicable proposed work areas.
	32.	Show existing and proposed utilities and pipes which affect the bridge construction.
	33.	Label all drainage facilities within the vicinity of the bridge.
	34.	Show stage construction limits, if applicable.
	35.	Show type and extent of slope protection, if applicable.
	36.	For retaining walls adjoining to the abutments, provide wall name and tie in with station and coordinates.
	37.	Temporary facilities, such as sheeting, and detour structures.
	38.	Permanent sheeting limits.
	39.	Show intersection of bridge roadway centerline with centerlines of roadways above or below. Provide station and angle between centerlines. Provide of right of way lines of the intersecting roadways.
	40.	For stream crossings, provide name of stream and direction of flow.
	41.	For railroad bridges or crossings, label all tracks and associated right of way lines. Each track shall be identified by the railroad line and branch number, and structure number where applicable, and be identified as active or inactive as determined through coordination with the owner.
	42.	Show boring locations.
	43.	Vehicular detector loops/pavement sensors for weather and traffic systems. Identify as active or inactive.
	44.	Show deck joint types and sizes.
GENERAL ELEVATION		
	45.	Label elevation as “ELEVATION”.
	46.	Scale of general elevation is no less than 1” = 30’ (preferably 1” = 16’).
	47.	Show and label abutments, piers, spans, slope protection, and piling as applicable.
	48.	Show and label location of minimum vertical clearance point for each roadway under bridge.
	49.	Ensure the elevation depicts the general features below the bridge including those that may affect access such as waterways, ditches, chain link fences, roadway protective features, or other permanent features.

	50.	Show existing and proposed ground lines.
	51.	Provide bottom of substructure footing elevations.
	52.	Show girder, slab, barrier, and railing.
	53.	Provide grade of the bridge.
	54.	Label bearings as fixed or expansion.
	55.	If there is a waterway below the structure, provide 1% Annual Exceedance Probability (100-year) flood elevations and normal water surface elevation, or mean high water where tidal.
	56.	Where applicable, provide hydraulic and hydrologic data table, including frequency, drainage area, design discharge, design water surface elevation, and design energy line elevation.

PROFILE		
	57.	Provide vertical curve data, including PVI station, PVI elevation, approach grade, departure grade, and curve length. Provide VPT and VPC with station and elevation.
	58.	Show minimum vertical clearances.
	59.	Show the existing ground line.
	60.	Provide existing and proposed elevations at 50’ intervals.

TYPICAL SECTION		
	61.	Label as “TYPICAL SECTION”. Label per span, if more than one. Indicate which direction the view is looking towards.
	62.	Provide transverse bridge dimensions. Include roadway width, lane widths, out-to-out width of deck, sidewalk, barrier, and median widths.
	63.	Label the existing and proposed cross-slope grades of the roadway.
	64.	Provide height of raised median at the gutterline.
	65.	Show and label type of barrier and/or railing.
	66.	Show and label deck or slab thickness and wearing surface thickness, if applicable.
	67.	Show and label girder type and size.
	68.	Provide girder spacing for all spans.
	69.	Label centerline(s) and baseline of roadway.
	70.	Label cross slope on sidewalks and medians.
	71.	Show stage construction limits, if applicable.

DEMOLITION DETAILS		
	72.	Show and hatch extent of removals. Provide angles and dimensions that tie into existing or proposed working points.
	73.	Show all cut lines and provide elevations or dimensions.
	74.	Show existing reinforcement and identify what is to be done with any exposed sections.
	75.	Show and label removal stages.
	76.	Provide notes to explain removals and pay items for removals.

STAGING DETAILS		
	77.	Show existing, interim, and final transverse sections. Tie in new centerline, baseline, and working points to existing ones.
	78.	Show temporary and permanent barriers.

STAGING DETAILS	
	79. Show applicable cut lines.
	80. Show and label arrows for direction of traffic.
	81. Show and label construction stages.
	82. Show and label sheet piling, if any. Note if sheeting is to be removed or remain in place.
	83. Show and label any utilities and drainage facilitates to remain, to be removed, or to be relocated.
	84. Provide notes to explain work and pay items for removals as necessary.

SUBSTRUCTURE DETAILS	
FOOTING PLAN	
	85. Label "FOOTING PLAN".
	86. Provide foundation layout including size and locations of piles or drilled shafts as applicable.
	87. Develop foundation details with pile or drilled shaft details and notes.
	88. Identify direction and angle of pile batter, if applicable.
	89. Tie pile or drilled shaft spacing to working points.
	90. Identify and number the test piles.
	91. Provide load tables for applicable foundations.
ABUTMENT PLAN	
	92. Scale is drawn to ¼" = 1' (preferably, the scale is no less than 3/16").
	93. Show and label working points.
	94. Show and label centerline of bearing.
	95. Show and label centerline and baseline of roadway.
	96. Show centerline of girders and wingwall angles.
	97. Label angle between roadway baseline and centerline of bearing.
	98. Tie abutment and wingwall dimensions, including front face and corners of fillets, to working points and centerline bearing.
	99. Provide girder and concrete pedestal spacing.
	100. Show and label construction joints.
	101. Show and label contraction joints, if applicable.
	102. Provide construction or contraction joint spacing.
	103. Show conduit through abutment backwall, if applicable.
	104. Include large scale corner details for highly skewed bridges and complex corners.
ABUTMENT ELEVATION	
	105. Scale is drawn to ¼" = 1' (preferably, the scale is no less than 3/16").
	106. Provide footing, stem, concrete pedestal, top of backwall, and top of parapet elevations.
	107. Show and label centerline of bridge girders.
	108. Slope bridge seat between concrete pedestals.
	109. Show and label approximate ground line.
	110. Show depth of footing below ground line.
	111. Show opening for conduit through abutment backwall, if applicable.
	112. Show piles or drilled shafts.
	113. Show and label construction and contraction joints and the size of shear key.
	114. Show and label utility blockouts.
	115. Show shear blocks and details as necessary.

	SUBSTRUCTURE DETAILS
	116. Show drainage system.
ABUTMENT SECTION AND DETAILS	
	117. Show and dimension abutment footing, bridge seats, and parapets.
	118. Label types of concrete for each part of section.
	119. Show and label centerline of bearing.
	120. Show and label construction joints and size of shear keys.
	121. Show piling and identify slope of battered piles.
	122. Provide pile spacing.
	123. Show and dimension pile cutoff.
	124. Show and label membrane waterproofing system.
	125. Show drainage pipe and label drainage system.
	126. Provide reinforcement plan and section views of footing, abutment stem, and abutment backwall.
	127. Provide general reinforcement elevation view of abutment.
	128. Show anchor rods, dimension anchor rod spacing, and include anchor rod template note, if applicable.
	129. Show, label, and dimension embedment of all dowels.
	130. Provide reinforcement lap splice lengths.
	131. Provide reinforcement clearances.
PIER PLAN	
	132. Scale is drawn to ¼” = 1’ (preferably, the scale is no less than 3/16”).
	133. Show and label working points.
	134. Show and label centerline of bearing.
	135. Show and label centerline and baseline of roadway.
	136. Label angle between roadway baseline and centerline of bearing.
	137. Tie pier dimensions, including front face and corners of fillets, to working points and centerline bearing.
	138. Provide girder and concrete pedestal spacing.
	139. Show and label construction joints and identify the nominal size of keyways.
	140. Show and label contraction joints, if applicable.
	141. Provide construction or contraction joint spacing.
PIER ELEVATION	
	142. Scale is drawn to ¼” = 1’ (preferably, the scale is no less than 3/16”).
	143. Provide footing, pier wall/column, pier cap, and concrete pedestal elevations.
	144. Show and label centerline of bridge girders.
	145. Slope bridge seat between concrete pedestals.
	146. Show and label approximate ground line.
	147. Show depth of footing below ground line.
	148. Show piles or drilled shafts.
	149. Show and label construction and contraction joints and the size of shear keys.
PIER SECTION AND DETAILS	
	150. Show and dimension pier footing, pier wall/column, pier cap, and pedestal.
	151. Show and label centerline of bearing.
	152. Show and label construction joints and size of shear keys.
	153. Show piling and identify slope of battered piles.

	SUBSTRUCTURE DETAILS
	154. Provide pile spacing.
	155. Show and dimension pile cutoff.
	156. Provide reinforcement plan and section views of footing, wall/columns, pier cap, and pedestal.
	157. Provide general reinforcement elevation view of pier.
	158. Show anchor rods, dimension anchor rod spacing, and include anchor rod template note, if applicable.
	159. Show, label, and dimension embedment of all dowels.
	160. Provide reinforcement lap splice lengths.
	161. Provide reinforcement clearances.

	SUPERSTRUCTURE DETAILS
FRAMING PLAN	
	162. Label “FRAMING PLAN”.
	163. Scale of framing should not be less than 1” = 20’.
	164. Show north arrow.
	165. Show and label working points.
	166. Provide girder spacing and types of girder.
	167. Show and label fascia girders, centerline of bearings, and centerline of piers.
	168. Label girders.
	169. Provide dimensions of girder off roadway baseline or working points.
	170. Identify bearing type at each location.
	171. Show and label end and intermediate diaphragm spacing, including any additional fascia bay diaphragms required over oncoming traffic lanes to protect against bridge hits.
	172. Dimension angle of diaphragms.
	173. Dimension distance to centerline bearings normal to centerline of pier and along centerline of girders.
	174. Show and label field splice for steel bridges.
GIRDER ELEVATION	
	175. Provide dimensions along girder.
	176. Provide girder dimensions and indicate supplementary requirements for notch testing as applicable.
	177. Call out all applicable welds for built-up members.
	178. Detail all applicable bolt sizes and quantity.
	179. Label bearing stiffeners.
	180. Indicate flange tension zones
	181. Label all longitudinal and transverse stiffeners.
	182. Show and label field splices.
	183. Label centerline of abutment bearing, pier, and field splices.
	184. Dimension shear stud spacing along girder.
	185. Show shear connector details.
	186. Call out reinforcement for concrete beams.
	187. For prestressed concrete beam, fill in calculated prestress losses, minimum concrete strengths, and prestressing strand diameter boxes.
	188. Fill in dimensions for centerline to centerline of bearing, out to out of beam, hold-down

SUPERSTRUCTURE DETAILS		
		location, and initial prestress force, if applicable.
	189.	Provide structural steel notes.
STRUCTURAL STEEL DETAILS		
	190.	Label angles, plates, and W beams.
	191.	Show weld locations, if applicable.
	192.	Show details for plates and spacing
	193.	Show plan view of end diaphragms.
	194.	Show elevation view of typical intermediate diaphragm and/or cross frames.
	195.	Provide details of top flange splice plate.
	196.	Provide details of bottom flange splice plate.
	197.	Provide details of web splice plate.
	198.	Show detail of all connections.
	199.	Call out all applicable weld types and sizes.
	200.	For bolted connections, label hole size, bolt size, and type of bolt.
	201.	Provide utility support details, if applicable.
	202.	Provide limits of bridge painting and any applicable notes.
STEEL GIRDER CAMBER		
	203.	Provide span lengths and overall length.
	204.	Divide each span into 10 equal spaces and label per its 10th point ordinate.
	205.	Provide camber values to 1/100”.
	206.	Provide camber for deflection due to structural steel.
	207.	Provide camber for deflection due to concrete slab.
	208.	Provide camber for deflection due to superimposed dead loads.
	209.	Provide camber required for vertical curvature.
	210.	Provide diagram that shows the full camber at the top of the girder web plate. Show field splice locations, if applicable. Show and label reference line.
	211.	Provide applicable camber table notes.
DECK ELEVATIONS		
	212.	Show north arrow.
	213.	Show working points.
	214.	Label centerline of bearing at abutments and centerline of piers.
	215.	Provide angle between baseline of roadway and substructures.
	216.	Dimension deck width. Include roadway, lane, barrier, sidewalk, and median widths, as applicable. Callout location of lane lines and other applicable reference lines used to establish deck elevations.
	217.	If skewed, show details for corners.
	218.	Provide span lengths and out-to-out of deck dimensions.
	219.	Show dimension from end of deck to working point.
	220.	Provide Typical Deck Section showing roadway, lane, barrier, sidewalk, and median widths, as applicable. Provide cross-slope grades. Callout location of lane line elevations and other applicable reference lines.
	221.	Provide Top Deck Elevation table with elevations to 1/100’at lane lines and other applicable reference lines
	222.	Provide deck placement sequence.

	SUPERSTRUCTURE DETAILS
DECK REINFORCEMENT PLAN	
	223. Show longitudinal reinforcement, top and bottom.
	224. Show transverse reinforcement bars, top and bottom.
	225. Provide reinforcement lap splices. Alternate lap locations where possible.
	226. Show and label additional reinforcement over piers in stagger detail and in plan.
	227. Provide reinforcement clearances.
	228. Show and label conduit systems, if applicable.
DECK SECTION	
	229. Provide transverse bridge dimensions. Include roadway width, lane widths, out-to-out width of deck, sidewalk, barrier, and median widths.
	230. Label the cross-slope grade of the roadway.
	231. Provide height of raised median at the gutterline.
	232. Show and label type of barrier and/or railing.
	233. Show and label deck or slab thickness and wearing surface thickness, if applicable.
	234. Show and label girder type and size.
	235. Provide girder spacing for all spans.
	236. Label centerline(s) and baseline of roadway.
	237. Label cross slope on sidewalks and medians.
	238. Show stage construction limits, if applicable.
	239. Label top and bottom longitudinal reinforcement and provide spacing.
	240. Label top and bottom transverse reinforcement and provide spacing.
	241. Provide reinforcement lap splices. Alternate lap locations where possible.
	242. Show and label additional reinforcement over piers.
	243. Provide reinforcement clearances.
	244. Show and label barrier and sidewalk reinforcement into deck.
	245. Provide drip V groove on the underside of deck edge.
	246. Show plan view of barrier limits (use break line if needed).
	247. Show elevation view of barrier limits (use break line if needed).
	248. Label longitudinal reinforcement and minimum lap lengths.
	249. Provide control joint spacing. Place control joint at all pier centerline/gutterline intersections.
	250. Show and label centerline of substructures
	251. Label barrier regions located on wingwall/approach panel and bridge deck.
DECK DETAILS	
	252. Provide barrier parapet reinforcement detail.
	253. Provide typical section at deck slab joint.
	254. Provide corner reinforcement detail, as applicable.

	MISCELLANEOUS SHEETS
	255. Provide approach slab plan, elevation, and details.
	256. Provide bearing and sole plate details.
	257. Provide bearing load table.
	258. Include structural jacking details.
	259. Provide typical plan and section of deck joints.
	260. Provide retaining wall limits and elevations.

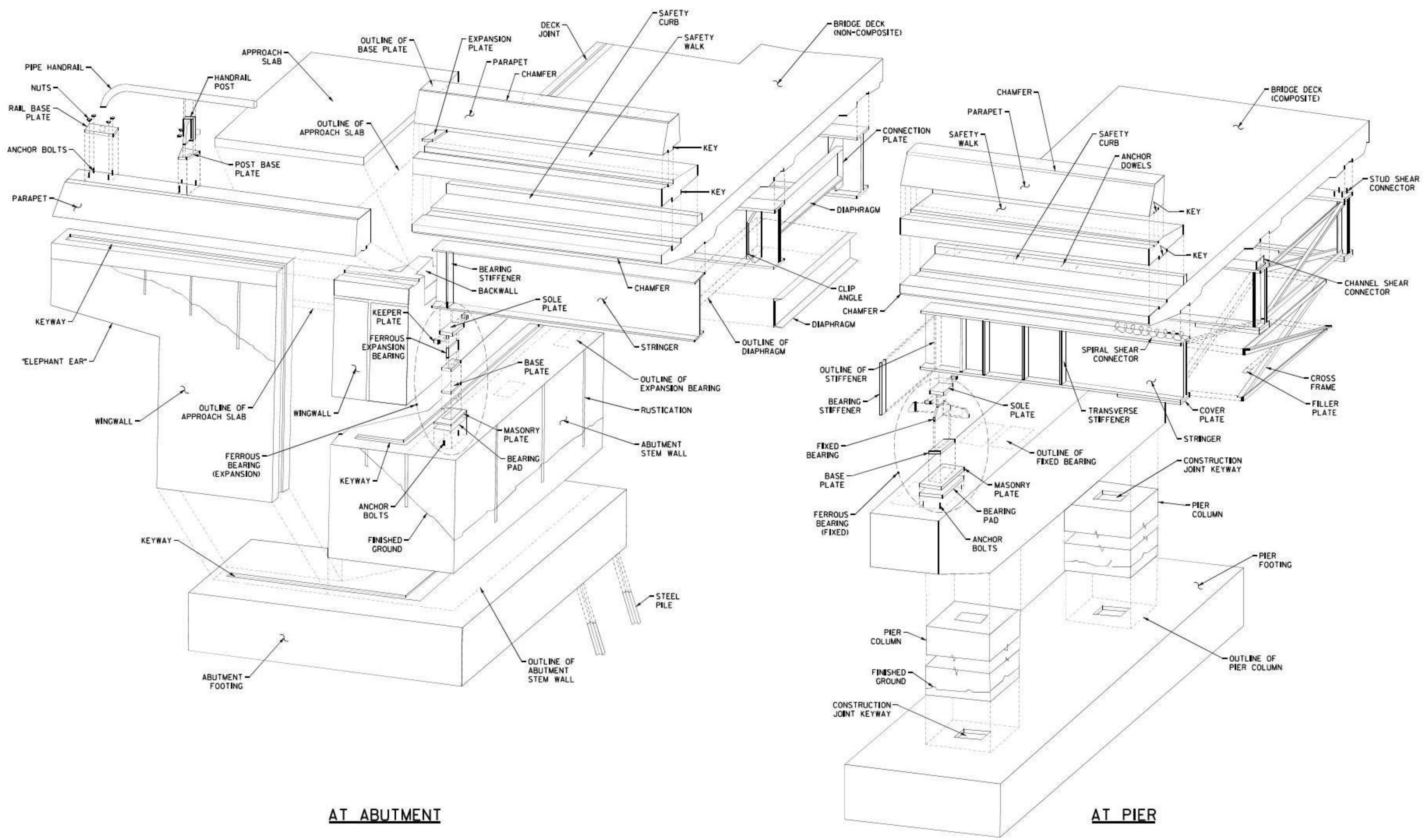
	MISCELLANEOUS SHEETS
	261. Provide details of temporary support systems.
	262. Provide repair details if needed.
	263. Include conduit and lighting system sheet if required.

List of Exhibits

Page No

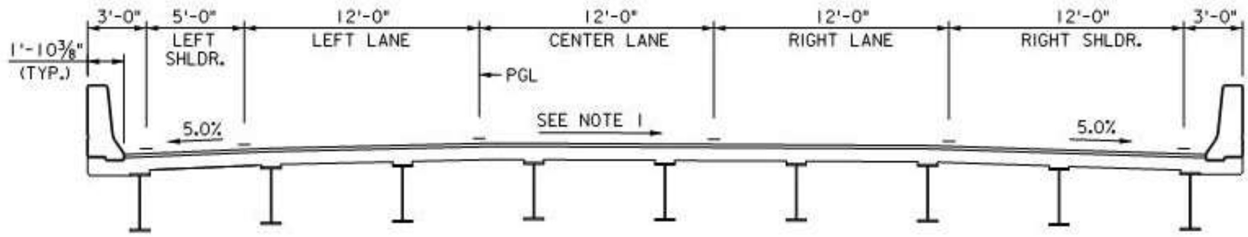
NEW JERSEY TURNPIKE AUTHORITY
DESIGN MANUAL

EXHIBIT 3-00 TYPICAL BRIDGE ANATOMY AND NOMENCLATURE

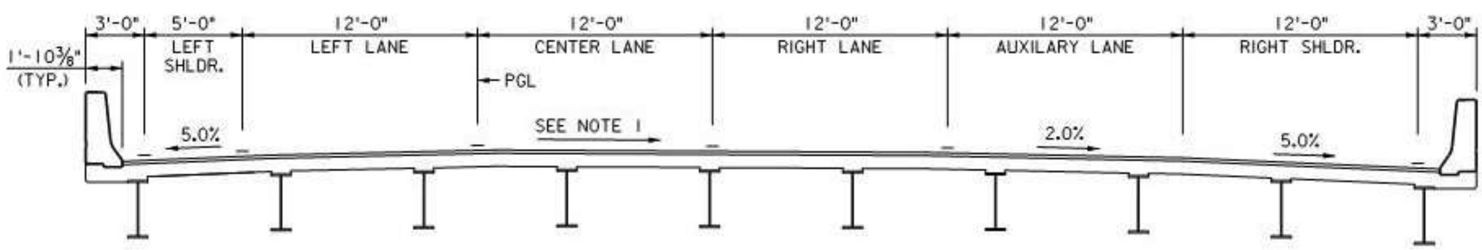


NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-100 TURNPIKE BRIDGE DECK GEOMETRY MAINLINE - 1



NORMAL SECTION



NORMAL SECTION WITH AUXILARY LANE

THREE LANE TURNPIKE ROADWAY

N.T.S.

NOTES:

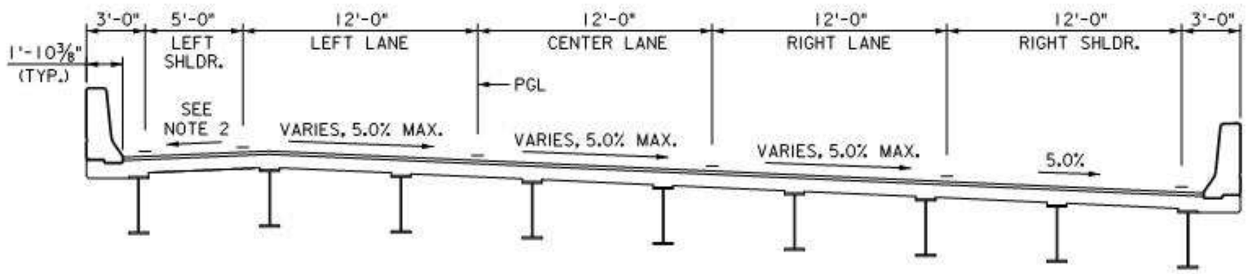
1. FOR LONGITUDINAL GRADES LESS THAN 0.5%, LANE CROSS SLOPES = 2.0% MIN.

   FOR LONGITUDINAL GRADES GREATER THAN OR EQUAL TO 0.5%, LANE CROSS SLOPES = 1.5% MIN.

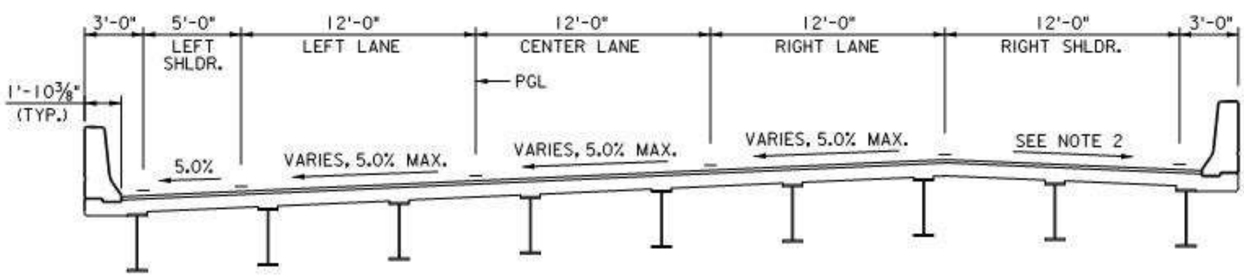
2. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-101 TURNPIKE BRIDGE DECK GEOMETRY MAINLINE - 2



SUPERELEVATED - CURVE RIGHT



SUPERELEVATED - CURVE LEFT

THREE LANE TURNPIKE ROADWAY

N.T.S.

NOTES:

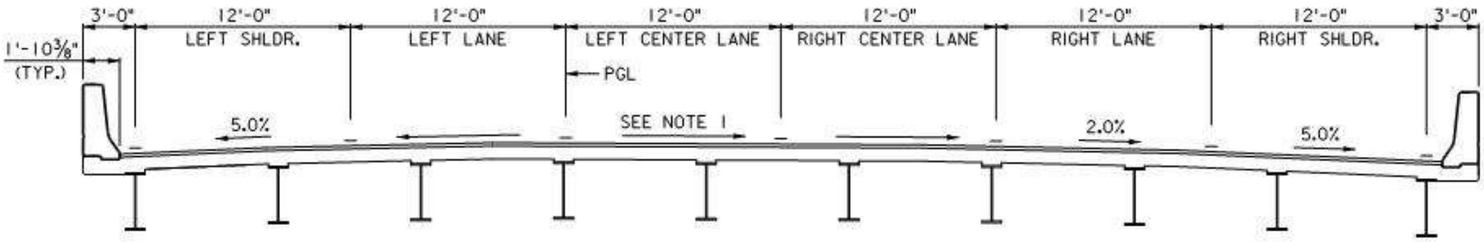
1. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

2. FOR SUPERELEVATED LANE CROSS SLOPE LESS THAN OR EQUAL TO 3.0% SHOULDER CROSS SLOPE SHALL BE 5.0% MAX.

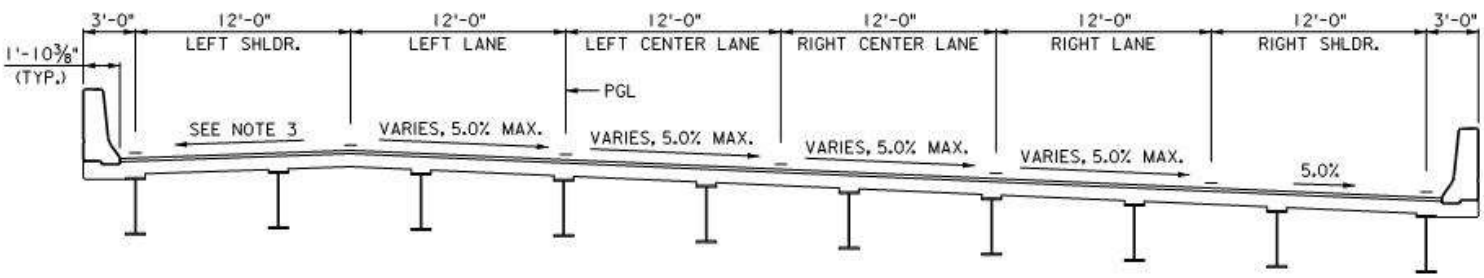
   FOR SUPERELEVATED LANE CROSS SLOPE GREATER THAN 3.0% TO 5.0% MAX. SHOULDER CROSS SLOPE SHALL VARY FROM 5.0% MAX TO 3.0% MIN. ROLLOVER SHALL NOT EXCEED 8.0% MAX.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-102 TURNPIKE BRIDGE DECK GEOMETRY MAINLINE - 3



NORMAL SECTION



SUPERELEVATED - CURVED RIGHT

FOUR LANE TURNPIKE ROADWAY

N.T.S.

NOTES:

1. FOR LONGITUDINAL GRADES LESS THAN 0.5%, LANE CROSS SLOPES = 2.0% MIN.

   FOR LONGITUDINAL GRADES GREATER THAN OR EQUAL TO 0.5%, LANE CROSS SLOPES = 1.5% MIN.

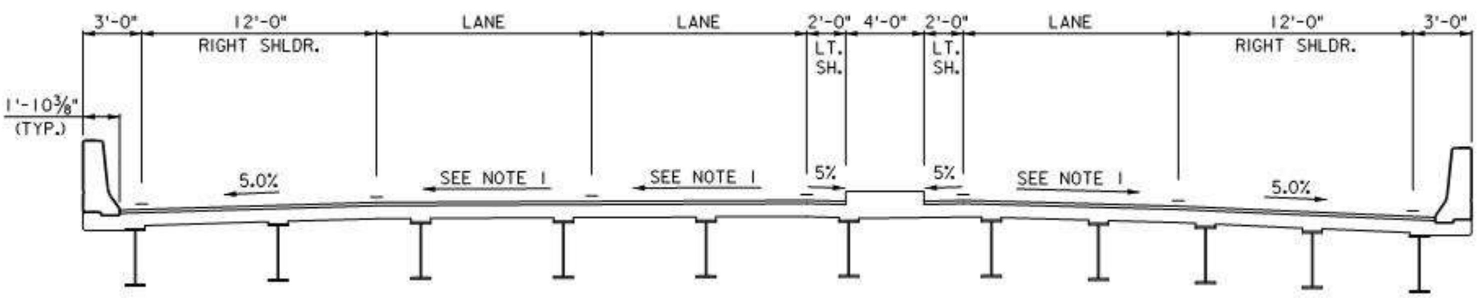
2. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

3. FOR SUPERELEVATED LANE CROSS SLOPE LESS THAN OR EQUAL TO 3.0%, SHOULDER CROSS SLOPE SHALL BE 5.0% MAX.

   FOR SUPERELEVATED LANE CROSS SLOPE GREATER THAN 3.0% TO 5.0% MAX., SHOULDER CROSS SLOPE SHALL VARY FROM 5.0% MAX TO 3.0% MIN. ROLLOVER SHALL NOT EXCEED 8.0% MAX.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-103 TURNPIKE BRIDGE DECK GEOMETRY RAMPS - 1



NORMAL SECTION

TWO WAY TURNPIKE RAMPS

N.T.S.

NOTES:

1. FOR LONGITUDINAL GRADES LESS THAN 0.5%, LANE CROSS SLOPES = 2.0% MIN.

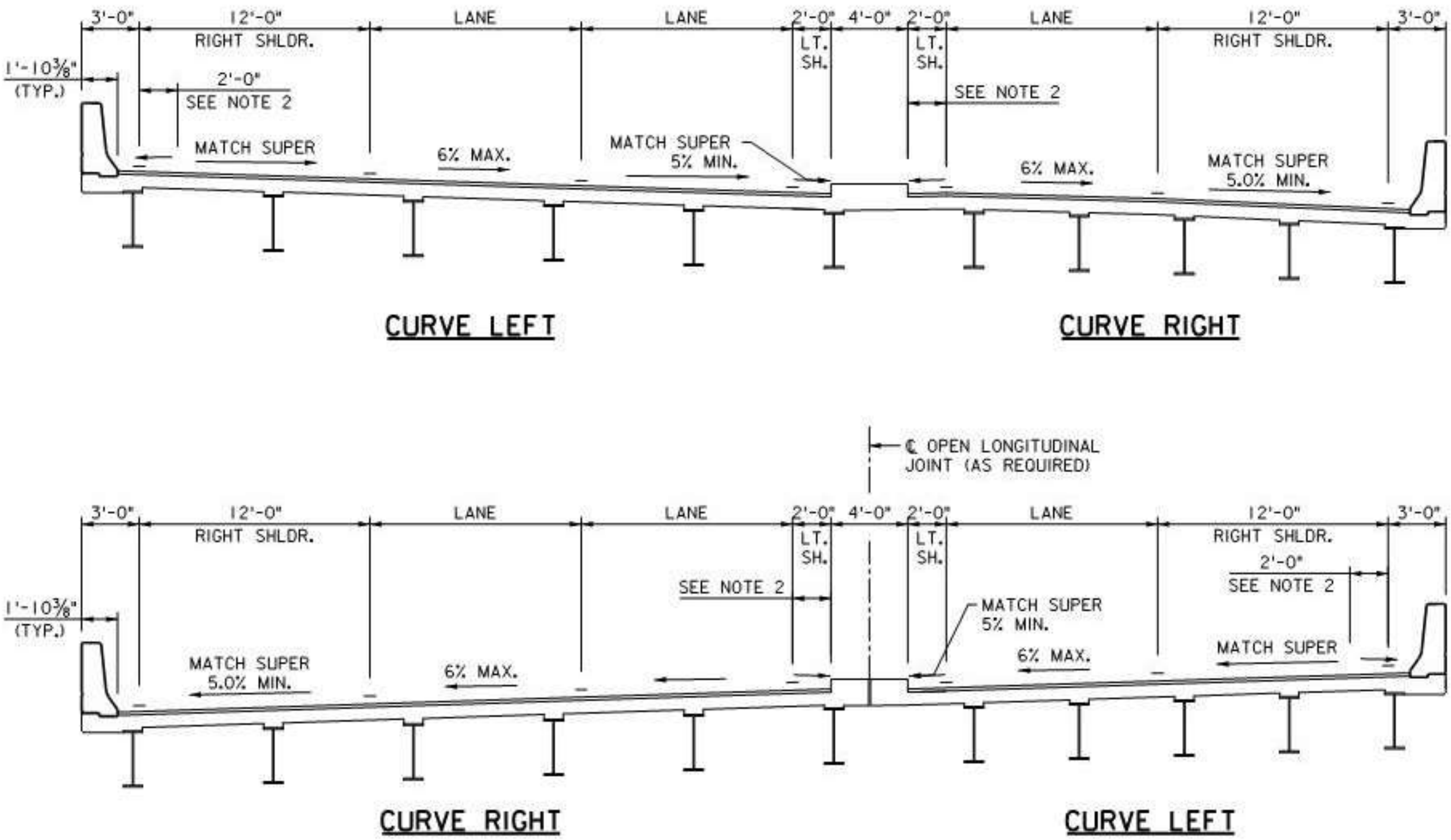
   FOR LONGITUDINAL GRADES GREATER THAN OR EQUAL TO 0.5%, LANE CROSS SLOPES = 1.5% MIN.

2. FOR ROADWAY WIDTHS AND CROSS SLOPES FOLLOW ROADWAY STANDARDS.

3. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-104 TURNPIKE BRIDGE DECK GEOMETRY RAMPS - 2



SUPER GREATER THAN 3.0%
TWO WAY TURNPIKE RAMPS

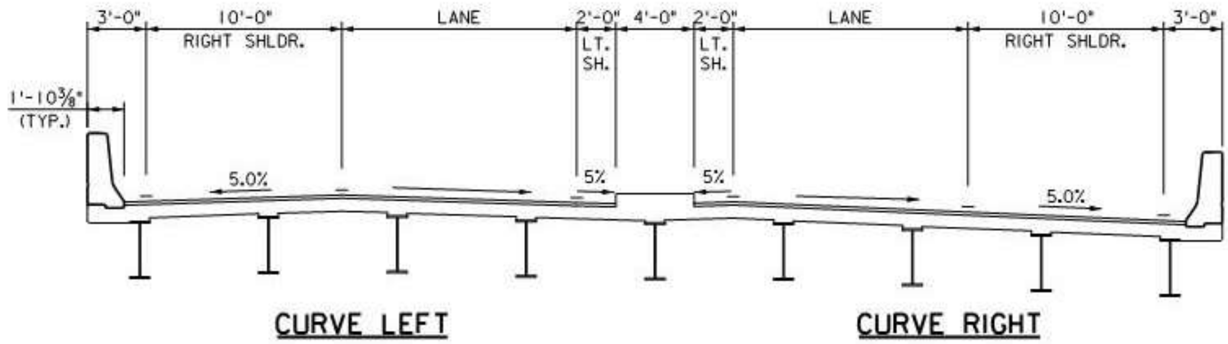
N.T.S.

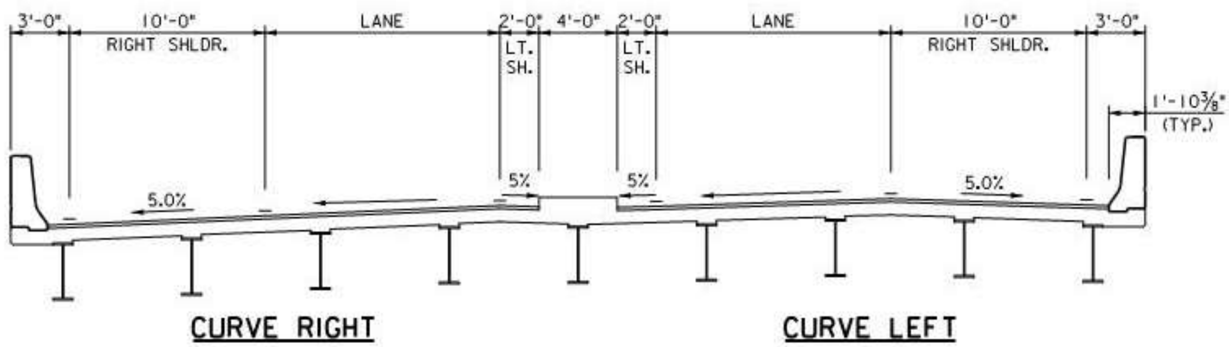
NOTES:

1. FOR ROADWAY WIDTHS AND CROSS SLOPES FOLLOW ROADWAY STANDARDS.
2. FOR SUPERELEVATED ROADWAY CROSS SLOPE GREATER THAN 3.0% TO 6.0% MAX., THE SHOULDER CROSS SLOPE SHALL VARY FROM 5.0% MAX. TO 2.0% MIN. ROLLOVER SHALL NOT EXCEED 8.0% MAX.
3. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-105 TURNPIKE BRIDGE DECK GEOMETRY RAMPS - 3





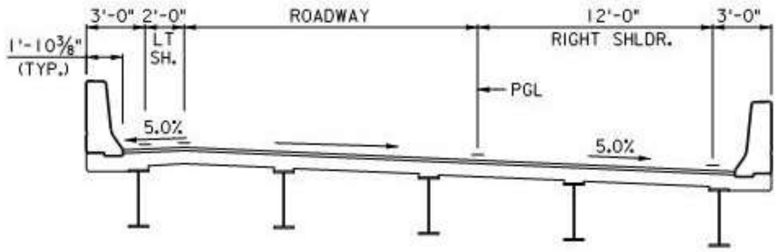
SUPER LESS THAN OR EQUAL TO 3.0%
TWO WAY TURNPIKE RAMPS
N.T.S.

NOTES:

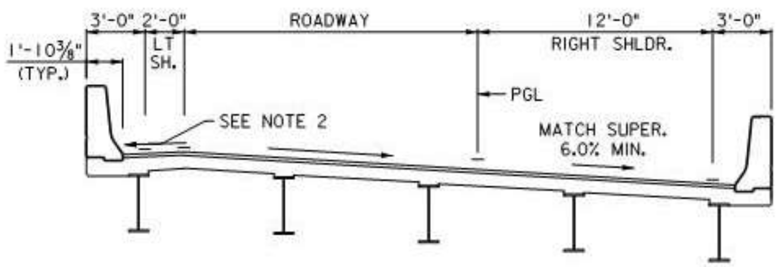
1. FOR ROADWAY WIDTHS AND CROSS SLOPES FOLLOW ROADWAY STANDARDS.
2. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-106 TURNPIKE BRIDGE DECK GEOMETRY RAMPS - 4



NORMAL SECTION



CURVE RIGHT

ONE WAY TURNPIKE RAMPS

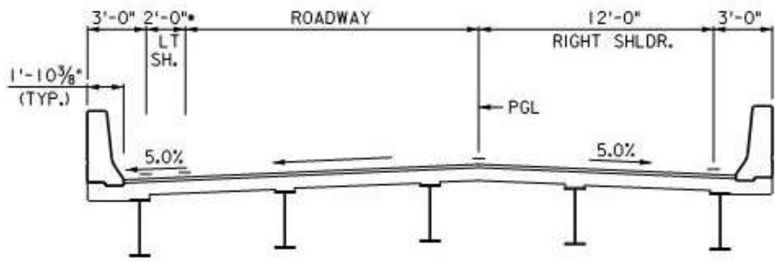
N.T.S.

NOTES:

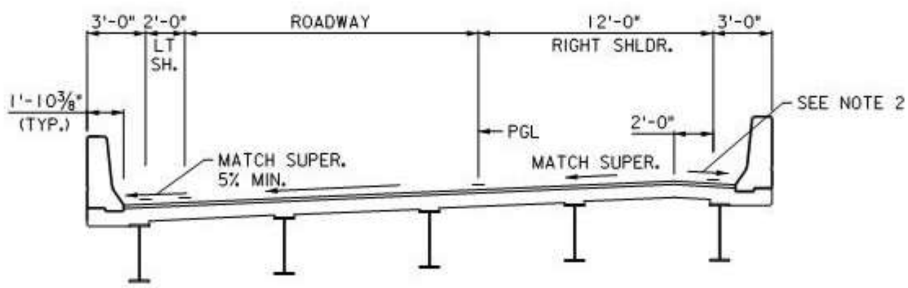
1. FOR ROADWAY WIDTHS AND CROSS SLOPES FOLLOW ROADWAY STANDARDS.
2. FOR SUPERELEVATED ROADWAY CROSS SLOPE LESS THAN OR EQUAL TO 3.0%, SHOULDER CROSS SLOPE = 5.0%.
3. FOR SUPERELEVATED ROADWAY CROSS SLOPE GREATER THAN 3.0% TO 6.0% MAX., SHOULDER CROSS SLOPE SHALL VARY FROM 5% MAX. TO 2.0% MIN.. ROLLOVER SHALL NOT EXCEED 8.0%.
4. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-107 TURNPIKE BRIDGE DECK GEOMETRY RAMPS - 5



SUPER LESS THAN OR EQUAL TO 3.0% CURVE LEFT



SUPER GREATER THAN 3.0% CURVE LEFT

ONE WAY TURNPIKE RAMPS

* WIDEN IF REQUIRED FOR HORIZONTAL SIGHT DISTANCE

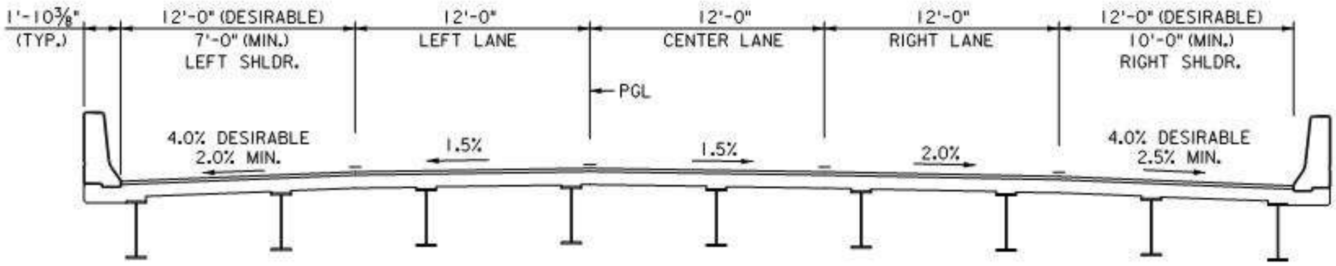
N.T.S.

NOTES:

1. FOR ROADWAY WIDTHS AND CROSS SLOPES FOLLOW ROADWAY STANDARDS.
2. FOR SUPERELEVATED ROADWAY CROSS SLOPE LESS THAN OR EQUAL TO 3.0%, SHOULDER CROSS SLOPE = 5.0%.
3. FOR SUPERELEVATED ROADWAY CROSS SLOPE GREATER THAN 3.0% TO 6.0% MAX., SHOULDER CROSS SLOPE SHALL VARY FROM 5.0% MAX. TO 2.0% MIN. ROLLOVER SHALL NOT EXCEED 8.0%.
4. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-108 PARKWAY BRIDGE DECK GEOMETRY MAINLINE - 1



NORMAL SECTION

THREE LANE PARKWAY ROADWAY

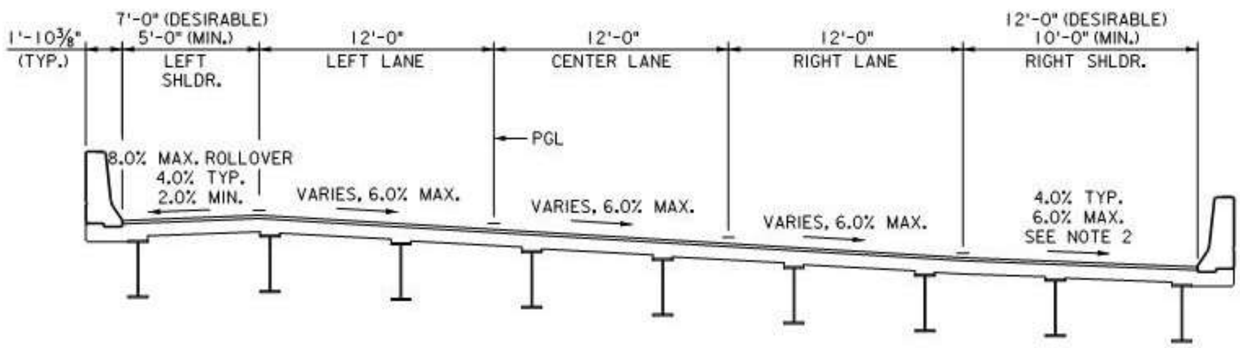
N.T.S.

NOTES:

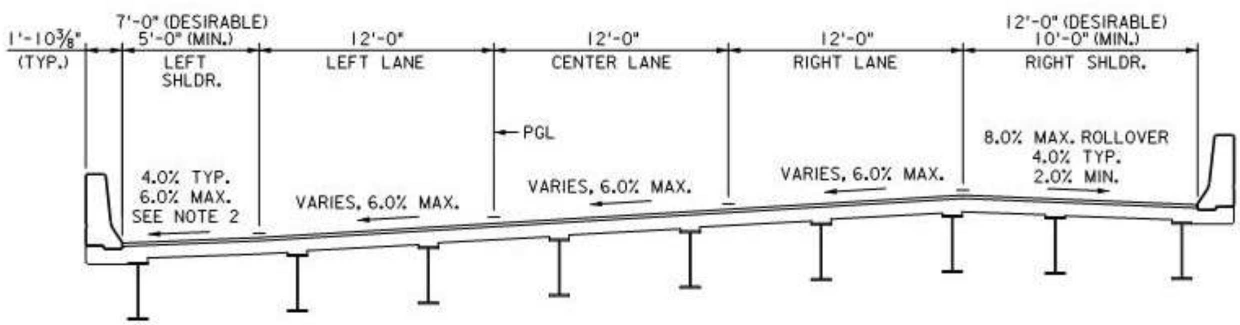
1. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-109 PARKWAY BRIDGE DECK GEOMETRY MAINLINE - 2



SUPERELEVATED - CURVE RIGHT



SUPERELEVATED - CURVE LEFT

THREE LANE PARKWAY ROADWAY

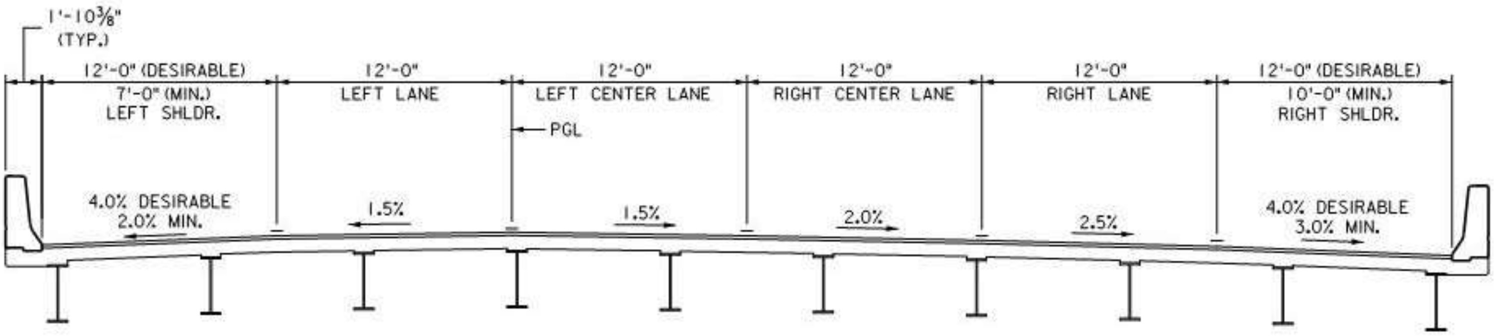
N.T.S.

NOTES:

1. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.
2. SHOULDER CROSS SLOPE SHALL MATCH ROADWAY CROSS SLOPE WHEN ROADWAY CROSS SLOPE EXCEEDS 4.0%.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-110 PARKWAY BRIDGE DECK GEOMETRY MAINLINE - 3



NORMAL SECTION

FOUR LANE PARKWAY ROADWAY

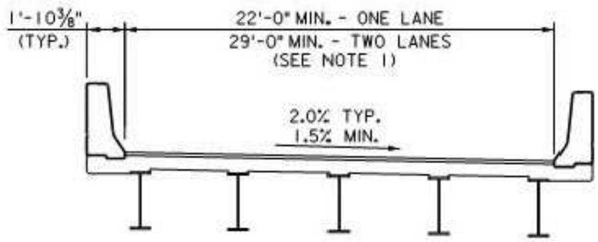
N.T.S.

NOTES:

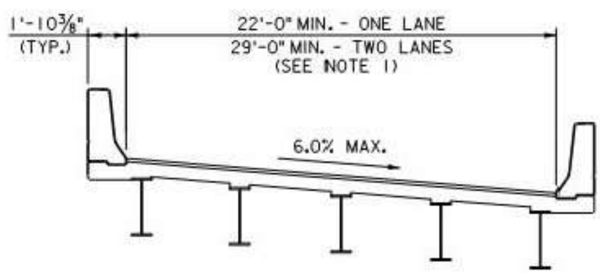
1. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-111 PARKWAY BRIDGE DECK GEOMETRY RAMPS - 1



NORMAL SECTION



CURVE RIGHT
CURVE LEFT SIMILAR

ONE WAY PARKWAY RAMPS

N.T.S.

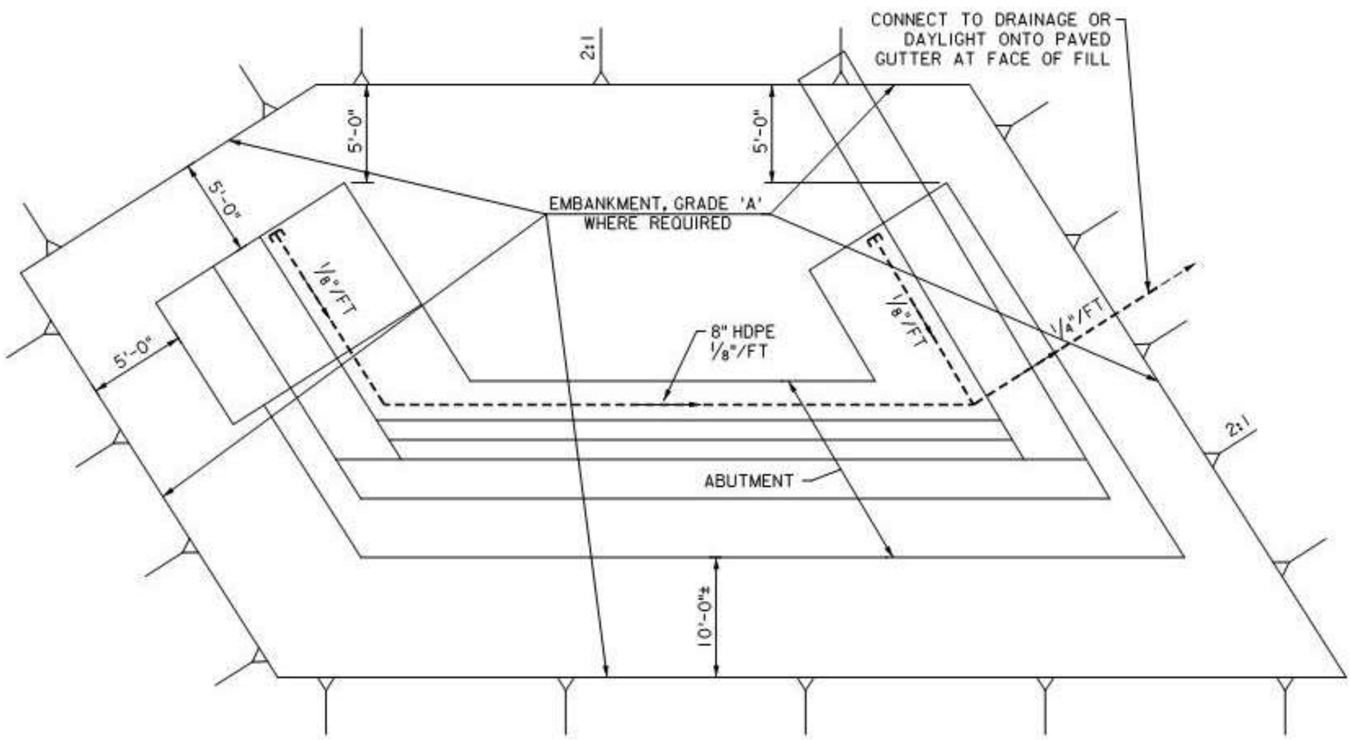
NOTES:

1. FOR ROADWAY WIDTHS, SHOULDER WIDTHS AND CROSS SLOPES FOLLOW ROADWAY STANDARDS.

3. SECTIONS APPLY TO NEW CONSTRUCTION. MODIFICATIONS TO EXISTING STRUCTURES WILL BE REVIEWED ON AN INDIVIDUAL BASIS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-200 SUBSTRUCTURE DETAILS - 1

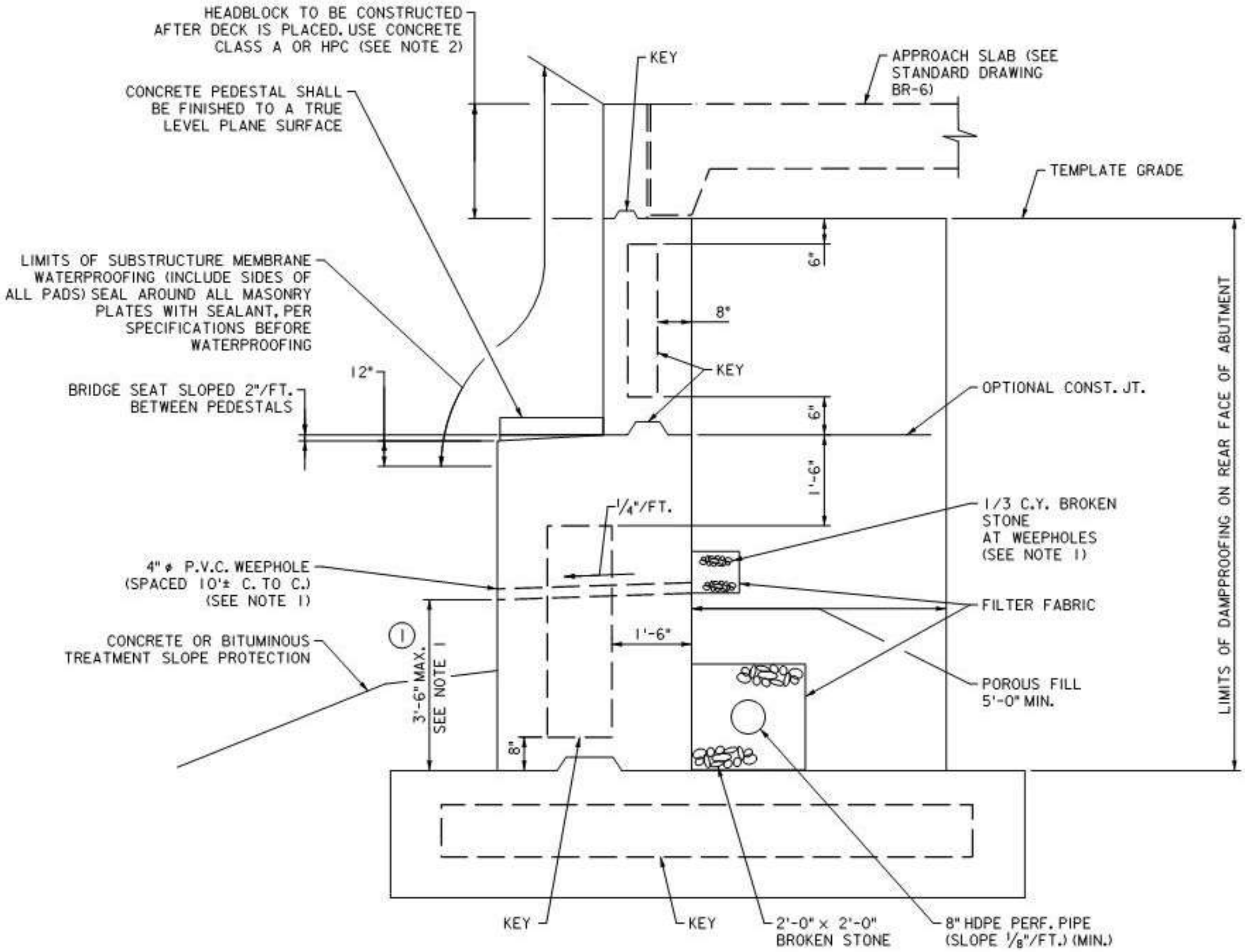


ABUTMENT PLAN

N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-201 SUBSTRUCTURE DETAILS - 2



TYPICAL ABUTMENT SECTION

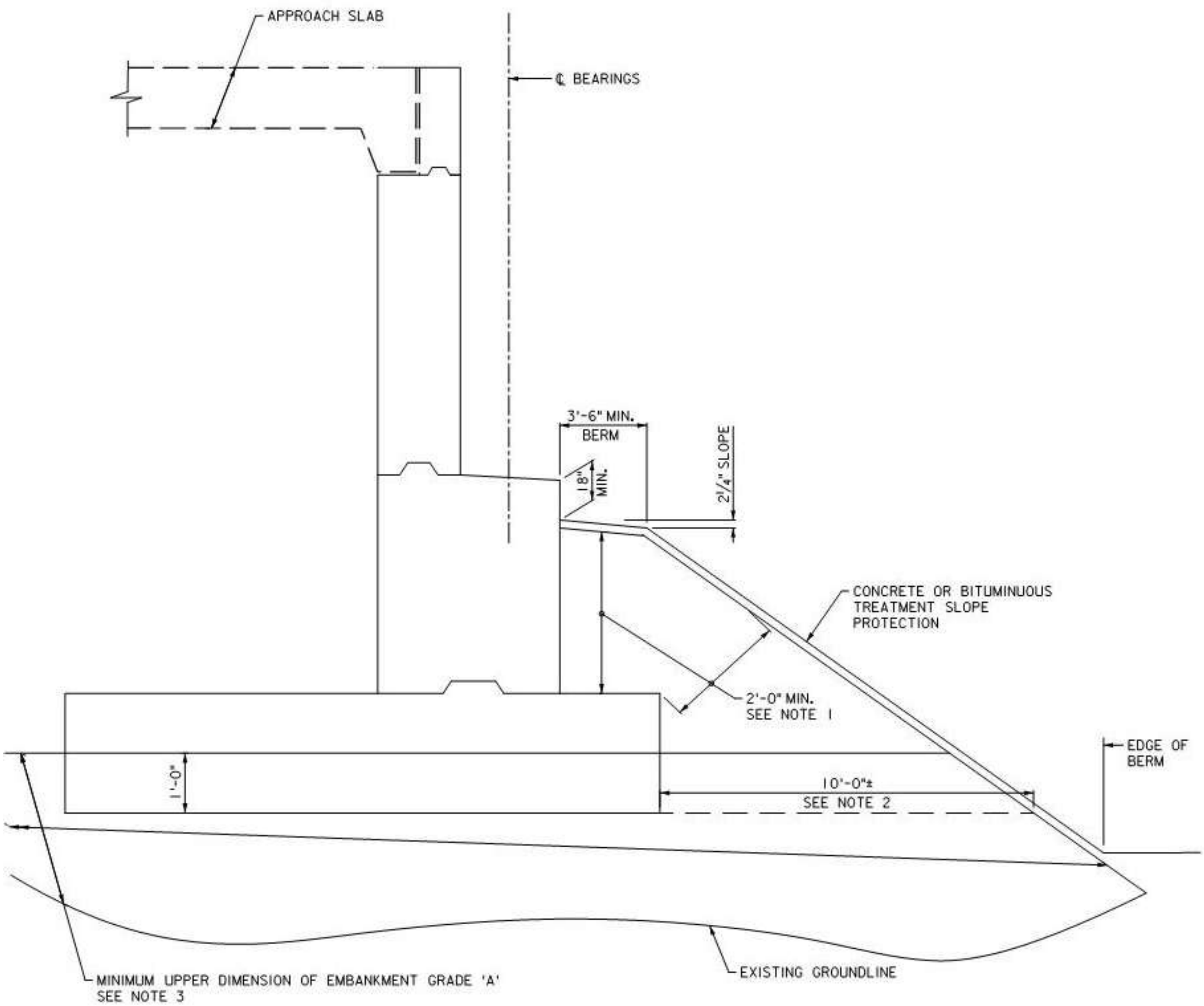
N.T.S.

NOTES:

1. ABUTMENTS AND WALLS WILL NORMALLY BE DRAINED BY WEEPHOLES AND 8" HDPE PIPE, AS SHOWN. THE WEEPHOLES SHOULD NOT BE USED WHERE THEY DRAIN ONTO A SIDEWALK OR ROADWAY, OR WHERE THEY MUST BE PLACED MORE THAN 3'-6" ABOVE THE TOP OF FOOTING.
2. HEADBLOCK SHALL BE HPC WHEN DECK IS CONSTRUCTED OF HPC.
3. PILES NOT SHOWN FOR CLARITY.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-202 SUBSTRUCTURE DETAILS - 3



ABUTMENT IN FILL ON SPECIAL SUBGRADE MATERIAL

ABUTMENT DETAILS

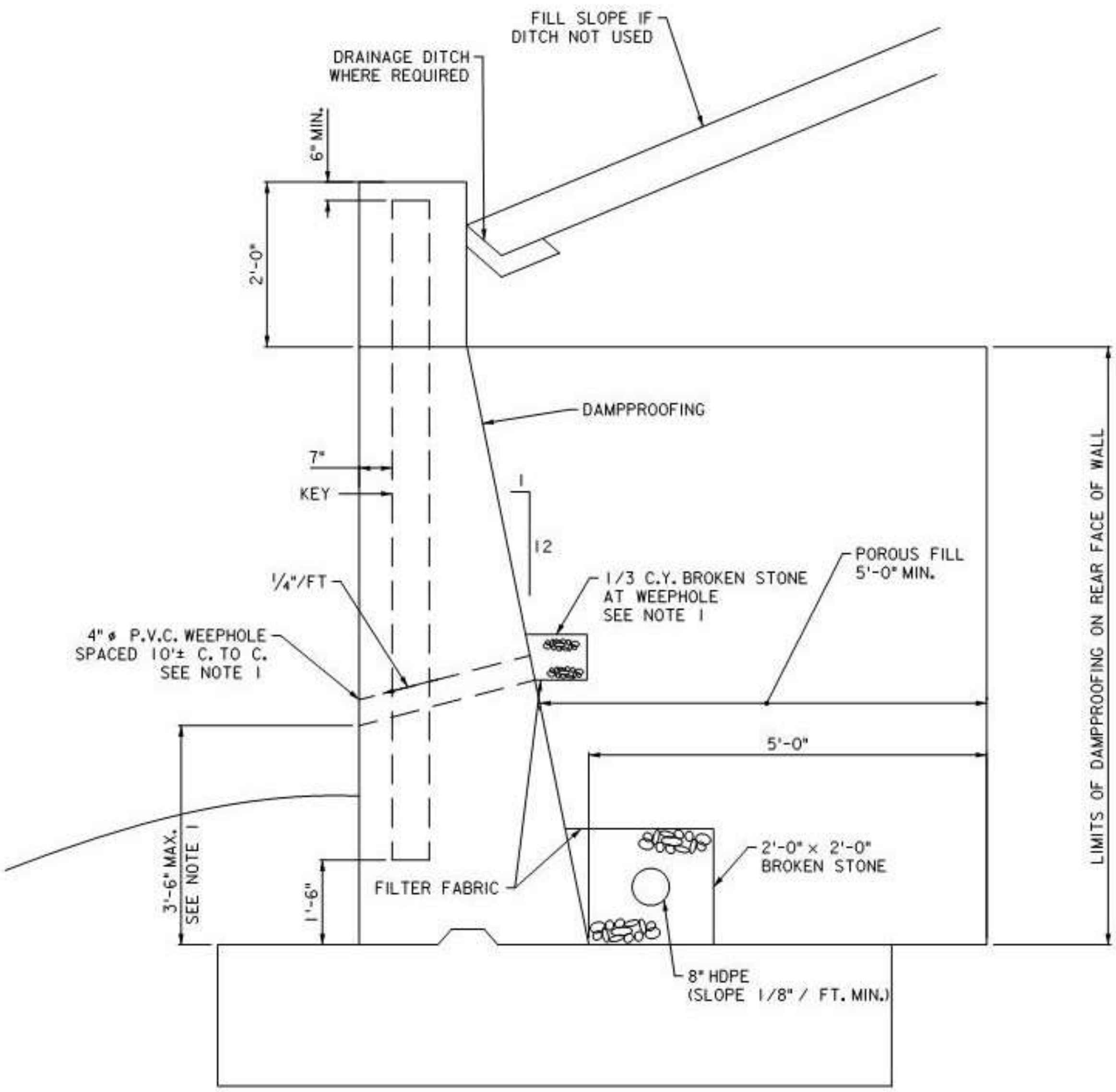
N.T.S.

NOTES:

1. MAINTAIN 2'-0" MIN. COVER TO ALL FOOTINGS. INCREASE BERM WIDTH, OR LOWER FOOTING IF NECESSARY.
2. FOR SOIL BEARING ABUTMENTS MAINTAIN 10FT ±. INCREASE BERM WIDTH, OR LOWER FOOTINGS IF NECESSARY.
3. PLACE COMMON EMBANKMENT IN FILL AREAS UNDER PILE SUPPORTED ABUTMENTS.
4. PILES NOT SHOWN FOR CLARITY.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-203 SUBSTRUCTURE DETAILS - 4



WINGWALL OR RETAINING WALL SECTION WITHOUT PARAPET

WALL DETAILS

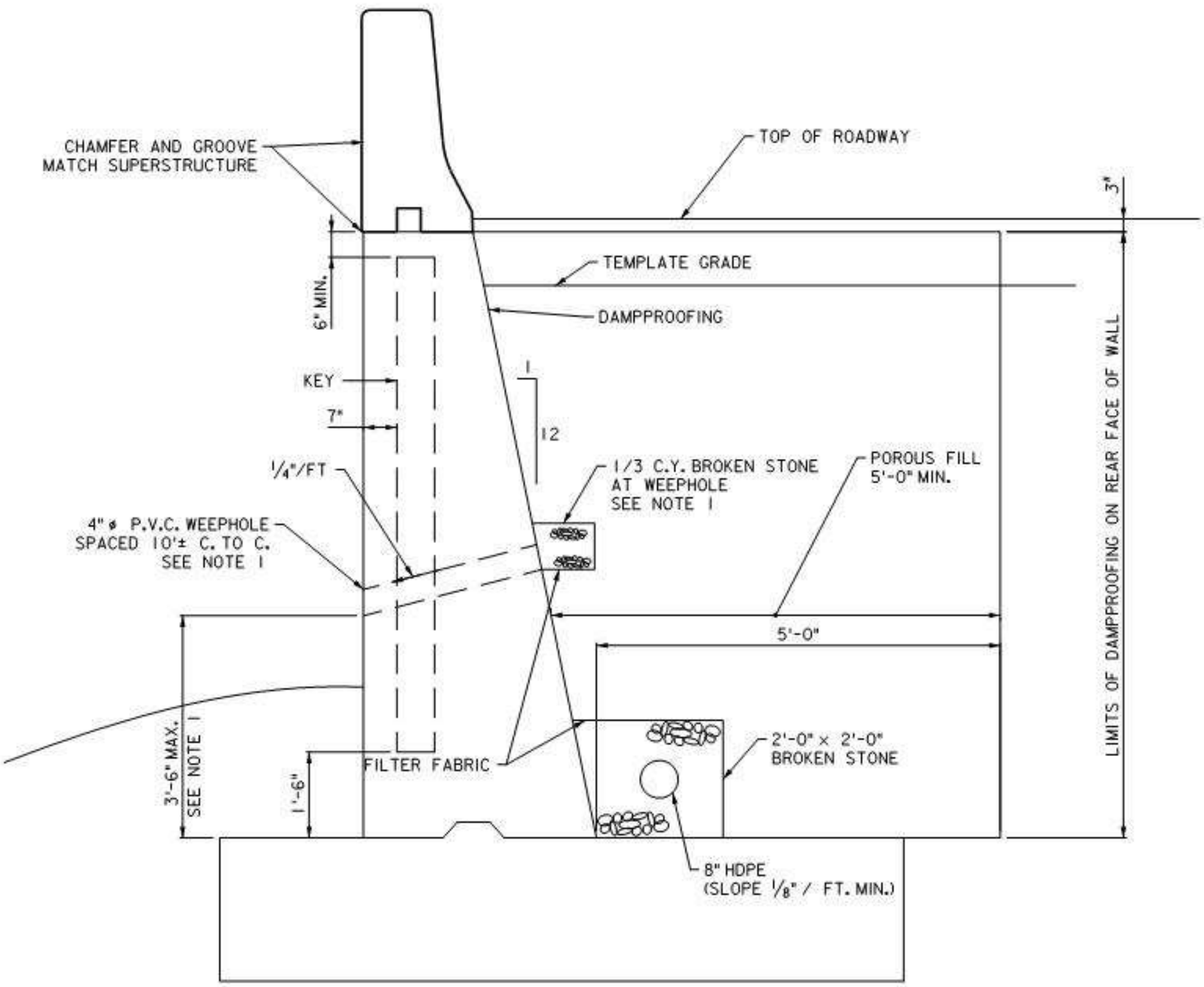
N.T.S.

NOTES:

1. ABUTMENTS AND WALLS WILL NORMALLY BE DRAINED BY WEEPHOLES AND 8" HDPE AS SHOWN. THE WEEPHOLES SHOULD NOT BE USED WHERE THEY DRAIN ONTO A SIDEWALK OR ROADWAY, OR WHERE THEY MUST BE PLACED MORE THAN 3'-6" ABOVE THE TOP OF FOOTING.
2. SEE PLATE EXHIBIT 2-202 FOR ADDITIONAL DETAILS.
3. PILES NOT SHOWN FOR CLARITY.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-204 SUBSTRUCTURE DETAILS - 5



WINGWALL OR RETAINING WALL SECTION WITH A PARAPET

WALL DETAILS

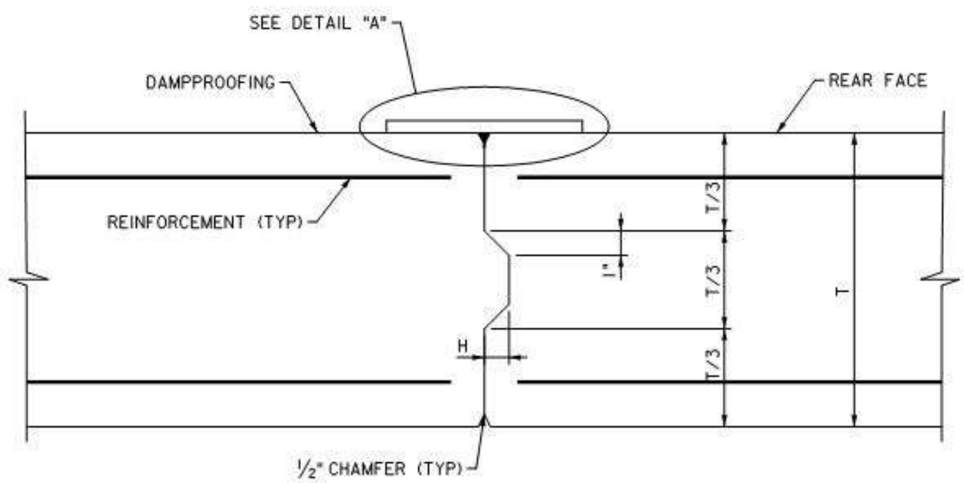
N.T.S.

NOTES:

1. ABUTMENTS AND WALLS WILL NORMALLY BE DRAINED BY WEEPHOLES AND 8" HDPE AS SHOWN. THE WEEPHOLES SHOULD NOT BE USED WHERE THEY DRAIN ONTO A SIDEWALK OR ROADWAY, OR WHERE THEY MUST BE PLACED MORE THAN 3'-6" ABOVE THE TOP OF FOOTING.
2. PILES NOT SHOWN FOR CLARITY.
3. SEE EXHIBIT 2-202 FOR ADDITIONAL DETAILS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-205 SUBSTRUCTURE DETAILS - 6



CONSTRUCTION JOINT

JOINT AND KEY DETAILS

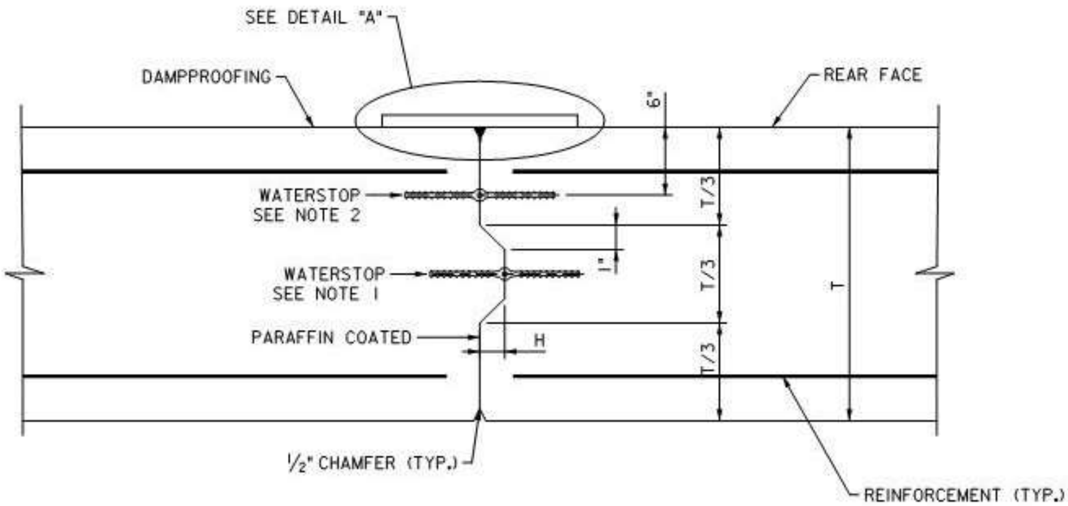
N.T.S.

NOTES:

1. H=2" FOR JOINTS BELOW HEADBLOCK AND 3" FOR ALL OTHER JOINTS.
2. FOR DETAIL A, SEE EXHIBIT 2-209.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-206 SUBSTRUCTURE DETAILS - 7



CONTRACTION JOINT

JOINT AND KEY DETAILS

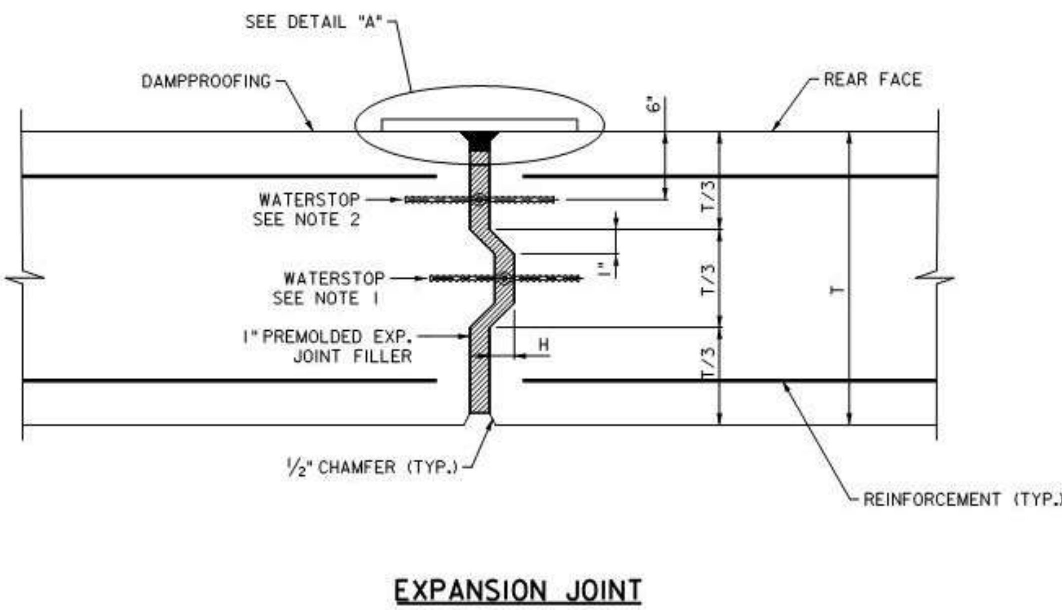
N.T.S.

NOTES:

1. PLACEMENT OF WATERSTOP IN BOX CULVERTS, TOLL PLAZA TUNNELS AND WALL LESS THAN 2'-0" WIDE.
2. PLACEMENT OF WATERSTOP IN ABUTMENTS AND BATTERED RETAINING WALLS.
3. REINFORCEMENT IS DISCONTINUOUS AT CONTRACTION AND EXPANSION JOINTS.
4. CONTRACTION JOINTS SHALL BE TIGHT AND SHALL BE PARAFFIN COATED.
5. H=2" FOR JOINTS BELOW HEADBLOCK AND 3" FOR ALL OTHER JOINTS.
6. FOR DETAIL A, SEE EXHIBIT 2-209.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-207 SUBSTRUCTURE DETAILS - 8



JOINT AND KEY DETAILS

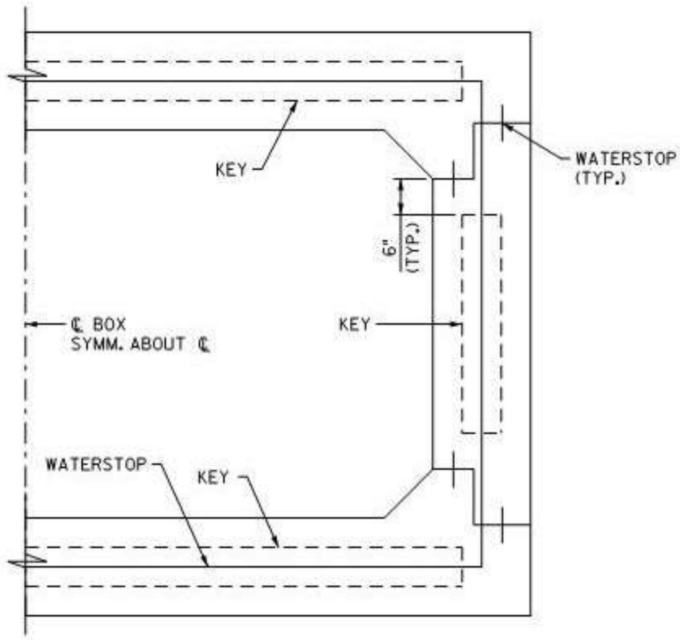
N.T.S.

NOTES:

1. PLACEMENT OF WATERSTOP IN BOX CULVERTS, TOLL PLAZA TUNNELS AND WALL LESS THAN 2'-0" WIDE.
2. PLACEMENT OF WATERSTOP IN ABUTMENTS AND BATTERED RETAINING WALLS.
3. REINFORCEMENT IS DISCONTINUOUS AT CONTRACTION AND EXPANSION JOINTS.
4. H=2" FOR JOINTS BELOW HEADBLOCK AND 3" FOR ALL OTHER JOINTS.
5. FOR DETAIL A, SEE EXHIBIT 2-209.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-208 SUBSTRUCTURE DETAILS - 9



BOX CULVERT OR TUNNEL

JOINT AND KEY DETAILS

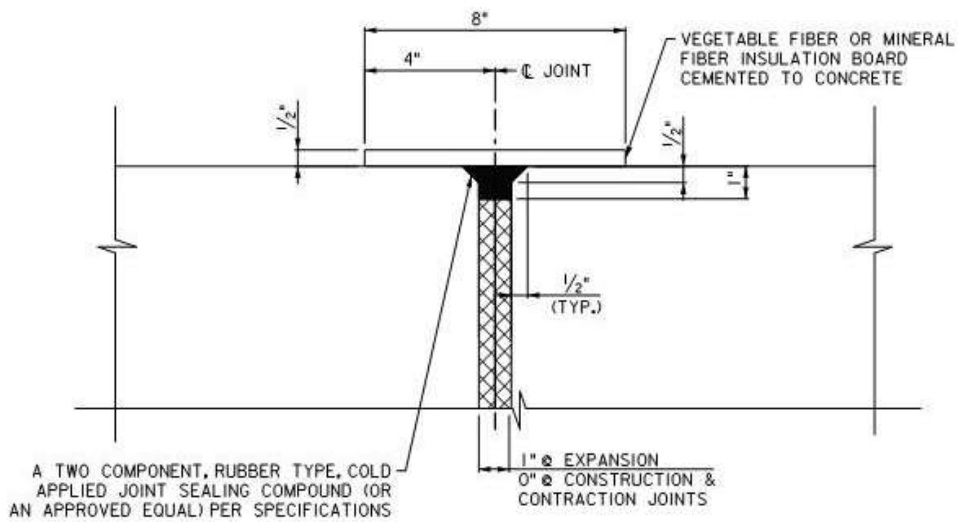
N.T.S.

NOTES:

1. WATERSTOPS SHALL BE CONTINUOUS PLASTIC WATERSTOPS, WITHOUT SPLICES, ALONG THE BOTTOM HALF OF CULVERTS OR TUNNELS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-209 SUBSTRUCTURE DETAILS - 10



DETAIL A

JOINT AND KEY DETAILS

N.T.S.

NOTES:

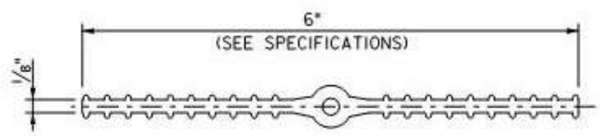
1. FOR LOCATION OF DETAIL A, SEE EXHIBITS 2-205, 2-206 AND 2-207.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-210 SUBSTRUCTURE DETAILS - 11

EXPANSION CONTRACTION

16 OZ. COPPER WATERSTOP - 10" WIDE



JOINT AND KEY DETAILS

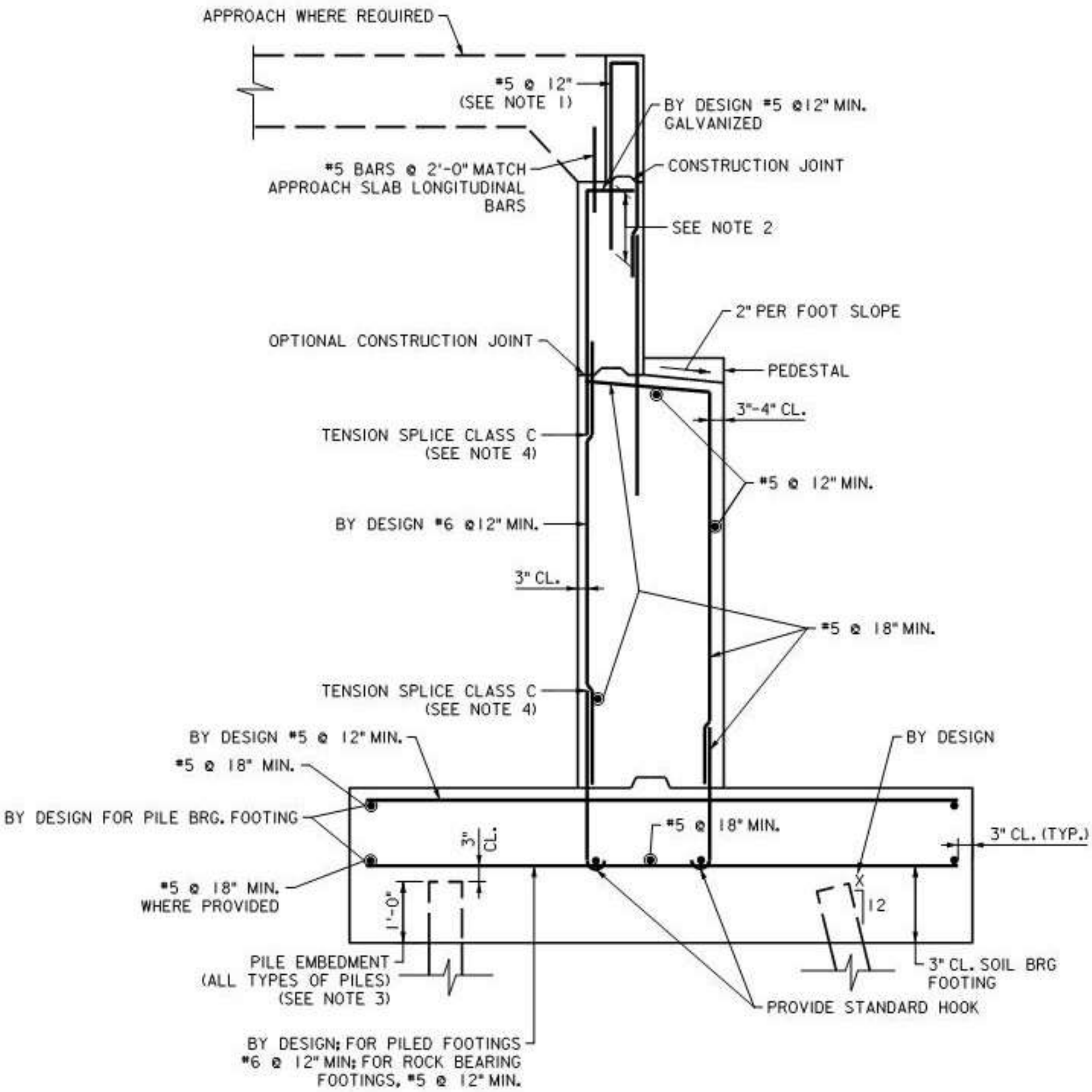
N.T.S.

NOTES:

1. WATERSTOP SHALL BE EITHER 6" PLASTIC, OR 16 OZ. COPPER (10" LONG), AS DIRECTED BY THE ENGINEER.
2. WHEREVER PRACTICABLE, WATERSTOP SHALL BE ONE CONTINUOUS LENGTH.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-211 SUBSTRUCTURE DETAILS - 12



ABUTMENT REINFORCEMENT DETAIL (WALL REINFORCEMENT SIMILAR)

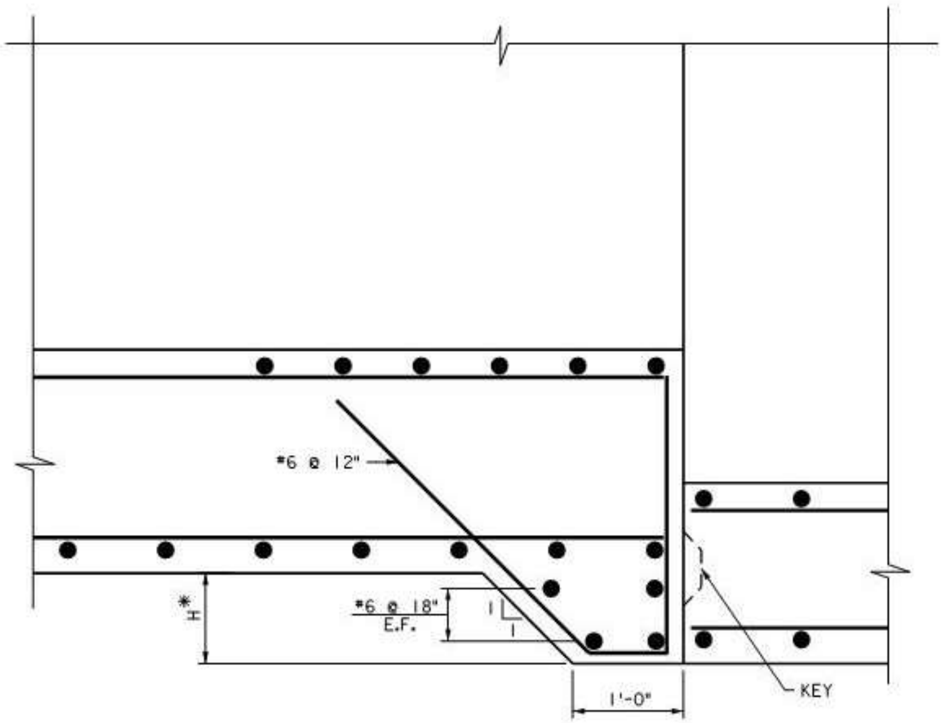
N.T.S.

NOTES:

1. ALL REINFORCEMENT IN HEADBLOCK SHALL BE GALVANIZED.
2. ALL BARS EXTENDING FROM HEADBLOCK INTO ABUTMENT STEM SHALL BE CONSIDERED TENSION SPLICES. REFER TO CURRENT AASHTO FOR REQUIREMENTS.
3. WHEN REQUIRED BY DESIGN THE PILES SHALL BE DESIGNED AND DETAILED TO RESIST UPLIFT.
4. FOR SPLICE CRITERIA REFER TO CURRENT AASHTO REQUIREMENTS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-212 SUBSTRUCTURE DETAILS - 13



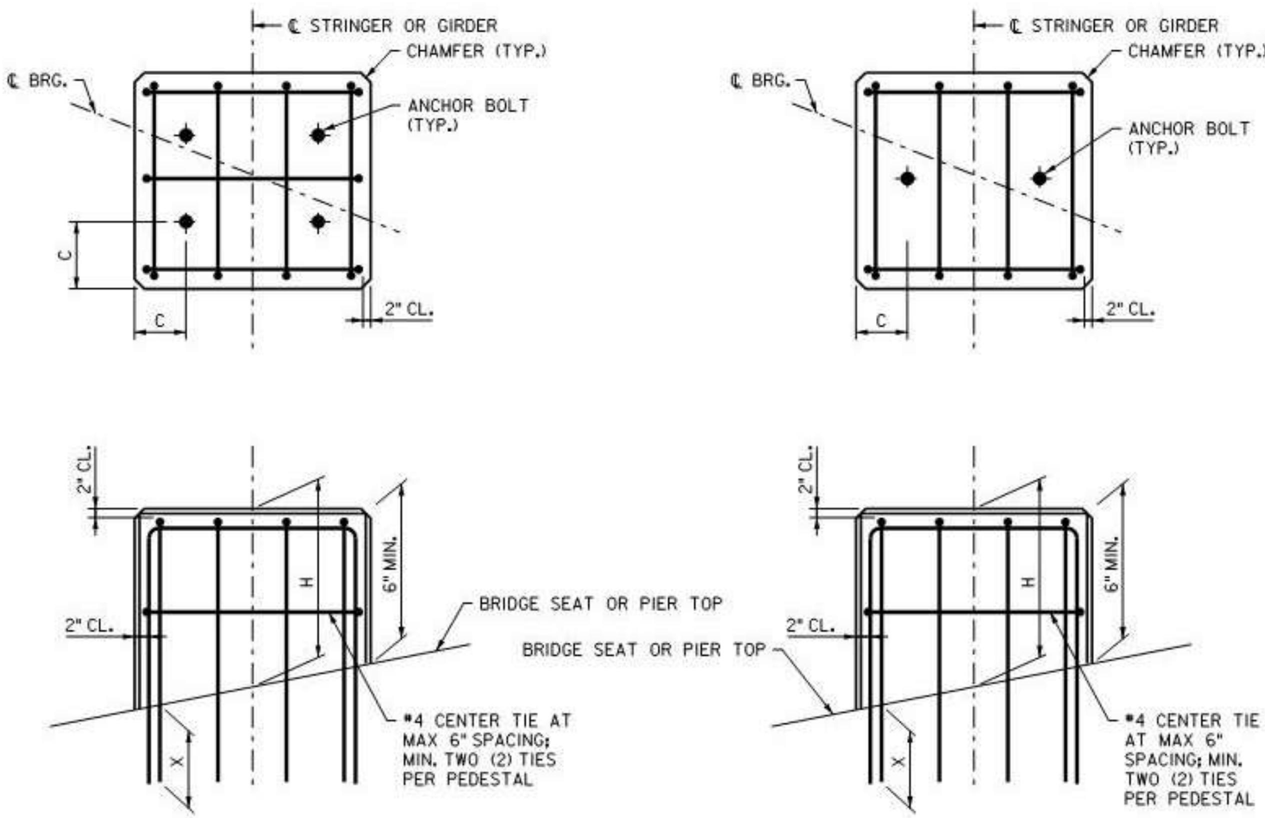
FOOTING HAUNCH DETAIL

N.T.S.

* REINFORCEMENT TO BE PROVIDED WHEN "H" GREATER THAN OR EQUAL TO 2'-0". "H" SHALL NOT BE GREATER THAN DEPTH OF THE FOOTING; EXCEPT THAT WHEN THE FOOTING IS ON PILES, "H" MAY BE TWICE THE DEPTH OF THE FOOTING.

NEW JERSEY TURNPIKE AUTHORITY
DESIGN MANUAL

EXHIBIT 3-213 SUBSTRUCTURE DETAILS - 14



FOUR ANCHOR BOLTS   TWO ANCHOR BOLTS

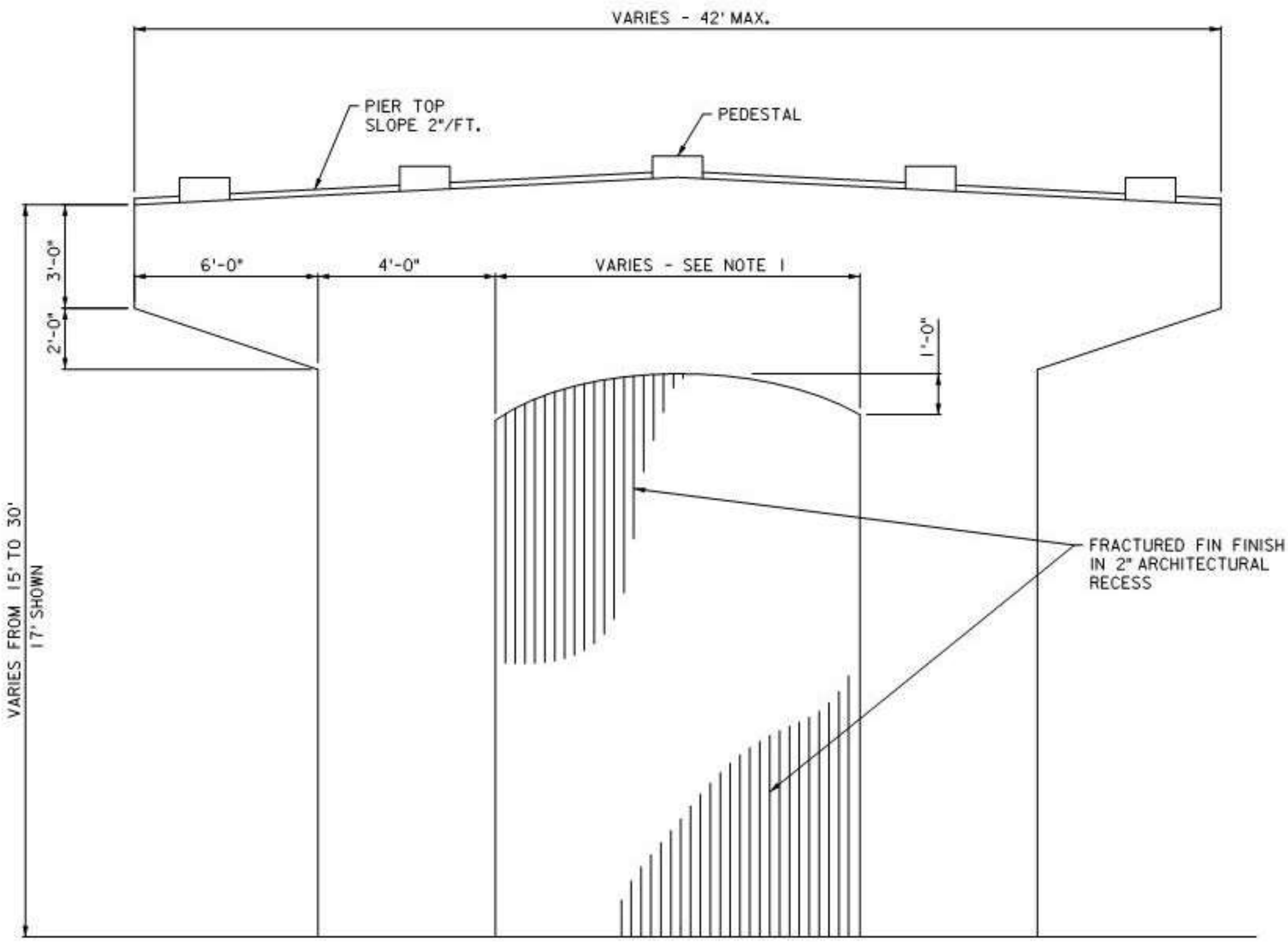
FOR H GREATER THAN 16", PEDESTALS SHALL BE DESIGNED AS COLUMNS.

H	C	BAR SIZE	X
TO 8"	5"	#4	12"
TO 12"	5"	#5	15"
TO 16"	6"	#5	15"

PEDESTAL REINFORCEMENT DETAILS
PIERS AND ABUTMENTS
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-214 SUBSTRUCTURE DETAILS - 15



TURNPIKE TYPICAL 'NARROW' PIER DETAIL GUIDELINES

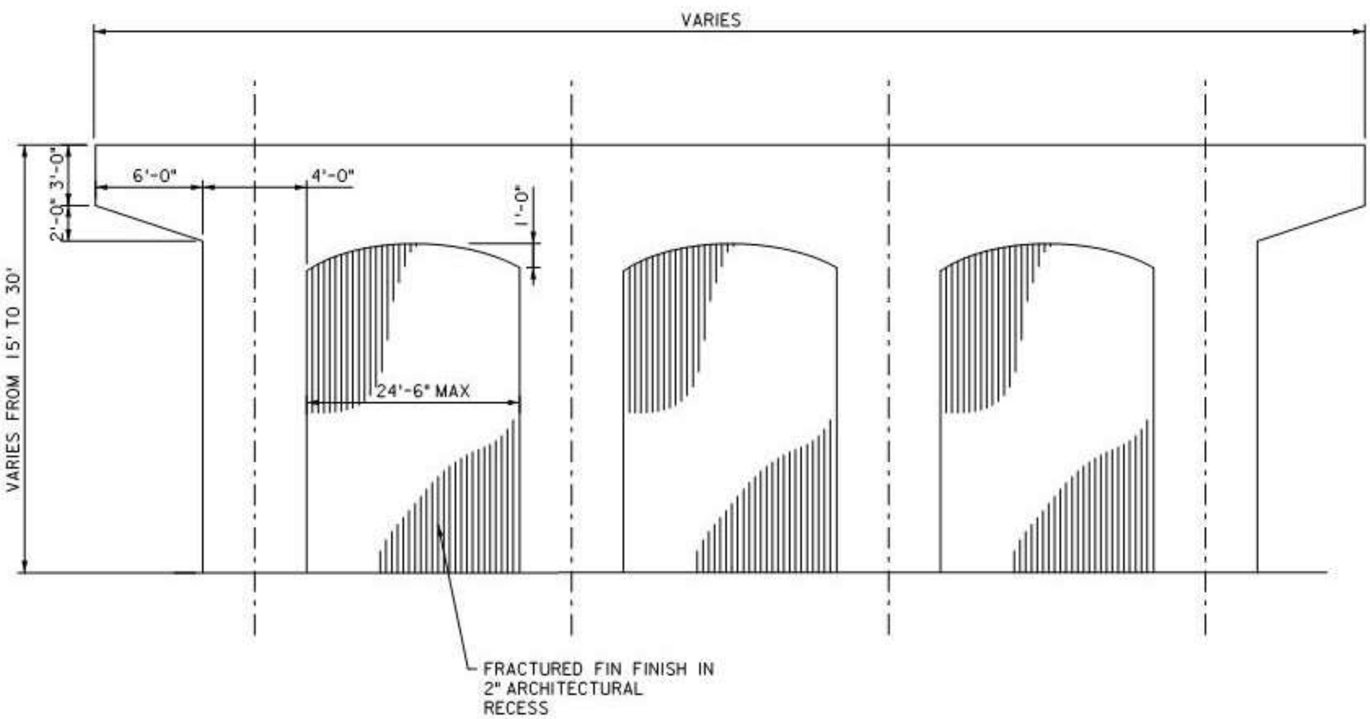
N.T.S.

NOTES:

1. WIDTH OF RECESS MAY VARY FROM 8'-22'. IF LESS THAN 8', OMIT RECESS.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-215 SUBSTRUCTURE DETAILS - 16

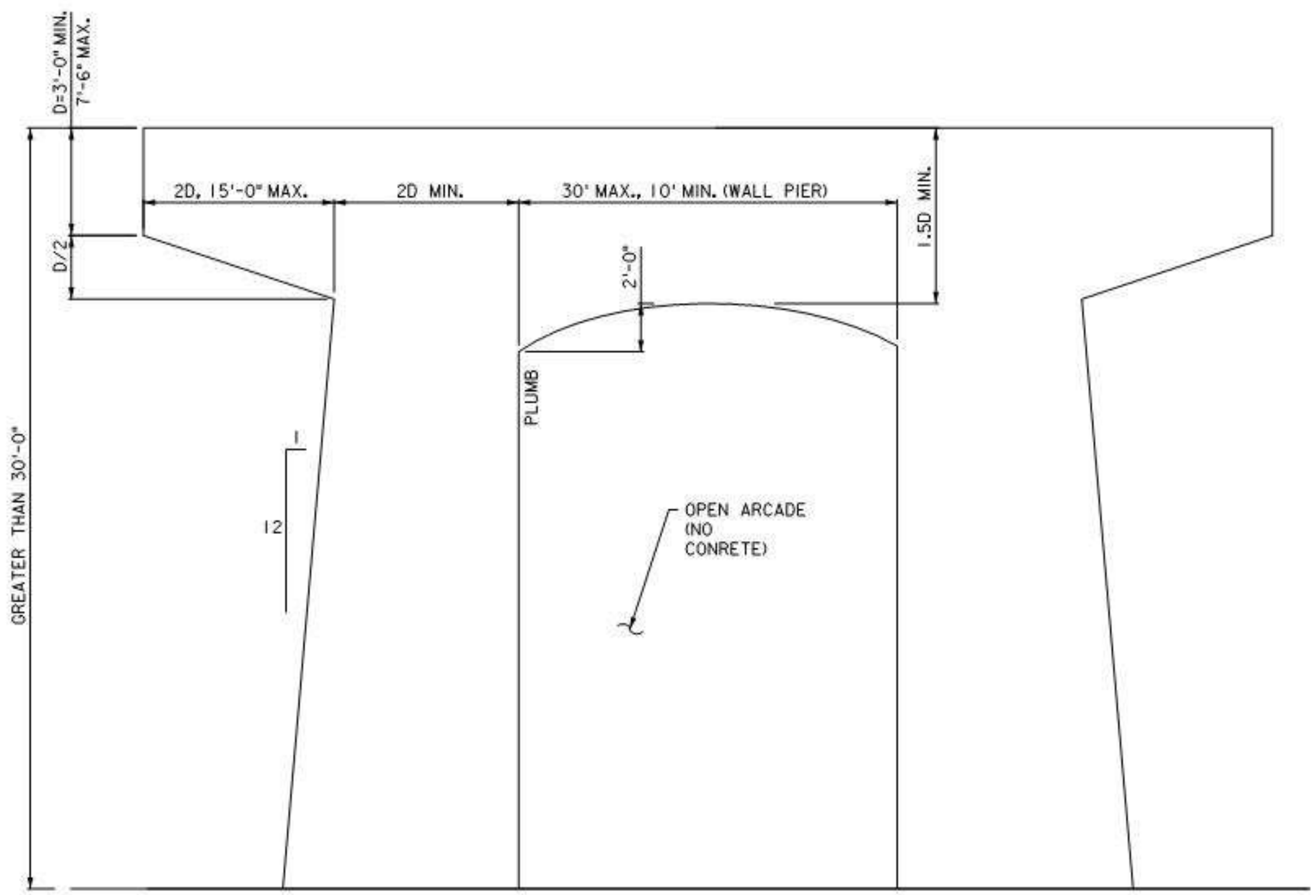


TURNPIKE TYPICAL 'WIDE' PIER DETAIL GUIDELINES

N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-216 SUBSTRUCTURE DETAILS - 17



TYPICAL MAJOR BRIDGE PIER

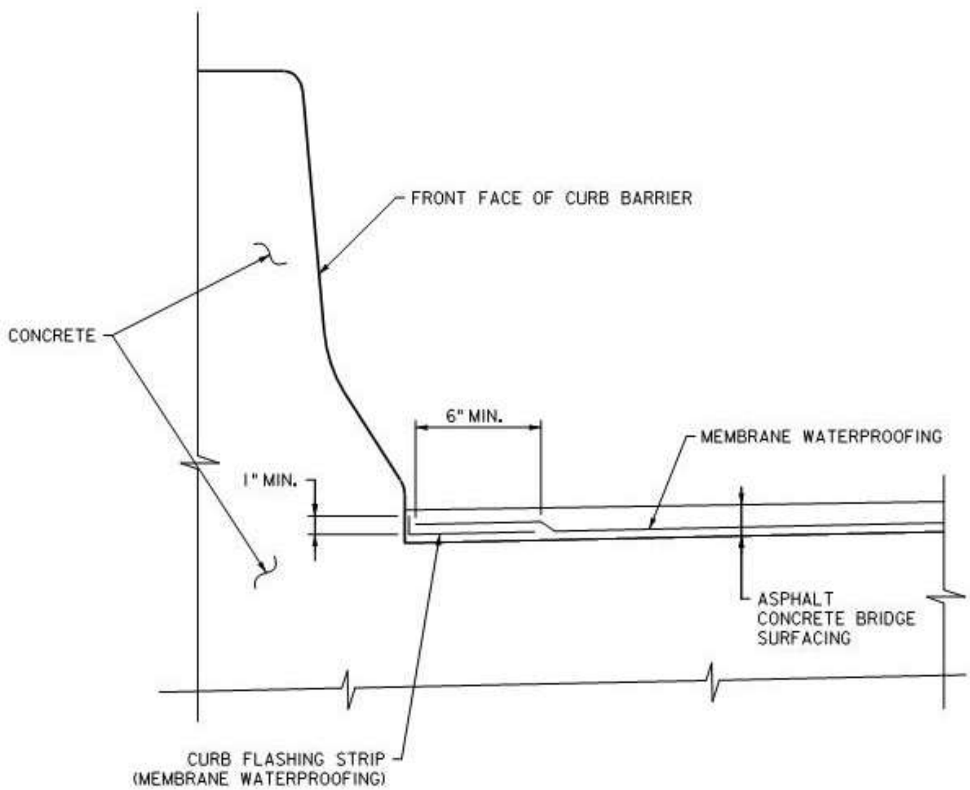
N.T.S.

NOTES:

1. THIS OPTION REQUIRES PRIOR APPROVAL FROM NJTA.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-300 DECK DETAILS - 1

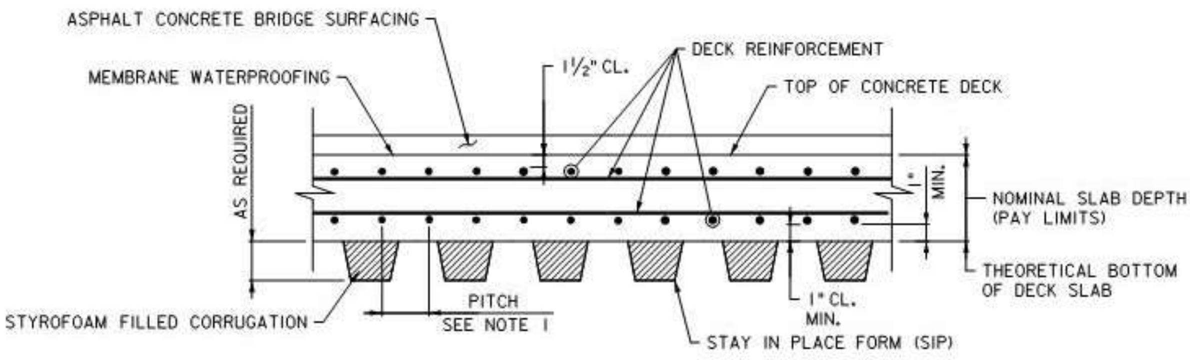


MEMBRANE WATERPROOFING DETAIL AT CURB

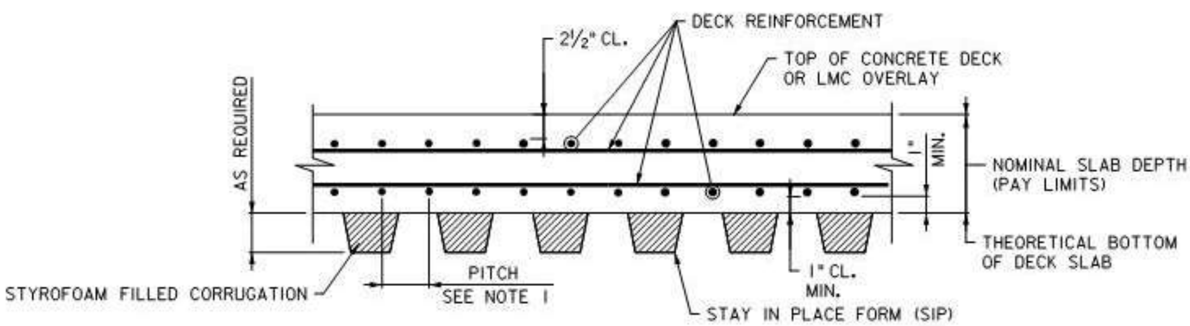
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-301 DECK DETAILS - 2



LONGITUDINAL SECTION
(ASPHALT SURFACED DECKS)



LONGITUDINAL SECTION
(BARE DECKS AND LMC OVERLAYED DECKS)

FORM AND REINFORCEMENT DETAILS

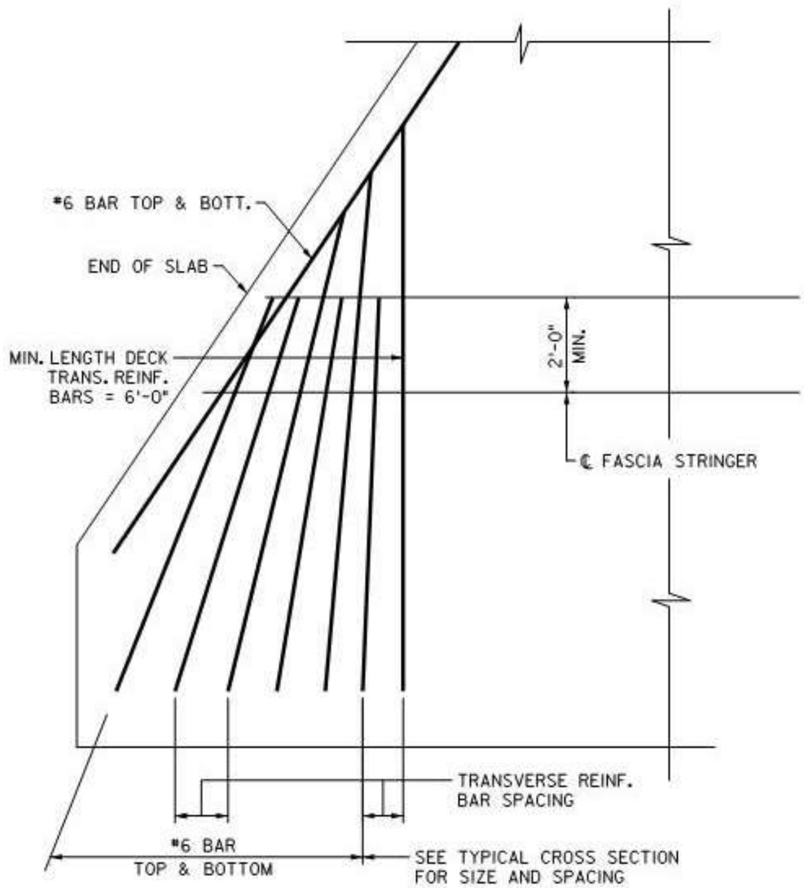
N.T.S.

NOTES:

1. SIP CORRUGATION PITCH NEED NOT MATCH REINFORCEMENT PITCH.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-302 DECK DETAILS - 3

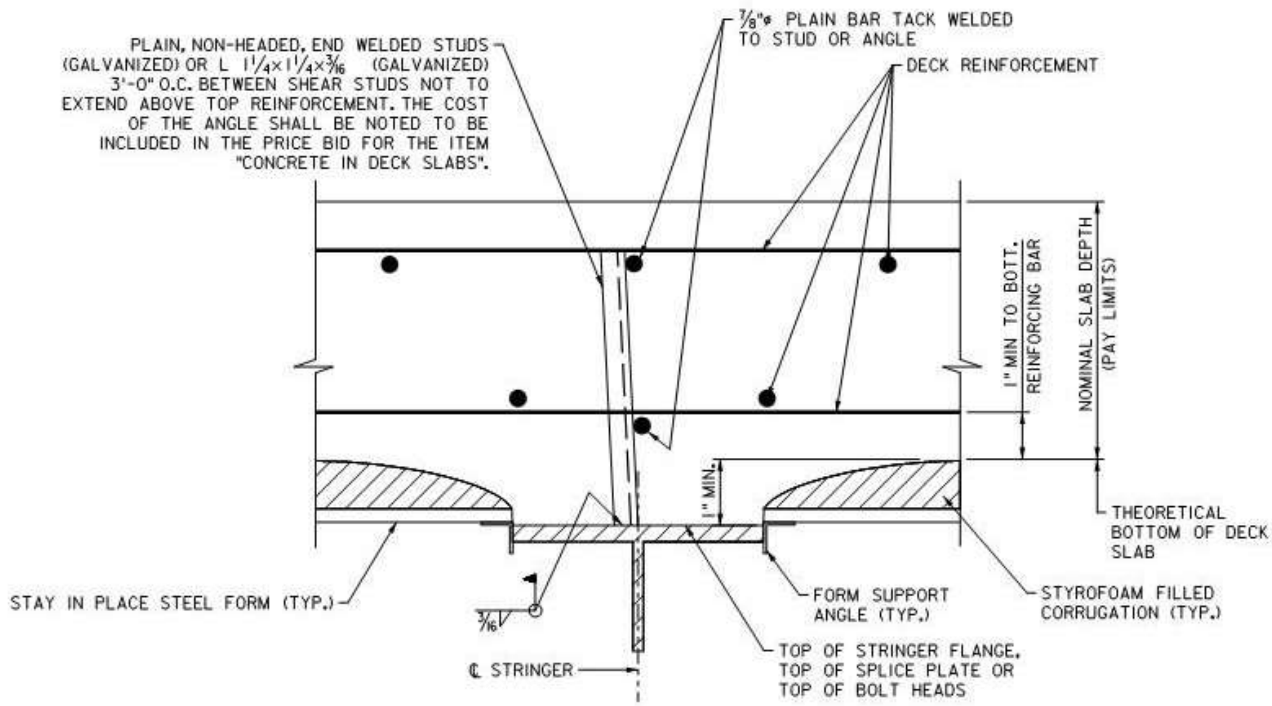


REINFORCEMENT IN CORNERS OF SKEWED SLABS

N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-303 DECK DETAILS - 4



TRANSVERSE SECTION
COMPRESSION FLANGES SHOWN
TENSION FLANGES SIMILAR (SEE BELOW)

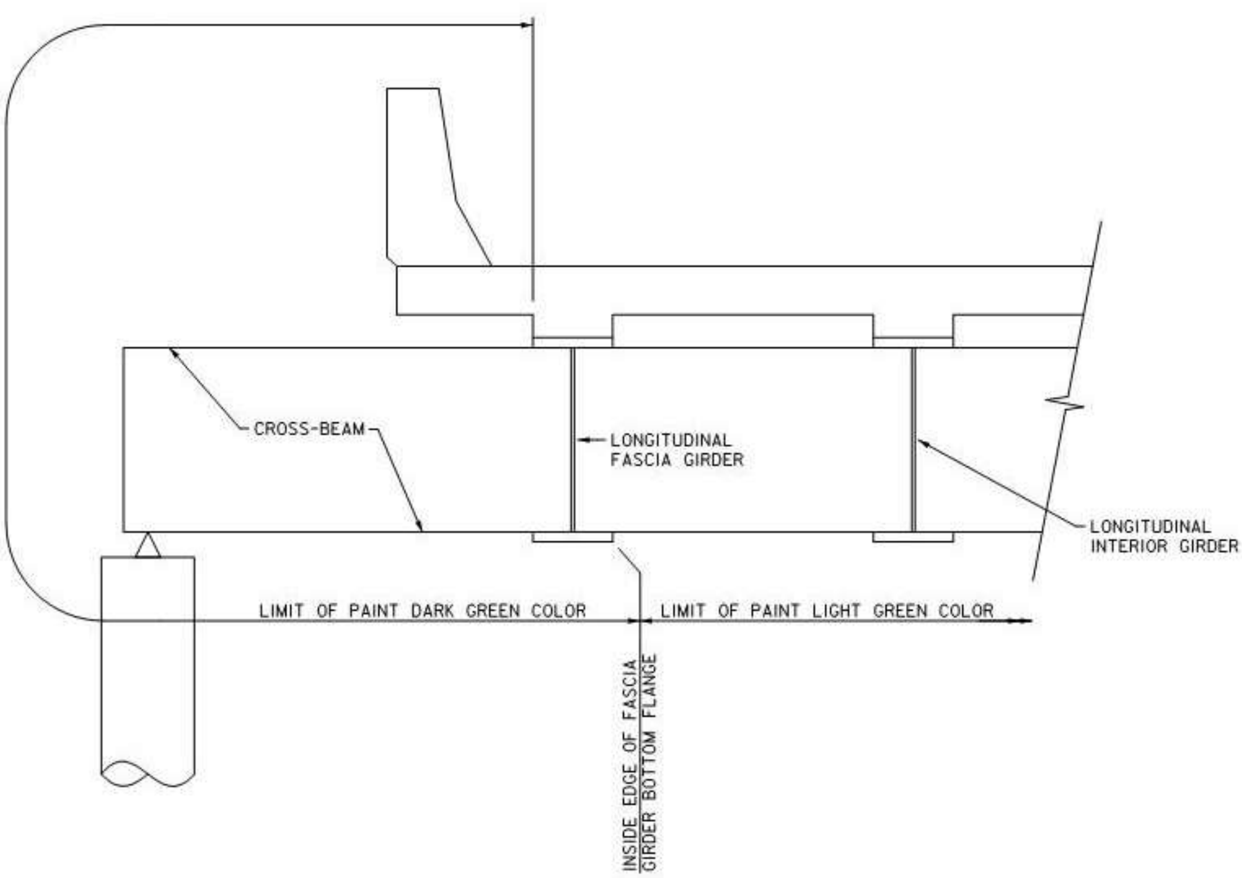
FORM AND REINFORCEMENT DETAILS
N.T.S.

NOTES:

1. FOR BEAMS WITH TENSION IN THE TOP FLANGE, REINFORCEMENT SUPPORT SHALL NOT BE WELDED DIRECTLY TO THE TOP FLANGE. CONTRACT PLANS SHALL INCLUDE NON WELDED CONNECTION DETAILS.

NEW JERSEY TURNPIKE AUTHORITY
DESIGN MANUAL

EXHIBIT 3-304 SUPERSTRUCTURE DETAILS- 1



GARDEN STATE PARKWAY BRIDGES
PAINT COLOR SCHEMATIC
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-400 OVERHEAD SIGN STRUCTURE NOTES

OVERHEAD SIGN STRUCTURE NOTES (FOR PLACEMENT):

A. ON SPAN STRUCTURES WHERE "LANE ENDS" SIGN IS USED, "LANE END" SIGN TO BE CENTERED OVER THE LANE TO BE DROPPED, EXIT DIRECTION SIGN TO BE OVER THE DECEL. LANE OR SHIFTED RIGHT TO OBTAIN 6" MIN. BETWEEN SIGNS IF NECESSARY, THE THREE LANE DESIGNATION SIGN IS TO BE CENTERED OVER THE REMAINING LEFT LANES OR SHIFTED LEFT TO OBTAIN THE 6" MIN. BETWEEN SIGNS, IF NECESSARY.

B. ON OTHER SPAN STRUCTURES, EXIT DIRECTION SIGN TO BE CENTERED OVER RIGHT LANE AND DECEL LANE; THE THRU LANE DESIGNATION SIGN IS TO BE CENTERED OVER THE REMAINING LEFT LANES OR SHIFTED LEFT LANES TO OBTAIN THE 6" MIN. BETWEEN SIGNS, IF NECESSARY.

C. SIGN PANELS FOR STRUCTURES WITH LIGHTING ARE TO BE CENTERED VERTICALLY BETWEEN CHORDS UNLESS OTHERWISE NOTED.

D. LIGHTING FIXTURE SPACING DIMENSIONS "A" AND "B" SHALL BE AS FOLLOWS:

DIM. "A" - 6 FEET NOMINAL, 5 FEET MIN., 6'-6" MAX..
DIM. "B" - 59/64 (W-XA) WHERE "X" IS ONE LESS THAN THE NUMBER OF FIXTURES AND "W" IS THE WIDTH OF SIGN PANEL.

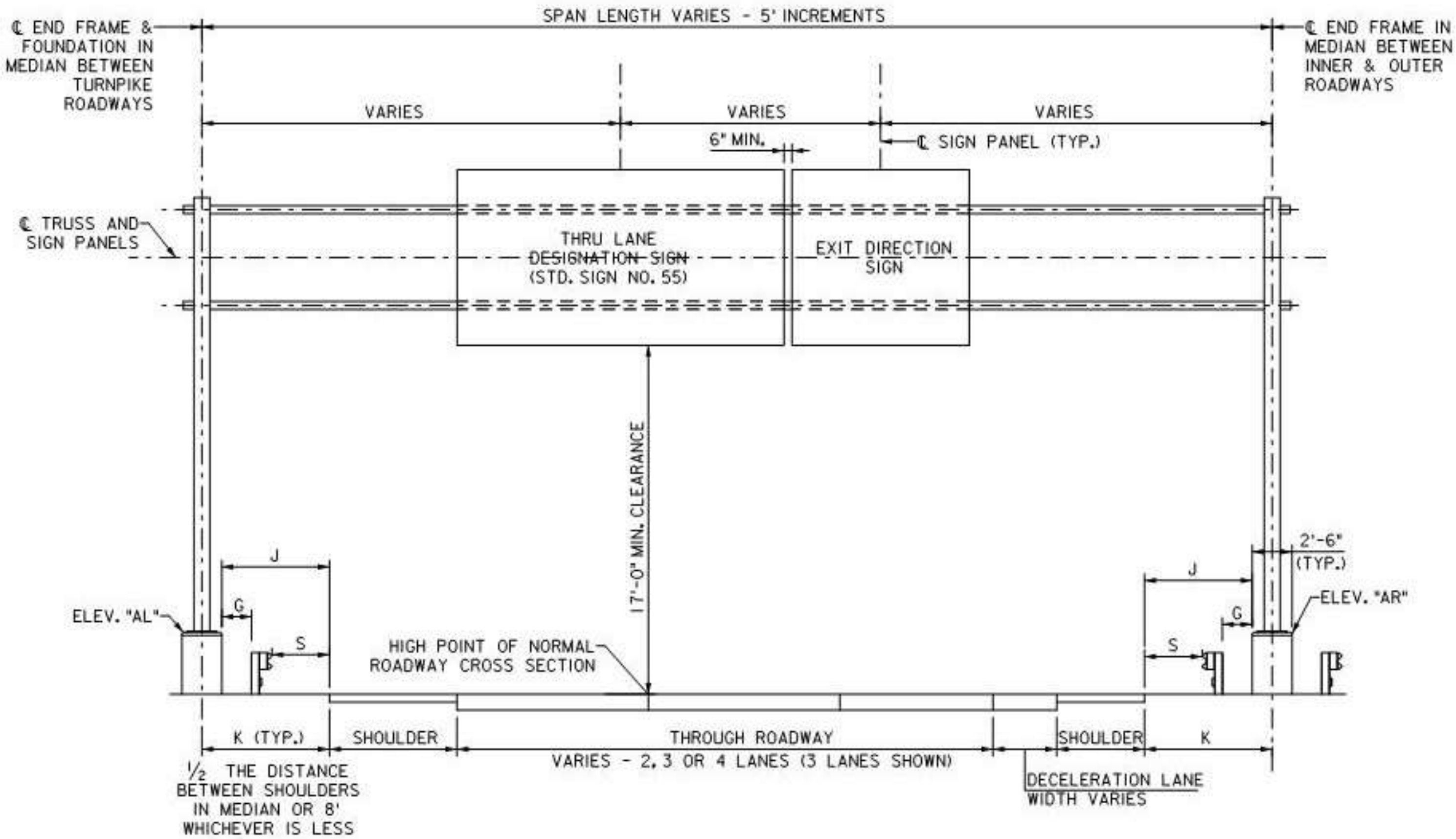
E. ELEV. "A" IS TO BE 4'-0" MIN. ABOVE THE HIGH POINT OF THE TURNPIKE/PARKWAY ROADWAYS, ELEV. "AR" AND "AL" ARE TO BE THE SAME.

F. SIGN ELEVATIONS WILL ALWAYS BE TAKEN IN THE DIRECTION OF THE DRIVER. RIGHT AND LEFT END FRAMES WILL BE REFERRED TO IN THIS MANNER.

G. NORMAL DIMENSIONS FROM FACE OF GUIDE RAIL TO BACK OF POST IS 1'-3".

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-401 TURNPIKE OVERHEAD SIGN STRUCTURES - 1



	WHEN K=4'-6"	WHEN K=8'-0"
G	1'-10"	3'-4"
S	0"	2'-0"
J	3'-3"	6'-9"

WHEN K IS GREATER THAN 8'-0", GUIDE RAIL CRITERIA TO GOVERN.
WHEN K IS LESS THAN 4'-6" CONCRETE BARRIER PROTECTION SHALL BE USED.

SPAN SIGN STRUCTURE

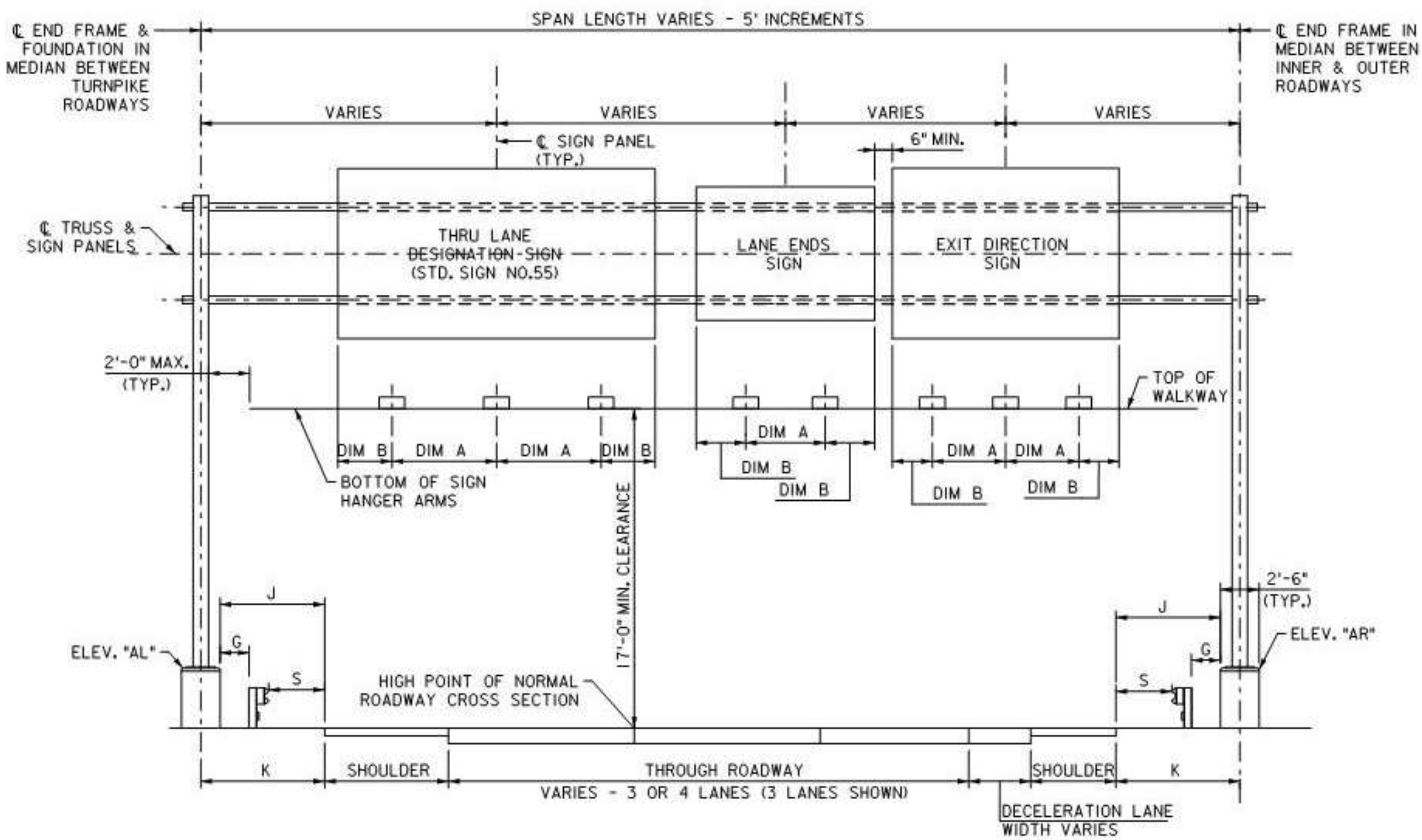
N.T.S.

NOTES:

1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-402 TURNPIKE OVERHEAD SIGN STRUCTURES - 2



SPAN SIGN STRUCTURE

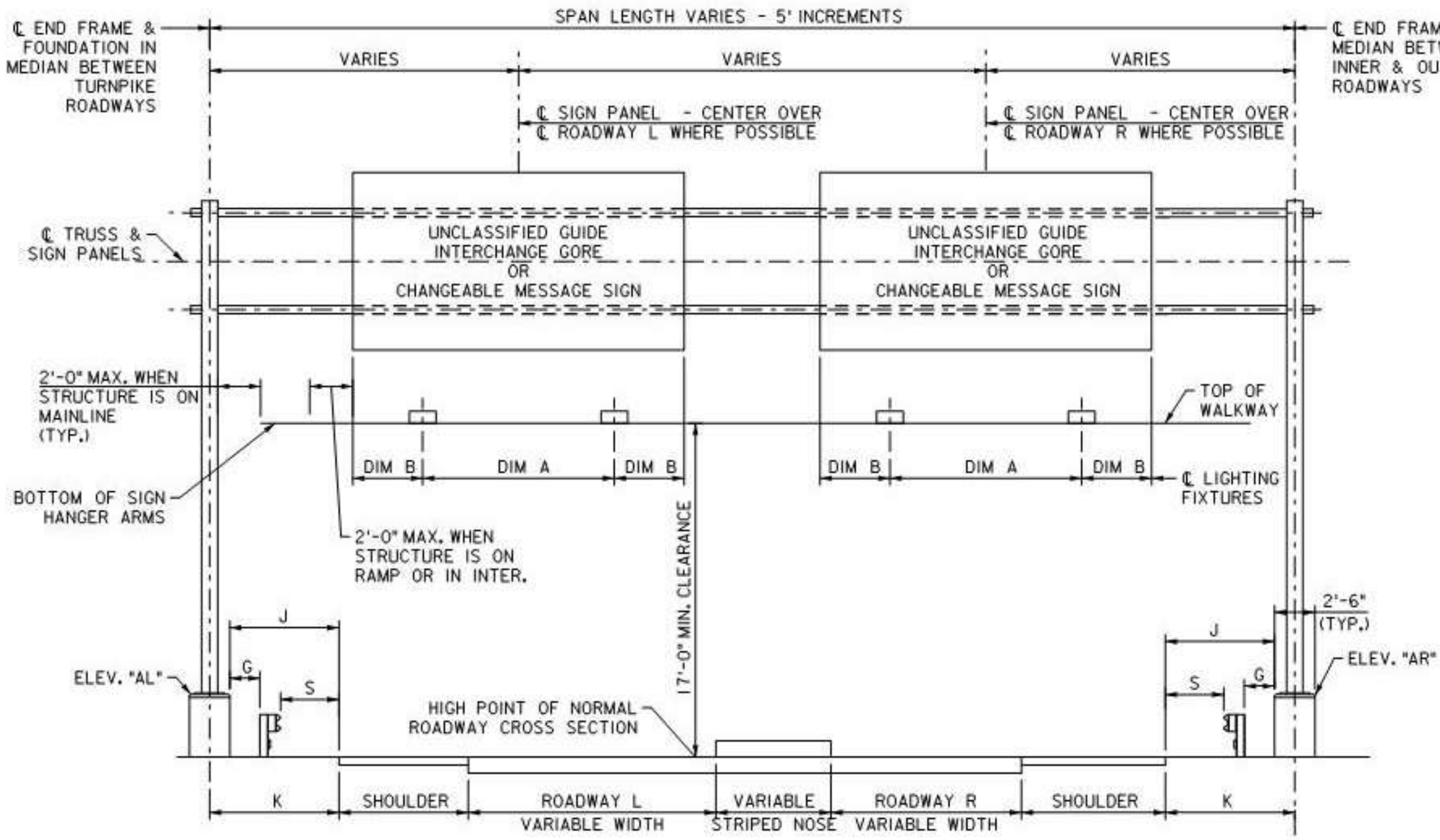
N.T.S.

NOTES:

1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.
2. SEE EXHIBIT 2-401 FOR ADDITIONAL TABLE.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-403 TURNPIKE OVERHEAD SIGN STRUCTURES - 3



SPAN STRUCTURE - VARIABLE WIDTH ROADWAY

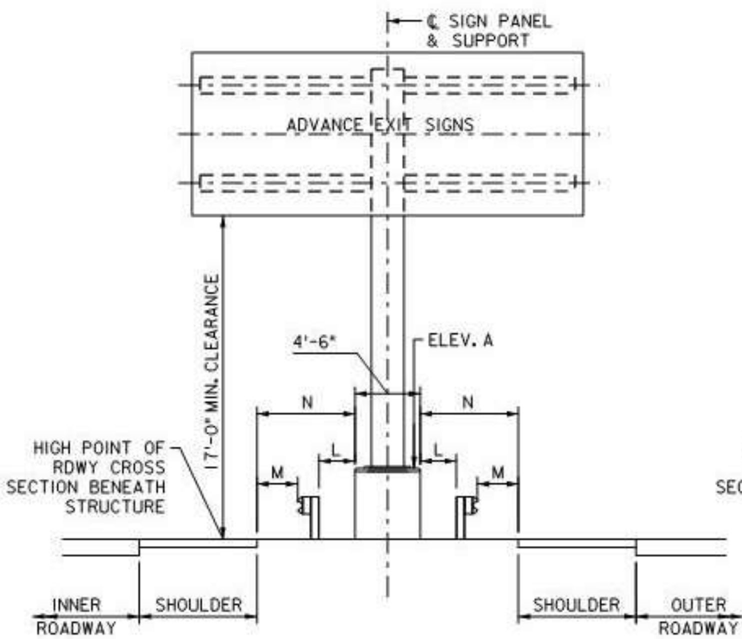
N.T.S.

NOTES:

1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.
2. SEE EXHIBIT 2-401 FOR ADDITIONAL TABLE.

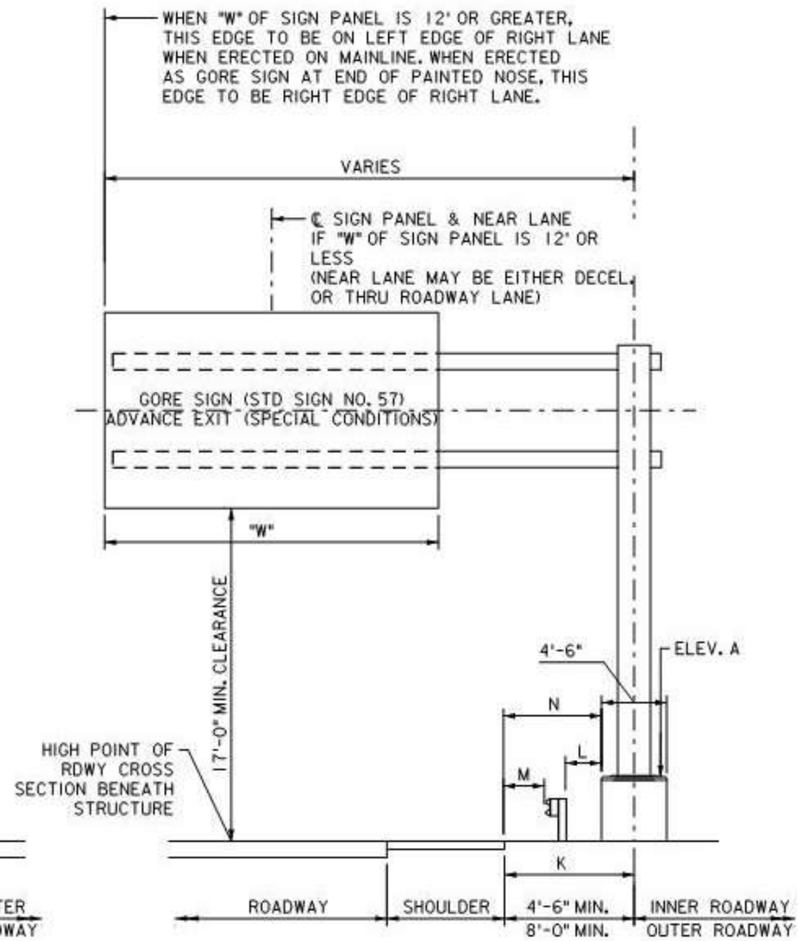
NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-404 TURNPIKE OVERHEAD SIGN STRUCTURES - 4



BUTTERFLY STRUCTURE

N.T.S.



CANTILEVER STRUCTURE

N.T.S.

	WHEN K=4'-6"	WHEN K=8'-0"
L	10"	2'-4"
M	0"	2'-0"
N	2'-3"	5'-9"

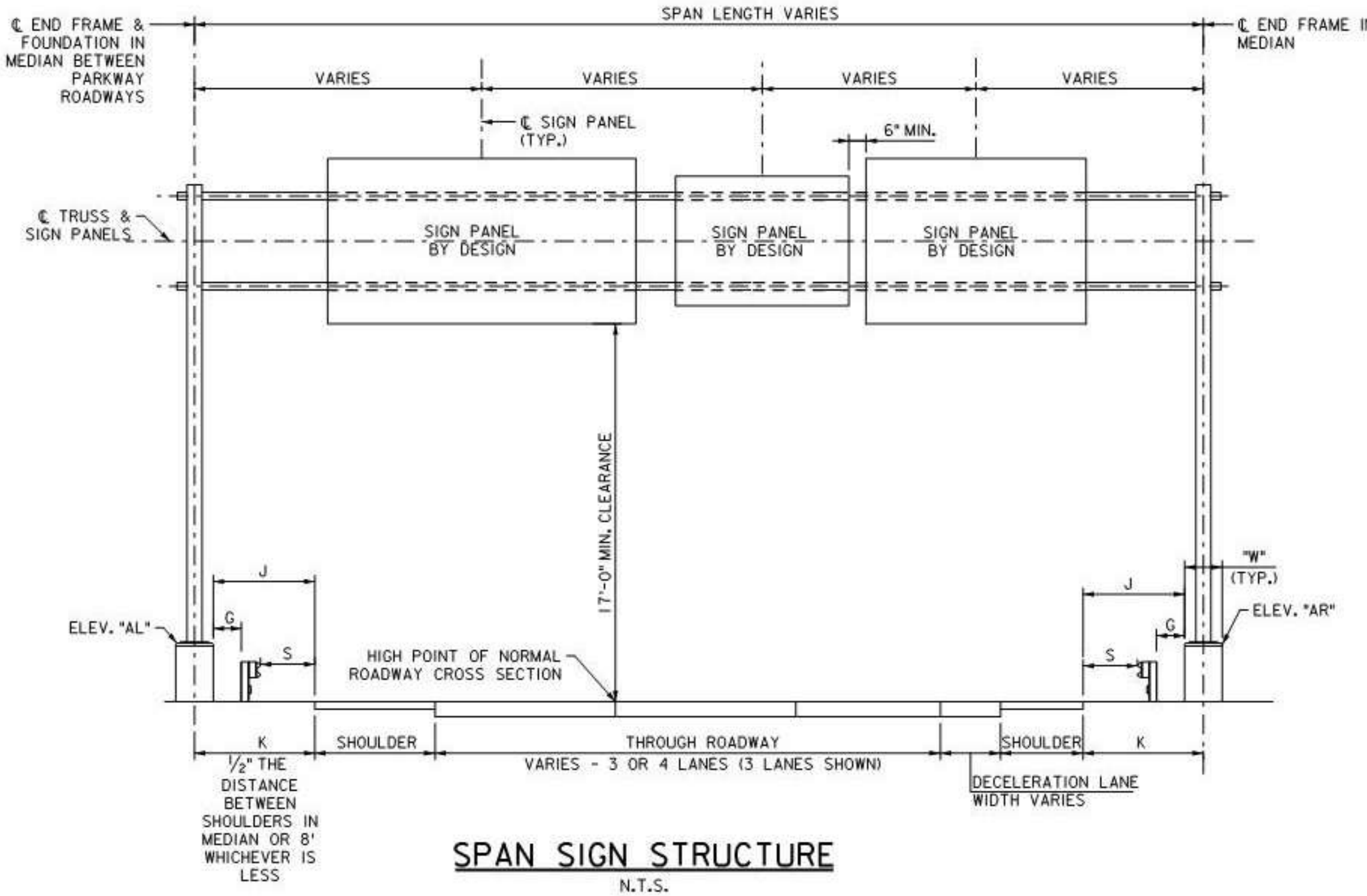
WHEN K IS GREATER THAN 8'-0", GUIDE RAIL CRITERIA TO GOVERN.
WHEN K IS LESS THAN 4'-6" CONCRETE BARRIER PROTECTION SHALL BE USED.

NOTES:

1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-405 PARKWAY OVERHEAD SIGN STRUCTURES - 1

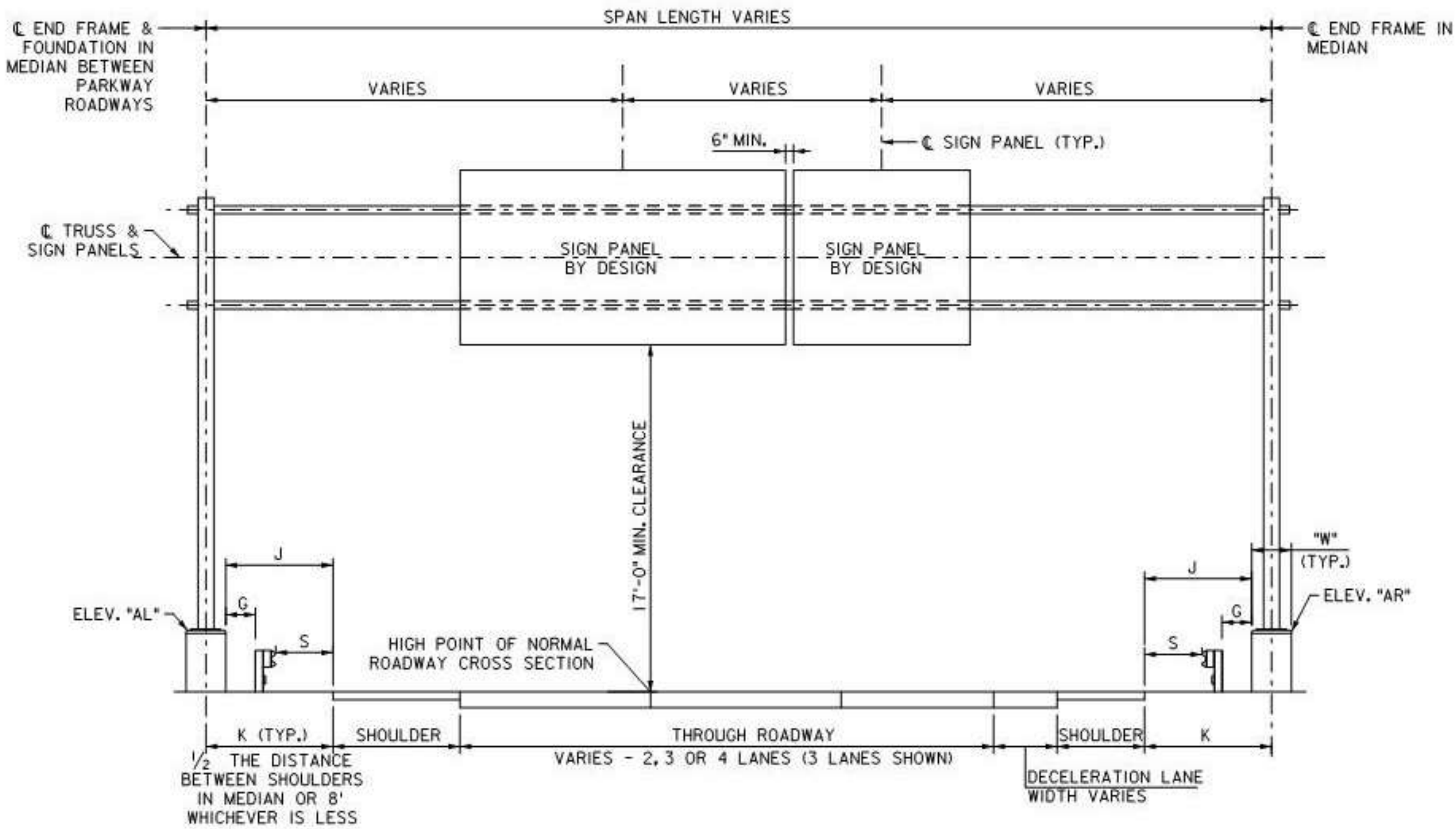


SPAN SIGN STRUCTURE
N.T.S.

NOTES:
1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.
2. SEE EXHIBIT 2-406 FOR ADDITIONAL TABLE.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-406 PARKWAY OVERHEAD SIGN STRUCTURES - 2



	W=3'-6"	
	WHEN K=4'-6"	WHEN K=8'-0"
G	2"	3'-0"
S	1'-10"	2'-0"
J	3'-3"	6'-9"

WHEN K IS GREATER THAN 8'-0", GUIDE RAIL CRITERIA TO GOVERN.
WHEN K IS LESS THAN 4'-6" CONCRETE BARRIER PROTECTION SHALL BE USED.

SPAN SIGN STRUCTURE

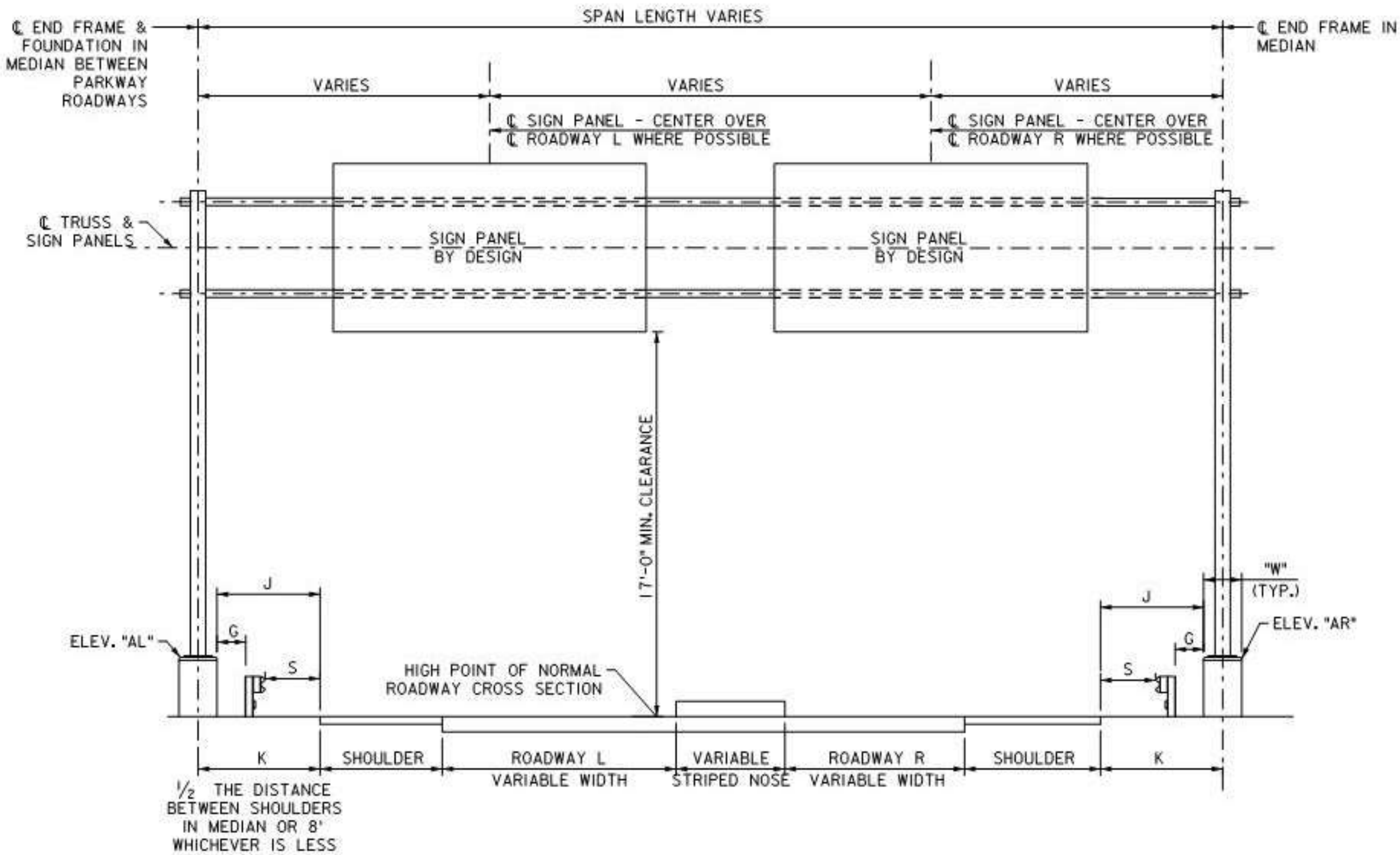
N.T.S.

NOTES:

1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-407 PARKWAY OVERHEAD SIGN STRUCTURES - 3



SPAN SIGN STRUCTURE - VARIABLE WIDTH ROADWAY

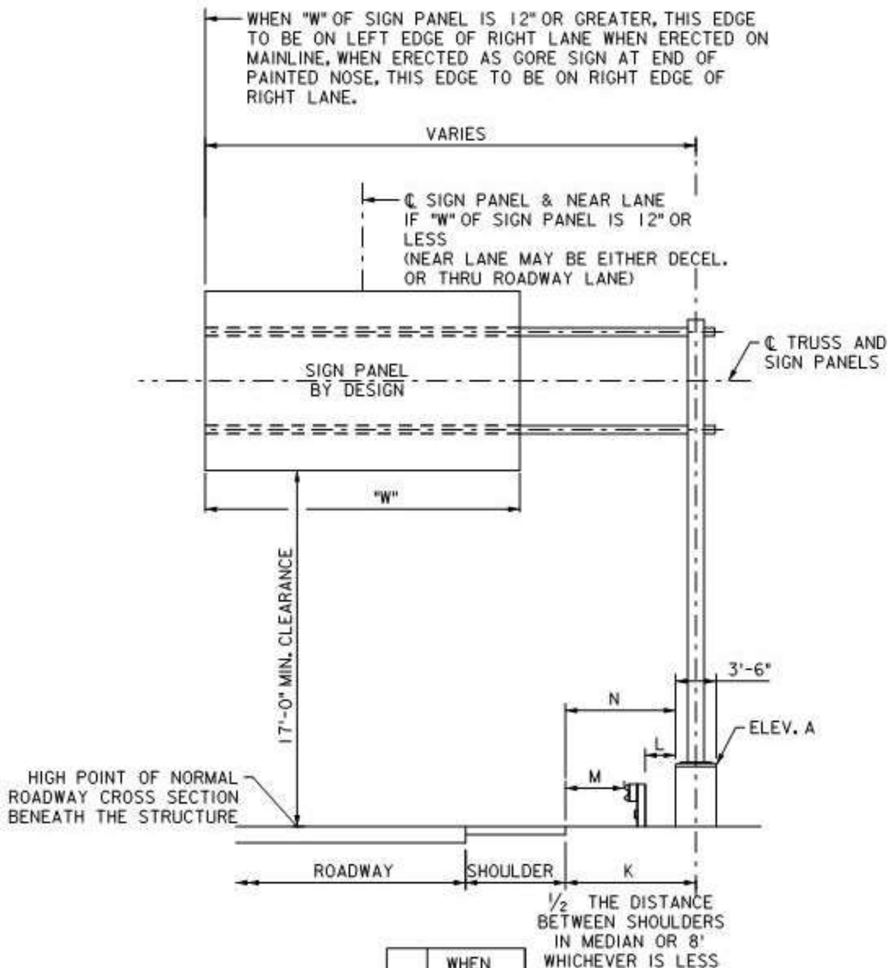
N.T.S.

NOTES:

1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.
2. SEE EXHIBIT 2-406 FOR ADDITIONAL TABLE.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-408 PARKWAY OVERHEAD SIGN STRUCTURE - 4



	WHEN K=8'-0"
L	3'-0"
M	2'-0"
N	6'-3"

WHEN K IS GREATER THAN 8'-0", GUIDE RAIL CRITERIA TO GOVERN.
WHEN K IS LESS THAN 4'-6" CONCRETE BARRIER PROTECTION SHALL BE USED.

CANTILEVER STRUCTURE

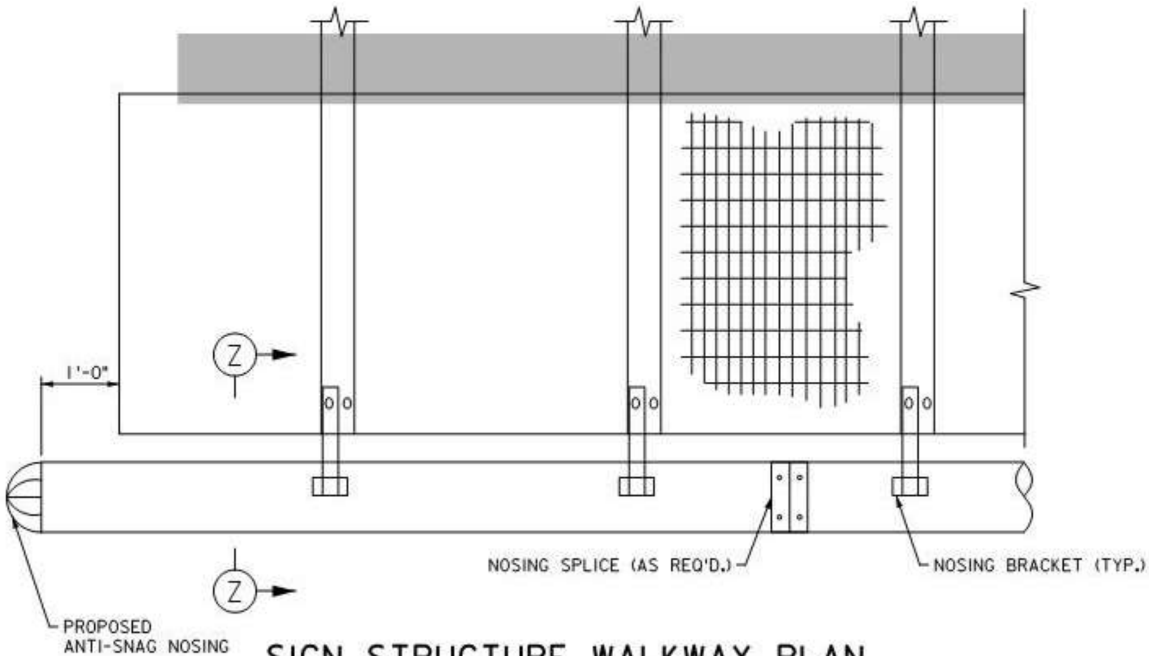
N.T.S.

NOTES:

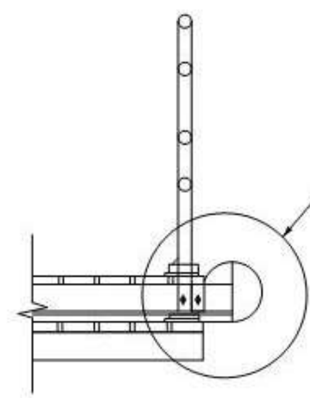
1. SEE EXHIBIT 2-400 FOR OVERHEAD SIGN STRUCTURE NOTES.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-409 ANTI-SNAG NOSING DETAILS - 1



SIGN STRUCTURE WALKWAY PLAN
N.T.S.



SECTION Z-Z
N.T.S.

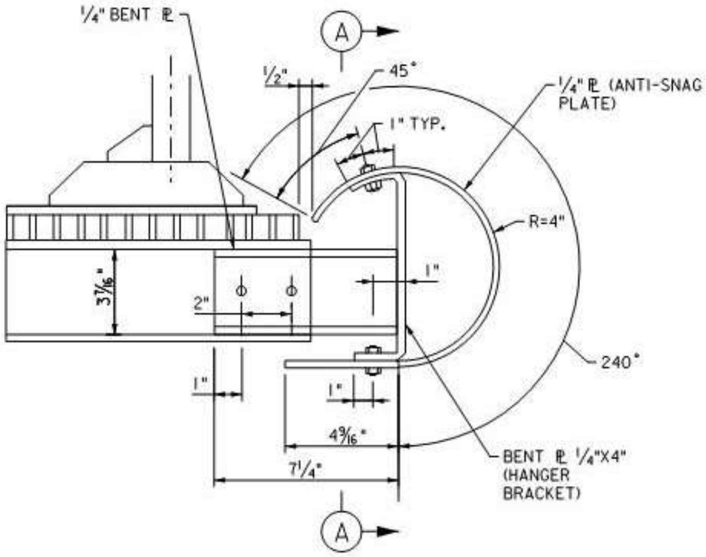
NOTES:

1. ALL SHAPES, PLATES, BRACKETS, HARDWARE AND FABRICATIONS SHOWN FOR THE ANTI-SNAG NOSING SHALL BE MADE FROM 6061-T6 ALUMINUM UNLESS OTHERWISE NOTED.

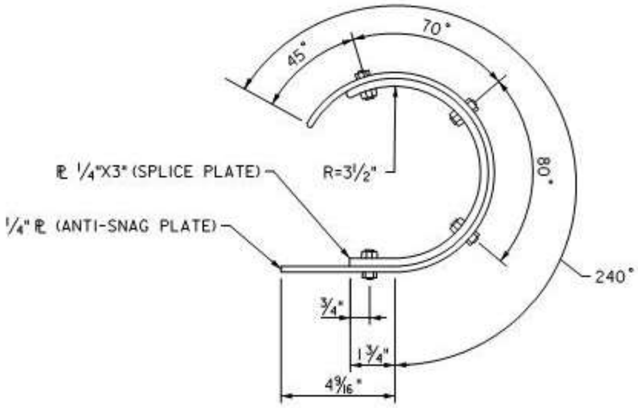
2. ANTI-SNAG ATTACHMENT HARDWARE SHALL BE 18-8 STAINLESS STEEL, BOLTS SHALL BE BUTTON-HEAD CAP SCREWS, McMASTER-CARR PART NO. 92949A587 OR APPROVED EQUAL. LOCKING NUTS, SHALL BE LOW-PROFILE TYPE WITH NYLON INSERTS, McMASTER-CARR PART NO. 90101A237 OR APPROVED EQUAL.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-410 ANTI-SNAG NOSING DETAILS - 2

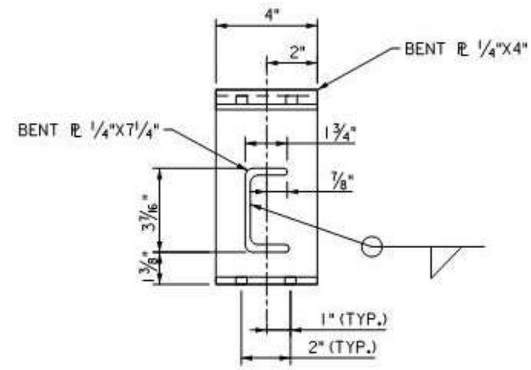


ANTI-SNAG DETAIL SECTION AT HANGER BRACKET
N.T.S.

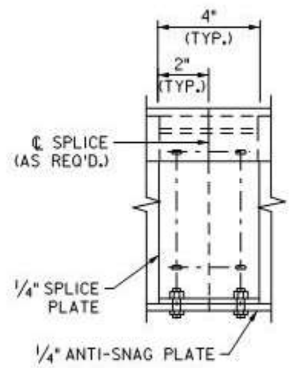


SECTION AT SPLICE PLATE
(SPLICE PLATE)
N.T.S.

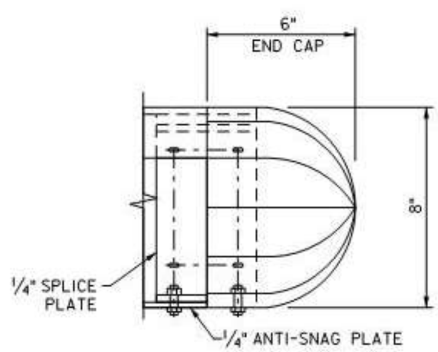
NOTES:
1. FOR NOTES, SEE EXHIBIT 2-409.



SECTION A-A
(HANGER BRACKET)
ANTI-SNAG PLATE NOT SHOWN FOR CLARITY
N.T.S.



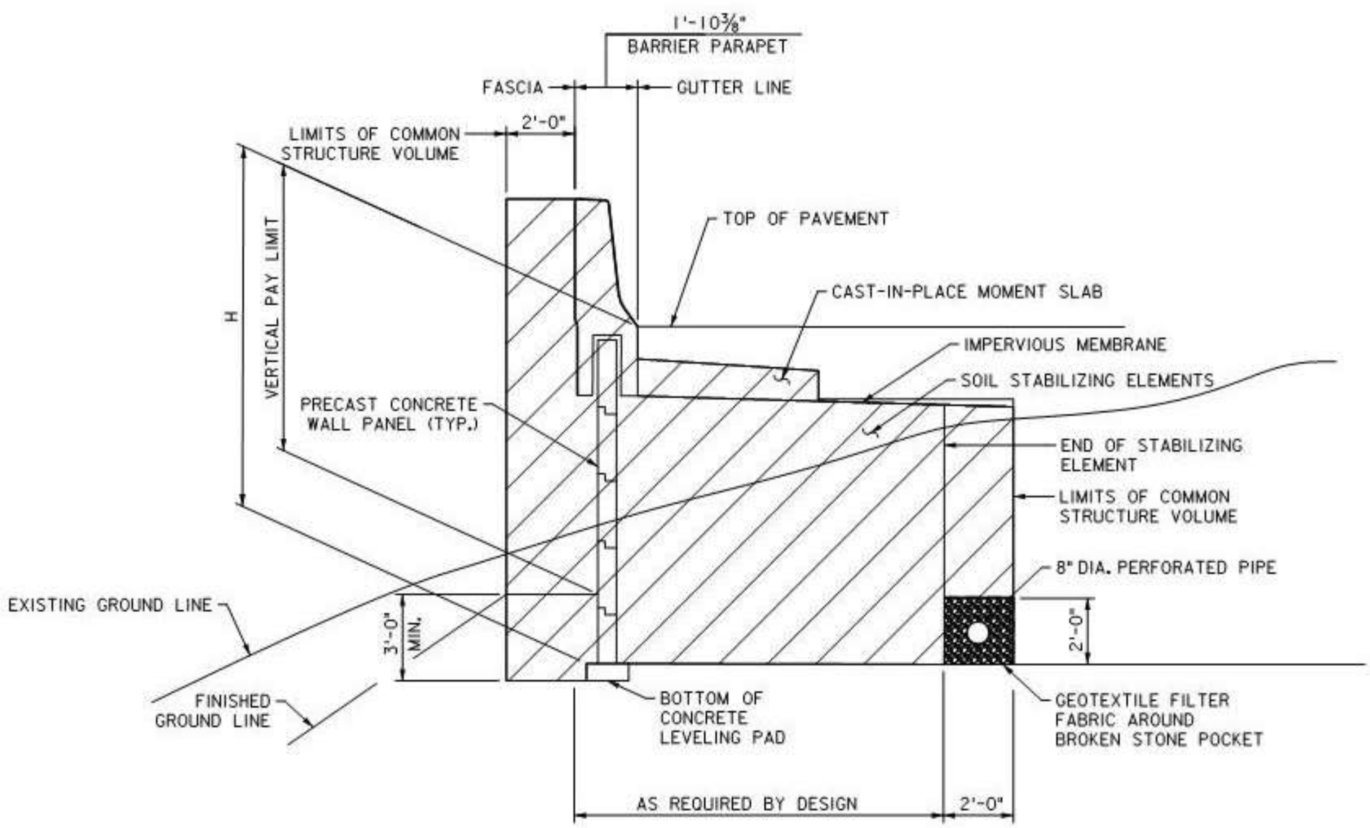
REAR ELEVATION AT SPLICE PLATE
N.T.S.



REAR ELEVATION AT END CAP
(TYPICAL)
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-500 PROPRIETARY RETAINING WALL DETAILS - 1

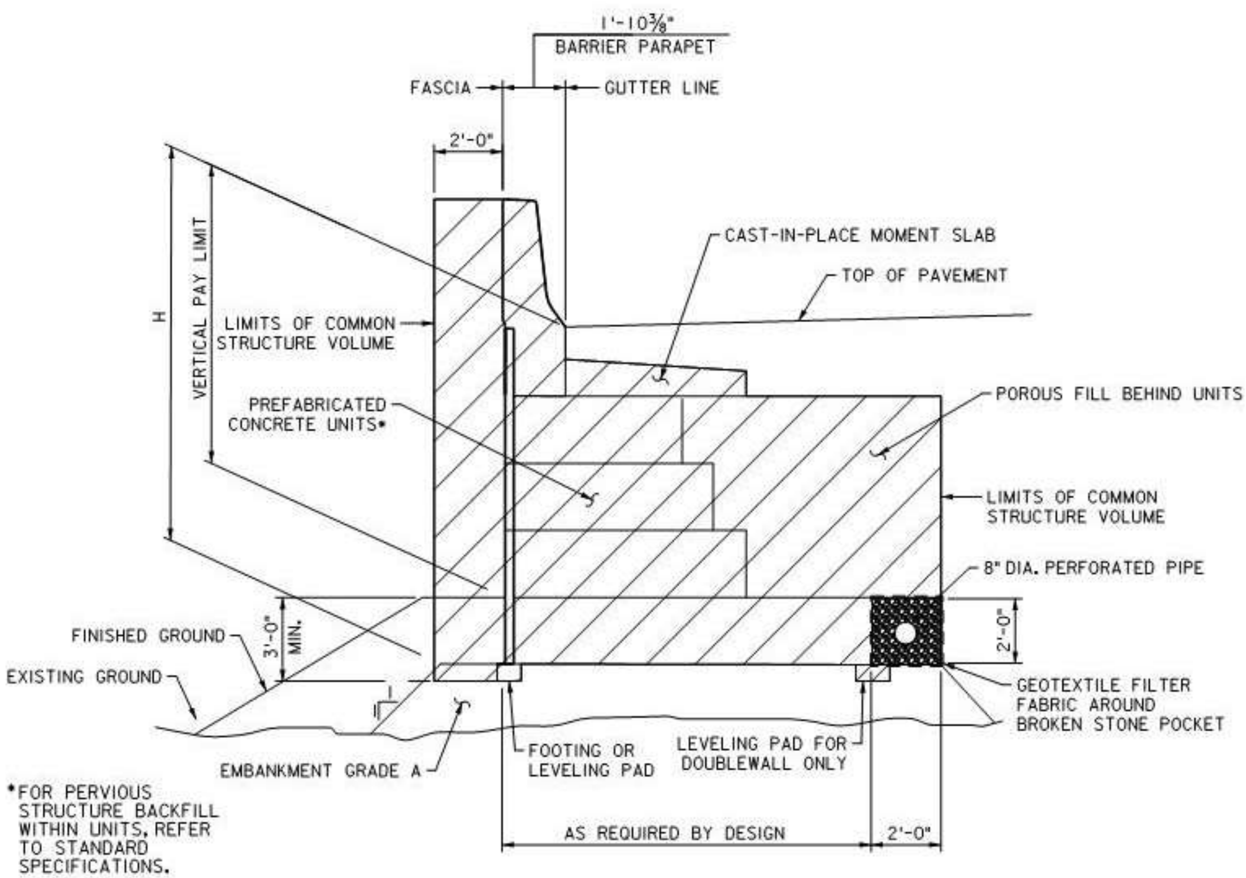


PROPRIETARY WALL SECTION

(MSE SHOWN)
(CUT SHOWN)
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

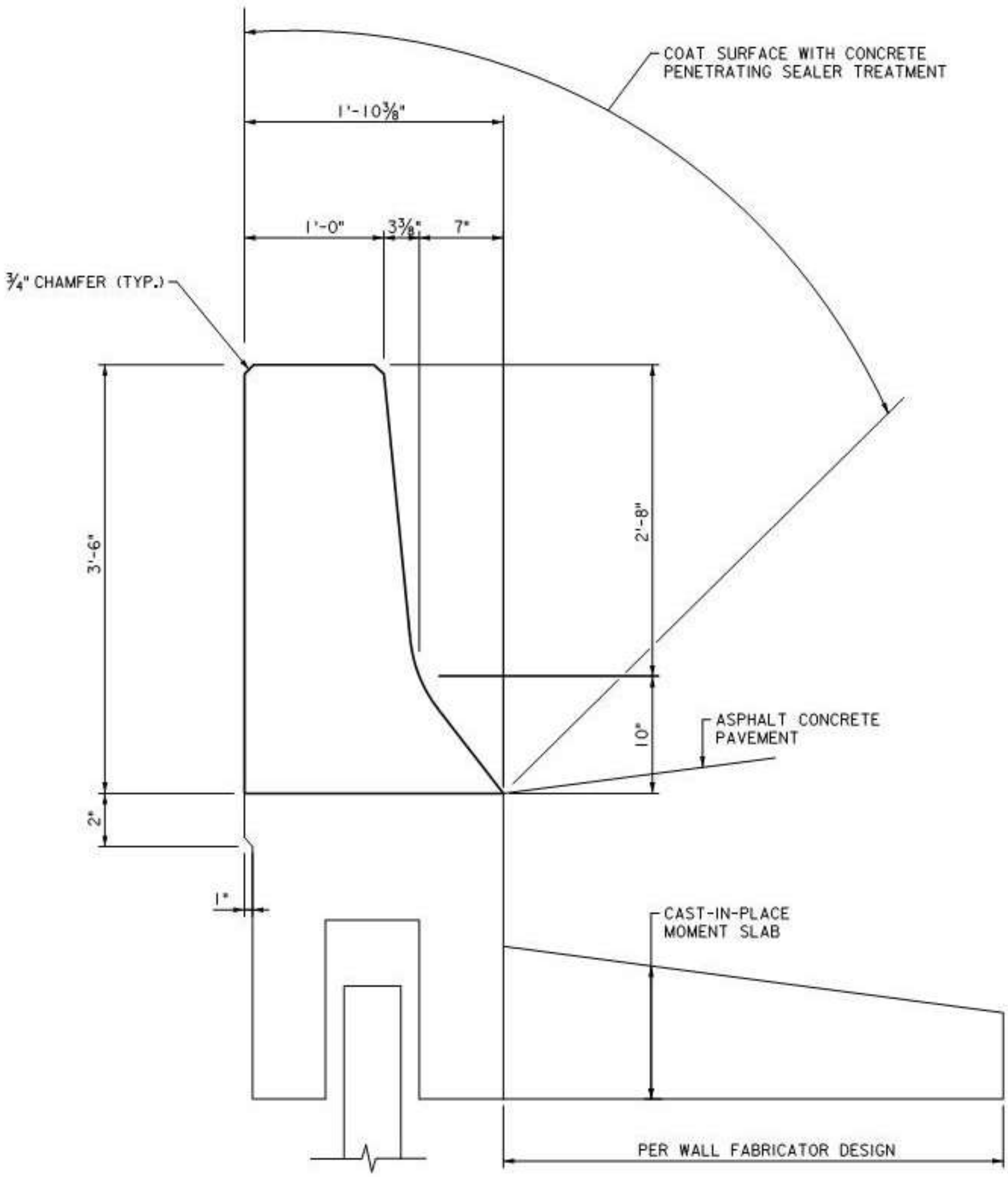
EXHIBIT 3-501 PROPRIETARY RETAINING WALL DETAILS - 2



PROPRIETARY WALL SECTION
(PREFABRICATED MODULAR WALL SHOWN)
(FILL SHOWN)
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

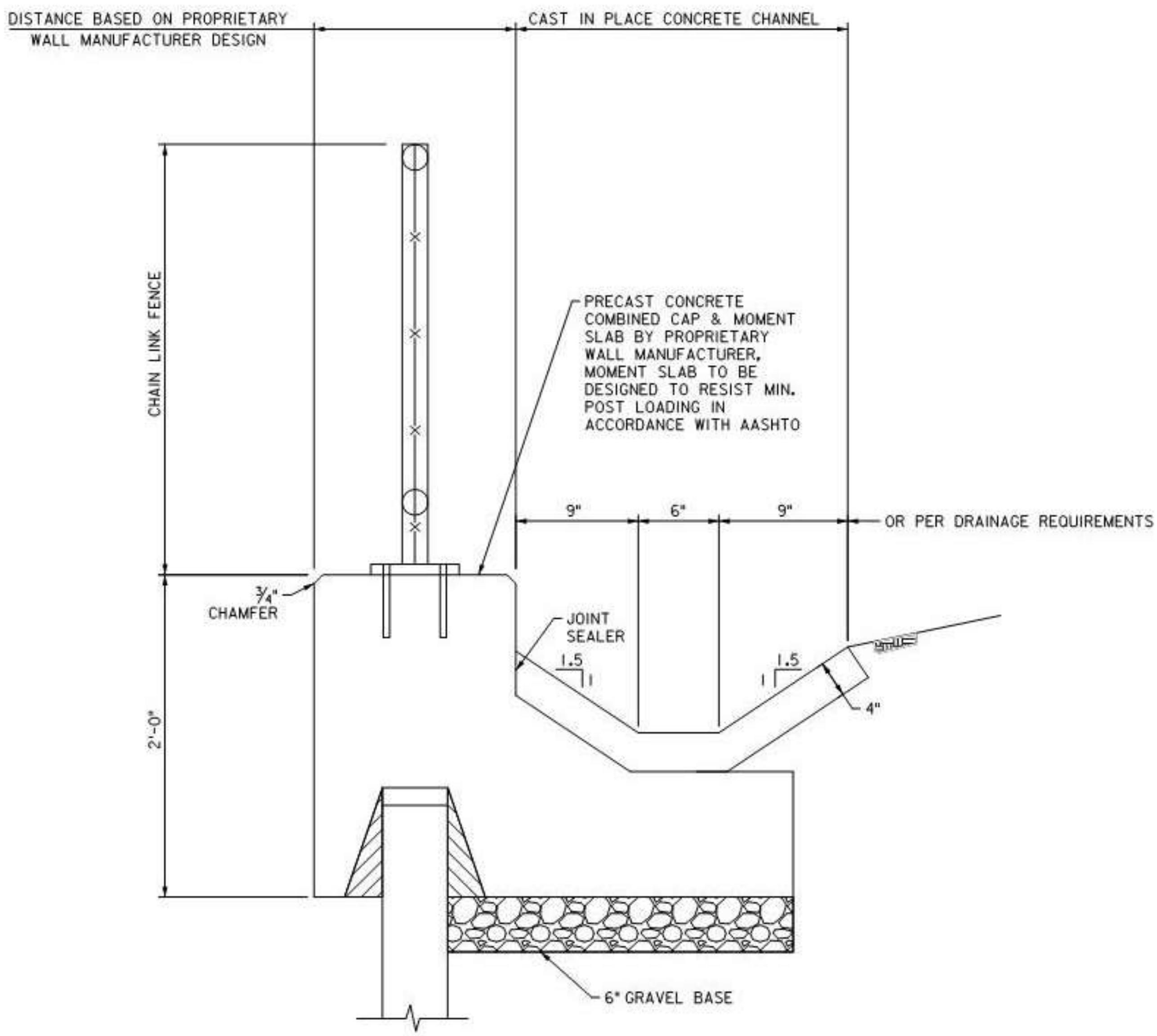
EXHIBIT 3-502 PROPRIETARY RETAINING WALL DETAILS - 3



PRECAST CONCRETE BARRIER SECTION
(FOR PROPRIETARY WALLS)
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-503 PROPRIETARY RETAINING WALL DETAILS - 4

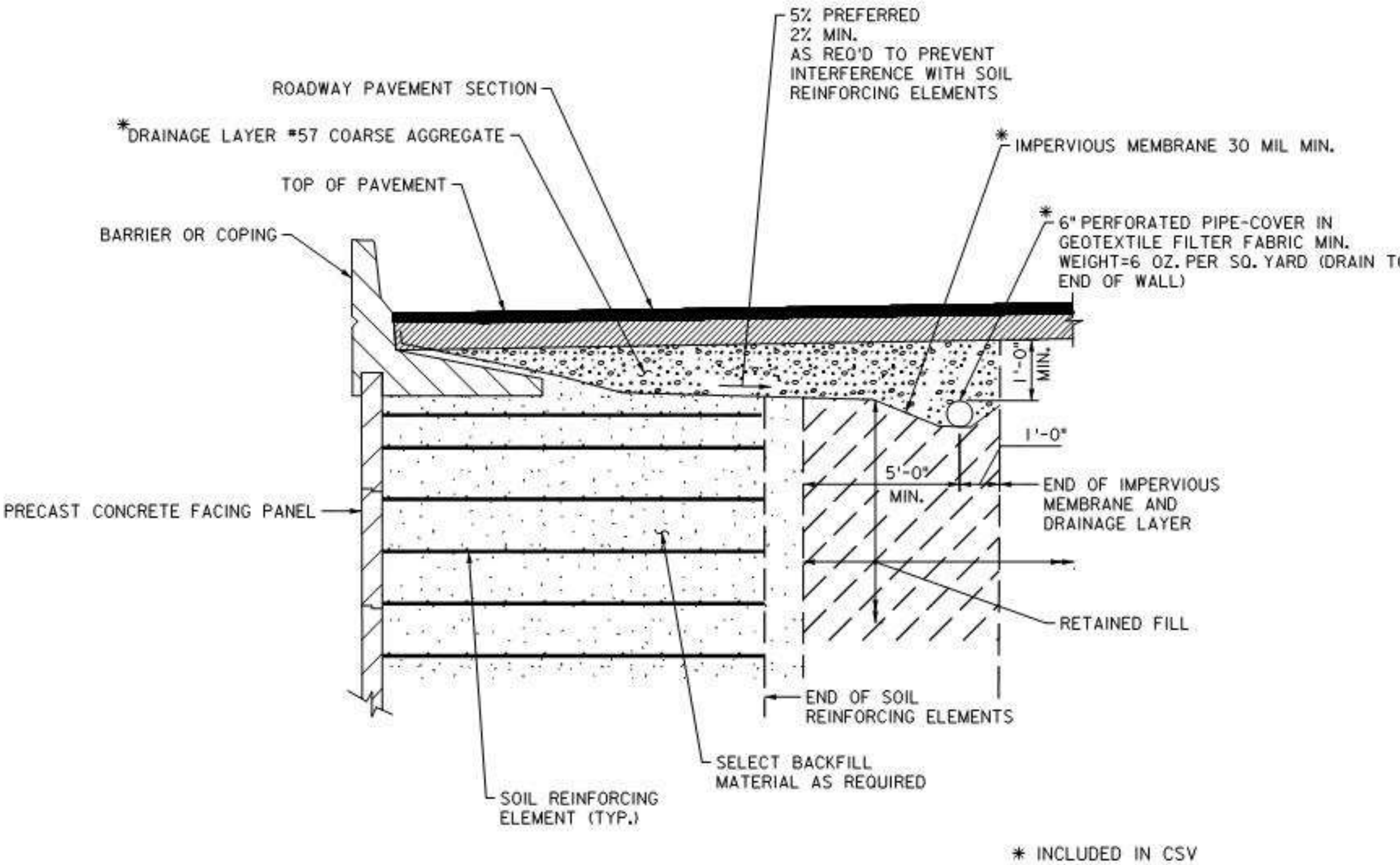


FENCE CAP AND MOMENT SLAB DETAIL FOR PROPRIETARY WALLS

N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

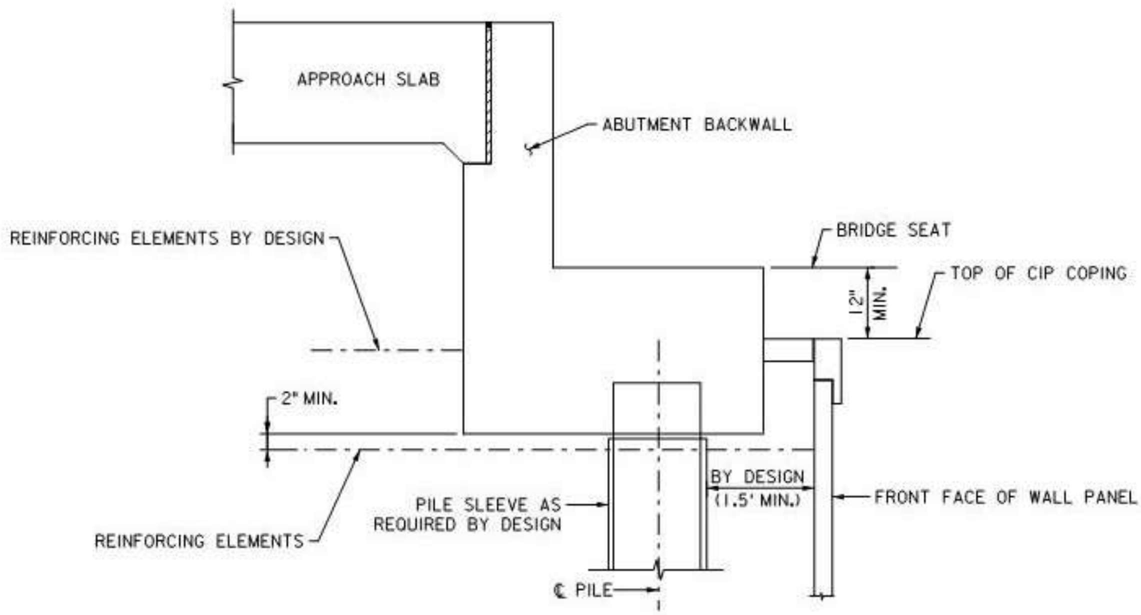
EXHIBIT 3-504 PROPRIETARY RETAINING WALL DETAILS - 5



IMPERVIOUS MEMBRANE DETAIL
(MSE WALLS)
N.T.S.

NEW JERSEY TURNPIKE AUTHORITY DESIGN MANUAL

EXHIBIT 3-505 PROPRIETARY RETAINING WALL DETAILS - 6



MSE ABUTMENT

N.T.S.

Appendix A -Bridge Design Checklist

Section 4 - GUIDE RAIL / MEDIAN BARRIER / ATTENUATOR DESIGN

4.1. INTRODUCTION

This Section is intended to provide guidance to the designer for determining conditions that warrant installation of permanent guide rail, roadside and median barrier, and attenuators, as well as the dimensional characteristics of these installations. For any items not adequately outlined in this section, the designer should refer to the latest editions of the AASHTO Roadside Design Guide and Manual for Assessing Safety Hardware (MASH).

Fixed objects when within the clear distance are preferred to be removed, relocated, or modified to be breakaway. When this is not practical, the obstruction should be shielded to prevent an impact of the obstruction by an errant vehicle.

For guidance on temporary barriers and attenuators, refer to Section 10 (Traffic Control During Construction) of this Manual.

4.2. GUIDE RAIL

It is the intention of the Authority to minimize the use of beam guide rail whenever feasible. Whereas guide rail is provided at obstructions or adjacent to high fills for safety reasons, elimination where possible of both the guide rail and potential hazard further reduces the chance of injury. Each guide rail installation should be evaluated in terms of economic (e.g. guide rail vs. flatter slope), safety, aesthetic, and engineering considerations. The designer should be prepared to justify to the Authority’s Engineering Department any use of guide rail or other attenuation device based on the above considerations.

4.2.1. Clear Zones

The clear zone for the New Jersey Turnpike roadway and ramps is a 30-feet minimum.

The clear zone for the Garden State Parkway roadway and ramps shall be determined as shown in **Exhibit 4-1**.

Exhibit 4-1 Clear Zones for Parkway

Design Speed	Design ADT	Foreslopes (ft)			Backslopes (ft)		
		6H:1V or flatter	5H:1V to 4H:1V	3H:1V	3H:1V	5H:1V to 4H:1V	6H:1V or flatter
40 mph or less	Under 750	7 - 10	7 - 10	**	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	**	10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16	**	12 - 14	12 - 14	12 - 14
	over 6000	14 – 16	16 - 18	**	14 - 16	14 - 16	14 - 16
45 - 50 mph	Under 750	10 - 12	12 - 14	**	8 - 10	8 - 10	10 - 12
	750 - 1500	14 - 16	16 - 20	**	10 - 12	12 - 14	14 - 16
	1500 - 6000	16 - 18	20 - 26	**	12 - 14	14 - 16	16 - 18
	over 6000	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	Under 750	12 - 14	14 - 18	**	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24	**	10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30	**	14 - 16	16 - 18	20 - 22
	over 6000	22 - 24	26 - 32*	**	16 - 18	20 - 22	22 - 24
60 mph	Under 750	16 - 18	20 - 24	**	10 - 12	12 - 14	14 - 16
	750 - 1500	20 - 24	26 - 32*	**	12 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40*	**	14 - 18	20 - 22	24 - 26
	over 6000	30 - 32*	36 - 44*	**	20 - 22	22 - 24	26 - 28
65 - 70 mph	Under 750	18 - 20	20 - 26	**	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36*	**	12 - 16	18 20	20 - 22
	1500 - 6000	28 - 32*	34 - 42*	**	16 - 20	22 - 24	26 - 28
	over 6000	30 - 34*	38 - 46*	**	22 - 24	26 - 30	28 - 30

*Where a site-specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear-zone shown in **Exhibit 4-1**. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or design indicates satisfactory performance.

**Since recovery is less likely on the unshielded, traversable 3H:1V slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery areas at the toe of slope should take into consideration right of way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 3H:1V slope should influence the recovery area provided at the toe of slope. While the application may be limited to several factors, the foreslope parameters which may enter into determining a maximum desirable recovery area are illustrated in Exhibit 4-3.

Note 1: Clear zone is measured from edge of traveled way.

Note 2: The clear zone widths should be increased on the outside of curves. The amount of increase should be determined by Exhibit 4-2.

Note 3: See Section 4.2.2 for guide rail warranting obstructions.

Exhibit 4-2 Horizontal Curve Adjustments

K_{cz} (Curve Correction Factor)							
Radius (ft)	**Design Speed (mph)**						
	40	**45**	**50**	**55**	**60**	**65**	**70**
2,950	1.1	1.1	1.1	1.2	1.2	1.2	1.2
2,300	1.1	1.1	1.2	1.2	1.2	1.2	1.3
1,970	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1,640	1.1	1.2	1.2	1.3	1.3	1.3	1.4
1,475	1.2	1.2	1.3	1.3	1.4	1.4	1.5
1,315	1.2	1.2	1.3	1.3	1.4	1.4	—
1,150	1.2	1.2	1.3	1.4	1.5	1.5	—
985	1.2	1.3	1.4	1.5	1.5	1.5	—
820	1.3	1.3	1.4	1.5	—	—	—
660	1.3	1.4	1.5	—	—	—	—
495	1.4	1.5	—	—	—	—	—
330	1.5	—	—	—	—	—	—

$CZ_c = (L_c)(K_{cz})$

Where:

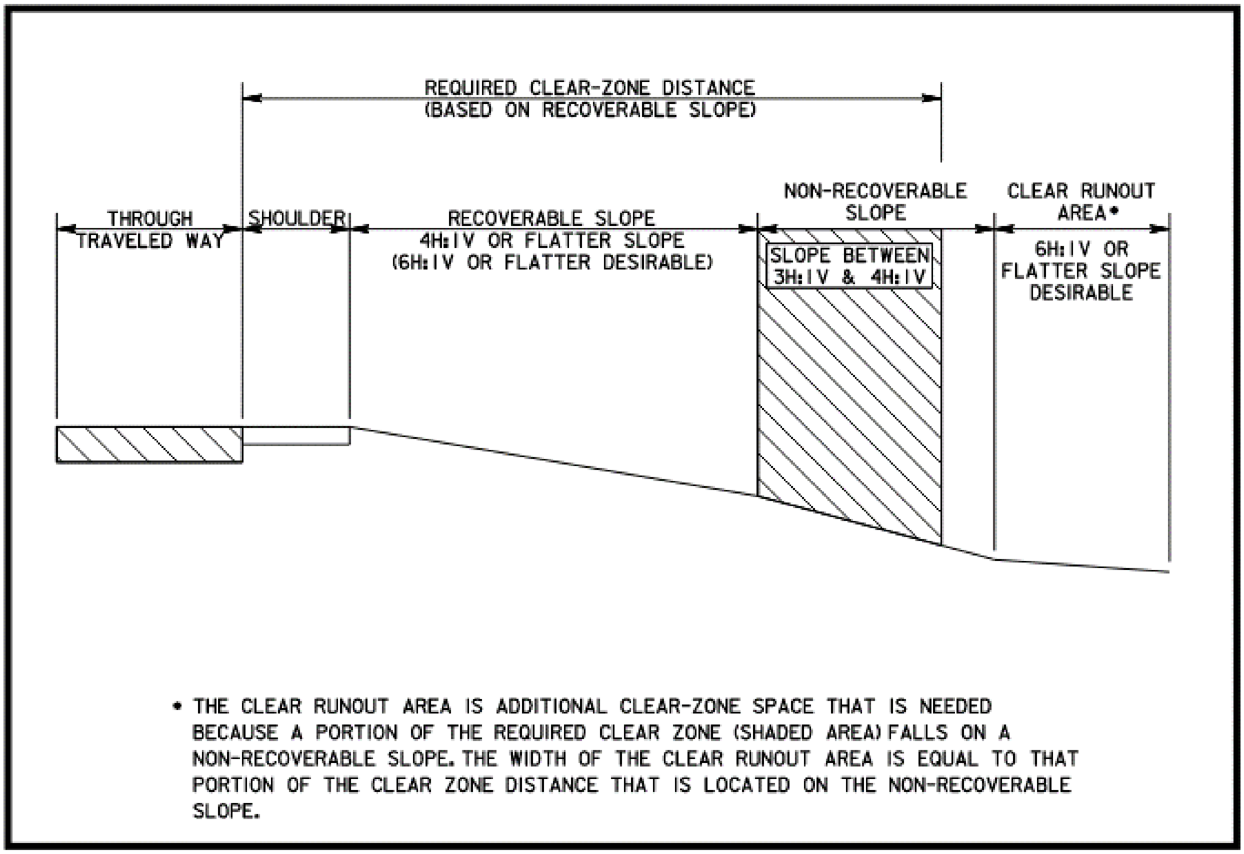
CZ_c = clear zone on outside of curvature, Feet

L_c = clear zone distance, feet (Exhibit 4-1)

K_{cz} = curve correction factor

Note:
The clear zone correction factor is applied to the outside of curves only. Curves flatter than 2,950 feet do not require an adjusted clear zone.

Exhibit 4-3 Clear Zone Example



4.2.2. Guide Rail Warrants

A warranting obstruction is defined as a non-traversable roadside or fixed object located within the clear zone and whose physical characteristics are such that injuries resulting from an encounter or impact with the obstruction would probably be more severe than injuries resulting from an impact with guide rail.

1. Fixed Objects

   Fixed objects are features within the clear zone which may cause excessive vehicle snagging rather than permit relatively smooth redirection. Obstructions may include but are not limited to bridge piers, retaining walls, sign support structures, drainage features, trees, rocks, etc. For new or upgraded roadside guide rail installations, breakaway or non-breakaway sign supports, light poles, or utility poles shall not remain in front of the guide rail.

   Signs on u-channel or breakaway wood post supports may be placed in front of dual-faced guide rail in the median with a desirable offset of 7 feet from the face of guide rail to the nearest sign post. If possible, relocate the sign behind single-faced guide rail or place a single post sign inside the dual faced guide rail (between the two rail elements).example. The designer should, therefore, evaluate each site before providing 3H:1V slopes without guide rail.

Roadside protection for all overhead and cantilever sign structure supports should be provided regardless of location beyond the clear zone to limit roadway operations disruption from impacts to sign supports.

2. Embankment (Fill) Slopes

A critical slope is one in which a vehicle is likely to overturn. Slopes steeper than 3H:1V fall into this category and may require guide rail. If a slope steeper than 3H:1V begins closer to the traveled way than the suggested clear zone distance and exceeds the maximum heights presented in Exhibit 4-4, guide rail is warranted if it is not practical to flatten the slope.

A non-recoverable slope is defined as one that is traversable, but the vehicle can be expected to travel to the bottom of the slope before steering recovery can be obtained. Embankments between 3H:1V and 4H:1V generally fall into this category. Fixed objects should not be constructed or located along such slopes that begin closer to the traveled way than the suggested clear zone distance. A clear runout area at the base of these slopes is desirable; see Exhibit 4-3 for an example. The designer should, therefore, evaluate each site before providing 3H:1V slopes without guide rail.

When flattening existing slopes to remove guide rail, the proposed side slopes should be recoverable, that is, 4H:1V or flatter. Where embankment slopes are being constructed, the designer should investigate the feasibility of providing a recoverable slope instead of a critical slope with guide rail.

Exhibit 4-4 Critical Slope Warrants

Critical Embankment (fill) Slopes	Maximum Height without Guide Rail
1 ½ H: 1V	3 ft.
2H: 1V	6 ft.
2 ½ H: 1V	9 ft.

3. Slopes in Cut Sections

Slopes in cut sections should not ordinarily be shielded with guide rail. However, there may be obstructions on the slope that warrant shielding, as referenced in 4.2.2.1 above.

4.2.3. Dimensional Characteristics

1. Without Curb in Front of Guide Rail

In general, the following offsets and slopes should be used:

a. To the extent possible, guide rail should be located as far as possible away from the traveled way to provide a recovery area for errant vehicles and to provide adequate sight distance along horizontal curves and at intersections.

b. The front face of the guide rail should desirably be 2 feet or more from the outside edge of pavement along Turnpike mainline and ramps. Along Parkway mainline and ramps the desired offset shall be 4 feet or more from the outside edge of pavement. Where these offsets are not possible, the guide rail should be installed flush with the edge of pavement.

c. Where guide rail is located at the top of an embankment slope, the posts should be a minimum of 2 feet from the PVI to the back of the post. When less than 2 feet from the PVI to the back of the post is provided, the post lengths, shown in Exhibit 4-5 should be used.

d. Guide rail shall be placed on slopes 10H:1V or flatter.

e. See **Exhibit 4-7** for the treatment of critical embankment slopes at approach guide rail end terminals.

Exhibit 4-5 Additional Post Length Requirements

Offset from Back of Post to PVI	Embankment Slopes	Additional Post Length
Less than 2 ft. but greater or equal to 1 ft.	6H:1V or Flatter	0
	Steeper than 6H:1V to 3H:1V	1 ft.
	Steeper than 3H:1V to 2H:1V	2 ft.
Less than 1 ft. or at PVI	6H:1V or Flatter	1 ft.
	Steeper than 6H:1V to 3H:1V	2 ft.
	Steeper than 3H:1V to 2H:1V	3 ft.

2. Concrete Curb in Front of Guide Rail

Concrete curb in front of guide rail should be avoided. New installations of concrete curb shall not be constructed on the Turnpike and Parkway mainline but may be constructed on ramps and at toll plazas. On projects that involve upgrading existing sections of mainline and ramps with concrete curb in front of guide rail, removal of the curb should be the first consideration.

If concrete curb is present and cannot be removed or avoided, the guide rail shall be placed flush with the gutter line. Curb height in front of the guide rail shall not exceed 4 inches; and, at end sections and parapet connections curb height shall not exceed 2 inches.

3. At Fixed Objects

   Where guide rail is used to shield an isolated obstruction, the guide rail should be located as far from the traveled way as possible to minimize the probability of impact. The distance from the face of the rail element to the face of obstruction should be a minimum of 4 feet - 9 inches. This distance may be reduced to a minimum of 3 feet – 6 inches for MASH approved breakaway features such as light poles and ground-mounted sign supports located behind the guide rail.

   If less than the minimum clearance is available, the guide rail shall be transitioned to a concrete median barrier protection configuration as per the GR Standard Drawings and with prior approval from the Authority’s Engineering Department.

4. At Bridges

   When there is a difference in the offset from the approach guide rail to the bridge parapet connection, a straight flare rate transition per Table 1 on **Exhibit 4-6** should be used to make up the offset difference. The offset transition flare should be accomplished at least one full beam guide rail element section in advance of the limits of the guide rail parapet connection. Refer to the GR Standard Drawings for attachment of guide rail to bridges and structures.

5. Rub Rail

   Rub rail shall be used whenever the clearance from the ground to the bottom of the rail element exceeds 21 inches. Additional length of guide rail posts may be required. Refer to the GR Standard Drawings.

   Rub rail is not required when curb is present if the top of guide rail height is 31 inches above the gutter line. Refer to the GR Standard Drawings.

4.2.4. **End Treatments**

When the approach end of guide rail is terminated within the clear zone it must be adequately protected from approaching traffic. This is typically accomplished using a tangent guide rail terminal. When there is insufficient area to install a tangent guide rail terminal, an impact attenuator may be used. If the approach end of the guide rail terminates near a cut slope, the guide rail may be terminated by a buried guide rail end terminal.

Trailing ends of beam guide rail not exposed to opposing traffic should be anchored with beam guide rail anchorage. Where the approach end of a guide rail installation is located outside the clear zone such that an end hit from opposing traffic is unlikely, the approach end may also be anchored with beam guide rail end anchorage with approval from the Authority's Engineering Department.

An impact attenuator shall be used when terminating the approach end of dual face beam guide rail within a median as depicted on the GR Standard Drawings. Refer to Section 4.4 for additional guidance on impact attenuators.

1. Tangent Guide Rail Terminals

   a. The approach end of the tangent guide rail terminal (Post No. 1) shall be placed a minimum distance of 12.5 feet beyond the length of need. The location of Post No. 1 shall be indicated on the plans. Tangent guide rail terminals constructed with a straight flare for the entire length of the terminal for a 2-foot offset is preferred. Where a 2-foot offset is not feasible, the terminal shall be constructed with a 0-foot offset.

   b. Where the guide rail is installed flush with the gutter line, a tangent guide rail terminal shall be constructed with a straight flare for its entire length and a 2-foot offset so that the guide rail terminal does not protrude into the roadway.

   c. An adjacent roadside recovery area shall be provided in advance of and behind the tangent guide rail terminal as indicated on the GR Standard Drawings.

   d. A Where a tangent guide rail terminal is installed along a horizontal curve, the terminal shall be constructed tangent to the curve (straight). Desirably, the terminal should have the same offset as the approach guide rail. In no case should the end of the terminal be offset more than 2 feet greater than the approach guide rail offset, nor shall the end of the terminal protrude into the roadway. The approach guide rail shall be extended or adjusted as needed to ensure the proper offset at the tangent guide rail terminal end.

   e. Where concrete curb is present at the tangent guide rail terminal, the maximum curb height in advance of and along the length of the terminal shall be 2 inches. The curb height shall be transitioned as depicted on the CU Standard Drawings.

   f. Rub rail, reduced post spacing, and double rail elements shall not be used within the limits of the tangent guide rail terminal.

   g. Lip curb shall not be present within the limits of the tangent guide rail terminal.

   h. When a tangent guide rail terminal is proposed on the approach to a beam guide rail parapet connection, the complete length of the terminal shall be a minimum of one full beam guide rail element section beyond the limits of the parapet connection. Refer to the GR Standard Drawings.

2. Buried Guide Rail End Terminals

In cut sections, the approach end of guide rail should be buried in the backslope as shown in the GR Standard Drawings. A straight flare rate per Table 1 on **Exhibit 4-6** should be used.

3. Beam Guide Rail Anchorage

   a. On one-way roadways or divided roadways with a non-traversable median, trailing ends of beam guide rail installations should be anchored with a beam guide rail end anchorage as shown in the GR Standard Drawings.

   b. On divided roadways separating same direction traffic, trailing ends of dual faced beam guide rail installations should be anchored with beam guide rail end anchorages as shown in the GR Standard Drawings.

   c. A minimum of 2 feet must be provided between the back of the anchorage and the PVI of a fill slope.

   d. Where concrete curb is present at the beam guide rail anchorage, the maximum curb height along the length of the anchorage shall be 2 inches. The curb height shall be transitioned as depicted on the CU Standard Drawings.

   e. Lip curb shall not be present within the limits of the beam guide rail anchorage.

   f. An adjacent roadside recovery area shall be provided in advance of and behind the beam guide rail anchorage as indicated on the GR Standard Drawings.

4.2.5. Approach Length of Need (L.O.N.)

The approach length of need is the minimum length of guide rail required in front of the warranting obstruction to shield it effectively. The minimum length of guide rail shall not be less than the length of the minimum adjacent roadside recovery area necessary for the end treatment as indicated on the GR Standard Drawings.

1. On Embankment Slopes and Obstructions

   The approach L.O.N. at fixed objects should be determined in accordance with **Exhibit 4-6**.

   The approach L.O.N. and guide rail treatment for critical embankment slopes is shown in **Exhibit 4-7**.

2. In a Cut Section

   The minimum L.O.N. measured from the point where the guide rail crosses the PVI of the foreslope and backslope to the obstruction being shielded shall not be less than 75 feet. See Exhibit 4-8 for an example of determining L.O.N. in a cut section with a buried guide rail end terminal. Refer to the GR Standard Drawings for the length of guide rail required beyond the PVI to bury the guide rail.

3. In Median

   In very wide medians where an obstruction is within the clear zone from only one direction of travel, the approach L.O.N should be determined as shown in **Exhibit 4-6** and **Exhibit 4-7**.

   Where the median obstruction is within the clear zone for both travel ways, the beam guide rail layout to shield the obstruction should be designed as per the median guide rail treatment alternatives shown on the GR Standard Drawings. The guide rail flare rate shall be determined using the straight flare rate shall be determined using the straight flare rate from Table 1 in **Exhibit 4-6**.

4. At Gore Areas

   It is desirable to provide a traversable and unobstructed gore area when possible since the gore area may serve as a recovery area for errant vehicles exiting or entering the mainline. When warranting obstructions, such as critical embankment slopes, parapets, or abutments in close proximity to gore areas cannot be avoided, guide rail treatment within the gore area may be required. Exhibit 4-9 and **Exhibit 4-10** provide guide rail treatment examples for gore areas, starting from less restricted or open gore areas in Exhibit 4-9 to more restricted or limited gore areas in **Exhibit 4-10**.

4.2.6. General Comments

1. All new guide rail shall be constructed using MASH TL-3 conforming guide rail measuring 31 inches high as shown on the GR Standard Drawings. Construction tolerances shall be in accordance with the Standard Specifications.
2. Wherever part of an existing guide rail run is lengthened or upgraded, the guide rail height shall be transitioned as shown on the GR Standard Drawings. Only NCHRP 350 guide rail (27 ¼ inch-high guide rail with synthetic blockouts) may be left in place provided that the remaining guide rail is less than 20 years old, assessed by the designer to be in a state of good repair, and with approval from the Authority’s Engineering Department. When at least 50 percent of an existing guide rail run is lengthened, reset, or upgraded, the entire run where practical shall be upgraded to the current guide rail standards, including the guide rail parapet connections and end treatments.
3. Guide rail should not restrict sight distance. Sight distances should be checked when guide rail is to be installed at intersecting roadways, maintenance driveways, ramp terminals, along sharply curving roadways, etc. If the sight distance is determined to be inadequate, the guide rail placement shall be adjusted.
4. Guide Project limits should end outside the limits of a guide rail run where practical.

5. Gaps of 200 feet or less between individual guide rail installations should be avoided where possible.

6. Guide rail should not be installed beyond the right of way unless easements or necessary right of way is acquired.

7. Refer to the GR Standard Drawings for the guide rail treatment between adjacent bridges. Guide rail between parapets is not required if there is a concrete connecting wall 42 inches high (minimum) between parapets.

8. New guide rail shall not be installed on bridge decks, parapet safety walks, concrete islands, sidewalks, footings, or other concrete structures using post weldment base plate attachments, or by any other non-standard means of attachment. Where existing beam guide rail attachments have been installed in such locations, consideration should be given to replace the existing guide rail with concrete median barrier, barrier parapet, or other approved longitudinal barriers systems as part of a future reconstruction project, and with approval from the Authority's Engineering Department.

9. Proposed guide rail set flush with the curb line along intersection radius returns should be checked with a truck turning template. Existing guide rail along radius returns that experience truck overhang or oversteering accidents shall redesign the radius returns for a larger design vehicle or eliminate the warranting need for guide rail.

10. With the exception of beam guide rail transitions for parapet connections as shown on the GR Standard Drawings, Thrie beam guide rail shall not be substituted for W-beam guide rail unless there are extenuating circumstances and then only with approval from the Authority's Engineering Department.

11. All approach end treatments (tangent guide rail terminals, buried end terminals, etc.) shall be located on the construction plans by station and offset. The applicable flare rate shall also be indicated. Grading work necessary for construction of the guide rail end treatments shall be shown on the construction plans and shall conform to the GR Standard Drawings.

12. Pay limits of the various end treatments, attachments, and connections shall be as indicated on the GR Standard Drawings

13. The plans shall indicate the location of existing conduits or shall include a notation where there is a possibility of conflict in driving the beam guide rail posts.

14. In order to reduce soil erosion and highway maintenance costs associated with spraying or trimming vegetation underneath guide rail, berm surfacing shall be applied underneath guide rail as follows:

Guide Rail Types	Conditions Warranting Use of Berm Surface
Existing Guide Rail	Where upgrading
	Where regrading berms
	Where resetting guide rail
New Guide Rail	All Cases

Berm surfacing shall be constructed to the limits shown on the GR Standard Drawings.

15. Asphalt lip curb shall be applied underneath guide rail to control stormwater runoff as needed and shall be constructed as shown on the CU Standard Drawings.

Exhibit 4-6 Length of Need at Obstruction

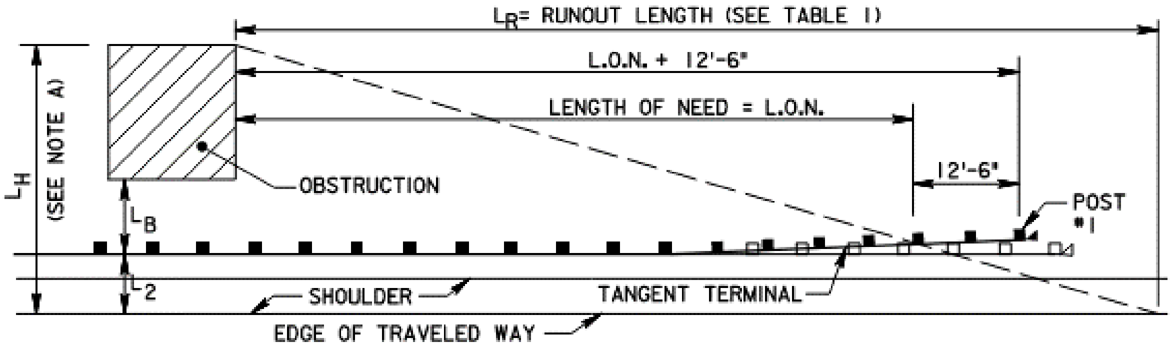


TABLE 1						
DESIGN SPEED (M.P.H.)	TRAFFIC VOLUME (A.D.T.)				SHY LINE OFFSET (FEET)	STRAIGHT FLARE RATE
	OVER 10,000	5,000 TO 10,000	1,000 TO 5,000	UNDER 1,000		
	L_R	L_R	L_R	L_R		
70	360	330	290	250	9	15:1
60	300	250	210	200	8	14:1
55	265	220	185	175	7	12:1
50	230	190	160	150	6.5	11:1
45	195	160	135	125	6	10:1
40	160	130	110	100	5	8:1
30	110	90	80	70	4	7:1

STEP 1. DETERMINING THE REQUIRED L.O.N. GRAPHICALLY IS THE PREFERRED METHOD. FOR TANGENT ROADWAYS, THE FOLLOWING FORMULAS MAY ALSO BE USED:

TANGENT TERMINAL WITH 2' OFFSET

$$L.O.N. = \frac{L_R\ (L_H - L_2 - 1.5)}{L_H}$$

TANGENT TERMINAL WITH 0' OFFSET

$$L.O.N. = \frac{L_R\ (L_H - L_2)}{L_H}$$

NOTE A. IF ROADWAY IS CURVED, THE L.O.N. MUST BE DETERMINED GRAPHICALLY. L_R IS MEASURED ALONG THE EDGE OF TRAVELED WAY. L.O.N. IS MEASURED ALONG THE GUIDE RAIL.

NOTE B. IF THE OBSTRUCTION EXTENDS BEYOND THE CLEAR ZONE, MAKE L_H EQUAL TO THE CLEAR ZONE, EXCEPT IF THE OBSTRUCTION IS A CRITICAL SLOPE, SEE EXHIBIT 4-7.

STEP 2. ADD AN ADDITIONAL 12'-6" TO GET THE REQUIRED LENGTH FROM THE OBSTRUCTION TO THE APPROACH END OF THE TANGENT GUIDE RAIL TERMINAL (POST #1).

STEP 3. COMPARE THE REQUIRED LENGTH FROM STEP 2 TO THE MINIMUM LENGTH IN TABLE 2 AND TO THE MINIMUM RECOVERY AREA LENGTH FROM THE GR STANDARD DRAWINGS. USE THE GREATER OF THE THREE LENGTHS.

NOTE C. FOR DIRECTIONS ON DETERMINING THE LENGTH OF THE BEAM GUIDE RAIL ITEM, SEE THE GR STANDARD DRAWINGS.

TABLE 2	
DISTANCE FROM FACE OF RAIL ELEMENT TO OBSTRUCTION (L_B)	MINIMUM LENGTH BASED ON POST SPACING (NOTE D)
$L_B \geq$ 4'-9"	50'-0"

NOTE D. MINIMUM DISTANCE FROM THE OBSTRUCTION TO THE APPROACH END OF TERMINAL (POST #1). SEE GR STANDARD DRAWINGS FOR REQUIRED POST SPACING.

NOTE E. THE TOTAL LENGTH OF A FREESTANDING GUIDE RAIL INSTALLATION INCLUDING THE APPROACH AND TRAILING END TREATMENTS SHOULD NOT BE LESS THAN 75'.

Exhibit 4-7 Length of Need Treatment for Critical Embankment Slopes

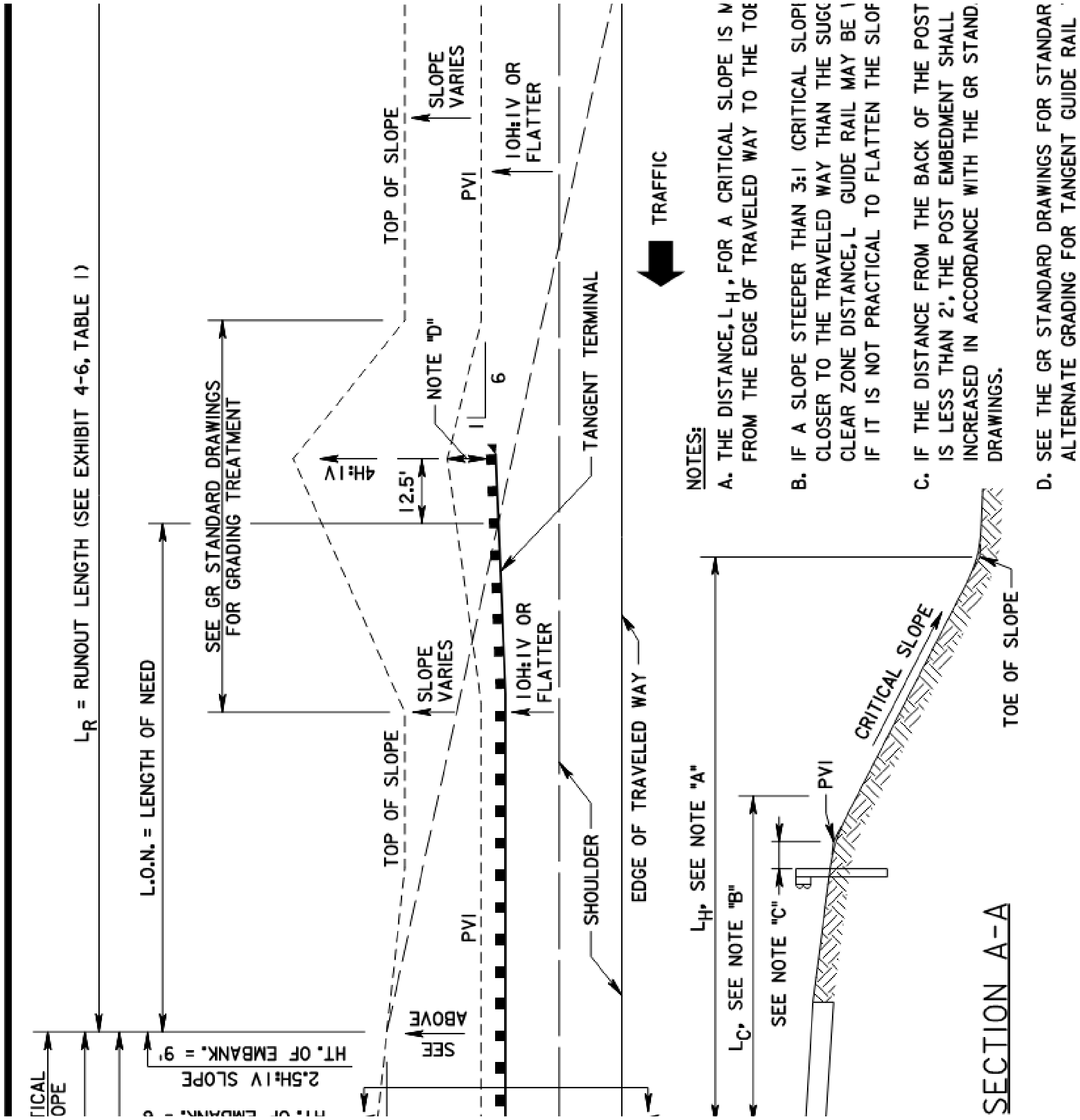
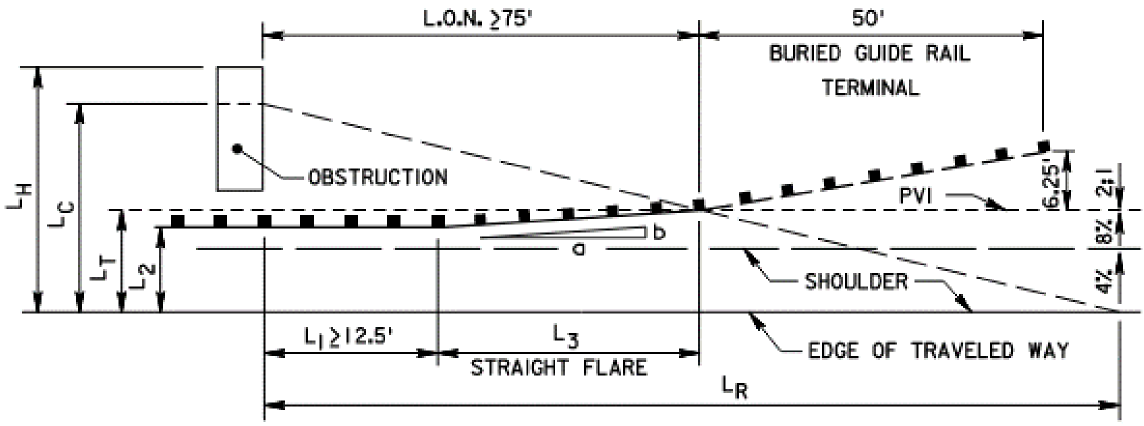


Exhibit 4-8 Length of Need Example for Buried Guide Rail End Terminal

WHERE AN OBSTRUCTION IS ENCOUNTERED IN A CUT SECTION AND IT IS TO BE SHIELDED WITH A BURIED GUIDE RAIL TERMINAL, IT IS DESIRABLE THAT THE LENGTH OF NEED (L.O.N.) END AT THE PVI (SEE GR STANDARD DRAWINGS FOR ADDITIONAL DETAILS). IN ORDER TO ACCOMPLISH THIS, THE LENGTH OF GUIDE RAIL PARALLEL TO THE PVI (L_1) MUST BE OBTAINED. THE FOLLOWING EXAMPLE SHOWS HOW THE L.O.N. IS COMPUTED:

EXAMPLE



V = 60 MPH

A.D.T. = 6,000

L_2 = 16'

L_H = 32'

L_R = 250' (FROM EXHIBIT 4-6, TABLE 1)

L_T = 19'

$\frac{a}{b}$ = 14:1 STRAIGHT FLARE (FROM EXHIBIT 4-6, TABLE 1)

L_C = 30' (FROM EXHIBIT 4-1, L_C=26'-30') FOR 8% FILL SLOPE

IF $L_H > L_C$ USE L_C IN FORMULA BELOW, IF $L_H < L_C$, REPLACE L_C WITH L_H IN FORMULA BELOW

$$L_1 = L_R - \frac{L_R\, L_T}{L_C} - \frac{a}{b}(L_T - L_2)$$

$$L_1 = 250 - \frac{250 \times 19}{30} - \frac{14}{1}(19 - 16) = 49.7'$$

49.7'/6.25' POST SPACING = 7.95 POSTS, THEREFORE, USE 8 POSTS AT 6.25' = 50' - L_1

FLARE LENGTH $L = \frac{a}{b}(L_T - L_2) = \frac{14}{1}(19 - 16) = 42'$

42'/6.25' POST SPACING = 6.72 POSTS, THEREFORE, USE 8 POSTS AT 6.25' = 50' - L_3

L.O.N. = $L_1 + L_3$ = 50' + 43.75' = 93.75'

THE MINIMUM L.O.N. AS SHOWN IN THE FIGURE ABOVE = 75'.

SINCE L.O.N. IS GREATER THAN 75', USE L.O.N. = 93.75'

Exhibit 4-9 Guide Rail Treatment for Open Gore Areas

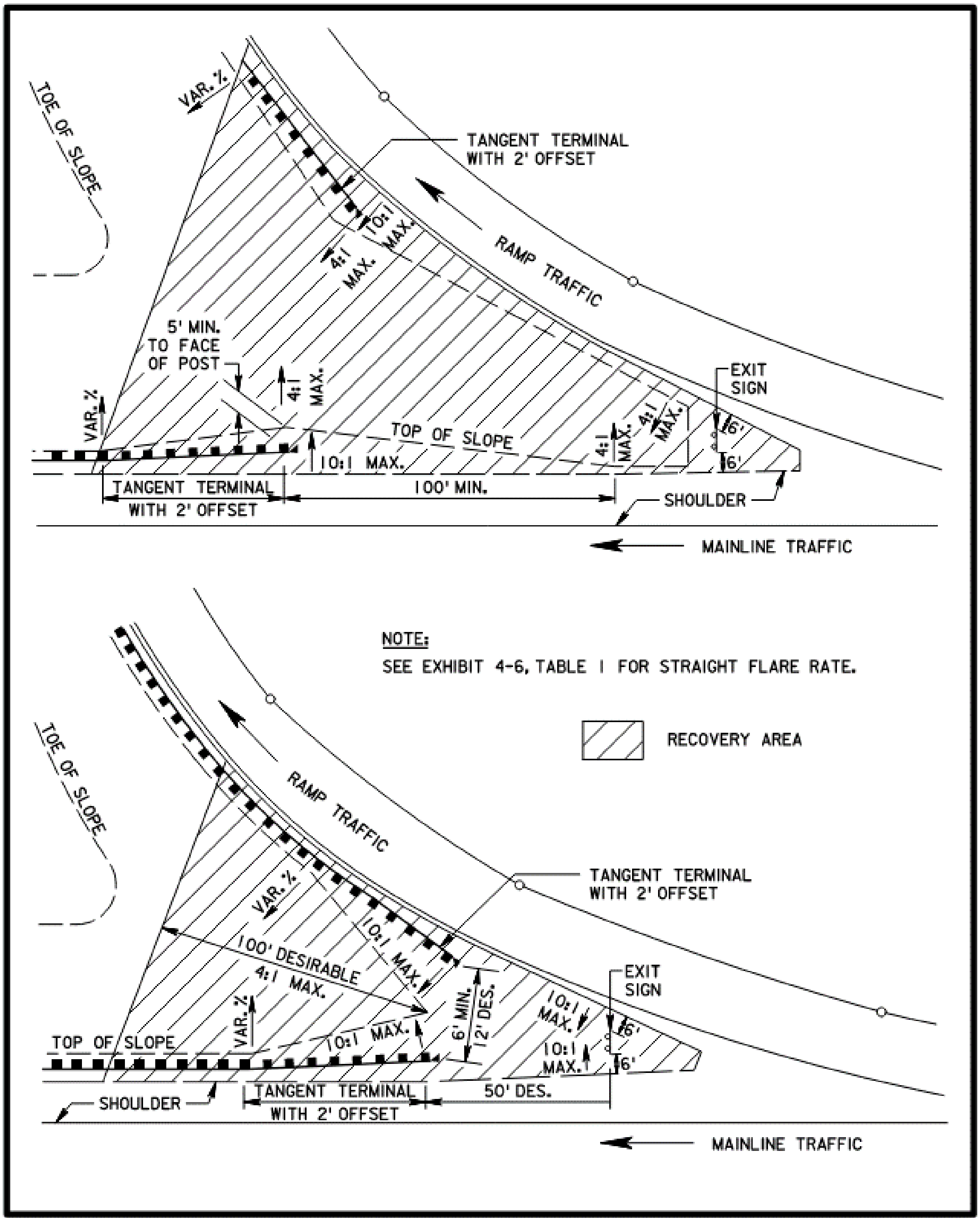
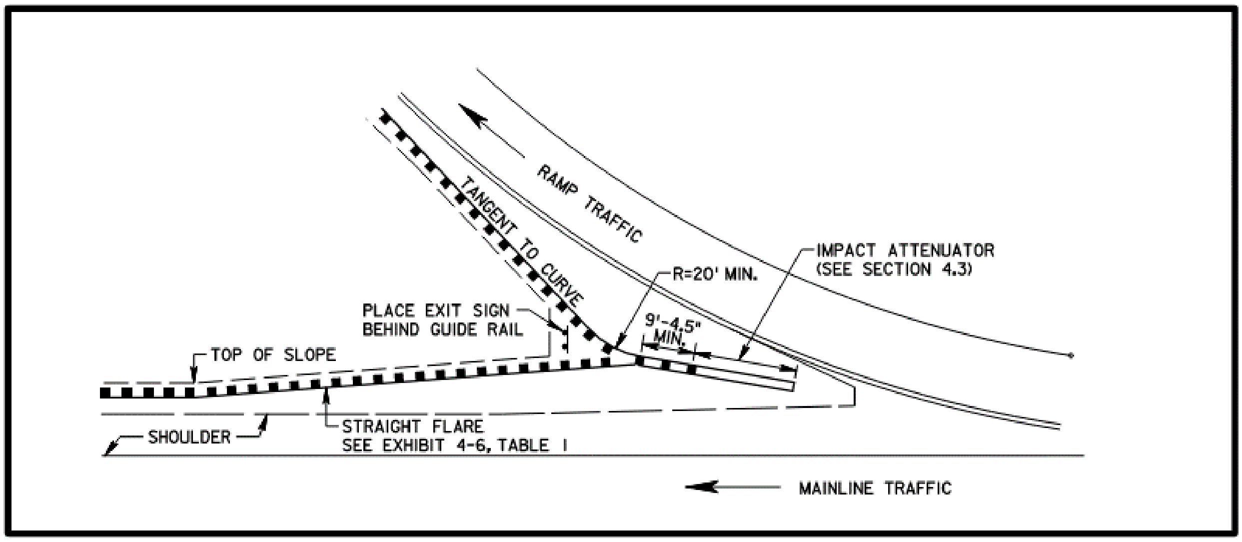


Exhibit 4-10 Guide Rail Treatment for Limited Gore Areas



4.3. MEDIAN BARRIERS

4.3.1. Median Barrier Warrants

1. Turnpike mainline roadways
   a. Concrete median barrier curb is required for all standard center median locations as indicated in Section 1 of this manual.
   b. Dual or single face guide rail is required for all standard inner-outer medians as indicated in Section 1 of this manual.
   c. Non-standard center and inner-outer medians which are 50 feet or greater in width do not warrant median barrier protection, unless otherwise directed by the Authority. At such locations, the median should be evaluated to determine if any fixed object obstructions or critical slopes are present within the clear zone of either adjacent roadway that would warrant roadside (guide rail) protection.
2. Parkway mainline roadways
   a. Median barrier is required for all medians less than 50 feet in width. Barrier type shall be as indicated in Exhibit 4-11.
   b. Medians which are 50 feet or greater in width do not warrant median barrier protection, unless otherwise directed by the Authority. At such locations, the median should be evaluated to determine if any fixed object obstructions or critical slopes are present within the clear zone of either adjacent roadway that would warrant roadside (guide rail) protection.

Exhibit 4-11 Median Width vs. Median Barrier Type

Median Width	Median Barrier Type
Up to 12 ft.	Concrete Barrier Curb
13 ft. to 26 ft.	Concrete Barrier Curb (Preferred Treatment) or Dual Face Beam Guide Rail
Above 26 ft.	Dual Face Beam Guide Rail

4.3.2. Dimensional Characteristics

Concrete median barrier curb for both Turnpike and Parkway roadways, when warranted, shall use MASH TL-5 conforming barrier that is a minimum 42-inches high (measured from gutter line at toe of barrier to top of barrier) as per the MB Standard Drawings.

Where concrete median barrier protection is used to shield an obstruction (bridge pier, abutment, sign pedestal, etc.) greater than 42 inches in height (measured from the gutter line elevation), the obstruction should desirably be offset as far as possible from the traffic face of the barrier to reduce the chance of impact from high profile vehicles leaning over the top of the barrier during collision. The minimum offset from the traffic face of the barrier to the nearest edge of the obstruction shall equal the zone of vehicle cab intrusion above the barrier. The zone of vehicle cab intrusion is defined as the distance between the pre-impact traffic face of the barrier (i.e. gutter line or toe of barrier) to the maximum lateral intrusion of a tractor trailer vehicle cab during the impact as derived from MASH Test 5-12 of concrete barriers with tractor trailer test vehicles. Reduction of the minimum shoulder widths as defined for each roadway in Section 1 and Section 2 of this manual to accommodate the desirable minimum barrier offset shall not be done without approval from the Authority's Engineering Department.

Design of the concrete median barrier curb shall account for the zone of vehicle cab intrusion values as summarized in **Exhibit 4-12**. The designer must specify modified concrete median barrier protection (72-inch height) when the nearest edge of the obstruction above the barrier (to a minimum height of 120 inches, measured from the gutter line elevation) does not accommodate the zone of vehicle cab intrusion of the standard 42-inch height barrier. The absolute minimum lateral offset from toe of barrier to nearest edge of the obstruction shall equal the zone of vehicle cab intrusion with 72-inch height barrier. For median sign pedestal foundations less than 72 inches tall, the height of the modified concrete median barrier protection shall be set flush with the top of pedestal foundation height. The designer shall not interpolate lateral cab intrusion for concrete median barrier protection heights between 42 inches and 72 inches. The full height of modified concrete median barrier protection should be developed and extended in advance of the obstruction as shown on the MB Standard Drawings.

Exhibit 4-12 Median Barrier Design Parameters

Median Barrier Type	Lateral Cab Intrusion (inches)
Concrete Median Barrier, Protection Concrete Median Barrier, Roadway Concrete Median Barrier, Bridge (42-inch Height)	21
Modified Concrete Median Barrier, Protection (72-inch Height)	15

Refer to Section 4.2.3 for dimensional characteristics of dual or single face beam guide rail when used in medians.

4.3.3. Median Barrier End Treatments

Where a median barrier terminates within the clear zone area, a crashworthy end treatment shall be used. Acceptable methods of developing a crashworthy end treatment are to use an impact attenuator with concrete barrier curb or dual-faced guide rail.

The introduction of new or existing median concrete barrier curb within the clear zone (other than at intersections) shall be protected with an impact attenuator regardless of the posted speed.

Refer to Section 4.2.4 for end treatments of dual or single face beam guide rail when used in medians.

4.4. Impact Attenuators

4.4.1. General

The following provides general guidance for the use of attenuators. Attenuators should be MASH compliant test level 3 (TL-3) devices. Attenuators which are NCHRP 350 compliant should only be considered when a MASH compliant TL-3 device suitable for the site-specific needs is unavailable, and with approval from the Authority's Engineering Department. The designer shall always consider site-specific conditions and consult with the Authority for their preferred devices when selecting attenuators. An attenuator is a type of traffic barrier that can be used to shield warranting obstructions such as overhead sign supports, bridge piers, bridge abutments, ends of retaining walls, bridge parapets, bridge railings, longitudinal barriers, etc. Due to the maintenance needs of attenuators, the Engineer shall attempt to place obstructions beyond the clear zone when practical or provide designs that will avoid the need to require shielding by attenuator.

The most common use of an attenuator is to prevent errant vehicles from impacting a warranting obstruction in a gore. However, an attenuator can also be used to prevent errant vehicles from impacting warranting obstructions in the median and along the roadside (see Exhibit 4-13).

Existing attenuators shall be evaluated to determine whether repairs or replacements are necessary.

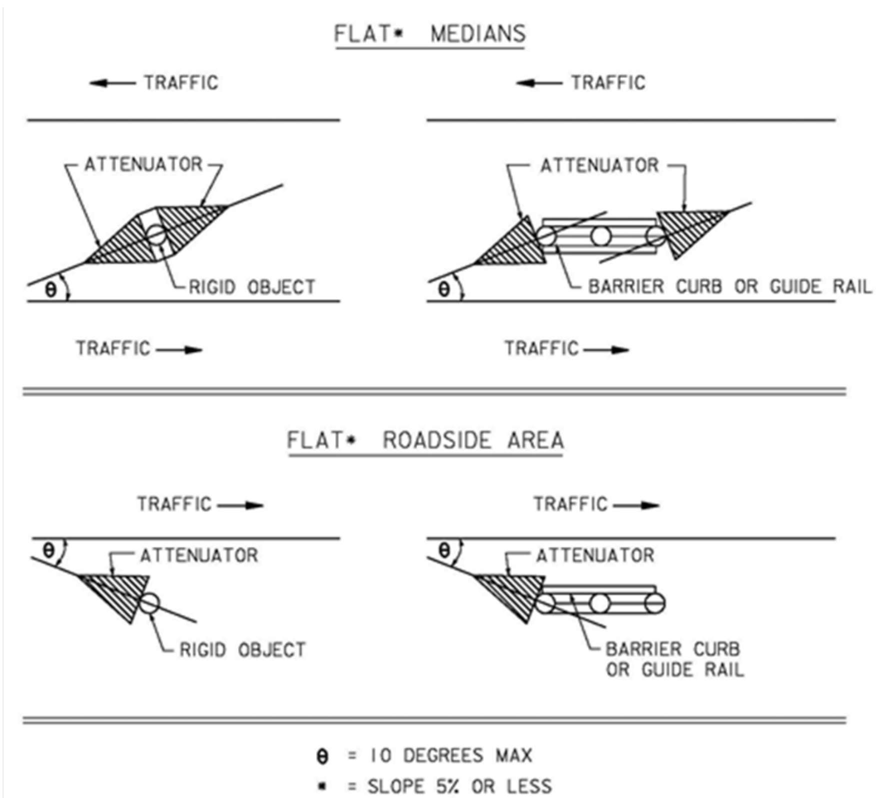
Several factors must be evaluated when selecting and placing an attenuator. The factors which normally should be considered are briefly discussed below. Use the manufacturer's design manual when designing an attenuator.

4.4.2. Dimensions of the Obstruction

The attenuator shall be the necessary width to shield the obstruction.

Attenuators are not ordinarily used along the length of an obstruction. Usually guide rail or barrier curb is used. Exhibit 4-13 shows typical installations where an attenuator is used in conjunction with a barrier curb or guide rail.

Exhibit 4-13 Attenuators in Median and Roadside



4.4.3. Space Requirements

1. Reserve area for attenuator:

   Exhibit 4-14 shows dimensions to be used in determining if adequate space is available for the installation of an attenuator. Although it depicts a gore location, the same recommendations will apply to other types of obstructions that require shielding by an attenuator. Also, Exhibit 4-14 shows a range of dimensions, the significance of which is as follows:

   a. Minimum:

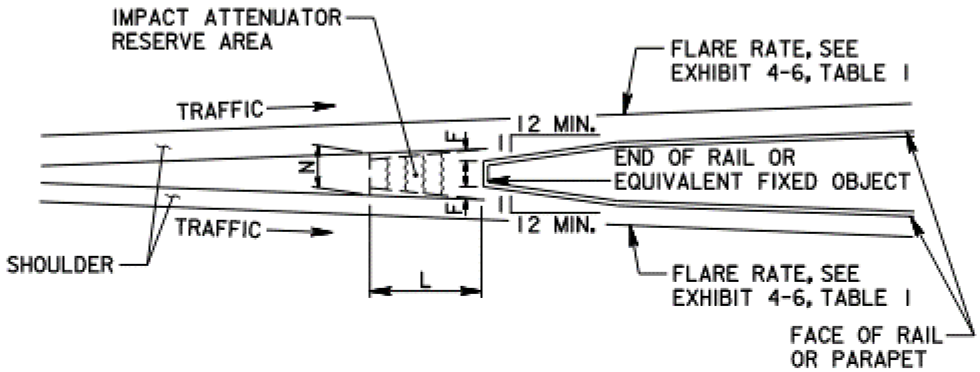
      Restricted Conditions - These dimensions approximately describe the space required for installation of the current systems without encroachment on shoulders and the nose of the device offset slightly back of the parapet or shoulder line.

      Unrestricted Conditions - These dimensions should be considered as the minimum for all projects where plan development is not far advanced except for those sites where it can be shown that the increased cost for accommodating these dimensions, as opposed to those for Restricted Conditions, will be unreasonable. For example, if the use of the greater dimensions would require a considerable increase in construction or property acquisition costs, then the lesser dimensions might be considered.

   b. Preferred:

      These dimensions should be considered optimum. There is no intention to imply that if a space is provided in accordance with these dimensions that the space will be fully occupied by an attenuator. The reason for proposing these dimensions is so that, if experience shows that attenuators should be designed for greater ranges of vehicle weights and/or for lower deceleration forces, there will be space available for installation of such attenuators in the future. In the meantime, the unoccupied reserved attenuator space will provide valuable additional recovery area.

Exhibit 4-14 Attenuator Reserve Area



DESIGN SPEED ON MAINLINE (M.P.H.)	DIMENSIONS FOR ATTENUATOR RESERVE AREA ON NEW CONSTRUCTION (FEET)								
	MINIMUM						PREFERRED		
	RESTRICTED CONDITIONS			UNRESTRICTED CONDITIONS					
	N	L	F	N	L	F	N	L	F
30	6	8	2	8	11	3	12	17	4
50	6	17	2	8	25	3	12	33	4
70	6	28	2	8	45	3	12	55	4

NOTE:

FOR INTERMEDIATE DESIGN SPEEDS, USE VALUES FOR THE HIGHER DESIGN SPEED (I.E. FOR DESIGN SPEED OF 40 M.P.H. USE VALUES FOR 50 M.P.H. DESIGN SPEED).

4.4.4. Geometrics of the Site

The vertical and horizontal alignments, especially curvature of the road and sight distance, are key factors to be considered. Adverse geometrics could contribute to a higher than normal frequency of impacts.

4.4.5. Physical Conditions of the Site

The presence of a curb can seriously reduce the effectiveness of an impact attenuator. All curb shall be removed 50 feet in front of an attenuator and along the unit's length. New curbs should not be built where attenuators are to be installed. When a curb originates behind an attenuator, the curb should be gently flared and/or ramped. Flares of 15:1 are recommended. Ramping of curb should be done in accordance with the CU Standard Drawings.

All attenuators should be placed on a concrete or asphalt surface as required by the manufacturer.

It is recommended that attenuators be placed on a relatively flat surface in accordance with the manufacturer's specifications. Longitudinal and transverse slopes in excess of the specified value could adversely affect the performance of an attenuator and should be avoided or altered as necessary.

Pavement joints, especially expansion joints, in the attenuator area may require design accommodations for those attenuators that require anchorage.

Site conditions should be evaluated in consideration of the attenuator gating and non-gating components. Attenuators may comprise a combination of gating and non-gating features. Gating systems are designed to allow vehicles impacting near the beginning or nose of the system to safely pass through the unit and travel behind the system. Non-gating systems are designed to capture vehicles striking the end of the system and safely decelerate them to a stop.

4.4.6. Redirection Characteristics

Consider the redirection capabilities of each type of attenuator specific to the physical conditions and space restrictions of the site. Attenuators used in a permanent condition shall be redirective. Attenuators used in a temporary condition may be either redirective or non-redirective.

4.4.7. Design Speed

The type of attenuator selected shall be designed to accommodate the design speed of the roadway where the warranting obstruction is present.

4.4.8. Allowable Deceleration Force

Where practical, attenuators should be designed for a deceleration force of 6G's. Where space is limited, an attenuator may be designed for a maximum of 8G's.

4.4.9. Backup Structure Requirements

Consider whether each type of attenuator requires a backup structure capable of withstanding the forces of an impact based on the manufacturer's specifications.

4.4.10. Anchorage Requirements

Consider whether each type of attenuator requires an anchorage capable of restraining the attenuator during an impact based on the manufacturer's specifications.

4.4.11. Maintenance

Consider which parts of each attenuator are typically reusable and which parts are not after a collision based on the manufacturer's specifications.

REFERENCES

Roadside Design Guide, AASHTO

Manual for Assessing Safety Hardware (MASH), AASHTO

Section 5 - DRAINAGE DESIGN

5.1. GENERAL INFORMATION

Established herein are the general guidelines of the Authority's policy for the perpetuation of existing watercourses affected by Authority projects, for the design of Authority roadway surface water and ground water drainage facilities, stormwater management facilities and for erosion protection measures to be incorporated into Authority projects.

Investigating the impacts of surface water on the roadway pavement, bridges, culverts, channels, and surrounding land is an integral part of every Authority project. The result of this investigation is a design, included in the plans, that provides an economical means of accommodating surface water to minimize adverse impacts in accordance with the design procedures and applicable regulations.

Traffic safety is related to surface drainage. Rapid removal of stormwater from the roadway pavement minimizes hazardous conditions, such as hydroplaning. Adequate cross-slope and longitudinal grade enhance such rapid removal. Where curbs and gutters are necessary, the provision of sufficient inlets in conjunction with satisfactory cross-slopes and longitudinal slopes are necessary to efficiently remove the water and limit the spread of water on the pavement. Inlets placed at strategic locations at ramp intersections and approaches to superelevated curves will reduce the likelihood of gutter flows spilling across roadways. Satisfactory cross-drainage facilities will limit the buildup of ponding against the upstream side of roadway embankments and avoid overtopping of the roadway.

Stormwater management is an important consideration in the design of roadway drainage systems. Existing downstream conveyance constraints, particularly in cases where the roadway drainage system connects to existing pipe systems, may warrant installation of stormwater best management practices to limit the peak discharge to the downstream system and provide water quality treatment. Specific stormwater management requirements to provide treatment and control the rate and volume of runoff may be dictated by various regulatory agencies.

The optimum roadway drainage design should achieve a balance between public safety, the capital costs, operation and maintenance costs, public convenience, environmental enhancement and other design objectives.

It is essential that the Engineer have a working knowledge of established hydrologic, hydraulic, and stormwater management principles and access to the reference material cited in this section, in order to implement the policies established herein. The purpose of this section is to provide the technical information and procedures required for the design of culverts, storm drains, channels, and stormwater management facilities. This section contains design criteria and information that will be required for the design of roadway drainage structures. The complexity and continual progress of the subject requires referring to additional design manuals, reports, and regulations for more detailed information on several subjects. The Engineer shall also refer to Section 10 (Landscaping) of this manual for additional requirements.

5.1.1. Definitions and Abbreviations

The following terms are used throughout this section.

ALLOWABLE HEADWATER ELEVATION (AWH) – The allowable water surface elevation upstream of a culvert or bridge.

ALLOWABLE WATER SURFACE ELEVATION (AWS) – The water surface elevation above which damage will occur or will result in a violation of a Federal, State, or Local regulation.

ANNUAL EXCEEDANCE PROBABILITY (AEP) – The probability (%) that a magnitude of the random variable event (e.g. 1% event) will be equaled or exceeded each year.

BACKWATER - The measurable increase in depth of water upstream from a dam, culvert, or other drainage structure due to the existence of an obstruction.

BEST MANAGEMENT PRACTICE (BMP) – A structural feature or non-structural development strategy designed to minimize or mitigate for impacts associated with stormwater runoff, including flooding, water pollution, erosion and sedimentation, and reduction in groundwater recharge.

BIORETENTION SYSTEM – A stormwater management treatment system used to address water quality treatment, quantity impacts, and groundwater recharge consisting of a soil bed planted with native vegetation. It can be configured as either a bioretention basin or a bioretention swale. Stormwater runoff entering the bioretention system is filtered first through the vegetation and then the sand/soil mixture before being infiltrated into the subsoil or conveyed downstream by an optional underdrain system.

CATEGORY ONE WATERS – Those waters designated in the applicable tables in N.J.A.C. 7:9B for the purposes of implementing the antidegradation polices in N.J.A.C. 7:9B for protection from measurable changes in water quality based on exceptional ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resource(s) to protect their aesthetic value (color, clarity, scenic setting) and ecological integrity (habitat, water quality and biological functions). More information on Category One Waters can be found on the New Jersey Department of Environmental Protection's (NJDEP) websites:

https://www.nj.gov/dep/ and https://www.nj.gov/dep/wms/bears/swqs.htm

CHANNEL - A linear topographic depression that continuously or intermittently confines and/or conducts surface water. It has a definite bed and banks which confine the water. A channel can be naturally occurring or manmade and, dependent upon its classification and drainage area, may be considered a regulated waterway by NJDEP.

CULVERT – A hydraulic structure that is typically used to convey surface waters through embankments. A culvert is typically designed to take advantage of submergence at the inlet to increase hydraulic capacity. It is a structure, as distinguished from a bridge, which is usually covered with embankment and is composed of structural material around the entire perimeter, although some are supported on spread footings with the streambed serving as the bottom of the culvert. Culverts are differentiated from bridges as having spans typically less than 25 feet.

DAM - Any artificial dike, levy or other barrier, together with appurtenant works, which impounds water on a permanent or temporary basis, that raises the water level 5 feet or more above its usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest; or, in the absence of an emergency spillway, to the top of dam.

DESIGN FLOW - The flow rate that is selected as the basis for the design or evaluation of a drainage system or hydraulic structure.

DRAINAGE STRUCTURE – A pipe, inlet, manhole, junction chamber, stormwater management measure, or other similar facility or device used for drainage and/or stormwater management purposes.

FLUVIAL FLOOD – A flood, which is caused entirely by runoff from rainfall in the upstream drainage area and is not influenced by the tide or coastal storm surge.

FLOOD HAZARD AREA – The land and space above that land, which lies below the flood hazard area design flood elevation, as defined by NJDEP regulations.

FLOODPLAIN – The land and space above that land, which lies below the design flood elevation. The portion of the land area susceptible to being inundated by floodwaters when a waterway overflows at its banks at flood stage. An area designated by a governmental agency as a floodplain.

GREEN INFRASTRUCTURE – A stormwater management measure that manages stormwater close to its source by treating stormwater runoff through infiltration into subsoil, treating stormwater runoff through filtration by vegetation or soil, or storing stormwater runoff for reuse.

PIPE - A conduit that conveys stormwater from the inlet(s) to an outfall where the stormwater is discharged to the receiving waters. The drainage system consists of differing lengths and sizes of pipe connected by drainage structures.

RECURRENCE INTERVAL – The reciprocal of the annual exceedance probability of a hydrologic or hydraulic event (also return period, exceedance interval, e.g. 100-year event).

REGULATORY FLOOD – The Design Flood event required to comply with NJDEP Flood Hazard Control Area Control Act Rules (N.J.A.C. 7:13), the NJDEP Dam Safety Standards (N.J.A.C. 7:20), or any other applicable Federal, State, or Local regulations. Regulatory compliance may be required even in the absence of a floodplain delineation based on State adopted flood studies or FEMA mapping.

SCOUR – Erosion of stream bed or bank material due to flowing water; often considered as being localized.

TIME OF CONCENTRATION (TC) – Time required for runoff to travel from the hydraulically most distant (but hydraulically significant) of the watershed to a point of interest within the watershed.

TOTAL SUSPENDED SOLIDS (TSS) - Solids in water that can be trapped by a filter, which include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage.

5.1.2. Design Procedure Overview

The following outlines the general process of design for roadway drainage systems. Detailed information regarding drainage design is included in the remainder of this Section.

1. Preliminary Investigation: Perform a preliminary investigation using available record data, including reports, studies, plans, topographic maps, etc., supplemented with field reconnaissance. Information should be obtained for the project area and for adjacent stormwater management projects that may affect the highway drainage.
2. Site Analysis: At each site where a drainage structure(s), hydraulic structure(s), or stormwater management facility(ies) will be constructed, the following items should be evaluated as appropriate information given by the preliminary investigation:
   a. Drainage Area
   b. Land Use
   c. Allowable Headwater
   d. Effects of Adjacent Structures (upstream and downstream)
   e. Existing Streams and Discharge Points
   f. Stream Slope and Alignment
   g. Stream Capacity
   h. Soil Erodibility
   i. Soil Hydraulic Conductivity (BMPs)
   j. Environmental permit concerns and constraints

   Coordination is needed with representatives of the various environmental disciplines to fully develop the site analysis.
3. Recurrence Interval: Select a recurrence interval in accordance with the design policy set forth in Subsection 5.1.2.3.

4. Hydrologic Analysis: Compute the design flow utilizing the appropriate hydrologic method outlined in Subsection 5.4.

5. Hydraulic Analysis: Select a drainage system to accommodate the design flow utilizing the procedures outlined in the following parts:

   a. Drainage of Roadway Pavement - Subsection 5.8
   b. Storm Drains - Subsection 5.9
   c. Median Drains - Subsection 5.10
   d. Channel Design - Subsection 5.11
   e. Culvert Design - Subsection 5.12
   f. Bridge Design – Section 3

6. Environmental Considerations: Environmental impact of the proposed drainage system and appropriate methods to avoid or mitigate adverse impacts should be evaluated. Items to be considered include:

   a. Stormwater Management
   b. Water Quality
   c. Soil Erosion and Sediment Control
   d. Special Stormwater Collection Procedures
   e. Special Stormwater Disposal Procedures
   f. Special Stormwater Offsite Feasibility Investigations
   g. Total Daily Maximum Load Requirements for a Receiving Waterway

   These elements should be considered during the design process and incorporated into the design as it progresses.

7. Drainage Review: The Engineer should inspect the drainage system sites to check topography and the validity of the design. Items to check include:

   a. Drainage Area – Size, land use and improvements.
   b. Effects of Allowable Computed Headwater.
   c. Performance of existing or adjacent structures; erosion and evidence of high water marks and indications of high groundwater.
   d. Channel Condition-Erosion, vegetation, alignment of proposed facilities with channels, and impacts on environmentally sensitive areas.

5.1.2.1. **Stormwater Management and Non-Point Source Pollution**

Stormwater is a component of the total water resources of a project area and should not be casually discarded but rather, where feasible, should be used to replenish the natural environment. In many instances, stormwater problems signal either misuse of a resource or unwise land activity.

Poor stormwater management increases total flow rates, flow volumes, flow velocity and depth of water in downstream channels. In addition to stormwater peak discharge and volume impacts, roadway construction or modification usually increases non-point source pollution primarily due to the increased impervious area. Properly designed stormwater management facilities, particularly green infrastructure BMPs, can also be used to mitigate non-point source pollution impacts by providing infiltration, filtration, and extended detention, thereby allowing absorption or settlement of suspended solids. Subsection 5.6 and the Stormwater Best Management Practices Manual prepared by the NJDEP provide the guidance in the planning, design, and maintenance of these facilities.

An assessment of the impacts the project will have on existing peak flows, volumes, and watercourses shall be made by the Engineer during the initial phase. The assessment shall identify the need for stormwater management (SWM) and non-point source pollution control (NPSPC) facilities and potential locations for these facilities. Mitigating measures can include, but are not limited to, bioretention systems, infiltration systems, detention basins, grassed swales, channel stabilization measures, and easements.

Stormwater management, whether structural or non-structural, on- or off-site, must fit into the natural environment, and be functional, safe, and aesthetically acceptable. Several approaches to manage stormwater and provide water quality are possible for any location. Careful design and planning by the Engineer, hydrologist, biologist, environmental scientist, and landscape architect can produce optimum results.

Design of SWM and NPSPC measures must consider both the natural and man-made existing surroundings. The Engineer should be guided by this and include measures in the design plans that are compatible with the site-specific surroundings. Revegetation with native, non-invasive grasses, shrubs and possibly trees may be required to achieve compatibility with the surrounding environment and compliance with environmental regulations. Design of major SWM and NPSPC facilities may require coordination with the Authority and other state and various regulatory agencies.

SWM and NPSPC facilities shall be designed in accordance with Subsection 5.6 and the NJDEP's Stormwater Best Management Practices Manual or other regulatory criteria where applicable, as directed by the Authority's Engineering Department.

Discharge of roadway runoff to nearby waterways that either cross the roadway or are adjacent to it spaced at large distances, requires installation of long conveyance systems. Vertical design constraints may make it impossible to drain a pipe or swale system to existing waterways. Discharging the runoff to the groundwater with a series of infiltration BMPs or other green infrastructure BMPs, may be an appropriate alternative if groundwater levels and non-contaminated, permeable soil conditions allow the system to function as designed. The decision to select an infiltration facility, designed to exceed applicable environmental water quality requirements, must consider geotechnical, maintenance, and possibly right of way (ROW) impacts and will only be allowed if no alternative exists.

The infiltration facilities must be designed to store the entire runoff volume for a design storm compatible with the storm frequency used for design of the roadway drainage facilities or as directed by the Authority's Engineering Department. As a minimum, the infiltration facilities shall be designed to manage stormwater runoff in accordance with the applicable NJDEP requirements, or other applicable environmental requirements. The facility's emergency overflow should be designed to safely convey the larger flows to a stable discharge point.

Installation of infiltration facilities can also satisfy runoff volume control and water quality concerns, which may be required by an environmental permit.

Additional design guidelines are included in the NJDEP Stormwater Best Management Practices Manual.

5.1.2.2. **Allowable Water Surface Elevation**

Determine the allowable water surface elevation (AWS) at every site where a drainage facility will be constructed. The proposed drainage structure should cause a ponding level, hydraulic grade line elevation, or backwater elevation no greater than the AWS when the design flow is imposed on the facility. The AWS must comply with NJDEP regulations for locations that require a permit from the Division of Land Resource Protection (e.g. Flood Hazard Area, CAFRA, or Waterfront Development). The AWS upstream of a proposed drainage facility at locations that do not require an NJDEP permit should not cause additional flooding outside the Authority's property or acquired easements. An AWS that exceeds a reasonable limit may require concurrence of the affected property owner.

Existing floodplain studies prepared by the NJDEP, the Federal Emergency Management Agency, the U.S. Army Corps of Engineers, or other recognized agencies may be available at some sites. The elevations provided in the approved study will be used in the hydraulic model. Additional elevations based on guidance from relevant agency resources (e.g. National Cooperative Highway Research Program or FHWA) must be discussed with regulatory staff and approved by the Authority's Engineering Department.

EXHIBIT 5-1 presents additional guidelines for determining the AWS at locations where a permit from NJDEP is not required.

EXHIBIT 5-1 ALLOWABLE WATER SURFACE (AWS)

Land Use or Facility	AWS
Residential, Commercial, Industrial Buildings	Floor elevation (slab floor), basement window, basement drain (if seepage potential is present)
Bridge	Low steel
Culvert	Top of culvert - New structure Outside edge of road - Existing structure
Levee	Min 1 foot below top of Levee
Dam	See NJDEP Dam Safety Standards (N.J.A.C. 7:20)
Channel	Min 1 foot below top of low bank
Road	Min 1 foot below top of grate or manhole rim for storm sewers

The peak 100-year water surface elevation for any new stormwater management facility must be contained within Authority property or acquired easements. No additional flooding shall result outside the Authority property or acquired easements.

5.1.2.3. Recurrence Interval

Select a flood recurrence interval/AEP consistent with EXHIBIT 5-2:

EXHIBIT 5-2 RECURRENCE INTERVAL/AEP

Recurrence Interval	AEP	Facility Description
NJ Flood Hazard Area Design Flood	N/A	Any bridge, culvert, or other drainage facility that conveys or impacts a waterway regulated by NJDEP Division of Land Resource Protection.
100-Year	1%	Any stormwater management facility that requires approval under a project specific NJDEP stormwater permit or the Authority's Highway Agency Municipal Separate Storm Sewer System (MS4) permit. Various drainage structures crossing waterways requiring hydraulic or scour analyses.
50-Year	2%	Any drainage structure that passes water under a freeway or interstate highway (New Jersey Turnpike & Garden State Parkway) embankment, with a headwall or open end at each side of the roadway, that is also not conveying a waterway regulated by NJDEP.
25-Year	4%	Pipes along the mainline of a freeway or interstate highway (New Jersey Turnpike & Garden State Parkway) that convey runoff from a roadway low point to the discharge point, a waterway, or a stormwater management facility.
15-Year	6.7%	Longitudinal systems and cross drain pipes of a freeway or interstate highway (New Jersey Turnpike & Garden State Parkway).

5-Year	20%	Parking lots and other paved areas not subject to high speed vehicular traffic.

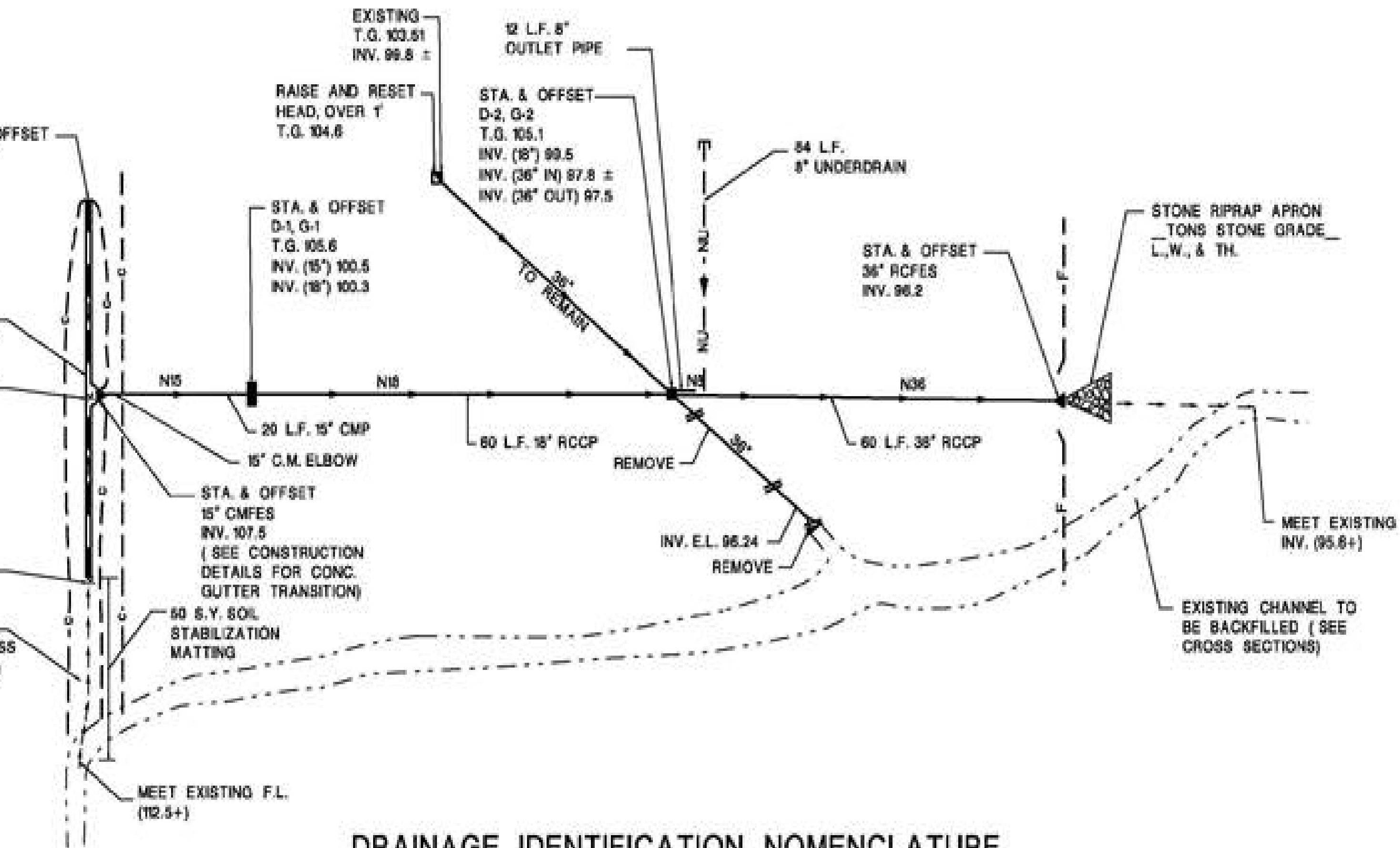
5.1.3. Plan Preparation and Submission Criteria

Plan preparation and submissions for construction contracts shall conform to the applicable requirements of Sections 3 (Submission Requirements), 6 (Roadway Plan Preparation) and 7 (Structures Plan Preparation) of the Procedures Manual. In addition, Exhibit 5-3 illustrates the required method of “Calling Out” drainage descriptions on the plan sheets. The concepts illustrated on this exhibit and in the following list below are to be utilized for the plan sheets for all contracts prepared with a plan and cross section format.

1. Roadway typical sections shall show typical pavement types which refer to the Standard Drawings for typical underdrain construction details.
2. Plan locations for infield inlets shall be as scaled from the Plans during construction.
3. Underdrain pipes running adverse to, or not parallel with, established roadway profiles shall be located vertically by invert elevation callouts on the Plans.
4. Gradients for 8” outlet pipes may be established by invert elevations on the Plans or by minimum gradients established by plan note or supplementary specifications.
5. All proposed drainage facilities including ditches shall be defined by construction details, except for those covered by the Standard Drawings.
6. Ditch inverts and offsets shall be shown on roadway cross sections; however, beginning, ending and critical intervening offsets and/or elevations shall be shown on the Plans.
7. All drainage quantities not shown on cross sections shall be noted on the Plans.

Permit documents and plans shall conform to the applicable requirements of Section 3 (Submission Requirements) of the Procedures Manual and Subsection 5.3 below.

EXHIBIT 5-3 DRAINAGE IDENTIFICATION NOMENCLATURE



DRAINAGE IDENTIFICATION NOMENCLATURE
PLAN / CROSS SECTION FORMAT

5.2. LEGAL ASPECTS

The New Jersey Courts, in recent decisions, have relied on the principle of "Reasonable Use" in determining liability with regard to a property owner's responsibility for the effect of drainage, generated by his land use, upon adjacent landowners. The Reasonable Use concept is subject to the interpretation of the courts for each individual situation, but, in general, the courts have recognized the right of a land owner to make use of his property and to discharge natural waters onto the property of a downstream land owner, so long as the use and the means of discharge do not unreasonably change existing conditions or burden the adjacent owner.

Conditions which, in the past have been interpreted by the courts as unreasonable use include: the diversion of waters by physically changing watershed boundaries; the concentration of flow at the point of discharge on downstream lands; and the movement of the point of concentrated discharge on downstream lands. The effect of paving upstream lands to an extent which increases the peak flow onto downstream lands has not been consistently ruled upon by the courts; however, such pavement situations are certainly within the scope of land uses to be decided by the courts as being reasonable or unreasonable.

In view of the aforementioned factors, all drainage practices which have in the past been considered unreasonable uses should be avoided on Authority projects. All existing watersheds should be defined and perpetuated as a prerequisite to all other drainage design considerations. Established watercourses should be used for the discharge of all Authority drainage systems. The effects of paving and other Authority construction on runoff rates, volumes, and other factors should be evaluated in light of the reasonable use concept. Stormwater management BMPs and other devices should be considered where Authority uses appear unreasonable or the system downstream is inadequate to handle even a reasonable increase.

In the absence of more specific guidelines, an overall runoff coefficient (Rational Method) of 0.35 for the aggregate of all paved and grassed areas within Authority Right of way is suggested as the upper limit of reasonable use of lands owned by the Authority, unless analysis of existing development of adjacent private lands in the same watershed results in a higher runoff coefficient. Under these latter circumstances, the higher runoff coefficient may be considered as the limit of reasonable use of Authority lands. These reasonable use guidelines are not applicable to floodplain areas along flood prone streams where appreciable previously available flood detention storage is being eliminated by the Authority project. Refer to N.J.A.C. 7:13 "Flood Hazard Area Control Act Rules", effective October 6, 2014 and all Amendments, for regulations relating to floodplain use.

5.3. PERMITS AND REGULATORY COMPLIANCE

Proposed construction must comply with the requirements of various regulatory agencies. Depending on the project location, these agencies could include, but are not limited to, the US Army Corps of Engineers, US Coast Guard, the New Jersey Department of Environmental Protection, the Pinelands Commission, New Jersey Sports and Exposition Authority, and the Delaware and Raritan Canal Commission.

The following is a listing of some of the permits and approvals that are normally required. It is not intended to be a comprehensive listing. Environmental regulations are "living" documents that are regularly created, amended, revised, replaced, or revoked. It is the Engineer's responsibility to ascertain which permits and approvals will be necessary. For large and complex projects, it is suggested that NJDEP Office of Permitting and Project Navigation be consulted. The Office of Permitting and Project Navigation provides a one-step permit identification process and single point of contact between the various NJDEP regulatory units.

The Engineer shall review the project during Phase "A" and determine which agencies will require a permit. A written summary of the findings shall be submitted to the Authority's Engineering Department. Subsequently, a pre-application conference should be arranged with the agencies to confirm their jurisdiction and permit requirements.

The Engineer shall prepare all the required permit documents and plans for review and execution by the Authority. Any review fees incidental to the permits should be paid for by the Engineer to be reimbursed by the Authority, unless otherwise provided in the contract or instructed by the Authority.

5.3.1. Federal

US Army Corps of Engineers – Section 404 Permit
Section 404 of the 1972 Federal Water Pollution Control Act (P.L. 92-500) requires that any dredging or filling within the waters of the United States (below mean high water) be regulated. The USACE has been assigned this regulatory function. Depending upon the location, either the New York District or the Philadelphia District will have jurisdiction. The USACE also has joint jurisdiction in the New Jersey Meadowlands.

US Army Corps of Engineers – Section 408 Approval
Section 14 of the Rivers and Harbors Act of 1899 (Section 408 of U.S.C. 33) requires alterations or impacts to Federal Civil Works projects (e.g. levees, maintained navigation channels) be regulated. The USACE has been assigned this regulatory function. Depending upon the location, either the New York District or the Philadelphia District will have jurisdiction.

US Army Corps of Engineers – Section 410 Permit
Section 10 of the Rivers and Harbors Act of 1899 requires authorization from the USACE for the construction of any structure in or over any navigable water of the

United States. The USACE has been assigned this regulatory function. Depending upon the location, either the New York District or the Philadelphia District will have jurisdiction.

US Coast Guard (USCG) – Bridge Permit

Section 9 of the Rivers and Harbors Act of 1899 and the General Bridge Act of 1946 require authorization from the USCG for the construction of any bridge in or over any navigable water of the United States. The USCG has been assigned the primary regulatory function under Section 9. Certain project situations may result in the regulatory functions being transferred to the USACE during initial inter-agency coordination. Depending upon the location, either USCG District 1 or 5 or USACE New York District or the Philadelphia District will have jurisdiction.

5.3.2. State

1. NJDEP - Division of Land Resource Protection
   a. Flood Hazard Area Control Act Rules – Permits are required in all regulated flood hazard areas and riparian zones. Minor impacts often qualify for Permits-by-Rule (PBR), General Permits by Certification (GPC) or General Permits (GP). Impacts exceeding PBR/GPC/GP limitations require an Individual Permit (IP). Specific requirements are contained in the Flood Hazard Area Control Act (FHA) Rules at N.J.A.C. 7:13, and NJDEP provides a guidance document through the Flood Hazard Area Technical Manual at https://www.nj.gov/dep/landuse/download/fh_044.pdf.

      Hydraulic evaluation of existing roadway stream crossings may reveal that the water surface elevation for the design event discharge overtops the roadway. Compliance with both the bridge and culvert requirements presented in the FHA Rules and the Authority requirement to avoid roadway overtopping may require coordination between the agencies involved to achieve a reasonable and permittable design approach. In addition to the bridge and culvert requirements, the Engineer may need to address environmental considerations in the FHA Rules that can affect Authority projects, including but not limited to habitat fragmentation, riparian zone mitigation, and Category One waters.

   b. Freshwater Wetlands Protection Act Rules – Permits are required for projects located within freshwater wetlands, State open waters and freshwater wetlands transition areas. Minor impacts often qualify for General Permits by Certification (GPC) or General Permits (GP). Impacts exceeding GPC/GP limitations require an Individual Permit (IP). Specific requirements are contained in the Freshwater Wetlands Protection Act Rules at N.J.A.C. 7:7A.

   c. Coastal Zone Management Rules – Permits are required for projects located within and adjacent to coastal waters regulated under three primary permit programs included in N.J.A.C. 7:7: Coastal Area Facility Review Act (CAFRA), Waterfront Development Law, and (Coastal) Wetlands Act of 1970. The permits included under these Rules typically include the application for a Water Quality Certificate under Section 401 of the Federal Clean Water Act and Federal consistency determinations under Section 307 of the Federal Coastal Zone Management Act. Note that projects within coastal waters may also require other Federal approvals, as discussed in the previous section.

d. Tidelands Act (riparian Lands) - NJDEP claims jurisdiction to all formerly flowed tidal areas and currently flowed tidal waters up to the Mean High-Water elevation. Typically, Authority projects encountering a Tidelands Claim require a Tidelands License or Grant from the Tidelands Resource Council. The Authority prefers that projects with infrastructure or facilities to remain in Tidelands Claim areas after construction receive Tidelands Grants. As such, early discussions with the Bureau of Tidelands Management are recommended to confirm this approach.

2. NJDEP – Division of Water Quality
   a. Stormwater Management Rules – Approvals are required for Authority projects that meet the definition of a “Major Development” as defined at N.J.A.C. 7:8 to provide water quality treatment, green infrastructure measures, water quantity reduction, and/or groundwater recharge. Projects that require certain permits from the Division of Land Resource Protection will be approved as part of those permits. Projects that are not subject to other NJDEP permits will be approved by the Authority as part of the Highway Agency Stormwater General Permit under the Municipal Separate Storm Sewer (MS4) regulatory program. Refer to Section 5.6 below for additional discussions and requirements related to Authority projects.

3. NJDEP – Division of Dam Safety & Flood Control
   a. Dam Safety Standards – Approvals are required for Authority projects that contain design elements, such as detention basins, or impact existing features that meet the definition of a “dam” as defined at N.J.A.C. 7:20.

5.3.3. **Local**

1. New Jersey Sports and Exposition Authority (formerly Meadowlands Commission) – Projects within the New Jersey Sports and Exposition Authority (NJSEA) jurisdiction will require coordination and a Resolution of Support prior to construction activities within the region. Additional information about the NJSEA can be found at https://www.njsea.com/.

2. New Jersey Pinelands Commission – Development approvals are required for projects located within the Pinelands Commission’s jurisdiction. Impacts to freshwater wetlands within this jurisdiction may also be regulated by the Pinelands Commission. The Pinelands Commission should be consulted regarding additional stormwater management criteria that may be more restrictive than NJDEP requirements. Specific development, freshwater wetlands, and stormwater management requirements are contained in the Pinelands Comprehensive Management Plan at N.J.A.C. 7:50. Additional information about the Pinelands can be found at: https://www.nj.gov/pinelands/.

3. Delaware River Basin Commission (DRBC) – Approval is required from the DRBC for any Authority project within the DBRC's jurisdiction and will need to address their Comprehensive Plan regulations.

4. Delaware & Raritan Canal Commission (DRCC) – Approval is required from the DRCC for any Authority project that is not otherwise exempt under the Regulations for the Review Zone of the Delaware and Raritan Canal State Park at N.J.A.C. 7:45.

5. Soil Conservation Districts – Soil Erosion and Sediment Control (SESC) Plan Certification is required from the Local Soil Conservation District for any Authority project that results in more than 5,000 square feet of land disturbance. The Engineer shall prepare the SESC plans, report, and calculations in accordance with the current version of the *Standards for Soil Erosion and Sediment Control in New Jersey* regulated under N.J.A.C. 2:90 and available from the NJ Department of Agriculture at https://www.nj.gov/agriculture/divisions/anr/. The SESC application shall include calculations and plans that address both temporary and permanent items for the engineering and vegetative standards. Calculations shall be shown for items that require specific sizing (e.g., riprap, settling basins, etc.).

   The New Jersey Pollution Discharge Elimination System (NJPDES) Construction Activities Stormwater Permit (5G3) is authorized by the NJDEP Division of Water Quality but administered by the NJ Department of Agriculture through the Local Soil Conservation Districts for all Authority projects that disturb more than one (1) acre of land. Upon receipt of the SESC Plan Certification from the Local Soil Conservation District, the Engineer shall submit a Request for Authorization (RFA) from NJDEP.

5.4. HYDROLOGY

Hydrology is generally defined as the science dealing with the interrelationship between water on and under the earth and in the atmosphere. For the purpose of this Subsection, hydrology will deal with estimating flood magnitudes as the result of precipitation. In the design of highway drainage structures, floods are usually considered in terms of peak runoff or discharge in cubic feet per second (cfs) and hydrographs as discharge per time. For drainage facilities which are designed to control volume of runoff, like stormwater management facilities, or where flood routing through culverts and bridges is used, then the entire discharge hydrograph will be of interest. The analysis of the peak rate of runoff, volume of runoff, and time distribution of flow is fundamental to the design of drainage facilities. Errors in the estimates will result in a facility/structure that is either undersized and causes more drainage problems or oversized and costs more than necessary.

The contributory watershed area shall be determined as a prerequisite to the design of all drainage facilities, hydraulic structures, channels and ditches. The watershed area shall be established on the largest scale topographic map or digital surface available of the watershed by careful interpretation of the contours and elevation data, supplemented by field investigations to verify the results as well as to locate any existing storm drain systems, roadways, or channels (not evident from the contours) which may convey drainage areas into or out of the watershed.

In the hydrologic analysis for a drainage facility or hydraulic structure, it must be recognized that many variable factors affect floods. Some of the factors which need to be recognized and considered on an individual site by site basis include:

1. Rainfall Amount and Storm Distribution,
2. Drainage Area Size, Shape and Orientation, Ground Cover, Type of Soil,
3. Slopes of Terrain and Stream (S),
4. Antecedent Moisture Condition,
5. Storage Potential (Overbank, Ponds, Wetlands, Reservoirs, Channel, Etc.),
6. Watershed Development Potential, and
7. Type of Precipitation (Rain, Snow, Hail, or Combinations Thereof), Elevation.

The type and source of information available for hydrologic analyses will vary from site to site. It is the responsibility of the Engineer to determine the information required for an analysis including any particular methods or procedures required by a regulatory agency. This Subsection contains hydrologic methods by which peak flows and hydrographs may be determined for the hydraulic evaluation of drainage systems, bridges, culverts, channels and median drains.

5.4.1. Selection of Hydrologic Methods

The following guidelines should be used to select the hydrology method for computing the design peak flow:

EXHIBIT 5-4 HYDROLOGIC METHOD

Size of Drainage Area	Hydrologic Method
Less than 20 Acres	Rational Formula or Modified Rational Method
Less than 5 Square Miles	NRCS* TR-55 Methodology ‡
Greater than 1 Acre	NRCS* TR-20, HEC-1 Method, HEC-HMS or others ‡ †

‡ For all projects in the New Jersey Coastal Plain Region, the use of the DELMARVA Unit Hydrograph shall be assessed for applicability and incorporated into the design procedure, as necessary. Coordinate with the NJDEP, NJ Pinelands Commission and local Soil Conservation District to determine if the DELMARVA unit hydrograph is appropriate for the project.

* US Natural Resources Conservation Service (NRCS), formerly the US Soil Conservation Service (SCS).

 These hydrologic models are not limited by the size of the drainage area. They are instead limited by uniform curve number, travel time, etc. Most of these limitations can be overcome by subdividing the drainage areas into smaller areas. See the appropriate user's manual for a complete list of limitations for each hydrologic model.

† Many hydrologic models exist beyond those that are listed here. If a model is not included, then the Engineer should ensure that the model is appropriate and that approvals are obtained from the Authority's Engineering Department and NJDEP, if applicable.

The peak flow from a drainage basin is a function of the basin's physiographic properties such as size, shape, slope, soil type, land use, as well as climatological factors such as mean annual rainfall and selected rainfall intensities. The methods presented in the guideline should give acceptable predictions for the indicated ranges of drainage area sizes and basin characteristics.

NOTE: As discussed in the Flood Hazard Area Control Act Rules, if a watercourse has a NJDEP adopted flood study or FEMA study (including Preliminary and Advisory Studies), the study resulting in the higher flood hazard area design flood and wider floodway must be used. NJDEP no longer publishes its own flood studies but the New Jersey Flood Hazard Area Design Flood (NJFHADF) is incorporated into the revised FEMA studies, maps and profiles. The Engineer should ensure that the hydrologic model used follows the requirements of the Flood Hazard Area Control Act Rules and any supplemental guidance provided in NJDEP's Flood Hazard Area Technical Manual, as necessary.

Computation of peak discharge must consider the condition that yields the largest rate. Proper hydrograph combination is essential. It may be necessary to evaluate several different hydrograph combinations to determine the appropriate peak discharge for basins containing hydrographs with significantly different times for the peak discharge. For example, the peak discharge for a basin with a large undeveloped area contributing toward the roadway may result from either the runoff at the time when the total area reaches the roadway or the runoff from the portion of the overland area contributing at the same time.

5.4.2. Rational Method

The Rational Method consists of an empirical formula relating runoff to rainfall intensity. The Rational Method can only be used to compute estimated peak flow rates but cannot provide runoff volumes or hydrographs. It is expressed in the following form:

$$Q = CIA$$

Where:

Q = peak flow in cubic feet per second, cfs
C = runoff coefficient (weighted)
I = rainfall intensity in inches (in) per hour
A = drainage area in acres

1. Basic Assumptions
   a. The peak rate of runoff (Q) at any point is a direct function of the average rainfall intensity (I) for the Time of Concentration (Tc) to that point.

   b. The recurrence interval of the peak discharge is the same as the recurrence interval of the average rainfall intensity.

   c. The Time of Concentration is the time required for the runoff to become established and flow from the most distant point of the drainage area to the point of discharge.

The Rational Method is limited to small watersheds due to the assumption that rainfall is constant throughout the entire watershed. Severe storms, say of a 100-year return period, generally cover a very small area. Applying the high intensity corresponding to a 100-year storm to the entire watershed could produce greatly exaggerated flows, as only a fraction of the area may be experiencing such an intensity at any given time.

The variability of the runoff coefficient also favors the application of the rational method to small, developed watersheds. Although the coefficient is assumed to remain constant, it actually changes during a storm event. The greatest fluctuations take place on unpaved surfaces, as in rural settings. In addition, runoff coefficient values are much more difficult to determine and may not be as accurate for surfaces that are not smooth, uniform and impervious.

The Rational Method provides the most reliable results when applied to small, developed watersheds and particularly to roadway drainage design. The validity of each assumption should be verified for the site before proceeding.

2. Procedure

   a. Obtain the following information for each site:

      - Drainage area
      - Land use (% of impervious area such as pavement, sidewalks or roofs)
      - Soil types (highly permeable or impermeable soils)
      - Distance from the farthest point of the drainage area to the point of discharge
      - Difference in elevation from the farthest point of the drainage area to the point of discharge

   b. Determine the Time of Concentration (Tc). See Subsection 5.4.4.

   c. Determine the rainfall intensity rate (I) for the selected recurrence intervals.

   d. Select the appropriate C value.

   e. Compute the design flow (Q = CIA).

The runoff coefficient (C) accounts for the effects of infiltration, detention storage, evapo-transpiration, surface retention, flow routing and interception. The product of C and the average rainfall intensity (I) is the rainfall excess of runoff per acre.

The runoff coefficient should be weighted to reflect the different conditions that exist within a watershed

Example:

$$\mathbf{C_w = \frac{A_1C_1 + A_2C_2 \ldots A_NC_N}{A_1 + A_2 \ldots A_N}}$$

NOTE: Calculations required for NJDEP stormwater management compliance must preclude the weighing of pervious and directly connected impervious surfaces unless the Tc values are identical. Refer to the NJDEP Stormwater Best Management Practices (BMP) Manual for additional guidance.

3. Value for C

Select the appropriate value for C from EXHIBIT 5-5:

EXHIBIT 5-5 RECOMMENDED COEFFICIENT OF RUNOFF VALUES FOR VARIOUS SELECTED LAND USES

Land Use	**Description**	**Hydrologic Soils Group**			
		A	**B**	**C**	**D**
Cultivated Land	without conservation treatment with conservation treatment	0.49 0.27	0.67 0.43	0.81 0.67	0.88 0.67
Pasture or Range Land Meadow	poor condition fair condition good condition	0.38 --- ---	0.63 0.25 ---	0.78 0.51 0.41	0.84 0.65 0.61
Wood or Forest Land	thin stand, poor cover, no mulch good cover	--- ---	0.34 ---	0.59 0.45	0.70 0.59
Land Use	Description	Hydrologic Soils Group			
Open Spaces, Lawns, Parks, Golf Courses, Cemeteries Good Condition Fair Condition	grass cover on 75% or more grass cover on 50% to 75%	--- ---	0.25 0.45	0.51 0.63	0.65 0.74
Commercial and Business Area	85% impervious	0.84	0.90	0.93	0.96
Industrial Districts	72% impervious	0.67	0.81	0.88	0.92
Residential Average Lot Size (acres) 1/8 1/4 1/3 1/2 1	average % impervious 65 38 30 25 20	 0.59 0.29 --- --- ---	 0.76 0.55 0.49 0.45 0.41	 0.86 0.70 0.67 0.65 0.63	 0.90 0.80 0.78 0.76 0.74
Paved Areas	parking lots, roofs, driveways, etc.	0.99	0.99	0.99	0.99
Streets and Roads	paved with curbs & storm sewers Gravel dirt	0.99 0.57 0.49	0.99 0.76 0.69	0.99 0.84 0.80	0.99 0.88 0.84

NOTE: Values are based on NRCS definitions and are average values.

Source: Technical Manual for Land Use Regulation Program, Bureau of Inland and Coastal Regulations, Flood Hazard Area Permits, NJDEP.

4. Determination of Rainfall Intensity Rate (I):

Determine the Time of Concentration (Tc) in minutes for the drainage basin. Refer to Subsection 5.4.4 for additional information.

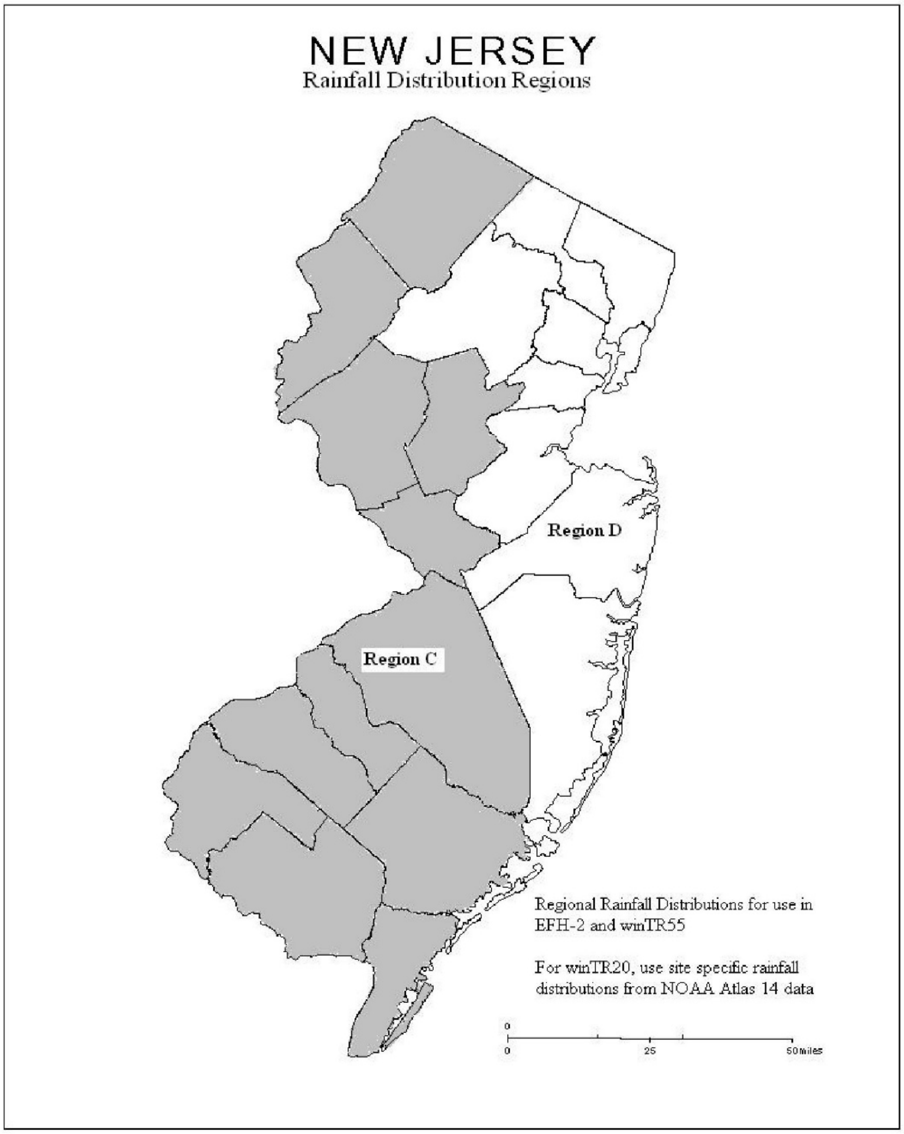
Determine the value for rainfall intensity for the selected recurrence interval with a duration equal to the Time of Concentration for the project location from NOAA's Precipitation Frequency (PF) Estimates available from NOAA's Precipitation Frequency Data Server at https://hdsc.nws.noaa.gov/hdsc/pfds/. Select the Precipitation Intensity Data Type and appropriate location using the interactive map. PF Estimates provide a table of precipitation intensities referenced to storm durations and recurrence intervals.

5.4.3. U.S. Natural Resources Conservation Services Methodology

Techniques developed by the US Natural Resources Conservation Service (NRCS), for calculating rates of runoff require the same basic data as the Rational Method: drainage area, a runoff factor, Time of Concentration, and rainfall. The NRCS approach, however, is more sophisticated in that it also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. With the NRCS method, the direct runoff can be calculated for any storm, either real or fabricated, by subtracting infiltration and other losses from the rainfall to obtain the precipitation excess. Details of the methodology can be found in the NRCS National Engineering Handbook, Part 630, Hydrology.

The NRCS method is based on a 24-hour storm event which has a certain storm distribution. The Type III storm distribution has been replaced with NOAA's Region C and Region D rainfall distributions for the State of New Jersey. The location of Regions C and D are shown in EXHIBIT 5-6 and tabular rainfall distributions are available from NOAA at https://www.nrcs.usda.gov/wps/portal/nrcs/main/nj/technical/engineering/ and NJDEP. To use these distributions, it is necessary for the user to obtain the 24-hour rainfall depth value for the frequency of the desired design storm. The 24-hour rainfall depth values should be obtained from NOAA's Precipitation Frequency (PF) Estimates available from NOAA's Precipitation Frequency Data Server at https://hdsc.nws.noaa.gov/hdsc/pfds/. Select the Precipitation Depth Data Type and appropriate location using the interactive map. PF Estimates provide a table of precipitation depths referenced to storm durations and recurrence intervals.

EXHIBIT 5-6 LOCATIONS OF REGIONS C AND D



Source: NRCS, Engineering Field Handbook NJ Supplement, August 2012

Central to the NRCS methodology is the concept of the Curve Number (CN) which relates to the runoff depth and is itself characteristic of the soil type and the surface cover. CN's in Table 2-2 (a to d) of the TR-55 Manual (June 1986) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate. Appendix A of the TR-55 Manual defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from the local Soil Conservation District offices, or from the U.S. Department of Agriculture (USDA) Web Soil Survey at https://websoilsurvey.nrcs.usda.gov/app/.

Several techniques have been developed and are currently available to engineers for the estimation of runoff volume and peak discharge using the NRCS methodology. Some of the more commonly used of these methods are summarized below:

1. NRCS Technical Release 55 (TR-55):

The procedures outlined in this document are the most widely used for the computation of stormwater runoff. This methodology is particularly useful for the comparison of pre- and post-development runoff rates and consequently for the design of control structures. There are basically two variations of this technique: the Tabular Hydrograph method and the Graphical Peak Discharge method. For a more detailed account of these methods and their limitations the Engineer is referred to the NRCS TR-55 document.

2. US Army Corps of Engineers HEC-HMS Model:

These models are used to simulate watershed precipitation runoff processes during flood events. These models may be used to simulate runoff in a simple single basin watershed or in a highly complex basin with a virtually unlimited number of sub-basins and for routing interconnecting reaches. They can also be used to analyze the impact of changes in land use and detention basins on the downstream reaches. They can serve as a useful tool in comprehensive river basin planning and in the development of area-wide watershed management plans. The NRCS Dimensionless Unit Hydrograph Option in the HEC-HMS program shall be used. Other synthetic unit hydrograph methods available in HEC-HMS can be used with the approval of the Authority's Engineering Department.

The HEC-HMS model is currently supported by a number of software vendors which have enhanced versions of the original US Army Corps models. Refer to the available Program Documentation Manuals for additional information.

3. NRCS TR-20 Model:

This computer program is a rainfall-runoff simulation model which uses a storm hydrograph, runoff curve number and channel features to determine runoff volumes as well as unit hydrographs to estimate peak rates of discharge. The dimensionless unit hydrographs from sub-basins within the watershed can be routed through stream reaches and impoundments. The TR-20 method may be used to analyze the impact of development and detention basins on downstream areas. The parameters needed in this method include total rainfall, rainfall distribution, curve numbers, Time of Concentration, travel time and drainage area.

NOTE: Calculations required for NJDEP stormwater management compliance must preclude composite CN values of pervious and directly connected impervious surfaces even where the Tc values are identical. Refer to the NJDEP BMP Manual for additional guidance

5.4.4. Time of Concentration

The Time of Concentration (Tc) is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. It may take a few computations at different locations within the drainage area to determine the most hydraulically distant point. Tc is computed by summing all the travel times for consecutive components of the drainage conveyance system.

Tc influences the shape and peak of the runoff hydrograph. Development usually decreases the Tc, thereby increasing the peak discharge, but Tc can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets, culverts, and bridges, or (b) reduction of land slope through grading.

1. Factors Affecting Time of Concentration and Travel Time

    a. Surface Roughness: One of the most significant effects of development on flow velocity is less retardance of flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by development; the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

    b. Channel Shape and Flow Patterns: In small watersheds, much of the travel time results from overland flow in upstream areas. Typically, development reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

    c. Slope: Slopes may be increased or decreased by development, depending on the extent of site grading or the extent to which storm sewers and roadway gutters are used in the design of the stormwater management system. Slopes will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

5.4.5. Computation of Travel Time and Time of Concentration

Water moves through a watershed as sheet flow, street/gutter flow, pipe flow, open channel flow, or some combination of these. Sheet flow is sometimes commonly referred to as overland flow. The type of flow that occurs is a function of the conveyance system and is best determined by field inspection, review of topographic mapping and subsurface drainage plans. The Engineer shall compute the Travel Time and Time of Concentration in accordance with the NRCS National Engineering Handbook, Part 630, Chapter 15 and the NJDEP BMP Manual.

Time of concentration (Tc) is the sum of travel time (Tt) values for the various consecutive flow segments. The three basic segments are sheet flow, shallow concentrated flow, and open channel flow. The maximum length of sheet flow to be used is 100 feet. The open channel portion may be a natural channel, man-made ditch, drainage pipe, or gutter flow along the roadway. The open channel portion time is determined by using the Manning's equation or other acceptable procedure for open channel flow such as HEC-RAS. Refer to the NRCS National Engineering Handbook, Part 630, Chapter 15 for detailed information on the procedures.

$Tc = Tt_1 + Tt_2 + . . . Tt_m$

where:

Tc = total Time of Concentration

Tt = travel time for each flow segment m = number of flow segments

The minimum Time of Concentration shall be used as summarized in EXHIBIT 5-7.

EXHIBIT 5-7 HYDROLOGIC METHOD

Hydrologic Method	Minimum Tc
Rational Formula	10 Minutes
NRCS TR-55	6 Minutes
NRCS TR-20, HEC-HMS or others	5 Minutes (or minimum available rainfall data)

5.4.6. Flood Routing

The traditional design of storm drainage systems has been to collect and convey runoff as rapidly as possible to a suitable discharge location. This type of design may result in major drainage and flooding problems downstream. Under favorable conditions, the temporary storage of some of the storm runoff can decrease downstream flows and often the cost of the downstream conveyance systems. Flood routing should be used to limit the amount of runoff from a project because the downstream structures are incapable of handling it, a zero increase in runoff is desired, and/or due to regulatory requirements. Flood routing shall be used to document the required storage volume to achieve the desired runoff control.

A hydrograph is required to accomplish the flood routing. A hydrograph represents a plot of the flow, with respect to time. The predicted peak flow occurs at the time, Tp (time to peak). The area under the hydrograph represents the total volume of runoff from the storm. A hydrograph can be computed using either the Modified Rational Method (for drainage areas up to 20 acres) or the NRCS 24-hour storm methodology described in previous Subsections. The Modified Rational Method is described in detail in Standards for Soil Erosion and Sedimentation Control in New Jersey. Due to the advancement in modeling and available data, the Modified Rational Method is not recommended for use without approval from the Authority's Engineering Department.

Storage may be concentrated in large basin-wide regional facilities or distributed throughout the watershed. Storage may be developed in roadway interchanges, parks and other recreation areas, small lakes, ponds and depressions. The utility of any storage facility depends on the amount of available storage, its location within the system, and its operational characteristics. An analysis of such storage facilities should consist of comparing the design flow at a point or points downstream of the proposed storage site with and without storage. In addition to the design flow, other flows in excess of the design flow that might be expected to pass through the storage facility should be included in the analysis. The design criteria for storage facilities should include:

1. Release Rate,
2. Storage and Volume,
3. Grading and Depth Requirements,
4. Outlet Works, and
5. Location.

Control structure release rates shall be in accordance with criteria outlined in Subsection 5.1.2, Design Procedures Overview. Multi-stage control structures may be required to control runoff from different frequency events. The Engineer shall perform a flood routing and design control structures in accordance with the NJDEP BMP Manual, NJDEP Flood Hazard Area Technical Manual, National Engineering Handbook, Part 630, Chapter 17, or other applicable regulatory requirements. The Engineer shall account for all applicable tailwater conditions that may affect the routing, such as downstream flood elevations.

Routing calculations needed to design storage facilities, although not extremely complex, are time consuming and repetitive. Many reservoir and reach routing computer programs such as HEC-HMS, TR-20 and a number of proprietary programs, are available to expedite these calculations. Use of programs to perform routings is encouraged.

Subsection 5.6 contain standards related to stormwater management and quality control.

5.5. FIELD INFORMATION

It is generally permissible to rely on as-built plans or topographic locations of existing drainage facilities in the area of Authority work, where such facilities are not affected by the Authority project. However, all existing drainage facilities to be modified, extended or connected to Authority work shall be located in plan and elevation by field survey, as a part of the process of defining existing features on the plans.

Where stream cross sections are required as a part of regulatory applications, such cross sections shall be obtained by field survey, referenced to an established baseline. Stream cross sections shall specifically define the contour of the stream bottom below the water surface, and the adjacent floodplains to an elevation above normal flooding. Where current one-foot contour interval topographic mapping is available, floodplain area above the water surface at the time of mapping may be cross sectioned from the map contours, in lieu of field cross sections.

5.6. STORMWATER MANAGEMENT

Stormwater management is an important consideration in the design of roadway drainage systems. Stormwater management practices, when properly selected, designed, and implemented, can be utilized to mitigate potential adverse hydrologic and hydraulic impacts caused by Authority facilities and mitigate the loss in groundwater, thereby protecting the health of streams and wetlands, and the yield of water supply wells, and downstream areas from increased flooding, erosion, and water quality degradation. Stormwater management is required for all Authority projects that meet the definition of a “Major Development” under the NJDEP Stormwater Management Rules (N.J.A.C. 7:8), typically where the proposed roadway project disturbs one (1) or more acres of land or creates at least 0.25 acres of new or additional motor vehicle surface; under the Pinelands Commission’s Comprehensive Management Plan (N.J.A.C. 7:50), typically where the project results in more than 5,000 square feet of disturbance; or any other applicable regulatory requirements. Compliance with the SWM Rules is required for all Authority projects under the Authority’s Highway Agency Stormwater General Permit, specifically Part IV.B.4 and Part IV.C.3, and as part of NJDEP Land Resource Protection permits when required. In accordance with Part IV.B.5 the Highway Agency Stormwater General Permit, all major development projects must be reviewed by Authority staff, or their designee, that have received official stormwater management review training from NJDEP. The Engineer shall be aware of any updates to the definitions by the regulatory agencies and design accordingly.

This Subsection will focus on general design elements of stormwater management facilities common to proposed roadway projects, or retrofits to existing roadways, which typically include green infrastructure BMPs, including but not limited to bioretention or infiltration systems, and gray infrastructure BMPs, such as detention basins or manufactured treatment devices approved by NJDEP.

Specific stormwater management measures to control the rate and/or volume of runoff, provide water quality treatment, and/or recharge groundwater may be dictated by various regulatory agencies listed in Subsection 5.3. Peak runoff discharge rates may also be limited by capacity constraints of existing downstream drainage systems. Additional guidance regarding the design of stormwater management facilities is presented in the NJDEP BMP Manual. All designs must comply with the appropriate regulatory requirements and the NJDEP BMP Manual.

5.6.1. Water Quality

Stormwater runoff from Authority facilities and activities can be a potential contributor to water quality degradation of receiving waterbodies. This Subsection will focus on the design of water quality BMPs to treat runoff from roadways. Refer to the NJDEP BMP Manual and the Standards for Soil Erosion and Sedimentation Control in New Jersey for water quality measures and recommendations, which can be used for other Authority facilities and activities.

Stormwater BMPs shall be designed to reduce the post-construction load of TSS in stormwater runoff generated from the water quality storm from the developed site. This Subsection and the NJDEP BMP Manual provide guidance in the planning and design of these facilities.

Water quality requirements can vary dependent upon the receiving waterbody's designation under NJDEP's Surface Water Quality Standards (N.J.A.C. 7:9B). The Engineer shall coordinate with the regulatory agency to confirm the appropriate treatment requirements and incorporate into the project accordingly.

5.6.1.1. Methodology

The water quality storm is a 1.25 inch rainfall event occurring over a 2 hour period. The water quality design storm peak rate and volume shall be determined in accordance with the SWM Rules at N.J.A.C. 7:8-5.5 and the NJDEP BMP Manual which currently require using either of the following:

1. NJDEP developed rainfall depth curve for NRCS and hydrograph methodologies,
2. NJDEP developed rainfall intensity curve for the Rational Method.

Note that it is only appropriate to assume an average rainfall intensity of 0.625 inches/hour when using the Modified Rational Method. Refer to the NJDEP BMP Manual for additional guidance.

5.6.1.2. Water Quality Treatment BMP Facilities and Design

As indicated in Subsection 5.1.2 water quality is an important consideration in roadway drainage system design. Water quality facilities shall be designed in accordance with all applicable regulatory requirements. The NJDEP has classified water quality BMPs into two groups: Green Infrastructure and Gray Infrastructure. Examples of water quality BMPs most applicable to Authority projects include, but are not limited to:

<u>Green Infrastructure:</u>

- Bioretention Systems
- Infiltration Basin
- Grass Swale
- Sand Filter*

- Constructed Wetlands
- Wet Ponds*
- Vegetated Filter Strip
- Cistern‡
- Dry Well‡
- Pervious Paving‡

Gray Infrastructure:

- Extended Detention Basin
- Manufactured Treatment Devices
- Sand Filters
- Subsurface Gravel Wetland
- Wet Pond

* BMPs must meet certain criteria or design features as required by the SWM Rules at N.J.A.C. 7:8 to be considered Green Infrastructure.

‡ BMPs are only applicable for use at facilities (e.g., maintenance yards, service areas, etc.). Early discussion and approval from the Authority's Engineering Department is required.

The use of Gray Infrastructure BMPs require additional justification and discussion with NJDEP for water quality treatment. Additional guidance regarding the design of water quality facilities is presented in the NJDEP BMP Manual and the following web site: http://www.njstormwater.org.

When other water quality measures are not feasible, the use of Manufactured Water Quality Treatment Devices (MTD) are permissible following the applicable NJDEP justification processes:

1. Use of MTDs are limited to devices approved by the NJDEP. A Complete list of Certified Stormwater Technologies approved by the NJDEP can be found at http://www.njstormwater.org.
2. Arrange the MTD in accordance with the NJDEP BMP Manual's "Stormwater Pollutant Removal Criteria". The design of the water quality device needs to ensure that it is located such that the structure can be easily maintained (i.e. the device is not located in the middle of a busy roadway).
3. Selection of the appropriate MTD should take the frequency of the maintenance into consideration. Maintenance of the device, once it is determined to be performing as designed, should be performed at most twice a year and at least once a year. The use of replacement filters is to be discouraged.
4. A maintenance plan shall be developed for the manufactured water quality devices and submitted to the Authority's Division of

Maintenance for review. The maintenance plan shall at a minimum contain specific preventative maintenance task and schedules and be in compliance with N.J.A.C. 7:8 and the Maintenance Guidelines for Stormwater Management Measures in the NJDEP BMP Manual.

5.6.2. Green Infrastructure

Green infrastructure is an established stormwater management practice and is recognized as an effective stormwater management strategy by NJDEP and the U.S. Environmental Protection Agency. The NJDEP SWM Rules require the use of Green Infrastructure BMPs that manage stormwater runoff through infiltration into the subsoil, filtration by vegetation or soil, or reuse.

The SWM Rules include contributory drainage area limits for the initially preferred Green Infrastructure BMPs listed in Table 5-1 at N.J.A.C. 7:8. However, there are alternative requirements for public roadway projects allowing the use of Green Infrastructure BMPs listed in Table 5-2. The Engineer shall be aware of additional variance requirements, waivers from strict compliance, or additional stipulations, such as memorandums of understanding or future regulations, that may be required from NJDEP to use Green Infrastructure BMPs that exceed the contributory drainage area limits or to use Gray Infrastructure BMPs for linear development projects. The Engineer shall coordinate with NJDEP to address the use of green infrastructure BMPs, the potential for offsite requirements, and any other requirements that may be applicable.

5.6.3. Water Quantity

BMPs to address water quantity shall be designed to control the peak rate and volume of runoff discharged from Authority projects. The Engineer shall design the project to prevent adverse impacts to downstream properties and waterways in accordance with all applicable regulatory requirements. Additional guidance regarding the design of water quantity BMPs is presented in the NJDEP BMP Manual and the following web site: http://www.njstormwater.org. Note that discharging to a tidal or tidally influenced waterway or flood hazard area does not preclude the project from requiring compliance with water quantity requirements.

The Engineer shall prepare stormwater management calculations, including flood routing and hydrologic calculations, in accordance with Subsection 5.4. The Engineer shall prepare Supplementary Specifications to include requirements that basin excavation shall be performed with construction equipment positioned outside the limits of the basin to avoid any compaction of the soils which will remain once the basin is constructed to the maximum extents practicable. In addition, the

Supplementary Specifications should include requirements for the basin bottom preparation, seeding, and planting.

5.6.4. Groundwater Recharge

As discussed in Subsection 5.6.2, groundwater recharge can be a primary component of Green Infrastructure BMPs to promote a hydrologically functional landscape through infiltration measures. The NJDEP SWM Rules require a project to maintain 100% of the average annual preconstruction groundwater recharge volume for the site or to infiltrate the increase in stormwater volume from the 2-year storm between the pre-construction and post-construction conditions. The Engineer shall design the project to meet the groundwater recharge requirements and coordinate with the Authority Engineering Department and NJDEP when the project cannot meet these requirements onsite. Chapter 6 of the NJDEP BMP Manual provides additional design requirements, such as minimum infiltration rates, and guidance for groundwater recharge methodology and the New Jersey Groundwater Recharge Spreadsheet, available at http://www.njstormwater.org.

In addition to determining groundwater recharge requirements, the installation of BMPs require assessments of hydraulic impacts to the groundwater table, commonly referred to as Groundwater Mounding. The NJDEP has adopted a modified version of the USGS's Groundwater Mounding Analysis workbook, also referred to as the Hantush Spreadsheet. The Engineer shall determine the hydraulic impacts to the groundwater table in accordance with the NJDEP SWM Rules and follow the analysis guidelines discussed in Chapter 13 of the NJDEP BMP Manual.

Projects subject to review and approval by the Pinelands Commission must follow the additional groundwater recharge requirements discussed in the Comprehensive Management Plan. The Comprehensive Management Plan requires the total runoff volume generated from the net increase in impervious surfaces from the 10-year, 24-hour storm event be retained and infiltrated onsite for projects meeting the definition of a Major Development. The Engineer shall design the project to meet the groundwater recharge requirements and coordinate with the Authority Engineering Department and the Pinelands Commission when the project cannot meet these requirements onsite.

The Engineer shall conduct soil tests and determine the applicable soil parameters in accordance with Section 6 of this manual and Chapter 12 of the BMP Manual.

5.6.5. Best Management Practices Locations

The location of stormwater management facilities will depend on several factors such as location of receiving watercourses, location of roadway profile low points, groundwater elevations, soil permeability, available right of way, etc.

The Engineer should first consider and make maximum use of locations within Authority right of way, e.g. at interchanges, ramp infield areas, wide medians, before locating facilities which require additional right of way. Specific authorization must be obtained from the Authority's Engineering Department to locate facilities outside Authority right of way. However, site/project specific constraints will ultimately dictate exact locations of stormwater management facilities. The Engineer shall conduct soil tests and determine the applicable soil parameters early in the design process to meet NJDEP's requirements for the use of infiltration and Green Infrastructure BMPs or exclude areas not feasible for these BMPs.

5.6.6. Best Management Practices Design Features

The varying levels of complexity required for stormwater BMPs requires the Engineer to carefully select an appropriate BMP and design the system to maximize its efficiency. The Engineer shall design the BMP to meet the design requirements and guidelines presented in the NJDEP BMP Manual. The Engineer shall design the project to prevent runoff from bypassing the SWM design events to the BMPs. The BMP Manual lists minimum requirements for design features including, but not limited to, outlet control structures, side slopes, drain times, infiltration rates, separation distances from the seasonal high groundwater elevation, planting bed thicknesses for bioretention systems, and safety ledges for wet ponds, etc. The Engineer shall also incorporate the following Authority specific minimum requirements into the BMP design:

- Side slopes shall be 3 horizontal to 1 vertical or flatter to facilitate mowing.
- A low flow channel shall be provided having a minimum slope of 0.5% and side slopes of 3 horizontal to 1 vertical or flatter for Extended Detention Basins.
- The bottom shall be graded to drain to the low flow channel at a minimum slope of 1.0% for Extended Detention Basins.
- All basin type BMPs shall be fenced or otherwise isolated from the general public. Guide rail shall be provided where errant vehicles could enter the basin.
- To the maximum extent practicable, outlet structures shall be designed to require minimal maintenance. Trash racks and safety grating shall be provided in accordance with the NJDEP BMP Manual.
- All portions of a BMP not subject to permanent inundation or intended as infiltration areas (e.g., sand blanket at bottom of infiltration basins) shall be topsoiled and seeded. Additional landscaping features in and around proposed BMPs shall be considered.
- Emergency overflow or spillways shall be provided where volumes in excess of design conditions could create hazardous conditions.

- An access ramp into basin type BMPs shall be provided to allow Authority maintenance personnel and equipment to enter the BMP for maintenance/cleaning operations. The access ramp shall accommodate truck access to the basin bottom and outlet control structure with a width of 13 feet and a desirable longitudinal slope of 8% (12% maximum).

Basin type BMPs may be excavated depressions (cut) or diked (dammed) by means of an embankment. It should be noted that any embankment/pond that raises the water level more than 5 feet above the usual mean, low water height, or existing ground, when measured from the downstream toe-of-dam to the spillway crest on a permanent or temporary basis must conform to N.J.A.C. 7:20 "Dam Safety Standards".

5.6.7. Best Management Practices Maintenance

The Engineer shall prepare a Stormwater Management Facility Maintenance Plan in accordance with the SWM Rules. At a minimum, the maintenance plan shall include specific preventative maintenance tasks and schedules. The maintenance plan shall include, at a minimum, the manufacturer's recommendation on the maintenance of their facility. Maintenance plan guidelines and additional maintenance information are available in the NJDEP BMP Manual, including recommended maintenance tasks and equipment, inspection procedures and schedules, ownership responsibilities, and design recommendations to minimize the overall need for maintenance while facilitating inspection and maintenance tasks.

A copy of the Stormwater Management Facility Maintenance Plan shall be submitted to the Authority. A sample Stormwater Maintenance Plan is provided in the References section, identified as Exhibit 5-15. If NJDEP permits are required, the Stormwater Management Facility Maintenance Plan shall be submitted, prior to the submission of the plan to the NJDEP with the permit application(s). **Upon approval of the NJDEP Permit(s), a copy of the approved permit documentation shall be provided.**

5.7. Soil Erosions and Sediment Control

Soil erosion or sedimentation may occur as a result of a temporarily unstable condition caused by the project's construction activities or by a permanent and potentially unstable condition inherent in the project design. Provisions should be made in the contract for the prevention and/or correction of significant erosion of either a temporary or permanent nature. Permanent erosion sources are relatively simple to define and treat. Temporary sources are often difficult to foresee, and hence address, since the contractor's construction methods frequently cannot be predicted accurately at the time of design. The Engineer shall design the project to comply with the "Standards for Soil Erosion and Sedimentation Control in New Jersey" design criteria and references.

5.7.1. Plant Format

Erosion prevention or sediment dispersion control measures of a specific type, shown to be constructed at a specific location on the plans shall be provided in all cases and particularly under the following circumstances:

1. Where instability against erosion due to permanent factors would otherwise exist in the completed contract.
2. Where instability against erosion due to temporary factors would otherwise exist at some defined and predictable location during some stage of construction.
3. Where sedimentation basins are to be constructed.

Erosion prevention or sediment dispersion control measures should be provided as pay items in the Contract.

5.7.2. Temporary Control Measures

1. Sedimentation Basins are excavations or impoundments created for the purpose of reducing the velocity of flowing water sufficiently to allow sediment deposition to occur within the basin confines. Sedimentation basins shall be considered for inclusion in the Contract as temporary sediment dispersion control devices under the following conditions:

   a. Where unusually sensitive environmental factors or other unique conditions require the absolute minimization of temporary sedimentation resulting from the project construction process.

   b. Where terrain, soil type or design considerations indicate that sedimentation resulting from the project would occur outside the Authority right of way in a manner or degree which would interfere with existing land or water use.

   c. Any other situation required by the Standards for Soil Erosion and Sediment Control in New Jersey or directed by the Local Soil Conservation District.

   Sedimentation basins shall be designed as per design criteria outlined in Standards for Soil Erosion and Sedimentation Control in New Jersey and the following additional criteria:

   a. All basins shall be located on Authority property.

   b. Basins requiring dikes or dams should be located off-line from existing watercourses.

   c. Basin construction shall in no way impede or impound the flow of previously existing watercourses.

d. Sedimentation basin size and shape shall be established using the criteria set forth in Standards for Soil Erosion and Sediment Control in New Jersey. Basins which impound more than 10,000 square feet of water surface area shall be approved in advance by the Authority's Engineering Department.

e. All dikes or dams built as impoundments for sedimentation basins shall be constructed of graded broken stone, such as Stone for Erosion Control, Grade A. Supplemental stone gradations shall be specified where required for stability under design conditions. Emergency spillways shall be provided for all dams and shall be capable of carrying the discharge of a 50-year storm without over-topping the dam crest or otherwise threatening the integrity of the dam.

2. Filter fabric silt fence or haybale sediment barriers are used to intercept and detain sediment from unprotected areas. Design Criteria for these sediment control measures are detailed in Standards for Soil Erosion and Sedimentation Control in New Jersey. Refer to the Standard "DR" Drawings.

3. Broken stone, including riprap, for erosion control in various gradations serve a multitude of erosion prevention uses. Grade C stone is generally used for sedimentation basin dikes, dams and impoundments. Grade B stone is generally used to stabilize swales, storm drain outfalls and ditches prior to permanent protection. Grade B stone is also excellent for the repair of eroded embankment slopes and for the temporary stabilization of cut slopes where groundwater conditions make slope stabilization difficult. Broken stone for erosion protection should always be included as an item in earthwork contracts, but not necessarily shown to be applied at specific locations on the plans.

4. Temporary berms and slope drains: The specifications for all earthwork contracts should require the Contractor to maintain berms or dikes which confine rainfall to the top plateau of the embankment under construction. These berms should channel the runoff to a series of temporary slope drains, which in turn, convey the runoff down the slope, without slope erosion, (see Standard "DR" Drawings).

5.7.3. **Permanent Control Measures**

1. Jute Mesh is used in normally dry swales and on steep slopes to hold topsoil and seed in place under mild scour conditions until the root system of the grass is established. This material is not normally suitable for ditch slope stabilization or for use in other areas subject to frequent, heavy water flows. Jute mesh is normally included as an item in earthwork contracts, but not always shown to be applied at specific locations on the Plans.

2. Sodding should be used in normally dry swales and ditches where jute mesh and seeded grass are not sufficiently stable to withstand the anticipated erosive action.

3. Stone or Concrete Slope Protection - Stone riprap, portland cement or asphalt concrete paving should be used in ditches or swales carrying continuously flowing water, where the native bottom material is unstable and where uncontrolled scouring would be detrimental. These materials should also be used where sodding is not sufficiently stable to provide the necessary erosion control.

4. Conduit Outlet Protection
The purpose of conduit outlet protection is to provide a stable section of area in which the exit velocity from the pipe is reduced to a velocity consistent with the stable condition downstream. The need for conduit outlet protection shall be evaluated at any location where drainage discharges to the ground surface or a channel, ditch or stream. This may occur at the downstream end of culverts or other drainage systems.

   The need for conduit outlet protection shall be determined by comparing the allowable velocity for the soil onto which the pipe discharges to the velocity exiting the pipe. The allowable velocity for the soil shall be that given in the Standards for Soil Erosion and Sediment Control in New Jersey. The velocity in the pipe shall be that which occurs during passage of the design storm or of the 25-year storm, whichever is greater. When the velocity in the pipe exceeds the allowable velocity for the soil, outlet protection will be required.

   For a detail of conduit outlet protection for a flared end section or headwall, see the Standard “DR” Drawings.

   a. Riprap Size and Apron Dimensions

      Conduit outlet protection and apron dimensions shall be designed in accordance with procedures in the Standards for Soil Erosion and Sedimentation Control in New Jersey. The minimum d50 stone size shall be 6 inches. A tail water depth equal to 0.2 Do shall be used where there is no defined downstream channel or where Tw cannot be computed.

   b. Energy Dissipaters

      Energy dissipaters are typically required when the outlet velocity is 15 feet/second or greater. Energy dissipaters shall be provided when the stable velocity of the existing channel is exceeded, or when design of standard riprap conduit outlet or channel protection results in an impractical stone size and/or thickness. Energy dissipaters for channel flow have been investigated in the laboratory, and many have been constructed, especially in irrigation channels. Designs for highway use have been developed and constructed at culvert outlets. All energy dissipaters add to the cost of a culvert; therefore, they should be used only to prevent or to correct a serious erosion problem that cannot be corrected by normal design of standard soil erosion and sediment control elements.

The judgment of engineers is required to determine the need for energy dissipators at culvert outlets. As an aid in evaluating this need, culvert outlet velocities should be computed. These computed velocities can be compared with outlet velocities of alternate culvert designs, existing culverts in the area, or the natural stream velocities. In many streams the maximum velocity in the main channel is considerably higher than the mean velocity for the whole channel cross section. Culvert outlet velocities should be compared with maximum stream velocities in determining the need for channel protection. A change in size of culvert does not change outlet velocities appreciably in most cases.

Outlet velocities for culverts flowing with inlet control may be approximated by computing the mean velocity for the culvert cross section using Manning's equation.

Since the depth of flow is typically not known, the use of computer programs, tables or charts is recommended in solving this equation. The outlet velocity as computed by this method will usually be high because the normal depth, assumed in using Manning's equation, is seldom reached in the relatively short length of the average culvert. Also, the shape of the outlet channel, including aprons and wingwalls, has much to do with changing the velocity occurring at the end of the culvert barrel. Tailwater is not considered effective in reducing outlet velocities for most inlet control conditions.

In outlet control, the average outlet velocity will be the discharge divided by the cross-sectional area of flow at the outlet. This flow area can be either that corresponding to critical depth, tailwater depth (if below the top of the culvert) or the full cross section of the culvert barrel.

Additional design information for energy dissipators is included in FHWA HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channels.

5.8. DRAINAGE OF ROADWAY PAVEMENT

Effective drainage of highway pavements is essential to maintenance of the service level of highways and to traffic safety. Water on the pavement slows traffic and contributes to accidents from hydroplaning, icing, and loss of visibility from splash and spray. Free-standing puddles which engage only one side of a vehicle are perhaps the most hazardous because of the dangerous torque levels exerted on the vehicle. Thus, the design of the surface drainage system is particularly important at locations where ponding can occur.

This Subsection contains design methods and criteria for surface runoff collection.

5.8.1. Runoff Collection and Conveyance System Type

Roadway runoff is collected in different ways based on the edge treatment, either curbed or uncurbed. Runoff collection and conveyance for a curbed roadway is typically provided by a system of inlets and pipes, respectively. Runoff from an uncurbed roadway, typically referred to as "an umbrella section", proceeds overland away from the roadway in fill sections or to roadside swales or ditches in roadway cut sections.

Conveyance of surface runoff over grassed overland areas or swales and ditches allows an opportunity for the removal of contaminants. The ability of the grass to prevent erosion is a major consideration in the design of grass-lined facilities. Use of an "umbrella" roadway section may require additional ROW. Areas with substantial development adjacent to the roadway, particularly in urbanized areas, typically are not appropriate for use of a roadway "umbrella" section. "Umbrella" sections should be avoided on land service roadways where there are abutting properties and driveways. The decision to use an "umbrella" section requires careful consideration of the potential problems. Benefits associated with "umbrella" sections include cost savings and eliminating the possibility of vehicle vaulting. "Umbrella" sections used on roadways with higher longitudinal slopes have been found to be prone to berm washouts. Debris build-up along the edge of the roadway creates a curb effect that prevents sheet flow and directs the water along the edge of the roadway. This flow usually continues along the edge until a breach is created, often resulting in substantial erosion. Some situations may also warrant installing inlets along the edge of an "umbrella" section to pick up water which may become trapped by berm buildup or when snow is plowed to the side of the roadway and creates a barrier that will prevent sheet flow from occurring.

Bermed sections are designed with a small earth berm at the edge of the shoulder to form a gutter for the conveyance of runoff. Care should be taken to avoid earth berms on steep slopes that would cause erosive velocities yielding berm erosion. An "umbrella" section should be used where practical. However, low points at umbrella sections should have inlets and discharge pipes to convey the runoff safely to the toe of slope. A Type "D-2" inlet, with a minimum 18" diameter pipe shall be used to drain the low point. Snow inlets (see Subsection 5.8.6) shall be provided where the plowed snow cannot be properly removed due to berms, guide rail, or noise barriers at low points.

Slope treatment shall be provided at all low points of umbrella sections and all Garden State Parkway and New Jersey Turnpike projects to provide erosion protection (see Standard "DR" Drawings).

5.8.2. Types of Inlets Used by the Authority

Inlet grate types used by the Authority consist of two types, combination inlets (with a curb opening), and grate inlets (without a curb opening) as shown on the current standard details as summarized below:

1. Combination Inlets D-3
2. Grate Inlets D-1 and D-2

A special inlet shall also be designed, with the appropriate detail provided in the construction plans, and the item shall be designated "Special Inlet", when the transverse pipe size requires a structure larger than the standard inlet types.

All chamber type inlets on Authority roadways shall be D-1 inlets except where the diameter of the through sewer or specific grate capacity problems require a larger inlet, in which case D2 or larger special inlets shall be used.

D3 inlets with bicycle grates shall be used only at Authority facilities and on incidental roadway relocations under the jurisdiction of other agencies where D-3 inlets are standard.

A scupper is a grate inlet that is used for bridge deck drainage. See Standard “BR” Drawings for details of the bridge scuppers. For general design guidelines refer to HEC-21 “Design of Bridge Deck Drainage”.

5.8.3. Flow in Gutters (Spread)

The hydraulic capacity of a gutter depends on its cross-section geometry, longitudinal grade, and roughness. The typical curbed gutter section is a right triangular shape with the curb forming the vertical leg of the triangle. The recurrence interval for design shall follow the requirements of Subsections 5.1.2.3 and 5.8.4.

The minimum inlet time (time of concentration) to the first inlet in a system shall follow the requirements of Subsections 5.1.2.3 and 5.8.4. The Manning equation has been modified to allow its use in the calculation of curbed gutter capacity for a triangular shaped gutter. The resulting equation is:

$$\mathbf{Q} = \left(\frac{\mathbf{0.56}}{\mathbf{n}}\right)\left(\mathbf{S_x^{5/3}}\right)\left(\mathbf{S_0^{1/2}}\right)\mathbf{T^{8/3}} \qquad (1)$$

where

Q = rate of discharge in cfs

n = Manning's coefficient of gutter roughness (EXHIBIT 5-8)

Sx = cross slope, in ft/ft

So = longitudinal slope, in ft/ft

T = spread or width of flow in feet

The relationship between depth of flow (y), spread (T), and cross slope (Sx) is as follows:

y = TS_x, depth in gutter, at deepest point in feet.

EXHIBIT 5-8 MANNING'S ROUGHNESS (N) COEFFICIENTS - GUTTERS

Street and Expressway Gutters		
a.	Concrete gutter troweled finish	0.012
b.	Asphalt pavement 1) Smooth texture 2) Rough texture	 0.013 0.016
c.	Concrete gutter with asphalt pavement 1) Smooth 2) Rough	 0.013 0.015
d.	Concrete pavement 1) Float finish 2) Broom finish	 0.014 0.016
e.	Brick	0.016
For gutters with small slope where sediment may accumulate, increase all above values of "n" by 0.002.		

5.8.4. Limits of Spread

The objective in the design of a drainage system for a highway pavement section is to collect runoff in the gutter and convey it to pavement inlets in a manner that provides reasonable safety for traffic and pedestrians at a reasonable cost. As spread from the curb increases, the risks of traffic accidents and delays and the nuisance and possible hazard to pedestrian traffic increase. The following shall be used to determine the allowable spread using a 15-year design storm and a 25-year design storm at low points except as noted:

1. Width of inside and outside shoulder along the Authority's mainline roadways.
2. Width of narrow inner shoulder plus one-half of travel lane on structures only subject to Authority's Engineering Department approval.
3. 1/3 width of ramps including service area ramps, 1/3 of live lanes next to curb and lanes adjacent to inside and outside shoulders on land service roads.
4. 1/2 width of acceleration or deceleration lanes.
5. 8-foot width next to curbs at service areas and maintenance yards (for a 5-year design storm).
6. 1/2 width of live lane when used temporarily during construction (for a 5-year design storm).

Since many roadway and bridge projects along the Turnpike and Parkway involve reconstruction of existing facilities it will be the Design Engineer's responsibility to determine the impact on gutter flow whenever an existing inlet grate is replaced with a new Eco grate or Eco curb piece. Each project presents a unique set of circumstances such as duration of each construction stage, speed limits, and whether the project involves a bridge or roadway. Each situation will need to be evaluated by the Design Engineer to determine the need for additional inlets or reductions in speed limits during construction and, if necessary, discussed with the Authority's Project Manager who will make the final determination.

5.8.5. Inlets

There are separate design standards for grates in pavement or other ground surfaces, and for curb opening inlets. Each standard is described below. These standards help prevent certain solids and floatables (e.g., cans, plastic bottles, wrappers, and other litter) from reaching the surface waters of the State. For new roadway projects, reconstruction, repaving, repair (excluding individual pothole repair), or resurfacing of existing highways, storm drain inlets must be selected or retrofitted to meet the following design requirements:

1. Grates in Pavement or Other Ground Surfaces

   Many grate designs meet the standard. The first option (especially for storm drain inlets along roads) is simply to use the Authority's bicycle safe grate. G-l and G-2 inlet frames and grates may be used in paved areas and in infields. Inlet grates shall be oriented to place the major bars of the grating parallel to the prevalent direction of water flow. The other option is to use a different grate, as long as each "clear space" in the grate (each individual opening) is:

   a. No larger than seven (7.0) square inches; or

   b. No larger than 0.5 inches (½ inch) across the smallest dimension (length or width).

2. Curb-Opening Inlets

   If the storm drain inlet has a curb opening, the clear space in that curb opening (or each individual clear space, if the curb opening has two or more clear spaces) must be:

   a. No larger than two (2.0) inches across the smallest dimension (length or width) - many curb opening inlets installed in recent years meet this criterion; or

   b. No larger than seven (7.0) square inches

   This complies with the latest NJDEP New Jersey Pollutant Discharge Elimination System requirements included in the NJDEP Highway Agency Stormwater Guidance Document and the NJDEP SWM Rules.

3. Exemptions

   The requirements for Grates in Pavement or Other Ground Surfaces or Curb-Opening Inlets do not apply in certain circumstances. See the NJDEP Highway

Agency Stormwater Guidance Document and the NJDEP SWM Rules for a complete list of exemptions.

Storm drain inlets that are located at rest areas, service areas, maintenance facilities, and along streets with sidewalks operated by the Authority are required to have a label placed on or adjacent to the inlet. The label must contain a cautionary message about dumping pollutants. The message may be a short phrase and/or graphic approved by the Authority's Engineering Department. The message may be a short phrase such as "The Drain is Just for Rain", "Drains to [Local Waterbody]", "No Dumping. Drains to River", "You Dump it, You Drink it. No Waste Here", or it may be a graphic such as a fish. Although a stand-alone graphic is permissible, the Authority strongly recommends that a short phrase accompany the graphic.

The hydraulic capacity of an inlet depends on its geometry and gutter flow characteristics. Inlets on grade demonstrate different hydraulic operation than inlets in at a low point. The design procedures for inlets on grade are presented in Subsection 5.8.5.1, "Capacity of Gutter Inlets on Grade". The design procedures for inlets at a low point are presented in Subsection 5.8.5.2, "Capacity of Grate Inlets at Low Points". Proper hydraulic design in accordance with the design criteria maximizes inlet capture efficiency and spacing. The inlet efficiency should be a minimum of 75%.

5.8.5.1. **Capacity of Inlet on Grade**

Collection capacity for gutter inlets on grade shall be determined using the following empirical equation:

$$\mathbf{Q_1} = \mathbf{16.88y^{1.54}\left(\frac{S^{0.233}}{S_x^{0.276}}\right)}$$

where

Q_1 = Flow rate intercepted by the grate (cfs)

y = gutter depth (ft) for the approach flow

S = longitudinal pavement slope

Sx = transverse pavement slope

The equation was developed for the standard Authority's Type "G-1" grate configuration and is to be used for all inlet grate types without modification.

On a roadway profile vertical curve, the gutter slope shall be defined for the purpose of these calculations, by the slope of a short chord not exceeding 25 feet at the inlet under consideration.

An alternative procedure, that yields results reasonably close to those obtained by using the runoff collection capacity equation presented above, is to compute the collection capacity in accordance with the procedures presented in FHWA, Hydraulic Engineering Circular No. 22 (HEC-22) "Urban Drainage Design Manual" using the following parameter values:

Grate type P-1-7/8 x 4 (P-50 x 100)

Constant representative splash-over velocity of 5.77 ft/s

Constant effective grate length of 2.66 feet

All other parameter values for use in this procedure are as stated in HEC-22. Use of computer programs is encouraged to perform the tedious hydraulic capacity calculations. HEC-22 contains useful charts and tables. The HEC-22 procedure is also incorporated in a number of computer software programs. Additional design assistance can be found in FHWA, Hydraulic Circular No. 22 (HEC-22) "Urban Drainage Design Manual".

5.8.5.2. Capacity of Inlets at Low Points

Hydraulic evaluation of the bicycle safe grate reveals that the grate functions as a weir for approach flow depths equal to or less than 9 inches and as an orifice for greater depths. Procedures to compute the collection capacity for each condition are presented separately below.

Weir Flow

Collection capacity shall be determined using equation 4-26 presented in HEC-22:

$$Q_i = C_W P y^{1.5}$$

where

Q_i = flow rate intercepted by the grate (cfs)

C_w = weir coefficient

P = perimeter around the open area of the grate (as shown on Chart 9B of HEC-22)

y = depth (feet) for the approach flow

The weir flow coefficient is 3.0. The perimeter around the open area for various Authority bicycle safe grate configurations and the resultant product of CwP are summarized as follows:

Inlet Type	Perimeter*(ft)	C_wP*
D1	5.28	15.84
D2, D3	6.96	20.88

*Type "D3" inlets have a curb opening that allows runoff to enter the inlet even when debris partly clogs the grate. The equations must be modified for use with inlets that do not have a curb opening to account for reduced interception capacity resulting from debris collecting on the grate. The perimeter around the open area of the grate (P) used in the weir equation should be divided in half for inlets without a curb opening. The perimeter and resultant product of CwP for inlet types “D1”, and “D2”, shown in the table reflect this modification.

Orifice Flow

Collection capacity shall be determined using equation 4-27 presented in HEC-22:

$$Q_i = C_0 A_0 (2gy)^{0.5}$$

where

Q_i = flow rate intercepted by the grate (cfs)

C_o = orifice coefficient

A_o = clear opening area of a single grate

y = depth (ft) for the approach flow

g = gravitational acceleration of 32.2 feet/sec^2

The orifice flow coefficient is 0.67. The clear opening area and resultant product of CoAo for various Authority bicycle safe grate configurations are summarized as follows:

Inlet Type	Clear Opening Area* (ft^2)	C_oA_o*
D1	1.45	0.97
D2, D3	2.90	1.94

*Type D3 inlets have a curb opening that allows runoff to enter the inlet even when debris partly clogs the grate. The equations must be modified for use with inlets that do not have a curb opening to account for reduced interception capacity resulting from debris collecting on the grate. The clear opening area of the grate (Ao) used in the orifice equation should be divided in half for inlets without a curb opening. The clear opening area and resultant product of CoAo for inlet types “D1”and “D2,” reflect this modification.

5.8.5.3. Location of Inlets

Proper inlet spacing enhances safety by limiting the spread of water onto the pavement. Proper hydraulic design in accordance with the design criteria maximizes inlet capture efficiency and spacing. Inlets should be located primarily as required by spread computations. See Subsections 5.8.5.1 and 5.8.5.2. Additional items to be considered when locating inlets include:

1. Low points in gutter grade. Adjust grades to the maximum extent possible to ensure that low points do not occur at driveways, handicap accessible areas, critical access points, etc.

    a. Check the Low Point inlet grate capacity at design discharge. When applicable consider the added capacity of snow inlets.

       If the spread of water, thus calculated, exceeds the allowable limits as indicated in Subsection 5.8.4, then recheck calculations by placing one double (D-2) inlet at low point. When placing D-2 inlet is not possible due to space limitation, two D-1 inlets, straddling the low point shall be used.

    b. If water spread, as calculated above, still exceeds the allowable limits, then place one or two "flanking" inlets on one or both sides of the low point D-1 inlet, at a maximum distance of 50 feet each or 0.2 feet above the top of grate elevation difference, whichever requires shorter connecting pipes.

2. At intersections and ramp entrances and exits to limit the flow of water across roadways.

3. Upgrade of cross slope rollover at the point fifty (50) feet upstream of the 0% cross slope or where the cross slope is 1%.

4. Upgrade of all bridges and downgrade of bridges in fill section before the end of curb where the curb is not continuous.

5. Along mainline and ramps as necessary to limit spread of runoff onto roadway in accordance with Subsection 5.8.4. Paved gore areas between merging roadways and ramps shall be depressed to effectively collect run-off generated on the adjacent roadway pavement. Where the roadway gradients result in a gore swale draining toward the point of the gore, a D-1 inlet shall be provided in the gore to intercept the accumulated runoff at the point where the gore width is approximately 6 feet.

6. Median Inlet location at 0% roadway profile.

   Inlet location in the left shoulder at 0% roadway profile, when introducing a concrete median barrier shall be in accordance with the following criteria:

Inlets shall be spaced at 120-foot intervals. To create a longitudinal gutter slope, vary shoulder cross slope from 1.5% minimum at gutter high point mid-way between inlets, to 3.3% minimum at inlet.

Additionally, the reveal at the concrete barrier base shall vary from 0 inches mid-way between inlets at gutter high point to a maximum of 2.5 inches at the inlet, at gutter low point, thus creating a maximum longitudinal gutter slope of 0.35%.

7. Inlets on Structures

   Inlets on structures shall be spaced in accordance with the criteria for roadway inlets and the following additional criteria:

   a. Inlets shall be located adjacent to piers, insofar as possible, where closed piping systems are required.
   b. Inlets are not required upgrade from sealed deck joints or open deck joints with drainage troughs.
   c. Inlets may be allowed to "free drop" from structures passing over existing water courses and from structures where the property below is owned by the Authority and unused. Piping for free drop inlets shall in all cases convey the discharge to a point below the bottom of low steel and a minimum of 25 feet from piers. Free-drop discharges may be subject to NJDEP Stormwater Management Regulations relating to quantity and quality.
   d. Water freezes on structures more rapidly than roadways, therefore greater care should be exercised to intercept runoff.
   e. Runoff shall be intercepted at the downstream end in fill and the upstream end in cut.

5.8.5.4. **Spacing of Inlets**

The spacing of inlets along the mainline and ramps is dependent upon the allowable spread and the capacity of the inlet type selected. Maximum distance between inlets is 400 feet where inlets are connected by pipes. The procedure for spacing of inlets is as follows:

1. Calculate flow and spread in the gutter. Tributary area is from high point to location of first inlet. This location is selected by the Engineer. Overland areas that flow toward the roadway are included.
2. Place the first inlet at the location where spread approaches the limit listed in Subsection 5.8.4.
3. Calculate the amount of water intercepted by the inlet, check the grate efficiency. This efficiency should be a minimum of 75%.

4. The water that bypasses the first inlet should be included in the flow and spread calculation for the next inlet.
5. This procedure is repeated to the end of the system. Sample calculations are presented in Subsection 5.14.

5.8.5.5. **Depressed Gutter Inlet**

Placing the inlet grate below the normal level of the gutter increases the cross-flow towards the opening, thereby increasing the inlet capacity. Also, the downstream transition out of the depression causes backwater which further increases the amount of water captured.

1. Locations of Depressed Inlets
   a. All inlets in shoulders greater than 4 feet wide.
   b. All inlets in one-lane, low speed ramps.
   c. Inlets in parking lots and other paved areas not potentially subject to high speed traffic.
   d. Inlets will not be depressed next to a riding lane, barrier curb, acceleration lane, deceleration lane, two-lane ramps, and direct connection ramps or within the confines of a bridge approach and transition slab.
2. Limits of Depression
   a. Begin depression a distance of 4 feet upgrade of inlet.
   b. End depression a distance of 2 feet downgrade of inlet.
   c. Begin depression 4 feet out from gutter line.
   d. Depth of depression, 2 inches below projected gutter grade.
3. Spacing of Depressed Inlets

   Use the same procedure as described in Subsection 5.8.5.4. This method will give a conservative distance between inlets; however, this will provide an added safety factor and reduce the number of times that water will flow on the highway riding lanes when the design storm is exceeded.

5.8.6. **Snow Melt Control**

Roadway safety can be enhanced by snowmelt runoff control. “Snow” inlets are chamber-type inlets set in the shoulder pavement to intercept snowmelt or rainfall runoff during winter periods when the gutter inlet may be blocked with plowed snow. Such inlets are required where maintenance forces cannot entirely clear the shoulder of heavy snow falls by normal plowing procedures, without resorting to snow hauling. Typical roadway configurations creating this condition include roadway cut sections and sections bounded by guide rail, barrier, and noisewalls.

Snow inlets are required where such roadway configurations are encountered at mainline profile low points and at both ends of 0% profiles, where they meet the vertical curve, to prevent potential flooding of the traveled way. In addition, the collection of snowmelt on the high side of superelevation is important to reduce icing conditions.

A discussion of each situation and the design approach is outlined

1. Snowmelt Collection on High Side of Superelevation

   Collection of snow melt on the high side of a superelevated section from roadway and berm areas before it crosses the roadway prevents icing during the freeze-thaw process. Therefore, a safety offset or small shoulder (4 feet wide) sloped back towards the curb at a rate of 6% will provide a means to convey the snowmelt water to inlets installed for this purpose. The snowmelt inlets should be placed along the outer curbline at the upstream side of all intersections and at convenient cross drain locations. The snowmelt inlets should be connected to the drainage system with a 15-inch diameter pipe to the trunk storm sewer. The small shoulder and snow inlets will not be designed to control stormwater runoff but shall be designed to handle only the small amount of expected flow from the snowmelt.

2. Snowmelt Collection at Low Points

   Collection of snowmelt is important at low points where the pile-up of snow over existing inlets prevents draining of snowmelt and runoff off the edge of the road. The addition of inlets placed away from the edge of curb and beyond anticipated snow piles provides a means to drain snowmelt.

   Snow inlets are required at all roadway profile low points. Where snow inlets are required, D-1 inlets shall be provided in both shoulders, with the inlet centerline set 2.0 feet inside the outside edge of shoulder except in the following case:

   - In 10-foot and 12-foot shoulders with concrete curb, asphalt lip curb or Concrete Median Barrier, inlet centerline shall be set 6.0 feet. inside the outside edge of shoulder.

   Snow inlets are not required on ramps.

   Snow inlets shall not be depressed.

   Snow inlets shall not be installed in shoulders where the width is so narrow that placement of a snow inlet will encroach upon the inlet at the curb or extend into the travel lane.

   Pipes draining snow inlets shall be a minimum 15 inches diameter, sloped at a 1% minimum grade wherever possible.

On projects where grading and paving are in separate contracts, snow inlets and the associated outlet pipe shall be constructed in the grading contract. Top of grate elevations are to be set to correspond with the subgrade elevations in the grading contract thus permitting the inlets to serve as temporary drains for the boxed out roadway template. These inlets shall then subsequently be raised and set to finished pavement grade in the paving contract.

5.8.7. Alternative Runoff Collection Systems – Trench Drains

Standard roadway inlets are used to collect runoff on curbed roadways. Compliance with the established spread criteria for roadways with flat grades typically requires many inlets, usually installed at close intervals. Use of alternative collection systems such as trench drains may be appropriate to reduce the number of inlets required to satisfy the spread criteria. Therefore, use of trench drains for runoff collection on roads with flat grades may be warranted. The trench drain should be located upstream of the inlet to which it connects. The length of trench drain should provide the capture capacity that together with the inlet limits bypass at the inlet to zero.

Trench drain capture computations require consideration of both frontal and side flow capture. Frontal flow captured by the narrow trench drain is small and is, therefore, disregarded. Side flow into the trench drain is similar to flow into a curb opening inlet. Hydraulic evaluation procedures for curb opening inlets are described in FHWA HEC-22. Side flow is computed using the procedures for curb opening inlets presented in FHWA HEC-22. The trench drain must be long enough to intercept the bypass after frontal flow plus the additional runoff contributed by the roadway for the length of the trench drain. The process includes the following steps:

1. Compute the total runoff to the inlet.
2. Compute the frontal flow captured by inlet with no bypass allowed for the spread limited to the width of the grate. The runoff to be intercepted by the trench drain is the total runoff minus the runoff captured by the inlet.
3. Compute the length of trench drain required to capture the discharge using the curb opening inlet procedures in FHWA HEC-22. The computed length shall be multiplied by two to reflect inefficiencies due to clogging.

Maintenance requirements for trench drains should also be considered in the evaluation of trench drains. Use of a trench drain system shall be discussed with the Authority’s Engineering Department early in the design process

5.8.8. Reset Casting – Manholes and Inlets

5.8.8.1. Reset Castings and Construction Practices

Where a manhole or inlet is to be raised using the item, Reset Frames and the existing hardware is excessively worn or in otherwise poor condition, a new frame and cover or grate shall be used. The Engineer shall verify the condition of the existing hardware in the field during the Phase A design.

The condition of the existing hardware and its probable performance after resetting needs to be assessed. If wear has caused the cover to be depressed more than 1/4 inch below the top of the frame, a new frame and cover or grate shall be specified.

On new pavement elevations exceeding 3-1/2 inches, castings shall be reset as follows: on multi-course resurfacing projects, the base and/or binder course shall be placed before a manhole frame is raised. This increases the accuracy in bringing the manhole to the proper grade and cross slope and leaves no more than 1-1/2 inches of casting exposed to traffic, thus permitting the roadway to be opened to traffic. If the specified cross slope of the overlay is different from that of the existing pavement, an extension ring with the necessary slope change built into the casting shall be specified.

For purposes of plan preparation, Cast Iron Extension Frames for Inlets and Extension Rings for Manholes shall be used to raise existing castings a maximum of 3-1/2 inches. When existing castings are required to be raised more than 3-1/2 inches to a maximum of 12 inches, the item Reset Frames shall be used. The item Reset Frames shall also be used to lower grades and elevations up to 12 inches. The Engineer shall verify that lowering a frame is possible without requiring reconstruction of the inlet and manhole. Adjustments of grades and elevations in excess of 12 inches will be considered as reconstructing inlets and manholes and the appropriate pay items shall be used.

Before Cast Iron Extension Frames or Rings are called for at a particular location, a determination shall be made by the Engineer as to whether the existing casting was previously raised using a Cast Iron Extension Frame or Ring, and what height was used. If a Cast Iron Extension Frame or Ring was previously used and the sum of the previous resetting plus the proposed resetting exceeds 3-1/2 inches, then the item Reset Frames or the appropriate reconstruction item shall be used.

5.8.8.2. Extension Rings and Frames

When structures contain existing frames or rings, these extension frames or rings shall be removed. Multiple extension frames and rings are not allowed. The Engineer may decide to reset a particular casting by either using the item, Reset Frames, or by installing an extension frame. This decision will primarily be influenced by the following factors:

1. The height to which the head is to be raised.

2. The maximum height of the casting above the roadway surface when open to traffic.
3. The prevailing traffic speed and volume.
4. The location of the casting in the traveled way or shoulder.
5. Expected interference with traffic flow.
6. The actual condition of the casting.
7. The comparative costs of resetting a casting (e.g. in concrete pavement, resetting is generally more expensive).

While some case-by-case analyses of these factors will be required, if the rise of casting is between 1-1/2 inches to 3-1/2 inches, an extension unit will generally be specified. If the rise of the elevation is less than 1-1/2 inches or more than 3-1/2 inches, the casting will be reset by the conventional method.

5.8.8.3. Extension Rings – Manholes

On all resurfacing projects where the proposed overlay thickness is between 1-1/2 inches and 3-1/2 inches, an extension ring shall be used to reset castings.

When installing the extension ring, any rise above 1-1/2 inches must be paved over and reset before the surface course is placed unless the binder course is placed before opening the roadway to traffic.

The minimum thickness for a manhole extension ring is 1-1/2 inches. Since the Standard Manhole Cover is 2 inches thick, any height adjustments in the range of 1- 1/2 inches and 2-1/4 inches will require a new Heavy Duty Cover (1 inch thick). Any salvageable cover in good condition can only be used in an extension ring 2-1/2 inch or more in height.

The following guidelines shall assist in determining where to use Extension Rings for Existing Manholes:

1. If the rise, R, is from 1-1/2 inches to less than 2-1/2 inches, an Extension Ring for Heavy Duty Cover (1-inch thick cover) is warranted.
2. If R is 2-1/2 inches to 3-1/2 inches, use a new Extension Ring for Standard Cover (2 inches thick cover).
3. If R is less than 1-1/2 inches or greater than 3-1/2 inches, use the item Reset Frames, to raise the manhole.

5.8.8.4. Extension Frames – Inlets

The minimum height of an inlet extension frame is 1-3/4 inches. Depending on how extensively depressed or "dished" an existing inlet may be, an extension of 2 inches, 2-1/2 inches, or 3 inches high may be required to enable the top elevation of the casting to be set flush with the finished grade of a 1-1/2 inches overlay.

The following guidelines shall assist in determining where to use Extension Frames for Existing Inlets:

1. If R is 1-3/4 inches to 3-1/2 inches, inclusive, use an extension frame.

2. If R is less than 1-3/4 inches or greater than 3-1/2 inches, the manhole is to be raised using the item, Reset Frames.
3. In general, inlets use a standard 1-1/4 inches grate on all extension frames.

5.8.8.5. Ramping

Ramping around the reset heads prior to final paving shall be accomplished as follows:

1. On single course (1-1/2 inches and variable) projects, a circular ramp of hot mix shall be placed about the periphery of the manhole to extend 3 feet laterally and shall leave 1/2 inch of the extension ring exposed; this should avoid the occurrence of under-compacted, shoddy-appearing areas (due to feathering) when the surface course is placed.
2. For multi-course resurfacing projects, the base and/or binder course should be placed before the casting is reset. This increases the accuracy of raising the casting to be flush with the finished pavement and enables the work progress to be in greater conformity with the policy of not having more than 1 1/2 inches exposed for more than 48 hours.
3. For a 3-inch resurfacing where 1-1/2 inches is to be milled off, after milling, the bituminous ramp will be placed as for the single course in "A". The binder course will then be placed so that the casting will end up being set flush with the finished pavement grade.
4. For the occasional 2-inch overlays, ramps will be constructed as for the 1 1/2 inches course.
5. Do not reset the casting until the topmost (if more than one) bottom course has been placed so that not more than 1-1/2 inches will be exposed for more than 48 hours before bringing the pavement to grade.
6. The brickwork shall be set with a high early strength, non-shrink mortar developing a one-hour compressive strength of 2500 PSI at 70°F. The mortar should not contain any gypsum, iron particles or chlorides.

5.9. Storm Drains

A storm drain is that portion of the roadway drainage system that receives runoff from inlets and conveys the runoff to some point where it can be discharged into a ditch, channel, stream, pond, lake, or pipe. This Subsection contains the criteria and procedures for the design of roadway drainage systems.

5.9.1. Material and Structural Requirements

1. Material Requirements (Storm Drains and Culverts)

a. Reinforced concrete pipe shall be used for normal culvert or storm drain installations on mild gradients with sufficient cover.

b. For culvert or storm drain installations on gradients exceeding 10% and in minimum cover conditions, the designer shall provide pipe material recommendations for approval by the Authority, such as double walled smooth interior High Density Polyethylene (HDPE) pipe or Ductile Iron Pipe. Corrugated steel or aluminum alloy pipes shall no longer be utilized within Authority right of way. HDPE pipe, shall be used only for pipe lengths outside of the roadbed of the mainline and ramps, for underdrains, and in certain cases in the repair of sections of corrugated steel or aluminum pipe. HDPE pipe is not allowed for lateral pipes or for the outlet pipe to a receiving watercourse or water body. The density of polyethylene pipe is less than water, therefore when wet conditions are expected, polyethylene pipe will float and should not be specified. End sections for HDPE pipe shall be either HDPE or cast in place concrete depending upon grading/slope conditions.

c. No pipe materials other than concrete, ductile iron, or HDPE shall be used for culverts and storm drains without prior approval by the Authority's Engineering Department.

d. Elliptical or arch-pipe shapes may be used where conditions prevent the use of circular shapes or make such use impractical.

e. Prefabricated shapes shall be used for culverts and storm drains to the maximum extents practicable. Culvert crossings consisting of not more than two parallel pipe lines may be considered where this configuration is justified as being more economical than the equivalent box culvert, and is acceptable to the respective outside agencies having jurisdiction.

2. Structural Requirements (Storm Drains and Culverts)

a. Reinforced concrete pipe shall be structurally designed in accordance with "Concrete Pipe Design Manual" and the following criteria:

i. Minimum cover for reinforced concrete pipe under roadways and shoulders shall be 3 feet from the finished grade to the top of pipe and there shall be no less than 12 inches from the bottom of aggregate base course to the top of pipe. Wherever possible, all storm sewers shall be set to provide at least 2 feet of cover between bottom of aggregate base course and top of pipe.

ii. Maximum cover for Class III reinforced concrete pipe shall be 10 feet, measured from finished grade to top of pipe. Where cover exceeds 10 feet, the specific installation shall be analyzed and the proper strength class determined and specified. Class III concrete pipe may be used under embankment heights exceeding 10 feet, provided justifying structural calculations are made.

iii. Class B Bedding may be considered to result from standard Authority trenching and backfilling operations.

b. Smooth interior HDPE pipe (as recommended by manufacturer).

c. Ductile Iron Pipe used to convey storm water shall be supplied with push on joints and be a minimum of class 150, or higher as per the Designer recommendations and approved by the Authority.

5.9.2. **Criteria for Storm Drains**

Storm drains shall be designed using the following criteria where applicable:

1. Minimum pipe size is 15 inches, except for lip curb inlet drains which shall be 12 inches.
2. Minimum pipe size is 18 inches downstream of mainline low points.
3. Storm sewer pipe materials for proposed systems typically include concrete, ductile iron and HDPE. Storm drain pipe material selection shall conform to the criteria established under the Materials and Structural Requirements of this Subsection. Manning's roughness coefficient "n" for concrete, ductile iron and HDPE pipe is 0.012. Manning's roughness coefficients for other materials occasionally encountered are presented in EXHIBIT 5-9:

   Pipe arches have the same roughness characteristics as their equivalent round pipes.

EXHIBIT 5-9 MANNING'S ROUGHNESS (N) COEFFICIENTS – OTHER

Manning's Roughness Coefficient, "n"		
Closed Culverts:		
Vitrified clay pipe		0.012-0.014
Cast-iron pipe, Uncoated		0.013
Steel pipe		0.009-0.011
Brick		0.014-0.017
Monolithic concrete:		
1.	Wood forms, rough	0.015-0.017
2.	Wood forms, smooth	0.012-0.014
3.	Steel forms	0.012-0.013
Cemented rubble masonry walls:		
1.	Concrete floor and top	0.017-0.022
2.	Natural floor	0.019-0.025
Laminated treated wood		0.015-0.017
Vitrified clay liner plates		0.015

4. Design to flow full, based on uniform flow without pressure head (other than 25- year storm conditions).
5. Normal cover over pipes under traveled roadways to be 2 feet below bottom of aggregate base course.

   NOTE: Minimum and maximum covers are set forth under the Material and Structural Requirements portion of this Subsection.
6. Storm sewer profiles shall be set generally parallel to roadway finished grades, or on the capacity slope or minimum velocity slope which most nearly approximates this condition so as to minimize excavation.
7. Minimum self-cleaning velocity of 2.5 feet/sec. should be maintained wherever possible.
8. Maximum grade on which concrete pipe should be placed is 10%.
9. Flared end-sections should be used whenever and wherever possible for concrete and HDPE pipe. Ductile Iron pipe, and in certain cases for HDPE pipe where slope conditions warrant, shall terminate at a concrete headwall.
10. All proposed storm sewers shall be laid on straight alignments between inlets. Where storm sewers are laid down embankment sideslopes, vertical deflections may be accomplished by using pipe elbows at the top and toe of slope and outside of paved areas.

Where storm sewers are laid down embankment slopes and terminate at a flared end section at the toe of slope, pipe elbows shall be used at the toe of slope to permit setting the flared end section generally horizontal and oriented compatibly with the embankment slope.

11. Headwalls and flared end sections shall conform to the requirements established under Culvert Design.
12. Stone Riprap Aprons are to be provided with all out-falling flared end sections for pipes greater than 18 inches in diameter and where erosive velocities are indicated for pipes 18 inches in diameter and less.
13. Pipe sizes should not decrease in the downstream direction even though an increase in slope would allow a smaller size.
14. The drainage layout should attempt to avoid conflicts with existing underground utilities and such items as utility poles, signal pole foundations, guide rail posts, etc. Implementation of the following design approaches may be necessary.
    a. Use of elliptical or arch pipe to minimize vertical dimension of pipe.
    b. Use of pipe material with the lowest friction factor to minimize pipe size.
    c. Test pits should be obtained early in the design process to obtain horizontal and vertical information for existing utilities. If the suggested design approaches do not avoid conflict, use of special drainage structures may be used to avoid the utility.
15. Drainage structures must accommodate all pipe materials used including concrete, ductile iron and HDPE.
16. Specially designed precast manholes or inlets shall be used for pipes 54 inches or larger diameter or when three or more pipes tie in and at least two of them are connected at some angles.
17. Cleaning existing drainage pipes and structures shall be incorporated on all projects when the existing drainage system has substantial accumulation of sediments. The cleaning shall extend to the first structure beyond the project limits.
18. On projects where contaminated areas have been identified, the drainage system should be designed to avoid these locations, if possible. If avoidance is not feasible, a completely watertight conveyance system, including structures such as manholes, inlets, and junction chambers, should be designed to prevent contaminated groundwater or other pollutants from entering the system. Possible methods to accomplish this include joining pipe sections with a watertight sealant and/or gasket, or the use of welded steel pipe. Retrofitting existing pipes to make them watertight may require installation of an appropriate internal liner. The Engineer shall provide recommendations prior to proceeding with the final design.
19. The soffits (overts or crowns) between the inflow and outflow pipes at a drainage structure shall be matched where possible. A minimum 1-inch drop between inverts within the structure shall be provided, if feasible.

20. Existing drainage facilities that are not to be incorporated into the proposed drainage system are to be completely removed if they are in conflict with any element of the proposed construction. Existing drainage facilities that are not to be incorporated into the proposed drainage system that do not conflict with any element of the proposed construction are to be abandoned. Abandonment of existing drainage facilities requires the following:
    a. Plugging the ends of the concrete pipes to remain, as a minimum. Concrete pipes to be abandoned under active roadways shall be evaluated on a case by case basis to determine if they need to be removed or filled. Issues to be considered are pipe size, age, depth, etc. Metal pipes shall be either removed or filled.
    b. Filling abandoned pipes in accordance with geotechnical recommendations.
    c. Removing the top of the drainage structure to 1 foot below the bottom of the pavement box, breaking the floor of the structure, and filling the structure with either granular material or concrete in accordance with geotechnical recommendations.
21. A concrete collar shall be used to join existing to proposed pipe of similar materials unless an approved adapter fitting is available.

5.9.3. Storm Sewer Design

Hydraulic design of the drainage system is performed after the locations of inlets, storm drain layout, and outfall discharge points have been determined. Hydraulic design of the drainage pipe is a two-step process. The first step establishes the preliminary pipe size based on hydrology and simplified hydraulic computations. The second step is the computation of the hydraulic grade line (HGL) for the system. This step refines the preliminary pipe size based on calculation of the hydraulic losses in the system using the hydrology computed in the first step for each section of pipe. The procedures to be performed in step 1 are presented in Subsection 5.9.4, "Preliminary Pipe Size". The procedures to be performed in step 2 are presented in Subsection 5.9.5, "Hydraulic Grade Line Computations".

5.9.4. Preliminary Pipe Size

The preliminary design proceeds from the upstream end of the system toward the outlet at which the system connects to the receiving downstream system. The design runoff for each section of pipe is computed by the Rational formula using the total area that contributes runoff to the system and the Time of Concentration to the upstream end of the pipe. The Time of Concentration increases in the downstream direction of the design and the rainfall intensity consequently decreases. All runoff from the contributing area is assumed to be captured. The inlet capture and by-pass computations used to determine the inlet layout are not used in the hydraulic computation.

The preliminary storm drain size should be computed based on the assumption that the pipe will flow full or practically full for the design runoff. The Manning equation should be used to compute the required pipe size. This preliminary procedure determines the required pipe size based on the friction losses in the pipe. All other losses are disregarded in the preliminary design. In general, the longitudinal grade of the roadway over the pipe being designed should be used as the slope in the hydraulic computation where practical. The HGL computations, as explained in Subsection 5.9.5, consider all losses and establish the actual pipe size required.

EXHIBIT 5-10 is recommended for use as guidance in performing the preliminary drainage system design. Use of computer programs to perform the computations is encouraged. The computational procedures and output results and presentation format presented in the FHWA Hydrain-Hydra program are recommended for use. Use of other computer programs is acceptable provided, as a minimum, the computational procedures and presentation of output are similar to those presented in EXHIBIT 5-10.

The following is an explanation of the Preliminary Storm Drain Computation Form, EXHIBIT 5-10. Data is to be presented for each reach of pipe being designed. The numbers refer to each column in EXHIBIT 5-10.

EXHIBIT 5-10 PRELIMINARY STORM DRAIN COMPUTATION FORM

PRELIMINARY STORM DRAIN COMPUTATION FORM

Computed By: ____________________ **Date:** ____________ **Route:** ____________________

Section: ____________________

Checked By: ____________________ **Date:** ____________ **County:** ____________________

Station & Offset (1)		L (ft)	Drainage Area "A" (Acres)		Runoff Coeff. "C"	"A" x "C"		Flow Time "Tc" (min.)			Rainfall "I" (in/hr)	Total Runoff Q=CIA (cfs)	Pipe Dia, (ft)	Slope (ft/ft)	Capacity Full (cfs)	Velocity (ft/s)		Invert Elevation	
Junction From	Junction To	(2)	Incre-Ment (3)	Total (4)	(5)	Incre-Ment (6)	Total (7)	Overland To Inlet (8)	In U/S Pipe (9)	Cum. Total in Pipe (10)	(11)	(12)	(13)	(14)	(15)	Full Flow (16)	Design Flow (17)	U/S End (18)	D/S End (19)

1. Station and Offset

   Input the location of the upstream and downstream structure for each pipe reach being designed referenced from the base line, survey line, or profile grade line (PGL) shown on the construction documents.

2. Length in feet
   Input the distance between the centerline of the upstream and downstream structure.

3. Incremental Drainage Area in acres
   Input the drainage area to each structure for each area with a different runoff coefficient that contributes runoff to the upstream structure.

4. Total Drainage Area in acres
   Input the cumulative total drainage area. This is a running total of column 3.

5. Runoff Coefficient

   Input the rational method runoff coefficient for each area contributing runoff to the structure.

6. Incremental "A" x "C"

   Input the incremental drainage area times its runoff coefficient for each area contributing runoff to the structure.

7. Total "A" x "C"

   Input the cumulative drainage area times the runoff coefficient. This is a running total of column 6.

8. Flow Time (Time of Concentration) to Inlet in Minutes

   Input the overland Time of Concentration to each structure.

9. Flow Time in Pipe in Minutes

   Input the flow time in the pipe upstream of the upstream junction (junction from). This time is computed by dividing the pipe length by the actual design flow velocity in the pipe (Column #2 divided by Column #17) for the pipe section upstream of the junction from structure (Column #1). The first pipe length will have no value. The flow time in the pipe will be used to compute the cumulative Time of Concentration (travel time) in the pipe.

10. Cumulative Time in the Pipe in Minutes

    Input the cumulative time in the pipe. This is a running total of column 9. If the overland flow to the inlet is greater than the cumulative time in the pipe, then that overland flow time will be added to subsequent flow time in the pipe to determine the longest cumulative Time of Concentration.

11. Rainfall Intensity "I" in inches per Hour

    Input the rainfall intensity in accordance with Subsection 5.4 and the longest Time of Concentration. The longest Time of Concentration is determined by using the larger of the overland flow time to the inlet (column 8) or the cumulative time in the pipe (column 10).

12. Total Runoff (Q = CIA) in cubic feet per Second

    Compute the total runoff using the area, runoff coefficient, and rainfall intensity identified in step 11.

13. Pipe Diameter in feet

    Compute the required pipe diameter using Manning's equation based on full flow. The tailwater is assumed to be at the elevation of the pipe soffit.

14. Slope in feet per feet

    Input the pipe slope used for the pipe design. The slope is typically as close as possible to the roadway longitudinal grade over the pipe reach being designed.

15. Capacity in cubic feet per Second

    Compute the pipe capacity using the Manning's equation and full flow conditions.

16. Velocity (full) in feet per Second

    Compute the pipe velocity using the full pipe capacity (V = Q/A).

17. Velocity (design) in feet per Second

    Compute the pipe velocity using the design discharge.

18. Invert Elevation (Upstream End)

    Input the pipe invert elevation at the upstream end.

19. Invert Elevation (Downstream End)

    Input the pipe invert elevation at the downstream end.

5.9.5. Hydraulic Grade Line Computations

The Hydraulic Grade Line (HGL) should be computed to determine the water surface elevation throughout the drainage system for the design condition. The HGL is a line coinciding with either: (1) the level of flowing water at any point along an open channel; or (2) the level to which water would rise in a vertical tube connected at any point along a pipe or closed conduit flowing under pressure. The HGL is normally computed at all junctions, such as inlets and manholes. All head losses in the storm drainage system are considered in the computation. The computed HGL for the design runoff must remain at least 1 foot below the top of grate or rim elevation.

Hydraulic control, also commonly referred to as "tailwater", is the water surface elevation from which the HGL calculations are begun. "Tailwater" elevation is established by determining water surface elevation at the locations where the new drainage system will discharge to the receiving waterway, such as a stream, ditch, channel, pond, lake, or an existing or proposed storm sewer system. The tailwater selected for the design should be the water surface elevation in the receiving waterway at the Time of Concentration for the connecting roadway storm sewer being designed or analyzed.

When the system is under pressure and when a higher level of accuracy is required considering storage in the pipe system, pressure flow routing can be performed using computer programs such as the "Pressure Flow Simulation" option in the FHWA Hydrain-Hydra program. Use of a pressure flow routing in the design of a new drainage system or analysis of an existing drainage system should be evaluated early in the initial design. A pressure flow routing is typically appropriate only in special cases, primarily when the available storage attenuates the peak discharge to the extent that downstream pipe sizes are minimized.

EXHIBIT 5-11 and

EXHIBIT **5-12** are recommended for use as guidance in performing HGL computations. HGL line computations must be provided for all projects. Use of computer software acceptable to the Authority to perform the computational procedures is encouraged. The computational procedures, output results, and presentation format similar to what is presented in EXHIBIT 5-11 and

EXHIBIT **5-12** are required as a minimum.

The following is an explanation of the computation of the Hydraulic Grade Line using EXHIBIT 5-11. The computed hydraulic grade line (HGL) for the design runoff must remain at least 1 foot below the roadway finished grade elevation at the drainage structure. Data is to be presented for each reach of pipe being designed. The pipe designation presented in the explanation refers to the pipe being designed unless otherwise noted. The numbers refer to each column in EXHIBIT 5-11.

1. Station and Offset

   Input the location of the upstream and downstream structure for each pipe reach being designed, referenced from the base line, survey line, or profile grade line (PGL) where applicable from the construction documents.

2. Pipe Diameter (Ø) in feet
   Input downstream pipe diameter.

3. Flow (Q) in cubic feet per Second
   Input flow in downstream pipe (outflow pipe).

4. Pipe velocity in feet per Second Input the design velocity of the pipe.

5. Hydraulic Radius (R) in feet
   Input the hydraulic radius (area divided by wetted perimeter) of the pipe.

6. Length (L) of Pipe in feet
   Input the distance between the centerline of the upstream and downstream structure.

7. Manning's "n" Roughness Coefficient

Input the Manning's coefficient "n". Use 0.012 for concrete, HDPE and smooth pipe.

8. Velocity Head (h) in feet

   Compute the velocity head, h = V2/2g, Where g = acceleration due to gravity.

9. Friction Loss (Hf) in feet

   Compute the friction loss in the pipe using the equation:

$$H_f = \frac{29.14 n^2 L}{R^{1.33}} \times \frac{V^2}{2g}$$

EXHIBIT 5-11 HYDRAULIC GRADE LINE COMPUTATION FORM

HYDRAULIC GRADE LINE COMPUTATION FORM

Computed By: ____________________ **Date:** ________

Checked By: ____________________ **Date:** ________

Route: ____________________

Section: ____________________

County: ____________________

Station & Offset (1)		(2)	Q (3)	V (4)	R (5)	L (6)	n (7)	h (8)	Hf (9)	He (10)	Hi (11)	Hs (12)	Ht (13)	TW (14)	HGL (15)	TOS (16)	CL (17)
Junction From	Junction To	Dia. (ft)	Flow (cfs)	Vel. (ft/s)	Hydr. Radius (ft)	Length (ft)	Manning's Roughness Coeff.	Vel, Head (ft)	Fric. Loss (ft)	Exit Loss (ft)	Entr. Loss (ft)	Struct. Loss (ft)	Total Head Loss (ft)	Tail-Water Elev. (ft)	Head-Water Elev. (ft)	Top of Struct. Elev. (ft)	TOS-HGL (ft)

EXHIBIT 5-12 STRUCTURAL AND BEND LOSS COMPUTATION FORM

STRUCTURAL AND BEND LOSS COMPUTATION FORM

Computed By: ____________________ **Date:** ________ **Route:** ____________________

Section: ____________________

Checked By: ____________________ **Date:** ________ **County:** ____________________

(1)	(2)	Q (3)	v (4)	$\frac{v^2}{2g}$ (5)	(6)	(7)	Ks (8)	Hs (9)	A (10)	Kb (11)	Hb (12)	Hs + Hb (13)
Junction Station & Offset	Downstream Dia. (ft0	Downstream Flow (cfs)	Downstream Velocity (ft/s)	Velocity Head (ft)	Junction Type (L, N, O)	Flow Type (P, O)	Structural Loss Coeff.	Structural Loss (ft)	Angle (deg)	Bend Factor	Bend Loss (ft)	Struct. Loss + Bend Loss (ft)

EXHIBIT 5-13 ENTRANCE LOSS COEFFICIENTS (KI)

This table shows values of the coefficient Ki to apply to the velocity head $\frac{V^2}{2g}$ to determine the loss of head at the entrance of a structure such as a culvert or conduit, operating full or partly full with control at the outlet.

Entrance head loss $H_i = V_i \frac{V^2}{2g}$

Type of Structure and Design of Entrance	Coefficient, K_i
A. Concrete Pipe and *Ductile Iron Pipe*	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = D/12)	0.2
Mitered to conform to fill slope	0.7
End-section conforming to fill slope *	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side or slope-tapered inlet	0.2
B. Concrete Box	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension,	
Or beveled edges on 3 sides	0.2
Wingwalls at 30 - 75 degrees to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension,	
Or beveled top edge	0.2
Wingwalls at 10 - 25 degrees to barrel	0.5
Square-edged at crown	
Wingwalls parallel (extension of sides)	0.7

Square-edged at crown	

*NOTE: "End sections conforming to fill slope", made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control.

10. Exit Loss (He) in feet
    Compute the exit loss of the drainage system using the equation: He = V2/2g, Where V = velocity of outflow pipe

    The exit loss is computed where the drainage system discharges to a swale, stream, pond, etc. via a headwall or a pipe open end. This loss is calculated for the last downstream pipe segment at the outlet end of the pipe being designed.

11. Entrance Loss (Hi) in feet
    Compute the entrance loss of the drainage system using the equation:

    $$H_i = V_i \frac{V^2}{2g}$$

    Where

    Ki = Entrance Loss Coefficient

    The entrance loss is computed at the upstream end of the system where the flow enters the first structure. This is either at a headwall / end section or the pipe in the beginning upstream inlet. Entrance loss coefficients are presented in EXHIBIT 5-13.

12. Structural Loss (Hs) in feet
    Input the structural loss. The structural loss corresponds to the structure at the upstream end of the pipe segment or "junction from".

13. Total Head Loss (Ht) in feet

    Compute the total head loss by adding the exit, entrance, friction, and structural loss. The exit and entrance losses are only added at the beginning and end of the pipe system, respectively.

14. Tailwater Elevation (TW) in feet

    Input the tailwater elevation at the downstream end of the pipe segment being designed. For the last downstream pipe segment, the tailwater elevation is established by determining the water surface elevation at the location where the pipe discharges to a stream, ditch, channel, pond, lake, or an existing or proposed storm sewer system. The tailwater selected for the design should be the water surface elevation in the receiving waterway at the Time of Concentration for the connecting roadway storm sewer being designed or analyzed. The tailwater elevation for each upstream pipe segment will be the computed headwater elevation (HGL) for the downstream pipe segment.

15. Headwater Elevation (HGL) in feet

    Compute the HGL at the upstream end of the pipe segment by adding the total head loss (Ht) to the tailwater elevation (TW) at the downstream end of the pipe.

16. Top of Structure (TOS) Elevation in feet

    Input the top of structure elevation which is the top of grate for inlets and rim elevation for manholes.

17. Clearance (CL) in feet

    Compute the clearance or difference in elevation between the top of structure (TOS) and the headwater elevation (HGL). The HGL shall be a minimum of 1 foot below the TOS.

The following is an explanation of the computation of structural losses using

EXHIBIT **5-12**. Data is to be presented for each reach of pipe being designed. The numbers refer to each column in

EXHIBIT **5-12**.

1. Station and Offset

   Input the location of each drainage structure referenced from the base line, survey line, or profile grade line (PGL) where applicable from the construction documents.

1. Pipe Diameter (Ø) in feet

   Input downstream pipe diameter (outflow). Equivalent diameter for elliptical or arch pipes may be used.

3. Flow (Q) in cubic feet per second

   Input flow in downstream pipe (outflow pipe).

4. Downstream Velocity (v) in feet per second Input the velocity in the pipe.

5. Velocity Head (h) in feet

   Compute the velocity head, $h=V^2/2g$

6. Structure Lateral Configuration

   The structural loss coefficient is related to the structure lateral configuration and type of flow. The lateral configuration designation is as follows:

   L = Junction with lateral
   N = Junction with no lateral
   O = Junction with opposed laterals

Flow Type

The structural loss coefficient is related to the structure lateral configuration and type of flow. The flow type designation is as follows:

P = Pressure flow

O = Open channel flow

8. Structural Head Loss Coefficient

   The structural head loss coefficient is related to the structure lateral configuration and type of flow. Insert the coefficient selected from Table 7-5 in HEC-22:

   Proper application of the structural loss to the drainage system requires an understanding of which pipe(s) is (are) considered the lateral(s) and which pipes are considered the main. For simplicity, the inflow pipe with the majority of the flow entering the structure is considered the main. All other inflow pipes are considered laterals.

   The hydraulic grade line computation for each lateral begins with the water surface elevation for the junction, which includes the structural head loss and bend head loss for the structure. No other losses are associated with the connection of the lateral to the junction.

9. Structural Loss in feet
   Compute the structural loss as the product of the structural loss coefficient (column 8) and velocity head (column 5).

10. Angle (A) in degrees
    Input the deflection angle between the inflow and outflow main pipes. The angle should be between 0 and 90 degrees.

11. Bend Factor

    Calculate the bend factor from Equation 7-5 in HEC-22: $H_b = 0.0033(\Delta)\left({V^2}/{2g}\right)$. Δ = Angle of curvature in degrees

12. Bend Loss in feet
    Compute the bend loss as the product of the bend factor (column 11) and velocity head (column 5).

13. Structural Loss + Bend Loss in feet
    Compute the sum of the structural loss (column 9) and the bend loss (column

5.9.6. Underdrains and Subgrade Drainage

5.9.6.1. Bleeder Drains

Turnpike pavement sections constructed prior to the 1969 Widening included a layer of penetration macadam base course which is quite pervious to groundwater flow. Pavement sections constructed during and after the 1969 Widening have replaced this penetration macadam base course layer with an impervious asphalt stabilized base course section.

Where this impervious pavement section is abutted against the previously used pavement section with macadam base course, as would occur during widening, subsurface water occurring in the macadam base course section may be trapped. It has been found that entrapped water is also occasionally present in the macadam base course layer under undisturbed existing conditions. Bleeder drains may be incorporated in Authority contracts to relieve the potential for accumulation of water when site specific soil condition justifies their usage, and in accordance with the following criteria:

1. On Continuous Grades - bleeder drains on 100-foot centers may be provided where 24 feet or more of macadam base course drain toward one shoulder (bleeder drains are not required where less than 24 feet of base course drain to one shoulder).
2. At Profile Low Points - bleeder drains may be provided on 50-foot centers for 150 feet each side of low points, regardless of macadam base course width.
3. At Bridge Abutments - bleeder drains may be provided at bridge abutments where the roadway profile causes the macadam base course to drain towards the abutment.

5.9.6.2. Underdrains

1. Where widening of existing Authority roadways previously founded on Grade A Subgrade material is required, underdrains shall be provided at all locations where the Grade A material layer is interrupted or otherwise modified so that free drainage of this layer to the side slope face is prevented. Turnpike pavements constructed during and prior to the 1969 Turnpike Widening were founded on this

layer of Special Subgrade material, Grade A, which served to drain subsurface water, occurring under the pavement section, transversely to the roadway side slope where the water occurring in the Grade A material was free to drain out the side slope face. Where this side slope was not exposed and free draining ("daylighted"), continuous underdrains were placed under the outside edge of shoulder to provide for subgrade drainage.

2. On new alignments, where the currently adopted deep asphalt pavement section is used, drainage of the Grade A material layer shall be done preferably through "daylighting" the roadway cross section whenever possible. Where "daylighting" is not practicable, installation of continuous underdrains shall be specified in accordance with the following criteria:

   a. Mainline roadway in cut: Underdrain both sides, regardless of superelevation.

   b. Normal three (3) lane mainline roadway in fill: Underdrains are to be installed on both sides.

   c. Normal two (2) lane mainline roadway in fill: Underdrain only the 12' shoulder.

   d. All superelevated mainline roadways in fill: Underdrain only on the low side of the superelevation.

   e. For ramps: Underdrain only the low side in both cut and fill sections.

   f. If ramp underdrains switch from one side to the other, overlap the horizontal placement of underdrains by 50 feet.

   g. All underdrains to be placed in fill sections may be eliminated from the contract as a result of field permeability tests.

   h. For contracts with separate grading and paving contacts:

      The grading contractor is only to place the underdrain adjacent to inlets in accordance with the Standard "DR" Drawings unless there is a groundwater problem, in which case the grading contractor should place all the underdrains required. The specifications for the grading contract should state that some special provision is made to the surface of underdrain backfill so as to prevent clogging of the material through slope erosion.

   i. Generally, the paving contractor is to place all the underdrains and the subbase outlet drains. A detail for the subbase outlet drain section and location is shown on the Standard "DR" Drawings.

No combination drains shall be used for subgrade drainage on Authority projects. Combination drains are storm drains laid in stone filled trenches with open joints or other interruptions in the pipe integrity which permit the infiltration of ground water and are not to be confused with combination underdrains.

Underdrains shall not be connected to inlets at the underdrain's upstream end.

Underdrain profiles shall generally follow roadway profiles. Where it is necessary to install underdrains on gradients adverse to the roadway profile, invert elevations shall be shown on the plans to establish underdrain profiles.

3. The need for underdrains in embankments is to be based upon the following criteria:

    a. The type of materials. It is necessary to know the types of materials going into the embankment construction. An embankment that is built entirely of free draining material will not require underdrains. If several different types of materials are used in the construction, the locations of the impermeable materials must be known in order to judge if underdrains will be required or not. At least the upper five feet of embankment should be entirely of free draining materials, with less permeable material below, before consideration may be given to eliminating underdrains.

    b. The permeability of the materials. This rating can be determined either by a field permeability test or by rating a sieve analysis test. The sieve analysis test will be easier to perform in the field; therefore, it is recommended. Areas in which underdrains may be deleted must meet the following grading requirements at least in the upper five feet, and may have lesser permeable materials below:

        i. If the material is a coarse to fine, well-graded sand or sand and gravel, the maximum percentage passing the #200 sieve shall be 10%.

        ii. If the material is a fine uniformly graded sand, the maximum percentage passing the #200 sieve shall be 2%.

    The percentage of minus #200 material shall be interpolated for intermediate gradations.

5.10. MEDIAN DRAINAGE

The basic purpose of a median is to separate opposing lanes of traffic. The widths, grade and shape of a median is determined for the most part by safety considerations. A wide, shallow, depressed median is usually selected as best fulfilling the median purpose. A provision to drain the median by means of inlets must be included in the median design. This Subsection contains procedures and criteria for the design of median drainage.

5.10.1. Median Inlet Type

All median inlets are to be Type D-2.

5.10.2. Median Design Criteria – Continuous Grade

Median inlets should intercept the total design flow from its discharge area plus any by-pass from upstream. The drainage area to each inlet must be adjusted by inlet spacing to limit the design flow to a maximum depth of 6 inches. In addition, the spread should be confined to the median and the top of flow should be below the pavement subgrade. Because of the variable parameters in the spread calculations, each inlet must be investigated.

The recurrence interval used in the design is the same as that of the longitudinal roadway system.

5.10.3. Procedure for Spacing Median Drains

Channel capacity shall be computed using the procedures presented in Subsection 5.11, Channel Design.

Inlet capture for inlets on grade shall be computed using the weir equation stated as follows:

$$Q_i = C_W P y^{1.5}$$

where

Q_i =	flow rate intercepted by the grate (cfs)
C_w =	weir coefficient
P =	perimeter around the open area of the grate (as shown on Chart 9B of HEC-22)
y =	depth (ft) for the approach flow

The weir flow coefficient is 3.0. The weir length to be used is the frontal flow length of the inlet.

Inlet capture for inlets at low points shall be computed using the procedures in Subsection 5.8.5.2 “Capacity of Grate Inlets at Low Points".

Judgment should be used in a cut section to place these inlets economically as well as functionally. Some leeway is afforded the Engineer to place the median inlets opposite roadway edge inlets. This simplifies connections and reduces pipe lengths.

The water that bypasses the inlet because of the above, should be added to the next inlet's design runoff.

5.11. Channel Design

Open channels, both natural and artificial, convey flood waters. Natural channels are crossed at highway sites and often need to be impacted or modified to accommodate the construction of a modern highway. Roadside ditches add to the natural drainage pattern. Dependent upon its classification and drainage area, a channel may be considered a regulated waterway by NJDEP. The Engineer shall be responsible for determining a channel's regulatory classification and coordinate with the NJDEP, accordingly. The Engineer shall avoid designing a new channel that meets the definition of a regulated waterway or modifying an existing channel such that it becomes a regulated waterway. Approval from the Authority's Engineering Department will be required for all channels that will become regulated waterways.

This part contains design methods and criteria to aid the Engineer in preparing designs incorporating these factors. Other open channel analysis methods and erosion protection information is also included.

5.11.1. Channel Type

The design of a channel is formulated by considering the relationship between the design discharge, the shape, slope and type of material present in the channel's bank and bed. Either grassed channels or non-erodible channels are typically used. The features of each are presented in the following narrative.

1. Grassed Channels: The grassed channel is protected from erosion by a turf cover. It is used in highway construction for roadside ditches, medians, and for channel changes of small watercourses. A grassed channel has the advantage of being compatible with the natural environment. This type of channel should be selected for use whenever possible.

   Rapid establishment of grass cover is vitally important for grassed channels. Temporary erosion protection measures should be used when analysis indicates a normal seeding and mulch cover will not sustain the mean annual design flow - 2.33-year storm.

2. Non-erodible Channel: A non-erodible channel has a lining that is highly resistant to erosion. This type of channel is expensive to construct, although it should have a very low maintenance cost if properly designed. Non-erodible lining should be used when stability cannot be achieved with a grass channel. Erosion resistant linings, where required, shall be selected on the basis of function and economy. Permissible linings include jute mesh, sod, riprap stone, polyvinyl coated gabions, concrete and concrete bag slope protection. There are currently available extruded grout lining processes which utilize fabric forms to contain the grout. Such linings may be specified as alternate bid items where appropriate for field conditions and where economical. Typical lining materials are discussed in the following narrative.

a. Concrete Ditch Lining: Concrete ditch lining is extremely resistant to erosion. Its principal disadvantages are high initial cost, susceptibility to failure if undermined by scour and the tendency for scour to occur downstream due to an acceleration of the flow velocity on a steep slope or in critical locations where erosion would cause extensive damage.

b. Aggregate Ditch Lining: This lining is very effective on mild slopes. It is constructed by dumping crushed aggregate into a prepared channel and grading to the desired shape. The advantages are low construction cost and self-healing characteristics. It has limited application on steep slopes where the flow will tend to displace the lining material.

c. Alternative Linings: Other types of channel lining such as gabion, or an articulated block system may be approved by the Authority's Engineering Department on a case-by-case basis, especially for steep sloped high velocity applications. HEC-23, provides some design information on other types of lining.

5.11.2. **Site Application**

The design should consider site conditions as described below.

1. Roadside Ditches: Roadside ditches are used to intercept runoff and groundwater occurring from areas within and adjacent to the right of way and to carry this flow to drainage structures or to natural waterways.

   Roadside ditches should be grassed channels except where non-erodible lining is warranted. A minimum desirable slope of 0.5% should be used.

2. Interceptor Ditch: Interceptor ditches are located on the natural ground near the top edge of a cut slope or along the edge of the right of way to intercept runoff from a hillside before it reaches the backslope.

   Interceptor ditches should be built back from the top of the cut slope, and generally at a minimum slope of 0.5% until the water can be emptied into a natural water course or brought into a road ditch or inlet by means of a headwall and pipe. In potential slide areas, stormwater should be removed as rapidly as practicable and the ditch lined if the natural soil is permeable.

3. Channel Changes: Realignment or changes to natural channels should be held to a minimum. The following examples illustrate conditions that warrant channel changes:

a. The natural channel crosses the roadway at an extreme skew.

b. The embankment encroaches on the channel.

c. The natural channel has inadequate capacity.

d. The location of the natural channel endangers the highway embankment or adjacent property.

4. Grade Control Structure: A grade control structure allows a channel to be carried at a mild grade with a drop occurring through the structure (check dam).

5. Channel Alignment: Channel alignment parallel to Authority roadways shall provide a minimum 5-foot berm between the toe of roadway slope and the top of channel slope. 12-foot berms shall be provided where the berm is to be used for maintenance access. The above separation criteria does not apply to Toe of Slope ditches, conveying roadway embankment or pavement runoff. For Toe of Slope ditches see detail on Design Std. Dwg. DR-5. Channel relocations shall begin and end in established existing streams, within the Authority Right of way where possible. Channel relocations shall be made upstream of the Authority roadway rather than downstream of such roadway, where possible.

6. Channel Cross Section: Channel cross section shall be trapezoidal with 2:1 or flatter side slopes, sized to carry the design discharge without adverse flooding.

5.11.3. **Channel Design Procedure**

The designed channel must have adequate capacity to convey the design discharge with 1 foot of freeboard.

Methods to design grass-lined and non-erodible channels are presented in the following narrative.

1. Grassed Channel: A grassed channel shall have a capacity designated in Subsection 5.1.2.3 – Recurrence Interval.

   A non-erodible channel should be used in locations where the design flow would cause a grassed channel to erode.

   The design of the grassed channel shall be in accordance with the Standards for Soil Erosion and Sedimentation Control in New Jersey. Culvert headwalls shall be oriented at right angles to the pipe centerline, whenever possible.

2. Non-Erodible Channels: Non-erodible channels shall have a capacity as designated in Subsection 5.1.2.3 – Recurrence Interval. The unlined portion of the channel banks should have a good stand of grass established so large flows may be sustained without significant damage.

The minimum design requirements of non-erodible channels shall be in accordance with the Standards for Soil Erosion and Sedimentation Control in New Jersey where appropriate unless otherwise stated in this Subsection.

a. Capacity: The required size of the channel can be determined by use of the Manning's equation for uniform flow. Manning's formula gives reliable results if the channel cross section, roughness, and slope are fairly constant over a sufficient distance to establish uniform flow. The Manning's equation is as follows:

$$Q = \left(\frac{1.486}{n}\right) AR^{2/3} S^{1/2}$$

Where

Q = Flow, cubic feet per second (cfs)

n = Manning's roughness coefficient

Concrete, with surface as indicated	Friction Factor Range
1. Formed, no finish	0.013-0.017
2. Trowel finish	0.012-0.014
3. Float finish	0.013-0.015
4. Float finish, some gravel on bottom	0.015-0.017
5. Gunite, good section	0.016-0.019
6. Gunite, wavy section	0.016-0.022

A = Area, square feet (ft^2)

P = Wetted perimeter, feet (ft)

R = Hydraulic radius (A/P)

S = Slope (ft/ft)

Design manuals such as Hydraulic Design Series No. 4 and Hydraulic Engineering Circular No. 15 can be used as a reference for the design of the channels.

For non-uniform flow, a computer program, such as HEC-RAS, can be used to design the channel.

b. Height of Lining: The height of the lined channel should be equal to the normal depth of flow (D) based on the design flow rate, plus 1 foot for freeboard if possible.

c. Horizontal Alignment: Water tends to superelevate and cross waves are formed at a bend in a channel. If the flow is supercritical (as it will usually be for concrete-lined channels), this may cause the flow to erode the unlined portion of the channel on the outside edge of the bend. This problem may be alleviated either by superelevating the channel bed, adding freeboard to the outside edge, or by choosing a larger radius of curvature. The following equation relates freeboard to velocity, width, and radius of curvature:

$$H = \frac{V^2 W}{32.2 R_C}$$

where

H = Freeboard in feet (ft.)

V = Velocity in ft/s

W = Bottom width of channel in feet (ft.)

$\mathbf{R_c}$ = Radius of curvature in feet (ft.)

d. Additional Design Requirements:

i. The minimum d50 stone size shall be 6 inches.

ii. The filter layer shall be filter fabric wherever possible.

iii. A 3 feet wide by 3 feet deep cutoff wall extending a minimum of 3 feet below the channel bed shall be provided at the upstream and downstream limits of the non-erodible channel lining.

iv. Additional design requirements may be required for permit conditions or as directed by the Authority's Engineering Department.

v. Gradation of Aggregate Lining: The American Society of Civil Engineers Subcommittee recommends the following rules as to the gradation of the stone:

- Stone equal to or larger than the theoretical d50, with a few larger stones, up to about twice the weight of the theoretical size tolerated for reasons of economy in the utilization of the quarried rock, should make up 50% of the rock by weight.
- If a stone filter blanket is provided, the gradation of the lower 50% should be selected to satisfy the filter requirements between the stone and the upper layer of the filter blanket.
- The depth of the stone should accommodate the theoretically sized stone with a tolerance in surface in rule 1. (This requires tolerance of about 30% of the thickness of the stone.)
- Within the preceding limitations, the gradation from largest to smallest sizes should be quarry run.

3. Water Quality Channel Design: The design of a water quality channel shall be in accordance with Authority and NJDEP requirements. Detailed requirements regarding water quality treatment is included in Subsection 5.6.1.

5.12. Culvert Design

A highway embankment constitutes a barrier to the flow of water where the highway crosses watercourses. A culvert is a closed conduit that provides a means of carrying the flow of water through the embankment.

5.12.1. Culvert Types

1. Pipes: Reinforced concrete pipe culverts, HDPE pipe and ductile iron pipe are shop manufactured products available in a range of sizes and standard shapes. Reinforced concrete pipes are available in round and elliptical shapes. Round shapes are generally more economical, due to their greater strength and common usage. Culvert pipe material shall conform to the criteria set forth under the Material and Structural Requirements Subsection 5.9.1.

   Pipe flow characteristics for different pipes change due to their relative roughness.

   Additional capacity can be obtained with multiple pipe installations. Multiple installations are accomplished by installing several individual culvert pipes parallel to each other with enough separation to allow for proper compaction.

2. Reinforced Concrete Boxes (RCB's): Box culverts are either precast off-site or constructed in the field by forming and pouring. Box culverts may be constructed to any desired size in either square or rectangular shapes. These designs may be easily altered to allow for site conditions. The flow characteristics of RCB's are very good as their barrels provide smooth flow and their inlet may be designed for extra efficiency where needed. Where a multiple culvert installation is indicated, the RCB may be constructed with two or more barrels. NJDEP regulations may dictate when multiple culverts can be used. The minimum width, if possible, will be 10 feet per box.

For waterways regulated by NJDEP, the NJDEP may also dictate the need to provide a fish passage in the culvert and/or address habitat fragmentation concerns. Guidance regarding fish passage and habitat fragmentation provisions in culverts are presented in Subsection 5.12.7.

5.12.2. Culvert Location

The alignment of a culvert in both plan and profile should ensure efficient hydraulic performance, as well as keep the potential for erosion and sedimentation to a minimum. The criteria given in Subsection 5.11, "Channel Design", should be considered in the location of the culvert.

The culvert alignment shall conform to the following minimum requirements for waterways not regulated by NJDEP:

1. Culvert outfalls shall discharge into existing, established watercourses, whenever possible.
2. Culvert headwalls shall be oriented at right angles to the pipe centerline, whenever possible.
3. Culvert inverts shall be set 0.2 foot below the natural stream bottom.

4. Side or slope-tapered inlets may be considered, where economical, as a means of reducing required culvert diameters.
5. Curved alignment may be considered on culverts 48" in diameter or larger, where such alignment facilitates a more economical solution to the specific problem.

Guide rail shall be specified along Authority roadways where flared end sections or headwalls for culverts are located within the clear zone. Refer to Section 4 for guide rail design criteria.

5.12.3. Culvert Selection

Select a culvert type and size that is compatible with hydraulic performance, structural integrity, economics, and regulatory requirements, if applicable. The structural requirements for various pipes may be found in references (1), (2), and (21). Minimum diameter for culverts shall be 24 inches or the area equivalent of a 24-inch diameter circular pipe for other cross-sectional shapes.

5.12.4. Culvert Hydraulics

Laboratory tests and field observations show two major types of culvert flow: flow with inlet control and flow with outlet control. Different factors and formulas are used to compute the hydraulic capacity of a culvert for each type of control. Under inlet control, the cross-sectional area of the culvert barrel, the inlet geometry and the amount of headwater or ponding at the entrance are of primary importance. Outlet control involves the additional consideration of the elevation of the tailwater in the outlet channel and the slope, roughness and length of the culvert barrel.

It is possible, by hydraulic computations, to determine the probable type of flow under which a culvert will operate for a given set of conditions. The need for making these computations may be avoided, however, by computing headwater depths from available computer programs, such as FHWA's HY-8, for both inlet control and outlet control and then using the higher value to indicate the type of control and to determine the headwater depth. This method of determining the type of control is accurate except for a few cases where the headwater is approximately the same for both types of control. Refer to FHWA HDS-5 – "Hydraulic Design of Highway Culverts" for detailed culvert design procedures. The Engineer shall determine if a detailed hydraulic computation using a program, such as the U.S. Army Corps of Engineers' HEC-RAS program, is required for design or compliance with a regulatory agency.

Maximum Allowable Headwater elevations or depths shall not exceed the following conditions:

(All criteria based on zero approach velocity)

1. One foot of freeboard between design water surface and P.V.I. of lowest roadway berm abutting the headwater pool.
2. One foot of freeboard from design water surface to flooding elevation of upstream improvements, abutting the headwater pool.
3. Headwater depth not more than the diameter of pipe plus one foot (measured from invert to water surface) for culverts 42 inches or less or the diameter of the pipe for culverts larger than 42 inches in diameter.
4. Other headwater controls established by the NJDEP, Division of Land Resource Protection.

5.12.5. **Culvert End Structures**

Culvert end structures may be used for the following purposes:

1. To improve the hydraulic efficiency of the culvert.
2. To provide erosion protection and prevent flotation.
3. To retain the fill adjacent to the culvert

These structures include headwalls, concrete flared end sections, corrugated metal end sections, and improved inlet structures to increase capacity.

Entrance and Outlet End Structures shall conform to the following requirements:

1. Flared end sections shall be provided at the outfall end of all culverts 48 inches in diameter or less.
2. Concrete headwalls shall be provided at the outfall end of all culverts larger than 72 inches and for all box culverts and small bridges.
3. Flared end sections shall be provided at the entrance end of all culverts 48-inch diameter or less, except where the use of concrete headwalls with improved entrance loss characteristics results in a reduction of the required culvert diameter.
4. Concrete headwalls with beveled entrances shall be provided at the intake end of all culverts larger than 72 inches in diameter and for all box culverts and small bridges.
5. For entrance and outlet conditions of pipes greater than 48 inches and less than 72 inches, economics shall govern whether flared end sections or concrete headwalls shall be used.

Each type of end structure is described in the following narrative.

1. Headwall: A headwall is a retaining wall attached to the end of a culvert, (see Standard "DR" Drawings). The alignment of the headwall should be normal to the centerline of the barrel to direct the flow into the barrel. The wingwalls should be long enough to prevent spillage of the embankment into the channel. A cutoff wall attached to the downstream end of the unit if a concrete apron is

not provided at the headwall. The cutoff wall may be a concrete unit across the entire width of the downstream end of the flared end section. The cutoff wall shall be a minimum of 1.5 feet thick and 3.0 feet deep.

2. Concrete Flared End Sections: A concrete flared end section is a precast unit with a beveled and flared end that provides an apron at the outlet end of the pipe (see Standard “DR” Drawings). The bevel approximately conforms to embankment slope. Limited grading of the embankment is usually required around the end of the flared end section. Installation of a flared end section requires installation of a cutoff wall attached to the downstream end of the unit. The cutoff wall may be a concrete unit across the entire width of the downstream end of the flared end section. The cutoff wall shall be a minimum of 1.5 feet thick and 3.0 feet deep.
3. HDPE End Sections: A HDPE end section is a flared end that provides an apron at the outlet end of the pipe, (see Standard “DR” Drawings). The bevel shall roughly conform to embankment slope. Limited grading of the embankment is usually required around the end of the end section. However, in circumstances dictated by slope and grading constraints HDPE pipe may be required to terminate at a concrete headwall.
4. Improved Inlet: An improved culvert inlet incorporates inlet geometry refinements to increase the capacity of a culvert operating with inlet control. These geometry improvements include beveled edges, side tapers and slope tapers functioning either individually or in combination.

5.12.6. Flood Routing at Culverts

The presence of substantial storage volume below the allowable headwater elevation at the upstream end of a culvert warrants evaluation of the resultant peak flow attenuation. The reduced peak discharge resulting from attenuation yields a reduced culvert size for a new crossing. Attenuation of the peak discharge at existing crossings may indicate that the existing culvert is adequate or may reduce the size of the relief or replacement culvert. For this reason, flood routing computations shall be performed for all culvert locations except where the proposed topography indicates that limited storage volume, such as is typical with deep incised channels, is available.

Flood routing evaluation at a culvert provides a realistic indication of hydrologic conditions at the culvert entrance. A more realistic assessment can be made where environmental concerns are important. The extent and duration of temporary upstream ponding determined by the flood routing computations can help improve the environmental assessment of the proposed construction.

The design procedure for flood routing through a culvert is the same as for reservoir routing. Additional information on flood routing and storage is included in Subsection 5.4.6.

5.12.7. Habitat Fragmentation (Fish and Wildlife Passage)

Fish passage is a concern with culverts. Failure to consider fish passage may block or impede upstream fish movements in the following ways:

1. Outlet of the culvert is installed above the streambed elevation to where fish may not be able to enter.
2. Scour lowers the streambed downstream of the culvert outfall and the resulting dropoff creates a potential vertical barrier.
3. High outlet velocity may provide a barrier.
4. Higher uniform velocities within the culvert than occur in the natural channel may prevent fish from entering or transiting the culvert.
5. Abrupt drawdown, turbulence, and accelerated flow at the inlet to the culvert entrance may prevent fish from exiting the upstream end of the culvert.
6. Natural channel replaced by an artificial channel may have no zones of quiescent water in which fish can rest.
7. Debris barriers (including ice) upstream or within the culvert may stop fish movement.
8. Shallow depths within the culvert during minimum flow periods may preclude fish passage.

In addition to fish passage, roadways and other linear infrastructure can create barriers to the movement of terrestrial species, known as habitat fragmentation. This fragmentation affects species in the following ways:

1. Wildlife-vehicle collisions from an animal attempting to cross a roadway creates a hazard to the traveling public and is potentially fatal for the animal.
2. The barrier can reduce or eliminate migration between populations, resulting in smaller isolated sub-populations and creates a higher risk of local extinction.

The Engineer shall design all new, reconstructed, and rehabilitated culverts in accordance with NJDEP regulations. The Engineer is encouraged to request a pre-application meeting with NJDEP early in the design of the culvert to determine if there are any fish passage or terrestrial corridor species habitat fragmentation concerns. For more guidance on fish passage provisions in proposed culvert installations, contact the NJDEP Division of Fish and Wildlife. For more guidance on habitat fragmentation, contact the NJDEP Division of Land Resource Protection and refer to the Flood Hazard Area Technical Manual.

5.13. SCOUR AT BRIDGES

A bridge scour evaluation is comprised of a three-discipline approach; hydrologic and hydraulic, geotechnical, and structural. In addition to the information presented within this Subsection, the specific guidance provided in Subsection 2.6 of the AASHTO LRFD Bridge Design Specifications should be referred to. As stated therein, the AASHTO Model Drainage Manual may be referred to for guidance and references on design procedures and references to hydrologic and hydraulic designs computer software. See Section 3 – Structures Design of this manual for additional information regarding scour.

The following FHWA Hydraulic Engineering Circular (HEC) reports provide guidance that should be used in performing a scour analysis:

HEC-18 – Evaluating Scour at Bridges. Procedures for designing new, replacement and rehabilitation of bridges to resist scour are presented.

HEC-20 – Stream Stability at Highway Structures. Guidance for identifying stream instability and for the selection and design of appropriate countermeasures to mitigate damage to bridges is presented.

HEC-23 – Bridge Scour and Stream Instability Countermeasures. Bridge scour and stream instability countermeasures that have been implemented by various State Departments of Transportation are identified in this Report. Also, design guidelines for the countermeasures are provided.

The NJDOT's "Design and Evaluation for Scour at Bridges" manual should also be used in performing a scour analysis.

5.13.1. Preliminary Scour Analysis

1. Data Collection and Review Process. To perform a scour analysis of an existing bridge location or for planning construction of a new bridge, data collection should include the following:
   a. Office Data Collection.
      i. Data on the waterway's history with respect to flooding and, if available, a Preliminary Scour Evaluation Report.
      ii. Contract plans, As-built drawings, Aerial Surveys, Drainage area.
      iii. Photographic documentation.
      iv. FEMA Flood Insurance Studies.
      v. Bridge Evaluation Survey & Underwater Inspection Report.
      vi. Foundation Reports and Boring logs.

vii. Existing Hydrologic and Hydraulic models, if available, from FEMA or NJDEP.

b. Review of field scour conditions and scour reports and documents on performance of scour analysis of existing upstream and downstream bridge structures.

2. Identifying Scour Analysis Variables

Specific bridge scour variables or parameters shall be identified for a mathematical scour analysis. Such variables or parameters shall include the following:

a. Hydrologic Analysis – Refer to Subsection 2.6.3 of the AASHTO LRFD Bridge Design Specifications and Chapter 2 of the FHWA HEC-18 manual for guidance. Determine the drainage area from USGS maps or other appropriate sources. List available flood records. Determine design flood discharge and discharges for other frequencies. Generate flood frequency and stage-discharge-frequency curves for the site.

b. Hydraulic Analysis – Subsection 2.6.4 of the AASHTO LRFD Bridge Design Specifications and Chapter 10 of the AASHTO Model Drainage Manual provides guidance in the hydraulic design of a stream crossing. The AASHTO Model Drainage Manual defines technical aspects of hydraulic design and presents a design procedure that may be followed. The following guidance should also be used for a hydraulic analysis.

   i. In the event of recent floods or shifting of a stream, the use of an old hydraulic study should be carefully reviewed before being considered reliable. A new study may need to be developed. The U.S. Army Corps of Engineers' HEC-RAS program, U.S. Bureau of Reclamation's SRH-2D program, or other applicable program, approved by the Authority's Engineering Department, may be used. Existing studies performed by FEMA, the U.S. Army Corps of Engineers, U.S. Soil Conservation Service and NJDEP may also be assessed.

   ii. The allowable velocity for a bridge location and the permissible backwater should be determined. This information may then be compared with computed velocities and backwater using one of the computer programs discussed above. The scour depth for a proposed bridge and, if economical, for an existing bridge should be estimated.

   iii. When a dam exists upstream of a bridge, the design flood for the dam and its spillway shall be considered when performing the scour analysis.

   iv. For criteria on bridge waterway sizing, refer to Subsection 2.6.4.3 of the AASHTO LRFD Bridge Design Specifications. Also, the NJDEP Flood Hazard Area Technical Manual should be referenced to verify permitted requirements.

5.13.2. Performing a Scour Analysis

The following types of analyses should be conducted in the overall scour analysis of a bridge:

Level 1 Qualitative assessment of stream stability, including lateral stability, vertical stability and determining the profiles and plan formations of streams and rivers, (Refer to HEC-20).

Level 2 More detailed quantitative analysis, including hydrologic, hydraulic and scour analysis to assess scour vulnerability, (Refer to HEC-18).

Level 3 Bridge scour design of stream instability countermeasures, (Refer to HEC-23).

5.13.3. Scour Countermeasure Development Procedures

1. Selection and Design of Scour Countermeasures
   Scour countermeasure methods shall provide vertical and lateral channel stability and minimize or eliminate aggradation, degradation, lateral erosion and local scour. Detail descriptions of approved methods are presented in HEC-20 and HEC-23.

2. Using Riprap as a Temporary Countermeasure

   a. Limitations of riprap: Although loose riprap is the most commonly used armoring, it requires monitoring since it is not held in position similar to other types of armoring; such as, articulated concrete blocks, grout filled bags, gabion or reno mattress.

   b. Riprap is not recommended for new piers and should be considered as a temporary measure for existing piers. Alternate countermeasures as described in HEC-23 and in this Section; such as, heavier armoring, river training measures, channel improvements, modifying the structural features including monitoring, shall be adopted.

   c. Rip-Rap Layout Procedures
      i. Riprap grading – Designate 50% of stones in a layer to be equal or greater than the specified size (D50). The specified size can be calculated by hydraulic considerations using FHWA formulae (see flow diagrams above). The remaining 50% of the stones can be of a smaller size than the (D50 to fill the smaller voids between the stones.
      ii. Maximum stone size in a layer < 1.5 D50.
      iii. Minimum thickness of each layer = 1 foot.
      iv. Minimum number of layers = 3.
      v. Width of a riprap layer on a footing, at the river side of an abutment or around the pier shall be the maximum of the following:
      vi. 2 x (width of abutment or pier at base) or
      vii. (1 foot + d cot θ), where d is the design scour depth at the abutment or the pier and θ is the angle of natural repose for the soil, as obtained from the Geotechnical Report.

viii. Place riprap around the footings with the slope starting at a distance of 1 foot from vertical face of the footing.
ix. Before placing riprap, check that the excavation line that is located adjacent to the abutment and around the pier meets OSHA safety requirement for the type of soil.
x. The top of riprap shall be below the riverbed to avoid encroachment of the river, or dislodging of the stones by floating debris, ice or currents.
xi. If a riprap design is based on a scour analysis, use a reduced design depth d = y/2, Where y = computed scour depth.

xii. If the design depth "d" is greater than the available depth between riverbed elevation and bottom of footing, and the rock is not available within depth "d", or if the computed D50 size > R-8, alternate countermeasures will be required.

5.13.4. Scour Report

The scour evaluation shall be summarized in a comprehensive report using a format similar to that found in NJDOT "Bridge Scour Evaluation Program Guidelines Manual for Stage II", dated June 1994.

5.14. Sample Hydrologic and Hydraulic Calculations

All storm sewer systems and ditches shall be formally analyzed hydraulically with computations completed and checked. Grate capacity computations are required to the extent noted. All such calculations shall be forwarded to the Authority's Engineering Department, together with the necessary supporting information, such as drainage area plans, as a part of the Phase "B" submission.

Computation format for all hydrologic and hydraulic data leading to the selection of the storm sewer pipe size shall be a part of the calculations. Such information shall be systematically organized in an understandable fashion utilizing the appropriate figures. Where computer methods are utilized, the program description shall accompany the calculations.

A sample storm sewer hydraulic computations and hydrologic stormwater management basin design demonstrates the design procedure for a simple storm sewer system and stormwater management basin as shown on EXHIBIT 5- 14EXHIBIT 5- 14 SAMPLE CALCULATION LAYOUT. For this sample, design a new freeway/interstate highway through a meadow in Woodbine, NJ.

Obtain Tc for overland flow to inlets 1, 3 and 4 (based on the hydraulically most distant point) (see Subsection 5.4.1) Obtain Tc on accordance with Subsection 5.4.4.

Inlet #1

Ground Cover is grass, Flow length = 800 ft

Elevation at farthest point = 112 ft, Elevation at inlet = 97.44 ft

Sheet Flow

Using the McCuen Spiess limitation for Sheet flow length, $L = \frac{100\sqrt{S}}{n}$

H = 14.56 ft

S = $\frac{14.56 ft}{800\ ft} = 0.018$ ft/ft

L = $\frac{100\sqrt{0.018}}{0.240} = 55.9$ ft

From TR-55, $T_t = \frac{0.007(0.240 \times 55.9)^{0.8}}{(3.33)^{0.5}(0.018)^{0.4}} = 0.153\ hours = 9.2\ minutes$

Tt = 9.2 minutes

Shallow Concentrated Flow

L = 800 ft – 55.9 ft = 744.1 ft

H = 14.56 ft – (55.9 ft x 0.018 ft/ft) = 13.55 ft

From TR-55, $V = \frac{1.486 r^{2/3} s^{1/2}}{n}$ or for Unpaved Channels, $V = 16.1345(s)^{0.5}$

S= $\frac{13.55\ ft}{744.1\ ft} = 0.018$ ft/ft

V= $16.1345(0.018)^{0.5} = \frac{2.16 ft}{s}$

$T_t = \frac{744.1\ feet}{2.16 \frac{ft}{s}} = 344 \sec = 5.7\ minutes$

Tt = 5.7 minutes

Tc to Inlet #1 = 15 minutes

Inlet #2

Ground Cover is pavement, Flow length = 500 ft

Elevation at farthest point = 99.54 ft, Elevation at inlet = 96.76 ft

Sheet Flow

Assume cross slope of 2%

S = 0.02 ft/ft

McCuen-Spiess L = $\frac{100\sqrt{0.02}}{0.011} = 1{,}285.6\ ft$

Maximum allowable sheet flow length is 100 feet

Maximum physical sheet flow length is 24 feet from roadway crown to gutter

From TR-55, $T_t = \frac{0.007(0.240 \times 24)^{0.8}}{(3.33)^{0.5}(0.018)^{0.4}} = 0.007\ hours = 0.4\ minutes$

Tt = 0.4 minutes

Shallow Concentrated Flow

H = 2.30 ft

TR-55 for Paved Channels: $\text{Paved Channels}, V = 20.3282(s)^{0.5}$

S = $\frac{2.30\ ft}{476\ ft} = 0.005$ ft/ft

V= $20.3282(0.005)^{0.5} = \frac{1.41 ft}{s}$

$T_t = \frac{476\ feet}{1.41 \frac{ft}{s}} = 336\ \text{sec} = 5.6\ minutes$

Tt = 5.6 minutes

Tc to Inlet #2 = 6 minutes for NRCS method, Use 10 minutes for minimum Tc for Rational method

Inlet #3

Ground cover is grass, Overland flow length = 770 ft

Elevation at farthest point = 98 ft, Elevation at inlet = 96.46 ft

Sheet Flow

Using the McCuen Spiess limitation for Sheet flow length, $L = \frac{100\sqrt{S}}{n}$

H = 1.54 ft

S = $\frac{1.54\ ft}{770\ ft} = 0.002$ ft/ft

L = $\frac{100\sqrt{0.002}}{0.240} = 18.6$ ft

From TR-55, $T_t = \frac{0.007(0.240 \times 18.6\ )^{0.8}}{(3.33)^{0.5}(0.002)^{0.4}} = 0.153\ hours = 9.2\ minutes$

Tt = 9.2 minutes

Shallow Concentrated Flow

L = 770 ft – 18.6 ft = 751.4 ft

H = 1.54 ft – (18.6 ft x 0.002 ft/ft) = 1.50 ft

From TR-55, $V = \frac{1.486 r^{2/3} s^{1/2}}{n}$ or for Unpaved Channels, $V = 16.1345(s)^{0.5}$

S= $\frac{1.50\ ft}{751\ ft} = 0.002$ ft/ft

V= $16.1345(0.002)^{0.5} = 0.72 \frac{ft}{s}$

$T_t = \frac{751\ feet}{0.72\frac{ft}{s}} = 1044\ \text{sec} = 17.4\ minutes$

Tt = 17.4 minutes

T_c to Inlet #3 = 27 minutes

Inlet #4

Ground Cover is grass, Overland flow length (farthest point from channel) = 480 ft

Elevation at farthest point = 118 ft, Elevation of channel invert = 102 ft

Sheet Flow

Using the McCuen Spiess limitation for Sheet flow length, $L = \frac{100\sqrt{S}}{n}$

H = 16 ft

S = $\frac{16\ ft}{480\ ft} = 0.033$ ft/ft

L = $\frac{100\sqrt{0.033}}{0.240} = 75.7$ ft

From TR-55, $T_t = \frac{0.007(0.240 \times 75.7)^{0.8}}{(3.33)^{0.5}(0.033)^{0.4}} = 0.15\ hours = 9.2\ minutes$

Tt = 9.2 minutes

Shallow Concentrated Flow

L = 480 ft – 75.7 ft = 404.3 ft

H = 16 ft – (75.7 ft x 0.033 ft/ft) = 13.50 ft

From TR-55, $V = \frac{1.486 r^{2/3} s^{1/2}}{n}$ or for Unpaved Channels, $V = 16.1345(s)^{0.5}$

S= $\frac{13.50\ ft}{404\ ft} = 0.033$ ft/ft

V= $16.1345(0.033)^{0.5} = 2.93 \frac{ft}{s}$

$T_t = \frac{404\ feet}{2.93\frac{ft}{s}} = 137.88\ \text{sec} = 2.3\ minutes$

Tt = 2.3 minutes

<u>Open Channel Flow (Trapezoidal)</u>

Grass lined trapezoidal channel with 2 ft bottom width and 3:1 side slope.

Elevation at farthest point = 102 ft, Elevation of channel invert = 92.85 ft

W = 2 ft

D = 2 ft

Z, Hz:V = 3 ft/ft

H = 9.15 ft

Flow length through the channel = 330 ft

S= $\frac{9.15\ ft}{330\ ft} = 0.028$ ft/ft

Cross-Sectional Flow Area, A (〖ft〗^2) = $\frac{DW+D^2}{\frac{1}{z}}$

A = $(2 \times 2) + \frac{2^2}{\frac{1}{3}}$ = 16 ft^2

Wetted Perimeter, Pw (ft) = $W + 2\left(\frac{D^2}{\frac{1^2}{z}+D^2}\right)^{0.5}$

Pw = $2 + 2\left(\frac{2^2}{\frac{1^2}{3}+2^2}\right)^{0.5} = 14.65\ ft$

Hydraulic Radius, Rh (ft) = $\frac{A}{Pw}$

Rh = $\frac{16}{14.65}$ = 1.09 ft

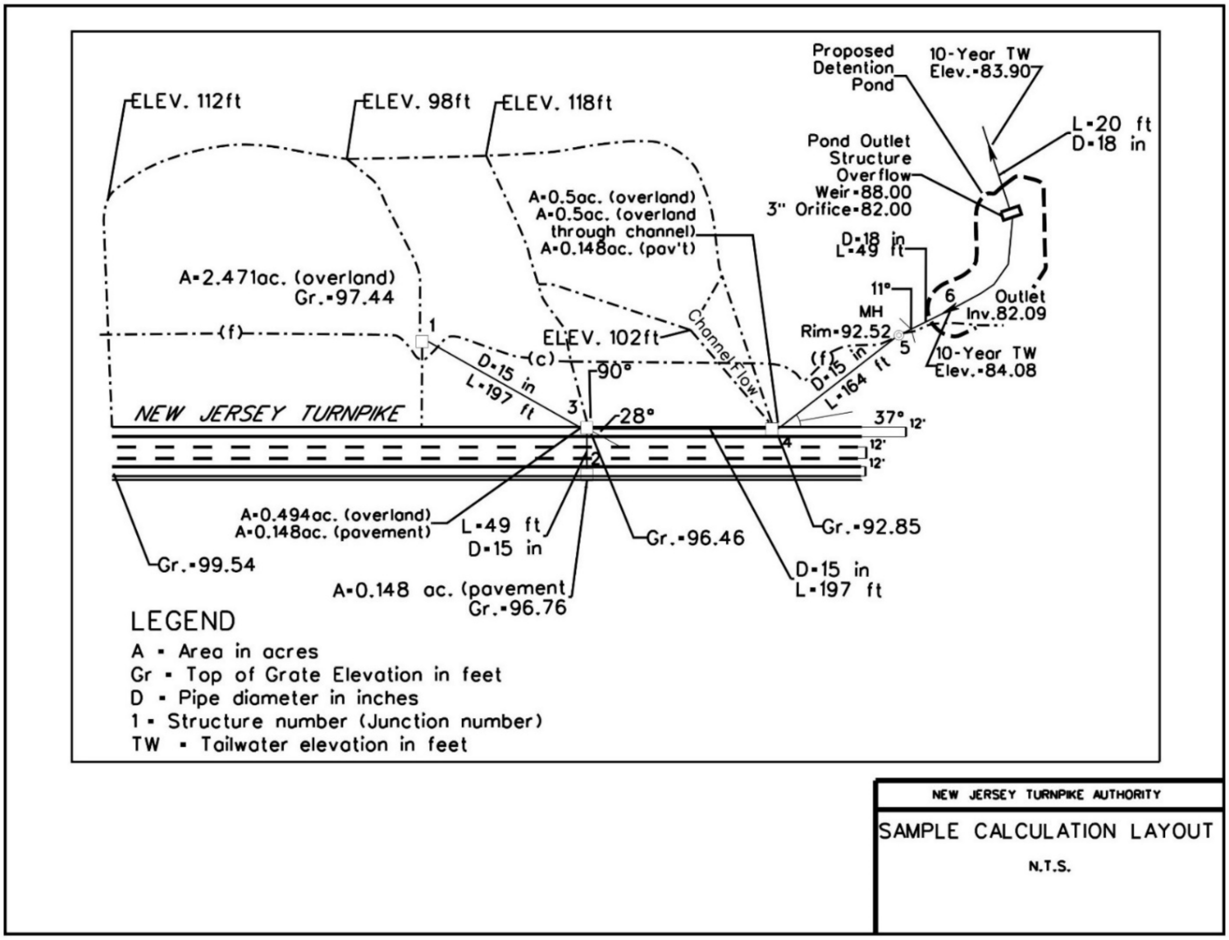
Flow velocity, V (ft/s) = $\frac{1.49 \times 1.09^{\frac{2}{3}} \times 0.028^{0.5}}{0.035}$ = 7.5 ft/s

$T_t = \frac{330\ feet}{7.5\frac{ft}{s}} = 42\ \text{sec} = 0.7\ minutes$

Tt = 0.7 minutes

<u>**Total Tc = 12 minutes**</u>

EXHIBIT 5- 14 SAMPLE CALCULATION LAYOUT



5.14.1. Sample Hydraulic Calculations

Using Rational Formula, find 15-year runoff to each inlet: (See Subsection 5.4.2)

Q=CIA

Refer to Exhibit 5 - 5 for runoff coefficients ("C"), using soil group B.

Using Exhibit 5 - 6, locate the project in Woodbine, NJ. The project is located in Region C.

To obtain rainfall intensity, below is a portion of the Point Precipitation Frequency Estimates Table for Woodbine, NJ taken from NOAA's National Weather Service Precipitation Frequency Data Server: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nj

NOAA Atlas 14, Volume 2, Version 3
Location name: Woodbine, New Jersey, USA*
Latitude: 39.2378°, Longitude: -74.8134°
Elevation: 44.7 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	4.18 (3.73-4.64)	4.76 (4.27-5.27)	5.24 (4.69-5.81)	6.26 (5.60-6.94)	7.03 (6.28-7.81)	7.86 (7.00-8.72)	8.50 (7.54-9.44)	9.12 (8.03-10.2)	9.74 (8.50-10.9)	10.5 (9.05-11.8)
10-min	3.34 (2.98-3.71)	3.81 (3.42-4.21)	4.20 (3.76-4.65)	5.00 (4.48-5.54)	5.60 (5.00-6.22)	6.26 (5.57-6.95)	6.76 (5.99-7.51)	7.23 (6.36-8.05)	7.70 (6.71-8.63)	8.26 (7.12-9.29)
15-min	2.78 (2.48-3.09)	3.19 (2.86-3.53)	3.54 (3.17-3.92)	4.22 (3.78-4.68)	4.74 (4.23-5.26)	5.28 (4.70-5.86)	5.69 (5.05-6.32)	6.08 (5.35-6.78)	6.46 (5.64-7.24)	6.91 (5.96-7.77)
30-min	1.90 (1.70-2.12)	2.20 (1.98-2.44)	2.52 (2.25-2.78)	3.06 (2.74-3.39)	3.51 (3.13-3.89)	3.98 (3.54-4.42)	4.36 (3.87-4.84)	4.73 (4.16-5.27)	5.14 (4.48-5.76)	5.59 (4.83-6.29)
60-min	1.19 (1.06-1.32)	1.38 (1.24-1.53)	1.61 (1.44-1.79)	1.99 (1.78-2.21)	2.34 (2.09-2.59)	2.70 (2.40-2.99)	3.00 (2.66-3.34)	3.32 (2.92-3.70)	3.69 (3.22-4.13)	4.08 (3.52-4.59)

Interpolate to find the 15-year storm Intensities and for times of concentration not included in the NOAA data.

Rainfall Information							
Precipitation Intensity (i) (in/hr)							
Return Period (years)	Time of Concentration (mins)						
	10	15	30	60		12	27
10	5.00	4.22	3.06	1.99		4.69	3.29
15	5.20	4.39	3.21	2.11		4.88	3.45
25	5.60	4.74	3.51	2.34		5.26	3.76

Inlet	Tc (min)	I (in/hr)
1	15	4.39
2	10	5.20
3	27	3.29
4	12	4.88

Inlet #1

$Q_1 = (0.25) \times \left(4.39\,\frac{in}{hr}\right) \times (2.471\ acres) = 2.71\ cfs$

Inlet #2

$Q_2 = (0.99) \times \left(5.20\,\frac{in}{hr}\right) \times (0.148\ acres) = 0.76 cfs$

Inlet #3

$Q_3 = \frac{(0.148 \times 0.99)+(0.494 \times 0.25)}{0.642} \times \left(3.29\,\frac{in}{hr}\right) x\ (0.642\ acres) = 0.93\ cfs$

Inlet #4

$Q_4 = \frac{(0.148 \times 0.99)+(1.0 \times 0.25)}{1.148} \times \left(4.88\,\frac{in}{hr}\right) x\ (1.148\ acres) = 1.94\ cfs$

Compute gutter spread width, intercepted flow, bypass flow and efficiency for each roadway inlet: (See Manual Subsections 5.8.3, 5.8.4, 5.8.5.1)

Using a modification of the Manning equation to obtain gutter spread width:

$$\mathbf{Q} = \left(\frac{\mathbf{0.56}}{\mathbf{n}}\right)\left(\mathbf{S_x^{5/3}}\right)\left(\mathbf{S_0^{1/2}}\right)\mathbf{T^{8/3}}$$

where

Q = rate of discharge in cfs

n = Manning's coefficient of gutter roughness (EXHIBIT 5-8)

Sx = cross slope, in ft/ft

So = longitudinal slope, in ft/ft

T = spread or width of flow in feet

The relationship between depth of flow (y), spread (T), and cross slope (Sx) is as follows:

y = TSx, depth in gutter, at deepest point in feet.

Inlet #2 (type D-1 inlet)

Gutter spread width (T_{all}) = $4\ ft\ (inside\ shoulder\ width)$

Given:

Q = 0.76 cfs

S_x = 0.04 ft/ft

S_o = 0.03 ft/ft

n = 0.013

T_{all} = 4 ft

$$T^{8/3} = \frac{0.76}{\left(\frac{0.56}{0.013}\right)\times 0.04^{\frac{5}{3}}\times 0.03^{\frac{1}{2}}} = 21.77\ ft$$

T = 3.17 ft < T_{all} of 4 ft

$$y = 3.17\ ft\ \times\ 0.04\frac{ft}{ft} = 0.127\ ft$$

For the standard Authority bicycle safe grate, the following equation shall be used to obtain inlet interception:

$$Q_i = 16.88y^{1.54}\left(\frac{S^{0.233}}{S_x^{0.276}}\right)$$

$$Q_i = 16.88(0.127)^{1.54}\left(\frac{0.03^{0.233}}{0.04^{0.276}}\right) = 0.76\ cfs$$

Determine bypass runoff = total runoff -intercepted runoff Bypass flow = 0.76 – 0.76 = 0 cfs (0.0 cfs would bypass to downstream inlet) Check inlet efficiency:

<u>0.76 cfs</u> = 1 > 75%, OK

0.76 cfs

Inlet #3 (type B inlet)

Gutter spread width (T_{all}) = $10\ ft\ (inside\ and\ outside\ shoulder\ width) = 10ft\ (allowable\ spread)$

Q = 0.93 cfs

S_x = 0.04 ft/ft

S_o = 0.03 ft/ft

n = 0.013

T_{all} = 10 ft

$T^{8/3} = \frac{0.93}{\left(\frac{0.56}{0.013}\right)\times 0.04^{\frac{5}{3}}\times 0.03^{\frac{1}{2}}} = 26.64\ ft$

T = 3.42 ft < T_{all} of 10 ft

y = $3.42 ft \ \times \ 0.04\frac{ft}{ft} = 0.14\ ft$

For the standard Authority bicycle safe grate, the following equation shall be used to obtain inlet interception:

$Q_i = 16.88(0.14)^{1.54}\left(\frac{0.03^{0.233}}{0.04^{0.276}}\right) = 0.85\ cfs$

Bypass flow = 0.93 – 0.85 = 0.08 (0.08 cfs will bypass to inlet #4)

Check inlet efficiency:

$\frac{0.85\ cfs}{0.93\ cfs}$ = 0.91 > 75%, OK

Inlet #4 (type B inlet)

Q=1.94 cfs + 0.08 cfs (bypass from inlet #3) = 2.02 cfs

S_x = 0.04 ft/ft

S_o = 0.03 ft/ft

n = 0.013

T_{all} = 10 ft

Using above equation to solve for T:

$T^{8/3} = \frac{2.02}{\left(\frac{0.56}{0.013}\right)\times 0.04^{\frac{5}{3}}\times 0.03^{\frac{1}{2}}} = 57.87\ ft$

T=4.58 ft < T_{all} of 10 ft, OK

Compute inlet interception:

When T=4.58 ft, y = $4.58\,ft \times 0.04\frac{ft}{ft} = 0.183\,ft$

Q_i = $16.88(0.183)^{1.54}\left(\frac{0.03^{0.233}}{0.04^{0.276}}\right) = 1.33\,cfs$

Check inlet efficiency:

$\frac{1.33\ \text{cfs}}{2.02\ \text{cfs}} = 0.66 < 75\%$

Since the efficiency is <75%, this inlet should be moved upstream.

When the spread width exceeds the shoulder width, the excess runoff extends into the adjacent lane, which typically has a different cross slope than the shoulder. The following example presented the computational procedure to determine the spread.

Obtain spread width for a composite gutter section:

Say conditions for inlet #2 are such that:

Q= 1.84 cfs

S_{x1}=0.04ft/ft for shoulder

S_{x2}=0.015ft/ft for lane

S= 0.005 ft/ft

n=0.013

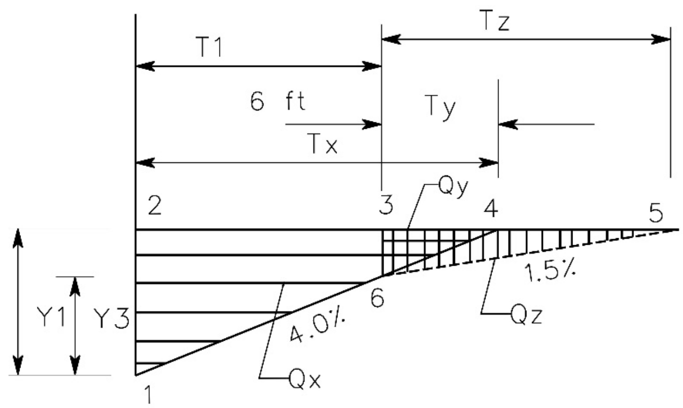
T (allowable) =6.0 ft (total shoulder width)

Using above equation to solve for T:

$T^{8/3} = \frac{1.84}{\left(\frac{0.56}{0.013}\right)\times 0.04^{\frac{5}{3}}\times 0.005^{\frac{1}{2}}} = 129.12\,ft$

T = 6.19 feet

Inside shoulder width is 6 feet, however, spread is beyond shoulder into adjacent through lane. Since the cross slope of the through lane differs from that of the shoulder, a composite gutter spread calculation must be performed to determine correct spread width.



Initially, a depth is assumed (y1). Qx,Qy and Qz are then calculated using the above equation. The flow contained in the composite section (Qt) is equal to Qx + Qz - Qy. This process is repeated until Qt = Q (actual flow in the gutter). T (actual spread width) is equal to Tx+ Tz - Ty.

Given T_1= 6 ft, y_3=6 ft (0.04)=0.24 ft

Find Qx (Triangle 1,2,4)

Assume y_1 = 0.26 ft , Tx = 6.50 ft

Q_x = $\left(\frac{0.56}{0.013}\right) \times 0.04^{\frac{5}{3}} \times\ 0.005^{\frac{1}{2}} \times 6.50^{2.67} = 2.11\ cfs$

Find Qz (Triangle 3,5,6)

Tz= $\frac{(y1-y3)}{0.015}$ = 1.0 ft

Q_z = $\left(\frac{0.56}{0.013}\right) \times 0.015^{\frac{5}{3}} \times\ 0.005^{\frac{1}{2}} \times 1^{2.67} = 0.003\ cfs$

Find Qy (Triangle 3,4,6)

Ty= $\frac{(y1-y3)}{0.04}$ = 0.50 ft

Q_y = $\left(\frac{0.56}{0.013}\right) \times 0.015^{\frac{5}{3}} \times\ 0.005^{\frac{1}{2}} \times 0.50^{2.67} = 0.0004\ cfs$

Q_t= 2.11 cfs + 0.00 cfs - 0.00 cfs= 2.11 cfs

Qt= Q, therefore, assumed depth is correct

Calculate T (actual spread width) (T1 + Tz - Ty) T= 6.0 ft + 1.00 ft – 0.50 ft = 6.50 ft

T = 6.50 ft<12 ft, OK

Compute inlet interception:

$Q_i = 16.88(0.26)^{1.54}\left(\frac{0.005^{0.233}}{0.04^{0.276}}\right) = 1.50\ cfs$

Check inlet efficiency:

1.50 cfs = 0.82 > 75%, OK

1.84 cfs

Obtain gutter spread width for inlet at low point:

Utilize same conditions at inlet #4, except s=0% (sag condition)

Q = 20.88(y)1.5 (for weir flow)

Solving for y = $\left(\llbracket\frac{1.84}{20.88}\right)\rrbracket^{0.67}$ = 0.20 ft

(Less than 0.75 ft, therefore use of weir equation is acceptable)

T = $\frac{d}{S_x}\ (d = y)$

T = $\frac{0.20}{0.04} = 5.00\ ft$

T=5.00 < T_{all} of 12 ft, OK

Compute storm drain pipe sizes for network using sample forms at end of this Subsection.

Backup Computations for Pipe Travel Time for EXHIBIT 5- 14

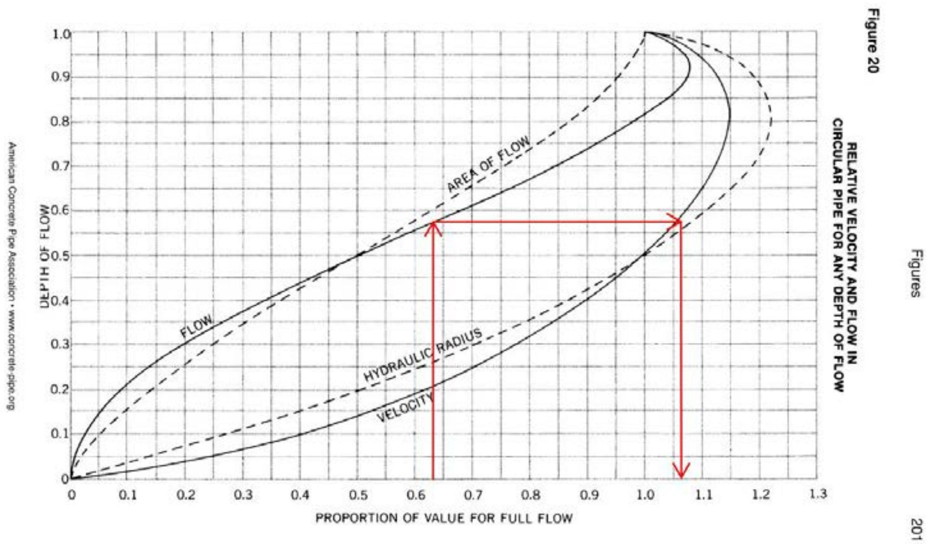
Find Tc for pipe flow for partly full pipe (pipe 1-3):

From column 12 - Q=3.11 cfs

From column 15 - Qc = 4.95 cfs

3.11 cfs = 0.63 (63% full)

4.95 cfs



From Concrete Pipe Design Manual chart, "Relative Velocity and Flow in Circular Pipe",

at 63% full, (proportion of value for full flow) v=1.06 of full velocity.

From column 16, v_{full} = 4.03 ft/s

$v_{des} = 4.03\frac{ft}{s} \times 1.06$ = 4.27 ft/s

$T_t = \frac{197\ feet}{4.27\frac{ft}{s}} = 46.14\,\text{sec} = 0.77\ minutes$

T_c = (14 min. to Inlet 1 + 0.77 min. (min travel time in pipe)) = 14.77 min

Since T_c at inlet 3 from overland flow is 34.0 min. > 14.77 min., use 34.0 min.

PRELIMINARY STORM DRAIN COMPUTATION FORM [SAMPLE]

Computed: ____________ **Date:** ____________ **Route:** ____________________

Section: ____________________

Checked: ____________ **Date:** ____________ **County:** ____________________

Station and Offset (1)		L (ft)	Drainage Area "A" (Acres)		Runoff Coef-ficient "C"	"A" x "C"		Flow Time "Tc" (min.)			Rainfall "I" in/hr	Total Runoff Q=CIA ft3/S	Dia. Pipe ft	Slope ft/ft	Capacity Full ft^3/S	Velocity ft/s		Invert Elevation	
Junction From	Junction To	(2)	Incre-ment (3)	Total (4)	(5)	Incre-ment (6)	Total (7)	Overland To Inlet (8)	In U/S Pipe (9)	Cum. Total in Pipe* (10)	(11)	(12)	(13)	(14)	(15)	Flowing Full (16)	Design Flow (17)	U/S End (18)	D/S End (19)
1	3	197	2.471	2.471	0.25	0.618	0.618	12.0	--	12.0	5.0	3.09	15	0.005	4.95	4.03	4.38	88.68	87.70
2	3	49	0.148	0.148	0.99	0.147	0.147	10.0	--	10.0	5.3	0.779	15	0.005	4.95	4.03	3.03	91.37	91.14
3	4	197	0.494		0.25	0.124		34.0											
			0.148		0.99	0.147			0.75	34.0	3.0								
				3.261			1.036		(Line 1-3)			3.11	15	0.02	9.90	8.06	7.39	87.60	83.66
4	5	164	1.0		0.25	0.25		10.0											
			0.148		0.99	0.147			0.39										
				4.41			1.433			34.39	3.0	4.30	15	0.006	5.42	4.42	4.97	83.56	82.58
5	6	49	--	4.41			1.433		0.37	34.76	3.0	4.30	18	0.005	8.05	4.55	4.73	82.35	82.09

- For Time of Concentration, use larger of overland flow to inlet or cumulative time in pipe.

HYDRAULIC GRADE LINE COMPUTATION FORM [SAMPLE]

Computed: ____________ **Date:** ____________ **Route:** ____________________

Section: ____________________

Checked: ____________ **Date:** ____________ **County:** ____________________

Station & Offset (1)		(2)	Q (3)	V (4)	R (5)	L (6)	n (7)	h (8)	H_f (9)	H_e (10)	H_i (11)	H_s (12)	H_t (13)	TW (14)	HGL (15)	TOS (16)	CL (17)
Junction From	Junction To	Dia. ft	Flow ft^3/S	Vel. ft/s	Hydraulic radius ft	Length ft	Manning's	Vel. Head ft	Fric. Loss ft	Exit Loss ft	Entr. Loss ft	Struct. Loss* ft	Total Head Loss ft	Tail-water Elev. ft	Head-water Elev. ft	Top of Struct. Elev. ft	TOS-HGL ft
6 (outlet)	5	18	4.30	2.43	0.375	49	0.012	0.092	0.069	0.092	--	0.01	0.171	84.08	84.251	92.52	8.269
5	4	15	4.30	3.50	0.312	164	0.012	0.190	0.616	--	--	0.08	0.696	84.251	84.947	92.85	7.903
4	3	15	3.11	2.53	0.312	197	0.012	0.099	0.387	--	--	0.03	0.417	84.947	85.364	96.46	11.096
3	2	15	0.779	0.63	0.312	49	0.012	0.006	0.006	--	0	--	0.006	85.364	85.37	96.79	11.42
3	1	15	3.09	2.52	0.312	197	0.012	0.099	0.384	--	0.020	--	0.404	85.37	85.774	97.44	11.666

h = Velocity head, = $(V)^2/2g$

H_f = Friction Loss, = $\frac{29.1N^2L}{R^{1.33}} \times \frac{(V)^2}{2g}$

H_i = Entrance Loss = $K_i(V)^2/2g$

H_e = Exit Loss, $H_e = (V)^2/2g$

Refer to Exhibit 4 - 17 for values of K_i

* For structural (junction) losses in inlets, manholes, see Exhibit 4 - 16.

STRUCTURAL AND BEND LOSS COMPUTATION FORM [SAMPLE]

Computed: ____________ **Date:** ____________ **Route:** ____________________

Section: ____________________

Checked: ____________ **Date:** ____________ **County:** ____________________

(1)	(2)	Q (3)	v (4)	$\frac{v^2}{2g}$ (5)	(6)	(7)	K_s (8)	H_s (9)	A (10)	K_b (11)	H_b (12)	$H_s + H_b$ (13)
Junction Station & Offset	Downstream Dia. ft	Downstream Flow ft^3/S	Downstream Velocity ft/s	Velocity Head ft	Junction Type (L,N or O)	Flow Type (P or O)	Structural Loss Coeff.	Structural Loss ft	Angle deg.	Bend Factor	Bend Loss ft	Structural Loss + Bend Loss ft
6	--	--	0	0	--	--		--	--	--	--	--
5	18	4.30	2.43	0.09	N	P	0.3	0.03	11	0.15	0.01	0.04
4	15	4.30	3.50	0.19	N	P	0.3	0.06	37	0.41	0.08	0.14
3	15	3.11	2.53	0.10	L	P	1.0	0.10	28	0.33	0.03	0.13
		3.11	--	--				--	--	--	--	--
2	15	0.779	0.44	0.003	N	P	--	--	--	--	--	--
1	15	3.09	1.75	0.05	N	P	--	--	--	--	--	--

H_S = Structural Loss = $K_S \times \frac{(V)^2}{2g}$, K_s from Exhibit 4 - 18

Channel
H_b = Bend Loss = $K_b \times \frac{(V)^2}{2g}$, K_b from Exhibit 4 – 19

NOTES:
1) Junction Type
L = with Lateral
N = with No Lateral
O = with Opposed Laterals

2) Flow Type
P = Pressure
O = Open

5.14.2. Sample Hydrologic Calculations

For the same project, design a stormwater management basin so that the post-construction peak runoff rates for the 2-year, 10-year, and 100-year storm events are 50%, 75%, and 80%, respectively, of the pre-construction rates. Due to the complexity of designing a stormwater management basin, use of computer software is encouraged. In this example, software was used and the input and output are summarized below.

Determine what the pre-construction and post-construction discharges are without a stormwater management basin.

Using the NRCS Method the discharges are the following:

Area Name	Area (Acre)	Curve Number	2-Year Flow (cfs)	10-Year Flow (cfs)	100-Year Flow (cfs)
Existing 1 (Offsite)	2.471	58	0.51	2.80	9.28
Existing 2 (Offsite Impervious)	0.148	98	0.53	0.84	1.46
Existing 3 (Onsite)	0.237	58	0.03	0.17	0.58
Existing 3 (Offsite)	0.331	58	0.05	0.24	0.81

Existing 3 (Offsite Impervious)	0.074	98	0.27	0.42	0.73
Existing 4 (Onsite)	1.074	58	0.23	1.28	4.17
Existing 4 (Offsite Impervious)	0.074	98	0.27	0.42	0.73
Total Existing Offsite*	**2.767**	**--**	**1.22**	**3.92**	**11.44**
Total Existing Onsite*	**1.311**	**--**	**0.25**	**1.38**	**4.57**
Proposed 1	2.471	58	0.51	2.80	9.28
Proposed 2 (Impervious)	0.148	98	0.45	0.71	1.23
Proposed 3 (Pervious)	0.494	58	0.07	0.35	1.20
Proposed 3 (Impervious)	0.148	98	0.53	0.84	1.46
Proposed 4 (Pervious)	1.000	58	0.22	1.20	3.89
Proposed 4 (Impervious)	0.148	98	0.53	0.84	1.46
Total Proposed*	**4.409**	**--**	**1.78**	**5.81**	**16.76**

*Total peak flows determined by hydrograph addition

With the aid of computer software, design a stormwater management basin so that the post-construction peak runoff rates for the 2-year, 10-year, and 100-year storm events are 50%, 75%, and 80%, respectively, of the pre-construction rates. The stormwater management basin should have design flows as follows:

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Storm Event (Year)	**Disturbed Area Discharges** (cfs)	**Required Reduction** Factor	**Maximum Allowable On-Site Discharges** (cfs)	**Undisturbed & Offsite Area Discharges** (cfs)	**Maximum Allowable Discharges** (cfs)	**Proposed Peak Discharges** (cfs)
2	0.25	50%	0.13	1.22	1.35	1.78
10	1.38	75%	1.04	3.92	4.96	5.81
100	4.57	80%	3.66	11.44	15.10	16.76

As can be seen in the table above by comparing Column 6 and 7, the proposed flows exceed the allowable flows. Therefore, a stormwater management basin to address the water quantity reduction standards is necessary.

Design a stormwater management basin with a bottom length of 75 feet, bottom width of 40 feet and with 3:1 side slopes. The stormwater management basin will be located as shown on Exhibit 5 - 25. The outlet structure will be a riser inlet box with a 3” orifice at elevation 82.0 feet and an overflow weir at elevation 88.0 feet. The outlet pipe from the outlet structure is an 18” reinforced concrete pipe. Note that different basin and outlet structure configurations may need to be tried to meet the design discharge. Use of a basin sizing wizard may be helpful in determining a starting point. If the required basin size is too large for the proposed project, multiple smaller basins may be used. The basin, as designed, has the following discharges and meets the water quantity reduction requirements.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Storm Event (Year)	**Disturbed Area Discharges** (cfs)	**Required Reduction** Factor	**Maximum Allowable On-Site Discharges** (cfs)	**Undisturbed & Offsite Area Discharges** (cfs)	**Maximum Allowable Discharges** (cfs)	**Proposed Peak Discharges** (cfs)
2	0.25	50%	0.13	1.22	1.35	0.20
10	1.38	75%	1.04	3.92	4.96	2.17
100	4.57	80%	3.66	11.44	15.10	10.79

5.15. REFERENCES

1. American Iron and Steel Institute, "HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS, FIFTH EDITION", 150 East 42nd Street, New York, 1994. Harrison, L.J., Morris, J.L., Normann, J.M., and Johnson, F.L.

2. American Concrete Pipe Association, "CONCRETE PIPE DESIGN MANUAL", Revised April 2004.

3. American Association of State Highway and Transportation Officials, "LRFD BRIDGE DESIGN SPECIFICATIONS, THIRD EDITION", with current interims, 2006.

4. Brater and King, "HANDBOOK OF HYDRAULICS", Fifth Edition, 1963.

5. FHWA, "DESIGN CHARTS FOR OPEN-CHANNEL FLOW", U.S. Government Printing Office, Washington, DC. 1961, (Hydraulic Design Series (HDS) No. 3).

6. FHWA, "HYDRAULIC DESIGN OF HIGHWAY CULVERTS", U.S. Government Printing Office, Washington, DC. September 2004, (HDS No. 5).

7. FHWA, Herr, Lester A. and Bossy, Herbert C., "HYDRAULIC CHARTS FOR THE SELECTION OF HIGHWAY CULVERTS", U.S. Government Printing Office, Washington, D.C. 1965, 54 p., (Hydraulic Engineering Circular (HEC) No. 5).

8. FHWA, "CAPACITY CHARTS FOR THE HYDRAULIC DESIGN OF HIGHWAY CULVERTS", U.S. Government Printing Office, Washington, D.C., March 1965, (HEC No. 10).

9. FHWA, "DESIGN OF RIPRAP REVETMENT", U.S. Government Printing Office, Washington, D.C., March 1989, (HEC No. 11).

10. FHWA, "DRAINAGE OF HIGHWAY PAVEMENT", U.S. Government Printing Office, Washington, DC., March 1984, (HEC No. 12).

11. FHWA, "HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS", August 1972, (HEC

No. 13).

12. FHWA, “HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS”, December 1975, (HEC No. 14).
13. FHWA, “DESIGN OF STABLE CHANNELS WITH FLEXIBLE LININGS”, U.S.D.O.T., October 1975, (HEC No. 15).
14. FHWA, “EVALUATING SCOUR AT BRIDGES, 4TH EDITION”, May 2001, (HEC No. 18).
15. FHWA, “STREAM STABILITY AT HIGHWAY STRUCTURES”, Third Edition”, March 2001, (HEC No. 20).
16. FHWA, “DESIGN OF BRIDGE DECK DRAINAGE”, U.S.D.O.T., May 1993, (HEC No. 21).
17. FHWA, “URBAN DRAINAGE DESIGN MANUAL”, November 1996, (HEC-22).
18. FHWA, “BRIDGE SCOUR AND STREAM INSTABILITY COUNTERMEASURES, 2ND EDITION”, March 2001, (HEC No. 23).
19. FHWA, "DESIGN OF URBAN HIGHWAY DRAINAGE-THE STATE OF THE ART", USDOT, TS-79-225, August 1979.
20. Horner, R. Skupien, J.J., Livingston, E.H., and Shaver, H.E., "FUNDAMENTAL OF URBAN RUNOFF MANAGEMENT: TECHNICAL AND INSTITUTIONAL ISSUES", Terrene Institute, Washington, D.C., August 1994.
21. Kaiser, "ALUMINUM STORMWATER CONTROL”, Corlix/Riveted Pipe/Structural Plate, 8th Edition, 1983.
22. New Jersey Department of Environmental Protection, "TECHNICAL MANUAL FOR LAND USE REGULATION PROGRAM, BUREAU OF INLAND AND COASTAL REGULATIONS, FLOOD HAZARD AREA PERMITS", Revised September 1995.
23. New Jersey Department of Environmental Protection, Division of Water Quality, "HIGHWAY AGENCY STORMWATER GUIDANCE", August 2004.
24. New Jersey Department of Environmental Protection, "NEW JERSEY STORMWATER BEST MANAGEMENT PRACTICES MANUAL", April 2004.
25. New Jersey Department of Transportation, “BRIDGE SCOUR EVALUATION PROGRAM GUIDELINES MANUAL FOR STAGE II IN-DEPTH SCOUR EVALUATION OF NEW JERSEY BRIDGES”, June 1994.
26. NOAA, “ATLAS 14, VOLUME 2, PRECIPITATION-FREQUENCY OF THE UNITED STATES”, June 2, 2005.
27. State of New Jersey, “STANDARDS FOR SOIL EROSION AND SEDIMENTATION CONTROL IN NEW JERSEY”, New Jersey State Soil Conservation Committee, April 1987.
28. “ANTIDEGRADATION POLICES”, N.J.A.C. 7:9B-4.
29. “STORMWATER MANAGEMENT RULE”, N.J.A.C. 7.8.
30. U.S. Department of Agriculture, NCRS (SCS), “NATIONAL ENGINEERING HANDBOOK, SECTION 4”, August 1972.

EXHIBIT 5 - 15
A SAMPLE STORMWATER MAINTENANCE PLAN

MAINTENANCE PLAN FOR STORMWATER MANAGEMENT MEASURES

[*Roadway Name*]
[*Interchange, Service Area, Toll Plaza, Maintenance Yard, or Milepost Numbers*]
[*Town, County*], New Jersey

NJTA Construction Contract No. [*#####*]
Order for Professional Services No. [*#####*]

Prepared For:

The New Jersey Turnpike Authority
581 Main Street
Woodbridge, New Jersey 07095

Prepared By:

[*Firm Name*]
[*Street Address*]
[*City, State, Zip Code*]

[*Completion Date*]

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❑ 1.0 INTRODUCTION

Pursuant to New Jersey Turnpike Authority Construction Contract No. [*#####*], Order for Professional Services (OPS) No. [*#####*], [*Firm name*] has prepared this maintenance plan for the stormwater management measures constructed at [*Roadway Name*] [*Interchange, Service Area, Toll Plaza, Maintenance Yard or Milepost Numbers*] in [*Town, County*], New Jersey. This plan describes the preventative and corrective maintenance tasks and procedures to be implemented by the New Jersey Turnpike Authority to ensure the effective and reliable performance of the constructed stormwater management measures.

❑ 2.0 RESPONSIBLE PERSON

The New Jersey Turnpike Authority is the owner of the stormwater management measures described in this plan. The designated person with overall responsibility for maintenance of the stormwater management measures is:

Joseph Lentini, Director of Maintenance
New Jersey Turnpike Authority
P.O. Box 5042
Woodbridge, New Jersey 07095-5042
Phone: (732) 442-8600 Ext. 2800

The effectiveness of this plan must be evaluated annually. Revisions will be made to the plan if needed to maintain its effectiveness. If revised, a copy of the revised plan will be distributed to the appropriate maintenance personnel.

❑ 3.0 MAINTENANCE OBJECTIVES

Preventative and corrective maintenance is required to preserve the intended operation and safe condition of the stormwater management measures described in this plan.

- Preventative Maintenance – Regular preventative maintenance will reduce the occurrence of problems and malfunctions of the stormwater management measures. This plan identifies the specific preventative maintenance tasks and maintenance schedules required.

- Corrective Maintenance – Corrective maintenance is required on an as-needed basis to restore a stormwater management measure's intended operation when a problem or malfunction is identified. This plan identifies corrective maintenance tasks that may be required based on observed conditions.

Corrective responses to emergency conditions at the stormwater management measures may also be required at times. Recommended responses to emergency conditions are included within the corrective maintenance portion of this plan.

❑ 4.0 STORMWATER MANAGEMENT MEASURES

The stormwater management measures constructed at [*Roadway Name*] [*Interchange, Service Area, Toll Plaza, Maintenance Yard or Milepost Numbers*] and addressed in this plan are depicted schematically on Figure 1 (Location Map) and Figure 2 (Schematic Plan of Stormwater Management Measures.

The specific stormwater management measures addressed in this plan include the following [*list each structural and non-structural measure below. If a particular measure is used multiple times, it is only required to be listed once below*]:

- [*name of stormwater management measure*] – [*provide a brief description of the measure, its purpose, and its normal operating conditions*]. A schematic depiction of the [*name of stormwater management measure*] is provided in Figure 3. As-built drawings are available through the Authority's Plan File Room Section.

- [*copy preceding paragraph and revise as appropriate for each additional stormwater management measure addressed in the plan*]

EXAMPLE

- *Infiltration Basin #1 – Infiltration Basin #1 is a basin constructed within highly permeable soils that provides temporary storage of stormwater runoff, removes pollutants, and infiltrates stormwater back into the ground. The basin does not have a structural outlet to discharge runoff, although it is equipped with a spillway to convey overflows downstream in a safe and stable manner. A schematic depiction of Infiltration Basin #1 is provided in Figure 3. As-built drawings are available through the Authority's Plan File Room Section.*

❑ 5.0 MAINTENANCE REQUIREMENTS

Preventative maintenance and corrective maintenance requirements for each stormwater management measure are summarized in the following sections.

Detailed maintenance checklists for each stormwater management measure are provided in Appendix B, and maintenance logs are provided in Appendix C. A checklist and maintenance log must be completed for each maintenance event. Copies of all maintenance-related work orders must be retained with the maintenance records.

Sediment, trash, debris and other materials removed from the stormwater management measures during maintenance operations shall be disposed of at disposal and/or recycling facilities permitted to accept such materials. The cost of all maintenance activities will be included in the Authority's annual budget.

❑ 5.1 [*Stormwater Management Measure Name*]

A schedule of regular preventative maintenance tasks and corrective maintenance tasks for the [*stormwater management measure name*] is provided in Table 1. The schedule identifies each maintenance task, frequency, required equipment, and recommended health and safety measures.

[*Copy preceding Section 5.1 and revise as appropriate for each additional stormwater management measure addressed in the plan*]

EXAMPLE

5.1 Infiltration Basin #1

A schedule of regular preventative maintenance tasks and corrective maintenance tasks for the infiltration basin is provided in Table 1. The schedule identifies each maintenance task, frequency, required equipment, and recommended health and safety measures. The required maintenance tasks include the following:

- *Inspect all components that receive or trap debris and sediment for clogging and excessive debris/sediment accumulation at least four times per year and after every storm exceeding 1 inch of rainfall. Remove excessive debris/sediment as needed, when the basin is thoroughly dry.*
- *Inspect all structural components annually for deterioration such as cracking, subsidence, spalling, and erosion. Repair deteriorated components as needed.*
- *Mow and/or trim vegetation regularly as needed based on site conditions. Grass shall be mowed at least once per month during the growing season.*
- *Inspect vegetated areas annually for erosion and scour. Repair erosion/scour and damaged vegetation as needed.*
- *Inspect vegetated areas annually for unwanted trees or other growth. Remove unwanted vegetation as needed with minimum disruption to the basin subsoil and vegetation to remain.*
- *When establishing or restoring vegetation, perform biweekly inspections of vegetation health during the first growing season or until the vegetation is established.*
- *Inspect established vegetation health, density, and diversity twice annually during growing and non-growing seasons. If vegetation has greater than 50 percent damage, re-establish the vegetation pursuant to the original project specifications.*
- *Maintain vegetation without the use of fertilizers or pesticides whenever possible. Any use of fertilizers, mechanical treatments, pesticides, and other means to assure optimum vegetation health must not compromise the intended purpose of the extended detention basin.*
- *The infiltration basin is expected to normally take [###] hours to completely drain. If significant increases or decreases in the normal drain time are observed, evaluation of the basin's bottom surface, subsoil, and both groundwater and tailwater levels is required to determine appropriate measures for maintaining the proper functioning of the basin.*
- *Inspect the bottom sand layer in the basin at least monthly as well as after every storm exceeding 1 inch of rainfall. The permeability rate of the soil below the basin may also be retested periodically. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken. Annual tilling by light equipment can assist in maintaining infiltration capacity and break up clogged surfaces*

❑ 6.0 REFERENCE STANDARDS

This maintenance plan was prepared in accordance with the latest editions of the following applicable New Jersey administrative codes, New Jersey Department of Environmental Protection (NJDEP) guidance, and manufacturer literature:

- NJAC 7:8 – Stormwater Management
- NJ Stormwater Best Management Practices Manual (BMP Manual)
- NJDEP Stormwater Management Facilities Maintenance Manual
- [*reference applicable manufacturer literature, O&M manuals, etc.*]

TABLES

TABLE 1
MAINTENANCE SCHEDULE FOR [*NAME OF STORMWATER MANAGEMENT MEASURE*]
[*ROADWAY NAME*]
[*INTERCHANGE, SERVICE AREA, TOLL PLAZA, MAINTENANCE YARD, OR MILEPOST NUMBERS*]
[*TOWN, COUNTY*], NEW JERSEY
NJTA CONTRACT NO. [*######*], OPS NO. [*######*]

Task Name	Schedule	Task Description	Required Equipment	Health and Safety	Reference Documents
[*Name of task*]	[*task frequency or "as-needed" for corrective maintenance tasks*]	[*Describe activities and procedures for completing task*]	[*list equipment tools and supplies needed to complete task*]	*[Describe health and safety procedures to be considered]*	[*reference any applicable manufacturer maintenance/repair literature provided in Appendix E*]

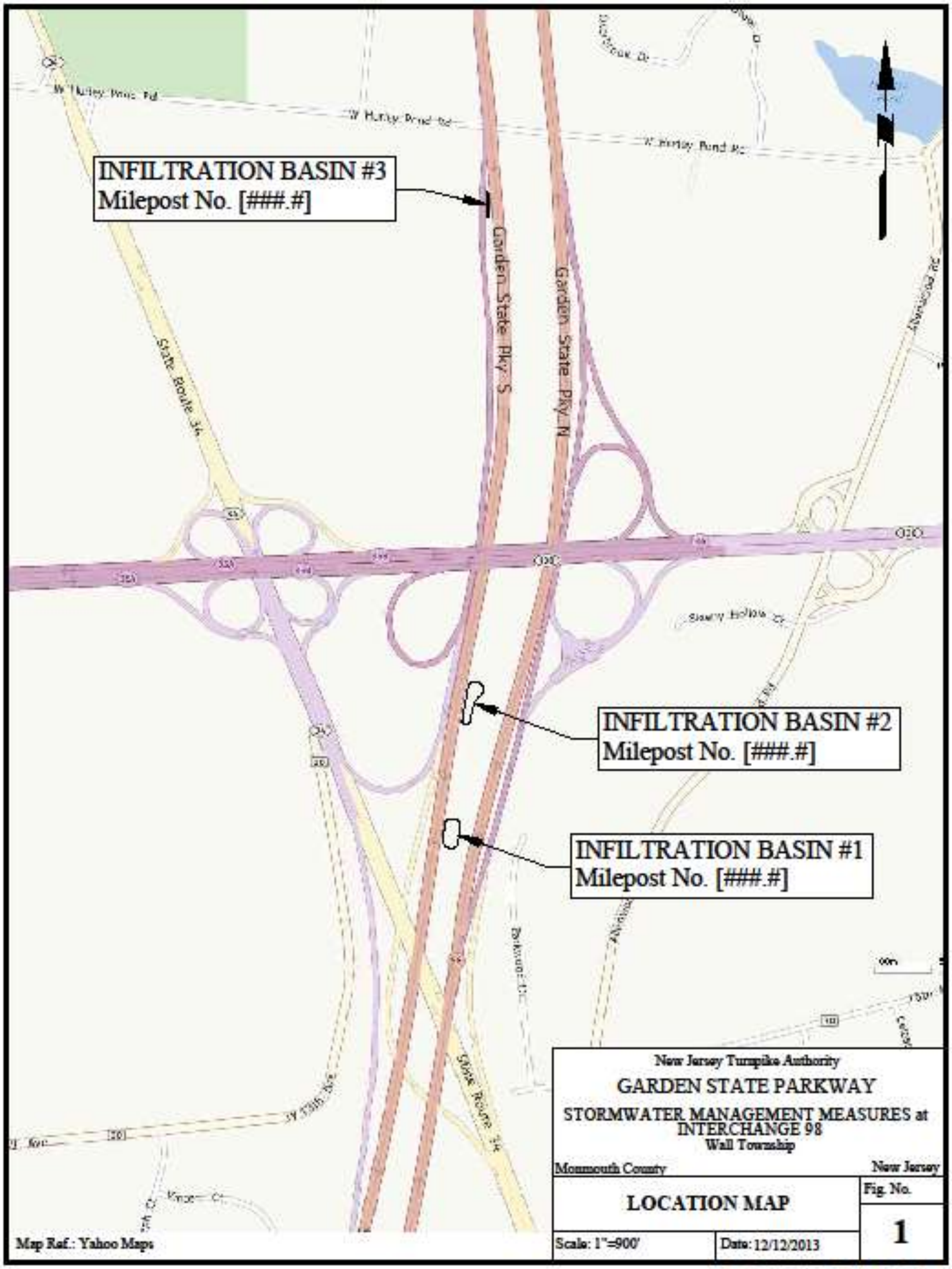
FIGURES

[*Insert street map indicating:*

- *Roadway names*
- *Stormwater management measure locations with corresponding milepost numbers*
- *North arrow*]

[*Map Reference*]

<table>
<tr><td colspan="3">New Jersey Turnpike Authority
[ROADWAY NAME]
STORMWATER MANAGEMENT MEASURES at [PROJECT LOCATION]</td></tr>
<tr><td colspan="2">LOCATION MAP</td><td>Fig. No.</td></tr>
<tr><td>Scale: [insert scale]</td><td>Date: [insert date]</td><td>1</td></tr>
</table>


INFILTRATION BASIN #3
Milepost No. [###.#]
INFILTRATION BASIN #2
Milepost No. [###.#]
INFILTRATION BASIN #1
Milepost No. [###.#]
Garden State Pky S
Garden State Pky N
State Route 34
New Jersey Turnpike Authority
GARDEN STATE PARKWAY
STORMWATER MANAGEMENT MEASURES at INTERCHANGE 98
Wall Township
Monmouth County
New Jersey
LOCATION MAP
Fig. No.
1
Scale: 1"=900'
Date: 12/12/2013
Map Ref.: Yahoo Maps

EXAMPLE

[*Insert schematic plan view of the project area indicating:*

- *Stormwater management measure locations*
- *Major site features and/or reference points*
- *North arrow*
- *Other information to assist maintenance crews to locate the stormwater management measures in the field*]

New Jersey Turnpike Authority

[*ROADWAY NAME*]

STORMWATER MANAGEMENT MEASURES at [*PROJECT LOCATION*]

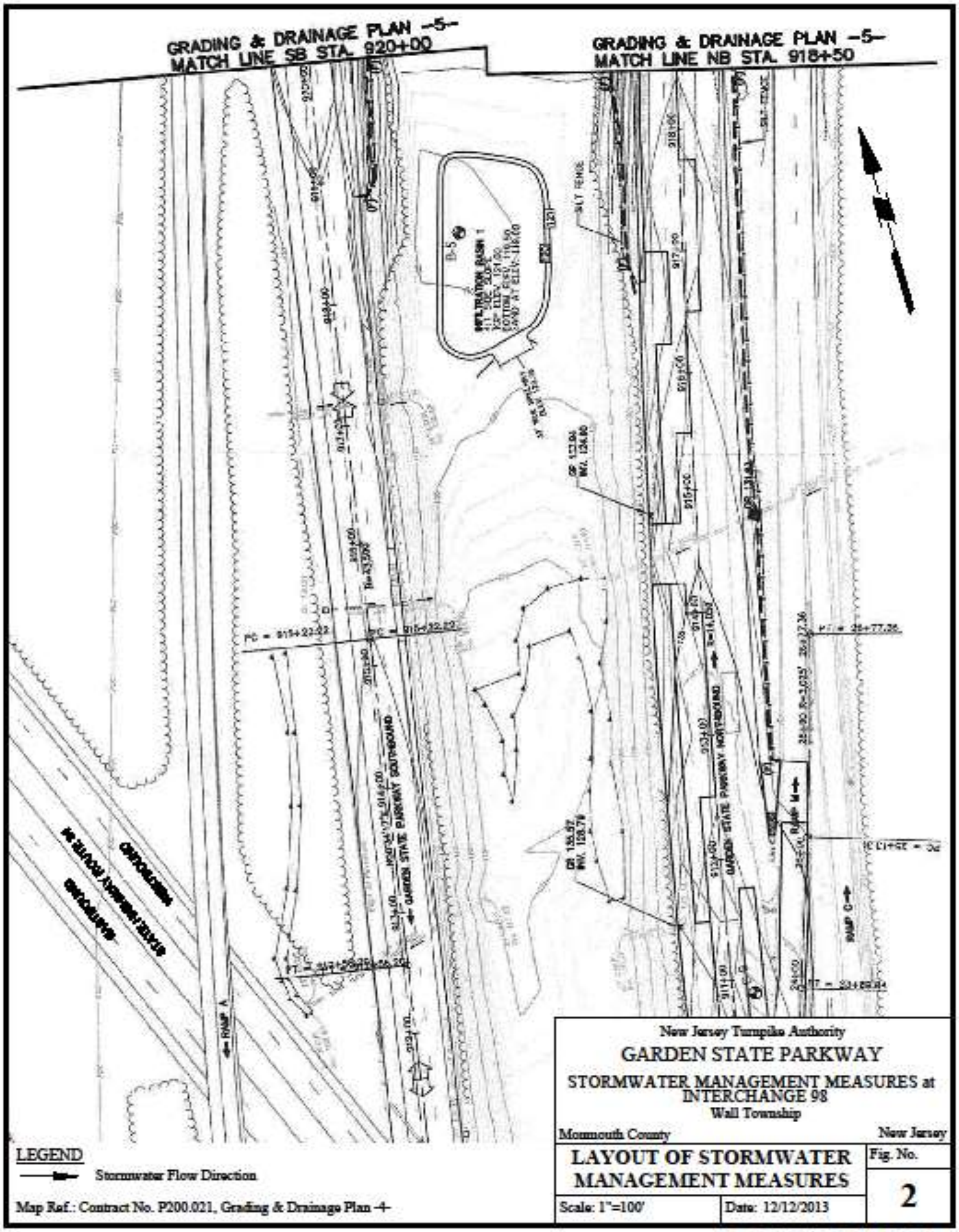
LAYOUT OF STORMWATER MANAGEMENT MEASURES

Fig. No. **2**

Scale: [*insert scale*]

Date: [*insert date*]

[*Map Reference*]


GRADING & DRAINAGE PLAN -5-
MATCH LINE SB STA. 920+00
GRADING & DRAINAGE PLAN -5-
MATCH LINE NB STA. 918+50
LEGEND
Stormwater Flow Direction
Map Ref.: Contract No. P200.021, Grading & Drainage Plan -4-
New Jersey Turnpike Authority
GARDEN STATE PARKWAY
STORMWATER MANAGEMENT MEASURES at INTERCHANGE 98
Wall Township
Monmouth County
New Jersey
LAYOUT OF STORMWATER MANAGEMENT MEASURES
Fig. No.
2
Scale: 1"=100'
Date: 12/12/2013

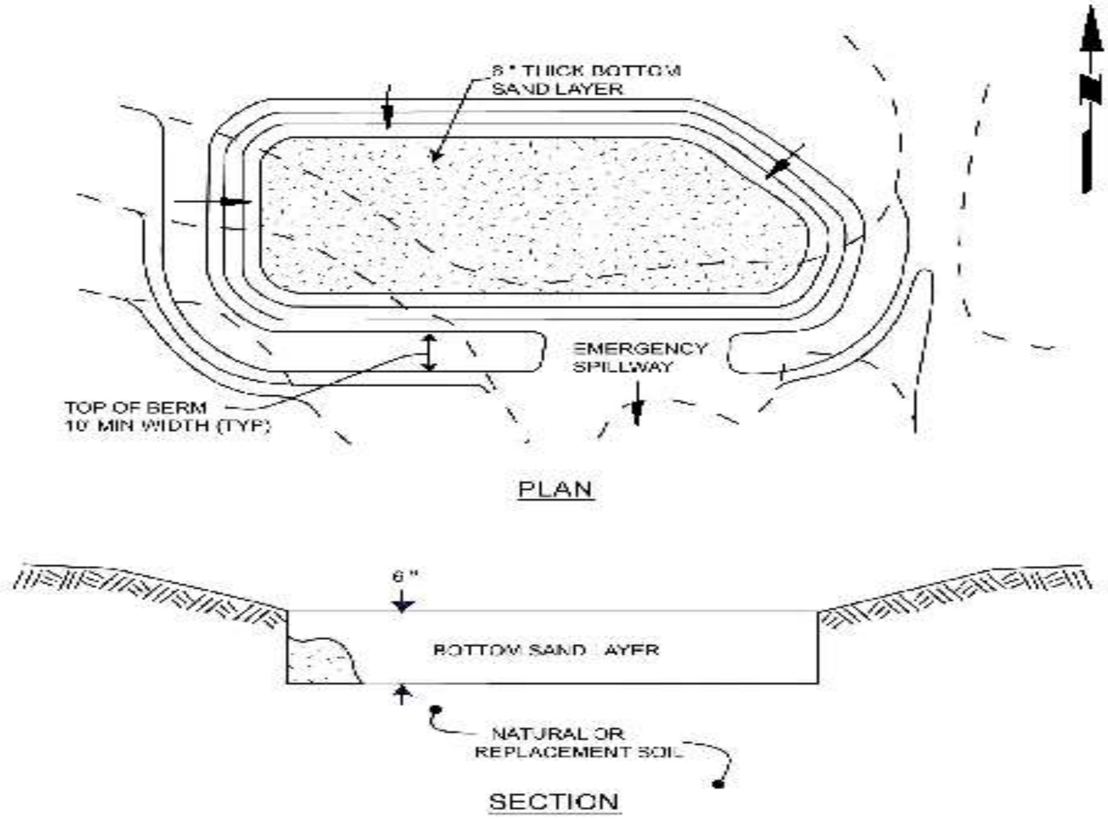
EXAMPLE

[*Insert schematic plan view of each stormwater management measure indicating:*

- *Stormwater management measure*
- *Individual elements of the stormwater management measure requiring maintenance pursuant to this plan*
- *Stormwater flow directions*
- *North arrow*
- *Other information that may assist maintenance crews to inspect and maintain the stormwater management measure*]

New Jersey Turnpike Authority [*ROADWAY NAME*] STORMWATER MANAGEMENT MEASURES at [*PROJECT LOCATION*]		
SCHEMATIC PLAN OF [*STORMWATER MANAGEMENT MEASURE NAME*]		Fig. No. **3**
Scale: [*insert scale*]	Date: [*insert date*]	

[*Map Reference*]



LEGEND

Stormwater Flow Direction

Map Ref.: *[Contract No., Drawing Name, Drawing No.]*

New Jersey Turnpike Authority

GARDEN STATE PARKWAY

STORMWATER MANAGEMENT MEASURES at INTERCHANGE 98

Wall Township

Monmouth County — New Jersey

SCHEMATIC PLAN OF INFILTRATION BASIN NO. 1

Fig. No. **3**

Scale: *[#"=##']* — Date: 12/12/2013

EXAMPLE

APPENDIX A

STORMWATER BMP GENERAL MAINTENANCE REQUIREMENTS

BIORETENTION SYSTEMS

A bioretention system consists of a soil bed planted with suitable non-invasive (preferably native) vegetation. Stormwater runoff entering the bioretention system is filtered through the soil planting bed before being either conveyed downstream by an underdrain system or infiltrated into the existing subsoil below the soil bed. Vegetation in the soil planting bed provides uptake of pollutants and runoff and helps maintain the pores and associated infiltration rates of the soil in the bed.

Maintenance requirements for bioretention systems are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All bioretention system components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include bottoms, trash racks, low flow channels, outlet structures, riprap or gabion aprons, and cleanouts.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass outside of the bioretention system should be mowed at least once a month during the growing season. Grasses within the bioretention system must be carefully maintained so as not to compact the soil, and through hand-held equipment, such as a hand held line trimmer. Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health should not compromise the intended purpose of the bioretention system. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the ground surface in the bioretention system. This normal drain time should then be used to evaluate the system's actual performance. If significant increases or decreases in the normal drain time are observed or if the 72 hour maximum is exceeded, the system's planting soil bed, underdrain system, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the system.

The planting soil bed at the bottom of the system should be inspected at least twice annually. The permeability rate of the soil bed material may also be retested. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken.

CONSTRUCTED STORMWATER WETLANDS

Constructed stormwater wetlands are wetland systems designed to maximize the removal of pollutants from stormwater runoff through settling and both uptake and filtering by vegetation. Constructed stormwater wetlands temporarily store runoff in relatively shallow pools that support conditions suitable for the growth of wetland plants.

Maintenance requirements for constructed stormwater wetlands are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All constructed stormwater wetland components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include forebays, bottoms, trash racks, outlet structures, and riprap or gabion aprons. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

The types and distribution of the dominant plants must also be assessed during the semi-annual wetland inspections described above. This assessment should be based on the health and relative extent of both the original species remaining and all volunteer species that have subsequently grown in the wetland. Appropriate steps must be taken to achieve and maintain an acceptable balance of original and volunteer species in accordance with the intent of the wetland's original design.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health should not compromise the intended purpose of the constructed stormwater wetland. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff and return the various wetland pools to their normal standing water levels. This drain or drawdown time should then be used to evaluate the wetland's actual performance. If significant increases or decreases in the normal drain time are observed, the wetland's outlet structure, forebay, and groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the wetland.

DRY WELLS

A dry well is a subsurface storage facility that receives and temporarily stores stormwater runoff from roofs of structures. Discharge of this stored runoff from a dry well occurs through infiltration into the surrounding soils. A dry well may be either a structural chamber and/or an excavated pit filled with aggregate.

Maintenance requirements for dry wells are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

A dry well should be inspected at least four times annually as well as after every storm exceeding 1 inch of rainfall. The water level in the test well should be the primary means of measuring infiltration rates and drain times. Pumping stored runoff from an impaired or failed dry well can also be accomplished through the test well. Therefore, adequate inspection and maintenance access to the test well must be provided.

Disposal of debris, trash, sediment, and other waste material removed from a dry well should be done at suitable disposal/recycling sites and in compliance with local, state, and federal waste regulations.

B. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume from the dry well. This normal drain time should then be used to evaluate the dry well's actual performance. If significant increases in the normal drain time are observed or if it exceeds the 72 hour maximum, appropriate measures must be taken to comply with the drain time requirements and maintain the proper functioning of the dry well.

EXTENDED DETENTION BASINS

An extended detention basin is a facility constructed through filling and/or excavation that provides temporary storage of stormwater runoff. It has an outlet structure that detains and attenuates runoff inflows and promotes the settlement of pollutants.

Maintenance requirements for extended detention basins are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All extended detention basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include bottoms, trash racks, low flow channels, outlet structures, riprap or gabion aprons, and inlets.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the bottom surface and remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides, and other means to assure optimum vegetation health must not compromise the intended purpose of the extended detention basin. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to completely drain the maximum design storm runoff volume from the basin. This normal drain time should then be used to evaluate the basin's actual performance. If significant increases or decreases in the normal drain time are observed, the basin's outlet structure, underdrain system, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the basin.

INFILTRATION BASINS

An infiltration basin is a facility constructed within highly permeable soils that provides temporary storage of stormwater runoff. An infiltration basin does not normally have a structural outlet to discharge runoff from the stormwater quality design storm. Instead, outflow from an infiltration basin is through the surrounding soil.

Maintenance requirements for infiltration basins are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All infiltration basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include bottoms, riprap or gabion aprons, and inflow points. This applies to both surface and subsurface infiltration basins.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. The structure must be inspected for unwanted tree growth at least once a year.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing season. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides, and other means to assure optimum vegetation health must not compromise the intended purpose of the infiltration basin. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

All vegetated areas should be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation and basin subsoil.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the bottom of the basin. This normal drain or drawdown time should then be used to evaluate the basin's actual performance. If significant increases or decreases in the normal drain time are observed, the basin's bottom surface, subsoil, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the basin. This applies to both surface and subsurface infiltration basins.

The bottom sand layer in a surface infiltration basin should be inspected at least monthly as well as after every storm exceeding 1 inch of rainfall. The permeability rate of the soil below the basin may also be retested periodically. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken. Annual tilling by light equipment can assist in maintaining infiltration capacity and break up clogged surfaces.

MANUFACTURED TREATMENT DEVICES

A manufactured treatment device is a pre-fabricated stormwater treatment structure utilizing settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to remove pollutants from stormwater runoff.

Maintenance requirements for manufactured treatment devices are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All manufactured treatment devices should be inspected and maintained in accordance with the manufacturer's instructions and/or recommendations and any maintenance requirements associated with the device's certification by the NJDEP Office of Innovative Technology. In addition, all device components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall.

Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetation

In those devices utilizing vegetation, trimming of vegetation must be performed on a regular schedule based on specific site conditions. Vegetated areas must be inspected at least annually for erosion and scour as well as unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation. All use of fertilizers, mechanical treatments, pesticides, and other means to ensure optimum vegetation health in devices utilizing vegetation should not compromise the intended purpose of the device. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the maximum level of oil, sediment, and debris accumulation allowed before removal is required. These levels should then be monitored during device inspections to help determine the need for removal and other device maintenance.

PERVIOUS PAVING SYSTEMS

Pervious paving systems are paved areas that produce less stormwater runoff than areas paved with conventional paving. This reduction is achieved primarily through the infiltration of a greater portion of the rain falling on the area than would occur with conventional paving. This increased infiltration occurs either through the paving material itself or through void spaces between individual paving blocks known as pavers.

Maintenance requirements for pervious paving systems are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

The surface course of all pervious paving systems must be inspected for cracking, subsidence, spalling, deterioration, erosion, and the growth of unwanted vegetation at least once a year. Remedial measures must be taken as soon as practical.

Care must be taken when removing snow from the pervious paving surface courses. Pervious paving surface courses can be damaged by snow plows or loader buckets that are set too low to the ground. This is particularly true at permeable paver systems where differential settlement of pavers has occurred. Sand, grit, or cinders should not be used on pervious paving surface courses for snow or ice control.

If mud or sediment is tracked onto the surface course of a pervious paving system, it must be removed as soon as possible. Removal should take place when the surface course is thoroughly dry. Disposal of debris, trash, sediment, and other waste matter removed from pervious paving surface courses should be done at suitable disposal/recycling sites and in compliance with local, state, and federal waste regulations.

B. Porous Paving Systems

The surface course of a porous paving system must be vacuum swept at least four times a year. This should be following by a high pressure hosing. All dislodged sediment and other particulate matter must be removed and properly disposed.

C. Permeable Paver Systems

Maintenance of permeable pavers should be consistent with the manufacturer's recommendations.

D. Vegetation

Mowing and/or trimming of turf grass used with permeable pavers must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. All vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the paver and remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, pesticides and other means to assure optimum vegetation health should not compromise the intended purpose of a pervious paving system. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

E. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the pervious paving system's surface course. This normal drain time should then be used to evaluate the system's actual performance. If significant increases or decreases in the normal drain time are observed or if the 72 hour maximum is exceeded, the various system components and groundwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the system.

SAND FILTERS

A sand filter consists of a forebay and underdrained sand bed. It can be configured as either a surface or subsurface facility. Runoff entering the sand filter is conveyed first through the forebay, which removes trash, debris, and coarse sediment, and then through the sand bed to an outlet pipe.

Maintenance requirements for sand filters are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All sand filter components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include inlets and diversion structures, forebays, sand beds, and overflows.

Sediment removal should take place when all runoff has drained from the sand bed and the sand is reasonably dry. In addition, runoff should be drained or pumped from forebays with permanent pools before removing sediment. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

In surface sand filters with turf grass bottom surfaces, mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. The filter bottom must be inspected for unwanted underbrush and tree growth at least once a year.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed during both the growing and non-growing season at least twice annually. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health must not compromise the intended purpose of the sand filter. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the top of the filter's sand bed. This normal drain or drawdown time should then be used to evaluate the filter's actual performance. If significant increases or decreases in the normal drain time are observed, the filter's sand bed, underdrain system, and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the filter.

The sand bed should be inspected at least twice annually. The infiltration rate of the sand bed material may also be retested. If the water fails to infiltrate 72 hours after the end of the stormwater quality design storm, corrective measures must be taken.

VEGETATIVE FILTERS

A vegetative filter is an area designed to remove suspended solids and other pollutants from stormwater runoff flowing through a length of vegetation called a vegetated filter strip. The vegetation in a filter strip can range from turf and native grasses to herbaceous and woody vegetation, all of which can either be planted or indigenous.

Maintenance requirements for vegetative filters are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All vegetated filter strip components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually and after every storm exceeding 1 inch of rainfall. Such components may include vegetated areas and stone cutoffs and, in particular, the upstream edge of the filter strip where coarse sediment and/or debris accumulation could cause inflow to concentrate.

Sediment removal should take place when the filter strip is thoroughly dry. Disposal of debris and trash should be done only at suitable disposal/recycling sites and must comply with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed during both the growing and non-growing season at least twice annually. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health must not compromise the intended purpose of the vegetative filter. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

All areas of the filter strip should be inspected for excess ponding after significant storm events. Corrective measures should be taken when excessive ponding occurs.

C. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take for the filter strip to drain the maximum design storm runoff volume and begin to dry. This normal drain time should then be used to evaluate the filter's actual performance. If significant increases or decreases in the normal drain time are observed or if the 72 hour maximum is exceeded, the filter strip's planting soil bed, vegetation, and groundwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the filter strip.

WET PONDS

A wet pond (also known as a retention basin) is a stormwater facility constructed through filling and/or excavation that provides both permanent and temporary storage of stormwater runoff. It has an outlet structure that creates a permanent pool and detains and attenuates runoff inflows and promotes the settlement of pollutants.

Maintenance requirements for wet ponds are summarized below. Further information is provided in the NJ Stormwater Best Management Practices Manual at http://www.njstormwater.org/bmp_manual2.htm

A. General Maintenance

All wet pond components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding one inch of rainfall. The primary location for debris and particularly sediment accumulation will be within a wet pond's permanent pool. Additional components may include forebays, inflow points, trash racks, outlet structures, and riprap or gabion aprons.

Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density and diversity should be performed at least twice annually during both the growing and non-growing season. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to ensure optimum vegetation health must not compromise the intended purpose of the wet pond. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion and deterioration at least annually. All outlet valves are to be inspected and exercised at least four times annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to completely drain the maximum design storm runoff volume and return the pond to its permanent pool level. This normal drain time should then be used to evaluate the pond's actual performance. If significant increases or decreases in the normal drain time are observed, the pond's outlet structure and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements.

APPENDIX B

MAINTENANCE CHECKLISTS

MAINTENANCE CHECKLIST FOR **[*STORMWATER MANAGEMENT MEASURE NAME*]**
[*ROADWAY NAME*] **[*INTERCHANGE, SERVICE AREA, TOLL PLAZA, MAINTENANCE YARD, OR MILEPOST*]** **[*TOWN, COUNTY*], NEW JERSEY**
DATE: **TIME:** **WEATHER CONDITIONS:** **INSPECTOR:**

Yes	No	Maintenance Evaluation	Action(s) Required if Answer "Yes"
❑	❑	[*describe specific evaluation/inspection item and conditions indicating that corrective action is required*]	[*describe specific corrective actions required if deficiency is identified*]
❑	❑		
❑	❑		
❑	❑		
❑	❑		
❑	❑		
❑	❑		
❑	❑		

MAINTENANCE CHECKLIST FOR INFILTRATION BASIN #1

INTERCHANGE 98
MILEPOST No. [###]
WALL TOWNSHIP, MONMOUTH COUNTY, NEW JERSEY

DATE:
TIME:
WEATHER CONDITIONS:

Yes	No	Maintenance Evaluation	Action(s) Required if Answer "Yes"
❑	❑	Is there a buildup of sediment (in excess of two inches), trash, debris or any other stormwater pollution within the basin and/or outlet structure?	Remove sediment, trash, debris, etc. Dispose debris in accordance with local, state and federal requirements.
❑	❑	Is there any structural failure to headwalls/retaining walls?	Consult engineer to determine safety and stability of the structures.
❑	❑	Are there visible signs of cracking (wider than half an inch), damage or deterioration on the outlet structure?	Consult engineer to determine safety and stability of the system.
❑	❑	Are there any signs of unusual color, odor or turbidity within the discharged water?	Evaluate upstream conveyance system for possible sediment, trash and debris. Cleanse system if any of the aforementioned obstructions are encountered. Dispose obstructions in accordance with local, state and federal requirements.
❑	❑	Are there root intrusions or any other plant growth occurring with the retaining wall system(s)?	Remove vegetation and dispose in accordance with local, state and federal requirements.
❑	❑	Is the recharge basin draining within 72-hours?	Investigate draining time in more detail (clogged outlet?, excessive debris buildup at outlet structure? etc.) and if basin is still not draining within 72-hours, remove and properly dispose of basin bottom soil and replace with new soil meeting basin soil specifications.

SAMPLE

APPENDIX C

MAINTENANCE LOGS

MAINTENANCE LOG FOR [*STORMWATER MANAGEMENT MEASURE NAME*]
[*ROAWAY NAME*] [*INTERCHANGE, SERVICE AREA. TOLL PLAZA, MAINTENANCE YARD, OR MILEPOST*] [*TOWN, COUNTY*], NEW JERSEY

DATE	PERSON CONDUCTING MAINTENANCE	AREA OF MAINTENANCE	PROBLEM(S) FOUND	ACTION(S) TAKEN
[*date maintenance performed*]	[*person(s) performing maintenance*]	[*item being maintained*]	[*deficiency being corrected*]	[*corrective actions performed*]

APPENDIX D

PHOTOS OF STORMWATER MANAGEMENT MEASURES

[*insert photographs of each stormwater management measure in plan*]

APPENDIX E

MANUFACTURER LITERATURE

[*insert manufacturers literature for each stormwater management measure in plan, including as applicable:*

- *Operation and maintenance instructions*
- *User manuals*
- *Product information*
- *Warranties*]

REFERENCES

1. American Iron and Steel Institute, “HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS, FIFTH EDITION”, 150 East 42nd Street, New York, 1994. Harrison, L.J., Morris, J.L., Normann, J.M., and Johnson, F.L.
2. American Concrete Pipe Association, “CONCRETE PIPE DESIGN MANUAL”, Revised April 2004.
3. American Association of State Highway and Transportation Officials, “LRFD BRIDGE DESIGN SPECIFICATIONS, THIRD EDITION”, with current interims, 2006.
4. Brater and King, “HANDBOOK OF HYDRAULICS”, Fifth Edition, 1963.
5. FHWA, “DESIGN CHARTS FOR OPEN-CHANNEL FLOW”, U.S. Government Printing Office, Washington, DC. 1961, (Hydraulic Design Series (HDS) No. 3).
6. FHWA, "HYDRAULIC DESIGN OF HIGHWAY CULVERTS", U.S. Government Printing Office, Washington, DC. September 2004, (HDS No. 5).
7. FHWA, Herr, Lester A. and Bossy, Herbert C., “HYDRAULIC CHARTS FOR THE SELECTION OF HIGHWAY CULVERTS”, U.S. Government Printing Office, Washington, D.C. 1965, 54 p., (Hydraulic Engineering Circular (HEC) No. 5).
8. FHWA, “CAPACITY CHARTS FOR THE HYDRAULIC DESIGN OF HIGHWAY CULVERTS”, U.S. Government Printing Office, Washington, D.C., March 1965, (HEC No. 10).
9. FHWA, “DESIGN OF RIPRAP REVETMENT”, U.S. Government Printing Office, Washington, D.C., March 1989, (HEC No. 11).
10. FHWA, "DRAINAGE OF HIGHWAY PAVEMENT", U.S. Government Printing Office, Washington, DC., March 1984, (HEC No. 12).
11. FHWA, “HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS”, August 1972, (HEC No. 13).
12. FHWA, “HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS”, December 1975, (HEC No. 14).
13. FHWA, “DESIGN OF STABLE CHANNELS WITH FLEXIBLE LININGS”, U.S.D.O.T., October 1975, (HEC No. 15).
14. FHWA, “EVALUATING SCOUR AT BRIDGES, 4TH EDITION”, May 2001, (HEC No. 18).
15. FHWA, “STREAM STABILITY AT HIGHWAY STRUCTURES”, Third Edition”, March 2001, (HEC No. 20).
16. FHWA, “DESIGN OF BRIDGE DECK DRAINAGE”, U.S.D.O.T., May 1993, (HEC No. 21).
17. FHWA, “URBAN DRAINAGE DESIGN MANUAL”, November 1996, (HEC-22).
18. FHWA, “BRIDGE SCOUR AND STREAM INSTABILITY COUNTERMEASURES, 2ND EDITION”, March 2001, (HEC No. 23).
19. FHWA, "DESIGN OF URBAN HIGHWAY DRAINAGE-THE STATE OF THE ART", USDOT, TS-79-225, August 1979.

20. Horner, R. Skupien, J.J., Livingston, E.H., and Shaver, H.E., "FUNDAMENTAL OF URBAN RUNOFF MANAGEMENT: TECHNICAL AND INSTITUTIONAL ISSUES", Terrene Institute, Washington, D.C., August 1994.
21. Kaiser, "ALUMINUM STORMWATER CONTROL", Corlix/Riveted Pipe/Structural Plate, 8th Edition, 1983.
22. New Jersey Department of Environmental Protection, "TECHNICAL MANUAL FOR LAND USE REGULATION PROGRAM, BUREAU OF INLAND AND COASTAL REGULATIONS, FLOOD HAZARD AREA PERMITS", Revised September 1995.
23. New Jersey Department of Environmental Protection, Division of Water Quality, "HIGHWAY AGENCY STORMWATER GUIDANCE", August 2004.
24. New Jersey Department of Environmental Protection, "NEW JERSEY STORMWATER BEST MANAGEMENT PRACTICES MANUAL", April 2004.
25. New Jersey Department of Environmental Protection, "HIGHWAY AGENCY STORMWATER, GUIDANCE DOCUMENT", August 2004
26. New Jersey Department of Transportation, "BRIDGE SCOUR EVALUATION PROGRAM GUIDELINES MANUAL FOR STAGE II IN-DEPTH SCOUR EVALUATION OF NEW JERSEY BRIDGES", June 1994.
27. NOAA, "ATLAS 14, VOLUME 2, PRECIPITATION-FREQUENCY OF THE UNITED STATES", June 2, 2005.
28. State of New Jersey, "STANDARDS FOR SOIL EROSION AND SEDIMENTATION CONTROL IN NEW JERSEY", New Jersey State Soil Conservation Committee, April 1987.
29. "ANTIDEGRADATION POLICES", N.J.A.C. 7:9B-4.
30. "STORMWATER MANAGEMENT RULE", N.J.A.C. 7.8.
31. U.S. Department of Agriculture, NCRS (SCS), "NATIONAL ENGINEERING HANDBOOK, SECTION 4", August 1972.

Section 6 - Geotechnical Engineering

6.1. Definitions

Definitions as provided below supersede definitions located elsewhere within the NJTA document library, for the purposes of this document only. Defined terms, where shown in this Section, will have only the first letter capitalized. Where capitalized terms are noted in the text but not below, the reader is implicitly directed to either the NJTA Procedures Manual, the NJTA Standard Specifications for definition of those terms.

ADDENDA: Written interpretations or revisions of any of the Contract documents made prior to the receipt of bids.

AUTHORITY: The New Jersey Turnpike Authority.

BIDDER: An individual, partnership or corporation, acting directly or through a duly authorized representative, legally submitting a Proposal.

BORING CONTRACTOR: Party of the second part to the Contract, acting directly or through agents or employees, and primarily liable for the acceptable performance of the Project and for the payment of all debts pertaining to the Project. The Boring Contractor services include all field work including Borings, sampling, testing, ground monitoring, permitting, and other work discussed in this Manual.

BORING(S): Unless otherwise noted, the term "Boring(s)" refers to a component of the Geotechnical Exploration which consists of soil drilling (hollow stem augers, mud rotary, sampling, down hole in-situ testing, etc.) with Standard Penetration Testing performed in accordance with ASTM D1586 and rock coring, if required.

BORING CONTRACT: The agreement covering the performance of the Project, hereinafter defined, and payments thereof, including the Invitation for Proposals, executed Proposal, executed Contract Agreement, executed Contract Bond (when required), Specifications, Plans, Addenda if issued, and supplementary agreements which may be entered into, all of which documents are to be treated as one instrument as if set forth at length in the form of Contract Agreement.

CONTRACT DOCUMENTS: Advertisement for Proposal, Proposal Guaranty, Contract Agreement, Contract Bond, Power of Execution, Standard Specifications, Supplemental Specifications, Special Provisions, Plans, Addenda, or other information mailed or otherwise transmitted to the prospective bidders prior to the receipt of bids, Change Orders, Field Orders, and Supplementary Agreements, all of which are to be treated as one instrument whether or not set forth at length in the written Contract Agreement.

CORROSION SPECIALIST: The Corrosion Specialist is an authorized representative of the Engineer who has knowledge and experience in corrosion damage mechanisms, metallurgy, materials selection, and corrosion monitoring techniques. NACE certification is required unless a registered PE with certification or licensing in corrosion control of buried metal pipes and tanks.

DESK STUDY: The Desk Study is part of the Phase A Geotechnical Engineering Report. The Desk Study should include review of available information and previously performed explorations including (but not limited to) published geologic information, aerial photographs, existing Boring information, existing construction information, and site visit(s). For additional information related to the Desk Study, see Subsection 6.3.1.

ENGINEER: The Chief Engineer of the Authority, or his duly authorized representative acting within the scope of the particular authority vested in him.

ENGINEER OF RECORD (EOR): Professional Engineer licensed to practice in New Jersey, responsible for the preparation of the Contract Documents. All communications with the Authority shall be through the EOR.

GEOLOGIC ENGINEER: The Geologic Engineer is an authorized representative of the Engineer with at least 10 years of geologic engineering experience and at least 5 years working as a geologic engineer in New Jersey. Practical experience with all the exploration, design and construction issues required for the project. The Geologic Engineer shall be a Professional Engineer or Geologist licensed to practice in New Jersey.

GEOTECHNICAL ENGINEER (GE): The Geotechnical Engineer is an authorized representative of the Engineer with at least 10 years of geotechnical engineering experience and at least 5 years working as a geotechnical engineer in New Jersey. Practical experience with all the exploration, design and construction issues required for the project. A Professional Engineer licensed to practice in New Jersey.

GEOTECHNICAL EXPLORATION: The term Geotechnical Exploration includes in-situ and ex-situ testing performed to characterize the geotechnical aspects of the Project site. The term includes a broad range of field and laboratory testing and sampling including but not limited to Borings, CPT soundings, Seismic Testing, Vane Shear Testing, Pressuremeter Testing, Dilatometer soundings, Groundwater Exploration, laboratory testing, geophysical testing, etc.

GEOTECHNICAL EXPLORATION PLAN (GEP): The GEP is part of the Phase A Geotechnical Engineering Report. This plan provides the rationale for any proposed geotechnical exploration plus detailed information such as a Boring Location Plan, Boring quantities, field and laboratory testing, and relevant procedures. The GEP should be referential of the Desk Study and all additional information to be obtained in that document should be accounted for in the GEP.

GEOTECHNICAL FIELD REPRESENTATIVE (GFR): Authorized representative of the GE, assigned to monitor the Subsurface Exploration. The purpose of the GFR is to monitor conformance of the Contractor's work with Plans and Specifications, and to collect relevant data as directed by the GE.

PLANS: The standard drawings, the official approved drawings specially prepared for the Project, profiles, cross-sections, and any supplemental drawings, or exact reproductions thereof, and that are current on the date the bids are received, and were furnished by the Authority, that indicate the location, character, dimensions, and details of the Work to be done.

PROJECT: The entire work to be performed within the limits and requirements specified for the Contract.

SPECIFICATIONS: The Standard Specifications, the Supplementary Specifications and Addenda, if issued, pertaining to the method or manner of performing the Project and to the qualities of the materials to be furnished for the Project.

SURETY: The corporate body which is bound with and for the Contractor, and which is responsible for the contractor's acceptable performance of the Project and for the payment of all debts pertaining to the Project.

WALL MANUFACTURER: Wall supplier/vendor and shall also include a Professional Engineer licensed in NJ, responsible for the preparation of the Working Drawings and calculations associated with the Retaining Wall.

6.2. PURPOSE & CONTENT

Section 6 of the Authority's Design Manual provides guidance, policies, and standard practice for the Geotechnical Exploration Plan (GEP), geotechnical analysis and design, and construction monitoring. The instructions found within Section 6 constitute the minimum required level of effort on the part of the EOR. The EOR is encouraged to exceed the minimum required level of effort when best practices dictate. The Authority desires the "best value" geotechnical solution, not the "lowest cost" geotechnical solution in cases when these two conditions are not the same.

Section 6 of the manual is intended to work in tandem with the Authority's Procedures Manual. As stated in the Procedures Manual, the Geotechnical Engineering effort will be conducted in Preliminary and Final Design Phases A through D:

- Preliminary Design - Perform Desk Study.
- Phase A - Geotechnical Engineering: Prepare and submit Phase A Geotechnical Engineering Report, Desk Study and GEP.
- Phase B - Geotechnical Engineering: Perform the Geotechnical Exploration, preliminary design recommendations, and preliminary Phase B Geotechnical Engineering Report.
- Phase C - Geotechnical Engineering: Finalize design recommendations, prepare preliminary plans and specifications, and finalize/revise the Phase B Geotechnical Engineering Report.
- Phase D - Geotechnical Engineering: Finalize plans and specifications.

All submittals shall include an electronic copy. Refer to Section 5 of the Procedure Manual for more information on submittal requirements.

The most current edition of the AASHTO LRFD Bridge Design Specifications (AASHTO-LRFD-BDS), with interims at the time the design is let, shall be used for geotechnical and foundation design features, unless otherwise requested by the Authority or when the following exceptions apply:

A. Foundations for structural features or protective features adjacent to railroads shall be designed in accordance with the applicable sections in the current AASHTO-LRFD-BDS with consideration given to AREMA Manual for Railway Engineering for vehicle load and load combinations.

B. Foundations for railroad structures shall be designed in accordance with the current edition of the AREMA, local railroad owner design criteria and supplemented by AASHTO Standard Specifications for Highway Bridges.

C. Foundations for sign structures, toll gantries, tower foundations, luminaries, and traffic signals shall be designed in accordance with the current edition of the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, with interims.

D. Foundations for buildings shall be designed in accordance with current International Building Code (IBC) and International Building Code - New Jersey Edition (NJBC), applications include toll plazas, maintenance facilities, and service areas.

E. Infiltration basins shall be designed in accordance with current New Jersey Department of Environmental Protection (NJDEP) New Jersey Stormwater Best Management Practices (BMP) Manual.

F. Temporary works shall be in accordance with the AASHTO Guide Design Specifications for Bridge Temporary Works, and AASHTO Construction Handbook for Bridge Temporary Works.

G. Analyzing Soil and Rock Slopes and Embankment Settlement and Global Stability shall be performed in accordance with the AASHTO Standard Specifications for Highway Bridges.

H. Foundations for fenders shall be designed in accordance with AASHTO Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges.

Subsection 6.6 of this Manual follows the organization of AASHTO-LRFD-BDS, and provides supplementary guidance and commentary when necessary, and remains silent otherwise.

Subsection 6.7 of this Manual provides additional guidance on geotechnical features and technical issues not addressed in AASHTO-LRFD-BDS.

Section 6 of the Design Manual shall be used with other Design Manual sections (e.g. Structures-Section3) and shall be supplemented by current versions of the Authority's Procedures Manual, Standard Specifications, and Standard Supplementary Specifications. Additional local, state, or federal specifications, supplemental text books, and technical articles are referenced throughout this Section, when appropriate or necessary.

Although this Section provides guidance on design and analysis procedures, it does not preclude the need for additional engineering analysis and design procedures to produce a safe, economical and maintainable structure. All calculations shall provide complete and accurate references, and clearly identify the meaning of any abbreviations and symbols. They shall adhere to accepted QA/QC protocol and include initials and date performed and checked. Often special conditions will require engineering judgment to be applied and shall be assessed by the Authority on a project specific basis.

6.3. PREPARATION OF THE PHASE A GEOTECHNICAL REPORT

The Phase A Geotechnical Report shall, at a minimum, consist of a Desk Study and the GEP. The purpose of the Phase A Geotechnical Report is to provide a sound basis for the Phase B work.

6.3.1. Desk Study

A Desk Study is an exploration of relevant existing information which has been previously performed and often by others. Results of this study will be helpful to define existing project conditions and assist in determination of appropriate geotechnical features and their respective design and construction procedures and analyses. A Desk Study shall be performed during Preliminary Design to determine the suitable foundation options for the alternates being evaluated. The information gathered during Preliminary Design for the Desk Study shall serve as the basis for the development of the GEP during Phase A and other contract documents. Minimum requirements for the Desk Study include:

Basic Geologic Understanding: The Desk Study shall provide a basic understanding of the geologic conditions of the site by thorough acquisition and review of available geologic literature relative to the site. "The Geologic Map of New Jersey by Lewis and Kummel" is the standard reference geology map of New Jersey. The New Jersey Geological Survey (NJGS) Surficial Geology Maps of New Jersey and NJGS Bedrock Geology Maps of New Jersey also provide valuable reference information. Additional engineering soils information and soil maps can be obtained from the Rutgers University publications entitled, "Engineering Soil Survey of New Jersey" for each county. The United States Department of Agriculture, Soil Conservation Service also publishes soil maps which are useful when evaluating the upper layers of soil.

Existing Information: Through the EOR the GE shall request from the Authority any existing information relative to the site. The information request shall address existing Borings/soundings made for previous construction nearby, aerial photographs, foundations plans, soil and foundation reports, agricultural soil maps, and Photogeologic Interpretation reports. Sources of information may include the NJDOT Soil Boring Database which is available online. Existing information from the Authority is typically available during the solicitation process.

Site Visit: Upon coordination with the Authority, it is recommended that the GE conduct a field reconnaissance of the proposed project site. Observe and record site features that may warrant additional consideration during the exploration.

Design Understanding: The GE shall establish a comprehensive understanding of the proposed design through meetings and open communication with the EOR's entire design team. It is understood that the complete project design will not be developed at this early project phase. However, it is important to obtain the anticipated approximate locations of major structures and project features that will affect the Geotechnical Exploration. If during initial meetings the overall project design has not been adequately advanced to provide preliminary structure and project feature locations within the Phase A deliverable deadline, the EOR shall contact the Engineer to discuss either accelerating the work, or rescheduling the Phase A deadline. Alternatively, the Geotechnical Exploration may be staged to allow the GE to advance their understanding of the subsurface conditions as the design progresses.

Design Parameters: The GE shall develop an understanding of the design parameters as they relate to the structures and other elements of design that require said parameters and geotechnical analysis. A list of these parameters with the proposed approach to their selection based on the testing and evaluation proposed shall be included as part of Phase A submission. Include an evaluation of the sensitivity of proposed and/or existing structures to these parameters and through the EOR advise the Authority if additional testing could reduce cost and/or accelerate schedule if alternative investigative methods are employed (as applicable).

Geotechnical Hazards: The Phase A Geotechnical Engineering Report shall include a list of potential geologic hazards such as soft compressible soils, urban fills, degradable shale rock, erratic rock conditions, presence of cobbles and boulders, potential for scour, foundation construction near existing structures and utilities, construction in confined space, spread footing on future thick engineered fills, and high and variable groundwater levels that could affect the design and construction of the Project. Additional examples include aggressive corrosivity, sulfate attack, microbiologically influenced corrosion, acid producing soils, and seismic hazards. Where these hazards present an obstacle to traditional subsurface exploration or design, recommend special geotechnical exploration and design to mitigate the identified potential risks to existing facilitates and/or the proposed project facilities. When hazards are identified, the Phase A Geotechnical Engineering Report shall include a hazard matrix which details each hazard, the anticipated risks of the hazard(s), and the recommendations to reduce risk associated with those hazard(s).

Environmental Constraints: Describe site specific environmental constraints known to exist based on discussions with the Project's environmental specialist. This may include the potential for the presence of contaminated soils which impact the proposed subsurface exploration methods in regards to Health and Safety Requirements, procedures, and costs. This information may also skew the foundation costs to be more favorable of one particular foundation type that would otherwise not be economically preferred (i.e. driven displacement piles require no soil disposal opposed to drilled shafts). Environmental subsurface exploration program shall be coordinated with geotechnical subsurface exploration program to minimize the cost. In addition, this section shall include any available historic maps such as Sanborn maps, which may provide an indication of past land use, which may be useful in identifying abandoned utilities, abandoned buried building foundations, etc.

6.3.2. Development of the Phase A Geotechnical Exploration Plan

The Phase A Geotechnical Engineering Report shall include a detailed GEP developed and submitted during Phase A and executed during Phase B. The plan shall include a boring location plan which indicates the anticipated locations of relevant structures and other project features. This plan should include a justification for the exploration and how the information is related to design and construction needs, design parameters, and how geotechnical hazards will be evaluated, analyzed and presented. The plan should also include a schedule of Borings and other investigative methods, including proposed boring type, termination, and sampling criteria. Also, the GE should provide a schedule of anticipated laboratory and in-situ testing (as required), as well as procedures for all field testing. The procedures shall reference standards such as ASTM, AASHTO and other standard tests, as appropriate. Also, if appropriate, the GE should provide recommendations for a multi-phase exploration approach that may be warranted for large or complex Projects or Projects subject to significant geometric or structure change.

The GE shall execute a 'right-sized' Geotechnical Exploration program consisting at a minimum of Borings and laboratory testing of samples retrieved. Other in-situ strength testing, direct-push technologies and geophysical testing may be incorporated into the program to further define soil and rock parameters. The program will serve to delineate changes in strata, provide information to assist with geomorphologic interpretation of the soil and rock encountered, and facilitate the planning, design and construction of the proposed bridges, roadways, embankments, retaining walls, sign structures, noise barriers, culverts, buildings and other facilities shall also be included or design features that will require geotechnical analysis.

Groundwater monitoring installations shall also be incorporated into the Geotechnical Exploration to identify the groundwater conditions for design and as described in Subsection 6.4.3. In-situ permeability testing to assist in the design of storm water management facilities and is discussed in Subsection 6.4.3.5. Soil and rock samples shall be tested in accordance with Article 6.4.10, “Laboratory Testing Program”.

The GE shall provide a GEP narrative including the criteria and justification used in developing the program, and the location of all in-situ testing and borings with their frequency, depths, and sampling intervals.

The Geotechnical Exploration shall be completed in and the findings published with the Phase B Geotechnical Engineering Report. Results of the Geotechnical Exploration shall be sufficient to provide all planned geotechnical input to advance the project through Phase C. The Phase B Geotechnical Engineering Report shall provide for suggested construction execution and sequence of foundation elements (constructability). The constructability of foundation elements is a critical component to the Phase B submission as it directly affects the design and constructability of all foundation elements, is of direct importance to the Maintenance and Protection of Traffic (MPT) and overall project constructability reports. Another purpose of the Phase B submission is to help identify significant risk related to constructability or performance after construction is completed. The GE shall consider availability of large or unusual foundation installation equipment and its potential to impact facilities that remain in service during construction. Additional consideration for appropriateness and cost shall be given to foundation designs that utilize techniques or foundation elements which are outside the expertise of the regional contractor community.

Phase A Geotechnical Engineering Report – Desk Study and Geotechnical Exploration Plan (GEP) – The minimum requirements for the Phase A GEP shall include the following. Deviations from this outline must be authorized by the Authority.

- Rationale for exploration plan
- Boring Location Plan
- Boring spacing, depth and termination criteria
- Exploration testing quantities
- Access constraints
- MPT impacts and needs
- Design parameter evaluation
- Procedures
- Inspection
- Schedule and phasing

6.3.2.1. **Justification for the Geotechnical Exploration Plan**

The GEP shall also present a detailed justification for the exploration, including the reasoning for the selected boring locations, spacing, termination criteria, anticipated depths, and proposed in situ and laboratory testing. The GEP shall include a discussion of the design features that will be addressed. This shall include a discussion of the requirements established by the design team including structure and facility locations, sizes, preliminary loads and deformation tolerances, other key design and construction inputs; and how the proposed exploration will provide information to support a design that meet those requirements. The GEP shall also discuss how the site conditions (geologic understanding, existing Borings, etc.) are anticipated to affect the proposed exploration. The GEP should also include a discussion on how the results will help minimize construction related risks associated with differing site conditions and the design and construction of the facilities.

6.3.2.2. **Proposed Boring Location Plan**

The Engineer shall submit a boring/structure location plan as a part of the GEP. The plan should identify all project features that will require geotechnical study. The approved boring location plan shall be prepared for the use of the Boring Contractor and the GE for field stake out purposes. The final construction boring location plan shall be accompanied by a list or schedule of the Borings, showing the NJ State Plane Northing and Easting coordinates, North American Vertical Datum ground elevation, baseline, station and offset, boring type, and planned depth.

The boring location plans shall include the following information and the location of all features of the project requiring geotechnical assessment, but not limited to:

A. Project baseline stationing (if available) at maximum 100’ intervals.

B. Property lines and Right of Way limits.

C. Block and Lot Numbers of private properties.

D. Aerial Photographs – if available.

E. Existing utilities known at the time of development of the GEP

F. Existing structures, roadways, embankments and retaining walls.

G. Anticipated facility locations.

H. Proposed boring locations with boring numbers as per Section 6.4.7.

If base mapping is not available at this stage of the project, the Engineer shall utilize photogrammetric images obtained from the NJ GIS database and the NJTA's Enterprise GIS to locate the exploration points in an effort to expedite the program.

6.3.2.3. **Boring Spacing and Depth**

The GE shall refer to the indicated publications below and Tables 6.3-1 and 6.3-2 to present and justify soil boring spacing and depths for:

Shallow and deep foundations and retaining walls shall be in accordance with Article 10.4.2 of AASHTO-LRFD-BDS, current edition, with interims.

Roadways, cuts, embankments, and culverts shall be in accordance with Article 2.5.2 of the FHWA document NHI-01-031, "Subsurface Investigations – Site Characterization".

Stormwater management facilities shall be in accordance with the "New Jersey Stormwater Best Management Practices (BMP) Manual", current edition.

Buildings and Toll Plazas shall be in accordance with the "International Building Code-New Jersey Edition".

The design of the exploration program, including but not limited to spacing and depth, is the responsibility of the GE. The GE may decrease spacing and increase depths to further explore areas with highly variable subsurface conditions as deemed appropriate. Through the EOR the GE shall obtain the concurrence of the Authority to modify exploration spacing and depths in the event that subsurface conditions are uniform over large areas. Through the EOR the GE shall obtain concurrence of the Authority to use exploration information previously performed from another exploration in lieu of and to supplement the proposed Subsurface Exploration Program and reduce the number of proposed Borings. The decision to rely upon existing data and the potential consequence are the sole responsibility of the GE.

The GE shall be responsible for performing field reconnaissance to determine accessibility of the proposed boring locations. Exploration contractors shall be present during the field reconnaissance to determine necessary equipment, access points, and staging areas for the proposed work. The GE shall be responsible for locating and staking out all soil boring and in-situ testing locations using appropriate methods suited for the project needs. The Boring Contractor may offset the boring only at the direction of the GE.

After having gained a preliminary knowledge of the geology and surface soils in the area, the GE shall prepare a boring layout plan that will provide the maximum amount of information at the lowest practical cost and shortest practical schedule. The size and complexity of the Project and the anticipated foundation type(s) along with the subsurface conditions expected will dictate the size of the GEP. The GE is encouraged to err on the side of additional and/or deeper Borings when project complexity or uncertainty regarding the subsurface conditions warrants.

The location, spacing, and depth of Borings for structural foundations shall adhere to the minimum modified AASHTO guidelines presented in Table 6.3-1. Similar minimum guidance for facilities not addressed in AASHTO are presented in Table 6.3-2. However, the GE must use judgment in determining the proposed location and spacing of the Borings for each Project. In general, if the subsurface profile is expected to be uniform and consistent, the spacing between Borings may be greater. On the other hand, if variable or non-uniform conditions are expected, the spacing should be reduced in an attempt to delineate variable conditions.

Table 6.3-1 Modified AASHTO Criteria for Boring Spacing and Depth

Application	Minimum Number of Exploration Points and Location of Exploration Points	Minimum Depth of Exploration
Retaining Walls	A minimum of one exploration point for each retaining wall. For retaining walls more than 100 ft. in length, exploration points spaced every 100 to 200 ft. with locations alternating from in front of the wall to back limit of the wall. For anchored walls, additional exploration points in the anchorage zone spaced at 100 to 200 ft. For soil-nail walls, additional exploration points at a distance of 1.0 to 1.5 times the height of the wall behind the wall spaced at 100 to 200 ft.	Investigate to a depth below bottom of wall at least to a depth where stress increase due to estimated foundation load is less than ten percent of the existing effective overburden stress at that depth and between one and two times the wall height. Exploration should be deep enough to fully penetrate soft highly compressible soils, e.g., peat, organic silt, or soft fine grained soils, into competent material of suitable bearing resistance, e.g., stiff to hard cohesive soil, compact dense cohesionless soil, or bedrock.

Application	Minimum Number of Exploration Points and Location of Exploration Points	Minimum Depth of Exploration
Shallow Foundations	For substructure, e.g., piers or abutments, widths less than or equal to 100 ft., a minimum of one exploration point per substructure is required however two is preferred. For substructure widths greater than 100 ft., a minimum of two exploration points per substructure is required. Additional exploration points should be provided if erratic subsurface conditions are encountered.	Investigate to a depth below the bottom of footing deep enough to fully penetrate unsuitable foundation soils, e.g., peat, organic silt, or soft fine grained soils, into competent material of suitable bearing resistance, e.g., stiff to hard cohesive soil, or compact to dense cohesionless soil or bedrock. The Borings shall extend at least to a depth where stress increase due to estimated foundation load is less than ten percent of the existing effective overburden stress at that depth; and if bedrock is encountered before the depth required by the second criterion above is achieved, exploration depth should be great enough to penetrate a minimum of 10 ft. into the bedrock, but rock exploration should be sufficient to characterize compressibility of infill material of near-horizontal to horizontal discontinuities. Note that for highly variable bedrock conditions, or in areas where very large boulders are likely, more than 10 ft. of rock core may be required to verify that adequate quality bedrock is present.

Application	Minimum Number of Exploration Points and Location of Exploration Points	Minimum Depth of Exploration
Deep Foundations	For substructure, e.g., bridge piers or abutments, widths less than or equal to 100 ft., a minimum of one exploration point per substructure is required however two points is preferred. For substructure widths greater than 100 ft., a minimum of two exploration points per substructure is required. Additional exploration points should be provided if erratic subsurface conditions are encountered, especially for the case of drilled shafts socketed into bedrock. To reduce design and construction risk due to subsurface condition variability and the potential for construction claims, at least one exploration per shaft should be performed during construction for large diameter shafts (e.g., greater than 5 ft. in diameter), especially when shafts are socketed into bedrock.	In soil, depth of exploration should extend below the anticipated pile or shaft tip elevation a minimum of 20 ft., or a minimum of two times the minimum anticipated pile group dimension, whichever is greater. All Borings should extend through unsuitable strata such as unconsolidated fill, peat, highly organic materials, soft fine-grained soils, and loose coarse-grained soils to reach hard or dense materials. For piles bearing on rock, a minimum of 10 ft. of rock core shall be obtained at each exploration point location to verify that the boring has not terminated on a boulder. For shafts supported on or extending into rock, a minimum of 10 ft. of rock core, or a length of rock core equal to at least three times the anticipated shaft diameter for isolated shafts or two times the minimum shaft group dimension, whichever is greater, shall be extended below the anticipated shaft tip elevation to determine the physical characteristics of rock within the zone of foundation influence. Based on the geologic conditions, bedrock is relatively competent along the Turnpike and Parkway and the rock core depth specified above may be excessive. Note that for highly variable bedrock conditions, or in areas where very large boulders are likely, more than 10 ft. of rock core may be required to verify that adequate quality bedrock is present.

1. From AASHTO-LRFD-BDS
2. Consider taking at least one boring per project geologic setting to a minimum of 100 feet or to bedrock, to determine seismic site class.

Table 6.3-2 Criteria for Boring Spacing and Depth not Specified in AASHTO

Application	Minimum Number of Exploration Points and Location of Exploration Points	Minimum Depth of Exploration
Roadways	A minimum of one boring every 100 to 400 feet along the center of the roadway per lane direction, additional borings should be provided for poor foundation conditions such as deep layers of soft clays or complex conditions where lenses of soft clay are found in layers of sand. Very wide areas, such as approaches to toll booths may require 2 to 3 boring per cross section. In marshes or swamps, continuous sampled Borings shall be specified at closer spacing to delineate the bottom of the organic deposits.	Embankments - For proposed embankments over 10 ft. in height, a minimum depth below the base elevation of the embankment of twice the embankment height or until the SPT result is 20 for two consecutive sample intervals, whichever is greater. For embankments less than 10 ft., the minimum depth is 15 ft. below the base elevation of the embankment Extend Borings 15 ft. below zones of peat, highly organic soils, soft fine-grained soils, or loose coarse-grained soils. Cuts - For roadway cut areas, the Borings shall extend a minimum of 15 ft. below the anticipated profile grade.
Sign Structures, E-Z Pass Tolling, VMS, High Mast Lighting, Tower Structures	A minimum of one boring for each foundation substructure.	Extend borings to minimum of 40 ft. in soil or 10 ft. into rock, whichever occurs first.
Stormwater Facilities	A minimum of one boring for each stormwater facility with less than 4000 square feet, and additional boring for large facilities. Additional borings are required where subsurface conditions are variable.	Extend borings a minimum of 10 ft. below the deepest anticipated grade of the stormwater facility.
Buildings	A minimum of one boring every 2,500 square feet of building plan footprint.	Follow the guidance as for shallow and deep foundations, respectively
Sound barriers, privacy walls, or solid type fencing	Follow the guidance as for retaining walls.	Follow the guidance as for retaining walls.

6.3.2.4. **Exploration Quantities**

The GEP shall summarize all proposed exploration quantities. The summary shall be in tabular form. The proposed quantities shall, at a minimum, include:

- Boring – by number and depth
- Sampling - by type
- In-situ testing (if utilized) - by type
- Laboratory testing - by type
- Groundwater exploration- by type

6.3.2.5. **Design Parameter Evaluation**

The GEP shall clearly state how the proposed borings, in situ testing and laboratory testing will be used to provide the required parameters for design and construction.

6.3.2.6. **Subsurface Exploration Procedures**

The GEP shall present relevant procedures for each element of the proposed exploration, and cite applicable ASTM and AASHTO standards when appropriate. If proprietary procedures are proposed, include them in the appendix. Also present the quality control procedures to be used for each method (see 6.3.2.7 below). When borings are to be taken on or adjacent to existing Authority roadways, applicable procedures must be followed regarding lane or shoulder closings, signing, etc.

6.3.2.7. **Quality Assurance**

Field oversight of all subsurface exploration work shall be under the supervision of a GE. It is the GE's responsibility to provide oversight and documentation of the boring contract.

The GE shall provide trained and experienced Geotechnical Field Representatives (GFR's) to monitor all boring operations and other field operations, and prepare boring logs. The GFRs will be under the supervision of the GE who will make periodic visits to the Project site during the course of the boring work. The GFR shall, at a minimum:

- Ensure that the locations for investigative methods presented in the GEP have been staked out per the boring contract plans. Confirm that both horizontal control and vertical ground elevations are recorded to the nearest one-tenth of a foot.

- Provide full-time monitoring (one assigned inspector per rig) of each boring rig on site and prepare a thorough record of the entire operation of that rig.
- Make and record measurements of the downhole tools used for the boring, including drill rods, samplers, other testing equipment and casing. The GFR shall measure accurately the depth to the top of each sample, record the penetration resistance of the sampler or the pressure used to push thin-walled samplers into the ground, and also record any unusual observations (driller's notes). Hammer type shall be automatic or safety.
- The GFR is responsible for QA monitoring of all field activities. The GFR shall have copies of all relevant procedures to the work. The GFR shall be knowledgeable about the procedures and with the GE identify any missing procedures, criteria, or issues related to the quality of the work. This shall be followed with a pre-work meeting with the Boring Contractor to review all quality procedures. It should be recognized that ASTM and other similar procedures are generally acceptable in their content; however, it is the responsibility of the GE to identify and supplement these procedures when they may be missing detailed information relative to the work.
- The GFR shall keep a Daily Field Report per Appendix C.
- The GFR shall identify the samples recovered with the split spoon sampler and shall be responsible for collecting representative samples and sufficient material in a labeled moisture resistant jar at the time the sample is retrieved. The jars shall be kept in a safe location and away from open sunlight or freezing temperatures.
- The GFR shall verify that groundwater levels are recorded at each boring in accordance with 6.4.3. Any water loss during drilling shall also be noted.
- The GFR shall verify that all boring holes are either backfilled or grouted in accordance with N.J.A.C. 7:9D-3.4 "Specific requirements for the decommissioning of Category 5 Wells-Geotechnical Borings" at the completion of the borings with the appropriate surface treatment and site restoration applied.
- The soil identification system to be used by the GFR is the Modified Burmister Soil Identification System which is noted in Appendix B. Undisturbed samples shall be properly sealed in accordance with the Boring Contract, by the driller in the presence of the GFR, and

placed in the required sample container. The GFR shall prevent damage from sunlight, impact or vibration, temperatures below the point of freezing, and carefully transport them to the laboratory.

- Each and every soil sample shall be photographed in accordance with the sample soil and core box photographs provided in **Exhibit 6-1**
- A GFR's Manual is provided in Appendix C. The boring log forms to be used are provided in **Exhibit 6-2** through **Exhibit 6-6**. Sample boring log templates are provided in Appendix C.

At the conclusion of the boring program, the GE shall prepare a revised list of borings showing the "as-drilled" boring station and offset, northing, easting, ground surface elevation, actual type and depth of each boring. This revised list of "as-drilled" boring information shall be utilized in locating the borings on the final construction contract plans.

Throughout the boring program, the field boring logs shall be reviewed by the GE for consistency and completeness. The GE shall provide a layout of the boring logs applicable to each final construction contract on standard size bordered plan sheets suitable to be incorporated in the construction plans as reference drawings. These drawings shall bear the PE number and signature of the GE.

The GE shall provide storage for the samples obtained during the boring program. All samples shall be carefully stored so that they are readily available until the design phase of the project is completed. Upon completion of the Design Contract, the GE shall select a representative 20 percent of the soil and rock samples collected to be shipped to the Authority's geotechnical storage facility. Before delivery of the samples, the GE shall write the Authority requesting authorization to ship selected samples and dispose of the remaining materials. Until further direction is given from the Authority, the samples shall be stored by the GE at their own facility for at least 7 years.

6.3.2.8. **Schedule and Phasing**

The GEP and the geotechnical design need to be completed prior to proceeding with other tasks and are often driven by overall project schedule, the GE shall prepare a schedule that shows all major work elements, which at a minimum shall include the following:

- Permitting and rights of entry
- Mobilization

- Field Work
- Laboratory Work
- All reporting documents and all Geotechnical Engineering Reports beyond Phase A.

The schedule shall be prepared using Primavera, Microsoft Project, or comparable software approved by the Authority. If phasing of work is required, this shall be shown in the schedule.

6.3.2.9. Boring Contract

It is required that proposals be solicited for the boring work from a minimum of three (3) qualified Boring Contractors, with the lowest responsible bidding contractor being awarded the work. Deviations from this recommendation may be permitted by the Authority on a case-by-case basis.

6.3.2.10. Submission

Unless the Authority approves otherwise, the Boring Contract for the entire Project is to be completed to 'ready-to-advertise' status and submitted no later than the overall Project Phase A submission.

Also submitted with the 'ready-to-advertise' Boring Contract for review shall be the Subsurface Exploration Cost Estimate and a list of not less than three qualified Bidders who shall be invited to bid. The Authority reserves the right to add or delete from this list as it deems to be in its best interest.

Shortly after the Phase A submittal, the Authority will notify the EOR of any changes to be made on the boring location plan by the GE. After any changes have been made, the EOR will be notified by the Authority to invite bids for the Boring Contract.

If it appears the Subsurface Exploration Cost Estimate for Boring Contract cost will exceed the authorized boring contract amount, permission shall be obtained from the Authority prior to exceeding the authorized contract amount.

6.3.2.11. Subsurface Exploration Cost Estimate

Each boring program must be accompanied by an Engineer's cost estimate, stating the various items proposed, the estimated quantities (See 6.3.2.4), the estimated unit cost, and the total Boring Contract amount. In addition to the normal boring items specified in Appendix A, the estimate should include a separate lump sum item to cover the Contractor's cost for Mobilization and Demobilization. The cost estimate should also include costs associated with site restoration and Maintenance and Protection of Traffic, to cover these costs when appropriate.

6.3.2.12. Laboratory Selection

At a minimum, laboratory qualifications shall include evidence of AASHTO Materials Reference Laboratory Accreditation (AMRL) certification for all applicable test items.

6.3.2.13. Contract Award

The GE will invite bids by sending a complete set of Boring Contract documents to each of the selected Bidders.

Through the EOR the GE will formally notify the Authority of the results of the bidding and recommend the disposition of the Boring Contract. The Authority will review the results of the bidding and the GE's recommendation. The Authority will formally notify the GE of their concurrence and the contract awarded as recommended.

When the Contract Agreement, the Contract Bond (when applicable) and all the required Insurance Certificates have been submitted by the selected Bidder, properly signed and executed, the GE will sign the Boring Contract Agreement and notify the Boring Contractor to proceed with the work. Boring Contractor shall not execute the work until a traffic permit is obtained.

6.4. GEOTECHNICAL EXPLORATION

6.4.1. Introduction

The Geotechnical Exploration shall be performed during Phase B and comply with the GEP approved by the Authority as part of the Phase A work.

6.4.1.1. Owner Notification (Notice of Entry)

Notice of Entry is discussed in Subsection 1.4.3 of the "Procedures Manual".

6.4.1.2. Locating and Protecting Utilities

The Boring Contractor shall be responsible for confirming the location of any utilities on the project site before performing work and shall be responsible for protecting the utilities throughout the performance of the proposed work. The Boring Contractor shall contact New Jersey One-Call at 811 or 1-800-272-1000 and any other municipal or private entities necessary to locate and mark out all utilities on the Project site prior to performing any work. In situations where records of known public or private utilities are incomplete, hand digging and/or soft digging shall be performed as directed by the GE to delineate utilities on the project site. A Ground Penetrating Radar (GPR) Survey, in accordance with ASTM D6432, and other geophysical methods may be considered at the discretion of the GE. The Boring Contractor shall also submit a written request to the Authority for information on utilities and other subsurface facilities in the Project area. A private locating service may be needed to locate and mark utilities if there are utilities that do not belong to the one-call system. The GE shall maintain a record of all One-Call Notification tickets, including their submittal and expiration dates.

6.4.2. **Soil Borings and Rock Coring**

6.4.2.1. **Soil Testing and Sampling**

The Authority preference for advancing soil borings shall be mud-rotary with casing employed for borehole stability when applicable. However, when deemed warranted by the GE, other methods may be permissible, such as hollow stem augers.

Sampling types and intervals will be based upon the Project performance requirements, proposed loads and foundation systems, as well as the soil and rock type, thickness of the strata sampled, and the scheduled laboratory testing. The GE shall tailor sampling intervals to identify stratigraphic transitions or loose, soft, weak, or compressible soils.

Standard Penetration Testing (SPT) shall be performed within all soil borings in accordance with ASTM D1586. All SPT samplers shall be driven 24 inches if feasible. SPT sampling shall be performed continuous to 12 feet below grade and at 5 foot intervals thereafter. Extended or truncated depths of continuous sampling may be warranted for certain applications as deemed necessary by the GE.

The Boring Contractor may use a 3-inch OD Split-Spoon sampler within gravelly soils, but only after the 2-inch OD Split-Spoon sampler has failed to retrieve adequate samples. Becker Hammer Penetration Test may also be used in gravelly soils.

Undisturbed soil sampling may be obtained using the thin walled tube sampler, Shelby Tube, Osterberg Piston, other piston samplers or the Dennison sampler (ASTM D1587). Thin-Walled Tube sampling shall be performed within fine-grained soils as required. When undisturbed samples are taken, at depths where SPT testing would otherwise be performed, a split spoon sample shall be taken immediately following the undisturbed sample.

6.4.2.2. **Rock Coring**

Boring termination (refusal of the SPT sampler) usually marks the beginning of coring. However, coring this zone may produce very low core recoveries. For this reason, the GEP shall describe in detail how refusal will be determined and how this transition zone will be investigated so as to maximize information. Acoustic Televiewer (ATV) or Optical Televiewer (OTV) logging may also be used to better define this zone.

The Rock Core samples shall be obtained using a five-foot long NX or NQ size, Double Tube Core Barrel (ASTM D2113). The use of wire line or triple barrel drilling equipment shall be permitted when deemed appropriate by the GE. Rock Core sampling shall begin upon encountering bedrock which is defined in Appendix C.

All attempts shall be made to increase core recovery. When core pieces must be broken to fit into the core box they shall clearly identified as such. The GFR shall make a careful record of the advance of the coring (advance rate, down pressure, water losses) and correlate this to the recovered core to the extent possible. The rock coring log forms to be used are provided in **Exhibit 6-1**

6.4.2.3. **Supplemental In-Situ Testing**

A. Cone Penetration Tests (CPT): Cone Penetration Tests with pore water pressure sensors (CPTu), and Seismic Cone Penetration Tests (SCPTu) shall be performed in accordance with ASTM D3441 (mechanical systems) or ASTM D5778 (electric and electronic systems). The CPT may be performed in conjunction with the soil borings to better define soil and other subsurface parameters. This test method is relatively inexpensive and can provide continuous data. Pore water dissipation testing may be performed and is useful for consolidation settlement analysis. Seismic CPT may be useful in characterizing the shear wave velocity and maximum (low strain) shear modulus.

B. Pressuremeter Testing (PMT): Where requested by the GE through the EOR and approved by the Authority, PMT shall be performed within the borehole in accordance with ASTM D4719. Pressuremeter tests may be used in conjunction with the soil borings to obtain geotechnical parameters including but not limited to undrained shear strength, effective angle of internal friction, elastic modulus, shear modulus, and at-rest earth pressure. The test results can also be utilized to develop site specific p-y curves used in lateral load response of deep foundation elements.

C. Vane Shear Testing (VST): Where requested by the GE through the EOR and approved by the Authority, VST shall be performed within the borehole in accordance with ASTM D2573. The Vane Shear Test may be used in conjunction with the soil borings to obtain the undisturbed undrained shear strength of fine-grained soils. Remolded undrained shear strength is also measured after a predetermined period of time has passed from the initial shearing.

D. Flat Plate Dilatometer Test (DMT): Where requested by the GE through the EOR and approved by the Authority, DMT shall be performed within the borehole in accordance with ASTM D6635. The DMT may be performed in conjunction with the soil borings to interpret soil type and other geotechnical parameters including at-rest lateral earth pressure, elastic modulus, effective angle of internal friction, and shear strengths of sand, silts, and clays.

6.4.2.4. **Geophysical Testing**

Geophysical Testing offers nondestructive and/or non-invasive methods that can be used for stratigraphic profiling and delineation of subsurface geometries. Certain geophysical tests shall either be required or recommended for different situations. A comprehensive reference on this subject is provided in the AASHTO "Manual on Subsurface Investigations" and Federal Highway Administration publication FHWA-IF-04-021 entitled "Application of Geophysical Methods to Highway Related Problems". A list of common methods is described below:

A. Crosshole Seismic Testing (CST): Where requested by the GE through the EOR and approved by the Authority, CST shall be performed in accordance with ASTM D4428. Crosshole Seismic Testing shall be performed to obtain soil shear wave velocities and is the preferred method for determination of this parameter. CST may be performed for site specific seismic design or liquefaction evaluation.

B. Downhole Seismic Testing (DST): Where requested by the GE through the EOR and approved by the Authority, DST shall be performed in accordance with ASTM D7400 as a substitute to the CST. Similar to the CST, it provides soil shear wave velocities, however only one cased borehole is required to perform the test. The DST may be replaced by suspension PS logging system.

C. Parallel Seismic Testing (PST): Where requested by the GE through the EOR and approved by the Authority, PST shall be performed in accordance with ASTM D8381. PST shall be performed to measure the depth of deep foundation elements for foundations are in consideration for reuse. PST should be considered for existing deep foundation elements where the as built information is not available.

D. Multichannel Analysis of Surface Waves (MASW): Where requested by the GE through the EOR and approved by the Authority, MASW may be performed to delineate construction debris within fills to assess the potential for obstructions, estimate removal volumes and costs or to identify shallow bedrock surfaces to estimate volumes and costs of rock excavation.

E. Acoustic Televiewer (ATV) and Optical Televiewer (OTV): Where requested by the GE through the EOR and approved by the Authority, ATV or OTV logging shall be performed in accordance with ASTM D5753. ATV and OTV logging may be performed within boreholes to log bedrock conditions including fracture location, orientation, size, strike, dip, and infill material. ATV and OTV logging may also be used to investigate the soil/rock interface, particularly if soil boring or rock coring may not provide adequate definition of conditions. ATV and OTV should be considered where rock socketed foundations are anticipated.

F. Ground Penetrating Radar (GPR): Where requested by the GE through the EOR and approved by the Authority, shall be performed in accordance with ASTM D6432. GPR is performed from the ground surface and is often limited in its depth of survey depending on subsurface conditions. It is often used to detect near surface utilities or obstructions.

6.4.2.5. **Sample Identification and Documentation**

Soil samples shall be identified in accordance with the Modified Burmister Soil Identification System which is described in Appendix B. Rock Core samples shall be identified in accordance with the Rock Identification System provided in Appendix B. Soil samples for stormwater facilities shall be identified in accordance with the United States Department of Agriculture System provided in Appendix B and the Modified Burmister Soil Identification System. The rock samples shall be assigned a Recovery and Rock Quality Designation (RQD) in accordance with ASTM D6032.

6.4.2.6. **Sample Photographs**

A digital photo of every sample shall be taken and incorporated into the Phase B Geotechnical Engineering Report. The soil photographs shall meet the following criteria:

- Image quality is adequate to discern soil type, grain size and color
- The photo taken perpendicular to the sample from above with sample in full view.
- A folding rule placed along the sampler for scale.
- The sampling jar cap with complete markings set aside sampler and within the photo for identification.
- The drilling fluid should be scraped from the sample to reveal the natural material's color and grain size distribution.

The rock core photographs shall meet the following criteria:

- Image quality is adequate to identify changes in rock type, weathered zones, and joints including joint filling.
- The rock sample and core box inside lid shall be included in the photograph
- Depths shall be clearly labeled on with core box, including wooden spacers.
- It may be desirable to wet the core to enhance the features.
- All rock cores shall be photographed in the field as soon as feasible after recovery.

Sample photos of soil and rock core documentation are shown in **Exhibit 6-1**.

6.4.2.7. **Sample Labeling, and Handling**

Care shall be taken during the labeling, handling, storage, and transportation of soil and rock samples to prevent disturbance. Securing of soil samples shall be in accordance with ASTM D4220, "Standard Practices for Preserving and Transporting Soil Samples." Group "B" provisions of ASTM D4220 shall apply to SPT samples, with the samples placed in moisture-proof jars, and "Group D" provisions for Thin-Walled Tube samples. The soil and rock samples shall be transported to a geotechnical laboratory for further review and select laboratory testing in accordance with Subsection 6.4.10. See **Exhibit 6-7** for examples of soil sample labeling.

A. Sample Jar Lids: Each sample jar lid shall contain the following information:

   1. NJTA Project Contract Number
   2. Boring Number

3. Sample Number; denoted as S-1, S-2, S-3
4. Sample depth
5. SPT Blow Counts for each 6-inches of penetration
6. Sample recovery length
7. Date sample was taken

B. Sample Jar Boxes: Sample jar boxes shall contain the following information on the top and on one of each of the long and short sides of the box:

1. Geotechnical Engineering Firm
2. NJTA Project Name
3. NJTA Project Contract Number
4. Boring and Sample Numbers; denoted BR-1 (S-1 to S-10), BR-2 (S-1 to S-16), etc.
5. Dates samples were taken
6. Initials of the GFR

C. Thin Wall Samples: Each Thin-Walled Tube Sample shall contain the following information, on the tube and on each of the end caps:

1. Geotechnical Engineering Firm
2. NJTA Project Contract Number
3. Boring Number
4. Sample Number should be designated by “U” and numbered according to occurrence in the boring sequence; i.e. S-1, S-2, U-1, S-3, S-4, S-5, U-2
5. Sample depth
6. Sample recovery length
7. Label the top and bottom of the tube
8. Date sample was taken
9. Initials of the GFR

D. Rock Core Boxes-Outside: The outside top and two side (one long and one short) of a Rock Core box shall contain the following information:

1. Geotechnical Engineering Firm

2. NJTA Project Contract Number
3. NJTA Project Name
4. Boring Number
5. Core run and depth; i.e. C-1 45’-50’, C-2 50’-55’, etc.
6. Core run recovery; length and percent of total 60 inches run
7. Core run RQD in length and percent of total 60 inches run
8. Date core was taken
9. Initials of the GFR

E. Rock Core Boxes-Inside: The inside of the Rock Core box lid shall be divided into four compartments by drawing three lines to mimic the compartments of the core box and contain the following information:

1. Boring Number; i.e. BR-1
2. Core run and depth; i.e. C-1 45’-50’
3. Core run recovery in percent of total 60 inches run.
4. Core run RQD in percent of total 60 inches run.
5. Label the top and bottom of the core run starting in the left corner of the upper compartment and work to the right. When compartment is filled, move down to the left corner of the next compartment and work to the right.
6. Draw break line in between cores where wooden block separates core runs in the compartments
7. Indication of natural and mechanical fractures (as shown in **Exhibit 6-8**)

See **Exhibit 6-8** for examples of rock core box labeling.

F. Rock Core Preservation: When desirable to maintain sample moisture, wrap the core in plastic to prevent drying. In the GEP, specify whether core will require wrapping (i.e. shale).

6.4.2.8. **Test Pits**

Test Pits may be advanced in conjunction with soil borings to perform infiltration testing and further delineate stratigraphy. Test Pits may be advanced to delineate limits of construction debris in fill material, locate the bedrock surface, identify soil mottling and perched groundwater, or to determine the thickness of surficial soil strata. Test pits shall be benched or sloped back in accordance with OSHA regulations. Bag and bulk soil samples shall be obtained for further review and select laboratory testing. The test pit log forms to be used are provided in **Exhibit 6-5**.

6.4.3. Groundwater Considerations

Groundwater considerations are often critical for a variety of Project aspects. Specific issues often include the depth to groundwater, fluctuations in ground water depth, and ground permeability as it affects groundwater inflow. The monitoring well log forms to be used are provided in **Exhibit 6-6**..

6.4.3.1. Bore Holes

The groundwater level shall be measured upon completion of each soil boring and after 24 hours, if feasible. Boreholes may be left open for up to 48-hours after the completion of a soil boring if and where directed by the GE. Emphasis shall be placed on observing perched groundwater conditions and soil mottling which is an indication of the seasonal high water level. However, it is also understood that a borehole may not provide a reliable indication of groundwater levels due to drilling fluids.

6.4.3.2. Temporary Observation Wells

At selected locations a temporary observation well, shall be inserted into the borehole to keep it open, and the water level measured each day by the GFR until it stabilizes. The method of installing the temporary observation wells shall be described in the GEP and the Boring Contract.

6.4.3.3. Monitoring Wells

Monitoring wells shall be installed and monitored to better identify the static groundwater level, artesian conditions and seasonal fluctuations. When authorized by the Authority, the GE may make groundwater level readings over an extended period to better define seasonal fluctuations. Rights of access shall be considered.

6.4.3.4. Piezometers

Piezometric levels of confined water bearing zones (aquifers) may be of importance to the design and construction of certain projects. Piezometers should be sealed into the zone of interest.

6.4.3.5. In-Situ Permeability Testing

In-situ Permeability Testing shall be performed to assist in the design of stormwater management basins and trenchless installations. The Authority prefers Double Ring Infiltrometer tests be performed when the zone of infiltration is readily accessible. This testing can also be accomplished utilizing Tube Permeameters in accordance with the BMP Manual, and also to as laboratory confirmation where the relative density of the in-situ material is known and can be established in the lab. Permeability rates shall be determined, when specified, using the following in-situ testing methods:

A. Double-Ring Infiltrometer Test: shall be performed in accordance with ASTM D3385. One test shall be performed at every soil boring location within a test pit excavated adjacent to the soil boring. The level at which the test is conducted shall be in accordance with Section 2 of Appendix E of the BMP Manual.

B. Tube Permeameters: shall be taken and tested in accordance with Appendix E of the BMP Manual.

C. Basin Flooding Test: shall be performed in accordance with Appendix E of the BMP Manual, when permeability testing is required in Bedrock is deemed necessary by the GE and approved by the Authority.

D. Well Pump Test: shall be performed in accordance with ASTM D4050. Well Pump Tests may be performed in areas where cuts or excavations extend below the static groundwater level and construction dewatering plans will be required.

E. Borehole Percolation Test: shall be performed in accordance with Appendix E of the BMP Manual, when permeability testing is required in proposed cut depth to bottom of basin is deep enough that test pits cannot be installed.

6.4.4. **Acid Producing Soils**

Areas containing acid producing soils shall be identified and delineated as part of the subsurface exploration program, so that mitigation measures can be incorporated into the Contract Documents. Refer to Section 7 of the “NJDEP Flood Hazard Area Technical Manual, NJAC 7:13” and the Standards for Soil Erosion and Sediment Control In New Jersey for general locations of acid-producing soil deposits, minimum boring frequencies and depths, chemical testing procedures, and mitigation and disposal standards. This reference shall be supplemented by the following:

A. In proposed cut sections, select test jar samples obtained from soil borings from existing ground elevation to three feet below bottom of proposed grade shall be tested for acid producing soils.

B. The GE shall interpolate the limits of acid producing soils, from each boring within this zone and provide the delineated anticipated volume of “Excavation, Acid Producing Soils” in the Contract Documents. The EOR shall prepare a supplemental specification for Section 202, which requires, "Acid Producing Soils as delineated by the Contract Documents, or otherwise approved by the EOR, shall be removed and replaced with non-acid producing soils or shall be treated to neutralize the acidity with lime for the top three feet. The above treatment shall take place for soils with pH values of 4.0 or less within the construction limits only."

C. A complete list of all pH tests, listed by Station and Offset, shall be included in the Phase B Geotechnical Engineering Report.

D. Tests for acid producing soils shall be performed in accordance with Subsection 7.4 of the NJDEP Flood Hazard Area Technical Manual.

E. The current Standards for Soil Erosion and Sediment Control in New Jersey require that "soils having a pH of 4 or less or containing iron sulfide shall be covered with a minimum of 12 inches of soil having a pH of 5 or more before seedbed preparation."

6.4.5. Pavement Subgrade Testing

The Authority has developed standard pavement sections and details, which are used for Turnpike and Parkway mainlines and ramps.

Applications where pavement design may be required include Authority Projects and pavement for other agencies including but not limited to the NJDOT, South Jersey Transportation Authority (SJTA), county, and municipality roadways. The following in-situ tests may be used to aid the pavement design, if deemed necessary by the EOR and approved by the Authority.

A. Pavement Cores shall be taken every 500 feet

B. California Bearing Ratio (CBR) shall be performed in accordance with ASTM D4429.

C. Dynamic Cone Penetrometer (DCP) shall be performed in accordance with ASTM D6951.

D. Falling Weight Deflectometer (FWD) shall be performed in accordance with ASTM D4694.

Pavement subgrade testing for other agencies roadways shall be performed in accordance with their standards.

6.4.6. Borehole and Well Abandonment and Site Restoration

All monitoring well casings shall be cut off a minimum of 2 feet below the ground surface or removed completely. Monitoring wells shall be abandoned in accordance with NJAC 7:9D-3.1. Boreholes shall be abandoned in accordance with NJAC 7:9D-3.4. Borings greater than 25 feet should be grouted using a tremie grout method.

The top surface shall receive the same treatment type and thickness as the existing condition. Boreholes in pavements shall be grouted using a tremie grout method and the upper portion backfilled with concrete to the same thickness as the existing pavement.

Test pits shall be backfilled in maximum 12-inch thick lifts and compacted at a minimum by repeatedly striking the soil with the excavator bucket. If directed, the GE may require additional compaction provisions based upon the sensitivity of the area to settlement.

All drilling mud and cuttings shall be hosed off or disposed of beyond developed areas, wherever feasible, and in a legal and environmentally approved manner. Test Pit locations shall be re-graded to match the existing conditions and grassed areas shall be seeded.

6.4.7. As-Drilled Boring Location Plans

For projects that require multiple plans, the first sheet of the Boring Location Plan set shall be a Key Plan with the entire project alignment at a maximum scale of 1:2400. The Key Plan shall be boxed out along the mainline alignment depicting the match line limits of each sheet of the Boring Location Plan at a scale of 1:600. Additionally, the Key Plan shall provide a Boring Schedule containing:

A. Boring numbers shall follow the following convention:

   Facility Feature - Consecutive Number. Boring type, groundwater monitoring installations and in situ testing designations shall be included within parenthesis after the boring number. All borings are assumed to include SPT and as such need not be denoted with “SPT”. See Subsection 6.4.7G for examples.

B. Facility Feature Designation:

   - BD – Buildings
   - BR – Bridges
   - CV – Culverts
   - DB – Detention, Infiltration, Stormwater Management Facilities
   - NB – Sound Barriers
   - RD – Roadways
   - RR – Railroads
   - RW – Retaining Walls
   - SS – Sign Structures

- TT – Trenchless Technologies

C. Boring Type Designation:

- SPT – Standard Penetration Test Boring
- CPT – Cone Penetration Test Boring
- SCPT – Seismic Cone Penetration Test Boring
- TP – Test Pit
- PC – Pavement Core

D. Groundwater Monitoring Designation:

- MW – Monitoring Wells
- OW – Observation Wells

E. In situ Test Designation:

- ATV – Acoustic Televiewer
- CST – Crosshole Seismic Test
- DMT – Flat Plate Dilatometer Test
- DST – Downhole Seismic Test
- OTV – Optical Televiewer
- PMT – Pressuremeter Test
- PSL – PS Logging
- PST – Parallel Seismic Test
- PT – Permeability Test
- VST – Vane Shear

F. Sample Designation

- D – Denison Sample
- G – Grabbed Sample/Bulk Sample
- P – Piston Sample
- S – Split Spoon Sample
- U – Shelby Tube Sample

G. Examples for Borings, Groundwater Monitoring, and In situ Tests are as follows:

- Boring Numbers – BR-08, CV-11 (CPT), RW-02 (SCPT), RD-04 (SCPTu), PC-14, TP-05
- Groundwater Monitoring – BR-12(OW), RD-06(MW)
- Field Tests – BR-25 (CST), DB-12 (PT), TP-21 (PT)

H. The legend shall also contain the following information for each Boring in tabular form:

- Boring Designation
- NAVD Ground Surface or Mudline Elevation at each Boring
- NJ State Plane Northing and Easting Coordinates for each Boring
- Station and Offset and baseline for each Boring
- Estimated Boring Depth
- Estimated Rock Coring Depth

In addition, notes shall be provided, stating the sampling Intervals, geophysical testing requirements, in-situ permeability testing requirements, and any other pertinent remarks.

Refer to **Exhibit 6-9** to view a sample Boring Location Plan.

6.4.8. Boring Logs

The GFR shall record all information associated with soil borings. Subsurface Exploration logs (boring logs) shall comply with the examples presented in Appendix C, and in the approved GEP. Boring logs shall be prepared using gINT or another commercially available software package as approved by the Authority.

6.4.9. Subsurface Profile

Using the subsurface information obtained during the Subsurface Exploration, the GE shall construct multiple subsurface profiles or cross sections as required.

The subsurface profiles shall contain:

- Existing and proposed grade lines
- Generalized descriptions of soil strata with boundaries
- Substructure locations
- Stationing or offsets
- Water elevation (e.g., mean high, mean low etc)
- SPT N Value data corrected for hammer energy

- Undrained shear strength if laboratory testing is available
- CPT, VST, DMT, or PMT locations
- Groundwater levels
- Rock type
- Rock core recovery and RQD
- Rock Strength if laboratory testing is available

The minimum vertical and horizontal scales shall be 1”=10’ and 1”=100’, respectively. The subsurface profile shall be included in the Phase B Geotechnical Engineering Report. Refer to **Exhibit 6-10** to view a sample Subsurface Profile. The subsurface profiles or cross sections shall be constructed at the following locations:

A. Longitudinally along the mainline roadways, ramps, and bridges

B. Transversely across each abutment, pier, and substructure

C. Longitudinally along a retaining wall, sound barrier wall, culvert centerline, railroad alignments, or trenchless alignment if the conditions vary considerably from those along the mainline.

D. Longitudinally and transversely along foundation grids for buildings

6.4.10. Laboratory Testing Program

A laboratory testing program shall be tailored to meet the specific design needs of the Project. As discussed previously, the GE shall present in the GEP the justification for the testing program and how the results will be used to provide the necessary information to the design team.

An abbreviated list and description of conventionally specified laboratory tests, including analysis and their application is presented below. A list of laboratory methods is also presented in Appendix D.

A. Moisture content (ASTM D2216) and specific gravity (ASTM D854) may be performed on disturbed or undisturbed soil samples.

B. Mechanical grain size analysis (ASTM D422 and D6913) and Atterberg limits (ASTM D4318) may be performed on disturbed or undisturbed soil samples, as appropriate. Testing laboratories shall use appropriate sieve sizes to perform Burmister classification. Hydrometer testing may be utilized when infiltration or permeability is of interest to better characterize the silt and clay contents. Test for amount of fines content (materials finer than No. 200 sieve) in accordance with ASTM D1140 may be utilized when only interested in fines content.

C. Resistivity (AASHTO T288), pH (AASHTO T299), chloride content (AASHTO T291), sulfate content (AASHTO T290), and organic content (AASHTO T267) shall be performed on disturbed or undisturbed soil samples to assess the aggressivity of the soil as related to corrosion. Specifically, the above battery of tests should be performed at different depths and in consideration location of the groundwater with respect to the testing and the facilities shall be considered in developing the testing program. For more accurate test results, these tests shall be expedited upon sampling to minimize the elapsed time between samples collected and samples tested.

D. One-dimensional consolidation testing (ASTM D2435) shall be performed on select undisturbed soil samples to provide compression properties of the soil which will be used to calculate primary, secondary settlement, and time-rate of settlement. Laboratories shall allow sufficient time for each load increment to obtain the secondary consolidation index.

E. Unconsolidated-undrained (UU) (ASTM D2850), consolidated-undrained (CU) (ASTM D4767 with and without pore pressure measurements), and consolidated-drained (CD) (ASTM D7181) triaxial compression tests shall be performed on select undisturbed soil samples to determine strength parameters of organic and inorganic silts and clays. The test sample total and effective stress conditions will affect the shear strength and must be selected depending on several conditions of the soil including mode of deposition, stress history, overburden stress, pre-consolidation stress, and whether the soil strength in the short term or long-term condition is a desired test output. The GE shall ensure the testing laboratory include images of the soil sample before and after the testing.

F. Consolidated-drained (ASTM D3080) and consolidated-undrained (ASTM D6528) direct shear tests and drained torsional shear tests (ASTM D6467, D7608) shall be performed on disturbed or undisturbed soil samples.

G. Unit weight determination shall be performed in accordance with ASTM D2937.

H. Several compressive strength tests (ASTM D7012) shall be performed on rock core samples. Point Load Index Tests may be performed on irregular or broken rock specimens, but shall not be used solely to estimate rock unconfined compressive strength. When Point Load Index Tests are conducted, a site specific correlation between Unconfined Compressive Strength Test results and Point Load Index Test results shall be developed. Splitting Tensile (Brazilian) Tests may be performed normal to the transverse axis of a trimmed rock core specimen to model horizontal discontinuities or foliations in the upper portion of the bedrock surface, if deemed necessary by the GE and approved by the Authority. The

Authority's preferred test is the Uniaxial Compressive Test with Elastic Modulus and stress strain curve. The test is performed normal to the longitudinal axis on a trimmed rock core specimen to model intact rock strength. The testing laboratory shall include images of the rock sample before and after the testing in the test report.

I. Slake Durability Test (ASTM D4644) may be performed on rock core samples of shales and similar weaker rocks to determine the Slake Durability Index (SDI). Los Angeles Abrasion Test (ASTM C131) and CERCHAR Test (ASTM D7625) may also be performed on similar rock types. The SDI and Abrasion Loss may be correlated to predict scour, erosion, degradation and deterioration of rock for design and during construction of shallow and deep foundations or earth retaining structures to account for residual strengths or excessive settlements from relaxation.

J. Chemical tests (Sulfate and pH) for acid producing soils shall be performed in accordance with Section 7 of the NJDEP Flood Hazard Area Technical Manual.

K. Permeability tests shall be performed in accordance with ASTM D2434 and D5084.

6.5. COMPUTER PROGRAMS

Most Projects will require the GE to use commercially available computer software as part of the analysis and design. Computer programs are explicitly noted as tools to be used by the GE. Use of these tools does not relieve the GE of responsibility for correctness and accuracy of geotechnical designs. Sole responsibility for correct use of software and verification/validation of all computer output rests with the GE.

The Phase B Geotechnical Engineering Report should identify the software name, developer and version used. For each software tool, provide a narrative which explains the input values and how they were determined, scope of the analysis and design, an interpretation and recommended use of the results. Tabular and graphical results should be provided. As appropriate, limitations of the software related to the limit state and performance requirement being studied should also be addressed. For example, limitations may include search routines for slope stability analysis, analytical models, convergence tolerance and accuracy and precision of results.

Commercially available spreadsheets or spreadsheets developed in house shall be validated. Formulas or other types of algorithm should be verified for correctness and erroneous calculations due to data remaining from previous calculations must be avoided. The templates should also be suitably checked for accuracy and reliability. These spreadsheets shall be dated and initialed by the developer with a Quality Control check on completion by the GE.

6.6. GEOTECHNICAL ENGINEERING ANALYSIS AND DESIGN…

SUPPLEMENT TO AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

6.6.1. Structural Foundations

6.6.1.1. Soil and Rock Properties

Soil and rock properties shall be obtained from the in-situ tests, laboratory tests, and published correlations developed for similar type of materials. Use of published correlations should be used with caution. Consideration to the source documents, basis of studies and sample population and study setting employed to establish such correlations needs to be carefully considered. Judgment shall be applied based on the relative importance and reliability of the methods. Published AASHTO-LRFD-BDS Subsection 10.4, FHWA Geotechnical Engineering Circular (GEC) No. 5, FHWA Soils and Foundation Reference Manual, FAVFAC Design Manuals 7.01 & 7.02, Unified Facilities Criteria (UFC) DM 7.1, and EPRI Manual on Estimating Soil Properties for Foundation Design shall be utilized. Parameters provided in technical manuals of computer programs may be used.

6.6.1.2. Limit States and Resistance Factors

Design and analysis shall be performed for all appropriate Strength, Service, and Extreme Limit States using the load and resistance factors provided in the AASHTO-LRFD-BDS. The Phase B Geotechnical Engineering Report should document the assumptions, loads, limit state conditions, and the date and source of this information, and performance requirements for all geotechnical features.

6.6.1.3. Selection of Structural Foundation Type

The GE shall investigate practical (constructible) and technically feasible foundation types to establish an economical design that safely conforms to prescribed structural criteria and properly accounts for the intended function of the structure. Essential to this work is a rational method of design, whereby various foundation types are systematically evaluated and the optimum alternative selected. The following foundation design approach is recommended.

A. Determine the direction, type and magnitude of foundation loads to be supported, tolerable temporary and permanent deformations and special constraints such as:

   1. Vertical under-clearance, terrain, access, and MPT requirements that limit foundation installation, and access of construction equipment.

2. Structure type and span length that limit allowable deformations and angular distortions.
3. Time constraints on construction.
4. Extreme event loading and construction load requirements.
5. The presence of cobbles/boulders, rock, or obstructions that may render particular foundation types infeasible.
6. Scour, settlement, or liquefaction which may preclude the use of a shallow foundation
7. Construction of proposed foundations in close proximity to existing foundations, such that construction may impact the performance of the existing structures which must remain in service.
8. Presence of contaminated soils which may skew the cost towards one particular foundation system.
9. The need for excavation support and dewatering.

B. Evaluate the subsurface exploration and laboratory testing data with regard to reliability and completeness. The chosen design methods shall be commensurate with the quality and quantity of available geotechnical data.

C. Consider alternative foundation types as applicable and conduct a cost and a schedule evaluation. Whether a shallow or deep foundation is feasible the cost evaluation shall be determined as a foundation support to cost assessment. The foundation system support cost should be expressed in terms of dollars per ton load that will be supported. For an equitable comparison (or total cost using the same loading assumptions for each alternative), the total foundation cost should include all costs and schedule impacts associated with a given foundation system such as the need for excavation and retention systems, environmental restrictions on construction activities, e.g. vibrations, noise, disposal of contaminated spoils, pile caps and cap size.

D. The Authority prefers all bridge foundations and directly adjacent bridge approach structures (such as wing wall and retaining walls) to be supported on deep foundations such as piles or drilled shafts. However, where subsurface conditions are appropriate to support spread footing foundations the GE shall ensure the structure can accommodate bearing and settlement criteria as per AASHTO and the constraints provided by the structural engineer. The use of spread footings with deep foundations on the same structure shall not be permitted without the written consent of the Authority.

E. The use of ground improvement methods shall also be considered as discussed in Subsection 6.7.5.

6.6.1.4. **Spread Footings**

A. Placement of spread footing foundations shall be based on the following conditions:

1. Spread footings shall be placed on competent soil and rock materials.
2. Bottom of footing shall be placed below a frost depth of 4 feet.
3. Bottom of footing shall be placed a minimum of 1 foot below the depth of total scour for the 500-year storm event.
4. Footings on slopes shall be minimum 4 feet from edge of slope.
5. Consideration of seasonal high groundwater shall be taken into account as it relates to design and constructability.
6. Consideration of seismic hazards specified in Subsection 6.8.

B. Nominal bearing resistance shall be obtained in accordance with AASHTO-LRFD-BDS Section 10 and verified to be adequate to resist factored bearing pressure under Strength and Extreme Event Limit States.

C. Overburden within the depth of total scour (for the 100 and 500-year storm events) shall be ignored in nominal bearing resistance determination.

D. Sliding and eccentricity limit states shall be checked in accordance with AASHTO-LRFD-BDS for strength limit state and extreme event.

E. Footings bearing on shallow rock shall be keyed or tied into rock to avoid exceeding the sliding or eccentricity limit states. The Authority prefers to not have an individual footing partially bearing on both soil and rock. The GE may choose to over-excavate the rock and place the foundation on compacted stone or over-excavate the soil to the rock surface and backfill with Class C concrete to the bottom of footing.

F. Settlement, lateral deformation and overall global stability shall be computed for service limit state. The global stability of footings in flood plains shall be checked for sudden drawdown conditions. Tolerable total and differential settlement shall be established in consultation with the structural engineer. Potential instability caused by extreme events shall be investigated.

G. Effective footing dimensions and factored and nominal resistances shall be based on meeting all Project specific performance requirements and limit states.

H. The following information shall be included in the Phase B Geotechnical Engineering Report and in Contract Documents:

- Nominal bearing resistance for strength limit state
- Factored bearing resistance for strength limit state
- Nominal bearing resistance for extreme event
- Coefficient of sliding friction (tan δ)
- Footing dimensions (base, length, thickness)
- Bottom of footing elevation
- Groundwater considerations, if necessary, to protect the subgrade from loosening by groundwater infiltration upon dewatering.

I. Vibration and displacement monitoring shall be performed in accordance with Subsection 6.10.2.6.

6.6.1.5. Driven Piles

A. In addition to the methods and recommendations outlined in the AASHTO-LRFD-BDS, the procedures in the FHWA GEC No. 12, Design and Construction of Driven Pile Foundations Reference Manual Volumes I & II (FHWA-NHI-16-009 & FHWA-NHI-16-010) shall be followed. Driven piles utilized for the support of fenders shall be designed with the requirements specified in this Subsection and Subsection 6.7.8.

B. Steel H-piles, cast-in-place (aka reinforced concrete filled steel pipe piles), open ended steel pipe piles, steel tapered piles, timber piles, and prestressed concrete piles shall be considered as driven piles.

C. Axial and lateral nominal resistance within the depth of total scour for the 100 and 500-year storm events shall be ignored as specified in the AASHTO and FHWA references.

D. Axial and lateral resistance shall be reduced in soils susceptible to liquefaction. See Subsection 6.8.4.

E. External loads from lateral squeeze due to underlying soft compressible soils, and lateral spread and lateral flow conditions due to soil liquefaction specified in Subsection 6.8.4 shall be considered in the design.

F. Strength limit state loads shall be utilized in determining nominal axial compression resistance and behavior of the pile under combined loads and moments. Service limit state loads shall be utilized to estimate the pile vertical and lateral deformations and overall stability. Extreme Event loads shall be utilized to verify the deformation, and structural resistance of piles. When analyzing pile groups, group efficiencies for axial load and lateral load reduction factors (aka P Multipliers) shall be obtained in accordance with AASHTO-LRFD-BDS. Lateral and group analysis should be performed for piles with pile lengths corresponding to an assumed estimated and minimum pile tip elevation. Vertical and lateral deformation analyses should also address tolerable post construction deformations of the driven pile group at the top of the pier or abutment seat.

G. Steel pile sections shall be reduced for corrosion as specified in FHWA-GEC No. 12. Additional section loss shall be considered where aggressive conditions exist. Refer to AASHTO and the FHWA driven pile reference for guidance on deterioration mechanisms and mitigation measures for piles. If the soils are of an aggressive nature, a site specific corrosion assessment shall be considered and if deemed necessary shall be performed by an underground Corrosion Specialist. Specific corrosion rates and protection methods shall be included in the Phase B Geotechnical Engineering Report submittal.

H. The design of driven piles shall consider the following requirements:

1. Nominal Axial Compression Resistance: Nominal Axial Compression Resistance is defined as the nominal resistance obtained from suitable soil or rock bearing materials (ignoring resistance from scourable soils, liquefiable soils, and unsuitable materials) using the design methods provided in AASHTO-LRFD-BDS. This resistance shall be multiplied by resistance factors provided in AASHTO-LRFD-BDS to determine the factored axial compression resistance.

2. Nominal Driving Axial Compression Resistance: Nominal Driving Axial Compression Resistance shall be obtained by including the nominal side resistance from scourable soils, soils susceptible to

downdrag, and other unsuitable materials not utilized as part of the nominal axial compression resistance determination. In addition to nominal side resistance from soils susceptible to downdrag, the factored downdrag load shall be added to determine nominal driving axial compression resistance. This resistance should account for changes in soil resistance which will occur during the driving process.

3. Maximum Driving Resistance: If hard/very dense materials or obstructions are expected in the intermediate layers and a higher resistance than the nominal driving axial compression resistance is anticipated to drive through such materials then it shall be reported as Maximum Driving Resistance. In this circumstance, an independent pile drivability analysis shall be performed to model this situation and assess any special guidance which should be included in the Contract Documents.

4. Minimum Pile Tip Elevation: Minimum Pile Tip Elevation is defined as the elevation corresponding to the minimum required depth of penetration. Not all projects will require a minimum pile tip elevation (i.e. structures with axial loads only). Pile length for driven pile foundations supporting bridge substructures should be determined to satisfy the second point of inflection on the deflection diagram. Minimum Pile Tip Elevation shall also be set deep enough to satisfy the nominal uplift resistance, and penetrate scourable and unsuitable materials, which may be present above the bearing stratum. A schematic for point of inflection is provided in **Exhibit 6-11**.

5. Estimated Pile Tip Elevation: Elevation corresponding to the depth where nominal axial compression resistance was estimated by static analysis methods shall be reported as Estimated Pile Tip Elevation.

I. The following downdrag reduction methods shall be considered where it's economical and feasible:

1. Isolating the piles from soils susceptible to downdrag by driving piles through preinstalled isolation casings.

2. Commercially available spray-on friction reducing coating (durability and survivability must be considered).

3. Wrapping the piles with Tyvek or similar barrier though embankment zones.

4. Driving piles after the settlement sufficient to develop downdrag has occurred (monitoring should be considered).

J. Test piles shall be installed to verify the estimated pile lengths, establish final production pile lengths and to establish a pile driving criteria for production pile driving. Production piles can be utilized as test piles or test piles may be located outside the footing area or, nearby, where the subsurface conditions are similar. The overburden materials above the bottom of the footing elevation shall be removed prior to driving test and production piles or the resistance associated with these materials carefully assessed and discounted from the resistance available. The use of a cleaned out shell or casing through the overburden is not a desired procedure and shall only be used under exceptional circumstances, and then only with prior approval of the Authority. The decision to require static load test piles shall be based upon the recommendation of the GE and the approval of the Authority. The GE should consider issues such as redundancy, pile type, load demand, cost benefits and site constraints in making this recommendation. The requirement to test two piles dynamically per substructure unit is the Authority's minimum standard (see 6.6.1.5L).

K. Based on review of the test pile results, estimated production pile lengths and recommended pile driving criteria shall be established by the GE and through the EOR submitted to the Authority. The pile driving criteria should specify the desired hammer blow count and corresponding stroke similar to that observed for the test piles. In addition, the GE should provide guidance for pile acceptance during original driving or restrike if the required nominal driving axial compression resistance is not achieved during initial driving. Finally, a refusal blow-count shall be provided in the event the piles are unable to advance below minimum tip elevation recommended.

L. Pile Dynamic Analyzer (PDA) tests with Case Pile Wave Analysis Program (CAPWAP) shall be performed on driven piles used for bridge substructures. A minimum of two piles or 5 percent of the piles, whichever is greatest, per substructure shall be subjected to PDA testing. If pile resistance is anticipated to increase due to pile setup, then the PDA test also shall be performed during restrike. The GE shall provide the appropriate waiting period for restrike and tip elevation or PDA resistance to halt the initial drive in the Contract Documents. If the Contractor elects to not perform restrikes when recommended where pile set is anticipated and drive the piles deeper to achieve the necessary capacity, the additional depth will be at no additional cost to the Authority. The restrike waiting periods shall be determined based on project specific conditions and recommended in the Phase B Geotechnical Engineering Report and reported on the Contract Plans. The CAPWAP shall be performed at the end of initial drive and at the beginning of restrike. Pile restrikes should be performed with an adequately sized hammer and appropriate stroke as to mobilize sufficient end bearing when side shear values may increase to the point where end bearing appears to diminish due to insufficient energy making it to the tip. Restrike testing shall also be performed on piles driven in dense to very dense granular materials or weathered shale to confirm there is no reduction in pile resistance due to relaxation.

M. Static axial Load tests shall be performed if required by the GE and through the approved by the Authority in accordance with ASTM D1143, “Standard Test Methods for Deep Foundations Under Static Axial Compressive Load”. Other methods such as “Standard Test Methods for Axial Compressive Force Pulse (rapid) Testing” (ASTM D7383) shall be specified and used only with approval by the Authority. When performing such tests on production piles, care shall be taken not to overstress the pile. Specific Project guidance should be included in the Contract Documents.

N. Lateral and uplift testing shall be performed if required by the GE, and approved by the Authority. Lateral load testing shall be performed in accordance with ASTM D3966 “Standard Test Method for Deep Foundations under Lateral Load”. The Authority prefers that if lateral load tests are required by the GE, they be performed in a pre-bid phase. Given the cost of installing a test pile and performing a lateral load test pre-bid, this is generally not considered cost efficient to the Authority. Uplift testing shall be performed in accordance with ASTM D3689 “Standard Test Method for Deep Foundation under Static Axial Tensile Load”

O. The following information shall be determined and included in the Phase B Geotechnical Engineering Report and in Contract Documents:

- Minimum Pile Tip Elevation
- Estimated Pile Tip Elevation
- Nominal Axial Compression Resistance

- Factored Axial Compression Resistance
- Nominal Driving Axial Compression Resistance
- Nominal and Factored Uplift Resistance
- Maximum Driving Resistance
- Bottom of Footing Elevation
- Pile type, size, and material
- Load testing requirement (PDA, Static Load Test)
- Cap dimensions (Length, Width, Thickness)
- Reinforcing cage details and compressive strength of concrete (if applicable)
- Overhead clearance, access, or MPT restrictions
- Environmental constraints
- Sequence of construction
- Pile Layout Plan

P. Vibration and displacement monitoring shall be performed in accordance with Subsection 6.10.2.6.

6.6.1.6. **Drilled Shafts**

A. In addition to the methods outlined in the AASHTO-LRFD-BDS Specifications, the procedures in the FHWA GEC No. 10, Drilled Shafts: Construction Procedures and Design Methods (FHWA-NHI-18-024) shall be followed. Drilled shafts utilized for the support of fenders shall be designed with the requirements specified in this Subsection and Subsection 6.7.8.

B. The minimum diameter of a drilled shaft shall be 30 inches. The minimum center to center spacing of any two drilled shafts shall be 3.0 diameters. However, if the center to center spacing is less than 4.0 diameters, the group reduction factors presented in Table 10.8.3.6.3-1 (Group Reduction Factors for Bearing Resistance of Shafts in Sand) of AASHTO-LRFD-BDS shall be applied, and the sequence of construction should be specified in the contract document.

C. Foundation redundancy shall be defined as when a single foundation unit contains 3 or more drilled shafts. Where a single foundation contains less than 3 drilled shafts, a 20 percent reduction shall be applied to the resistance factors presented in Table 10.5.5.2.4-1 “Resistance Factors for Geotechnical Resistance of Drilled Shafts” of AASHTO-LRFD-BDS.

D. Axial and lateral nominal resistance within the depth of total scour, for the 100 and 500-year storm events, shall be ignored as specified in the AASHTO and FHWA references.

E. Lateral resistance shall be reduced in soils susceptible to liquefaction when socketed into rock. Both axial and lateral resistance shall be reduced in soils susceptible to liquefaction when founded in soils. See Subsection 6.8.4.

F. External loads and overburden pressure which result in lateral squeeze due to underlying soft compressible soils, and lateral spread and lateral flow conditions due to soil liquefaction specified in Subsection 6.8.4, shall be considered in the design.

G. Strength limit state loads shall be utilized in sizing drilled shafts to have sufficient nominal axial compression resistance and behavior of shafts under combined loads and moments. Service limit state loads shall be utilized to estimate the shaft deformations and compared with tolerable limits. Extreme Event and Service shall be utilized to verify the deformation, and structural resistance. When analyzing shaft groups, group efficiencies for axial loads and lateral load reduction factors shall be obtained in accordance with AASHTO-LRFD-BDS. Lateral and group analysis should be performed for shafts with lengths corresponding to the estimated or minimum shaft tip elevation.

H. Permanent Steel Casing sections shall be reduced for corrosion as specified in FHWA GEC No. 10. Additional section loss shall be considered where aggressive conditions exist. Refer to AASHTO and the FHWA driven pile reference for guidance on deterioration mechanisms and mitigation measures for piles If the soils are of an aggressive nature, a site specific corrosion assessment shall be considered and if deemed necessary shall be performed by an underground Corrosion Specialist. Specific corrosion rates and protection methods shall be included in the Phase B Geotechnical Engineering Report submittal.

I. Factored downdrag load shall be included in design.

J. Rock socket length of drilled shafts shall be at least 1.5 times the shaft diameter.

K. Shaft length for drilled shaft foundations supporting bridge substructures should be determined to satisfy the second point of inflection on the deflection diagram, nominal axial compression resistance, and nominal uplift resistance. A schematic for point of inflection is provided in **Exhibit 6-11**. Lateral analysis should also address tolerable post construction lateral deformations of the drilled shaft group at the top of pier or bridge abutment seat.

L. Casings shall be defined as one of the following types:

Temporary – This casing is not specified in the contract drawings. It is used and selected as required by the Contractor to facilitate shaft construction upon approval of the GE and is removed during shaft construction.

Interim – The use of this casing is specified in the Contract Document; however, is not incorporated into the structural design of the shaft. It is used to facilitate construction and remains in place. The casing utilized is selected by the contractor to withstand installation forces.

Permanent – This casing is specified by the GE in the contract drawings and may be incorporated into the structural resistance of the shaft. Where an outer permanent casing is necessary to satisfy the bending or deflection requirements, proper structural design shall be performed for composite behavior of shafts if so desired. Shear rings and shear studs shall be considered inside and outside the casing. Consideration of corrosion loss or protection should be considered given the installed setting. Positive mechanical shear attachment shall be included to consider true composite action. However, the stiffness of the casing should still be considered additive to that of the shaft if no positive mechanical attachment is to be used. Composite or non-composite casings shall not be considered effective for end moment restraint at rock sockets or top of shaft to substructure element connection points.

M. One verification boring shall be performed by the Contractor prior to shaft construction at each drilled shaft location with a rock socket for drilled shaft diameter 6 feet or larger. The number of construction phase borings for smaller diameter shafts shall be estimated based on the site variability. All verification borings shall extend to twice the shaft diameter below the design tip elevation, unless otherwise approved by the Authority.

N. Shaft Inspection Device (SID) inspection of the drilled shaft excavation bottom shall be performed for all shaft designs which include any contribution of end bearing to the nominal axial compressive resistance. The GE shall evaluate use of the SID based on the shaft design, and make specific recommendation for its use in the Contract Documents.

O. Crosshole Sonic Logging (CSL) tests shall be performed in all drilled shafts to confirm their integrity in accordance with ASTM D6760. Additional investigation such as tomography, concrete cores, etc. shall be performed when CSL results indicate discontinuities are present which may affect the structural or geotechnical nominal resistance of the drilled shaft.

P. Thermal Integrity Profile (TIP) testing in accordance with ASTM D7949 shall be required by the Authority for all shafts with diameters of 6 feet or greater.

Q. The decision to require load testing and/or demonstration shafts shall be based upon the recommendation of the GE at the approval of the Authority. The GE should consider issues such as redundancy, shaft diameter, load demand, and site constraints in making this recommendation. At a minimum, load tests shall be performed on demonstration or production shafts (as recommended) to verify the geotechnical resistance or establish the final shaft tip elevation during construction for bridge substructures. Bidirectional-Load Cells, ASTM D8169 or AASHTO TP 100 “Standard Method of Test for Deep Foundation Elements under Bidirectional Static Axial Compressive Load”, and or ASTM D1143, "Standard Test Methods for Deep Foundations Under Static Axial Compressive Load" are acceptable test methods. Other methods such as Statnamic load tests or the "Standard Test Methods for Axial Compressive Force Pulse (rapid) Testing" (ASTM D7383) shall be specified and used only with approval by the Authority. When performing such tests on production shafts, care shall be taken not to fail the shafts and specific project guidance should be included in the Contract Documents.

R. Lateral and uplift testing shall be performed if required by the GE, and through the EOR approved by the Authority. Lateral load testing shall be performed in accordance with ASTM D3966 "Standard Test Method for Deep Foundations under Lateral Load". Uplift testing shall be performed in accordance with ASTM D3689 "Standard Test

Method for Deep Foundation under Static Axial Tensile Load". The Authority prefers that if lateral load tests are required by the GE, they be performed in a pre-bid phase. Given the cost of installing a test shaft and performing a lateral load test pre-bid, this is generally not considered cost efficient to the Authority.

S. The following information shall be obtained from the design and included in the Phase B Geotechnical Engineering Report and in Contract Documents:

- Nominal Axial Compression Resistance
- Factored Axial Compression Resistance
- Nominal Uplift Resistance
- Factored Uplift Resistance
- Top of Drilled Shaft Elevation
- Estimated Top of Rock Socket Elevation (where appropriate)
- Estimated Tip of Drilled Shaft Elevation
- Shaft diameter
- Rock socket diameter (where appropriate)
- Reinforcing size, type, grade and layout
- Spiral bar No. and Pitch or Hoop Bar Nos. and Spacing
- Concrete compressive strength
- Casing outside diameter (thickness, and grade if permanent)
- Casing type (interim or permanent)
- Demonstration and load testing requirement (Bi-Directional Load Test or Static Load Test)
- Boring requirements
- Thermal Integrity Testing and Shaft Inspection Device Requirements
- Bottom of cap elevation (if applicable)
- Cap dimensions (if applicable)
- Length of Casing Seated into Rock
- Overhead clearance, access, or MPT restrictions
- Environmental constraints

- Rock laboratory test results and boring logs
- Sequence of construction (i.e. communication, downdrag)
- Drilled Shaft Layout Plan

T. Vibration and displacement monitoring shall be performed in accordance with Subsection 6.10.2.6.

6.6.1.7. **Micropiles**

In addition to the methods outlined in the AASHTO-LRFD-BDS, the procedures in the Federal Highway Micropile Design and Construction Reference Manual FHWA-NHI-05-039 shall be followed.

A. The minimum center to center spacing between micropiles shall be not less than 30 inches or 3.0 diameters center to center whichever is greater. Axial and lateral nominal resistance within the depth of total scour, for the 100 and 500 Year storm events, shall be ignored as specified in the AASHTO and FHWA references.

B. Axial and lateral resistance shall be reduced in soils susceptible to liquefaction. See Subsection 6.8.4.

C. External loads and overburden pressure which result in lateral squeeze due to underlying soft compressible soils, and lateral spread and lateral flow conditions due to soil liquefaction or other phenomenon shall be considered in the design.

D. Factored downdrag load shall be included in design.

E. Micropiles shall be specified and paid for on a per micropile basis to allow the Contractor to optimize installation methods as they are directly related to resistance.

F. Strength limit state loads shall be utilized in determining nominal axial compression and uplift resistances and behavior of piles under combined loads and moments. Service limit state loads shall be utilized to estimate the pile deformations and overall stability and compared with tolerable limits. Extreme event loads shall be utilized to verify the deformation, and demand to capacity ratio to be within the tolerable limits. When analyzing micropile groups, the group efficiencies for axial loads and lateral load reduction factors shall be obtained in accordance with the AASHTO-LRFD-BDS. Lateral and group analysis should be performed for micropiles with lengths corresponding to minimum tip elevation or estimated tip where there is no lateral or uplift demand on the foundation.

G. Steel casing sections shall be reduced for corrosion as specified in FHWA-NHI-05-042. Additional section loss shall be considered where aggressive conditions exist. Refer to AASHTO and the FHWA driven pile reference for guidance on deterioration mechanisms and mitigation measures for piles. If the soils are of an aggressive nature, a site specific corrosion assessment shall be considered and if deemed necessary shall be performed by an underground Corrosion Specialist. Specific corrosion rates and protection methods shall be included in the Phase B Geotechnical Engineering Report submittal.

H. Micropile casing thickness shall be reduced by 50% to account for casing joint thread reduction in accordance with Subsection 5.18.3 of FHWA Micropile Reference Manual, FHWA-NHI-05-039.

I. Combined axial compression and bending stresses shall be evaluated in accordance with Subsection 6.12 AASHTO-LRFD-BDS.

J. End bearing resistance shall be ignored in soils and soft rock. In hard rock micropiles may be designed for end bearing, although this is usually negligible.

K. Downhole Close Circuit Television (CCTV) inspection shall be performed for all rock socketed micropiles. The depth of the camera shall be shown continuously on the screen as the camera is moving along the socket during the inspection. Video copy of all downhole televised inspections shall be submitted to GE for review.

L. Load tests shall be defined as verification and proof tests.

M. Verification tests shall be performed on sacrificial micropiles to confirm design assumptions and establish nominal unit grout-to-ground bond resistances. The GE shall specify the verification test(s) to maximize the micropile resistance by potentially shortening the bond zone and possibly increasing the bar size to accommodate a large enough load to fail the micropile grout-to-ground bond resistance.

N. One verification test micropile shall be performed for each geologic unit and each different micropile size and type. Verification test piles shall be loaded to failure, or two times the nominal resistance. These piles are thus sacrificed and shall not be included as part of the structure.

O. Load tests shall be performed in accordance with ASTM D1143, "Standard Test Methods for Deep Foundations Under Static Axial

Compressive Load". A tension test is an acceptable test method to establish bond resistance in lieu of a compression test for piles not deriving capacity on hard rock which may include end bearing. Generally, uplift (tension) testing is preferred by the Contractor as it generally is less expensive. Uplift testing shall be performed in accordance with ASTM D3689 "Standard Test Method for Deep Foundations under Static Axial Tensile Load".

P. Lateral testing shall be performed if required by the GE, and approved by the Authority. Lateral load testing shall be performed in accordance with ASTM D3966 "Standard Test Method for Deep Foundations under Lateral Load".

Q. Proof load tests on production piles shall be performed in accordance with ASTM D3689 “Standard Test Method for Deep Foundations under Static Axial Tensile Load”. Production piles shall be tested at a frequency of one pile per substructure or five (5) percent of the total piles, whichever is greater. Production piles are not tested to failure. Production piles shall be tested to 0.7 times the nominal resistance shown on the plans for the substructure where the proof load test is being performed.

R. The following information shall be obtained from the design and included in the Phase B Geotechnical Engineering Report and in Contract Documents:

- Nominal Axial Compression Resistance
- Factored Axial Compression Resistance
- Nominal Uplift Resistance
- Factored Uplift Resistance
- Top of micropile elevation (Micropile Cutoff Elevation)
- Minimum tip of casing elevation
- Estimated Bond Zone Length
- Minimum Bond Zone Length (may be required)
- Micropile casing outside diameter, grade and wall thickness
- Micropile type (typically A in Rock, B in Soil)
- Number and location of Verification Load Tests
- Modified structural properties for Verification Load Test (i.e. bigger bar, if required)

- Location of proof load test (only if larger bar is required for structural tensile resistance, otherwise, select suspect micropiles during construction based on installation observations)
- Reinforcing size, type, grade and layout
- Grout compressive strength
- Cap dimensions (length, width, depth)
- Micropile Layout Plan

S. Vibration and displacement monitoring shall be performed in accordance with Subsection 6.10.2.6.

6.6.2. Walls and Abutments

In addition to Section 11 of AASHTO-LRFD-BDS, Subsection 3.3 of this Design Manual and FHWA Earth Retaining Structures Reference Manual (FHWA-NHI-07-071) the guidance below shall be followed.

6.6.2.1. Wall Type Selection

Wall type selection should be based on a systematic evaluation process. The objective of wall selection is to determine the most appropriate wall type that is cost effective, practical to construct, stable, and aesthetically and environmentally consistent with its surroundings. Consideration of existing and proposed utilities shall be considered as they relate to constructability of the proposed wall systems. The GE shall consider both the drained and undrained conditions where appropriate in areas where cohesive soils are retained. All wall systems shall be designed to support all earth, hydrostatic, and surcharge loads as required in Subsection 3.11 of AASHTO-LRFD-BDS. Additionally, all wall systems including walls not subjected to surcharge loading during service shall be designed to support a minimum live load surcharge of 250 psf or greater as deemed appropriate by the GE for the anticipated construction equipment traffic above the wall. Where it is anticipated that construction staging will require large cranes or other specialized equipment, the contract documents shall include a maximum surcharge load for an assumed construction approach as well as require the Contractor to perform independent assessment such as surcharge, strip, line, or point loads and be taken into account in the crane mat design. When the foundation recommendations indicate the use of wall types other than Cast in Place type walls based on cost, a cost comparison of the alternates assessed shall be provided so the Authority may determine the final wall type.

6.6.2.2. **Soil and Rock Properties**

Soil and rock properties shall be obtained from the in-situ tests, laboratory tests, and published correlations developed for similar type of materials. Judgment shall be applied based on the relative importance and reliability of the methods. AASHTO-LRFD-BDS Subsection 10.4, FHWA GEC No. 5, and FHWA Soils and Foundation Reference Manual shall be utilized. Backfill placed behind walls should be specified, and compactive effort near the wall should be limited to avoid excess earth pressures.

Reinforced soils, retained soils, foundation soils, and fills shall be tested for pH, resistivity, chloride content, and sulfate content in accordance with Section 6.4.10 to assess if the soils are of an aggressive nature.

6.6.2.3. **Drainage**

In addition to AASHTO-LRFD-BDS Subsection 11.6.6, FHWA-NHI-07-071, “Earth Retaining Structures”, shall be followed. The drainage system shall be designed to completely drain the entire retained and reinforced soil volumes. The details of the drainage system should be prepared by the Project Drainage Engineer. Long term plugging of the drainage system can cause drainage system failure and create much higher hydrostatic loads on the wall than considered in the design. Weep holes or geocomposite panel drains at the wall face do not assure fully drained conditions and in some cases blanket slope drains, foundation base drains and drilled horizontal drains may be used to achieve a complete drained condition behind and immediately beneath the wall.

For cantilever walls, gravity, semi-gravity, and MSE walls (see definitions in Section 3 of the Design Manual); the drainage system shall include a perforated collector drain pipe. The drainage system shall run along the heel of cantilever, semi-gravity or gravity retaining walls; at the bottom of the rear face of the reinforced soil mass in MSE walls; or at the bottom of the back of the wall facing elements and solid outlet pipes. Section 3 of the Design Manual provides standard drainage details for cast in place and MSE walls. The outlet pipes shall convey the water through weep holes in the wall face or to a storm water basin or drainage system. The size of the pipes shall be determined on a Project specific basis based on analyzing flow nets and estimating seepage volumes. Seepage volumes shall be determined utilizing USACOE – Seepage Analysis and Control for Dams EM1110-2-1901. Appropriately designed geocomposite drains may be substituted for aggregate drain details for all wall types.

The collector drain pipe shall be either perforated corrugated HDPE drainage pipe that conforms to AASHTO M 294 and is Type S (smooth interior with annular corrugations) with gasket water-tight joints or perforated PVC drainage pipe that conforms to ASTM D2729. The outlet pipes shall be solid plastic drainage pipe conforming to NJTA Standard Specifications. All drainage details shall include clean out pipes to maintain the drainage system.

A layer of washed gravel, in accordance with NJTA Standard Specifications, surrounding the perforated collector pipe and wrapped in a geotextile with an apparent opening size equivalent to the #30 sieve and in accordance with NJTA Standard Specifications or geotextile filters shall be designed in accordance with AASHTO M 288 and FHWA Geosynthetic Design and Construction Guidelines (FHWA-HI-95-038).

For temporary sheet pile walls drainage weep holes should be created in the sheets prior to driving below the elevation of static groundwater in order to provide equilibrium in groundwater on both sides of the sheet face. In addition, weep holes should be installed on the exposed face using commercially available prefabricated drains at the toe of wall.

The potential should be assessed for ponding of overland flow at the top of the wall, which could create greater hydrostatic forces behind the wall. As stated previously, drainage behind all walls is a critical issue.

6.6.2.4. **Lateral Earth Pressures**

Active, at-rest, and passive lateral earth pressure coefficients shall be calculated in accordance with Subsection 3.11 of AASHTO-LRFD-BDS and Section 10 of FHWA Soils and Foundations-Volume II. Earth pressures due to external loads (uniform surcharge, point load, line load, and strip load) shall be calculated in accordance with Subsection 3.11.6 of AASHTO-LRFD-BDS. Live Load Surcharge shall be obtained from Subsection 3.11.6.4 of AASHTO-LRFD-BDS. Load factors shall be obtained from Section 3 of AASHTO-LRFD-BDS. Seismic earth pressures shall be calculated in accordance with Section 11 of AASHTO LRFD and Subsection 6.8 of this manual. All permanent retaining walls shall be designed for drained and undrained conditions.

6.6.2.5. **Limit States and Resistance Factors**

Design for all walls and abutments shall be performed for Strength, Service, and Extreme Limit States using the resistance factors provided in AASHTO-LRFD-BDS Subsection 11.5.

6.6.2.6. **Abutments and Conventional Retaining Walls**

Rigid gravity and semi-gravity retaining walls may be used for bridge and other substructures or grade separation applications and are generally permanent. Rigid gravity and semi-gravity walls shall not be used without deep foundations support where bearing soil/rock is prone to excessive total or differential deformations. Abutments supported on spread footings on MSE walls are not permitted for use on NJTA facilities.

6.6.2.7. **Non-Gravity Cantilevered Walls**

Non-gravity cantilevered walls may be considered for either temporary or permanent support. These walls are all used in cut (top down construction) and require much less ROW behind the wall when compared to a conventional retaining wall. The feasibility of using a non-gravity wall at a particular location shall be based on the suitability of the soil and rock conditions within the depth of the vertical element embedment to support the wall. Non-gravity cantilevered walls including discrete and continuous vertical elements shall be considered. Ground anchors should be considered based upon tolerable deformations, ROW limits, and cost.

Tolerable lateral and vertical deformations at the top of wall shall be determined by the EOR. The GE shall consider protection of structures behind the wall and potential damage to the wall. The justification for tolerable deformation shall be presented in the Phase B Geotechnical Engineering Report.

The selection of cantilever wall systems such as sheet pile or soldier pile and lagging systems should include consideration of excessive vibration and deformations resulting from the installation process into some formations as well as the potential that obstructions could prevent or alter the installation of soldier piles. The retained soil should be studied carefully as it is the required support at the base of the wall to support the cantilever structure.

The resistance from upper 2 feet in front of the wall shall be discounted to accommodate the likelihood of future excavation in front of the wall. Global stability analysis shall be performed for permanent walls.

Care should be taken as many computer software applications used to design these types of walls were not developed for LRFD methods. The following steps shall be followed for design:

- Perform force and moment equilibrium analysis with load and resistance factors provided in AASHTO-LRFD-BDS to determine the minimum embedment length.
- Design minimum sheet pile section or soldier pile section with or without drilled shaft.

- Perform lateral analysis using computer software with the minimum section properties and embedment length obtained from force and moment equilibrium analysis.
- Increase section properties and embedment length (if needed) to limit lateral deflection.

Drainage requirements shall be in accordance with Subsection 6.6.2.3.

Corrosion rates published in Subsection 8.8 of FHWA-NHI-05-042 shall be used as a guideline for predicting corrosion rates in marine and non-marine applications; however, if the soils are of an aggressive nature, a site specific corrosion assessment shall be performed by an underground Corrosion Specialist. Corrosion will occur on all exposed surfaces and therefore may advance from both sides of steel sheet piles, and piles. The corrosion rate may differ between sides based on the level of exposure and this phenomenon shall be accounted for when designing corrosion protection measures.

The steel sheet pile and pile sections shall be designed to account for corrosion while maintaining the factored structural and geotechnical resistances under Strength, Service, and Extreme Event Limit States throughout the structure's design life. Providing sacrificial steel thickness to the steel sheet pile section shall be the primary mode of protection from corrosion. Secondary measures to protect from corrosion shall be galvanizing or coal-tar epoxy coating. Coal-tar epoxy coatings shall be in accordance with the NJTA Standard Specifications and the NJTA Supplementary Specifications.

A. Steel Sheet Pile Walls

1. In addition to FHWA-NHI-07-071, NAVFAC DM7.02 – Foundations & Earth Structures, and the US Steel Sheet Piling Design Manual shall be followed.
2. Ground anchors shall be installed to limit lateral wall deflection and bending moments if increasing the sheet piles section modulus is not feasible. If and where required, ground anchors shall be designed in accordance with Subsection 6.6.2.8.
3. Temporary sheeting design is the responsibility of the Contractor; however, all relevant geotechnical soil properties, groundwater level, and minimum loading and surcharge criteria shall be provided on the Contract Plans. Permanent steel sheeting design is the responsibility of the EOR, including complete detailing of the wall. The EOR shall take care to execute designs that either do not

conflict or appropriately modify the provisions of the NJTA Standard Specifications.

4. Vibration and displacement monitoring shall be performed in accordance with Subsection 6.10.2.6.

5. The following minimum information shall be provided in the Contract Documents for permanent sheet pile walls:

   - Assumed Sheet Pile Section and Type
   - Minimum Plastic Section Modulus and Moment of Inertia
   - Minimum Sheet Pile Tip Elevation
   - Coating

6. The following minimum information shall be provided in the Contract Documents for temporary sheet pile walls:

   - Soil properties (friction angle, unit weight, undrained shear strength, drained shear strength)
   - Groundwater level
   - Limits of sheeting
   - Surcharge loads

B. Soldier Pile and Lagging Walls

Soldier pile and lagging wall systems (also known as post and panel or post and plank walls) are commonly used for temporary excavation support in dense or stiff soil and are preferred over sheet pile. They are also frequently used for permanent earth retaining structures. Soldier pile and lagging walls consist of soldier piles usually spaced at 5 to 10 feet on center and lagging which spans the distance between the soldier piles. The soldier piles may be driven or placed in drilled shafts. The lagging is used to retain the soil face from sloughing and to transmit the lateral earth pressure to the soldier piles. Non-Gravity Cantilevered Walls shall be designed in accordance with AASHTO-LRFD-BDS Subsection 11.8.

The following information shall be provided in Contract Documents:

- Soldier Pile: type, size, length, grade and top of pile elevation.
- Drilled shaft diameter, top of shaft elevation, tip of shaft elevation, estimated top of rock elevation, rock socket length, and center to center shaft spacing.
- Lagging type, size and material requirements

C. Tangent/Secant Pile Walls

Tangent/Secant Piles are continuous vertical elements that can be a viable alternative to steel sheet piles when a stiffer wall system with higher resistance to bending moments is required. Additionally, Tangent/Secant Pile Walls may also be installed in close proximity to vibration sensitive structures, in soils containing cobbles and boulders where driving steel sheeting or piles may not be feasible, or also in environmentally critical locations due to their low permeability.

1. In addition to AASHTO-LRFD-BDS Subsection 11.8, FHWA GEC No. 2 FHWA-SA-96-038 shall be followed.
2. The diameter of the individual piles within the wall shall be no greater than 42 inches. The length of the individual piles shall be limited to 100 feet. Should these restrictions prevent the use of a cantilevered wall, ground anchors shall be installed and the wall shall be considered an anchored wall.
3. The installation of the individual piles shall be phased such that the primary piles are installed first at every other pile location along the wall alignment and the secondary piles are installed between the primary piles. The duration between the primary and secondary pile installation shall be staged such that the concrete/grout in the primary piles can be partially drilled and the primary and secondary piles can be overlapped.
4. Tangent/Secant Piles Walls comprised of continuous flight augers (CFA) piles shall not be permitted in soil profiles with very soft silt and clay layers or loose granular soils with a shallow groundwater table. Drilled Displacement (DD) piles shall be installed in these conditions to preclude the occurrence of necking, bulges, structural defects, and soil mining in the pile.
5. Earth pressures shall be calculated in accordance with AASHTO-LRFD-BDS Subsection 3.11. Drainage requirements shall be as addressed in Subsection 6.6.2.3. The individual piles shall then be modeled as a simple concrete beam in bending to size pile diameters and determine the amount of reinforcing steel required. Steel reinforcement in the form of a rebar cage or a steel beam shall be placed within the secondary piles.
6. The following information shall be provided in the Contract Documents:

- Pile diameter
- Pile reinforcement and required concrete strength
- Top and bottom pile elevation
- Pile spacing
- Field QA/QC Requirements

6.6.2.8. **Anchored Walls**

Anchor walls (also referred to as tieback walls), whose elements may be proprietary, employ grouted anchor elements, vertical elements and facing. Any of the above Non-Gravity Cantilever Walls could be augmented with ground anchors to increase stability or decrease ground movements. The feasibility of using an anchored wall at a particular location should be based on the suitability of subsurface soil and rock conditions within the bonded anchored stressing zone. The availability of permanent ROW for the ground anchors must also be considered.

AASHTO-LRFD-BDS Subsection 11.9 and FHWA GEC No. 4-Ground Anchors and Anchor Systems (FHWA-IF-03-017) shall be followed. Corrosion protection for anchored wall systems shall be in accordance with AASHTO-LRFD-BDS Subsection 11.9.7 and GEC No. 4, Chapter 7 Corrosion Consideration in Design" Class I or Class II corrosion protection is required for permanent applications. Anchored Wall drainage systems shall be in accordance with Section 6.6.2.3.

The following ground anchor information shall be provided on the contract documents in addition to the wall information previously discussed:

- Type (i.e. A tremie, B pressure), location, and spacing of ground anchors
- Strand/Bar size, minimum bond length, minimum unbonded length, and proposed inclination, Bar or Strand material
- Anchor loads, test loads, lock off loads and test requirements
- Corrosion protection as required
- Wall facing/ground anchor details
- Grout compressive strength
- Drill hole diameter
- Hollow bars not allowed for permanent applications
- Depth to rock (if applicable)

6.6.2.9. **Mechanically Stabilized Earth Walls (MSE)**

Mechanically Stabilized Earth (MSE) walls may be considered where conventional gravity, cantilever or counterfort retaining walls and prefabricated modular walls are considered, and particularly when substantial total and differential settlements are anticipated. MSE systems are defined as:

- Walls whose elements may be proprietary, and
- Employ either metallic or geosynthetic tensile reinforcing elements in the soil mass, and
- Include a facing system which is vertical or near vertical.

The design shall address issues relating to backfill quality, reinforcement conflicts with drainage and electrical facilities, vehicular impact resistance, and traffic barrier moment slab construction. The GE shall conduct a cost analysis to verify cost effectiveness of MSE over other wall types. The design shall also allow only permissible MSE systems shown as permissible in the NJTA Specifications. MSE Wall Systems shall not be used in zones of potential scour without permission of the Authority.

Due to past experience with construction of MSE systems in NJTA projects, the Authority prefers alternate wall types under the following circumstances:

- Walls along single lane roadways and ramps where staging is a concern
- Wall supporting large skewed bridges
- Utility and drainage structure crossings where post construction repairs are problematic.

AASHTO-LRFD-BDS and FHWA GEC No. No. 11-Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Volumes I and II (FHWA-NHI-10-024 and 025) shall be supplemented with the following:

A. Wall systems specified in NJTA Specifications shall be used. Other type of MSE wall types shall be pre-approved by the Authority.

B. NJTA Standard and Supplementary Specifications.

C. The GE is responsible for the external stability of MSE walls including bearing resistance, eccentricity, sliding and global stability.

Slope stability analysis shall be performed to investigate global stability and compound stability.

- Global stability analysis shall be conducted such that the failure surfaces are forced outside of the reinforced zone by modeling the reinforced portion of the wall as a rigid body.
- Compound stability analyses shall be performed for MSE walls to investigate potential compound failure surfaces by allowing failure planes to pass behind or under and through a portion of the reinforced soil zone. When compound stability becomes as a concern, the GE shall provide minimum reinforcement requirements in the Contract Plans (Ex: minimum 3 layers of reinforcement in bottom 5 feet). See Subsection 11.10.4.3 of AASHTO-LRFD-BDS and Subsection 4.4.10 of FHWA GEC No. 11 for more details.

D. Design guidelines for geometrically complex MSE wall systems such as tiered walls, back-to-back walls, or walls which have trapezoidal sections shall be in accordance with the procedures in FHWA GEC No. 11.

E. Drainage details shall follow the guidance in Subsection 6.6.2.3.

F. The top of the leveling pad shall be situated a minimum 3 feet below the proposed ground surface in front of the wall. Embedment provisions for sloping ground, erosion, scour, or future excavation shall be in accordance with AASHTO-LRFD-BDS Subsection 11.10.2.2.

G. The tolerance for MSE wall to settlements shall be determined by the wall supplier and the GE. If estimated total and/or differential settlements are greater than the tolerance for the wall or AASHTO-LRFD-BDS guidelines, ground improvement techniques maybe required or a two-stage wall considered. However, technical and cost evaluation of ground improvement techniques in lieu of surcharge or other wall types shall be performed.

H. Guidelines for corrosion/degradation of steel or geosynthetic reinforcements shall be in accordance with FHWA GEC No. 11 and shall be supplemented with NJTA Standard and Supplementary Specifications.

The following information shall be included in Contract Documents:

- Nominal Bearing Resistance for Strength Limit State
- Factored Bearing Resistance for Strength Limit State

- Nominal Bearing Resistance for Extreme Event
- Tolerable vertical and lateral deformation criteria
- All drainage requirements, flood elevations.
- Coefficient of sliding friction at the base of the MSE reinforced soil volume.
- Confirmation that external stability of the MSE Wall system has been checked and determined adequate for static and dynamic conditions by the EOR.
- Minimum reinforcement requirements to satisfy compound stability.

The following additional information shall be reported in contract documents which include MSE "wrap-around" abutments supported on deep foundations. These loads are associated with forces on the stub abutment backwall restrained by reinforcing elements attached to the backwall:

- Nominal lateral load from abutment for strength limit state
- Nominal lateral load from abutment for seismic event

Geosynthetically Reinforced walls shall not be used to wrap or support bridge abutments or utilized in retaining walls in excess of 20 feet tall, unless approved by the Authority.

For wrap-around abutments or MSE walls directly adjacent to cast in place abutments, post construction settlement must be less than 1 inch, otherwise ground improvement techniques shall be implemented as described in the Design Manual.

Refer to Section 3 of the Design Manual for additional considerations for MSE type retaining walls.

6.6.2.10. Prefabricated Modular Walls

Prefabricated Modular Wall systems (PMW) may also be considered where conventional gravity, cantilever or counterfort concrete walls are technically feasible. Prefabricated modular wall systems, whose elements may be proprietary, generally employ interlocking soil filled reinforced concrete or steel modules or bins, rock filled baskets, precast concrete units, or dry cast segmental masonry concrete units (without soil reinforcements) which resist lateral earth pressures by acting as gravity retaining walls. AASHTO-LRFD-BDS should be supplemented with the following:

A. Wall systems specified in NJTA Supplemental Specification shall be used. Other type of prefabricated wall types may be pre-approved by the Authority on a case by case basis.

B. Leveling pads and footings shall be placed a minimum of 3 feet below the proposed ground surface.

C. The GE shall check the external stability of the PMW. The GE is responsible for the external stability of PMW walls including bearing resistance, eccentricity, sliding, global stability, and compound stability.

   - Global stability analysis shall be conducted such that the failure surfaces are forced outside of the wall by modeling the wall as a rigid body.
   - Compound stability analyses shall be performed to investigate potential compound failure surfaces by allowing failure planes to pass behind or under and through a portion of the wall. When compound stability becomes as a concern, the GE shall provide minimum wall dimensions in the Contract Plans (Ex: minimum width of 20 feet in bottom 5 feet).

D. The GE shall check the anticipated post construction vertical and lateral deformations and compared to tolerable limits for the wall system and the Project performance requirements. If estimated deformations are greater than the tolerance for the wall or the serviceability requirements, ground improvement techniques maybe required. However, technical and cost evaluation of ground improvement techniques in lieu of surcharge or other wall types shall be performed.

E. In addition to AASHTO-LRFD-BDS Subsection Article 11.11.8, Prefabricated Modular Wall drainage systems shall be in accordance with Subsection 6.6.2.3.

The following information shall be included in Contract Documents:

- Nominal Bearing Resistance for Strength Limit State
- Factored Bearing Resistance for Strength Limit State
- Nominal Bearing Resistance for Extreme Event
- Tolerable vertical and lateral deformation criteria
- All drainage requirements

- Coefficient of sliding friction at the base of the modular wall and the soil volume
- Confirmation that external stability and compound stability of the modular wall system has been checked and determined adequate for static and dynamic conditions by the EOR.

6.6.2.11. Soil Nail Walls

Soil nail walls shall be used in applications where ground anchor walls are considered but where construction access, and subsurface conditions indicate a soil nailed structure may be more cost effective or technically feasible. Soil nail walls may require additional right-of-way. Soil nail walls are constructed to support temporary excavations, reinforce existing soil slopes, and permanent cut walls. Soil nails are typically closely spaced (4 to 6 ft.) and unlike ground anchors are not prestressed. Soil nail walls should be designed and constructed following the recommendations and procedures outlined in Subsection 11.12 of AASHTO-LRFD-BDS and FHWA GEC No. 7 “Soil Nail Walls” (FHWA-NHI-14-007). Only solid bars are allowed by the Authority for permanent soil nail applications. Hollow bars are allowed for temporary applications.

The following information shall be included in Contract Documents:

- Nominal Tensile Resistance for Strength Limit State
- Factored Tensile Resistance for Strength Limit State
- Nominal Tensile Resistance for Extreme Event
- Tolerable vertical and lateral deformation criteria
- All drainage requirements
- Confirmation that external stability of the soil nail wall has been checked and determined adequate for static and dynamic conditions by the GE.
- Soil nail bar size, length and grade
- Grout compressive strength
- Type of soil nail (Type A or Type B)
- Corrosion protection requirements
- Soil nail spacing and inclination (typical section and layout plan)
- Soil nail testing requirements

- NJTA does not have a standard or supplemental specification for soil nails and a supplemental specification need to be prepared by the GE.

6.6.2.12. Temporary Wall Designs

The following guidance applies to all walls types for temporary applications. Temporary walls shall be defined as walls with a design life of three years or less and their design shall be the responsibility of the Contractor. It is common practice to not design temporary walls for seismic limit states; however, seismic design shall be performed if and where directed by the Authority. Contract documents shall explicitly direct the Contractor to refer to this section of the Design Manual where, in addition to all other provisions of this section, the following shall apply:

The Contractor shall submit to the Authority for approval prior to the construction of the wall:

A. The temporary wall design calculations and construction plans signed and sealed by a Professional Engineer licensed in the State of New Jersey with a minimum of 10 years of geotechnical engineering experience.

B. The temporary wall design engineer shall have completed a minimum of 10 projects with temporary and/or permanent wall systems, shoring, and cofferdams.

C. Design for temporary works shall be performed in allowable stress design in accordance with AASHTO Guide Design Specifications for Bridge Temporary Works and AASHTO Construction Handbook for Bridge Temporary Works.

6.6.3. Buried Structures

The design of all buried structures shall follow the AASHTO-LRFD-BDS, Section 12. Buried structures include:

- Metal pipe
- Structural plate pipe
- Long-span structural pipe
- Structural plate box
- Reinforced concrete pipe
- Reinforced concrete cast-in-place and precast arch

- Box and elliptical structures
- Thermoplastic pipe
- Fiberglass pipe
- Buried structures may include, but are not limited to, culverts or tunnels.

6.6.3.1. **Soil and Rock Properties**

Subsurface exploration shall be carried out to determine the presence and influence of geologic conditions that may affect the performance of buried structures. For buried structures supported on footings and for pipe arches and large diameter pipes, a foundation exploration should be conducted to evaluate the capacity of foundation materials to resist the applied loads and to satisfy movement requirements of the structure. Soil and rock properties shall be obtained from the in-situ tests, laboratory tests, and published correlations developed for similar type of materials. Judgment shall be applied based on the relative importance and reliability of the methods. AASHTO-LRFD-BDS Section 10.4, FHWA GEC No. 5, and FHWA Soils and Foundation Reference Manual shall be utilized.

6.6.3.2. **Limit States and Resistance Factors**

Buried structures and their foundations shall be designed by appropriate methods specified in the AASHTO-LRFD-BDS, Subsections 12.7 through 12.15 to resist the load combinations specified in Subsection 12.5. The factored resistance shall be calculated for each applicable limit state.

Buried structures shall be investigated at Service Load Combination I, as specified in AASHTO-LRFD-BDS Subsection 12.5.2.

Buried structures and tunnel liners shall be investigated for construction loads and at Strength Load Combinations I and II, as specified in AASHTO-LRFD-BDS Subsection 12.5.3.

Resistance factors for buried Structures shall be taken from AASHTO-LRFD-BDS Subsection 12.5.5.

6.6.3.3. **Design Considerations**

The following variables shall be considered during the design:

- Strength and compressibility of foundation materials;
- Chemical characteristics of soil and surface waters, e.g. pH, resistivity, sulfate and chloride content of soil and pH, resistivity, and sulfate and chloride content of surface water;

- Stream hydrology, e.g. flow rate and velocity, maximum width, allowable headwater depth, and scour potential; and
- Performance and condition survey of culverts in the vicinity.

The following information shall be included in Contract Documents:

- Nominal Bearing Resistance for Strength Limit State
- Factored Bearing Resistance for Strength Limit State
- Nominal Bearing Resistance for Extreme Event
- Tolerable vertical and lateral deformation criteria

6.6.4. Sound Barriers

Sound Barriers shall be designed in accordance with AASHTO-LRFD-BDS Section 15 and shall be supplemented with the following.

Sound barriers shall be designed to satisfy the following loads and performance requirements:

- Lateral Wind Load
- Earth Load
- Vehicle Collision Load
- Extreme (Seismic) Load
- Lateral deformation under the service limit state factored lateral load and moment at the top of the sound barrier shall be 1.5 inch or less.

Spread Footings shall follow Subsection 6.6.1.4

Driven Pile Foundations shall follow Subsection 6.6.1.5

Drilled Shafts shall follow Subsection 6.6.1.6 (3.) a. through d.

6.7. GEOTECHNICAL ENGINEERING ANALYSIS AND DESIGN…

GENERAL DESIGN TOPICS AND TOPICS NOT EXPLICITLY ADDRESSED IN AASHTO-LRFD-BDS OR FHWA GUIDANCE

6.7.1. Scour

The following should be considered in addition to the guidance provided in the AASHTO-LRFD-BDS Subections 2.6.4.4.2 and 3.7.5:

1. Scour analysis and scour countermeasures shall be in accordance with AASHTO-LRFD-BDS Subsection 2.6.4.4, Hydraulic Engineering Circulars HEC 18 (FHWA-HIF-12-003), HEC 20 (FHWA-HIF-12-004) and HEC 23 (FHWA-NHI-

09-111 & 112). Scour in cohesive soils are specified in FHWA-HRT-15-033 and scour in erodible rocks are specified in NCHRP Report 717. Changes in the bed level of a stream affect highway structures and may be described by three types of actions: (1) general scour (contraction scour), (2) local scour and (3) degradation or aggradation of the stream channel. Scour and degradation are discussed in this section. Scour evaluations of new and existing bridges should be evaluated by an interdisciplinary team of hydraulic, geotechnical and structural engineers. Hydraulic studies shall include estimates of scour at bridge piers and evaluation of abutment stability. Bridge foundations shall be designed to withstand the effects of scour for the worst conditions resulting from flood events specified in HEC 18.

2. In general, foundations shall be designed to be stable without relying on scour countermeasures. The only exception to this is when designing for local scour at abutments. Because the local scour equations tend to overestimate the magnitude of scour at abutments, they are generally used only to gain insight into the scour potential at an abutment. In most cases, a scour countermeasure, properly designed and installed in accordance with the procedures outlined in HEC 23, is provided to resist the local scour at abutments. Both the abutment foundation and the scour countermeasure must be designed to be stable after the effects of the estimated long-term degradation and contraction scour. Ensure that the top of the footing is below the sum of the long-term degradation, contraction scour, and lateral migration; stub abutments are an exception to this requirement, but the slopes in front of them should be adequately protected and/or sheeting should be provided to prevent undermining of the abutment and loss of fill. Riprap shall be designed and used to protect abutments from erosion for maintenance purposes, even if it is not required to resist the effects of local scour.

6.7.2. Sign Structures, Luminaries, Toll Gantries and Towers

The GE shall refer to Subsection 3.5 (Sign Supports) of the Design Manual and the NJTA standard sign structure foundation drawings (SI-22 to SI-22B for Turnpike structures, SI-39 to SI-41 for Parkway structures, VM-08 & 09 for VMS structures) and the details shown in the CM, E, ITS, SI, and VM drawings. The EOR shall reference AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signal, current edition and in accordance with Section 3 of the NJTA Standards.

A. Spread Footings: Procedures shall follow AASHTO-LRFD-BDS Subsection 10.6.

1. Bottom of footing shall be placed below the frost depth
2. Footing thickness shall be a minimum 2 feet

B. Driven Pile Foundations: Procedures shall follow AASHTO-LRFD-BDS Subsection 10.7 and be supplemented as follows:

1. Pile head deflections shall be limited to 0.75 inches unless a deflection criteria provided by the Structural Engineer.
2. Minimum pile tip elevation, estimated pile tip elevation, ultimate axial compression capacity, and allowable axial compression capacity shall be provided in Contract Documents.

C. Drilled Shafts: Procedures shall follow AASHTO-LRFD-BDS Subsection 10.8 and be supplemented as follows:

1. Minimum size of drilled shaft shall be 30 inches
2. Minimum center-to-center spacing shall be 2.5 diameter of drilled shaft
3. Deflection at top of shaft shall be limited to 0.75 inches unless a deflection criteria provided by the Structural Engineer.
4. Short pile behavior shall be avoided. Deflection at tip of the shaft shall be limited to 0.1 inch. See **Exhibit 6-11**.
5. Overhead sign structures supported on two drilled shafts per each side shall be designed to satisfy the following factored loads:
   a) Axial compression load
   b) Uplift load
   c) Lateral wind load
6. Overhead sign structures and toll gantries supported on one drilled shaft per each side or butterfly sign structure shall be designed to satisfy the following factored loads:
   a) Axial compression load
   b) Lateral wind load
7. Cantilever sign structures supported on one drilled shaft shall be designed to satisfy the following factored loads:
   a) Axial compression load
   b) Lateral wind load
   c) Torsional moment
8. The following minimum resistance factors shall be achieved by design:

a) For axial compression load - AASHTO-LRFD-BDS Table 10.5.5.2.3-1

b) For axial uplift load – AASHTO-LRFD-BDS Table 10.5.5.2.3-1

c) 0.65 for torsional moment

6.7.3. Soil and Rock Slopes

This section addresses geotechnical design issues associated with cuts and fill in soil and rock.

6.7.3.1. Soil and Rock Properties

Soil and rock properties shall be obtained from the in-situ tests, laboratory tests, back analysis and published correlations developed for similar type of materials. Judgment shall be applied based on the relative importance and reliability of the methods. AASHTO-LRFD-BDS Subsection 10.4, FHWA GEC No. 5, and FHWA Soils and Foundation Reference Manual shall be utilized.

6.7.3.2. Slope Stability

Stability of embankments and soil and rock cut slopes shall be evaluated using computer program in accordance with Subsection 6.5. Design procedures should follow FHWA-NHI-01-026 "Soil Slope and Embankment Design" and FHWA-TS-89-045 "Rock Slopes: Design, Excavation, Stabilization", and FHWA's Rockfall Catchment Area Design Guide.

The design analyses shall consider both short and long-term stability (drained and undrained) and shall address translational, rotational and irregular shape failure modes of surficial and deep seated failure surfaces. Slope stabilization measures to address stability shall consider long-term performance, constructability and initial and long-term cost. A performance requirement of a minimum safety factor of 1.3 shall be provided for all new slopes and rehabilitated soil and rock slopes.

If potential problems of stability or excessive settlement exist for a proposed embankment then methods to overcome these problems shall be investigated, evaluated and addressed.

Rock slope stability evaluation shall require geologic mapping of dip, dip direction, and condition of discontinuities. Subsequently, stereographic analysis shall be performed to identify failure mechanisms kinematically feasible. If any failure mechanisms (planar sliding, wedge, or toppling) are kinematically feasible, kinematic analysis of those failure mechanisms shall be performed to determine the factor of safety. If the factor of safety is less than tolerable, reinforcement such as, but not limited to untensioned fully grouted dowels, tensioned rock bolts, or anchored mesh systems shall be evaluated, which will result in an acceptable factor of safety.

In addition, when required, rockfall simulation modeling shall be performed for catchment ditch and rockfall barrier design. Catchment design shall be in accordance with the FHWA's Rockfall Catchment Area Design Guide, using 95 percent rockfall retention and with 4H:1V catchment area slope, if possible, or otherwise as approved by the Authority.

All rock fall hazard mitigation or rock slope stabilization projects shall include rock drains. All untensioned fully grouted dowels or tensioned rock bolts shall be galvanized or epoxy coated, with a minimum service life of 75 years. All mesh products shall be PVC coated with a minimum service life of 75 years. All Shotcrete shall be fiber reinforced. Cable lashing will not be accepted by the Authority for stabilizing rock blocks. A specification for rock fall hazard mitigation and rock slope stabilization construction methods is not available in the NJTA Standard Specifications and NJTA Supplemental Specification, and would need to be developed by the GE on a project specific basis.

6.7.3.3. **Vertical and Lateral Deformations**

Vertical and lateral deformations of soil below engineered earthwork features (e.g. embankments) shall be estimated using the methods specified in AASHTO-LRFD-BDS Subsection 10.4, FHWA GEC No. 5, and FHWA Soils and Foundation Reference Manual. Laboratory test results, in-situ test results, and published correlations shall be utilized in determining accurate soil parameters. Federal Highway GEC No. 5 FHWA-IF-02-034 shall be followed.

A. Deformation estimates should include:

   1. Immediate or elastic vertical and lateral deformation

   2. Consolidation vertical and lateral deformations of compressible soils

   3. Secondary consolidation settlement of soft cohesive soils and organic soils.

B. Differential deformations between adjacent transportation features shall be within tolerable limits.

C. If deformations are excessive, ground improvement techniques shall be considered. In evaluating alternative ground improvement treatments, consideration should be given to relative stability, expected post construction settlement and treatment cost.

6.7.3.4. **Rehabilitation of Existing Slopes**

The assessment and selection of the stabilization methods shall be predicated upon minimizing risk, minimizing cost and schedule, working within site constraints, and material availability. The GE shall submit a list of considered stabilization methods to the Authority with associated advantages and disadvantages and preliminary unit cost estimates prior to design in the Phase B submission.

A. Existing soil and rock slopes may deteriorate, and become unstable. These slope conditions may require an exploration to determine the cause of distress and assess stabilization treatments for rehabilitation. A preliminary field inspection will be authorized by the Authority and shall include:

   A visual assessment of:

   1. Soil slope movements at the slope toe, slope crest, slope face, adjacent roadways, railroads, structures, embankments, and utilities including scarps, bulges and aerial subsidence.

   2. Rock slope movements at the slope toe, crest, and face, all lithologies, structural discontinuities, wedges, blocks and areas of instability. Measure and record typical dip, dip direction, and condition of discontinuities. Assess the presence of potential triggering mechanism such as seepage, root heave, ice buildup, etc.

   3. Photo documentation of all observations made. All areas with observed slope movement shall be mapped on an oblique photomosaic.

   4. Planning of a subsurface exploration to further assess the existing condition and potential stabilization treatment.

   5. Determine whether a simple, solution exists or a comprehensive investigation is required.

B. Slope Instability Exploration: If deemed necessary given the observed conditions and mechanisms which exist, the GE shall propose a right sized exploration and monitoring program to be submitted to the Authority for authorization. The slope instability exploration may consist of some of the components noted below:

   1. Soil Slopes: A geotechnical exploration including soil borings with SPT’s, CPT’s, installation of monitoring wells or piezometers, and laboratory and in-situ testing of soil shall be performed to an elevation below the anticipated failure surface.

Additionally, inclinometers shall be installed to monitor ongoing movements of the slope during and after the exploration and stabilization. The exploration objective is to determine residual soil strength values as well as potentially locate the failure surface. Using the information obtained from the geotechnical exploration, the GE shall perform slope stability analysis to determine acceptable slope geometries, soil and groundwater conditions, and loading conditions to determine an appropriate stabilization method. Appropriate stabilization methods include but are not limited to:

a) Reducing the driving force of the slope by partial removal and replacement with lightweight fill material.

b) Improvement of internal and external drainage of the slope.

c) Implementation of a ground improvement program to compact or reinforce the foundation soils.

d) Installation of a toe cut-off wall to intercept the failure surface and eliminate continuing movement.

e) Installation of a ground anchor system or other restraining system through the slope face.

2. Rock Slopes: A geotechnical exploration including geologic mapping for joints, bedding, and other weak planes in the slope, soil borings with rock cores, installation of monitoring wells, and laboratory and in-situ testing or rock shall be performed to an elevation below the anticipated failure surface. An important issue is the alignment of weak planes (dip and dip direction) with respect to the slope. Because laboratory testing of the strength of these weak planes is difficult, an experienced geologic engineer shall be employed. The exploration objective is to determine in-situ rock strength values, determine groundwater conditions as well as to locate the failure surface. Using the information obtained from the geotechnical exploration, the GE shall perform stability analysis to model slope geometries, rock groundwater conditions, and loading conditions and to determine an appropriate stabilization method.

6.7.4. Pavement Design

The GE shall verify subgrade suitability and provide adequate subgrade stabilization methods to improve the subgrade for soils exhibiting inadequate strength as specified in Section 6.4.5.

6.7.4.1. General Guidelines

A. The following general guidelines shall be applicable to Turnpike and Parkway pavements:

B. The Authority shall participate in any decision to diverge from published pavement standards.

When computing quantities for asphaltic concrete items, the following conversion factors are to be used for preliminary estimates and are to be verified for each project prior to completion of the final quantities:

Surface Course	156.0 ± pcf
Intermediate Course	157.5 ± pcf
Base Course	159.0 ± pcf

Conversion factors are to be verified for each project prior to completion of final quantities.

C. Tack coat shall be applied to all existing (milled) pavement surfaces just prior to asphalt resurfacing. Tack coat shall also be applied to all exposed cut surfaces of an existing asphalt pavement section which is stepped to interface with a proposed pavement section. Tack coat will not be required between subsequent asphalt layers of proposed pavement unless:

1. The underlying layer has been contaminated.
2. The underlying layer has been exposed to prolonged traffic use.
3. It is otherwise required on the drawings or in special provisions.

D. In locations where existing pavement is widened, Grade A material is to be deeper, if necessary, to match template grade of existing pavement. Template grade (top of subgrade below Grade A embankment) shall slope transversely a minimum of 2% or match cross slope of roadway. Template grade shall be constructed transversely under the full section, without breaks in cross slope, on each individual roadway and in such a manner as to provide positive drainage (daylight section or underdrains).

E. At interfaces between Turnpike or Parkway pavement and the pavement of outside agencies, the higher-class pavement shall be constructed first, with offset and steps per course as shown. Account for offset and stepping quantity computations.

F. Asphalt pavements shall be constructed in accordance with the Standard Specifications, as amended by the Supplemental Specifications. Surface and Intermediate courses shall each be placed in a single lift. The base course for Turnpike Pavement shall be placed in two lifts. Pavement course lifts shall conform to the following:

1. The minimum lift thickness shall be three times the nominal maximum aggregate size of the specified pavement mix type.

2. The maximum lift thickness shall be five times the nominal maximum aggregate size of the specified pavement mix type.

G. The above lift requirements shall apply to U-Turn, Z-Turn, and Car Parking pavement sections, as well as any variations of Turnpike Pavement used in resurfacing / re-grading projects.

6.7.4.2. **Turnpike Pavements**

The following pavement sections and guidelines for Turnpike mainlines, ramps, U- Turns, Z-Turns, and Parking Lots shall be followed:

A. The mainline pavement section shall be constructed as shown on **Exhibit 6-12**. Current pavement mix types to be used for each of the courses shown in the pavement sections shall be as directed by the Authority.

B. The pavement section for Z-Turns shall be Turnpike Pavement as shown on **Exhibit 6-12**.

C. For parking lots and driveways at toll plaza buildings and other locations within the Turnpike right of way, the pavement section shall be as shown on **Exhibit 6-13**.

D. The pavement section for grade separated U-Turns shall be as shown on **Exhibit 6-14**.

E. The various pavement interface and stepping details shown on **Exhibit 6-15** through **Exhibit 6-19** are for Turnpike pavement. Adjust steps accordingly to match other pavement sections. Account for stepping quantity computations. With curb, courses terminate at curb face as shown, any stepping shall be from back of curb.

F. In the pavement interface details shown on **Exhibit 6-18**, the existing pavement is from the 1985-90 widening construction. Each area shall be reviewed and adjusted to conform with existing construction. Where proposed widening includes resurfacing the adjacent existing pavement, omit the 6-inch removal of the top course and place the new surface course pavement joint at least 2 feet from the existing edge of pavement.

G. Embankment, Grade A, shall be a minimum of 18 inches deep under travel lanes.

H. In areas where existing and currently designed resurfacing depth approaches 12 inches, or more, at the existing pavement / shoulder interface, investigations shall be made as to the feasibility of leaving the existing shoulder in place as a portion of the proposed pavement section.

6.7.4.3. **Parkway Pavements**

The following pavement sections for Parkway mainlines, ramps, U- Turns, Z-Turns, and Parking Lots and guidelines shall be followed:

A. The mainline pavement section shall be constructed as shown on **Exhibit 6-20**. Current pavement mix types to be used for each of the courses shown in the pavement sections shall be as directed by the Authority.

B. The pavement section for U-Turns and Z-Turns shall be Parkway Pavement as shown on **Exhibit 6-20**.

C. For parking lots and driveways at toll plaza buildings and other locations within the Parkway right of way, the pavement section shall be as shown Exhibit 6-21.

D. The pavement section for grade separated U-Turns shall be as shown on **Exhibit 6-20**.

E. The various pavement interface and stepping details shown on Exhibit 6-22 through Exhibit 6-26 are for Parkway pavement. Adjust steps accordingly to match other pavement sections.

F. Account for stepping (see Exhibit 6-22) in quantity calculations. With curb, courses terminate at the curb face. Any stepping shall be from back of curb.

G. When required, Embankment, Grade A, to be a minimum of 8 inches. Inclusion of Embankment Grade A to be determined on a contract-by-contract basis following an existing substrata investigation.

H. In areas where existing and currently designed resurfacing depth approaches 9 inches, or more, at the existing pavement / shoulder interface, investigations shall be made as to the feasibility of leaving the existing shoulder in place as a portion of the proposed pavement section.

6.7.4.4. **Other Pavements**

Where local roads are being replaced, the intent of the Authority with respect to any work under the jurisdiction of the state, county, municipality, or any other agency is "replacement in kind", according to present standards of that agency. All such work is subject to the approval of the Authority and must be previously agreed to in writing by the concerned agency, as noted elsewhere in this manual and the Procedures Manual.

Similarly, all detouring and / or closing of local roads during construction must be approved by the appropriate agencies in accordance with the Procedures Manual.

Applications where pavement design may be required include Authority Projects which include pavement of other agencies roadways, follow those agency standards.

6.7.5. **Ground Improvement Methods**

Significant sections of the existing Authority roadways are underlain by soft, weak, compressible soils which include peats, organic silty clays and varved clays. These areas have required special foundation treatment to maintain a stable embankment and minimize roadway settlements. In some areas the Authority's roadways are in cuts that extend into clayey soils which have required underdrains and/or undercutting to maintain stability and a smooth pavement surface. These potential problems should be investigated and evaluated as part of the preliminary exploration of embankment foundation and cut areas.

Ground improvement techniques shall be considered to strengthen loose granular soils or compressible organic and inorganic silts and clays, to provide adequate foundation or embankment support or to reduce deformations and accelerate the time rate of consolidation. Guidance for analysis and design of ground improvement techniques shall be found in FHWA GEC No. 13-Ground Modification Methods Reference Manual, Volumes I and II (FHWA-NHI-16-027 and 028), ASCE Geotechnical Special Publications No. 104, 112, 119, 120, 124, 136, 168, 172, 187, 188, 207, 228, 238, and SHARP 2 Geotech Tools Website, however many ground improvement methods are performance based and/or proprietary and may require design input by others. Following methods shall be considered:

A. Remove and Replace

Removing the unsuitable materials and backfilling with regular weight or lightweight backfill material shall be considered with the following conditions:

- Removal and disposal of the unsuitable materials
- Regulated waste materials
- Support of excavation
- Groundwater

Lightweight materials such as granular lightweight fill, fly ash, expanded shale, geofoam, controlled low strength material, or foamed concrete shall be utilized to reduce the excess pressure from standard fills. The following issues shall be considered:

- Buoyant weight of lightweight material and stability under flooding conditions
- Drainage
- Availability of the materials
- Durability
- Environmental concerns
- Durability with existing ground conditions

B. Preload and surcharge with or without prefabricated vertical drains

Preloading and surcharging until the completion of settlement is a suitable option for loose sands and soft clays. The following issues shall be considered:

- Effect of preloading on existing structures, roadways embankments, and utilities
- Staged construction
- Time taken for settlement to complete

Prefabricated vertical drains may help accelerate the time rate of settlement in fully saturated low permeability soft clays. The GEP should identify the suitable subsurface exploration methods for proper assessment. Site constrains regarding the following should be examined

- Steep slopes
- Contamination migration
- Installation through obstructions, dense to very dense sand or gravelly materials, and stiff to hard clays
- Overhead or subsurface utility interference
- Collection and disposal of contaminated water
- Sand blankets

C. Stone columns or continuous modulus columns

Stone columns are generally constructed by downhole vibratory methods known as vibro-replacement or vibro-displacement techniques and are best suited for improving clays, silts, and loose sands. In addition, vibro-concrete columns (VCC) and geotextile encased columns (GEC) are some other types of applications which may be considered. A feasibility study of stabilizing soft ground with stone columns shall be conducted addressing the following concerns:

- Lateral support from subsurface materials to prevent large deflections and bulging
- Presence of dense overburden, boulders, cobbles, and obstructions which may require predrilling
- Limitations on using wet methods
- Environmental constrains
- Effect of vibrations on existing structures and utilities
- Interference with utilities
- Overhead clearance
- Load transfer platform

D. Vibro-compaction

Vibro-compaction is a technique suitable for densifying granular cohesionless soils using a vibrator. The following concerns shall be addressed:

- Effect of vibrations on existing structures and utilities
- Vibration induced liquefaction and effects
- Interference with utilities
- Overhead clearance

- Obstructions

E. Dynamic Compaction

Dynamic compaction technique is suitable for densifying loose granular soils by dropping large weights. Consideration shall be given to the following:

- Due to the significant vibration generated by the impact of the weight, this method is not recommended within a minimum of 100 feet of existing structures and utilities
- Locations where high groundwater exists
- Overhead clearance
- Ground vibration

F. Soil Mixing

The following shall be considered for deep mixing of soil with lime or cement grout to improve or stabilize the ground:

- Time taken for stabilization
- Presence of dense overburden, boulders, cobbles, and obstructions which requires predrilling
- Overhead clearance
- Disposal of spoils
- Chemical and mineralogical properties of the soil and reaction with stabilizing agent
- Artesian conditions or high hydraulic gradient

G. Grouting

Compaction grouting, permeation grouting, chemical grouting, soil fracture grouting, jet grouting, bulk void filling, and mud/slab jacking techniques shall be utilized based on subsurface conditions, and subsurface material characteristics. Consideration shall be given to the following:

- Ground settlement or heave and lateral ground movement
- Effect on existing structures and utilities
- Temporary support system or underpinning to prevent structural damages
- Groundwater, artesian conditions or high hydraulic gradient
- Subsurface material characteristics

H. Column Supported Embankments

Geosynthetically reinforced column supported embankments or load transfer platforms generally consist of vertical columns of stone or deep foundation elements and shall be utilized with the following consideration:

- Lateral stability
- Utility relocation
- Environmental constrains
- Effect of vibrations on existing structures and utilities

The selection of technically feasible and cost effective ground improvement methods will vary based on project requirements and schedule, subsurface conditions including subsurface improvement depth and material and the treatment area size. Subsequent to certain performance based ground improvement the GE may order the execution of either soil borings with SPT's, CPT's, PMT's, DMT's, VST's, other field measures, or laboratory tests to verify the improvement in the subsurface materials. The proposed subsurface exploration program, suitable ground improvement methods, assumptions, limitations, and a cost comparison shall be included in the GEP and the Geotechnical Engineering Report. Project specific performance based special provisions shall be developed which address specific acceptance criteria and the basis of ground improvement acceptance.

The following information shall be included in Contract Documents:

- Project specific performance based special provisions
- Ground improvement plans and details
- Instrumentation locations and details
- Monitoring of vibrations, settlements, and cracks on existing structures and utilities

6.7.6. Buildings

Foundations for toll plaza buildings, NJSP facilities, maintenance facilities, and service areas shall be designed in accordance with current International Building Code (IBC) and International Building Code - New Jersey Edition (NJBC) and supplemented by AASHTO Standard Specifications for Highway Bridges.

6.7.6.1. Spread Footings

A. Requirements specified in Subsection 6.6.1.4 shall be followed.

B. The following information shall be included in the Contract Documents:

- Ultimate bearing capacity
- Allowable bearing capacity for static conditions
- Allowable bearing capacity for seismic conditions
- Other parameters specified in Subsection 6.6.1.4 (H).

6.7.6.2. Deep Foundations

A. Requirements specified in Subsection 6.6.1.5 shall be followed for driven piles.

B. Requirements specified in Subsection 6.6.1.6 shall be followed for drilled shafts.

C. Requirements specified in Subsection 6.6.1.7 shall be followed for micropiles.

D. The following information shall be included in the Contract Documents:

- Ultimate Capacity in Compression
- Allowable Capacity in Compression
- Ultimate Driving Capacity for driven piles
- Ultimate Uplift Capacity
- Allowable Uplift Capacity
- Maximum Driving Capacity for driven piles
- Other parameters specified in Subsection 6.6.1.5 (O) for driven piles.
- Other parameters specified in Subsection 6.6.1.6 (R) for drilled shafts.
- Other parameters specified in Subsection 6.6.1.7 (O) for micropiles.

6.7.7. Reuse of Foundations

Important technical issues must be addressed to ensure that foundation reuse is undertaken appropriately. Foundation reuse is not explicitly addressed in current foundation design standards and may not comply with current standards, particularly for materials and construction quality control. The amount of investigation of a reused foundation system may need to be balanced against perceived risks as well as the amount and veracity of information. Guidance on the type of investigations shall be found in AASHTO Manual on Subsurface

Investigations. The design of foundations that are reused or incorporate reused elements may require explicit assessment to address the uncertainty inherent in current understanding of foundation behavior.

A. As a minimum, the following Existing Foundation Information shall be obtained from contract plans, as-built drawings, and reports:

1. Bottom of footing elevation
2. Foundation type
3. Foundation bearing materials
4. Foundation loads
5. As-built tip of deep foundation elevation
6. Design standards used
7. Material strength (concrete, reinforcements, shells, timber, etc.)

B. Investigations for existing foundations shall be prepared including the following:

1. Review existing foundation information
2. Review existing subsurface explorations
3. Planning additional subsurface explorations to determine subsurface conditions, subsurface material properties, and unknown foundation depth. See Subsection 6.4.
4. Planning investigations on existing foundations to determine foundation integrity, deterioration of foundation elements, chemical and physical attacks on foundation elements, and service life remaining on foundation elements.

C. Risk Management

1. A Risk Management Plan shall be prepared describing how the risk will be managed on the project.
2. A Risk Register listing the risks that may affect the project and the actions that are proposed to deal with the risks shall be prepared.
3. Qualitative or semi-quantitative risk assessment by assessing the importance of risks without quantification shall be prepared during early stages of the project.
4. Quantitative risk assessment, quantifying the risks and assessing the possible range of outcomes for the project in terms of cost and time shall be prepared at the beginning of the design. A sample risk assessment worksheet is shown as **Exhibit 6-27**.

D. Foundation design shall be performed to confirm load bearing and deformation criteria are met. Service life of the foundations and retaining walls shall be estimated from AASHTO Guide Specifications for Service Life Design of Highway Bridges.

   1. Structural foundations shall follow Subsection 6.6.1.
   2. Walls and Abutments shall follow Subsection 6.6.2.
   3. Buried Structures shall follow Subsection 6.6.3.
   4. Sound Barriers shall follow Subsection 6.6.4.
   5. Sign Structures, Luminaries and Toll Gantries shall follow Section 6.7.2.
   6. Buildings shall follow Subsection 6.7.6.

E. Cost analyses shall be performed for partially or complete reuse option and new construction option including the following:

   1. Direct costs (investigation cost, material cost, foundation costs)
   2. Risk costs (additional foundation cost, delay of construction due to unknown conditions)
   3. Benefits (early accomplishments, future redevelopment)
   4. Maintenance cost (annual inspection, annual repairs)
   5. A Life Cycle Cost Analysis shall be performed.

F. Reuse options for foundations shall be submitted with Preliminary Design, Phase A, and Phase B submissions.

   1. Desk Study during Preliminary Design and Phase A Submission shall include the following:
      - Existing Foundation Information
      - Existing Subsurface Exploration details
      - Proposed Subsurface Exploration details
      - Proposed Investigation for Foundations
      - Qualitative or semi-quantitative risk assessment
   2. Phase B Geotechnical Engineering Report shall include the following in addition to the Phase A submission:
      - Risk Management
      - Foundation Design
      - Cost Analysis

- Life Cycle Cost Analysis
- Recommendations

6.7.8. Fenders

Bridge structures in navigable waterways shall be protected from vessel collision. Bridge structures shall either be designed to withstand collision force or shall be protected against vessel collision forces by fenders, dikes, dolphins, berms, islands, or other sacrifice-able devices. AASHTO-LRFD-BDS and AASHTO Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges shall be followed.

6.7.8.1. Design of Bridge Substructure Foundations for Collision Force

The foundations shall be designed to withstand the impact loads in an elastic manner. Inelastic design shall not be permitted for foundations to prevent collapse. The design shall be in accordance with AASHTO-LRFD-BDS with the foundation design specified in Subsection 6.5.

6.7.8.2. Design of Protective Systems

The foundations shall be designed to withstand the impact loads in an elastic or inelastic manner and to provide a protective system to reduce the magnitude of the impact loads to less than the strength of the bridge substructure or superstructure components or to independently protect those components. The design shall be in accordance with AASHTO Guide Specification or Vessel Collision with the foundation design specified in Subsection 6.5. The following shall be considered:

A. Effect on scour and collection of debris shall be taken into consideration in the design.

B. Section loss due to material degradation such as corrosion, oxidization & reduction due to wet & dry shall be considered.

C. Foundation stiffness shall be developed for deep foundation elements.

D. The design information specified in Subsection 6.5 shall be included in the Phase B Geotechnical Engineering Report and in Contract Documents.

6.8. Seismic Analysis and Design

6.8.1. Bridge Classifications

Seismic ground shaking hazard information, bridge importance classification, and guidelines to select suitable design events are provided in Subsection 3.2.6.3.

6.8.2. Seismic Effects

6.8.2.1. Seismic Site Class

A site shall be classified, based on the stiffness of the subsurface material, as A though F in accordance with the Site Class definitions in Table 3.10.3.1-1 of AASHTO-LRFD-BDS and AASHTO Guide Specification for LRFD Seismic Bridge Design. Site classification shall be determined using shear wave velocity, SPT blow counts, and/or undrained shear strength for the surficial 100 feet of subsurface. The methods specified based on SPT blow count or based on correlated shear strength values may not be representative for sites with zero or very low SPT blow counts especially in very soft clayey/organic soils and very loose sands. A Project site may be subdivided into different site classes depending on site variation.

Site class for building structures shall be performed in accordance with IBC NJ Edition.

6.8.2.2. Acceleration Coefficients

Peak Ground Acceleration coefficient on rock (PGA), horizontal response spectral acceleration coefficient at 0.2-sec period on rock (S_S), and horizontal response spectral acceleration coefficient at 1.0 sec period on rock (S_1) are provided in Subsection 3.10 of AASHTO-LRFD-BDS for 1,000 Year return period event (7% probability in 75 years). The acceleration coefficients for 2,500 Year return period events can be obtained from USGS website: http://earthquake.usgs.gov/hazards/. The acceleration coefficients for buildings shall be obtained from IBC NJ Edition.

The following information shall be included in Contract Documents:

- Seismic Site Class
- Peak Ground Acceleration Coefficient on rock (PGA)
- Short period horizontal response spectral acceleration coefficient at 0.2-sec period on rock (S_S)
- Long period horizontal response spectral acceleration coefficient at 1.0-sec period on rock (S_1)

6.8.3. Design Response Spectrum

6.8.3.1. Standard Response Spectrum

- Site factors for zero-period, short period, and long period shall be obtained from Subsection 3.10.3 of AASHTO-LRFD-BDS.

- Horizontal response spectrum shall be developed in accordance with Subsection 3.10.4 of AASHTO-LRFD-BDS.

6.8.3.2. Site Specific Response Spectrum

Site specific response spectrum shall be developed for bridges as to satisfy the criteria specified in Subsection 3.2.6.3. The site specific seismic study includes development of dynamic soil properties, selection of target spectrum, and selection of bedrock acceleration time histories.

- The bedrock response spectrum or the target spectrum shall be obtained from USGS website (http://geohazards.usgs.gov/hazardtool/application.php).
- Processed bedrock acceleration time histories can be obtained from the following strong motion data websites:
    - Center for Engineering Strong Motion Data (CESMD) – http://www.strongmotioncenter.org/
    - California Strong Motion Instrumentation Program (CSMIP) – http://www.conservation.ca.gov/cgs/smip
    - Pacific Earthquake Engineering Research (PEER) Ground Motion Database – http://ngawest2.berkeley.edu/
    - Consortium of Organizations for Strong-Motion Observation Systems (COSMOS) – http://www.cosmos-eq.org/
- The ground motion data should represent the project site in terms of:
    - Similar geological conditions
    - Earthquake magnitude
    - Distance between the nearest active fault and the project site should be similar to the distance between the epicenter of the earthquake and instrumentation location
- The acceleration time histories shall be adjusted to match the target spectrum using computer programs (RSPMATCH, RASCAL).
- Shear and compressional wave velocity profiles shall be developed using field test methods such as crosshole seismic testing, downhole seismic testing, suspension logging testing, seismic cone testing, etc.
- Shear modulus reduction curves and damping reduction curves shall be developed from laboratory tests or from available models.

- Soil and rock material properties such as initial shear modulus, unit weight, gradation, plasticity index, and relative density are important parameters in obtaining an accurate and appropriate site-specific response spectrum. Selection of these material properties can be in accordance with FHWA GEC No. 3-LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations Reference Manual (FHWA-NHI-11-032). In order to accommodate the variation in material properties, sensitivity studies should be conducted. A range of material parameters an appropriate range based upon the standard deviation above and below the average value should be assessed.
- A one dimensional or two-dimensional shake analysis shall be performed using a commercial software in accordance with Subsection 6.5 and the response spectrum shall not be lower than 2/3 of the standard spectrum specified in Subsection 6.8.3.1.

6.8.3.3. **Vertical Response Spectrum**

Vertical response spectrum shall be taken as 2/3 of the horizontal design spectrum.

6.8.4. Foundation Design

- Shallow foundations shall not be permitted on liquefiable soils unless ground improvement to prevent liquefaction is proposed.
- Lateral support from liquefiable zone shall be ignored for deep foundations.
- Downdrag due to earthquake induced ground movement shall be considered.
- Horizontal loads due to lateral spread and lateral flow shall be included.
- Soil-foundation-structure interaction should be evaluated.
- Foundations shall be evaluated for seismic loads (Extreme Event).

6.8.4.1. **Soil-Foundation-Structure Interaction**

Chapters 8, 9, and 10 of FHWA GEC No. 3 and MCEER Seismic Retrofitting Manual for Highway Structures (MCEER-08-SP-02) shall be followed. Variation in subsurface material properties, foundation element properties, casings left in place, pre and post corrosion effects and foundation cap properties shall be considered in developing foundation stiffness. The upper and lower bound stiffness values shall be provided.

A. The upper bound stiffness shall be obtained by modeling the foundations with upper bound subsurface material properties, upper bound concrete and steel properties, ignoring section losses, and including interim casings and permanent casings.

B. Lower bound stiffness values shall be obtained by modeling the foundations with lower bound subsurface material properties, lower bound concrete and steel properties, including section losses, only including the casings which is considered as structural elements after the section loss reduction, and incorporating subsurface material strength reduction for granular soils susceptible to liquefaction and cohesive soils susceptible to cyclic softening.

Foundation stiffness values (lateral, vertical, rotational, & torsional, a six by six matrix) for dynamic loading shall be developed using the following methods:

- Shallow foundations using Chapter 9 of FHWA GEC No. 3.
- Deep foundations using Chapter 10 of FHWA GEC No. 3.
- Deep foundations using pushover analysis.
- Stiffness values for liquefied conditions should also be provided.

6.8.5. **Retaining Walls**

- Lateral seismic earth pressure coefficient shall be obtained from Section 11 of AASHTO-LRFD-BDS.
- External stability for seismic events shall be performed.
- Internal stability of proprietary walls shall be performed by the wall manufacturer.
- Global stability and compound stability of the wall shall be performed. Resistance factors provided in BDS Subsection 11.5.8 shall be used.

6.8.6. **Seismic Hazards**

- The site-adjusted peak ground acceleration, As (Fpga × PGA, as specified in AASHTO-LRFD-BDS Article 3.10.3.2), shall be used for evaluating seismic hazards.
- Earthquake Magnitude of 6.0 shall be used unless directed by the Authority.
- Liquefaction potential shall be evaluated using FHWA GEC No. 3 or EERI Monograph 12-Soil Liquefaction During Earthquakes.
- Liquefaction induced ground movements including ground settlement, lateral spread, and lateral flow shall be evaluated.

6.8.7. Overall Stability of Embankment and Slopes

- Factor of safety against overall stability shall not be less than 1.1 for the seismic loading condition.
- 50 percent of site-adjusted peak ground acceleration shall be used.

6.9. CONSTRUCTION SPECIFICATIONS

Construction Standard and Supplemental Specifications to be utilized are available at the NJTA website. The GE shall assess these standard specifications and modify them as necessary.

6.10. CONTROL OF CONSTRUCTION

6.10.1. General

Control of normal methods of construction is covered by the New Jersey Turnpike Authority's Standard Specifications and the Supplementary Specifications.

The methods of construction and construction control shall be clearly stated in the Contract Documents to the Field Engineers and GFRs. The following provides additional guidance for special construction considerations which should be addressed.

A. Embankments

When the GE has determined, from an examination of the subsurface profile and calculations, that the foundation soils are not competent to support the proposed embankment loadings, the GE shall determine the actual embankment quantity to be placed accounting anticipated settlement and the Contractor shall be advised in the Contract Documents of the anticipated settlement and to allow for the settlement and the potential for staged placement in their bid prices.

B. Unsuitable Materials

The GE shall evaluate the extent of soils unsuitable for roadway subgrade based on borings, site inspection, and other information. The GE should also evaluate the potential for unknown unsuitable soil and present recommendations for proof-rolling or other methods to locate and mitigate these soils. The GE shall prepare specifications that detail the removal of unsuitable soils and replacement with suitable material. The GE shall also establish payment quantities for such removal and replacement, and present detailed methods for measurement.

Where any ground improvement methods are proposed for construction the necessary instrumentation should be included in the Contract

Documents. Also, monitoring and instrumentation threshold values should be presented in the Phase B Geotechnical Engineering Report.

C. Soft Clays and Silts

Clays and silts with low shear strength make poor foundation material. However, with proper treatment, their engineering properties can be enhanced, thus improving their performance as a foundation material.

These materials often have low permeability and may require a substantial time period for consolidation to occur. The coefficient of consolidation shall be investigated in both the vertical and horizontal directions, and the soil samples shall be carefully inspected for possible horizontal sand or silt layers.

D. Roadway Cuts

Most problems encountered in roadway cuts involve either, or both, high groundwater conditions and soft subgrades. Two other problems less frequently encountered are unstable cut slopes and sloughing of cut slopes. These latter two problems are usually encountered when clay or silt soils are encountered in highway cuts. The potential for these problems shall be investigated in all proposed cuts.

The evaluation of the potential for these roadways cut problems should be addressed in the Phase B Geotechnical Engineering Report.

6.10.2. **Field Instrumentation**

Field instrumentation shall be installed to monitor existing and proposed construction as well as adjacent structures. The planning of instrumentation for construction control should consider duplication and location of the instruments because of potential damage during construction operations. The GE shall submit a Field Instrumentation Plan (FIP) included in the Phase B Geotechnical Engineering Report and submitted to the Authority. The FIP shall be developed by an instrumentation specialist providing locations, depths, and installation procedures of all field instrumentation to be installed for approval prior to implementing the plan. The FIP shall be included in the Contract Documents. The GE may be retained by the Authority to read the instruments, analyze the data, and identify and mitigate potential issues during construction; this work may also be performed by others. Potential construction control instrumentation devices are provided below. The GE shall address noise and vibration monitoring requirements and follow guidance provided in the supplemental specifications.

6.10.2.1. **Inclinometers**

Inclinometers shall be installed to monitor displacements within existing and proposed slopes, embankments, cuts, and adjacent structures before, during, and after construction, when deemed necessary by the GE and approved by the Authority. Inclinometers and inclinometer casings shall be installed in accordance with ASTM D6230.

6.10.2.2. **Monitoring Wells**

Monitoring wells shall be installed when specified prior to construction to monitor groundwater levels during placement of embankment fills, performance of surcharging programs, excavation of cuts, and performance of construction dewatering. The GE shall use the information to identify potential rising and falling groundwater levels which may induce deformation. Monitoring wells to be installed in accordance with Subsection 6.4.3.3.

6.10.2.3. **Vibrating Wire Piezometers**

Vibrating wire piezometers when specified shall be used in conjunction with or without monitoring wells or to monitor pore water pressures during construction. Applications of monitoring pore water pressures include:

- Determine safe rates of fill or excavation.
- Locate the piezometric surface through slopes or embankments to aid in slope stability analysis.
- Monitor the effects of dewatering systems used for excavations on adjacent structures to identify drops in water level inducing additional effective stress in the soil and possible settlement.
- Monitoring the effects of ground improvement systems such as surcharging and the use of vertical prefabricated drains. Increases and decreases in the pore water pressure during the surcharging program to determine time for consolidation which must be allotted or when soil consolidation has slowed and the program may be terminated.

6.10.2.4. **Settlement Platforms**

Settlement platforms shall be installed when specified to monitor the magnitude and rate of settlement experienced by compressible soil layers during foundation loading, embankment loading, or fill placement. The selection of an external or internal reference point system shall be determined on a project specific basis. In general, when an unyielding stratum below the compressible layer is shallow, the GE shall use an internal reference point system, and when it is deep an external reference point system utilizing adjacent benchmarks to measure elevation changes shall be provided. Isolation casing shall be installed for all systems to prevent extraneous sources such as frost heave or down drag to affect the settlement readings. Settlement platforms shall be installed and monitored in accordance with ASTM D6598. In addition to the requirements specified herein, any manufactures requirements for product accessories or installation shall be followed. The GE may also propose the use of remote settlement surface and subsurface instrumentation, as appropriate. The GE shall consider the total cost of such systems (capital cost plus monitoring cost) and the reliability of remote systems.

6.10.2.5. Deep Settlement Points

Deep settlement points (Borros-Type anchors) shall be installed when specified to monitor displacements during foundation or embankment loading, fill placement, and tunnel construction. Guidance on deep Borros anchors, can be found in FHWA-NHI-10-034.

6.10.2.6. Vibration and Displacement Monitoring

Vibration and displacement monitoring shall be considered on a case by case basis given soil/groundwater conditions, proximity to sensitive structures and construction methods anticipated. Where deemed appropriate by the GE a vibration and Displacement Monitoring program shall be developed and performed in accordance with the NJTA Supplementary Specifications and supplemented by the GE on a project specific basis.

6.11. Post Design Services

Geotechnical Engineer (GE) shall be involved in the following tasks during construction:

6.11.1. Foundations

6.11.1.1. Driven Piles

A. Review site specific work plan, in particular:

1. Wave equation and/or driveability analysis & selection of hammer
2. Load test program
3. Equipment and access
4. Refer to Pile Specification for Additional Requirements

B. Observe installation of test piles

C. Observe load testing

D. Review Load test results

E. Provide recommendation for production pile driving criteria:

1. Penetration at termination (capacity blow count to be achieved over a minimum penetration)

2. Provisionary criteria if penetration rate is not achieved within a certain number of feet below the production tip.

3. An order list indicating the production pile length assumed to remain in the completed structure and modified for unanticipated site conditions. The Contractor may increase the lengths as necessary to accommodate handling per their means and methods, at no additional cost to the Authority.

F. Observe initial period of production pile installation to ensure the construction inspector is aware of the driving criteria and completing the driven pile installation log properly.

G. Reevaluate the foundations for piles out of tolerance and damaged piles.

6.11.1.2. Drilled Shafts

A. Review site specific work plan, in particular:

1. Method of casing installation
2. Slurry management
3. Method of cleaning hole
4. Method of verifying shaft is cleaned out
5. Method of casing removal
6. Method of placing concrete
7. CSL and TIP testing
8. Materials manufacturer’s data sheets
9. Load testing, if applicable
10. Equipment and access
11. Refer to drilled shaft specification for additional requirements

B. Observe installation of test shafts

C. Observe load testing

D. Review Load test results, if applicable

E. Provide recommendation for production drilled shafts, if load testing is performed or unexpected subsurface conditions are encountered.

F. Observe initial period of production shaft installation to ensure the construction inspector is completing the driven pile installation log properly.

G. Review integrity test reports and provided recommendations for additional testing or repair, if any.

H. Observe the taking of concrete core, if coring of drilled shafts is required.

6.11.1.3. Micropiles

A. Review site specific work plan, in particular:

1. Method of casing installation
2. Method of cleaning hole
3. Method of verifying micropile is cleaned out
4. Method of casing removal
5. Method of placing grout
6. Proof and verification load testing
7. Materials manufacturer's data sheets
8. Equipment and access
9. Refer to micropile specification for additional requirements

B. Observe installation of test micropiles

C. Observe load testing

D. Review load test results

E. Review contractor proposed bond lengths following load testing

F. Observe one day of production pile installation to ensure the construction inspector is aware of the driving criteria and completing the driven pile installation log properly.

G. Review inspection reports and videos.

H. Review proposed repairs for damaged or defective micropile or micropile abandoned.

6.11.2. Retaining Walls

6.11.2.1. Proprietary Walls

A. Review shop drawings for internal stability, external stability, and foundation layout

B. Review site preparation plan

C. Review backfill material soil test results

6.11.2.2. Support of Excavation

A. Review shop drawings and calculations

6.11.2.3. Tiebacks

A. Review site specific work plan

B. Review load test program

C. Observe tieback installation and ensure construction inspector is able to complete installation log properly

D. Observe proof and verification load testing

E. Review load test results

F. Review inspection reports

6.11.2.4. Construction Monitoring

6.11.2.5. Vibration Monitoring

A. Review site specific work plan

B. Review Baseline Reports

C. Review monitoring reports

6.11.2.6. Instrumentation (Vibrating wire piezometers, inclinometers, settlement platforms, etc.)

A. Review site specific work plan

B. Review installation records

C. Review monitoring reports

D. Provide recommendations.

6.11.2.7. Abandoning Existing Monitoring Wells

A. Coordinate with installer to abandon the wells

6.11.3. Trenchless Utility Installations, Relocations and Adjustments

6.11.3.1. Trenchless Installations

A. Review site specific work plan

1. Materials
2. Equipment
3. Method of construction

B. Review Protection Measures in Place

1. Protection against soil instability
2. Protection against uncontrolled ground water inflow
3. Prevention of soil subsidence/settlement along the alignment
4. Protection against flooding and means for emergency evacuation
5. Protection of falling objects

C. Instrumentation/monitoring procedures

D. Monitoring for hazardous gases

E. Calculations

1. Excavation Support System
2. Determination of loads
3. Adequacy of proposed pipe section and material
4. Scour potential and countermeasures
5. Geotechnical bearing resistance and settlement of pipe
6. Dewatering
7. Ground improvement
8. Preventing pavement box from drilling fluid
9. Impact of vibration to existing foundations or utilities

F. Utility plans

G. Post Installation Survey, Explorations and Remedy

6.12. References

1. American Association of State Highway and Transportation Officials (AASHTO), "AASHTO Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges," 2nd Edition, 2009 with 2010 Interim Revisions.

2. American Association of State Highway and Transportation Officials (AASHTO), "AASHTO Guide Specifications for LRFD Seismic Bridge Design," 2nd Edition, 2011 with 2012, 2014, 2015, 2022 Interim Revisions.

3. American Association of State Highway and Transportation Officials (AASHTO), "Guide Specification for Service Life Design of Highway Bridges," 1st Edition, 2020.

4. American Association of State Highway and Transportation Officials (AASHTO), "LRFD Bridge Design Specifications," 9th Edition, 2020.

5. American Association of State Highway and Transportation Officials (AASHTO), "LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," 1st Edition, 2015.

6. American Association of State Highway and Transportation Officials (AASHTO), "Manual on Subsurface Investigations," 2nd Edition, 2022.

7. American Association of State Highway and Transportation Officials (AASHTO), "Standard Specifications for Highway Bridges," 17th Edition, 2002.

8. American Association of State Highway and Transportation Officials (AASHTO), "Standard Specifications for Transportation Materials and Methods of Sampling and Testing.

9. American Railway Engineering and Maintenance-of-Way Association, "Manual for Railway Engineering," Volumes 1-4, 2022.

10. American Society of Civil Engineers (ASCE), Geotechnical Special Publications.

11. Arneson, L.A., Zevenbergen, L.W., Lagasse, P.F., and Clopper, P.E., "Hydraulic Engineering Circular (HEC) 18 – Evaluating Scour at Bridges," Federal Highway Administration Publication No. FHWA-HIF-12-003, Fifth Edition, April 2012.

12. ASTM International, "Annual Book of ASTM Standards".

13. Berg, R.R., Christopher, B.R., Samtini, N.C., "Geotechnical Engineering Circular (GEC) No. 11 – Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volumes I & II," Federal Highway Administration Publication Nos. FHWA NHI-10-024 & FHWA NHI-10-025, November 2009.

14. Brown, D.A., Dapp, S.D., Thompson III, WR., Lazarte, C.A., "Geotechnical Engineering Circular (GEC) No. 8 – Design and Construction of Continuous Flight Auger (CFA) Piles," Federal Highway Administration Publication No. FHWA-HIF-07-039, April 2007.

15. Brown, D.A., Turner, J.P., Castelli, R.J., Loehr, E.J., “Geotechnical Engineering Circular (GEC) No. 10 - Drilled Shafts: Construction Procedures and Design Methods,” Federal highway Administration Publication No. FHWA-NHI-18-024, September 2018.

16. Buckle, I.G., Friedland, I., Mander, J., Martin, G., Nutt, R., Power, M., “Seismic Retrofitting Manual for Highway Structures: Part 1 – Bridges,” Multidisciplinary Center for Earthquake Engineering Research Publication No. MCEER-06-SP10, December 2006.

17. Burmister, D.M., “Principals and Techniques of Soil Identification,” Proceedings of the Highway Research Board, December, 1949.

18. Carlos A. Lazarte, Ph.D., P.E., Victor Elias, P.E., R. David Espinoza, Ph.D., P.E., Paul J. Sabatini, Ph.D., P.E., “Geotechnical Engineering Circular (GEC) No. 7 – Soil Nail Walls,” Federal Highway Administration Publication No. -. FHWA-NHI-14-007.

19. Collin, J.G. (2004). "Column Supported Embankments - Technical Summary #7. Ground Improvement Methods", FHWA NHI-04-001, October, Federal Highway Administration, Washington, D.C.

20. Collin, J. G., Hung, J. C., Lee, W. S., Munfakh, G., “Soil Slope and Embankment Design Reference Manual,” Federal Highway Administration Publication No. FHWA-NHI-01-026, March 2001.

21. Dalton, R., Monteverde, D., Sugarman, P., and Volkert, R., “Bedrock Geologic Map of New Jersey,” New Jersey Department of Environmental Protection, 2014.

22. Golder Associates, “Rock Slopes: Design, Excavation, Stabilization,” Federal Highway Administration Publication No. FHWA-TS-89-045, September 1989.

23. Han, J. and Akins, K. (2002). "Case Studies of Geogrid-Reinforced and Pile-Supported Earth Structures on Weak Foundation Soils," Proceedings of the International Deep Foundation Congress, Geotechnical Special Publication No. 116 - Deep Foundations 2002, M. W. O'Neill and F. C. Townsend (Eds.), ASCE, Orlando, FL, pp. 668-67

24. Hannigan, P.J., Rausche, F., Likins, G.E., Robinson B.R., and Becker M.L., “Geotechnical Engineering Circular (GEC) No. 12 – Design and Construction of Driven Pile Foundations – Volumes I & II,” Federal Highway Administration Publication Nos. FHWA-NHI-16-009 & FHWA-NHI-16-010, September 2016.

25. Holtz, R.D., Christopher, B.R., and Berg, R.R., “Geosynthetic Design and Construction Guidelines,” Federal Highway Administration Publication No. FHWA-NHI-07-092, August 2008.

26. Hung, C.J., Monsees, J., Munfah, N., and Wisniewski, J., “Technical Manual for Design and Construction of Road Tunnels – Civil Elements,” Federal Highway Administration Publication No. FHWA-NHI-10-034, December 2009.

27. Idriss, I.M., Boulanger, R.W., “Soil Liquefaction during Earthquakes,” Earthquake Engineering Research Institute Monograph 12, 2008.

28. International Code Council Inc., “International Building Code – New Jersey Edition,” 2021.

29. Kavazanjian Jr., E, Matasovic, N., Hadj-Hamou, T., Sabatini, P.J., “Geotechnical Engineering Circular (GEC) No. 3 – Design Guidance: Geotechnical Earthquake Engineering for Highways - Volumes I & II,” Federal Highway Administration Publication No. FHWA-SA-97-076 & FHWA-SA-97-077, May 1997.

30. Kavazanjian Jr., E., Wang, J.J., Martin, G.R., Shamsabadi, A., Lam, I. (Po), Dickenson, S.E., Hung, J.C., “Geotechnical Engineering Circular (GEC) No. 3 – LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations,” Federal highway Administration Publication No. FHWA-NHI-11-032, August 2011 (Rev. 1).

31. Keaton, J.R., Mishra, S.K., and Clopper, P.E., “Scour at Bridge Foundations on Rock,” Transportation Research Board – National Cooperative Highway Research Program Report No. NCHRP-Report-717, 2012.

32. Kimmerling, R.E. “Geotechnical Engineering Circular (GEC) No. 6 – Shallow Foundations,” Federal Highway Administration Publication No. FHWA-SA-02-054, September 2002.

33. Lagasse, P.F., Clopper, P.E., Pagán-Ortiz, J.E., Zevenbergen, L.W., Arneson, L.A., Schall, J.D., and Girard, L.G., “Hydraulic Engineering Circular (HEC) 23 – Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance – Volumes I & II,” Federal Highway Administration Publication No. FHWA-NHI-09-111 & FHWA-NHI-09-112, Third Edition, September 2009.

34. Lagasse, P.F., Zevenbergen, L.W., Spitz, W.J., and Arneson, L.A., “Hydraulic Engineering Circular (HEC) 20 – Stream Stability at Highway Structures,” Federal Highway Administration Publication No. FHWA-HIF-12-004, Fourth Edition, April 2012.

35. Lewis, J.V., and Kummel, H.B., “Geologic Map of New Jersey,” Geological Survey of New Jersey, 1912.

36. Mayne, P.W., Christopher, B.R., DeJong, J., “Subsurface Investigations – Geotechnical Site Characterization Reference Manual,” Federal Highway Administration Publication No. FHWA-NHI-01-031, May 2002.

37. Munfakh, G., A. Arman, J. G. Collin, J. C.-J. Hung, and R. P. Brouillette. 2001. *Shallow Foundations Reference Manual*, FHWA-NHI-01-023. Federal Highway Administration, U.S. Department of Transportation, Washington, DC.

38. National Cooperative Highway Research Program (NCHRP) Report 408, “Corrosion of Steel Piling in Nonmarine Applications”, 1998.

39. National Resources Conservation Center (NRCS), “Part 633 National Engineering Handbook,” Chapter 26 – Sand and Gravel Filter Design, October 1994.

40. Naval Facilities Engineering Command (NAVFAC), “Soil Mechanics - Design Manual 7.01,” U.S. Navy, 1986.

41. Naval Facilities Engineering Command (NAVFAC), "Foundations & Earth Structures - Design Manual 7.02," U.S. Navy, 1986.

42. New Jersey Administrative Code, "Title 7 Chapter 9D - Well Construction and Maintenance; Sealing of Abandoned Wells."

43. New Jersey Department of Agriculture, "The Standards for Soil Erosion and Sediment Control in New Jersey," 7th Edition, January 2014.

44. New Jersey Department of Environmental Protection (NJDEP), "New Jersey Stormwater Best Management Practices (BMP) Manual," February 2004.

45. New Jersey Department of Environmental Protection (NJDEP), "Flood Hazard Area Technical Manual," December 2008.

46. New Jersey Department of Transportation (NJDOT), "NJDOT Standard Specifications for Road and Bridge Construction," 2019.

47. New Jersey Turnpike Authority (NJTA) Procedures Manual.

48. New Jersey Turnpike Authority (NJTA) Standard Specifications.

49. New Jersey Turnpike Authority (NJTA) Supplementary Specifications.

50. Puckett, J.A., Garlich, M.G., Nowak, A., Barker, M., "Development and Calibration of AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," Transportation Research Board (TRB) National Cooperative Highway Research Program (NCHRP) Report 796, 2014.

51. Rutgers University College of Engineering, "Engineering Soil Survey of New Jersey," Rutgers University College of Engineering Research Bulletins - Nos. 15 through 36.

52. Sabatini, P.J., Bachus, R.C., Mayne, P.W., Schneider, J.A., Zettler, T.E. "Geotechnical Engineering Circular (GEC) No. 5 – Evaluation of Soil and Rock Properties," Federal Highway Administration Publication No. FHWA-IF-02-034, April 2002.

53. Sabatini, P.J., Elias, V., Schmertmann, R. Bonaparte, "Geotechnical Engineering Circular (GEC) No. 2 – Earth Retaining Systems," Federal Highway Administration Publication No. FHWA-SA-96-038, February 1997.

54. Sabatini, P.J., Pass, D.G., Bachus, R.C., "Geotechnical Engineering Circular (GEC) No. 4 – Ground Anchors and Anchored Systems," Federal Highway Administration Publication No. FHWA-IF-99-015, June 1999.

55. Sabatini, P.J., Tanyu, B., Armour, T., Groneck, P., Keeley, J., "Micro Pile Design and Construction Reference Manual," Federal Highway Administration Publication No. FHWA-NHI-05-039, December 2005.

56. Samtani, N.C., Nowatzki, E.A., "Soils and Foundations Reference Manual – Volumes I & II," Federal Highway Administration Publication No. FHWA-NHI-06-088 & FHWA-NHI-06-089, December 2006.

57. Schaefer, V.R., Berg, R.R., Collin, J.G., Christopher, B.R., DiMaggio, J.A., Filz, G.M., Bruce, D.A., and Ayala, D., "Geotechnical Engineering Circular (GEC) No. 13 – Ground Modification Methods - Reference Manual – Volumes I & II," Federal Highway Administration Publication No. FHWA-NHI-16-027 & FHWA-NHI-16-028, April 2017.

58. Shan, H., Shen, J., Kilgore, R., and Kerenyi, K., "Scour in Cohesive Soils," Federal Highway Administration Publication No. FHWA-HRT-15-033, May 2015.

59. Tanyu, B.F., Sabatini, P.J., and Berg, R.R., "Earth Retaining Structures," Federal Highway Administration Publication No. FHWA-NHI-07-071, June 2008.

60. Terzaghi, K. and Peck, R.B., "Soil Mechanics in Engineering Practice," 2nd Edition.

61. Turner, J. P. 2006. *NCHRP Synthesis 360: Rock-Socketed Shafts for Highway Structure Foundations*. Transportation Research Board, National Research Council, Washington, DC, 148 pp.

62. Unified Facilities Criteria (UFC), Soil Mechanics – DM 7.1, UFC-3-220-10, 2022.

63. United States Department of Agriculture (USDA), "Soil Maps".

64. United States Steel (USS), "Steel Sheet Piling Design Manual," Updated and Reprinted by United States Department of Transportation (USDOT)/FHWA with permission, July 1984.

65. U.S. Army Corps of Engineers, "Seepage Analysis and Control of Dams," USACOE Publication No. EM1110-2-1901, April 1993 (change 1).

66. Wightman, W.E., Jalinoos, F., Sirles, P., and Hanna, K., "Application of Geophysical Methods to Highway Related Problems," Federal Highway Administration Publication No. FHWA-IF-04-021, 2003.

Exhibit 6-1 Sample Soil and Core Box Photograph

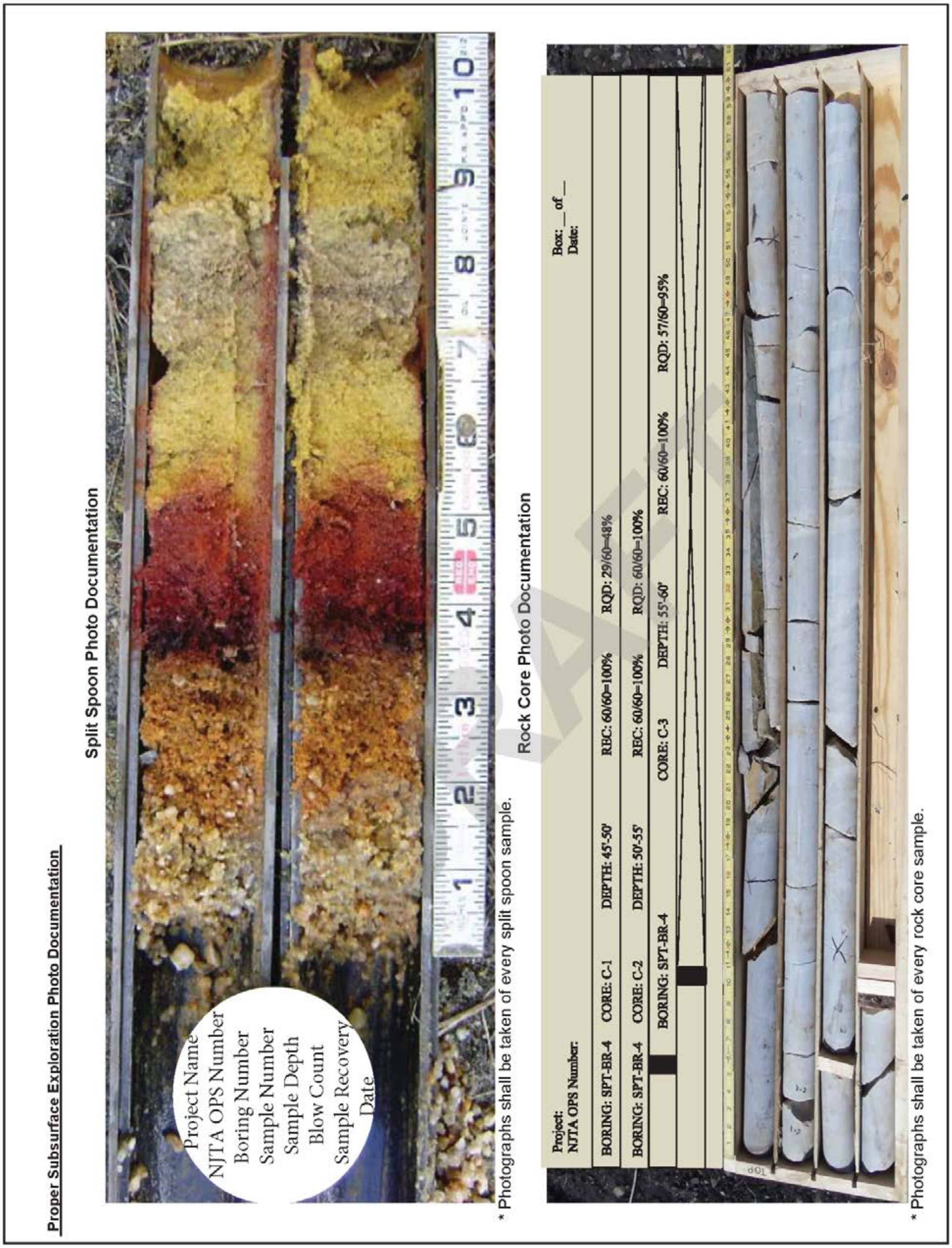


Exhibit 6-2 Boring Log Forms – First Page

<Consultant Logo>

GEOTECHNICAL BORING LOGS FOR

Boring No. ________
Sheet No. ____ of ____

New Jersey Turnpike Authority
(Owner)

(Project)

(Contractor)

Contract No. ____________ Purpose ____________________________ Structure No. ________
Location ____________ RDWY. ____________________ STA. ________ OFF. ________

Rig No. ________ Type ____________ Driller ______________ Helper ______________
DATE
TIME STARTED
TIME FINISHED
WEATHER
DEPTH REACHED

GROUND ELEVATION ______________
ZERO OF BORING LOG ______________

M.L.W. ELEVATION ______________
ELEVATION GROUND WATER ______________

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LINEAL FEET OF ROCK CORE		
2-½ in	3 in	4 in			ORD. DRY	UNDIST. DRY		1-7/8" ID (NQ)	2-1/8" ID (NX)	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM

Drilling Mud Unit Weight ________ Casing: Type ________ Size ________ Weight of Hammer ________ Average Fall ________ Hammer Type ________
Ordinary Dry Samples O.D. ________ I.D. ________
Undisturbed Samples Type ____________ Length __________ O.D. __________ I.D. __________

GROUND WATER READINGS
DATE
TIME
DEPTH

GENERAL REMARKS:

NORTHING: EASTING:

All elevations refer to the NAVD 88 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

The subsurface information shown hereon was obtained for NJTA design and estimate purposes. It is made available to authorized users only that may have access to the same information available to the NJTA. It is presented in good faith, but is not intended as a substitute for investigations, interpretation, or judgement of such authorized users.

INSPECTOR ______________________ GEOTECHNICAL ENGINEER ______________________

Boring Log Forms – Subsequent Pages

BORING LOG

Boring No. ____________
Sheet No. ____ of ____

CONTRACT NO. RDWY. STA. OFF.

Elev. (ft)	Blows on Casing	Blows on Spoon For 6-in Penetration		Sample		Log	Material & Remarks
				No.	Depth (ft)		

*indicates that soil description has been verified based on laboratory test results.

Exhibit 6-3 Boring Log Forms for Stormwater Facilities – First Page

<Consultant Logo>

GEOTECHNICAL BORING LOGS FOR

New Jersey Turnpike Authority
(Owner)

(Project)

(Contractor)

Boring No. ____________
Sheet No. _____ of _____

Contract No. ________________ Purpose ______________________________________ Structure No. __________
Location ____________________ RDWY. __________________________ STA. __________ OFF. __________

Rig No. ________ Type ____________	Driller ____________________			Helper ____________________		
DATE						
TIME STARTED						
TIME FINISHED						
WEATHER						
DEPTH REACHED						

GROUND ELEVATION ____________________ M.L.W. ELEVATION ____________________
ZERO OF BORING LOG ____________________ ELEVATION GROUND WATER ____________________

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LINEAL FEET OF ROCK CORE		
2-½ in	3 in	4 in			ORD. DRY	UNDIST. DRY		1-7/8" ID (NQ)	2-1/8" ID (NX)	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM

Drilling Mud Type __________ Casing: Type __________ Size __________ Weight of Hammer __________ Average Fall __________ Hammer Type __________
Ordinary Dry Samples O.D. __________ I.D. __________ __________ __________ __________
Undisturbed Samples Type ______________ Length ___________ O.D. ___________ I.D. ___________

GROUND WATER READINGS							
DATE							
TIME							
DEPTH							

GENERAL REMARKS:

NORTHING: EASTING:

All elevations refer to the NAVD 88 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

The subsurface information shown hereon was obtained for NJTA design and estimate purposes. It is made available to authorized users only that may have access to the same information available to the NJTA. It is presented in good faith, but is not intended as a substitute for investigations, interpretation, or judgement of such authorized users.

INSPECTOR ______________________________ GEOTECHNICAL ENGINEER ______________________________

Boring Log Forms for Stormwater Facilities – Subsequent Pages

BORING LOG

BORING NO. ______
SHEET NO. ____ OF ____

CONTRACT NO. RDWY. STA. OFF.

Elev. (ft)	Blows on Spoon	Sample		Log	Material & Remarks
		No.	Depth (ft)		

* Indicates that soil description has been verified based on laboratory results.

Exhibit 6-4 Rock Coring Log Forms

ROCK CORING LOG

Boring No. ______________
Sheet No. ______ of ______
CONTRACT NO. RDWY. STA. OFF.

Core Data										Rock Description									Discontinuity Description								Lab Testing			
	Run			Water	Rock Core					General				Fabric		Structure			Planes		Joints									
																					Joint Surface									
Elev.	Sample no.	Depth (ft)	Core Time (ft/min)	Gain/Loss	No. of Pieces	Recovery		Rock Quality Designation, RQD		Rock Type	Color	Weathering	Strength	Grain Size	Grain Shape	Fracture Spacing	Bedding Spacing	Foliation Angle	Fracture Type	Fracture Aperture	Shape	Roughness	Joint Infilling	Infilling Strength	Water Content	Joint Roughness Coefficient	Strength (ksi)	Unit Weight (pcf)	Other (Specify)	Other (Specify)
						in	%	in	%	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)

(a) Amphibolite, Argillite, Basalt, Chert, Claystone, Conglomerate, Diabase, Dolomite, Gneiss, Granite, Hornfers, Limestone, Marble, Metaquartzite, Mudstone, Phyllite, Quartzite, Sandstone, Schist, Serpentinite, Shale, Siltstone, Slate

(b) Bl-Blue, Bk-Black, Br-Brown, Gr-Gray, Grn-Green, Or-Orange, Rd-Red, Tn-Tan, Yl-Yellow, Lt-Light, Dk-Dark

(c) I-Unweathered, II- Slightly Weathered, III-Moderately Weathered, IV-Highly Weathered, V-Completely Weathered, VI- Residual Soil

(d) R0-Extremely Weak, R1-Very Weak, R2-Weak, R3-Medium Strong, R4-Strong, R5-Very Strong, R6- Extremely Strong

(e) Sedimentary: VF- Very Fine, FG-Fine, MG-Medium, CG-Coarse, VC-Very Coarse; Igneous & Metamorfic: P- Pegmatitic, CG-Coarse, MG-Medium, FG-Fine, A- Aphanitic

(f) AG-Angular, SA-Subangular, SR-Subrounded, RD-Rounded, WR-Well Rounded

(g) ECF- Extremely Close, VCF-Very Cloase, CF-Close, MF-Moderate, WF-Wide, VWF-Very Wide

(h) TLB-Thinly Laminated, LB- Laminated, VTNB-Very Thin, TNB-Thin, MB-Medium, TKB-Thick, VKTB-Very Thick (massive)

(j) J-Joint, Ft-Fault, Sh-Shear, Fo-Foliation, V-Vein, B-Bedding

(k) T-Tight, SO-Slightly Open, MO-Moderately Open, O-Open, MW-Moderately Wide, W-Wide

(l) P-Planar, U-Undulating, WU-Wavy, ST-Stepped, IR-Irregular

(m) SL- Slickensided, SM-Smooth, SR-Slightly Rough, RG-Rough, VR-Very Rough

(n) Ca-Calcite, Fe-Iron, Qtz-Quartz, C-Clay, M-Silt, S-Sand, G-Gravel

(o) S1-Very Soft, S2-Soft, S3-Firm, S4-Stiff, S5-Very Stiff, S6-Hard

(p) D-Dry, M-Moist, W-Wet

Exhibit 6-5 Test Pit Log Forms

<Consultant Logo>

NEW JERSEY TURNPIKE AUTHORITY
FIELD TEST PIT LOG

TEST PIT NO. ______
SHEET ____ OF ____
DATE: START ______
END ______

Contract No. ______ Purpose ______ Structure No. ______
Location ______ RDWY ______ STA. ______ OFF. ______
NORTHING ______ EASTING ______ GROUND ELEVATION ______
EQUIPMENT USED ______
INSPECTOR ______ DRILLERS NAME/COMPANY ______
PIT DIMENSIONS: LENGTH ______ ; WIDTH ______ ; DEPTH ______
WATER LEVEL DEPTH: ______ NOT ENCOUNTERED ☐
CHECKED BY: ______ ; DATE: ______

DEPTH (FT)	SAMPLE NO. AND TYPE	POCKET PENT/ TORVANE (TSF)	WATER CONTENT	DESCRIPTION	REMARKS
0.0					

NOTE: All elevations refer to the NAVD 88 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

Exhibit 6-6 Monitoring Well Log Forms

Observation Well Instalation Log

WELL NO.: ____________

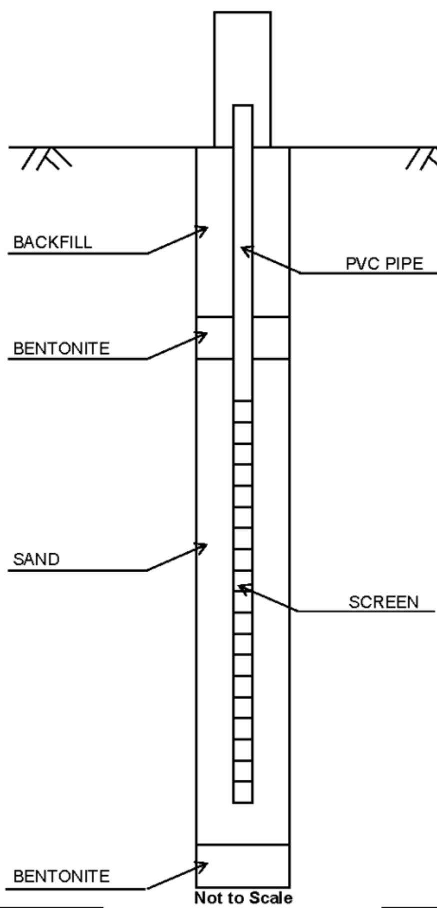
PROJECT NAME: ________________________________ PROJECT NO.: ____________

DATE INSTALLED: ____________ INSPECTOR: ____________ HOLE DEPTH: ____________

CONTRACTOR: ____________ DRILLER: ____________ HELPER: ____________

LOCATION: ________________________________ GROUND ELEVATION: ____________

POINTS OF INTEREST



_______ FT = LENGTH OF COVER FROM THE GROUND SURFACE

____________ BACKFILL MATERIAL

_______ FT = BENTONITE SEAL DEPTH

_______ FT = TOP OF SAND DEPTH

_______ FT = TOP OF SCREEN DEPTH

_______ FT = LENGTH OF SCREEN

_______ FT = BOTTOM OF SCREEN DEPTH

_______ FT = BOTTOM OF SAND DEPTH

_______ FT = BOTTOM OF HOLE DEPTH

WELL READINGS

DATE	BY	DEPTH(FT)

Depth recorded is depth below ground surface

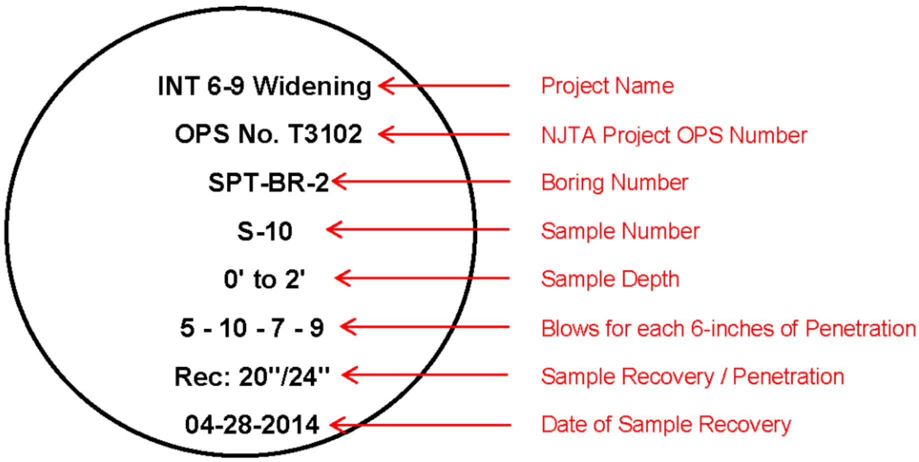
WELL DATA

ITEM	DESCRIPTION
PVC Well Casing Inside Diameter	
Lock Installed	
Standpipe or Flushmount	
Bags of Sand Used	
Bags of Bentonite Used	
Development	

NOTES:

Exhibit 6-7 Soil Sample Labeling (Jars, Boxes and Undisturbed Samples)

a) Proper Labeling of Soil Sample Jar Tops



b) Proper Labeling of Soil Sample Boxes

Top of Sample Box

Project: INT 6-9 Widening
NJTA OPS Number: T3102

Boring:	SPT-BR-2	SPT-BR-3
Sample:	S-13 to S-19	S-1 to S-5
Depth:	55' to 85'	0' to 17'
Date:	10-23-2007	10-26-2007
Inspector:	MDR	MDR
Box:	2 of 2	1 of 2

Front of Sample Box

Project: INT 6-9 Widening
NJTA OPS Number: T3102

Boring:	SPT-BR-2	SPT-BR-3
Sample:	S-13 to S-19	S-1 to S-5
Depth:	55' to 85'	0' to 17'
Date:	10-23-2007	10-26-2007
Inspector:	MDR	MDR
Box:	2 of 2	1 of 2

Side of Sample Box

Project: INT 6-9 Widening
NJTA OPS Number: T3102

Boring:	SPT-BR-2	SPT-BR-3
Sample:	S-13 to S-19	S-1 to S-5
Depth:	55' to 85'	0' to 17'
Date:	10-23-2007	10-26-2007
Inspector:	MDR	MDR
Box:	2 of 2	1 of 2

Note:
Label both sides of sample box.

c) Proper Labeling of Undisturbed Samples

Side of Sampler

Project: INT 6-9 Widening
NJTA OPS Number: T3102

Boring:	SPT-BR-2	Top ↑
Sample:	U-1	
Depth:	55' to 57'	
Rec::	20"/24"	
Date:	10-23-2007	
Inspector:	MDR	

Top of Sampler

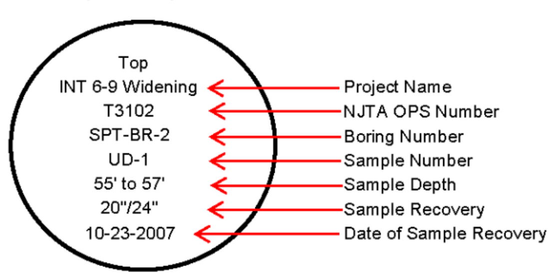


Exhibit 6-8 Rock Core Box Labeling Inside & Outside

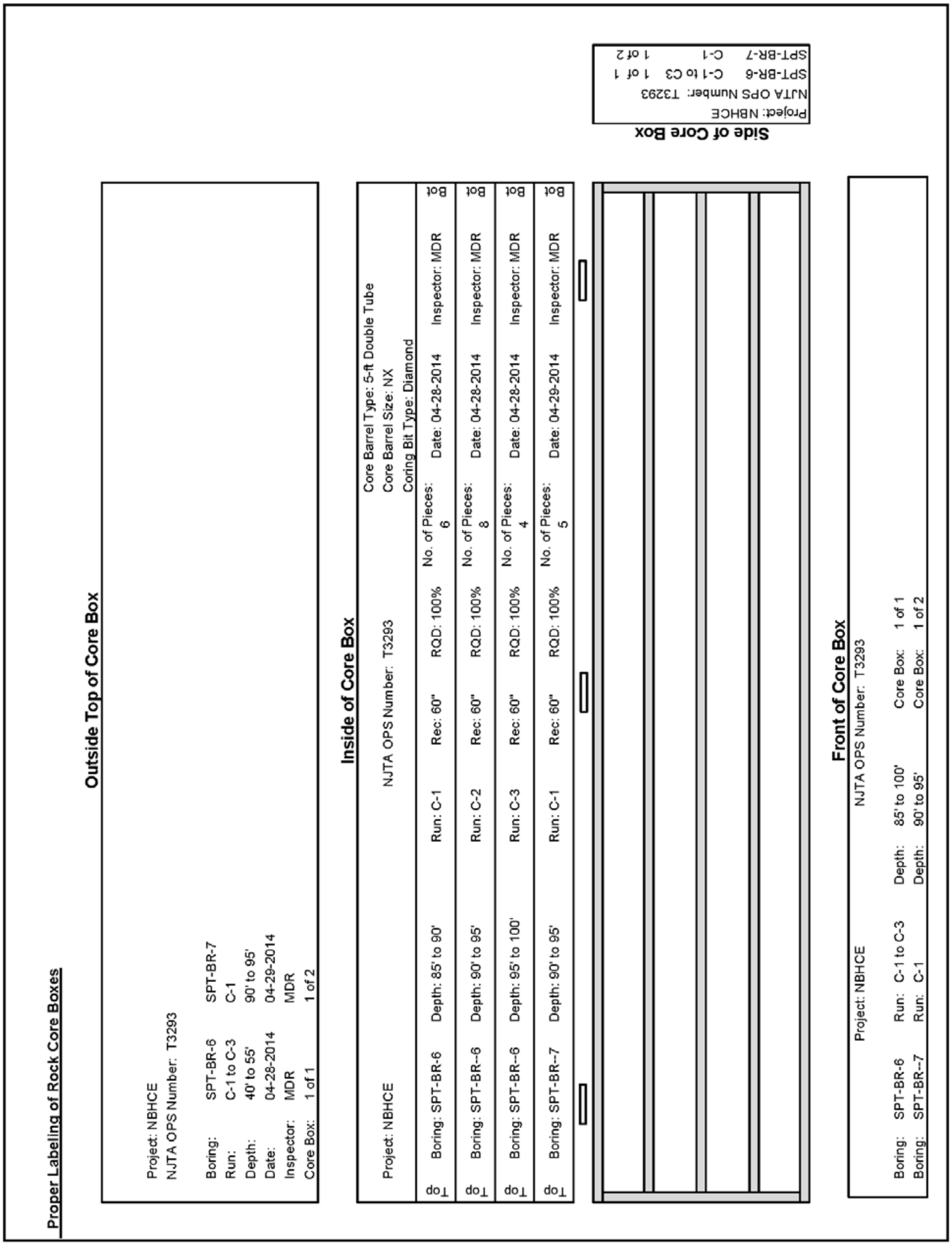


Exhibit 6-9 Sample Boring Location Plan

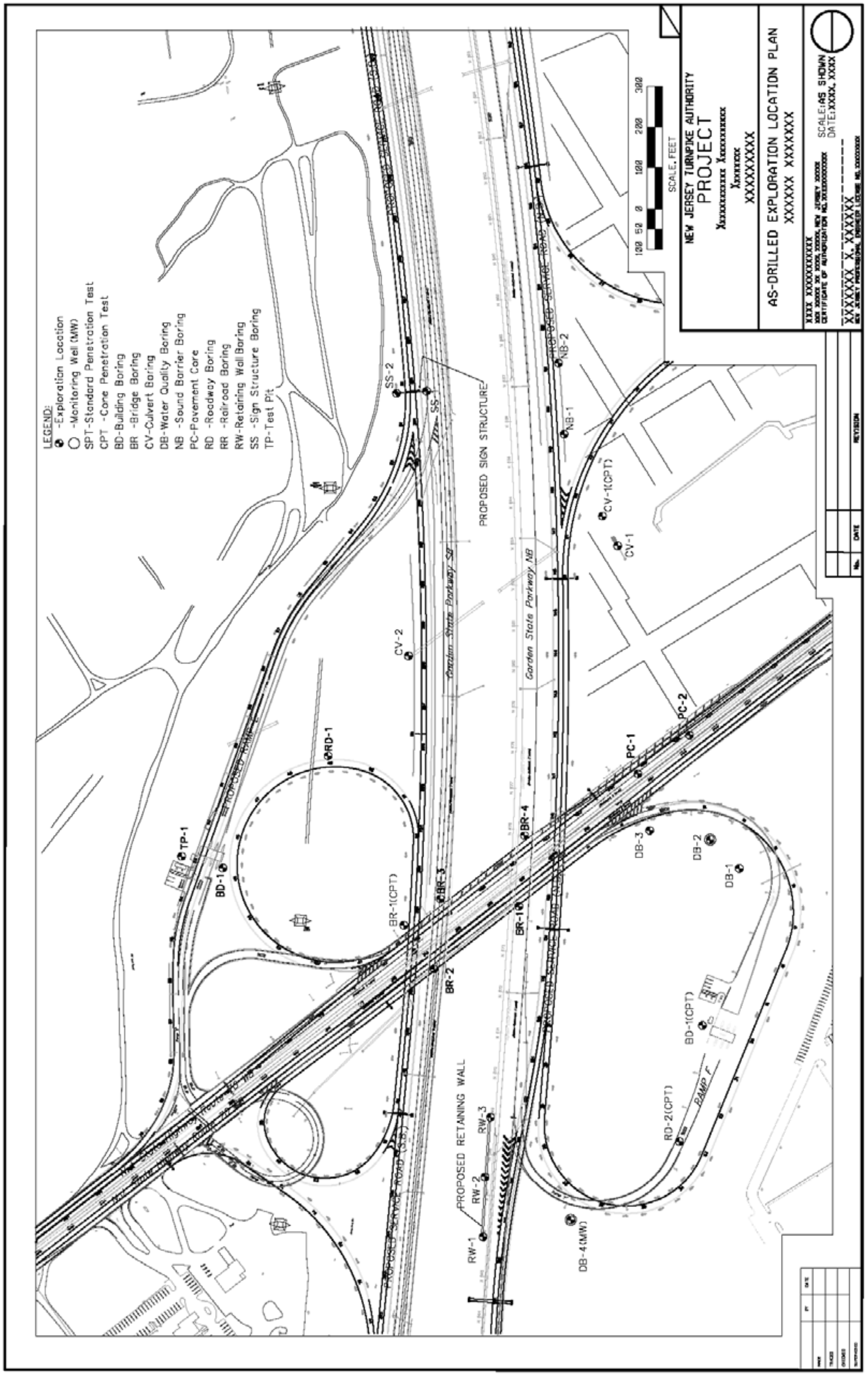


Exhibit 6-10 Sample Subsurface Profile

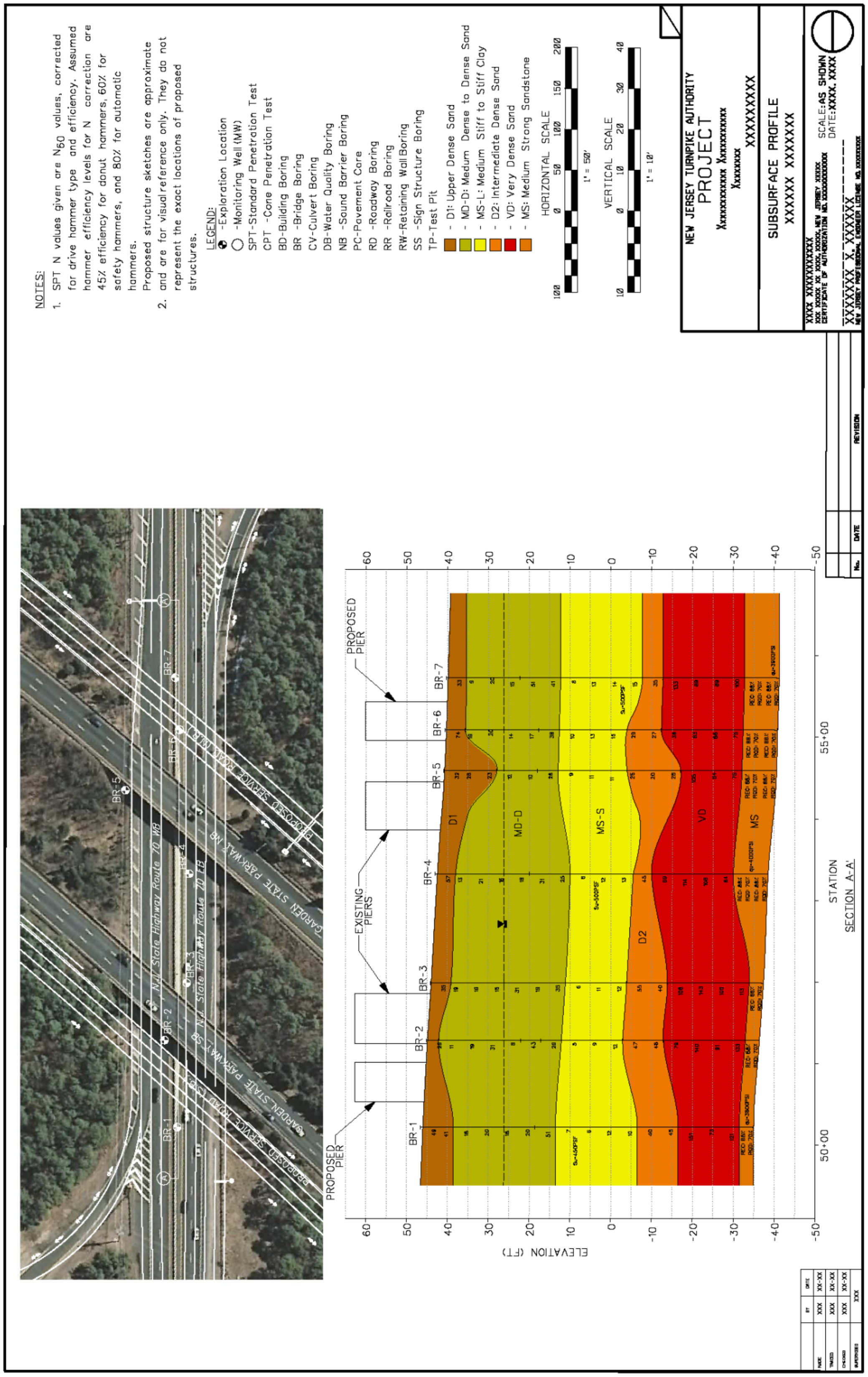
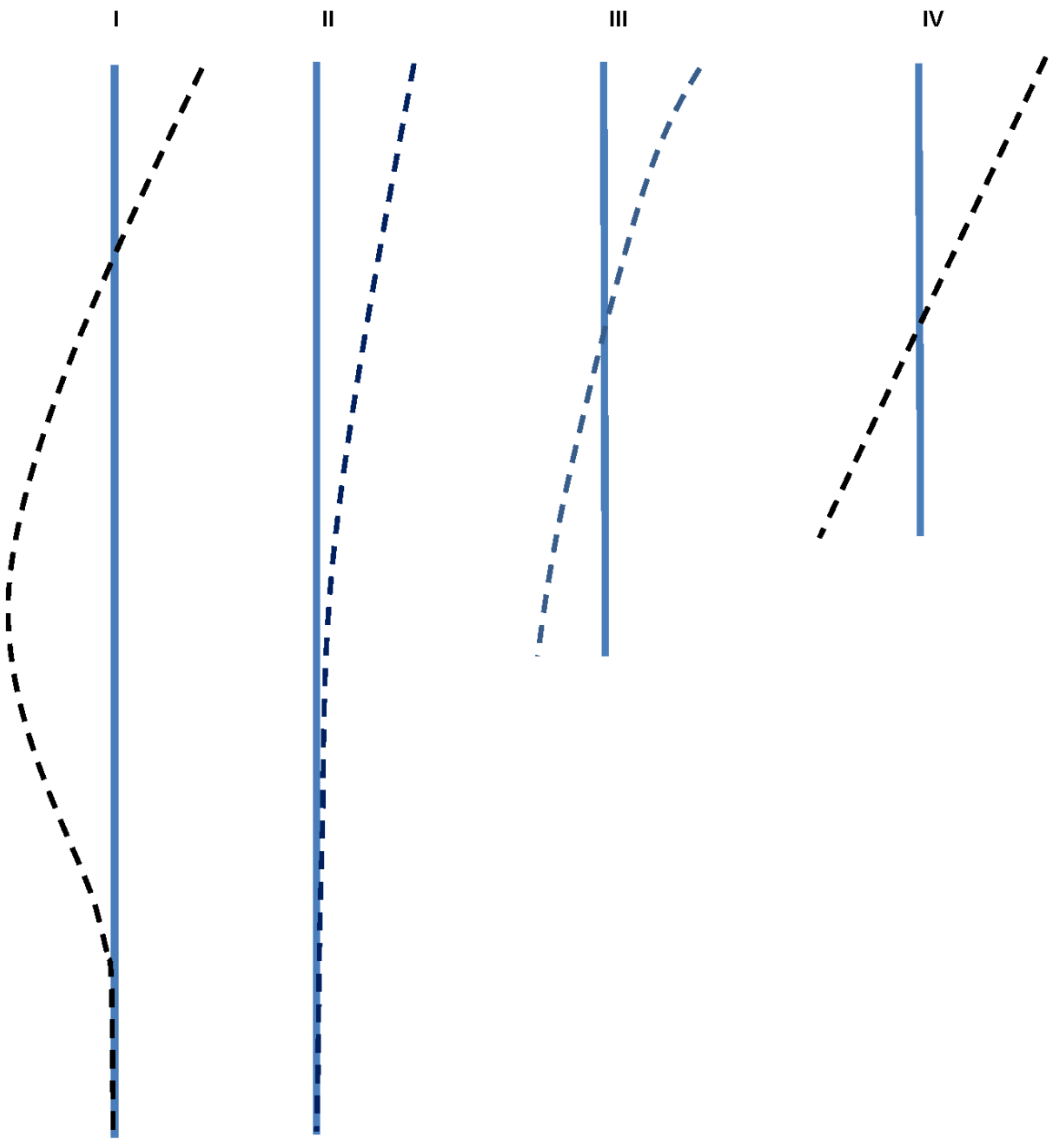


Exhibit 6-11 Criteria for Estimating Minimum Length for Deep Foundations based on Lateral Stability



I - Recommended for deep foundations of Bridge Substructures, Culverts, Buildings, Retaining Walls supporting Structures

II - Same as I.

III - Recommended for deep foundations of Retaining Walls not supporting Structures, Sound Barriers, Sign Structures, High Mast Lighting, Traffic Signals. Lateral tip movement is limitted to 0.1 inch.

IV - Not recommended for any structures. May be considered for temporary works.

Exhibit 6-12 Turnpike Pavement Section (Mainline, Ramps, Shoulders & Z-Turns)

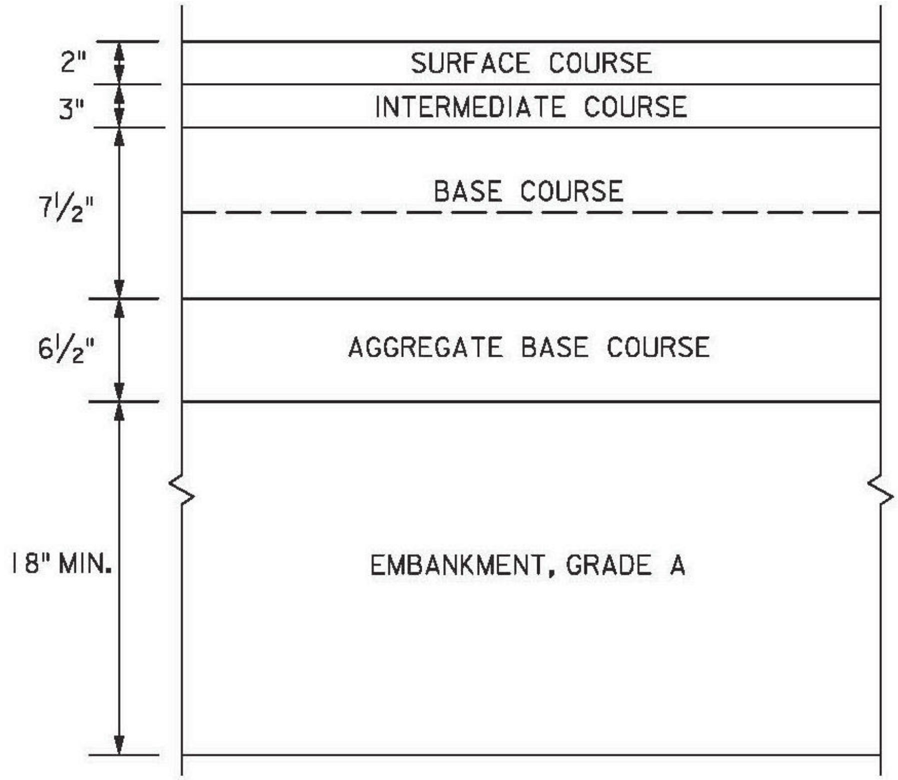
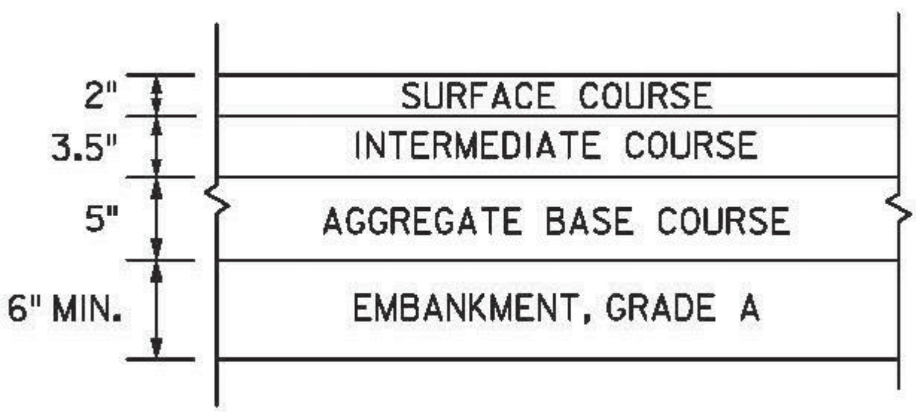


Exhibit 6-13 Turnpike Car Parking Pavement Section



NOTES:

1. TRUCK PARKING AREAS SHALL BE PAVED WITH TURNPIKE PAVEMENT, AS SHOWN IN EXHIBIT 6-12.

Exhibit 6-14 Turnpike U-Turn Pavement Section

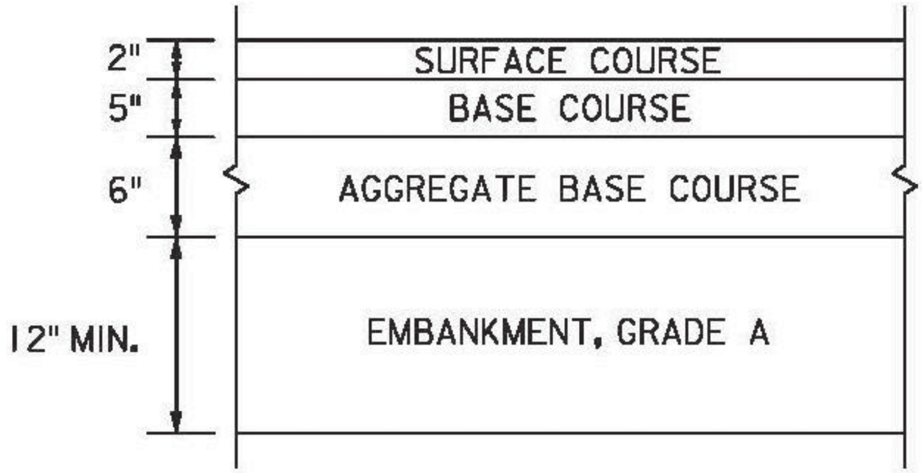
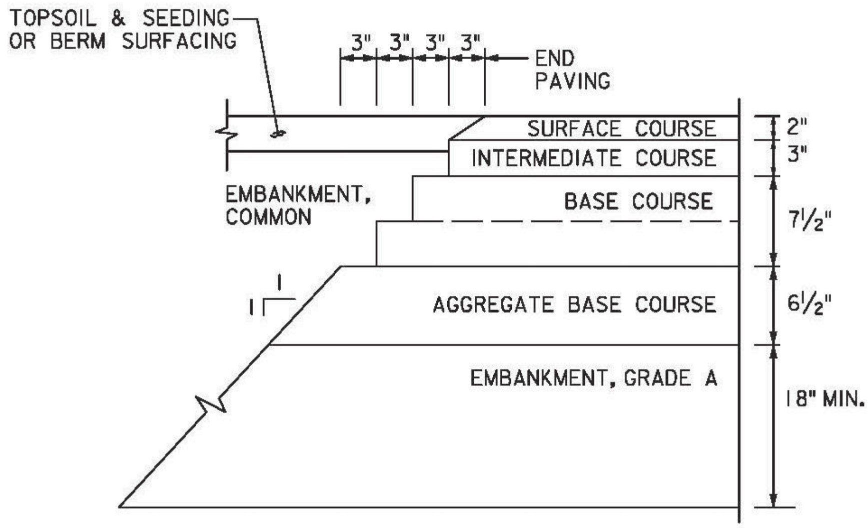
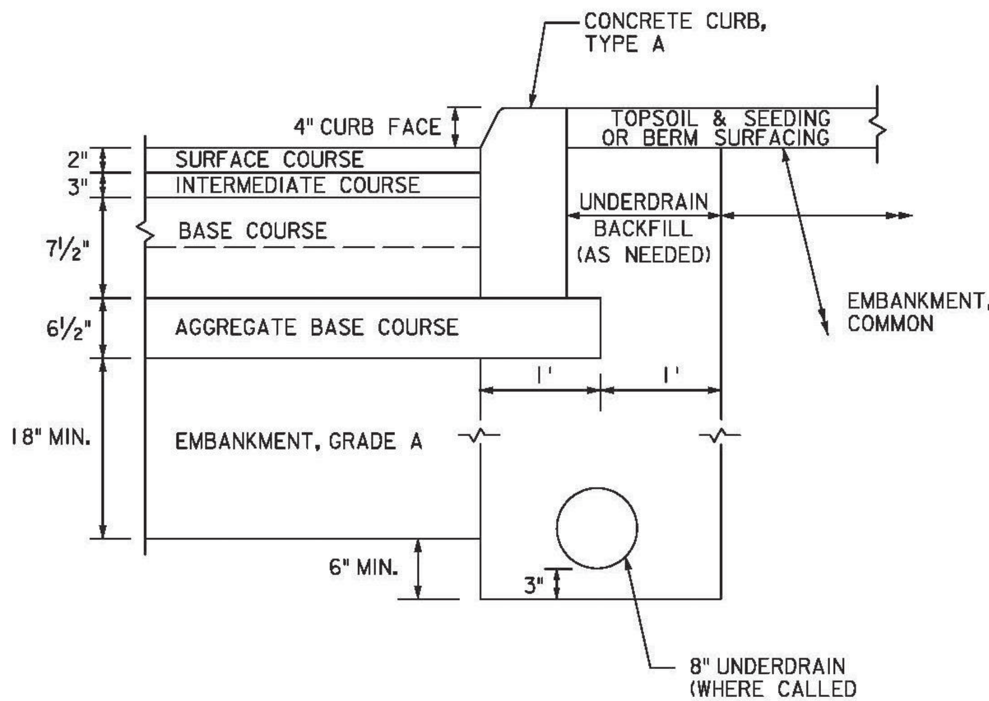


Exhibit 6-15 Turnpike Transverse Pavement Stepping Detail



WITHOUT CURB



WITH CURB

NOTES:

1. BASE COURSES OVER 4" THICK SHALL BE INSTALLED IN TWO LIFTS.

Exhibit 6-16 Turnpike Longitudinal Pavement Stepping Detail

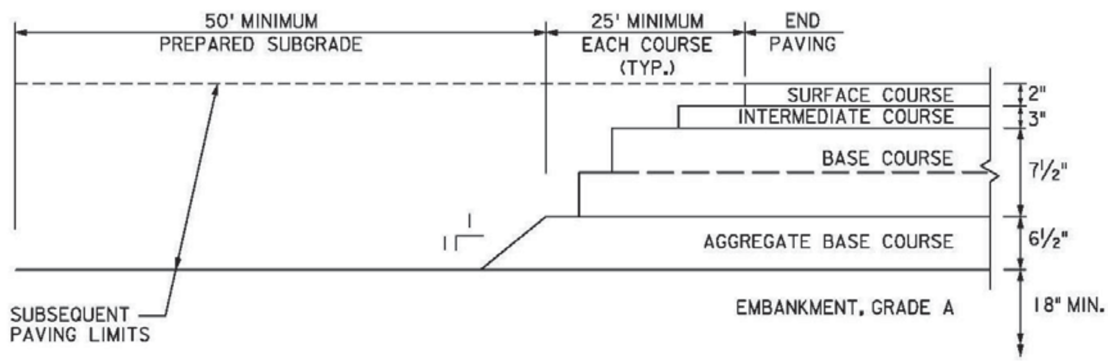


Exhibit 6-17 Turnpike New Pavement Interface with Existing Pavement

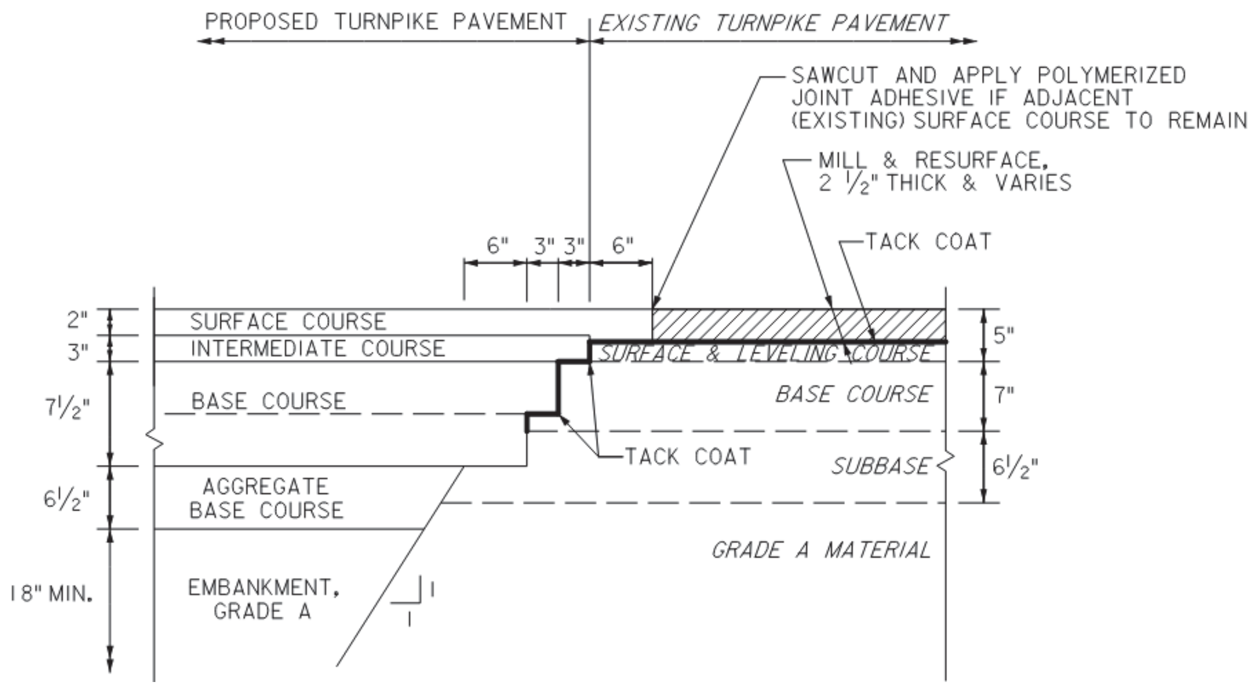


Exhibit 6-18 Turnpike Toll Plaza Pavement Interface

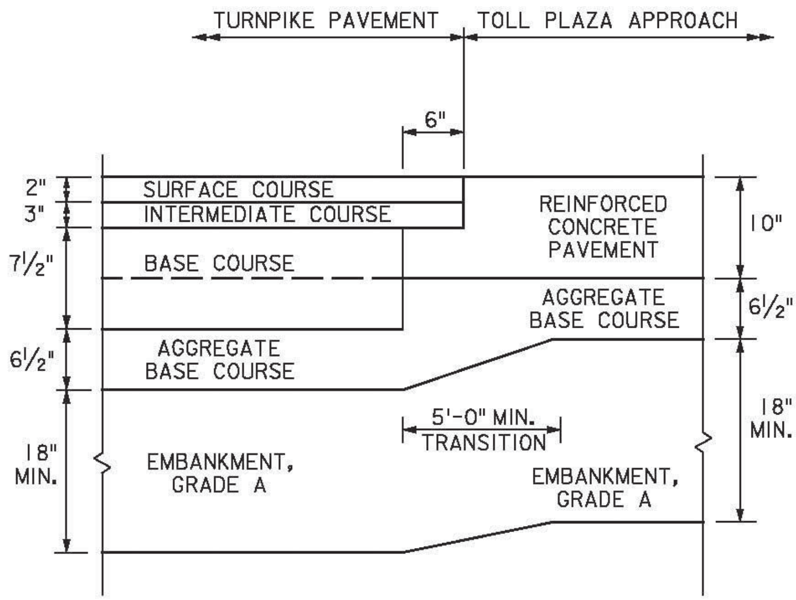


Exhibit 6-19 Turnpike Pavement Removal and Reconstruction Detail

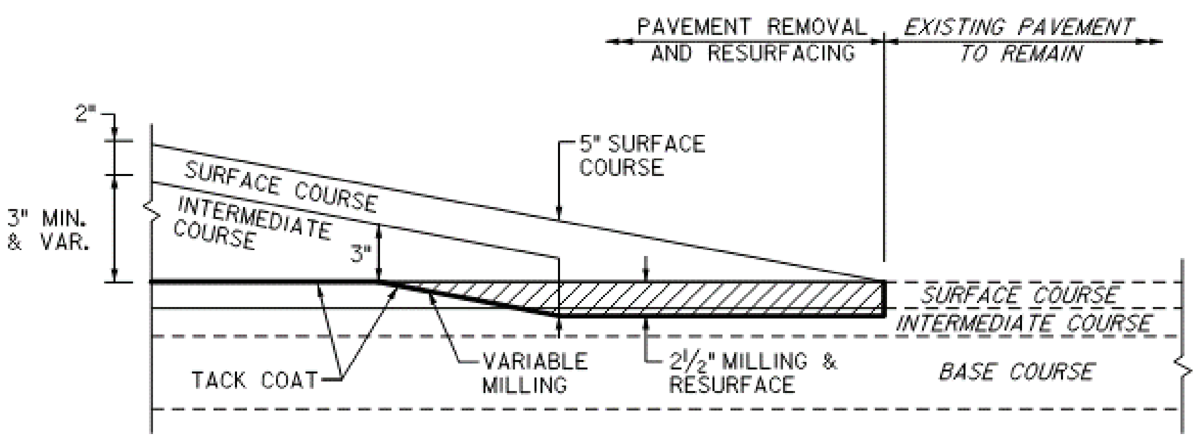


Exhibit 6-20 Parkway Pavement Section (Mainline, Ramps, Shoulders, U-Turn & Z-Turn)

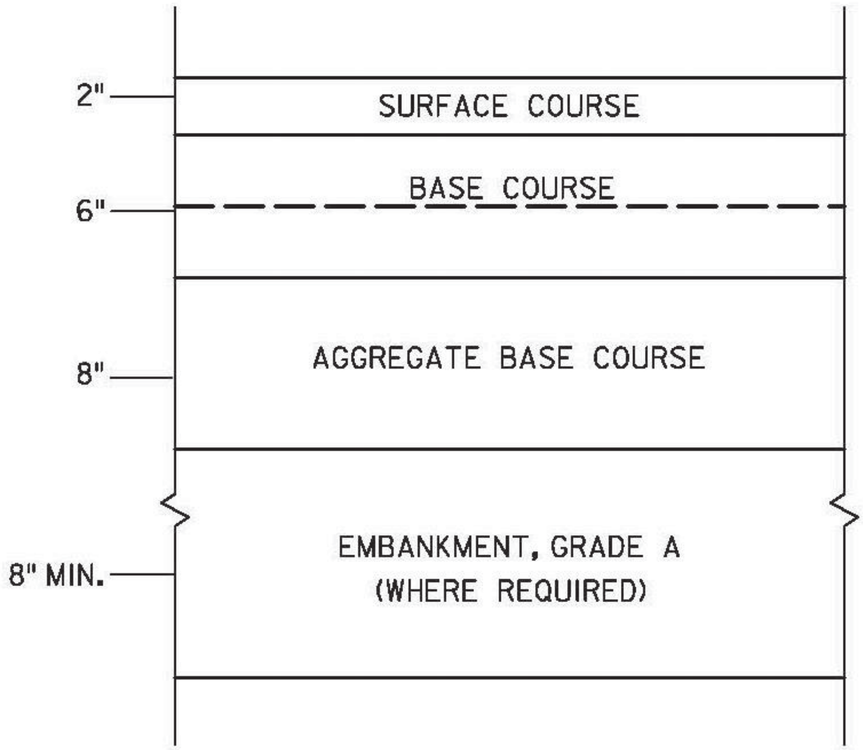
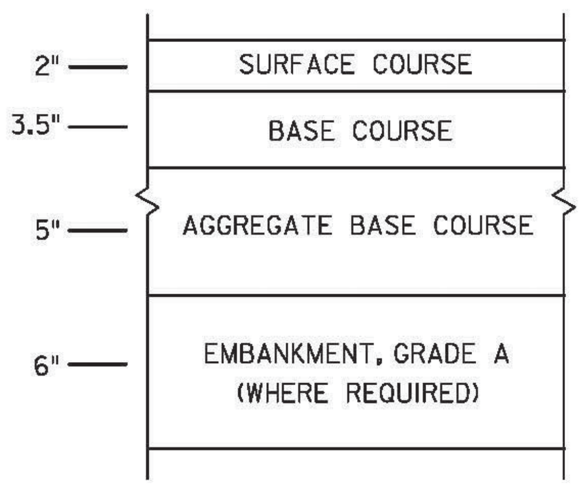


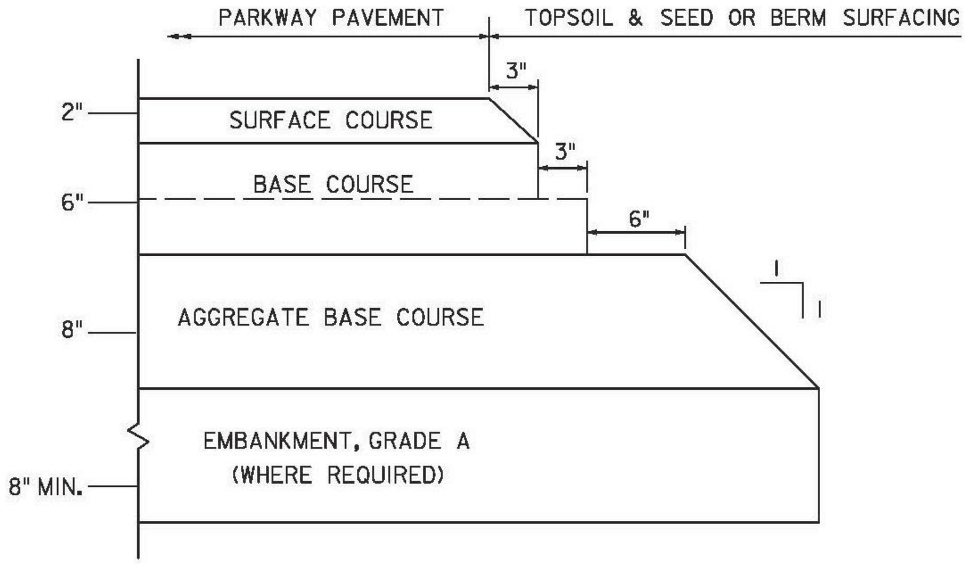
Exhibit 6-21 Parkway Car Parking Pavement Section



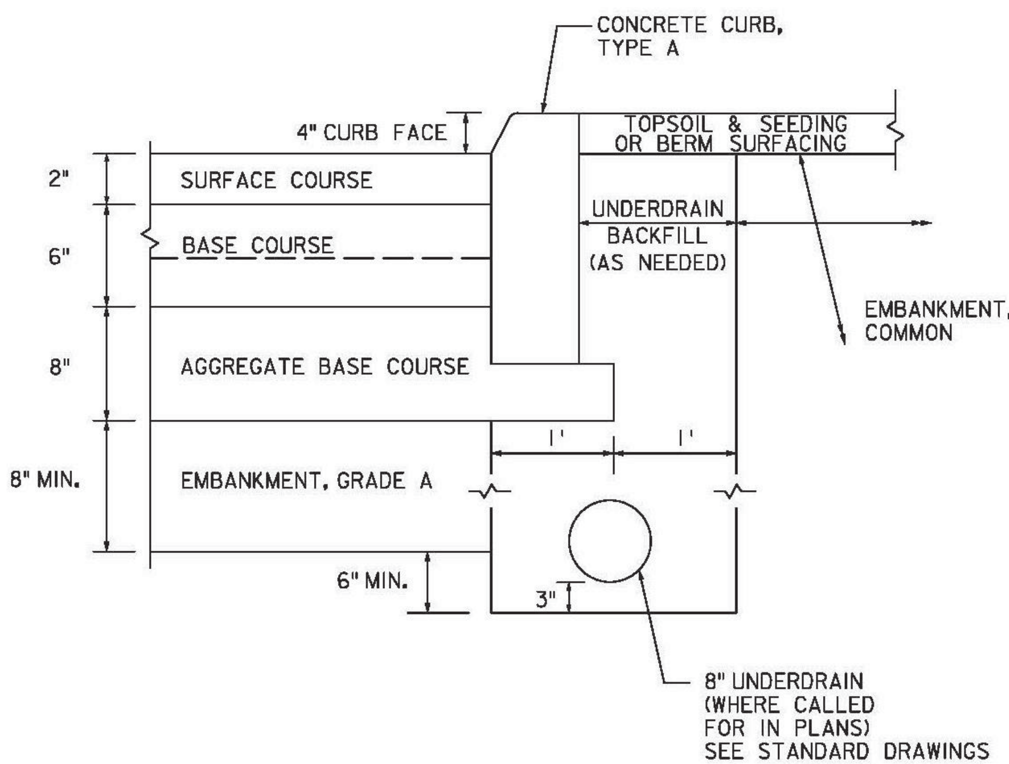
NOTE:

TRUCK PARKING AREAS ARE TO BE PAVED WITH PARKWAY PAVEMENT.

Exhibit 6-22 Parkway Pavement Stepping Detail



WITHOUT CURB



WITH CURB

Exhibit 6-23 Parkway Longitudinal Paving Interface

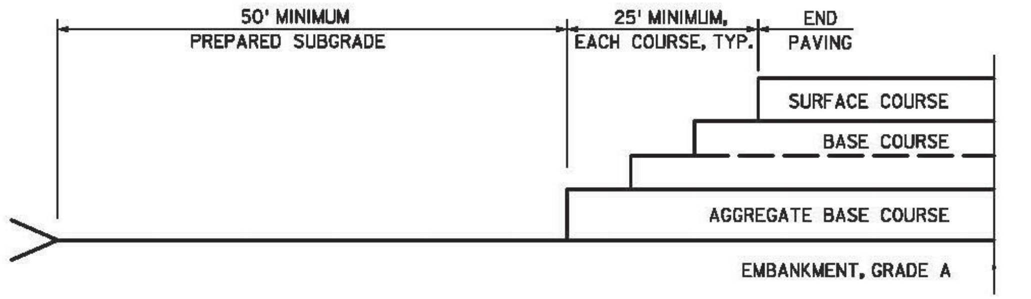


Exhibit 6-24 Parkway New Pavement Interface with Existing Pavement

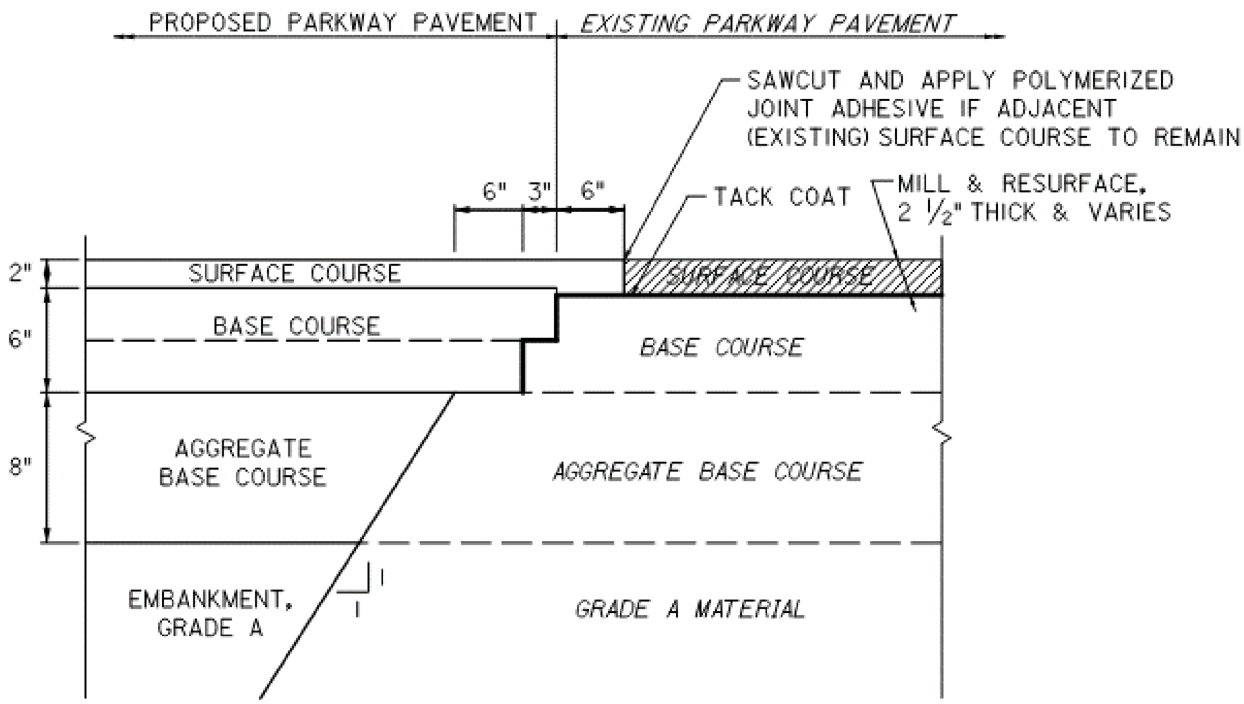


Exhibit 6-25 Parkway Toll Plaza-Transverse/Longitudinal Paving Interface

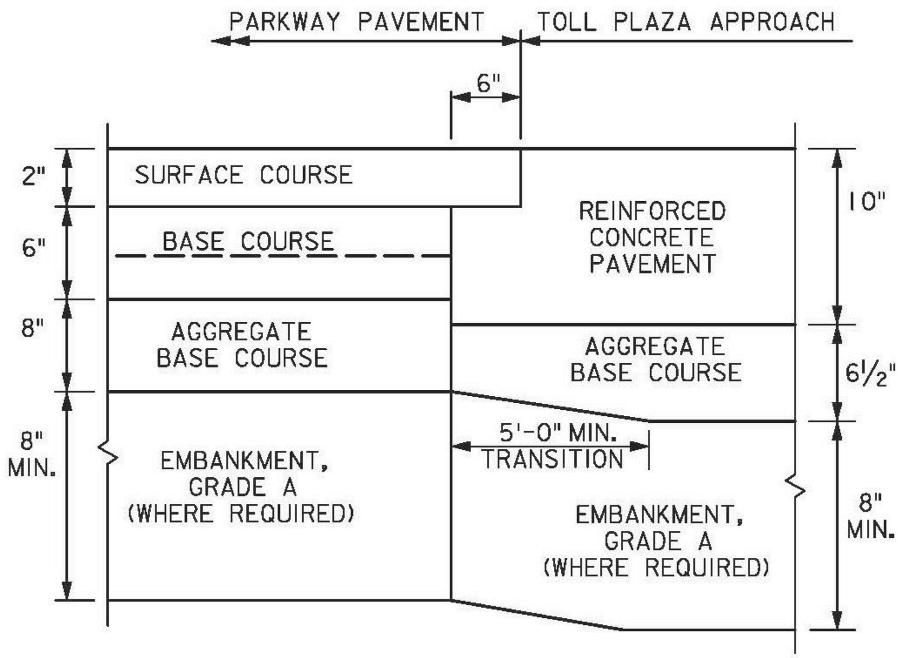


Exhibit 6-26 Parkway Pavement Removal & Reconstruction Detail

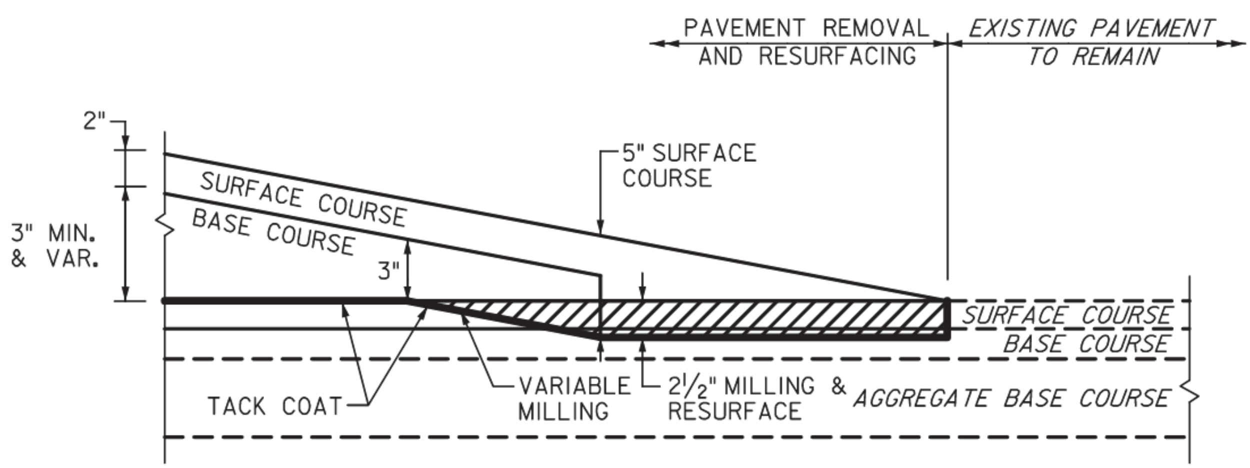


Exhibit 6-27 Sample Risk Analysis Worksheet

RISK ANALYSIS

Risk Identification								Quantitative Analysis					Qualitative Display of the Best Guess Impact			Risk Response Plan		Monitoring and Control			Critical Issue
Priority	Status	ID #	Date Ident. / Project Phase	Project Stage	Summary Description Threat and/or Opportunity	Detailed Description of Risk Event (Specific, Measurable, Attributable, Relevant, Timebound) [SMART]	Risk Trigger	Type	Probability (%)		Risk Impact ($M) and (Month)	Expected Impact ($M)	Probability	Impact	Risk Matrix (Probability of Occurrence by Best Guess Impact)	Strategy	Action To Be Taken (response actions including advantages and disadvantages. Specify the time frame)	Risk Owner	Risk Review Dates	Date, Status and Review Comments (to show the history of risk's monitoring do not delete previous comments)	Is Risk on Critical Path?
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	[10a]	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
EXAMPLE	Active		Mar-06 Phase A	Pre-construction	Threat Reuse Option vs New Foundation Threat	Methods identified to reuse existing foundation may be more expensive than designing a new foundation.	A damaged or fatigued component results in loss of communication	Cost Schedule	40%	MIN MAX BEST GUESS MIN MAX BEST GUESS	4.70$M 26.30$M 8.70$M 0.5Mo 2.0Mo 1.0Mo	0.03	High	Low	Probability: VH H M L VL; Impact: VL L M H VH; x	Acceptance	Notification alarms will alert responsible team personnel of loss of communication throughout the monitoring system. Replacement components will be available, should they fail. Repairs/replacements will be undertaken within 24 hours of notification.	Geotech	2006-Dec-2 2007-Jan-2		YES
EXAMPLE	Active		Mar-06 Phase B	Pre-construction	Opportunity Traffic Control Threat	Issues during construction may require more traffic control.	Excessive noise or vibrations expected during the pile installation.	Cost Schedule	35%	MIN MAX BEST GUESS MIN MAX BEST GUESS	8.80$M 35.00$M 13.20$M 0.6Mo 2.4Mo 1.0Mo	0.45	Moderate	Very Low	Probability: VH H M L VL; Impact: VL L M H VH; x	Avoidance	There is every indication that the impacts associated with pile installation will be less than initially anticipated.	Traffic	2006-Dec-2 2007-Jan-2		YES
EXAMPLE	Active		Mar-06 Phase B	Pre-construction	Opportunity Remaining Service Life of the Existing Foundation Threat	The anticipated remaining service life of the existing foundation may be less than two years.	Based on lab testing, corrosion potential is very high for the site.	Cost Schedule	40%	MIN MAX BEST GUESS MIN MAX BEST GUESS	7.00$M 19.60$M 14.00$M 0.2Mo 1.2Mo 0.4Mo	1.00	High	Low	Probability: VH H M L VL; Impact: VL L M H VH; x	Mitigation	An experienced subcontractor will be utilized with appropriate methods employed to mitigate this potential risk.	Geotech	2006-Dec-2 2007-Jan-2		YES
EXAMPLE	Active		Mar-06 Phase C	Pre-construction	Opportunity Support Current Design Standards Threat	As a result of further analysis, foundation may not be able to support the new design loads	Foundation Loads were very high	Cost Schedule	20%	MIN MAX BEST GUESS MIN MAX BEST GUESS	2.50$M 27.00$M 7.50$M 0.7Mo 8.0Mo 1.1Mo	0.50	Low	Very Low	Probability: VH H M L VL; Impact: VL L M H VH; x	Mitigation	Rehabilitate the foundations to satisfy the current standards.	Geotech	2006-Dec-2 2007-Jan-2		YES
EXAMPLE	Active		Mar-06 Phase C	Pre-construction	Opportunity Support Current Design Standards Threat	Identification of major flaws in existing foundation due to poor design, damage during construction or after construction.	Piles exceed deflection tolerance.	Cost Schedule	15%	MIN MAX BEST GUESS MIN MAX BEST GUESS	1.50$M 10.00$M 3.00$M 0.5Mo 1.0Mo 0.8Mo	3.50	Very Low	NO RISK	Probability: VH H M L VL; Impact: VL L M H VH	Mitigation	Strengthen the existing foundations	Structures	2006-Dec-2 2007-Jan-2		YES

Risk Identification (1) – (8): It determines, describes, and characterizes the risks that might affect the project. The risk identification is an iterative process as new risks may come to light as the project progresses.

(1) **Priority -** provides ranking of importance.

(2) **Status -** offers three options to choose from:
- **Active -** the risk is actively monitored and controlled.
- **Dormant -** the risk is in low priority but may become high priority in the future.
- **Retired -** the risk is demised and its contribution equals zero.

(3) **ID# -** assigns a unique number to the risk for tracking purposes.

(4) **Date Identified and Project Management Phase** - represents the date and project management phase (Phase A, B, C, D & Construction) at which the risk was first identified.

(5) **Project Stage -** lists project delivery stages: Preconstruction and Construction.

(6) **Summary Description (Threat and/or Opportunity) -** presents a summary of risk's definitions and outcomes:
- **Threat -** the risk outcome provides negative impact on the project, higher cost and/or longer duration, which should be minimized.
- **Opportunity –** the risk outcome provides positive impact to the project, lower cost and/or shorter duration, which should be maximized.

(7) **Detailed Description of Risk Event (SMART) -** stands for Specific, Measurable, Attributable (a cause is indicated), Relevant, and Timebound.

(8) **Risk Trigger -** highlights symptoms and warning signs that point to the likelihood of occurrence. This information is essential to timely implementation of the Risk Response Plan.

Quantitative Analysis (9) - (12): It analyzes numerically the probability of occurrence and consequences of risk impact. Please, note that the "BEST GUESS" value should not be too close to lowest or highest value.

Qualitative Display of the Best Guess Impact (13) - (15): It displays the results of the Risk Quantitative Analysis.

Risk Response Plan (16) – (17): It identifies strategies and actions, developed by The Project Manager and the team, to address the risk. The strategies are:
- **Avoidance -** adopting changes to the project plan aimed at eliminating the risk or protecting the project objectives from risk's impact. This can be achieved by changing scope, adding time or resources thus relaxing the so-called "triple constra".
- **Transference -** transferring the financial impact of the risk by contracting out some work. Its success depends on the contractor's ability to reduce risk.
- **Mitigation -** reducing the probability or consequences of risk's impact to an acceptable threshold. It can be accomplished through some means specific to the project and the risk. However, mitigation is costly and time consuming.
- **Acceptance -** the Project Manager and the team accept the risk.

Monitoring and Control (18) – (20): It identifies and assigns parties to handle each risk response. This process ensures that each risk has an owner. Risk monitoring and control continues throughout the life of the project.
If an unanticipated risk emerges, or a risk's impact appears greater than expected, the planned response strategy and actions may not be adequate. The Project Manager and the team must apply additional response strategies and take actions to stay in control of the risk, for example:
- Choose alternative response strategy,
- Implement a contingency plan,
- Take corrective actions,
- Re-plan the project.

The Task Manager, assigned to the risk, reports periodically to the Project Manager on the effectiveness of the plan, unintended consequences, and makes suggestions on mid-course corrections to further mitigate the risk.

Critical Issue (21): It determines whether the risk is on the Critical Path, because if it is not, its value doesn't influence the total project duration.

APPENDIX A
Sample Boring Specifications

Sample Boring Specifications

The contract between the Engineer and the Boring Contractor shall contain all clauses of the contract between the Authority and the Engineer (often referred to as 'flow down clauses'). In addition, the Engineer-Test Boring Contract shall contain the following clauses specific to performing work within the Authority right-of-way.

1.1. Jurisdiction and Authority of the State Police

Traffic on Authority facilities is under the direct supervision and control of the New Jersey State Police who will enforce all statutory laws including the Authority's established "Regulations Relating to the Control of Traffic on the New Jersey Turnpike and Garden State Parkway", as they pertain to the Contractor as well as to the traveling public. A copy of the Regulations will be included with the Contract documents; additional copies will be issued upon request. The Boring Contractor shall familiarize themselves with and adhere strictly to the requirements of these Regulations and to the requirements of the Specifications.

If the State Police should observe any hazardous condition connected with or related to the Boring Contractor's operations, or of any violation of the Authority Regulations they will so notify the Boring Contractor and all work related to such hazardous condition or violation shall immediately be stopped and prompt remedial action shall be taken by the Boring Contractor, to the satisfaction of the NJTA Operations Department, before such work is resumed. All cost incurred as a result of discontinuing the work, and of all remedial action required, shall be borne entirely by the Boring Contractor without recourse against the Authority.

1.2. Traffic Permit

The Boring Contractor shall not commence work under this Contract, which would require occupation of or entry upon any Authority facility until they have been issued a Traffic Permit. Guidelines provided in the latest edition of NJTA Manual for Traffic Control in Work Zones shall be followed and the NJTA Traffic Permit Application (http://www.state.nj.us/turnpike/professional-services.html) completed. NJTA's online Traffic Closure Portal (http://tplc.newjerseyturnpike.com) shall be used for all lane closings, shoulder closings, and slowdowns requests.

At least ten working days prior to the time the Boring Contractor intends to occupy any portion of Authority facilities or intends to start any operations affecting Authority Traffic, and from time to time thereafter as directed by the Engineer, the Boring Contractor shall apply for a traffic permit and submit complete details of the intended methods to employ for the safe restriction to the movement of traffic required for their operations. These methods will be reviewed by the Engineer and when satisfactory, approved. Methods not approved will be returned for revision and shall be resubmitted for final review. Approval by the Engineer will be in the form of a Traffic Permit issued to the Boring Contractor by the NJTA Operations Department through the Engineer. No operations will be performed by the Contractor within 30 feet of a traveled lane until a Traffic Permit has been issued.

The Boring Contractor's methods submitted for approval shall include complete information, the data and/or sketches covering the following:

1. The nature and location of the work.
2. The proposed obstructions or other hazards to traffic, including all operations within 30 feet of a traveled lane.
3. The length of time during which it is anticipated that hazards or obstructions to traffic will exist.

4. The means proposed by the Boring Contractor for the protection of the public and their own personnel and equipment, including layouts and schedules showing the anticipated lane and shoulder closings, truck protection of traffic, and anticipated dates and rates of work.
5. The names and the day and night telephone numbers of the Boring Contractor's Superintendents assigned to the Project.

When work is not progressing in accordance with the Traffic Permit and when directed by the Engineer, the Boring Contractor shall revise the details of their plan of operations and resubmit them for approval. Such revisions, when approved by the Engineer, will form the basis of an Addendum to the Traffic Permit. Work affected by the revisions shall not be undertaken until an Addendum to the Traffic Permit has been issued.

If the approved methods of operations or revisions thereto, submitted by the Boring Contractor for a Traffic Permit are not strictly adhered to by the Contractor, the Engineer shall have the right to revoke the permit, and when so revoked, all work which, in the opinion of the Engineer, will affect the maintenance and protection of traffic, shall be summarily discontinued. The Permit will not be renewed and such work shall not be resumed until the Engineer is assured and satisfied that the Boring Contractor will perform the work in conformity with the approved methods of operations. The Boring Contractor shall have no claim against the Authority or Engineer for losses or delays caused by the revocation of the Permit.

1.3. Maintenance and Protection of Traffic

When any portion of the work under this Contract requires one or more traffic lane(s) and/or one or more shoulder of an Authority roadway be closed, such closings shall be made only at the times, to the limits, and in the manner that the movement of traffic by the closings will be at a minimum, and that all traffic moving on portions of the roadway not closed will be able to flow smoothly, and will be protected from all hazards attendant on the Boring Contractor's operations because of the closings, all in accordance with the requirements of the latest edition of NJTA Manual for Traffic Control in Work Zones. NJTA's online Traffic Closure Portal (http://tplc.newjerseyturnpike.com) shall be used for all lane closings, shoulder closings, and slowdowns requests.

The Boring Contractor is advised that Authority facilities are in continuous operation 24 hours a day, 7 days a week, and that the work under this Contract has been planned to cause no interference or as little interference to traffic as possible. The Boring Contractor shall, therefore, plan their operations to permit the continuous flow of traffic along the roadways.

It is the intent of the Contract to limit toll lane and shoulder closings to an absolute minimum and that work requiring closings be carried out in an expeditious manner.

The work for maintenance and protection of traffic is a joint Contractor and Authority effort and consists in general of furnishing and/or placing traffic protection devices for closing lanes and shoulders; furnishing personnel immediately and solely employed for the maintenance of the devices and protection of the traveling public; the transportation of devices to and from the site of the Project; placing or installing the devices; moving devices from one position to another as required; all in accordance with the Traffic Permit, the Plans and the General and Special Provisions of the Contract. Confirm with the Maintenance Department if the Authority will provide maintenance and protection of traffic.

No signs except traffic protection signs and traffic direction signs specified or as directed by the Engineer shall be erected by the Boring Contractor or their subcontractors on or near the Authority right of way.

The safety measures outlined and prescribed shall be considered elementary only and not necessarily sufficient in every instance to guarantee the protection of the traveling public. Compliance with the safety measures and precautions prescribed in the Specifications and on the Plans shall not relieve the Boring Contractor of responsibility for taking all necessary measures to protect and safeguard the public, nor relieve them of responsibility for the installation of adequate safety measures and for the protection of the traveling public and their own personnel on Authority roadways and premises, shall rest with the Boring Contractor. The cost of safety measures for which payment is not specifically provided under scheduled items in the Proposal, shall be included in the prices bid for the various items scheduled in the Proposal.

1.3.1. Lane and Shoulder Closings

(a). Condition and Situation Requirements

The Boring Contractor’s personnel, vehicles or equipment shall not occupy any part of a toll lane, through lane, ramp, or shoulder until the lane or shoulder has been closed.

The Boring Contractor’s personnel, vehicles or equipment shall not occupy any area within 30 feet from the outside edge of a shoulder where there is no guide rail (typ.) until the shoulder has been closed. The storage of materials and equipment will be permitted within the Authority right of way only at specific locations to be designated by the Engineer which shall be not less than 30 feet from outside edge of shoulder or behind guide rail (typ.).

Whenever any equipment occupying a shoulder or through lane and not behind barrier curb will be within 3 feet of a traveled lane or will come within three feet when operated (such as a tractor, or a crane swinging), the lane adjacent to the shoulder shall also be closed.

Materials or equipment shall not be stored in a closed lane or shoulder unless protected by barrier curb.

(b). Times for Closings

Because of heavy traffic during morning and evening commuter rush hours, on weekends, over holidays, and during the summer vacation periods (between Memorial Day and Labor Day) the times or hours when a toll lane or lanes may be closed and work requiring toll lane closings may be performed, are limited.

Toll Lane Closings Permitted. Toll lanes may be closed, and work requiring toll lanes to be closed may be performed only during the times prescribed in the Special Provisions of the Contract.

Shoulder Closings Permitted. Shoulder closings by use of cones, as necessitated by work in progress, will be permitted at any time except that simultaneous closing of both the right and left shoulder of a roadway will not be permitted.

Work requiring the use of barrier curb shall be completed at the earliest time so that prompt removal of the curb can be accomplished.

Emergency Closings. When it becomes necessary, in the opinion of the Chief Engineer, to make prompt repairs to work in progress or to other facilities that are damaged, the lanes will be closed. In such event the Boring Contractor shall provide all the materials and manpower necessary, and shall work continuously on a 24 hour per day basis to complete the emergency repairs and again make all lanes available to use by public traffic. Compensation for emergency repairs of damage beyond the Boring Contractor's control will be paid on a cost-plus basis as specified in the New Jersey Turnpike Authority's Standard Specifications or on such other basis as agreed upon by the Contractor and the Engineer. All costs incurred as a result of emergency repairs of damage caused solely by the Contractor's procedures shall be borne entirely by the Contractor.

(c). Number and Length

During permissible lane closing hours, no more than one traffic lane may be closed at any one time in any one work area unless multiple traffic lane closings are permitted in the Special Provisions of the Contract.

All shoulder closings shall be of the shortest overall length necessary to protect traffic from a hazardous condition. It is essential that as much shoulder as possible be kept open for use by disabled vehicles.

(d). Methods

Toll lanes and shoulders shall be closed in accordance with the Specifications and with the typical closing procedure and traffic protection devices shown on the New Jersey Turnpike Authority Standard Drawings.

The Boring Contractor shall give the Engineer 48-hour prior notice of the proposed time to place or remove any toll lane closing.

The traffic protection devices (cones and/or pylons) for closing a toll lane or shoulder shall always be set up progressively in the direction of traffic from a truck equipped with not less than two approved six inch diameter flashing vehicle lights to warn traffic, and with the truck traveling in the lane or shoulder to be closed. The protection devices shall always be removed in the reverse order by the truck backing up in the closed toll lane or shoulder.

The Boring Contractor's personnel shall, while working on foot, wear a sleeveless vest the same as that specified below to be worn.

1.3.2. Movement of Contractor's Vehicles, Equipment and Personnel

(a). General

Pedestrians are not allowed on Authority roadways at any time; the Boring Contractor's employees shall not walk across any Authority roadway, nor walk along any Authority roadway except within areas coned off or otherwise closed to the traveling public.

The Boring Contractor shall be responsible for transporting all their personnel, in accordance with N.J.S.A. 39.4-69-Riding on Part Not Intended for Passengers Prohibited, to and from enclosed or closed-off work areas. Personal vehicles will not be permitted to park anywhere within Authority or private properties except in areas designated by the Engineer. Whenever the Boring Contractor's vehicles operate on any Authority roadway or ramp pavement which is open to traffic, travel shall always be with and not across or against traffic.

Whenever the Boring Contractor intends to transport oversize or slow moving equipment, or any equipment whose movement may be disruptive to the traveling public, on Authority roadways open to the public, they shall first notify the Engineer or the Engineer's duly authorized representative at least 24 hours in advance of the intended move and the Engineer will establish the time and the route to be taken. At least two approved flashing vehicle lights shall be mounted on all slow moving vehicles.

Vehicles shall enter and leave work areas in a manner which will not be hazardous to or interfere with traffic. During permissible times for lane closings or shoulder closings, automobiles operated solely for the transportation of supervisory personnel, or approved GFRs will be allowed access to the work site provided such vehicles are operated in a safe manner.

Vehicles shall not park or stop in roadways or on shoulders except within areas of toll lanes or shoulders coned off or otherwise closed to the traveling public.

Unless otherwise specified the Boring Contractor's vehicles will not be permitted to use Z-turns, median U-turns, grade separated U-turns, or make U-turns across the median or in any Toll Plaza area. Any vehicle making an illegal turn will be subject to a summons by the State Police.

When, in the opinion of the Engineer, the security of the Authority roadways might become endangered by an operation of the contractor, their subcontractors or suppliers which would permit unauthorized entry to or exit from Authority property, the Boring Contractor shall take immediate measures to restore the security of the Authority right of way.

(b). Vehicle Access to Work Areas

The Boring Contractor's vehicles entering or leaving a work area via the Authority roadways shall be operated in a safe manner without creating any hazard or danger to the traveling public. They shall leave and enter the traffic stream at designated points, as shown on the Plans, or as specified herein, or as directed by the Engineer.

Delivery of materials or personnel and movement of vehicles and equipment, into and out of a work area via the Authority roadways shall be made only during the times for closings prescribed above.

(c). Traffic Protection Devices

Whenever the Boring Contractor's work requires closing of any toll lane or shoulder, the Authority will furnish, at no cost to the Boring Contractor certain traffic protection devices required for the Project. These devices will be identified and listed in the Special Provisions of the Contract.

1.4. Authority's Utilities:

The Plans indicate the locations of some subsurface structures within the vicinity of the proposed borings. The Boring Contractor shall not proceed with their work at any one boring location until diligent inquiries have been made at the office of the Engineer, utilities and private companies and municipal authorities, to determine the existence and exact locations of subsurface structures. The Boring Contractor shall also comply with the State's Underground Facility Protection Act and notify the State's One Call System before performing any work. The Boring Contractor shall exercise extreme care in accurately locating all utilities and in carrying out operations, and shall be solely responsible for any damages caused to utilities and to the facilities affected by such utility damage, whether such utilities are shown on any available plan or not.

The Boring Contractor shall fill all holes caused by their operations and shall take every precaution against injuring paving, utilities, or private or public property, and shall promptly repair, at their own expense and to the satisfaction of the Engineer and the owners, any damage to such paving, utilities and property caused by their operations. This shall also include sodding of any areas where the grass is damaged.

Upon completion of the Boring Contractor’s operations at each site, they shall remove their equipment therefore, including pulling all casing and shall clear the area of all debris and restore it to the condition existing before the start of their operations.

APPENDIX B1
Modified Burmister Soil Identification System

MODIFIED BURMISTER SOIL IDENTIFICATION SYSTEM

IDENTIFICATION OF SOILS

A. Object

Included herein is the Modified Burmister System for identification of soils that is to be used by the GE and GFR. It provides a concise and accurate description of the soil, yet is simple enough to determine the soil components by visual identification.

This system provides a description of the granular materials, Silt, Sand and Gravel, that is based upon particle size. The description of cohesive soils is based upon the plasticity. The criteria for soil identification using this system are noted later with examples.

B. Modified Burmister Soil Identification System

Following in outline form, are the criteria for the identification of soils. Figure B1-1 summarizes this system and Figure B1-2 shows the standard semi-log graph used for graphic presentation of soils identifications. The plot gives the Percentage Finer by Weight vs. Grain Size in Millimeters. Beneath the graph are the particle size limits of the soil components used for the identification system.

1. Particle Size Limits for Soil Components.

(a) Cobbles and Boulders: Greater than 3 inch diameter (76.2 MM)

(b) Gravel: 3 inch diameter (76.2 MM) to No. 10 sieve (2.0 MM)

(c) Sand: No. 10 Sieve (2.0 MM) to No. 200 Sieve (0.074 MM)

(d) Silt: Material passing the No. 200 Sieve (0.074 MM) of a non-plastic nature

(e) Clay: Material passing the No. 200 Sieve (0.074 MM) of plastic nature

(f) Miscellaneous: Materials such as mica, shells, organic silt, peat, decomposed bedrock in place, etc. These materials are described per se, without regard to grain size.

2. Particle Size Limits for Granular Soil Functions.

The above mentioned constituents in Categories b, c and d are further sub-divided into coarse, medium and fine components.

Following is a list of the component parts of the above mentioned constituents and their size limits:

(a) Gravel Coarse: Less than 3 inches (76.2 MM) Greater than 1 inch (25.4 MM)

Medium: Less than 1 inch (25.4 MM) Greater than 3/8 inch (9.52 MM)

Fine: Less than 3/8 inch (9.52 MM) Greater than No. 10 Sieve (2.0 MM)

(b) Sand - Coarse: Less than No. 10 Sieve (2.0 MM) Greater than No. 30 Sieve (0.59 MM)

Medium- Less than No. 30 Sieve (0.59 MM) Greater than 60 Sieve (0.25 MM)

Fine: Less than No. 60 Sieve (0.59 MM) Greater than No. 200 Sieve (0.074 MM)

(c) Silt - Coarse: Material passing the No. 200 Sieve that is free draining in character

Fine: Material passing the No. 200 Sieve that is slow draining in character

The predominant fraction of any constituent can be noted by a plus sign. For example:

Mainly coarse Gravel = “Coarse + to fine Gravel” or

Mainly fine Sand = “Medium to fine + Sand”

3. Quantitative Description of Granular Components.

Soils that are essentially granular in character are identified by the classification system outlined above and are described on this basis and by the percentages by weight of each component part. Descriptive adjectives therefore precede the name of the soil component, which cover a rather narrow range of percentages of that component, by weight. Following is a list of descriptive adjectives and the percentage range of the total soil sample that they represent.

a. Not described	Less than 1%
b. Trace	1-10%
c. Little	10-20%
d. Some	30-35%
e. And	35-50%

4. Description of Granular Soil.

The major constituent of the soil sample is written in upper case letters. The minor components are written, along with their descriptive adjectives in lower case letters. Commas separate the various components. The color of the soil precedes the description.

Example: A soil sample is composed of the following percentages by weight of the various components.

Gravel (Medium and Fine only)	25%
Sand (Coarse, Medium & Fine Combined)	70%
Silt (Coarse & Fine Combined)	5%

The soil color is brown.

The written description of the soil is as follows:

“Brown coarse to fine SAND, some medium to fine Gravel, trace Silt”

5. Description of Cohesive Soil.

For soils that are essentially cohesive in character, the clay-silt fraction is described on the basis of plasticity, since silt and clay in intimate combination cannot be easily separated. The soil is described then, on the basis of its plasticity index, which is a function of the types of clay minerals present, and of the clay-silt ratio. Following is a list of terms used to describe the clay-silt fraction of a soil, along with its range of plasticity indices.

Description	Plasticity Index
Silt	0
Clayey Silt	1 -5
Silt & Clay	5 -10
Clay & Silt	10-20
Silty Clay	20 - 40
Clay	Greater than 40
Organic Clayey Silt,	An organic soil,
Organic Silt & Clay, etc.	usually black in color.

The description, based on plasticity index, is the same as for ordinary clays and silts.

Example: A soil sample contains the following percentage by weight of these soil components:

Gray Gravel	15%(fine Gravel only)
Gray Sand	30%(all components)
Gray Silt-Clay	50%(Plasticity Index of 15)
Shell Material	5%

The above soil sample is described as follows:

"Gray CLAY & SILT, some coarse to fine Sand, little fine Gravel, trace Shells."

6. Shorthand - For Field Use Only

Symbol	Word
C	Clay
$	Silt
S	Sand
G	Gravel
O$	Organic Silt
c	Coarse
m	Medium
f	Fine
t	Trace
l	Little
s	Some

Symbol	Word
and	And

C. Visual Identification of Soils.

To facilitate visual identifications of soils in the field, the following methods are recommended. The use of these methods will provide easy and accurate identifications of soils with a little practice.

The best approach is to identify each sample by following a series of steps, as outlined below:

1. Color

   Determine the color or colors if the sample is mottled.

2. Gravel Content

   Determine the percent of the total sample that is gravel by separating out the gravel and estimating by eye. Allowance should be made for fine gravel that was missed when picking over the sample.

3. Gravel Gradation

   The size of the largest piece of gravel should be determined. Use an average dimension, not the maximum dimension. Estimate by eye the predominant size. If there is a predominant size, note with a plus sign as shown in Section 2.

4. Sand Content

   After separating the gravel, take a pinch of the remaining soil and rub it between the fingers and thumb. The presence of coarse and medium sand can be noted by a gritty feeling. By rubbing in the palm of the hand with a finger, the soil can be dried. The sand grains can then be distinguished and the percentage of sand in the Sand-Silt-Clay portion of the sample noted. This percentage should be corrected for the whole sample, to include the gravel, as illustrated below.

Gravel separated out	30%
Remaining Sand-Silt-Clay portion of sample	70%
Sand content of Sand-Silt-Clay portion of sample	50%
Sand content of whole sample = 50 x 70	35%

5. Sand Gradation

   By drying a pinch of the sample in the palm of the hand as previously noted, the gradation of the sample can be determined. An easy way to distinguish between fine Sand and Silt is that the individual grains of the Sand can be distinguished by eye whereas the individual grains of Silt cannot.

6. Silt-Clay Content

   Moisten a 1/2 inch diameter ball made from the Sand-Silt-Clay portion of the sample. Shake this ball in the palm of the hand and notice if moisture appears on the surface of the ball. If moisture appears, no clay is present; if no moisture appears, there is clay in the sample. If moisture appears on the surface of the ball, gently squeeze the ball between the forefinger and the thumb till the moisture disappears, then release. If moisture reappears, the sample is coarse Silt; if no moisture appears, or appears very slowly the sample is coarse and fine Silt.

For soils that contain both Silt and Clay, or Clay only, the plasticity index can be estimated by a rather simple test. A 1/2 inch diameter ball of the soil is made. The consistency or strength of the ball is brought to that of modeling clay by drying or adding moisture to the ball of soil. A piece of the ball is then rolled into a thread on a flat surface, and the diameter at which the thread crumbles indicates the Clay-Silt content, as noted below:

Thread Diameter	Plasticity Index	Identification
¼”	0	SILT
¼”	1- 5	Clayey SILT
1/8”	5-10	SILT & CLAY
1/16”	10 - 20	CLAY & SILT
1/32”	20 - 40	Silty CLAY
1/64”	40	CLAY

It is helpful to have a 1/2 inch diameter ball of modeling clay available when performing the test. By squeezing the clay in one hand, and the soil in the other with the index finger and thumb, a good check on the consistency can be made by comparison.

7. Another test to help determine the soil plasticity is the resistance of a piece of dried soil to crushing by finger pressure. A soil specimen is molded to the consistency of putty, adding water if necessary. The moist pat of soil is allowed to dry (in oven, sun, or air) and is then crumbled between the fingers. Soils with slight dry strength crumble readily with very little finger pressure. Silt soils have almost no dry strength. Organic soils and clayey silt soils of low plasticity have slight dry strength. Soils of medium dry strength require considerable finger pressure to powder the sample. Silt and clay and clay and silt soils exhibit medium dry strength. Soils with high dry strength can be broken but cannot be powered by finger pressure. High dry strength is indicative of silty clay or clay soils as well as some organic clays of high plasticity.

An additional aid in classifying soil types that consist of various components of sand, silt and clay is the sedimentation test in a glass jar or test tube. The various percentages of the components are estimated from the sedimentation test which is performed as follows:

A small quantity of soil is placed in the bottom one-half or one-quarter of a test tube or jar such that it is compact without any large air spaces. The height of sample is then noted. A supply of water is then added to the test tube and the test tube is vigorously shaken until the soil sample is entirely in suspension. All sand particles should settle out of the suspension within 30 seconds after the shaking has stopped. The silt particles will settle out of the suspension within

30 minutes after the shaking has stopped. The relative depth of sand and silt to the original depth of sample will provide for an estimate of the percentage of sand and silt in the total sample. The clay will still be all in suspension at the end of 30 minutes and it may take up to 24 hours for all the clay to settle out. Therefore, there is no advantage in performing the test more than 30 minutes.

Figure B1-1

MODIFIED BURMISTER SOIL IDENTIFICATION METHOD

1. SOIL MATERIALComposition, Gradation, and Plasticity Characteristics

a) Soil Components and Soil Fractions

Sieve	3"	1"	3/8"	No. 10 2 mm	No. 30	No. 60	No. 200 0.076 mm	0.02 mm
Granular Components Fractions	GRAVEL coarse	medium	fine	SAND coarse	medium	fine	SILT coarse	fine
Clay Soil Components							CLAY-SOIL Defined and named on a Plasticity Basis	

b) Identifying Terms for Granular Soils
Composition and Proportion Terms for Components

Component		Proportions Terms	Defining Range of Percentages
Principal Components - GRAVEL, SAND, SILT (all capitals)			
Minor Components -	Gravel	and	35 to 50%
	Sand	some	20 to 35%
	Silt	little	10 to 20%
		trace	1 to 10%

Gradation Terms for Granular Soils				ORGANIC SOILS
coarse	to	fine	all fractions are more than 10%	Plasticity Basis, as
coarse	to	medium	fine less than 10%	
medium	to	fine	coarse less than 10%	Organic SILT, H. PI
medium			coarse and fine less than 10%	
fine			coarse and medium less than 10%	Organic SILT, L. PI

PLUS or minus signs used to indicate nearer upper or lower limits.

c) Identifying Terms for CLAY, Soils. Plasticity Basis for Combined Silt
And Clay Components, Expressing the Relative Dominance of Clay.

Overall plasticity	Plasticity Index			Principal Component	Minor Component
Non-Plastic		0		SILT	Silt
Slight	1	to	5	Clayey SILT	Clayey Silt
Low	5	to	10	SILT & CLAY	Silt & Clay
Medium	10	to	20	CLAY & SILT	Clay & Silt
High	20	to	40	Silty CLAY	
Very High		more than	40	CLAY	

Example: Soil 60% coarse to fine Sand, 25% medium to fine Gravel, 15% Clayey Silt and color-brown.

Identification: Br. Coarse to fine SAND, some medium to fine Gravel, little Clayey Silt.

Reference:

1) D.M. Burmister, "Principles and Techniques of Soil Identification" 29th Highway Research Board Proceedings, 1949.

2) "Identification and Classification of Soils - An appraisal and Statement of Principles," ASTM Special Publication No. 113, 1951

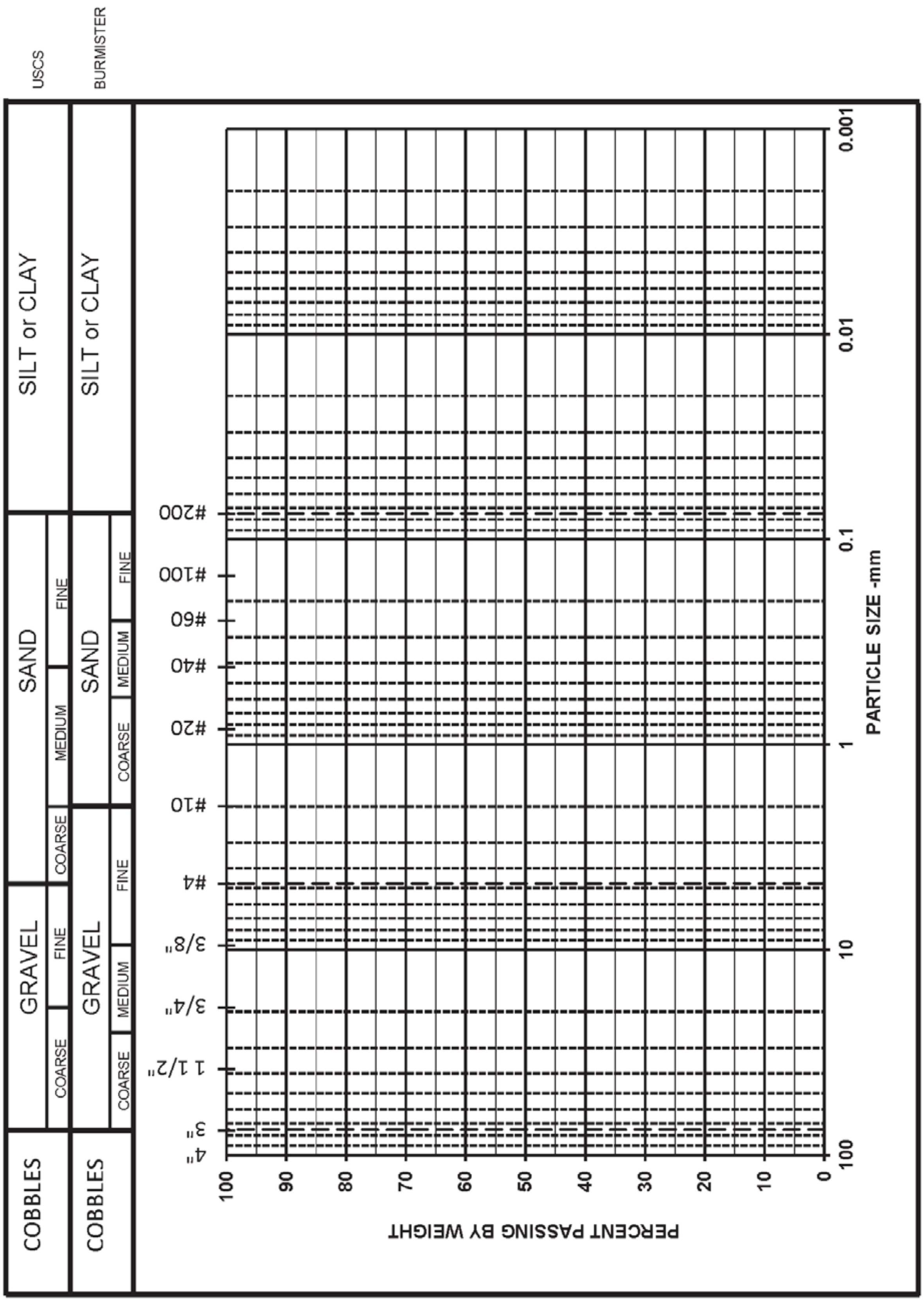

USCS
BURMISTER
SILT or CLAY
SILT or CLAY
SAND
FINE
MEDIUM
COARSE
SAND
FINE
MEDIUM
COARSE
GRAVEL
FINE
COARSE
GRAVEL
FINE
MEDIUM
COARSE
COBBLES
COBBLES
#200
#100
#60
#40
#20
#10
#4
3/8"
3/4"
1 1/2"
3"
4"
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING BY WEIGHT
0.001
0.01
0.1
1
10
100
PARTICLE SIZE -mm

Figure B1-2

APPENDIX B2
Rock Identification System

ROCK CLASSIFICATION AND LOGGING

IDENTIFICATION OF ROCKS

A. Object

The basic objectives of classifying and logging core are to provide accurate and concise record of the important geological and physical characteristics of engineering significance. Data reported in geologic logs not only must be accurate, consistently recorded, and concise, but also must provide quantitative and qualitative descriptions.

Most engineering rock shear strength parameters, published in recent AASHTO and FHWA documents, are functions of the two rock classification systems Rock Mass Rating (RMR) Geomechanics Classification and Geological Strength Index (GSI) Classification Systems.

Core logs are to be prepared such that necessary information to estimated shear strength parameters of rock. In addition, further need for additional exploration or testing, final design criteria, treatment design, methods of construction, and the evaluation of structure performance may depend on core logs.

Rock core logs with adequate descriptions of recovered cores and samples shall be prepared through visual or hand specimen examination of the core with the aid of simple field tests using the following classification.

The order of classification terminology for identification of rock core samples will follow the following order:

Core Data	Run	Elevation	
		Sample Number	
		Depth Range	
		Core Time	
	Water	Gain/Loss	
	Rock Core	Number of Pieces	
		Recovery	
		RQD	
Rock Description	General	Rock Type	
		Color	
		Weathering	
		Strength	
	Fabric	Grain Size	
		Grain Shape	
	Structure	Fracture Spacing	
		Bedding Spacing	
		Foliation Angle	
Discontinuity Description	Planes	Fracture Type	
		Fracture Aperture	
	Joints	Joint Surface	Shape
			Roughness
		Joint Infilling	
		Water Content	
		Joint Roughness Coefficient	
Lab Testing	Strength		
	Unit Weight		
	Other Tests		

B. Rock Classification

1. Rock Core Data

(a) Recovery

The core recovery is the length of rock core recovered from a core run. The recovery ratio is the ratio of the length of core recovered to the total length of the core drilled on a given run, expressed as a percentage. Core length should be measured along the core centerline. When the recovery is less than the length of the core run, the non-recovered section should be assumed to be at the end of the run unless there is reason to suspect otherwise (e.g., weathered zone, drop of rods, plugging during drilling, loss of fluid, and rolled or re-cut pieces of core). The correct procedure for measuring the recovery is illustrated in Figure B2-1.

(b) Rock Quality Designation (RQD)

The RQD is a quantitative measure that represents a modified core recovery percentage. By definition the RQD is the sum of the lengths of all pieces of sound core over 4 inches long divided by the length of the core run (Deere 1963). The correct procedure for measuring RQD is illustrated in Figure B2-1.

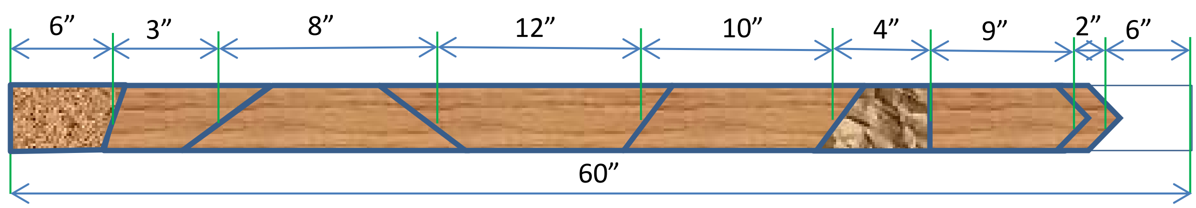


Figure B2-1

Core Run = 60”

Recovery = 6” + 3” + 8” + 12” + 10” + 4” + 9” + 2” = 54”

Recovery % = 54”/60” x 100 = 90 %

RQD = 8” + 12” + 10” + 9” = 39”

RQD % = 39”/60” x 100 = 65 %

2. Rock Description

(a) General

i. Rock Type

Division	Class	Type
Igneous	Coarse-Grained (Intrusive)	Granite
		Diabase
	Fine-Grained (Extrusive)	Basalt
Sedimentary	Calcareous	Limestone
		Dolomite
	Siliceous	Conglomerate
		Sandstone
		Quartzite
		Claystone
		Mudstone
		Siltstone
		Argillite
		Shale
		Chert
Metamorphic	Foliated	Slate
		Phyllite
		Schist
		Amphibolite
		Hornfers
	Nonfoliated	Marble
		Metaquartzite
		Serpentinite
		Gneiss

ii. Color

Record the color of rock core in wet condition using terminology consistent with those used for logging of soil samples. Use descriptive terminology such as light, dark, banded, mottled, streaked and stained if appropriate for a more complete description of rock mass.

iii. Weathering

Weathering can be indicated visually by changes in color and texture of the body of the rock, color and condition of the fracture filings and surfaces, physical properties such as hardness based on the guidelines provided in the tables below.

Term	Description	Grade
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and be somewhat weaker externally than in its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/ or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.	III
Highly Weathered	More than half of the rock material is decomposed and/ or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Note: See table below for definition of rock weathering terminology used in the above rock weathering descriptions.

Term	Discoloration Extent	Fracture Condition	Material Condition	Grade
Fresh	No discoloration or oxidization	Slight to no discoloration	Unchanged	I
Slightly Weathered	Discoloration/oxidation penetrates a short distance away from fracture	Discolored; may contain soil or altered mineral filling	Partial Discoloration	II
Moderately Weathered	Significant discoloration/ oxidation. Penetrates a significant distance away from fracture	Discolored; may contain soil or altered mineral filling	Partial to complete discoloration; Parent rock/ minerals beginning to decompose into soil	III

Term	Discoloration Extent	Fracture Condition	Material Condition	Grade
Completely Weathered	Throughout	-	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact	IV
Residual Soil	Throughout	-	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	V

(Modified From U.S. Department of the Interior, Bureau of Reclamation (2001), *Engineering Geology Field Manual, 2nd Edition, Chapter 4, table 4.4*, and Brown, E.T., 1981, Rock Characterization Testing and Monitoring, ISRM Suggested Methods, p., 31)

Definition of Rock Weathering Terminology

Term	Definition
Fresh	No visible sign of weathering of rock material.
Discolored	The color of the original fresh rock material is changed. The degree of change from the original color should be indicated. If the color change is confined to particular mineral constituents, this should be mentioned.
Decomposed	The rock is weathered to the condition of a soil in which the original material fabric is still intact, but some or all of the mineral grains are decomposed.
Disintegrated	The rock is weathered to the condition of a soil in which the original material fabric is still intact. The rock is friable, but the mineral grains are not decomposed.

iv. Strength

Strength of rock can be described based on field identification method or based on laboratory uniaxial compressive strength based on the guidelines in the following table.

Description	Field Identification	Approximate Range of Uniaxial Compressive Strength (psi)	Grade
Extremely Weak Rock	Indented by thumbnail	36 - 150	R0
Very Weak Rock	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	150 - 725	R1
Weak Rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	725 - 3,600	R2
Medium Strong Rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	3,600 - 7,250	R3
Strong Rock	Specimen requires more than one blow of geological hammer to fracture it.	7,250 - 14,500	R4
Very Strong Rock	Specimen requires many blows of geological hammer to fracture it.	14,500 - 36,000	R5
Extremely Strong Rock	Specimen can only be chipped with geological hammer.	>36,000	R6

(b) Fabric

i. Grain Size

Criteria for Sedimentary Grain Size

Description	Criteria	Group
Very Fine-Grained	Individual grains cannot be distinguished with naked eye; < 0.0029” (0.075 mm)	VF
Fine-Grained	Not visible to barely visible with naked eye; 0.0029”-0.0165” (0.075 mm – 0.425 mm)	FG
Medium grained	Barely to easily visible with naked eye; 0.0165”-0.0787” (0.425 mm – 2.0 mm)	MG

Coarse-Grained	Easily visible; 0.0787”-0.187” (2.0 mm – 4.75 mm)	CG
Very Coarse-Grained	Grains sizes are greater than popcorn kernels ; > 0.187” (4.75 mm)	VC

Criteria for Igneous and Metamorphic Grain Size

Description	Criteria	Group
Pegmatitic	Average crystal size greater 3/8”	P
Coarse-grained	Average crystal size (A) is 3/16” < A <3/8”	CG
Medium Grained	Average crystal size (A) is 1/32” < A < 3/16”	MG
Fine-grained	Average crystal size (A) is 1/250” < A < 1/32”	FG
Aphanitic	Crystal size not visible with naked eye	A

(From Soil and Rock Logging, Classification, and Presentation Manual, 2010, State of California Department of Transportation Division of Engineering Services; Geotechnical Services, Figure 2-27, pg. 27)

ii. Grain Shape

Criteria for Grain Shape

Description	Criteria	Group
Angular	Showing very little evidence of wear. Grain edges and corners are sharp. Secondary corners are numerous and sharp	AG
Subangular	Showing definite effects of wear. Grain edges and corners are slightly rounded off. Secondary corners are slightly less numerous and slightly less sharp than in angular grains	SA
Subrounded	Showing considerable wear. Grain edges and corners are rounded to smooth curves. Secondary corners are reduced greatly in number and highly rounded	SR
Rounded	Showing extreme wear. Grain edges and corners are smoothed off to broad curves. Secondary corners are few in number and rounded	RD
Well Rounded	Completely worn. Grain edges or corners are not present. No secondary edges or corners are present	WR

(c) Structure

Fracture is a terminology used for describing any natural breaks excluding shear zones in geologic material. Bedding features provide the rock anisotropic properties or represent potential failure surfaces. Joint (bedding or foliation joints), bedding plane separation due to stress relief, random fracture (not belonging to a joint set), and mechanical breaks during sampling can be described in terms of fracture/bedding spacing and fracture surface type based on the tables below.

i. Fracture Spacing

Discontinuity Type	**Description**	**Spacing**	**Group**
Fracture Spacing (Joints, Faults, Other Fractures)	Extremely Close	<3/4 in	ECF
	Very Close	3/4 in-2-1/2 in	VCF
	Close	2-1/2 in-8 in	CF
	Moderate	8 in-2 ft.	MF
	Wide	2 ft. - 6 ft.	WF
	Very wide	6 ft. -20 ft.	VWF

ii. Bedding Spacing

Discontinuity Type	**Description**	**Spacing**	**Group**
Bedding Spacing (may include Foliation or Banding)	Thinly Laminated	<1/4 in	TLB
	Laminated	1/4 in -1/2 in	LB
	Very Thin	1/2 in-2 in	VTNB
	Thin	2 in-1 ft.	TNB
	Medium	1 ft. - 3 ft.	MB
	Thick	3 ft.- 10 f	TKB
	Very Thick/Massive	> 10 ft.	VTKB

iii. Foliation Angle

3. Discontinuity Description

(a) Planes

i. Fracture Type

Fracture	Description	Group
Joint	A discontinuity in which there has been no to very little observable relative movement. Joints may be open, healed, or filled; and surfaces may be striated due to minor movement	J
Fault	A discontinuity along which there has been an observable amount of displacement. Faults are rarely single planar units; normally they occur as parallel or sub-parallel sets of discontinuities along which movement has taken place to a greater or less extent.	Ft
Shear	A structural break where differential movement has occurred along a surface or zone of failure; characterized by polished surfaces, striations, slickensides, gouge, breccia, mylonite, or any combination of these.	Sh
Foliation	Parallel orientation of platy minerals or minerals banding in metamorphic rock	Fo
Vein	Fractures filled with secondary crystallization	V
Bedding	A separation along bedding planes after exposure due to stress relief or slaking parallel to the surface of deposition, which may or may not have physical expression. Fractures which are parallel to bedding are termed bedding joints or bedding plane joints.	B

ii. Fracture Aperture

Descriptor	Fracture Width (FW) (in)	Group
Tight	No visible Separation	T
Slightly open	<1/32	SO
Moderately Open	1/32 ≤FW ≤ 1/8	MO
Open	1/8 ≤ FW ≤ 3/8	O
Moderately Wide	3/8 ≤ FW ≤ 1	MW
Wide	1 ≤ FW	W

(From U.S. Department of the Interior, Bureau of Reclamation (2001), *Engineering Geology Field Manual, 2nd Edition, modified from Chapter 5 Table 5.5*)

(b) Joints

i. Joint Surface

Criteria for Describing Surface Shape of Joint

Shape	Description	Group
Planar		P
Undulating		U
Wavy	Waviness is the result from large scale Undulations contained within a rock mass	WU
Stepped		ST
Irregular	No Discernable pattern to surface of joint	IR

(This table should be used in conjunction with criteria for describing roughness of the surface of the joint for a more complete description of the fracture.)

Criteria for Describing Roughness of Surface

Roughness	Description	Group
Slickensided	Surface smooth, glassy finish with visual evidence of striations	SL
Smooth	Surface appears smooth and feels so to the touch	SM
Slightly Rough	Asperities on the discontinuity surfaces are distinguishable and can be felt	SR
Rough	Some ridges and side angle steps are evident, asperities are clearly visible, & discontinuity surface feels very abrasive	RG
Very Rough	Near vertical steps and ridges occur on the discontinuity surface	VR

ii. Joint Infilling

Joint Infilling Materials

Material	Identification	Notation
Chlorite	Light to dark green, grayish green. Slightly greasy texture. Predominately found in metamorphic rocks	Cl

Material	Identification	Notation
Calcite	Common infilling material found in a variety of colors. Will effervesce when exposed to weak acid solution. Low hardness that can be scratched by copper penny	Ca
Gypsum	Light colored mineral typically found in sedimentary rocks. No major physical identification characteristics and requires lab testing to identify	Gy
Mica	Found as dark colored (Biotite) or light colored (Muscovite). Can be peeled apart in thin sheets and has a lustrous appearance. Typically found in Metamorphic rocks	Mc
Iron-bearing Minerals	Typically occur as Hematite (He) and Magnetite (Mt). Common rock forming minerals that when exposed to moisture stains red to reddish brown. Typically found as staining on walls of discontinuities.	Fe
Pyrite	Yellowish Gray to gold in color. Sulfur bearing mineral typically found as weathered flakes with distinctive gold lustrous appearance	Py
Quartz	Most common rock forming mineral found in a large variety of colors. Hard mineral that can't be scratched by pocket knife	Qtz
Talc	Light colored mineral typically found in metamorphic rocks. Talc is very soft and can be scratched with fingernail. Greasy texture	Tl
Clay	See Appendix B-1 for identification	C
Silt	See Appendix B-1 for identification	M
Sand	See Appendix B-1 for identification	S
Gravel	See Appendix B-1 for identification	G

Descriptive Terminology for Strength of Joint Filling Material

Grade	Description	Field Identification	Approximate Range of Uniaxial Compressive Strength (psi)
S1	Very Soft Clay	Easily penetrated several inches by fist.	500
S2	Soft Clay	Easily penetrated several inches by thumb.	500 – 1,000
S3	Firm Clay	Can be penetrated several inches by thumb with moderate effort.	1,000 – 2,000
S4	Stiff Clay	Readily indented by thumb but penetrated only with great effort.	2,000 – 5,000
S5	Very Stiff Clay	Readily indented by thumbnail.	5,000 – 10,000

Grade	Description	Field Identification	Approximate Range of Uniaxial Compressive Strength (psi)
S6	Hard Clay	Indented with difficulty by thumbnail.	>10,000

Note: Grades S1 to S6 apply to cohesive soils such as clays, silty clays, and combination of silts and clays with sand, generally slow draining. If non-cohesive fillings are identified, qualitatively identify, e.g., fine sand.

iii. Water Content

Descriptive Terminology for Water content in Rock Fracture

Description	Criteria	Group
Dry	Fracture is dry tight with no evidence of previous water flow or staining.	D
Moist	The fracture filling (where present) is damp and evidence of minimal amounts of free water is visible.	M
Wet	The fracture has sizeable amounts of free water and filling material (where present) shows signs of piping and or washing out.	W

iv. Joint Roughness Coefficient

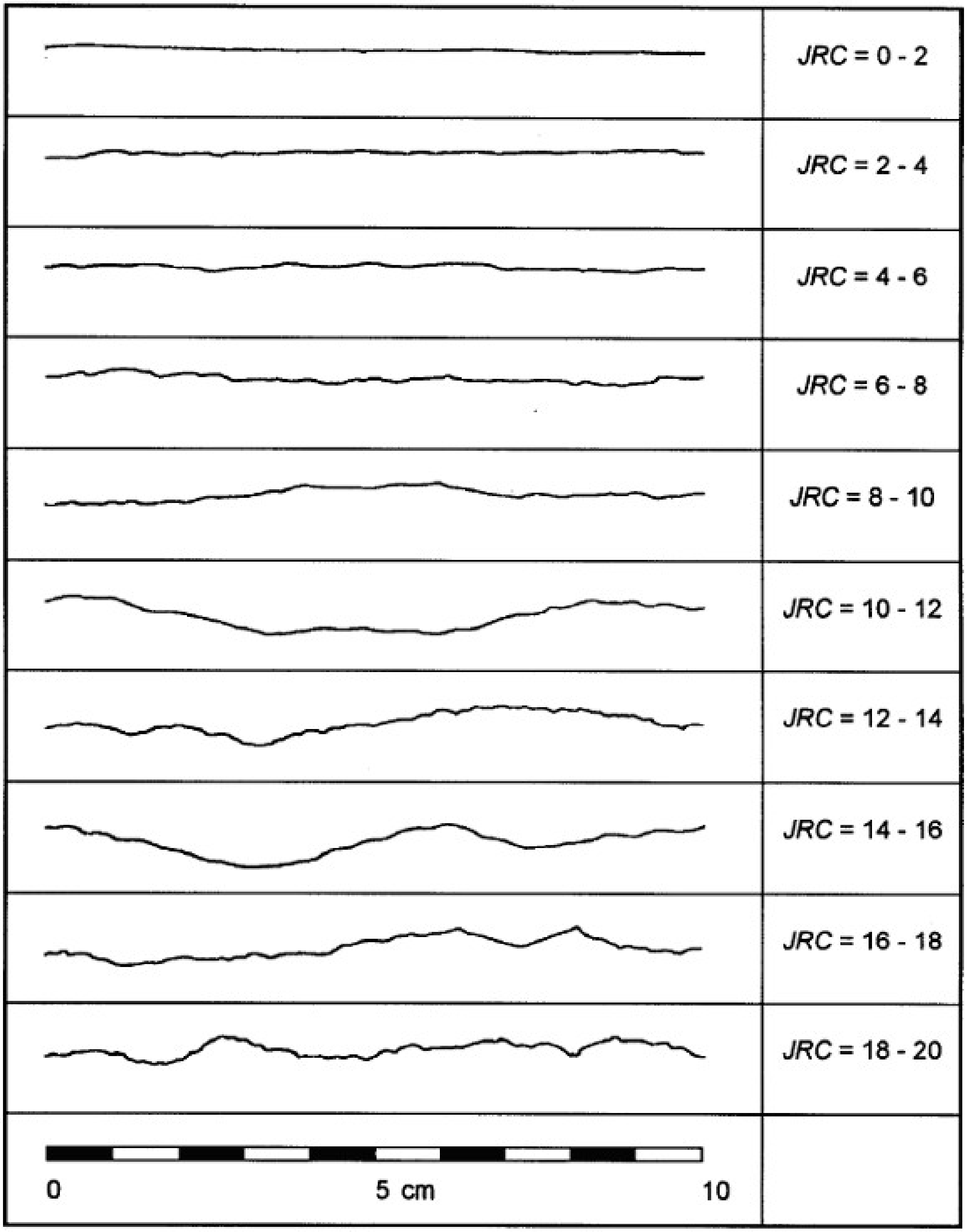


Figure B2-2

APPENDIX B3
USDA Soil Identification System

USDA SOIL CLASSIFICATION AND LOGGING

IDENTIFICATION OF SOILS

A. Object

The basic objectives of classifying and logging core are to provide accurate and concise record of the important geological and physical characteristics of engineering significance. Data reported in geologic logs not only must be accurate, consistently recorded, and concise, but also must provide quantitative and qualitative descriptions.

B. USDA Classification

1. Particle Size Definition

Soil	Fraction	Actual Sizes
Boulders		> 600 mm
Stones		600mm to 250 mm
Cobbles		250 mm to 76 mm
Gravel	course	76 mm to 20mm
	medium	20 mm to 5 mm
	fine	5 mm to 2mm
Sand	very coarse	2.0 to 1.0 mm
	coarse	1.0 mm to 0.5 mm
	medium	0.5 mm to 0.25 mm
	fine	0.25 mm to 0.10 mm
	very fine	0.10 mm to 0.05 mm
Silt		0.05 mm to 0.002 mm
Clay		< 0.002 mm

2. Soil Texture

This is the numerical proportion (percent by weight) of sand, silt and clay in soil.

Texture Classes/ Subclasses	Definition
Sands	More than 85% percent sand, the percentage of silt plus 1.5 times the percentage of clay is less than 15.
Coarse sand	*A total of 25 % or more very coarse and coarse sand and less than 50% any other single grade of sand.*
Sand	*A total of 25 % or more very coarse, coarse, and medium sand, a total of less than 25 percent very coarse and coarse sand, and less than 50% fine sand and less than 50 % very fine sand.*
Fine Sand	*50% or more fine sand: or a total of less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.*
Very Fine Sand	*50 % or more fine sand.*

Loamy Sands	Between 70 and 91 percent sand and the percentage of silt plus 1.5 times the percentage of clay is 15 or more; and the percentage of silt plus twice the percentage of clay is less than 30.
Loamy coarse sand	*A total of 25 % or more very coarse, and coarse sand and less than 50 % any other single grade of sand.*
Loamy sand	*A total of 25 % or more very coarse, coarse, and medium sand and a total of less than 25 % very coarse and coarse sand, and less than 50 % fine sand and less than 50 % very fine sand.*
Loamy fine sand	*50 % or more fine sand; or less than 50 % very fine sand and a total of less than 25% very coarse, coarse, and medium sand.*
Loamy very fine sand	*50% or more very fine sand.*
Sandy loams	7 to 20 % clay, more than 52% sand, and the percentage of silt plus twice the percentage of clay is 30 or more; or less than 7 % clay, less than 50 % silt, and more than 43% sand.
Coarse sandy loam	*A total of 25% or more very coarse and coarse sand and less than 50 % any other single grade of sand.*
Sandy loam	*A total of 30% or more very coarse, coarse, and medium sand, but a total of less than 25% very coarse and coarse sand and less than 30% fine sand and less than 30% very fine sand; or a total of 15 % or less very coarse, coarse, and medium sand, less than 30% fine sand and less than 30% very fine sand with a total of 40% or less fine and very fine sand.*
Fine sandy loam	*30% or more fine sand and less than 30 % percent very fine sand; or a total of 15 to 30% very coarse, coarse, and medium sand; or a total of more than 40 percent fine and very fine sand, one half or more of which is fine sand, and a total of 15% or less very coarse, coarse, and medium sand.*
Very fine sandy Loam	*30 % or more very fine sand and a total of less than 15% very coarse, coarse, and medium sand; or more than 40% fine and very fine sand, and more than half of which is very fine sand, and a total of less than 15% very coarse, coarse, and medium sand.*
Loam	7 to 27 % clay, 28 to 50 % silt, and 52 % or less sand.
Silt loam	50 % or more silt and 12 to 27 % clay, or 50 to 80 % silt and less than 12 % clay.
Silt	80% or more silt and less than 12 % clay.
Sandy clay loam	20 to 35 % clay, less than 28 % silt, and more than 45 % sand.
Clay loam	27 to 40 % clay and more than 20 to 46 percent sand.
Silt Clay loam	27 to 40 % clay and 20 % or less sand.
Sandy clay	35 % or more clay and 40 % or more sand.
Silty clay	40 % or more clay and 40 % or more silt.
Clay	40 % or more clay, 45 % or less sand, and less than 40 % silt.

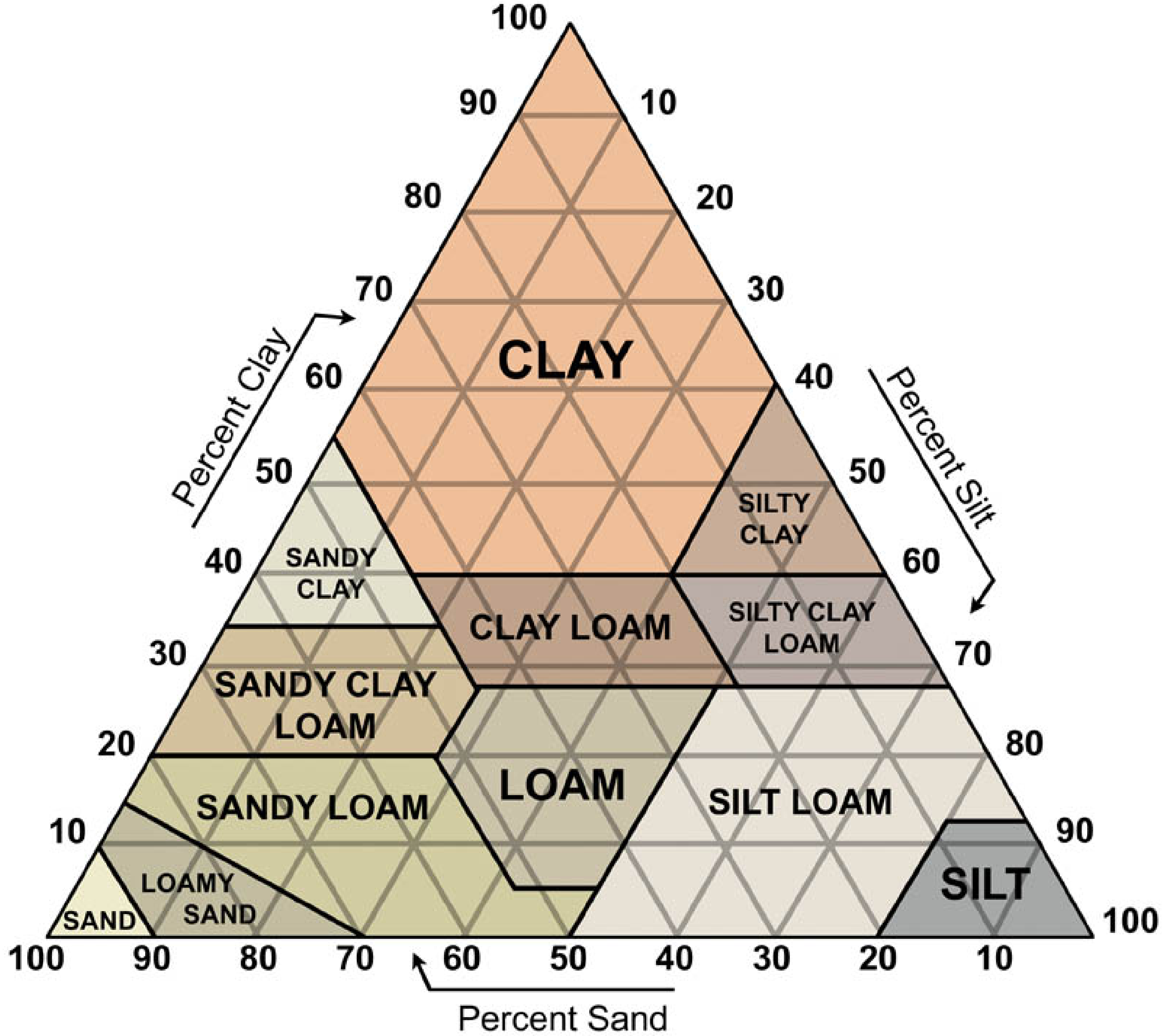


Figure B3-1

3. Grouping of Soil Texture Classes

General terms	Texture	Texture classes
Sandy soil materials	Coarse-textured	Sands (coarse sand, sand, fine sand, very fine sand) Loamy sands (loamy coarse sand, loamy sand, loamy fine sand, loamy very fine sand)
Loamy soil materials	Moderately coarse-textured	Coarse sandy loam, sandy loam, fine sandy loam
	Medium-textured	Very fine sandy loam, loam, silt loam, silt
	Moderately fine-textured	Clay loam, sandy clay loam, silty clay loam
Clayey Soils	Fine textured	Sandy clay, silty clay, clay

4. Rock Fragments- Size and Quantity

Fragment content % by volume	Rock fragment Modifier usage
<15	No texture adjective is used (noun only; e.g., loam)
15 to <35	Use adjective for appropriate size; e.g., gravelly
35 to <60	Use "very" with the appropriate size adjective; e.g., very gravelly.
60 to <90	Use "extremely" with the appropriate size adjective; e.g., extremely gravelly.

5. Soil Color

Identify the colors of the soil matrix with Munsell notation (Hue, Value, Chroma)

Munsell Notation	Consists of about 250 different colored papers or chips arranged on hue cards according to their Munsell notation. The color system uses three elements of color: hue, value and chroma.
Hue	Measure of the chromatic composition of light that reaches the eye.
	5 principal hues: red (R), yellow(Y), green (G), blue (B) and purple (P).
	Intermediate hues are yellow-red (YR), green-yellow (GY), blue-green (BG), purple-blue (PB), and red-purple (RP).
	Each of the 10 major hue is divided into 4 segments of equal visual steps. Yellow-red (YR) hue are identified as 2.5 YR, 5 YR, 7.5 YR, and 10 YR. The standard chart for soil has separate hue cards from 10 R through 5Y.
Value	Indicates the degree of lightness or darkness of a color in relation to a neutral gray scale.
	Pure black (0/), Gray (5/), white (10/). A card of the color chart for soil has a series of chips arranged vertically to show the lightest to the darkest shade of the hues.
Chroma	Indicates the degree of saturation of neutral gray by the spectral color. /0 Neutral colors to /8 as the strongest expression of color used for soil.
	The color chips are arranged horizontally by increasing chroma from left to right on the color card.
	At the extreme left of the card are symbols such as N6/. These are colors of zero Chroma. They have no hue and no chroma and range in values from black (N 2/) to white (N 8/). Gray is N 5/.

E.g., Pale brown 10 YR 6/3, Very dark brown 10 YR 2/2.

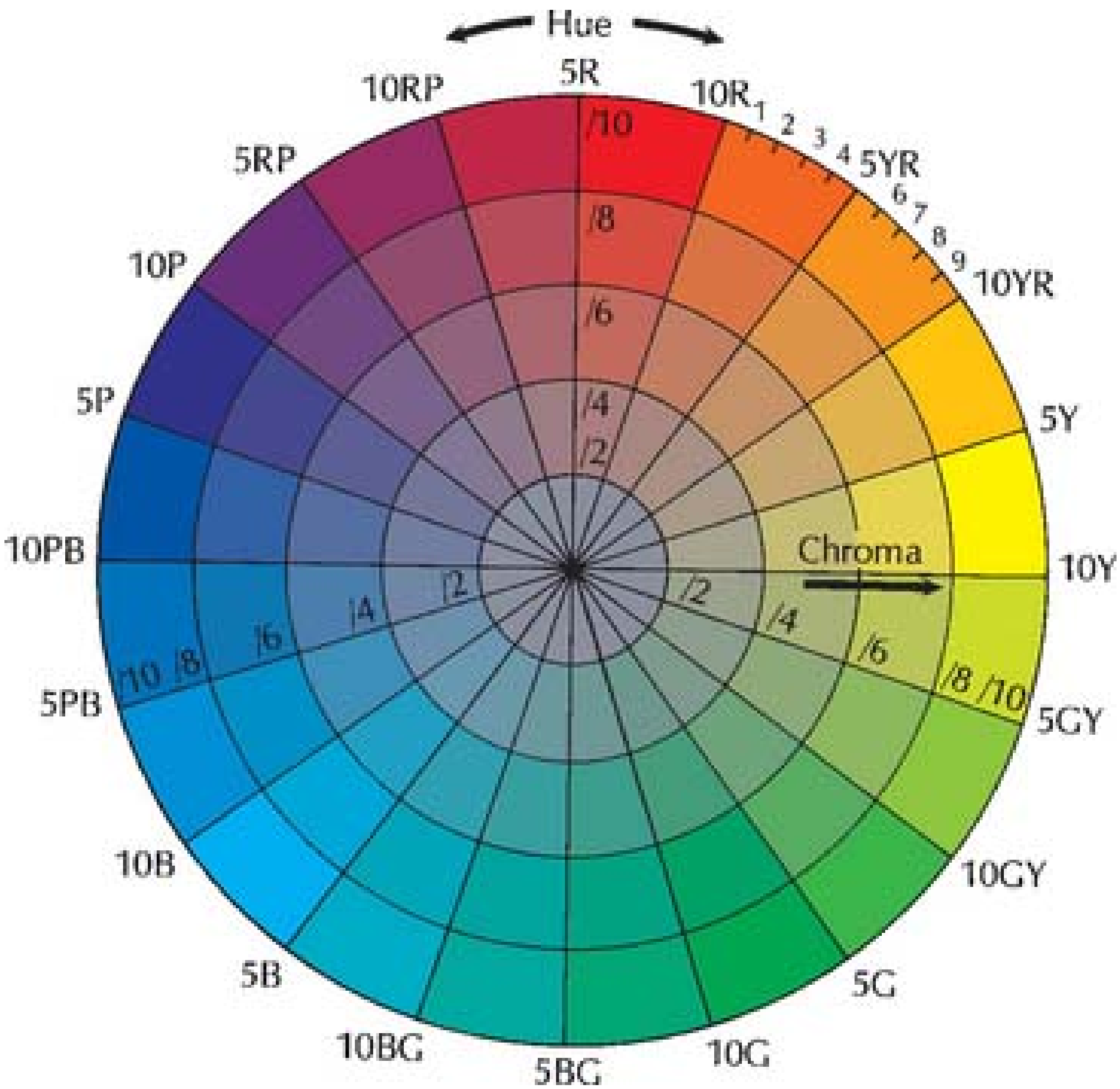


Figure B3-2

6. Mottling

Mottling refers to repetitive color changes that cannot be associated with compositional properties of the soil. Redoximorphic features are a type of mottling that is associated with wetness. Mottles are described by quantity, size, contrast, color and other attributes in that order.

Mottling	Measure	Composition
Quantity	few	less than 2%
	common	2 to 20%
	many	more than 20%
Size	fine	smaller than 5mm

Mottling	Measure	Composition
	medium	5 mm to 15 mm
	coarse	larger than 15 mm
Contrast	faint	Evident only on close examination. Faint mottles commonly have the same hue as the color to which they are compared and differ by no more than 1 unit of chroma or 2 units of value. Some faint mottles of similar but low chroma and value differ by 2.5 units (one card) of hue
	distinct	Readily seen but contrast only moderately with the color to which they are compared. Distinct mottles commonly have the same hue as the color to which they are compared but differ by 2 to 4 units of chroma or 3 to 4 units of value; or differ from the color to which they are compared by 2.5 units (one card) of hue but by no more than 1 unit of chroma or 2 units of value
	prominent	Contrast strongly with the color to which they are compared. Prominent mottles are commonly the most obvious color feature of the section described. Prominent mottles that have medium chroma and value commonly differ from the color to which they are compared by at least 5 units (two pages) of hue if chroma and value are the same; at least 4 units of value or chroma if the hue is the same; or at least 1 unit of chroma or 2 units of value if hue differs by 2.5 units (one card)

APPENDIX C
Geotechnical Field Representative (GFR) Manual

GEOTECHNICAL FIELD REPRESENTATIVE (GFR) MANUAL

INTRODUCTION

This publication provides a guide to field monitoring, preparation of boring logs, sample preservation and compilation of boring contract records. Soil identification is covered in Appendix B and should be utilized in the preparation of boring logs.

ORGANIZATION

All borings are to be performed under the supervision of a GFR located in the field with the boring equipment. The GFR is to be under the supervision of the GE who will make periodic visits to the boring work.

Prior to initiating any field exploration, the GFRs and the Drilling Superintendent must be thoroughly briefed relative to anticipated subsurface conditions, boring locations, boring numbering, boring depth criteria, sampling procedures, boring access and other provisions required of the field exploration. Such information and instruction shall be covered in the boring contract plans and specifications.

The GE shall be contacted by telephone daily, or as directed, during the course of the Exploration. These reports are to document conditions encountered and to check on possible changes in the boring program and sampling procedures. No boring rig should be allowed to demobilize or otherwise leave the site without the GE’s knowledge. In the event that the GE is unavailable for a decision, which cannot be made by the GFR, then the person next in command above the GE who is associated with the Project should be consulted.

QUALITY ASSURANCE MONITORING

The GFR is responsible for QA monitoring of all field activities. The GFR shall have copies of all relevant procedures relative to the work. The GFR shall be knowledgeable about the procedures and with the GE identify any missing procedures, criteria, or issues related to the quality of the work. This shall be followed with a pre-work meeting with the Boring Contractor to review all quality procedures. It should be recognized that ASTM and other similar procedures are excellent in their content, but may be missing detailed information relative to the work.

The boring method can have a significant impact on data quality. The GFR shall monitor the boring operations to confirm that the borehole (including bottom of the borehole) is sufficiently stable to allow sampling and testing.

The GFR is responsible for the following field activities:

1. Quality assurance monitoring that all boring, sampling, and testing is performed in accordance with Project standards
2. Preparation of accurate boring logs, daily reports, and other documentation
3. Determination of pay quantities including daily reconciliation with the Boring Contractor
4. Accurate location and elevations of all borings
5. Documentation of any field operations that may impact the quality or reporting of field data
6. Documentation of any interaction with third parties, including clients, residents, etc.
7. Final abandonment of the borings and site clean up

The GFR is also responsible for observing and recording drilling operation issues that may provide additional subsurface information. These include but are not limited to:

- Water losses
- Resistance to drilling (advance rate and down pressure, particularly in hard soils or rock)
- Dropping of drill rod

BORING RECORDS

The boring log is the basis for every foundation analysis and it is, therefore, important that a complete and accurate record of all aspects of the subsurface exploration be maintained. Exhibit 5-2 to Exhibit 5-6 are the templates for the boring logs, and Exhibit C-1 to Exhibit C-5 give a sample boring logs. The following items should be carefully observed and recorded on the field boring log.

1. Dates and times of beginning and completion of work.
2. Identifying number and location of test boring.
3. Ground surface and elevation at the boring and source of reference.
4. Diameter and description of casing.
5. Total length of each size of casing.
6. Length of casing extending below ground surface at the completion of the boring.
7. Weight, number of blows, and the length of drop of hammer used to drive the casing each successive foot.
8. Water level observation with remarks on possible tidal variations. (All measurements from original ground surface.)
9. Depth to top of each different material penetrated.
10. Depth to the bottom of sampler at start of driving for each sample and depth to which the sampler was driven.
11. Sampler type and dimensions.
12. Weight of hammer, hammer type, the length of drop used to drive the split spoon sampler, and the number of blows required to drive the sampler, measured in 6-inch intervals, throughout its full depth of penetration.
13. Methods and forces used to push sampler tube when not driven.
14. Length of sample recovered.
15. Loss or gain of drilling fluid or mud.
16. Any sudden dropping of drill rods or other abnormal behavior.
17. An accurate record of any change in the original boring location.
18. Identification of the subsoils and bedrock including color, moisture, structure, condition, etc.
19. Type of drilling operation used to advance hole.
20. Comparative resistance to drilling.

On the field boring log form all data on the drilling and sampling should be noted along with the identification of the soil samples obtained and soil strata changes. It is best to include too much information rather than too little. A sample boring logs are attached that provides guidance (see

Exhibits C-1 through C-5). The GE should be consulted to be sure sufficient information is provided on the boring logs.

Generally, the driller should be the entity best able to detect changes in strata and drilling resistance during the course of drilling. There should, therefore, be a close liaison between the driller and the GFR at all times. When changes in strata are indicated by the driller in between scheduled sampling intervals, samples should be taken at the strata change wherever such is feasible.

There are a number of abbreviations and terms that are useful in preparing boring logs that may be utilized. Abbreviations for soil identifications should only be used when lack of space prohibits their being written out in full.

STANDARD ABBREVIATIONS

Soil Identification

Gravel	G	**Silty Clay**	$yC
Sand	S	**Clay**	C
Silt	$	**Peat**	Pt
Clayey Silt	Cy$	**fine**	f
Silt & Clay	$&C	**medium**	m
Clay & Silt	C&$	**coarse**	c

Color

light gray	LtGr	**tan**	Tn
gray	Gr	**yellow**	Yl
dark gray	DkGr	**green**	Grn
black	Bk	**blue**	Bl
brown	Br	**red**	Rd

Samplers

Split spoon	SS	**Diamond core size**	BX, NX
Shelby Tube	ST	**Torvane**	Tv
Piston Sampler	PS	**Field Vane**	Fv
Denison Sampler	DS	**Pocket penetrometer**	Pp

Modifications

organic	org	**seam, seams**	sm, sms
calcareous	calc	**streaks**	stks
ferrous	fer	**nodules**	nod
lignitic	lig	**laminated**	lam
very	v	**slickensided**	sls

slightly	sl	**interbedded**	intbdd
at	@	**intermixed**	intmx
with	w/		

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	-	surfaces that are slick and glossy in appearance or polished.
Fissured	-	extensive crack or cracks.
Sensitive	-	pertaining to cohesive soils that are subject to appreciable loss of strength when remolded.
Varved	-	alternating thin layers of silt (or fine sand) and clay.
Laminated	-	composed of thin layers and texture, 1 cm or less, in thickness.
Interlayered	-	composed of alternate layers of different soil types.
Parting	-	a very thin layer one or two grains thick.
Calcareous	-	containing appreciable quantities of calcium carbonate.

BORING LOCATIONS AND GROUND SURFACE ELEVATION

Accurate boring location and ground surface elevation are a critical part of the boring and to the interpretation of the boring results. It is the GFR's responsibility, in conjunction with the GE, to assure that this information is accurate.

Location: The GRF shall determine the boring location to the greatest accuracy feasible (to an accuracy of approximately one-half foot). This can be done by several methods:

- Referencing (taping) to site features shown on the Boring Location Plan. The GFR shall be responsible for confirming that the reference site features match the boring location plan.
- Use of hand held GPS unit.
- Reference (taping) to the proposed boring location stake, if the stake was determined by accurate methods as discussed above.
- Survey of the actual boring location. This is the most accurate method, and is required for as built locations. However, it should be noted that survey may occur several months after the boring operation. It is the GFR's responsibility to ensure that the survey team finds the actual boring location.

Ground Surface Elevation: Determination of accurate ground surface elevation is often problematic. Typically, interpolation from topographic information does not provide an adequate elevation. An accuracy of 0.1 foot is required. The following are considered accurate methods:

- Survey of the actual boring location. Note the requirement to assure that the survey team finds the actual boring location.

- Referencing to site feature with a known elevation. If the elevation difference is not too much (less than approximately 5 feet) the elevation difference can be field determined (with care) using hand levels and folding rules.
- Referencing to staked boring location, if the elevation was determined an accurate method. The same limitations and methods as discussed in the previous paragraph are applicable.

Documentation: Documentation of both location and elevation determination. This should include detailed recording of dimension, reference featured, methods, etc. The notes should be attached to the Daily Report.

Daily Geotechnical Field Representative Report

Daily Geotechnical Field Representative Reports (DGFRR) should include, in chronological order, the following:

1. Job number, name, location, date, weather conditions, client, owner and contractor representatives.
2. Arrival and departure of all personnel involved.
3. Record all delay and down-times, their causes and eventual conclusion.
4. Summaries of any discussions, conversations and meetings relevant to the Project work including any instructions and change orders.
5. Summarize all work, progress for the day. Include, whenever possible, a location diagram of work areas for that day.
6. Record all contacts made, the names of the parties contacted, and who they represent.
7. Tabulate daily pertinent data such as water level readings, boring footage (rock and soil), and footage for observation well installation, etc.
8. Document all equipment used and maintain an accurate record of all expenses incurred.

A sample of a DGFRR is attached for guidance; see Exhibit C-6.

Following is a list of necessary equipment and supplies to be used by the GFR.

1. Clip board.
2. Boring plans and Specifications
3. Boring log forms.
4. Daily report and other type of forms.
5. 6-foot Folding Engineers ruler.
6. Pocket knife.
7. Optional equipment:

   100-foot Measuring tape

   Pocket penetrometer, Torvane

   Hand level

   Flagging tape

Indelible black ink marker pen

Geologic Hammer

Litmus Paper

SITE RECONNAISSANCE

It is important that a site reconnaissance be made. Any conditions which may affect design considerations or construction should be noted and logged into the DGFRR and verbally reported to the GE. Examples might be: the presence of buildings or old foundations left over from demolition; man made or sanitary landfills; indications of sinkholes, depressions or open caves; existing rock outcrops; surface drainage; etc. Careful documentation throughout the field operations is critical. The GFR shall prepare sketches with reference dimensions if feasible.

SOIL BORINGS

The Authority preference for advancing soil borings shall be mud-rotary with casing employed for borehole stability where applicable. However, when deemed acceptable by the GE other methods may be permissible.

The GFR has several responsibilities with respect to the drilling operation:

- The GFR should be knowledgeable about the drilling operation and be aware of issues which could affect data quality. If the GFR is not familiar all aspects, he should notify the GE and request assistance and training.
- The bottom of the bore hole is where the samples are attained. The bottom can be affected by unbalanced hydrostatic forces among other issues.
- The GFR should be aware of the length of all tools that use in the drilling operation, including rods, drill bits, and samplers. With this information, and working with the driller, the GFR can determine that the "drilled to" depth and the sample depth are the same. If they are not, this could indicate bottom instability.

<u>SPT Sampling</u>: The GRF shall be familiar with the requirements of the Standard Penetration Test (ASTM D1586). The Authority preference is to use an Automatic Hammer. The GFR should inspect the hammer with the driller to assure proper operation.

Immediately upon removal from the hole the split barrel sampler should be split open to provide for visual inspection of the intact sample by the GFR. It may be necessary to remove mud from side of the sample, or possibly cut the lengthwise so that soil and soil structure can be observed. After examining the exposed soil, a digital photo of the sample shall be taken and incorporated into the Phase B Geotechnical Engineering Report. The soil photographs shall meet the following criteria:

- Image quality is adequate to discern soil type, grain size and color
- The photo taken perpendicular to the sample from above with sample in full view.
- A folding rule placed along the sampler for scale.
- The sampling jar cap with complete markings set aside sampler and within the photo for identification.

- The drilling fluid should be scraped to reveal the natural material's color and grain size distribution.
- The entire sample contents of the split spoon shall be photographed.

Before the samples are selected, be sure a complete record of the sample is recorded, including interbedded zones, soil structure, etc. Samples should be selected to represent different soil types in the sampler, if present. In no cases, shall soils with different characteristics be placed in the same sample jar.

Samples should then be tightly sealed in screw-top glass jars or bottles at least 3-1/2 inches high, approximately 1-1/2 inch inside diameter at the mouth, and with inside diameter of the jar no more than ¼-inch larger than that at the mouth. The jars shall be provided with metal screw caps containing a rubber or waxed-paper gasket.

Samples shall be placed in the jars in the condition in which they are removed from the split barrel sampler without squeezing, mashing or otherwise excessively distorting the sample. Samples which have been recovered and preserved should be numbered consecutively; i.e. S1, S2, etc. If the sample from the split barrel is divided into subsamples because of material change, then the sample designation number will be followed by a letter designation assigned alphabetically from top to bottom; i.e. S1A, S1B, etc. If no sample is recovered it will be designated by an "NR" and no sample number assigned. No jar need be placed in the jar box to show N position.

Each sample jar and box shall be labeled as follows (see Exhibit 5-7 for examples of soil sample labeling).

a. Sample Jar Lids: Each sample jar lid shall contain the following information:

i. NJTA Project Name
ii. NJTA Project Contract Number
iii. Boring Number
iv. Sample Number; denoted as S-1, S-2, S-3, etc.
v. Sample depth
vi. SPT Blow Counts for each 6-inches of penetration for a total of 24-inches
vii. Sample recovery length
viii. Date sample was taken

b. Sample Jar Boxes: Sample jar boxes shall contain the following information on the top and on one of each of the long and short sides of the box:

i. Geotechnical Engineering Firm
ii. NJTA Project Name
iii. NJTA Project Contract Number
iv. Boring and Sample Numbers; denoted BR-1 (S-1 to S-10), BR-2 (S-1 to S-16), etc.
v. Dates Samples were taken
vi. Initials of the GFR

Undisturbed Samples

As shown in the GEP, the driller may be required to take undisturbed samples. These samples are often collected using a three-inch O.D. open-type "Shelby" tube sampler with sample tubes 30 inches long and provided with a positive ball check valve in its head. Such samples shall be obtained by pushing or jacking the sampler into undisturbed soil at the bottom of the hole.

Wherever possible, the equipment for advancing the sampler shall measure the force required to penetrate the soil. The GFR shall record the force required to penetrate the soil. The GFR shall record this force, depth of penetration and length of sample recovered. These samples shall be sealed in the tubes in which they are obtained and carefully labeled to show location and depth of sample (i.e.: U-1, U-2, etc.). When there are problems with obtaining undisturbed samples using Shelby tubes, undisturbed soil samples shall be recovered by means of special piston- type samplers.

When ready to take Shelby or piston-type samples, all loose and disturbed materials shall be removed to the bottom of the casing or of the open hole. This final cleaning should be accomplished with a device in which washwater is fully deflected in an upward direction. No washing with downward directed jets should be permitted within four inches of the intended top of the undisturbed sample. Cleaning out should be done in such a manner that the soil immediately below the bottom of the casing is as nearly undisturbed as possible. The sampling device connected to the drilling rod should then be lowered slowly to the bottom of the hole and the sampler forced into the soil for a distance of not less than 24 inches or more than 27 inches.

In the operation of securing the undisturbed samples, the samplers should be forced into the soil at a rate of four to five inches per second. The samplers should be pushed or jacked downward, and not to be driven unless the character of the soil is such that driving with the hammer is absolutely necessary and is approved by the Project engineer.

The sampler with its contained soil sample should be rotated, and then carefully removed from the hole. The thin-walled tube containing the sample should be detached from the driving head. A portion of the undisturbed sample should always be carefully removed from both ends of a tube (a minimum of ½ inch thickness) and squared and preserved whether the sample is sealed in the tube or extruded in the field and preserved in cartons. The removed samples from the top and tip of the tube should then be described on the boring log along with any other information which may be helpful in determining subsurface conditions. If stated in the GEP, it may be necessary to perform Pocket Penetrometer and field Torvane tests on the bottom of the recovered undisturbed samples. Care must be taken to prevent sample disturbance to the thin-walled tube samples.

The ends of the tube are wiped clean and the end spaces filled with hot paraffin or hot melted beeswax. Snug-fitting metal or plastic caps should be placed on the ends of the tube. The caps should be sealed with friction tape. Finally, the ends of the tube should be dipped in hot paraffin or beeswax to provide airtight seals.

Undisturbed samples, designated by a “U” should be numbered according to their occurrence in the sampling sequence: i.e., U-1, U-2, etc. The boring log should provide the type of undisturbed sampling types (Shelby Tube, piston sampler, etc.)

Each Undisturbed (Thin-Walled Tube) Sample shall contain the following information:

i. Geotechnical Engineering Firm
ii. NJTA Project Contract Number
iii. NJTA Project Name
iv. Boring Number
v. Sample Number should be designated by “U” and numbered according to occurrence in the boring sequence; denoted as S-1, S-2, U-1, S-3, S-4, S-5, U-2, …
vi. Sample depth
vii. Sample recovery length
viii. Label the top and bottom of the tube
ix. Date sample was taken
x. Initials of the GFR

Undisturbed soil tube should be clearly and permanently marked to show the top and bottom of the tube. Undisturbed samples should be handled and transported in a cushioned rack with the top of the sample always upright. It should be delivered to the laboratory with extreme care in order to minimize disturbance effects which may render laboratory test results useless.

During the winter months, precautions must be taken to prevent undisturbed samples from freezing during handling and shipping; if allowed to freeze, the samples will be worthless for strength or consolidation testing.

Tubes for undisturbed samples are to be provided by the driller, and should be of steel, seamless brass or hard aluminum. Sample tubes should have a machine-prepared sharp cutting edge with a flat bevel to the outside wall of the tube. The cutting edge shall be drawn in to provide an inside clearance beyond the cutting edge of 0.015 inch± - 0.005 inch.

When recovery of samples by use of Shelby tubes is poor, then undisturbed soil samples are to be recovered by means of a thin-wall piston-type sampling device with piston rods that extend to the ground surface, or a self-contained hydraulically-operated piston sampler, such as the "Osterberg" sampler. The sampler selected should be designed to utilize sample tubes with a three-inch outside diameter. When samplers, utilizing piston rods extending to the ground surface, are used, positive locking of the piston rods with respect to the surface of the ground must be provided to prevent upward or downward motion of the piston during the advance of the sampling tube and the piston rods must be positively locked to the drill pipe at the surface during removal of the sampler for the depth to which it penetrated undisturbed soil. If the piston rods are locked to the mast of a truck-mounted drill rig, the rig should be blocked and anchored to the ground in such a manner as to prevent motion of the rig during the sampling operations.

If specifically approved in advance by the GE, samples may be recovered in hard soils by an open-type, thin-wall sampling device.

In very soft soils, a weighted drilling mud may be required, whether or not casing is used, in order to maintain a pressure on the soil as nearly equal as possible to that existing before the drilling operations.

Under certain conditions, continuous sampling with three-inch diameter "Shelby" tubes may be required in cohesionless materials encountered in 3½ inch undisturbed sample Borings.

ROCK CORING AND FIELD LOGGING

When it has been determined that bedrock has been encountered, and not a boulder or very dense soils, then it may be feasible to core. The decision to core is not to be determined by the results of the Standard Penetration Test alone, but may be used as an indication that coring is possible. Knowledge of local geologic conditions, known or anticipated, and soil samples recovered, must be considered in any decision as to whether to begin coring. However, coring this zone may produce very low core recoveries. For this reason, the GEP shall describe in detail how refusal will be determined and how this transition zone will be investigated so as to maximize information. Acoustic Televiewer (ATV) or Optical Televiewer (OTV) logging may also be used to better define this zone.

Once the driller is set up to core, the GFR should document the following information on the boring log:

1. Type of core barrel, diameter (ID), drill bit type and condition (which should be good);

2. Note any circulating fluid losses, depth and time of occurrence and any actions or reasons resulting in loss of core;

3. The starting and completion depth (to the nearest tenth of a foot) of each run, with no core run length to exceed 5.0 feet unless approved by the GE;

4. The core run designation (i.e. C-1, C-2, etc.) and the recovery;

5. The type of rock recovered, color, the core recovery, RQD (Rock Quality Designation) and any other related information, see Exhibit C-4.

In addition to the above, the GFR should insure that:

1. Casing has been sealed into bedrock;

2. Coring equipment used is of a type that would maintain continuous contact between the core bit and the rock being drilled.

Each core should be packed in well-constructed wooden boxes, provided by the Boring Contractor, with dividing strips to hold the cores in position and in the order in which they were recovered from each hole. Wooden blocks should be placed in the box to separate the core runs and should be marked to identify the core depth. When the core recovered is fragmented, all pieces of a size less than the core diameter should be put in plastic bags and placed in the core box in its appropriate position within that core run. When desirable to maintain sample moisture wrap the core in plastic to prevent drying. In the GEP, specify whether core will require wrapping. Core boxes should be marked on the inside and the outside as describe below and as shown in Exhibit 5-8.

<u>Rock Core Boxes - Top:</u> The outside top of a Rock Core box shall contain the following information:

i. Geotechnical Engineering Firm
ii. NJTA Project Contract Number
iii. NJTA Project Name
iv. Boring Number
v. Core run and depth; denoted as C-1 45’-50’, C-2 50’-55’, etc.
vi. Core run recovery in percent of total 5’ run
vii. Core run RQD in percent of total 5’ run
viii. Date cores was taken
ix. Initials of the GFR

<u>Rock Core Boxes - Inside Lid</u>: The inside of the Rock Core box lid shall be divided into four compartments by drawing three lines to mimic the compartments of the core box and contain the following information:

i. Boring Number
ii. Core run and depth
iii. Core run recovery in percent of total 5’ run
iv. Core run RQD in percent of total 5’ run
v. Label the top and bottom of the core run starting in the left corner of the upper compartment and work to the right. When compartment is filled, move down to the left corner of the next compartment and work to the right.
vi. Draw break line in between cores where wooden block separates core runs in the compartments

vii. Indication of natural and mechanical fractures

BORING TERMINATION

The GEP should have a clear explanation of boring termination. This should include a minimum depth assigned to each boring location. The GEP should also give the GFR guidance about when to extend Borings deeper. The following present conditions when Borings might not be terminated at the designated completion depths:

1. The boring is in soft clays or organic silts or some compressible stratum;
2. Sampling blow counts have been decreasing significantly or are very low to begin with (i.e. fewer than 10 to 20 blows per foot);
3. A void is encountered just before or at the design completion depth;
4. Unanticipated subsurface conditions have been encountered;
5. Minimum criteria for terminating a boring as established by the GE have not been met (i.e. blow count, core recovery, RQD, particular stratum, etc.)

Before proceeding further with the boring, the GFR should consult with the GE for further instructions. If the GE is unavailable, then consult the person next above in the chain of command, such as another engineer, the project manager or principal-in-charge.

GROUNDWATER LEVEL EXPLORATION

Groundwater levels should be recorded when first encountered during drilling, at the start of work each morning for Borings in progress and at the completion of each boring. Groundwater levels should also be recorded at the end of the field exploration project. The date and approximate time after boring completion should also be recorded for each water level reading. All water level observations should be summarized on the boring logs in the spaces provided. Observations should be made of ground water levels at the start of each day and in all completed holes. Any unusual water conditions and gain or loss of water in boring operations should be recorded completely in the boring logs. Whenever required by the GE, bore holes should be bailed for observations of groundwater conditions. When the open hole drilling method is used, and natural or commercial drilling mud utilized to stabilize the hole, the hole may have to be flushed thoroughly with clean water at the completion of the boring for the purpose of observing groundwater levels.

Groundwater level observations can be made in an open hole by filling the hole with clean water to a point above the natural groundwater level and observing the drop in the level of water in the hole. This may be followed by bailing the hole to a point below the natural groundwater level and observing the rise in the level of water in the hole. All individual measurements of the water level in holes should state the time elapsed since the last filling or bailing of the hole.

INSTALLATION OF STAND-PIPE OBSERVATION WELLS

Stand-pipe observation wells provide long term ground water observation and are often required by the Contract plans and specifications. Upon reaching the completion depth of a boring it may be part of the drilling program that an observation well be installed. In Borings advanced with casing or hollow-stem augers, the well pipe, usually 1 inch to 2 inch diameter PVC pipe, may be inserted with its screen tip into the casing or hollow stem augers prior to their being withdrawn. In the event that the grain size gradation of the stratum into which the well tip screen has been placed, is finer than the screen opening size, then the screen should be packed with graded granular material to avoid plugging of the screen. Once the well has been installed, it should be backflushed with clean water to clear the screen and the well-developed. Upon removal of casing or augers and completion of backfilling, it may be desirable to again backflush by applying a slightly increased hydrostatic pressure and monitoring its drop to assure the screen is still open. When drilling with mud, those Borings which require observation wells should be drilled with biodegradable mud if possible. If no biodegradable mud is available, then the hole should be thoroughly backflushed after the pipe and screen have been installed and tested, after backfilling. When non-biodegradable muds are used, boring wall permeability may be obstructed and may result in unreliable water level readings. No observation well installed using a non-biodegradable mud should be accepted unless the driller demonstrates that the well is in working order or unless directed by the GE. A sample Monitoring Well Log is provided as Exhibit C-4.

ABANDONED BORINGS

Borings should not be abandoned before reaching the final depth ordered except with the approval of the GE or his representative. No payment will be made for Borings abandoned by reason of an accident or negligence attributable to the driller.

Borings abandoned before reaching the required depth, due to an obstruction or other reasonable cause not permitting completion of the boring by standard procedures, shall be replaced by a supplementary boring adjacent to the original one and carried to the required depth. Penetration to the bottom depth of the abandoned boring may be made by any means selected by the driller and approved by the GFR unless payment is being rendered for the overlapped portion of the bore hole, in which case standard drilling procedures should be used. Samples to be taken in the supplementary boring should commence from the last sampling elevation at which the original boring was abandoned in the manner specified for the original boring. This will establish a sampling continuity between the two Borings.

All borehole and monitoring well casings shall be cut off a minimum of 2 ft. below the ground surface or removed completely. Monitoring wells shall be abandoned in accordance with NJAC 7:9D-3.1. Boreholes shall be abandoned in accordance with NJAC 7:9D-3.4 which allows boring less than 25 feet to be backfilled with drill cuttings. Borings greater than 25 feet should be grouted using a tremie grout method. The top surface shall receive the same treatment type and thickness as the existing condition (i.e. topsoil, crushed stone, and ballast). Boreholes in pavements shall be grouted using a tremie grout method and the upper portion backfilled with concrete to the same thickness as the existing pavement.

Test pits shall be backfilled in minimum 12-inch thick lifts and compacted by repeatedly striking the soil with the excavator bucket. If and where directed, the GFR may require additional compaction provisions based upon the sensitivity of the area to settlement.

All drilling mud and cuttings shall be hosed off or disposed of beyond developed areas, wherever feasible, and in a legal and environmentally approved manner. Test locations shall be re-graded to match the existing conditions and grassed areas shall be seeded.

Upon completion of the work the driller should remove his rigs, all equipment, unused material and soil removed from the holes and leave the site in a clean condition satisfactory to the owner and Engineer.

HNTB

GEOTECHNICAL BORING LOGS FOR

Boring No. BR-1
Sheet No. 1 of 2

New Jersey Turnpike Authority
(Owner)

NJTA Interchange 15E
(Project)

XYZ Drilling, Inc.
(Contractor)

Contract No. T500.250 Purpose Bridge Structure No. 1455-23
Location Newark, NJ RDWY. Turnpike SND STA. 109+35 OFF. 35' LT.

Rig No. 8 Type CME75 Driller Dave Mueller Helper Dan Smith

DATE	07/01/10					
TIME STARTED	07:00 am					
TIME FINISHED	03:00 pm					
WEATHER	Sunny 80					
DEPTH REACHED	42 ft					

GROUND ELEVATION 34.5 ft
ZERO OF BORING LOG 34.5 ft
M.L.W. ELEVATION
ELEVATION GROUND WATER 26.3 ft

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LINEAL FEET OF ROCK CORE		
2-½ in	3 in	4 in			ORD. DRY	UNDIST. DRY		1-7/8'' ID (NQ)	2-1/8'' ID (NX)	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
---	---	42'	---	---	10	1	---	---	---	---

Drilling Mud Type Revert

	Type	Size	Weight of Hammer	Average Fall	Hammer Type
Casing:	HW	4"	140 lb	30"	Auto
Ordinary Dry Samples O.D.	2"	I.D. 1-3/8"	140 lb	30"	Auto

Undisturbed Samples Type Shelby tube Length 30" O.D. 3" I.D. 2-7/8"

GROUND WATER READINGS

DATE	07/01/10	07/02/10					
TIME	03:10 pm	07:30 am					
DEPTH	12.5 ft	8.2 ft					

GENERAL REMARKS:
1. Boring moved 10' west to avoid utility.
2. Drilling mud introduced from 11'.
3. Boring tremie grouted on 07/02/10 @ 10:30 AM.

NORTHING: 695428.6 EASTING: 611603.8

All elevations refer to the NAVD 88 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

The subsurface information shown hereon was obtained for NJTA design and estimate purposes. It is made available to authorized users only that may have access to the same information available to the NJTA. It is presented in good faith, but is not intended as a substitute for investigations, interpretation, or judgement of such authorized users.

INSPECTOR Gearge Sable GEOTECHNICAL ENGINEER Sam Connor

Exhibit C-1: Sample Boring Log

HNTB BORING LOG

Boring No. BR-1
Sheet No. 2 of 2

CONTRACT NO. XX345 RDWY. Turnpike SND STA. 109+35 OFF. 35' LT.

Elev. (ft) 34.5	Blows on Casing	Blows on Spoon For 6-in Penetration		Sample No.	Sample Depth (ft)	Log	Material & Remarks
	27	27	11	S-1	0' - 2'		Brown cf SAND, some cf Gravel, trace Silt
	32	12	13				Rec=12"
	206	2	2	S-2	2' - 4'		Red c+m SAND, little Silt & Clay, trace f Gravel
	76	3	14				Rec=15"
	93	32	69	S-3	4' - 6'	Sand	*Gray f SAND, and Silt, trace f Gravel
	70	42	28				Rec=14"
	72						
▼	56						
	78						
24.5	85						
	54	2	3	S-4	10' - 12'		Yellowish brown Silty CLAY, trace f Sand
		5	4				Rec=21"
	M					Silty Clay	
	U						
19.5	D						
	U	WOR	WOH	S-5	15' - 17'		Dark brown PEAT
	S	1	1			Peat	Rec=18"
	E			U-1	17' - 19'		Shelby Tube Pushed
15.5	D						Rec=22"
		3	1	S-6	19' - 21'		Brown CLAY & SILT, trace+ f Sand
		2	2				Rec=24"
						Clay & Silt	
10.5							
				C-1	25' - 27'	Boulder	Boulder
7.5							Rec=14"
		37	29	S-7	27' - 28.3'		Gray cf GRAVEL, some cf Sand
		100/4"					Rec=18"
		11	50	S-8	30' - 32'	Gravel	* Gray cm+f Sand, trace+ Silt, and+ mf+ Gravel
		67	44				Rec=16"
-0.5							
		34	49	S-9	35' - 37'		Brownish red cf GRAVEL, some mf Sand, trace Silt
		54	54				(Decomposed Shale) Rec=12"
						Decomposed Rock	
		52	49	S-11	40' - 41.2'		*Brownish mf sand, and Silt & Clay, some f Gravel
-6.7		100/2"					(Decomposed Shale) Rec=12"
						41.2 ft	End of soil sampling at 41.2 feet and start coring rock.
							See Rock Core Log for details.

* Indicates that soil description has been verified based on laboratory results.

Exhibit C-1: Sample Boring Log

ROCK CORING LOG

Boring No. BR-1
Sheet No. 3 of 3

CONTRACT NO. T3954 RDWY. NBHCE STA. 45+50 OFF. 25' LT

Core Data										Rock Description									Discontinuity Description								Lab Testing			
Run				Water	Rock Core					General				Fabric		Structure			Planes		Joints									
																					Joint Surface									
Elev.	Sample no.	Depth (ft)	Core Time (ft/min)	Gain/Loss	No. of Pieces	Recovery		Rock Quality Designation, RQD		Rock Type	Color	Weathering	Strength	Grain Size	Grain Shape	Fracture Spacing	Bedding Spacing	Foliation Angle	Fracture Type	Fracture Aperture	Shape	Roughness	Joint Infilling	Infilling Strength	Water Content	Joint Roughness Coefficient	Strength (ksi)	Unit Weight (pcf)	Slake Durability (%)	Other (Specify)
						in	%	in	%	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)
55.5	C-1	50	2.0		22	57	95	33	55	Shale	Br	IV	R3	VF		CF	TNB		B	SO	P	SR	Fe		M	4			92	1.5
		51	2.5									III	R3	VF		CF	TNB		B	SO	P	SR	Ca		M	4	3.5	148	95	1.0
		52	3.0									II	R4	VF		CF	TNB		B	T	P	SM	-		M	4				
		53	3.0									II	R4	FG		VCF	MB		B	T	IR	SM	C	S2	M	5				
		54	2.5									II	R4	FG		VCF	MB		B	T	IR	SM	-		M	5	3.3	149		
50.5	C-2	55	3.0		8	60	100	48	80	Shale	Br	II	R4	FG		VCF	MB		B	T	IR	SM	-		M	3				
		56	3.0									II	R4	FG		VCF	MB		B	T	P	SM	C	S2	M	4				
		57	3.0									II	R4	FG		VCF	MB		B	T	P	SM	-		M	4	4.5	155		
		58	3.0									II	R4	FG		VCF	MB		B	T	IR	SM	Ca		M	5				
		59	3.5									II	R4	FG		VCF	MB		B	T	IR	SM	-		M	4				

(a) Amphibolite, Argillite, Basalt, Chert, Claystone, Conglomerate, Diabase, Dolomite, Gneiss, Granite, Hornfers, Limestone, Marble, Metaquartzite, Mudstone, Phyllite, Quartzite, Sandstone, Schist, Serpentinite, Shale, Siltstone, Slate

(c) I-Unweathered, II- Slightly Weathered, III-Moderately Weathered, IV-Highly Weathered, V-Completely Weathered, VI- Residual Soil

(d) R0-Extremely Weak, R1-Very Weak, R2-Weak, R3-Medium Strong, R4-Strong, R5-Very Strong, R6- Extremely Strong

(e) Sedimentary: VF- Very Fine, FG-Fine, MG-Medium, CG-Coarse, VC-Very Coarse; Igneous & Metamorfic: P- Pegmatitic, CG-Coarse, MG-Medium, FG-Fine, A- Aphanitic

(f) AG- Angular, SA- Subangular, SR- Subrounded, RD-Rounded, WR- Well Rounded

(g) ECF- Extremely Close, VCF-Very Cloase, CF-Close, MF-Moderate, WF-Wide, VWF-Very Wide

(h) TLB-Thinly Laminated, LB- Laminated, VTNB-Very Thin, TNB-Thin, MB-Medium, TKB-Thick, VKTB-Very Thick (massive)

(j) J-Joint, Ft-Fault, Sh-Shear, Fo-Foliation, V-Vein, B-Bedding

(k) T-Tight, SO-Slightly Open, MO-Moderately Open, O-Open, MW-Moderately Wide, W-Wide

(l) P-Planar, U-Undulating, WU-Wavy, ST-Stepped, IR-Irregular

(m) SL- Slickensided, SM-Smooth, SR-Slightly Rough, RG-Rough, VR-Very Rough

(n) Ca-Calcite, Fe-Iron, Qtz-Quartz, C-Clay, M-Silt, S-Sand, G-Gravel

(o) S1-Very Soft, S2-Soft, S3-Firm, S4-Stiff, S5-Very Stiff, S6-Hard

(p) D-Dry, M-Moist, W-Wet

(u) CAI as per ASTM D7625

Exhibit C-2: Sample Rock Coring Log

HNTB

GEOTECHNICAL BORING LOGS FOR

Boring No. DB-1
Sheet No. 1 of 3

New Jersey Turnpike Authority
(Owner)

NJTA Interchange 15E
(Project)

XYZ Drilling, Inc.
(Contractor)

Contract No. XX345 Purpose Stormwater Basin Structure No. 1455-23
Location Newark, NJ RDWY. Turnpike SND STA. 109+35 OFF. 35' LT.

Rig No. 8 Type CME75 Driller Dave Mueller Helper Dan Smith

DATE	07/01/10					
TIME STARTED	07:00 am					
TIME FINISHED	03:00 pm					
WEATHER	Sunny 80					
DEPTH REACHED	12 ft					

GROUND ELEVATION 53.3 ft
ZERO OF BORING LOG
M.L.W. ELEVATION
ELEVATION GROUND WATER

PAY QUANTITIES										
LINEAL FEET OF BORING					SAMPLES			LINEAL FEET OF ROCK CORE		
2-½ in	3 in	4 in			ORD. DRY	UNDIST. DRY		1-7/8" ID (NQ)	2-1/8" ID (NX)	
ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM
---	---	14'	---	---	10	---	---	---	---	---

	Type	Type	Size	Weight of Hammer	Average Fall	Hammer Type
Drilling Mud		Casing: HW	4"	140 lb	30"	Auto
Ordinary Dry Samples	O.D. 2"	I.D. 1-3/8"		140 lb	30"	Auto
Undisturbed Samples	Type	Length		O.D.	I.D.	

GROUND WATER READINGS

DATE							
TIME							
DEPTH							

GENERAL REMARKS:
1. Boring moved 10' west to avoid utility.
2. Boring tremie grouted on 07/02/10 @ 10:30 AM.

NORTHING: 695428.6 EASTING: 611603.8

All elevations refer to the NAVD 88 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

The subsurface information shown hereon was obtained for NJTA design and estimate purposes. It is made available to authorized users only that may have access to the same information available to the NJTA. It is presented in good faith, but is not intended as a substitute for investigations, interpretation, or judgement of such authorized users.

INSPECTOR Gearge Sable GEOTECHNICAL ENGINEER Sam Connor

Exhibit C-3: Sample Boring Log for Stormwater Facilities

BORING LOG

BORING NO. DB-1
SHEET NO. 2 OF 3

CONTRACT NO. XX345 RDWY. Turnpike SND STA. 109+35 OFF. 35' LT

Elev. (ft) 53.3	Blows on Spoon	Sample No.	Sample Depth (ft)	Log	Material & Remarks
	1	S-1	0 - 2	LOAMY SAND	3" Topsoil; Dark Yellowish Brown (10YR 4/4) coarse grained Loamy SAND, single grained, very loose; no mottles, no Gravel, moist, (m-f(+) SAND, little Silt).
	2				Rec.: 14"
	1				
51.3	2				
	4	S-2	2 - 4	SAND	Light Olive Brown (2.5Y 5/3) coarse grained SAND, single grained, loose; no mottles, no Gravel, moist, (m-f SAND, trace Silt).
	5				Rec.: 18"
	4				
	3				
	1	S-3	4 - 6	SILTY CLAY	Reddish Gray (10R 5/1) fine grained Silty CLAY, massive, medium stiff; many, medium, distinct, Yellowish Brown (10YR 5/8) mottles, no Gravel, moist.
	2				(SILT & CLAY) Rec.: 18"
	2				
47.3	4				
	1	S-4	6 - 8	CLAY LOAM	Gray (10YR 5/1) fine grained Clay LOAM, massive, medium stiff; common, coarse, distinct, Strong Brown (7.5YR 4/6) mottles, no Gravel, moist, (CLAY & SILT, some(+) m-f Sand).
	2				Rec.: 16"
	4				
45.3	4				
	2	S-5	8 - 10	SANDY LOAM	Gray (N5) coarse grained Sandy LOAM, massive, loose; no mottles, no Gravel, (m-f SAND, some Clayey Silt). Rec.: 8"
	3				
	3				
43.3	3				
	4	S-6	10 - 12	CLAY	Very Dark Gray (N3) fine grained CLAY, massive, medium stiff; no mottles, no Gravel, moist, (Silty CLAY, trace(+) f Sand, micaceous).
	4				Rec.: 6"
	3				
41.3	3				

*Indicates that soil description has been verified based on laboratory results.

Exhibit C-3: Sample Boring Log for Stormwater Facilities

BORING LOG

BORING NO. DB-1
SHEET NO. 3 OF 3

CONTRACT NO. T500.250 RDWY.Turnpike SND STA. 109+35 OFF. 35'LT

Elev. (ft) 41.3	Blows on Spoon	Sample No.	Sample Depth (ft)	Log	Material & Remarks
	WOH	S-7	12 - 14	SILT LOAM	Gray (2.5Y 5/1) medium grained Silt LOAM, massive, medium stiff; many, coarse, distinct, Reddish Brown (2.5YR 4/4) mottles, no Gravel, moist. (SILT, and f Sand) Rec.: 24"
	2				
	2				
39.3	4				
	2	S-8	14 - 16	SILTY CLAY LOAM	Reddish Gray (10R 5/1) fine grained Silty Clay LOAM, massive, medium stiff; many, coarse, distinct, Strong Brown (7.5YR 5/6) mottles, no Gravel, moist. (Clayey SILT, trace(+) f Sand) Rec.: 18"
	3				
	4				
37.3	6				
	6	S-9	16 - 18	LOAM	Yellowish Brown (10YR 5/4) medium grained LOAM, massive, soft; no mottles, no Gravel, moist. (Clayey SILT, some(+) f Sand) Rec.: 16"
	6				
	6				
35.3	6				
					End of Boring at 18 feet

*Indicates that soil description has been verified based on laboratory results.

Exhibit C-3: Sample Boring Log for Stormwater Facilities

New Jersey Turnpike Authority HNTB

Observation Well Installation Log

WELL NO.: RD-11 (OW)

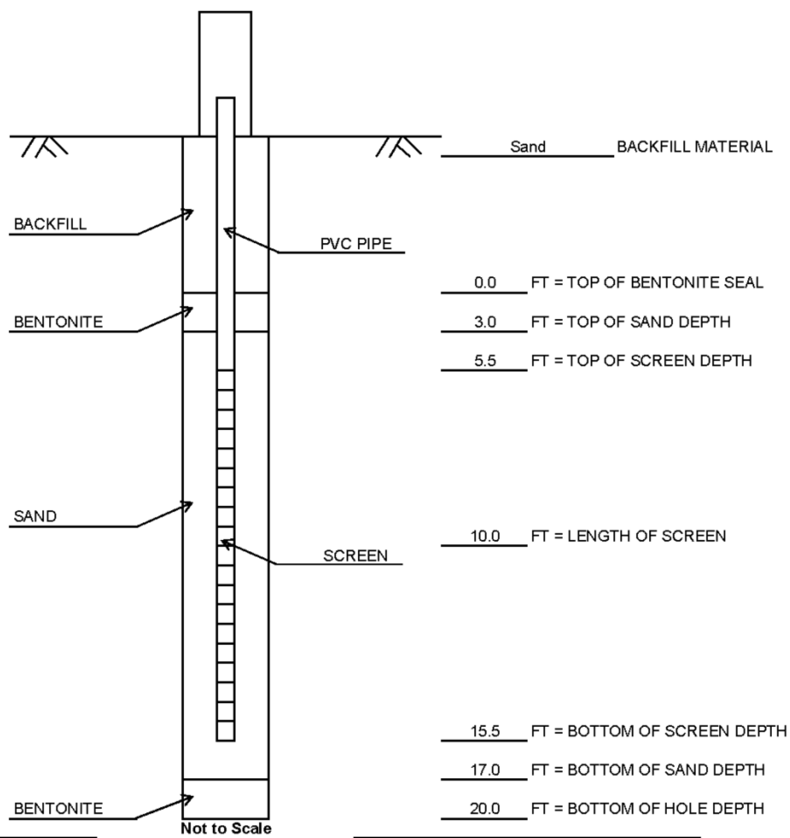
PROJECT NAME: NJTA Interchange 15E CONTRACT NO.: T500.250

DATE INSTALLED: 2/25/2015 INSPECTOR: George Sable HOLE DEPTH: 20'

CONTRACTOR: XYZ Drilling DRILLER: Dave Mueller HELPER: Dan Smith

LOCATION: Newark, NJ GROUND ELEVATION: 26.9

EASTING: 587021.8 NORTHING: 448165.1 STATION: ____ OFFSET: ____ BASELINE: ____



WELL READINGS

DATE	BY	DEPTH(FT)	EL.
3/3/2011	HJ	7.2	19.7
3/22/2011	JCJ	6.9	20.1
4/7/2011	JCJ	7.2	19.7
4/15/2011	PDT	7.1	19.8

WELL DATA

ITEM	DESCRIPTION
PVC Well Casing Inside Diameter	2" I.D.
Lock Installed	No
Standpipe or Flushmount	Standpipe
Bags of Sand Used	1 x 50LB
Bags of Bentonite Used	1/4 bucket
Development	

Depth recorded is depth below ground surface

All elevations refer to the NAVD 86 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

NOTES:

1. Estimated water level 11' at installation.
2. Revert and easy mud used during drilling.

Exhibit C-4: Sample Observation Well Log

HNTB

NEW JERSEY TURNPIKE AUTHORITY
FIELD TEST PIT LOG

TEST PIT NO. TP-7
SHEET 1 OF 1
DATE: START 12/14/15
END 12/14/15

Contract No. T500.250 Purpose Bridge Structure No. 1455-23
Location Newark, NJ RDWY Turnpike SND STA. 102+35 OFF. 35' L
NORTHING 611603.8 EASTING 695428.6 Ground Elevation 34.5 ft
EQUIPMENT USED CAT Backhoe
INSPECTOR George Sable DRILLERS NAME/COMPANY XYZ Drilling
PIT DIMENSIONS: LENGTH 6.0 ft ; WIDTH 4.0 ft ; DEPTH 8.0 ft
WATER LEVEL DEPTH: ______ NOT ENCOUNTERED [X]
CHECKED BY: Roy Roger ; DATE: 12/14/15

DEPTH (FT)	SAMPLE NO. AND TYPE	POCKET PENT/ TORVANE (TSF)	WATER CONTENT	DESCRIPTION	REMARKS
0.0	G-1		Dry	Brown cmf SAND, some(-) cm(+)f Gravel, trace(+) Silt (roots) (Topsoil)	
2.0				2.5	
	G-2		Dry	Brown black cmf(+) SAND, little Silt, trace(-) f Gravel	Bag sample collected.
4.0				4.0	
	G-3	1.0/ 0.5	Dry	Gray SILT, little cmf Sand, little(-) mf Gravel (mica)	
6.0				6.0 Gray brown Clayey SILT, some(-) cmf (+) Sand	
	G-4	2.5/ 1.0	Moist	7.0	
				Light brown mf SAND, little Silt, trace f Gravel	Permeability test performed at 8ft.
8.0				8.0	
				End of Test Pit at 8 ft.	
10.0					

NOTE: All elevations refer to the NAVD 88 datum. Horizontal locations refer to the NJ State Plane coordinate system as per the NAD 83 datum.

Exhibit C-5: Sample Test Pit Log

	SUBSURFACE EXPLORATION DAILY REPORT	Date	Day	Team Color
		Report No.	Page	
Project		Job No.		
Exploration Contractor		Weather		

EQUIPMENT ON JOB

DRILL RIG			
NO.	TYPE	MAKE	HAMMER TYPE
1			
2			

BORING INFORMATION

BORING NO.	DATE STARTED	IN PROGRESS	DATE COMPLETED	TOTAL DEPTH	GROUND ELEV.	CASING (C) OR MUD (M)	SAMPLES TAKEN		
							JAR	UNDIST.	ROCK CORE

Visitors ______________________ Representing ______________________

REMARKS

By initialing each box below I attest to the following.

- ☐ I have completed the log and indicated:
  Blow counts
- ☐ Recoveries
- ☐ Soil description
- ☐ Indicated sample moisture
- ☐ Utilized a pocket penetrometer on cohesive soils, where appropriate
- ☐ Utilized a torvane on cohesive soils, where appropriate
- ☐ Tightly sealed all jars and taped jars containing cohesive soils
- ☐ Core boxes properly labeled and samples wrapped.
- ☐ Undisturbed tubes have all relevant data (Project No., Boring No., Tube No., Depth and Date).
- ☐ Undisturbed tubes have been properly retrieved and recorded on the logs
- ☐ Undisturbed tubes do not have evidence that the spilt spoon intruded on the sample (i.e. donut)
- ☐ Undisturbed tubes have been properly wadded with a moist (not wet) rag to fill any void in tube, and wax applied to a clean tube interior to ensure a good seal
- ☐ Remained on-site until departure of drillers and witnessed that site was left in original condition
- ☐ Box labeled both sides with contents
- ☐ Samples listed above were turned over to the driller

If the answer is "No", please explain: ______________________

Inspector ________ Date ________ Driller ________ Date ________

Exhibit C-6: Subsurface Exploration Daily Report

APPENDIX D
Laboratory Testing for Soils and Rocks

LABORATORY TESTING FOR SOILS

			Tests	Reference
I.	Identification Tests:			
	A.	Mechanical Analysis		
		1.	Sieve Analysis (with grain size curve)	ASTM D 422
		2.	Percent passing #200 Sieve	ASTM D 1140
		3.	Hydrometer Analysis including Specific Gravity (with grain size curve)	ASTM D 422
	B.	Index Properties		
		1.	Preparation of Sample for Testing: Wet Preparation	ASTM D 2217
		2.	Liquid Limit - with flow curve	ASTM D 4318
		3.	Plastic Limit	ASTM D 4318
		4.	Shrinkage Limit	ASTM D 427
	C.	Specific Gravity		ASTM D 854
	D.	Water Content Determination		ASTM D 2216
	E.	Maximum & Minimum Density of Granular Soil (Dry State)		ASTM D 4253 / ASTM D 4254
	F.	Visual identification and classification of Jar Samples		Ref. D.1
	G.	Visual identification and log of undisturbed tube samples - including opening of tubes		Ref. D.1
	H.	Natural Dry Density and Water Content Determination of Shelby Tube Samples		Ref. D.2
II.	Permeability Tests:			
	A.	Permeability of granular Soils (Constant Head)		ASTM D 2434
	B.	Permeability of undisturbed sample in 2.5 inch Dia. consolidation apparatus with a maximum pore water back pressure of 60 psi, reporting permeability (K20), natural water content and dry density.		Ref. D.2
III.	Strength Tests:			
	A.	Unconfined compression test on undisturbed soil sample, including maximum stress and strain at failure, visual identification, initial water content, dry density, stress-strain curve and failure sketch. Minimum rate of strain 1% per minute.		ASTM D 2166
	B.	Direct Shear Test (Consolidated-Quick) on undisturbed soil sample for each normal load, including trimming, visual identification and consolidation of sample, initial and final water contents, dry density and stress-strain curve. Rate of shear one-half percent per minute.		ASTM D 3080 and Ref. D.2

C. Triaxial Compression Test for 2.8 inch Dia. or 1.4 inch Dia. undisturbed or remolded soil sample.

1. Unconsolidated-Undrained for each lateral pressure including visual identification initial water content, dry density, stress-strain curve and failure sketch. Minimum rate of strain 1 percent per minute. — ASTM D 4767

2. Consolidated-Undrained for each lateral pressure at maximum of 24 hour consolidation, with or without back pressure including visual identification, initial and final water contents, strain dry density, stress— curve and failure sketch. Minimum rate of strain 1 percent per minute. — ASTM D 4767/ Ref. D.3

3. Consolidated Drained for each lateral pressure at maximum of 24 hour consolidation, with or without back pressure including visual identification, initial and final water contents, dry density, stress- strain curve and failure sketch. Minimum rate of strain 1 percent per minute. — Ref. D.3

D. Test Method for Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils. — ASTM D 6528

IV. Consolidation Tests:

A. Consolidation test for 2.5 inch and not less than 0.75 inch high sample on undisturbed sample. — ASTM D 2435
For one load cycle and each load increment imposed for a maximum of 24 hours, and unloading to zero, including preparation, initial and final water contents, dry density, void ratio/log pressure curve or unit strain/log pressure curve. — Ref. D.4

B. Each unloading/reloading cycle consisting of two decrements and two increments. — Ref. D.4

C. For each additional day required for consolidation to define secondary consolidation. — Ref. D.4

D. For permeability test — Ref. D.4

E. One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled Strain Loading. — ASTM D4186

V. Compaction Test:

A. Moisture/Density Relations of Soils using 10 pound Rammer and 18 inch Drop including sample preparation and moisture density curve (modified Proctor). — ASTM D 1557 / AASHTO T180

B. Moisture/Density Relations of Soils using 5 pound Rammer and 12 inch Drop including sample — ASTM D 698 / AASHTO T99 preparation and moisture density curve (Standard Proctor).

C. Standard Method of Test for California Bearing Ratio (CBR)with Stress Penetration Curve (cylinder soaked up to 3 days)including required sample preparation and compaction either (a) or (b) above. Moisture Density relations determined by ASTM D 1557/AASHTO T-180. — ASTM D 1883 / AASHTO T193

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B.	Test Method for pH of Peat Materials	ASTM D 2976
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E.	Determination of the Point Load Strength Index of Rock	ASTM D 5731
F.	Standard Test Method for Slake Durability of Shales and Similar Weak Rocks	ASTM D 4644
G.	Standard Test Method for Laboratory Determination of Abrasiveness of Rock using the CERCHAR Method	ASTM D 7625
H.	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact Angeles Machine	ASTM C 131 in the Los

IX. Tests on Acid Producing Soil Samples:

A. Sulfate and pH Tests for acid producing soils shall be performed in accordance with Section 7 of the NJDEP Flood Hazard Technical Manual.

REFERENCES

D.1 Burmister, D. M. PRINCIPLES AND TECHNIQUES OF SOIL IDENTIFICATION.

Proceedings Highway Research Board: Dec. 1949.

D.2 Lambe, T. W. SOIL TESTING FOR ENGINEERS. John Wiley and Sons: 1951.

D.3 Bishol, A. W. and Henkel, D. J. THE MEASUREMENT OF SOIL PROPERTIES IN THE TRIAXIAL TEST. 2nd Ed. Edward Arnold Ltd.

D.4 Burmister, D. M. THE APPLICATION OF CONTROLLED TEST METHODS IN CONSOLIDATION TESTING. ASTM Symposium of Consolidation Testing of Soils, Special Technical Publication No. 126: 1951.

APPENDIX E
Table of Content for Reports

PHASE A GEOTECHNICAL ENGINEERING REPORT

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APPENDIX

Section 7 - SIGNING AND STRIPING

7.1. GENERAL

The Authority has developed the signing and striping design criteria contained herein for the particular needs of the Authority's roadways. They are intended to equal or exceed standards currently being used for limited access highways and should be considered minimum criteria, to be exceeded wherever practical and appropriate. Signing for highways and other limited access roads requires the use of engineering judgment for placement and spacing so that the signs have sufficient visibility to drivers and are in a logical sequence. Striping and other delineation for highways and limited access roads must provide clear and positive delineation and advance notification for decision points. These goals are particularly important given the traffic volumes and particular characteristics of the Authority's facilities.

The design criteria presented in this Section reflect a supplement to the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), approved by the Federal Highway Administration (FHWA). All references in this Manual to the MUTCD shall be construed as the latest approved and published edition. Note that the numbering of specific MUTCD Sections referenced in this Manual refers to the numbering in the 2009 edition of the MUTCD. Should there be any contradiction between the MUTCD and the Design Manual or any other publication of the Authority, the Authority's publications shall govern. Unless a particular traffic control device (signing or striping) has been modified by language in this Section, the Engineer should refer to the MUTCD, including published revisions and errata.

This Section generally describes the type of signs used, sign supports for small highway signs, sign layout, panel construction, consideration for sign lighting, pavement striping, delineator layout, design procedures and plan preparation methods. This information applies to all of the Authority's roadways and interchange areas. It is noted that some criteria described herein only apply in specific cases, such as the dualized section of the Turnpike or approaching barrier and ramp toll plazas on the Parkway.

Traffic control devices on roadways not owned or operated by the Authority will be subject to the criteria of the controlling agency. The Authority will determine the locations of permanent trailblazers outside of the immediate mainline or interchange area.

All references in this Section to the Authority's Specifications shall be construed as the most recently published Standard Specifications, with any modifications contained within project-specific Supplementary Specifications.

7.2. SIGNS

The signs to be used on the Authority's roadways are classified as regulatory, warning, directional or informational. Regulatory signs inform the roadway user of traffic laws or regulations, and indicate the applicability of legal requirements that would not otherwise be apparent. Warning signs inform the driver of situations that may violate driver expectancy. The directional and informational signs are to furnish the drivers with clear instructions for orderly progress to their destinations.

The letters “R” and “L” (right and left) are omitted from sign designations in this Section for simplicity. When any sign in the MUTCD or this Section may be used in either a right or left orientation, including the use of arrows or the text “RIGHT” or “LEFT,” the appropriate “R” or “L” suffix should be added to the sign designation to indicate the specified orientation. For example, sign M(NJTA)5 4aL would read “KEEP LEFT” and sign M(NJTA)5 4aR would read “KEEP RIGHT.”

For clarification of design procedures, signs are divided into four categories – standard, NJTA, contract and special. Most regulatory and warning signs are Standard Signs or NJTA Signs, while many guide signs are Contract Signs due to the need for customized messages.

7.2.1. Standard Signs

Standard Signs are those found in the MUTCD and are to be used in accordance with standards set forth in the MUTCD.

7.2.2. NJTA Signs

NJTA Signs are commonly used signs not included in the MUTCD for which the Authority has standardized dimensions and layouts. The specific use of each of the NJTA Signs is detailed in Subsection 7.4. Detailed dimensions and layouts for the NJTA Signs are provided in the SL Standard Drawings and requirements for materials are included in the Authority’s Specifications. The Figures in this Design Manual are for illustrative purposes only.

Most toll plaza signs are also NJTA Signs. Toll plaza signs include all of the signs required at or leading up to Turnpike and Parkway toll plazas to inform traffic of different payment options or to provide additional warning, regulation or guidance. Specific uses and typical placement of signs at and approaching toll plazas are detailed in Subsection 7.4.2.4.

7.2.3. Contract Signs

Contract signs are the fixed-message signs, such as guide signs, that have not been standardized by the Authority and are designed on a location-by-location basis. The messages for contract signs should be concise and coherent. Specific uses of contract signs are detailed in Subsection 7.4. Typical sign panel layouts for contract signs are discussed in Subsection 7.4.2. Design details not covered by the Authority’s Design Manual, Standard Drawings or Specifications are to be found in the MUTCD.

7.2.4. Special Signs

There are three types of special signs used on the Turnpike and Parkway.

7.2.4.1. **Variable Speed Limit Signs (VSLS)**

Variable Speed Limit Signs (VSLS) are located on all mainline Turnpike roadways. These signs have speed limit messages that are changed to the desired speed from a master control panel at the Statewide Traffic Management Center (STMC). Further details of the VSLS are given in Subsection 7.4.4 and shown on the VM Standard Drawings.

7.2.4.2. **Variable Message Signs (VMS)**

Variable Message Signs (VMS) are used on all mainline Turnpike and Parkway roadways. These signs can be programmed to disseminate specific information on current roadway conditions, either on the Authority's roadways or on neighboring facilities, information on major events or general safety messages. The programmed messages displayed on the VMS are remotely controlled from the STMC. Each VMS is independent, so messages can be customized to address the particular needs of a specific portion of the roadway. Further details of VMS are given in Subsection 7.4.5 and shown on the Standard Drawings.

7.2.4.3. **Hybrid Changeable Message Signs (HCMS)**

Hybrid Changeable Message Signs (HCMS) are located wherever northbound and southbound traffic is divided by vehicle classification into the Inner and Outer Roadways (Turnpike) and may also be located at divisions between the Express and Local Roadways (Parkway). Locations may include the gore areas of Interchange and Service Area entrance ramps and any other major decision point so determined by the Authority. Each sign consists of a VMS panel and a rotating drum containing three or four messages. The messages displayed on both the VMS panel and the rotating drum are remotely controlled from the STMC. By utilizing various combinations of messages, traffic may be segregated because of congestion, accidents or construction. Further details are shown on the Standard Drawings. The approximate locations of HCMS are described in Subsection 7.4.6.

7.3. SIGN SUPPORTS

Design guidelines for sign supports for ground mounted signs and sign structures for overhead signs are covered in Section 3 (Structures Design) of this Manual.

7.4. SIGN LOCATION LAYOUT

Based on the definition of Major Interchanges in Section 2E.32 of the MUTCD, all interchanges within the Turnpike toll-ticket system are considered major interchanges for the purposes of sign location layout. Other Turnpike and Parkway interchanges may be considered major, intermediate or minor. Considerations related to Advance Guide Signs are described in Subsection 7.4.3.1 (Mainline Signing) of this Manual.

The Supplemental Sign Policy issued by the Authority, available at the Authority's website at http://www.state.nj.us/turnpike/documents/NJTA-sign-guide.pdf, contains requirements and guidelines for applicants who wish to list a destination on a Supplementary Guide sign (MUTCD Section 2E.35), including recreational and cultural interest areas. The most recent published edition of the Supplemental Sign Policy is to be used where referenced throughout this Section.

7.4.1. Standard Signs

The descriptions and applications of signs found in the MUTCD are as stated in the MUTCD. The Authority's policy includes the following modifications to language found in the following Sections of the MUTCD:

MUTCD Section 2A.17: The Authority's policy regarding use of overcrossing structures for sign installation instead of separate sign structures is described in Subsection 7.5 of this Manual.

MUTCD Section 2B.40: When One Way (R6 1) signs are installed to the same post as Do Not Enter (R5 1) and/or Stop (R1 1) signs, the One Way signs are mounted above and perpendicular to the other signs.

MUTCD Section 2B.41: On Authority ramp termini at intersecting crossroads, One Way and No Left/Right Turn signs are placed where shown in MUTCD Figure 2B 18. For these signs only, the asterisk and "Optional" note in Figure 2B 18 are to be disregarded. Note that these signs are to be sized according to the classification of the intersecting crossroad, not the ramp.

MUTCD Section 2B.47: The applicable parking regulations on Authority roadways are "No Stopping or Standing," as opposed to "No Parking." As described in Subsection 7.4.2, the NJDOT R(NJ)7 4 series signs replace the MUTCD R7 4 series signs.

MUTCD Section 2C.14: The figure shown in Exhibit 7-1 in this Manual replaces MUTCD Figure 2C 3 to reflect conditions encountered on the Authority's roadways.

MUTCD Section 2C.55: Distances shown in miles on Distance Ahead and Next Distance plaques (W16 3 series, W7 3aP) may use the fractions ¼, ½ or ¾ instead of an integer.

MUTCD Section 2D.09: Turnpike and Parkway legends are given preference below Interstate and above United States routes.

MUTCD Section 2D.11: The NJTA County Route (M(NJTA)1 6) sign is used on guide signs instead of the standard County Route (M1 6) sign to provide increased legibility. The County name is removed and numerals are enlarged.

MUTCD Sections 2D.26 to 2D.28: The Authority's Maintenance Department may continue to use available sign stocks of Turnpike and Parkway arrows until they are depleted. All new arrow signs will follow MUTCD specifications, using a green background and either a white legend (Turnpike) or yellow legend (Parkway).

MUTCD Section 2D.29: Turnpike and Parkway route signs are given preference below Interstate and above United States route signs.

MUTCD Section 2E.34: Use of the "Next Exit" plaque is to be approved by the Authority.

MUTCD Section 2H.02: The only political boundary signs that may be posted on Authority roadways are State and County line signs. Municipal or other local boundaries shall not be posted. The State or County pictograph shall not be displayed.

MUTCD Section 2H.05: On the Turnpike Easterly and Westerly Alignments, D(NJTA)10-4 and D(NJTA)10 4a signs (NJTA Signs) are used instead of MUTCD D10-series signs to show the 'E' or 'W' letter designation for the roadway. On the Turnpike and Parkway, D(NJTA)10-1a, 2a and 3a signs (NJTA Signs) are used instead of MUTCD D10 a series signs to show tenth-mile intervals.

MUTCD Chapter 2M: Signing for recreational and cultural areas is to follow the Authority's Supplemental Sign Policy.

7.4.2. NJTA Signs

The various NJTA Signs are shown on the SL Standard Drawings. As hereinafter described, each of these signs has one or more specific locations where it is to be used. The designation prior to each of the following descriptions corresponds to the Sign Designation shown on the Standard Drawings and listed below. Where a sign lists a specific distance, such as MSS 1, W(NJTA)9 2a or W(NJTA)9 6, the distance shall be rounded to the nearest allowable increment:

- 100, 200, 300, 400, 500, 750, 1000, 1500, 2000 feet
- ¼, ½, ¾, 1, 1½, 2 miles
- Other distances require approval by the Authority.

Many of the descriptions may be clarified by reference to the sketches on Exhibit 7-2 through Exhibit 7-7,, or to the MUTCD.

Sign Designation/Name	Description of Installation Location(s)
D(NJTA)4-2a / 4-2b Park and Ride Advance Guide Sign	As provided in the MUTCD for Park – Ride Supplemental Guide signs. In addition to the Park – Ride symbol, pictographs may be added to the sign for the type(s) of transit present at the Park and Ride facility.

Sign Designation/Name	Description of Installation Location(s)
D(NJTA)10-1 Integer Mile Marker, 1 Digit	Replaces D10-1 sign (see MUTCD).
D(NJTA)10-1a Tenth-Mile Marker, 2 Digits	Replaces D10-1a sign (see MUTCD).
D(NJTA)10-2 Integer Mile Marker, 2 Digits	Replaces D10-2 sign (see MUTCD). The first digit may be replaced by a letter for Turnpike roadway (“P” for Pearl Harbor Memorial Turnpike Extension, “N” for Newark Bay – Hudson County Extension).
D(NJTA)10-2a Tenth-Mile Marker, 3 Digits	Replaces D10-2a sign (see MUTCD). The first digit may be replaced by a letter for Turnpike roadway (“P” for Pearl Harbor Memorial Turnpike Extension, “N” for Newark Bay – Hudson County Extension).
D(NJTA)10-3 Integer Mile Marker, 3 Digits	Replaces D10-3 sign (see MUTCD).
D(NJTA)10-3a Tenth-Mile Marker, 4 Digits	Replaces D10-3a sign (see MUTCD).
D(NJTA)10-4 Integer Mile Marker, 4 Digits	Used in the same manner as D(NJTA)10-3 with an additional letter for roadway, on Turnpike Easterly (“E”) and Westerly (“W”) alignments.
D(NJTA)10-4a Tenth-Mile Marker, 5 Digits	Used in the same manner as D(NJTA)10-3a with an additional letter for roadway, on Turnpike Easterly (“E”) and Westerly (“W”) alignments.
D(NJTA)10-5 Parkway Reassurance Sign	Mounted above Integer Mile Markers on the Garden State Parkway at Mile 10, 20, 30, etc.
D(NJTA)10-7a Structure Identifier, 1 to 4 Digits	Mounted on all Authority structures with identification numbers of up to 4 digits.
D(NJTA)10-7b Structure Identifier, 5 Digits	Mounted on all Authority structures with identification numbers of 5 digits.
D(NJTA)10-7c Structure Identifier, 6 Digits	Mounted on all Authority structures with identification numbers of 6 digits.
D(NJTA)10-7d Structure Identifier, 7 Digits	Mounted on all Authority structures with identification numbers of 7 digits.
D(NJTA)10-7e Structure Identifier, 8 Digits	Mounted on all Authority structures with identification numbers of 8 digits.
D(NJTA)12-5GSP Parkway Travel Info	Replaces D12-5 sign (see MUTCD) along Parkway.
D(NJTA)12-5aNJT Turnpike Travel Info	Replaces D12-5 sign (see MUTCD) along Turnpike mainline south of Interchange 6.

Sign Designation/Name	Description of Installation Location(s)
D(NJTA)12-5bNJT Turnpike / Interstate Travel Info	Replaces D12-5 sign (see MUTCD) along all Turnpike roadways except the mainline south of Interchange 6. I-78 is used for the Newark Bay – Hudson County Extension and I-95 is used otherwise.
D(NJTA)13-3a Parkway Entrance	On an intersecting roadway at the gore or intersection of a Parkway entrance ramp, except where US Route 9 enters or is co-designated with the Parkway. The Toll (M4-15) sign is erected left-justified above D(NJTA)13-3aR and right-justified above D(NJTA)13-3aL.
D(NJTA)13-3b Parkway and US 9 Entrance	On an intersecting roadway at the gore or intersection of a Parkway entrance ramp where US Route 9 enters or is co-designated with the Parkway (Interchanges 25 to 29, 48 to 50, 80 to 83). The Toll (M4-15) sign is used as described for D(NJTA)13-3a at the Interchange 29 entrance only due to the downstream toll plaza.
D(NJTA)13-3c Turnpike and Interstate Entrance	On an intersecting roadway at the gore or intersection of a Turnpike entrance ramp, along all Turnpike roadways except the mainline south of Interchange 6. I-78 is used for the Newark Bay – Hudson County Extension and I-95 is used otherwise. The Toll (M4-15) sign is erected left-justified above D(NJTA)13-3cR and right-justified above D(NJTA)13-3cL.
D(NJTA)13-3d Turnpike Entrance	On an intersecting roadway at the gore or intersection of a Turnpike entrance ramp along the mainline south of Interchange 6. The Toll (M4-15) sign is erected left-justified above D(NJTA)13-3dR and right-justified above D(NJTA)13-3dL.
E(NJTA)4-2 NJTA Supplemental Guide Sign	As provided in the MUTCD for Supplemental Guide Signs. E(NJTA)4-2 signs are only erected with messages and at locations approved by the Authority based on the Authority's Supplemental Sign Policy.
E(NJTA)6-1 series Inside Entry – Diagonal Arrows	Over the theoretical gores of interchange toll plaza inside entries to Turnpike roadways where signs are not directly over the indicated travel lanes. Signs with left arrows are arranged similarly, except on signs with one arrow, the text is placed on the right side of the arrow. Sign configurations, messages and arrows are selected on a location-by-location basis.
E(NJTA)6-2 series Inside Entry – Down Arrows	Over the theoretical gores of interchange toll plaza inside entries to Turnpike roadways where signs are directly over the indicated travel lanes. Sign configurations, messages and arrows are selected on a location-by-location basis.
E(NJTA)6-3 series Authority Pull-Through Signs	Replaces E6-2 series (see MUTCD) on Turnpike and Parkway. May be modified based on engineering judgment to include down arrows over all applicable lanes at complex interchanges.
GS-HAR Urgent Message	Off the right shoulder where determined by the Authority.
I(NJTA)1 Traffic Regulations	In the toll plaza area on all interchange entries to the Turnpike, located where it is safe to pull over and read the regulations.
M(NJTA)1-1 Parkway Sign	On all Parkway roadways, route sign assemblies and guide signs on intersecting highways.
M(NJTA)1-2 Turnpike Sign	On all Turnpike roadways, route sign assemblies and guide signs on intersecting highways.
M(NJTA)1-6 County Route Sign	Used for 500-series county routes incorporated on guide signs only.
M(NJTA)5-4a Keep Right (Left)	On an intersecting roadway in advance of a Turnpike or Parkway entrance when there are intermediate intersections or major driveways.

Sign Designation/Name	Description of Installation Location(s)
M(NJTA)5-4b Next Right (Left)	On an intersecting roadway in advance of a Turnpike or Parkway entrance when the entrance is the next turn in that direction.
MSS-1 Service Area X Miles	In advance of all exit ramps to service areas by a whole number of miles, determined on a location by location basis.
MSS-2 Service Area Next Right	In advance of all exit ramps to service areas by ½ mile, adjusted by up to ¼ mile depending on sight distance and geometric constraints on sign location and visibility. The actual distance may replace the action message of "Next Right/Left" based on field conditions.
MSS-3a Next Service Area	Beneath one or more MSS-1 and/or MSS-2 signs in advance of all service areas except where MSS-3b is used.
MSS-3b Last Service Area	Beneath one or more MSS-1 and/or MSS-2 signs in advance of the last service area on the Turnpike or Parkway in that direction.
MSS-4a Service Area Gore	Replaces D5-2 (see MUTCD), located at exit gore.
MSS-4b Overhead Service Area Gore	Overhead above the deceleration lane at the theoretical exit gore for all exit ramps to service areas.
MSS-5a Freeway Service Sign, Six Logos	In advance of interchanges where the Authority has approved listing up to six service facilities on intersecting or connecting roads.
MSS-5b Freeway Service Sign, Four Logos	Used in the same manner as MSS-5a where there are no more than four service facilities anticipated to be provided at the interchange.
MSS-6a Ramp Service Sign, Six Logos	On interchange exit ramps where the Authority has approved listing up to six service facilities on intersecting or connecting roads.
MSS-6b Ramp Service Sign, Three Logos	Used in the same manner as MSS-6a where there are no more than three service facilities anticipated to be provided at the interchange.
MSS-7a Service Area Parking Regulations	At all Service Area parking facilities, located so as to be visible to all patrons within the facility.
MSS-7b Park-Ride Lot Regulations	At all Authority park and ride facilities, located so as to be visible to all patrons within the facility.
MSS-7c Permit Parking Only Regulations	At all parking lots within Authority jurisdiction where part or all of the lot is restricted to parking by permit only, so as to be visible to all patrons within the permit-restricted area or lot.
MSS-8aP / 8bP Call #95 / #477	Mounted below R(NJTA)8-7b. MSS-8aP is used on the Turnpike and MSS-8bP is used on the Parkway.
Overcrossing Identification Signs	Mounted on overpasses crossing Authority roadways, located as shown on Standard Drawing SL-27.
R(NJTA)3-10 Alt Fuel Preferential Lane Sign	Replaces R3-10a (see MUTCD).
R(NJTA)3-11 Shoulder – Cars Only	At the beginning of the ramp segment governed by the applicable regulation and at intervals appropriate to ramp operating speeds and sight distances.

Sign Designation/Name	Description of Installation Location(s)
R(NJTA)5-11 Official Use Only	At median Z-turns and U-turns, grade separated U-turns, ramps to Authority and State Police facilities, employee parking lots and roadways and other restricted roadways where only vehicles authorized by the Authority and/or NJ State Police are allowed to enter. Must be mounted beneath an appropriate R3- series sign (such as R3-1, R3-2, R3-3, etc.) or similar movement prohibition sign (such as R5-1).
R(NJTA)8-7a Park Disabled Vehicles on Grass	Where a full-width paved shoulder is not available and the immediately adjacent landscaped area is accessible from and at the same grade as the edge of pavement, at the beginning of such an area and at periodic intervals throughout the area as determined by the Authority.
R(NJTA)8-7b Remain with Disabled Vehicle	Along the right shoulder at periodic intervals as determined by the Authority based on roadway geometry, sight distance, locations of other signs and other considerations. MSS-8aP or MSS-8bP is mounted below.
R(NJTA)8-9 Authority Employee Parking Only	At the entrances to parking facilities intended for exclusive use by Authority employees and other authorized personnel, such as toll plaza employee parking areas. Also used within otherwise public parking facilities to demarcate areas for exclusive use by authorized personnel.
R(NJTA)9-4a Passengers Prohibited	In toll plaza areas and anywhere else where the Authority has identified an existing or potential concern with pedestrian activity.
R(NJTA)12-7a No Trucks/Buses/ Trailers Left Lane	At the beginning of the applicable restriction and at periodic intervals throughout the restriction as determined by the Authority.
R(NJTA)12-7b No Trucks/Buses/ Trailers 2 Left Lanes	At the beginning of the applicable restriction and at periodic intervals throughout the restriction as determined by the Authority.
R(NJTA)12-7c No Buses/Trailers 2 Left Lanes	At the beginning of the applicable restriction and at periodic intervals throughout the restriction as determined by the Authority.
R(NJTA)12-7d No Buses/Trailers Left Lane	At the beginning of the applicable restriction and at periodic intervals throughout the restriction as determined by the Authority.
R(NJTA)12-7e No Trucks or Trailers 2 Left Lanes	At the beginning of the applicable restriction and at periodic intervals throughout the restriction as determined by the Authority.
R(NJTA)12-7f Left Lane Restriction Ahead	In advance of the beginning of the applicable restriction, to be located based on site-specific conditions.
R(NJTA)12-7g End Left Lane Restriction	At the end of the applicable restriction.
Ramp Identifier	Off the right shoulder at the beginning of the indicated ramp.
TPR-1 Stop – Get Ticket	Replaces the combination of R1-1 and R3-30P (see MUTCD) at Turnpike toll plaza entries (including barrier toll plazas), mounted flush to the bumper block. Not installed at lanes dedicated to E-ZPass.
TPR-2 Stop – Pay Toll	Replaces the combination of R1-1 and R3-29P (see MUTCD) at Turnpike toll plaza exits (including barrier toll plazas), mounted flush to the bumper block. Not installed at lanes dedicated to E-ZPass.

Sign Designation/Name	Description of Installation Location(s)
TPR-3a Your Speed (2 lines)	At the entrance to dedicated E-ZPass lanes, mounted beneath VMS that display approach speeds, to augment TPR-4 signing. Choice of TPR-3a or TPR-3b is based on site-specific conditions.
TPR-3b Your Speed (1 line)	At the entrance to dedicated E-ZPass lanes, mounted beneath VMS that display approach speeds, to augment TPR-4 signing. Choice of TPR-3a or TPR-3b is based on site-specific conditions.
TPR-4 E-ZPass Toll Speed	Replaces R2-1 (see MUTCD) when mounted on an element of the toll plaza booth or canopy structure or when installed on a ramp in advance of the ramp toll plaza. See MUTCD Section 2F.05, paragraph 8.
TPR-5 Car Toll	In advance of Parkway mainline and ramp toll plazas.
TPR-6a Trailers Prohibited	In advance of Parkway mainline and ramp toll plazas with Exact Change lanes north of Interchange 105, where trucks are prohibited.
TPR-6b Trucks-Trailers Prohibited	In advance of Parkway mainline and ramp toll plazas with Exact Change lanes from Interchange 105 south, where trucks are allowed.
TPR-7a E-ZPass Tag Holders Only	In advance of mainline and ramp toll plazas.
TPR-7b E-ZPass Accepted All Lanes	In advance of toll plazas where E-ZPass transactions can be completed in any lane, including lanes designated for other payment modes.
TPW-1 Ramp Divides	Off the right shoulder on the entrance ramps to the northbound (TN) and southbound (TS) roadways along the Dual-Dual section of the Turnpike, at least 800 to 1,200 feet in advance of the ramp splits for the Inner and Outer Roadways.
TPW-2 Toll Plaza Advance	At locations with high-speed E-ZPass lanes where not all traffic is required to slow or stop, only where directed by the Authority.
W(NJTA)9-1 Right (Left) Lane Ends X Feet	Replaces W9-1 (see MUTCD), for ground-mounted sign locations only.
W(NJTA)9-2 Lane Ends Merge	Replaces W9-2 (see MUTCD), over the lane to be dropped.
W(NJTA)9-2a Lane Ends X Feet	Replaces W9-1 (see MUTCD), for overhead-mounted sign locations only.
W(NJTA)9-6 Reduce Speed Pay Toll	On Turnpike exit ramps, typically at least 1,000 feet in advance of the toll plaza (subject to site conditions). Typically post-mounted, may only be overhead mounted where directed by the Authority. May also be on Parkway exit ramps based on engineering judgment.
W(NJTA)9-6a Toll Plaza Ahead	On Turnpike entrance ramps, typically 500 to 700 feet in advance of the toll plaza (subject to site conditions). Typically mounted overhead, only where directed by the Authority. May also be on Parkway entrance ramps based on engineering judgment.
W(NJTA)9-7a Exit Only (2 Line)	Replaces W9-7 (see MUTCD).
W(NJTA)9-7b Exit Only (4 Line)	Replaces W9-7 (see MUTCD) for constrained locations only where W(NJTA)9-7a cannot be installed.

7.4.2.1. Integer Mile and Tenth-Mile Markers

On mainline roadways with two or three lanes, Integer Mile and Tenth-Mile Markers (D(NJTA)10 1 to 10 4 and D(NJTA)10 1a to 10 4a) are installed on the right-hand side of the roadway. On roadways with four or more lanes and where determined to be beneficial based on site-specific conditions, these markers are also installed in the median so that the two signs at each integer or decimal mile point are directly across from each other. Integer Mile and Tenth-Mile Markers may also be installed between two same-direction roadways, such as the New Jersey Turnpike Inner and Outer Roadways or Garden State Parkway Express and Local Roadways, such that they are visible to motorists on both roadways.

On the Parkway mainline, the Parkway Reassurance Sign (D(NJTA)10 5) is installed every 10 miles in both directions, beginning at Mile 10. It is mounted above (not replacing) the regular Integer Mile Markers at those locations. The sign includes the roadway direction and the Parkway Sign.

7.4.2.2. Service Area Signs

Service Area Signs are defined as specific service signs that provide road users with business identification and directional information and mileage for service areas. Service Areas require a minimum of three advance exit signs and an exit direction sign. Service Area signs may be located farther in advance (upstream) of the Service Area exit ramp based on site-specific conditions. Proposed new installations more than 2 miles from the service area exit ramp require approval by the Authority.

The Authority enters into contracts to provide products and services to the public at Service Areas. Therefore, any services that are provided at Service Areas, such as gas and food, are only displayed on Service Area advance guide signs. The names or symbols of these services are not included on General Service signs and logos for related businesses are not included on Specific Service signs at interchanges. Refer to the Authority’s Supplemental Sign Policy for additional information.

Service Area guide signs (MSS 1 or MSS 2) shall be limited to no more than six logo panels. When there are more than six services provided at a Service Area, the Authority determines which approved products and services within the Service Area are displayed on each advance guide sign. Refer to the Authority’s Supplemental Sign Policy for additional information.

Standard Drawing SL 24 lists the Service Areas on the New Jersey Turnpike and Garden State Parkway.

7.4.2.3. General and Specific Service Interchange Signs

The policy for Specific Service Signs (as defined in Chapter 2J of the MUTCD) is included in the Authority's Supplemental Sign Policy. For General Service Signs (as defined in Chapter 2I of the MUTCD), service symbols or text (Gas, Food, etc.) are subject to the same policies as logos on Specific Service Signs. The following design guidelines also apply:

1. In general, Lodging is the only specific service signed on service signs, although the Supplemental Sign Policy permits a limited number of other services to be signed if approved by the Authority.
2. For General Service Signs, the exit number is to be displayed within the sign (MUTCD sign D9 18b).
3. The 24-Hour Pharmacy program described in the MUTCD has not been adopted in New Jersey and will not appear on service signs.
4. The Interstate Oasis program described in the MUTCD has not been adopted by the Authority.
5. The Authority has approved the use of Specific Service signs for alternative fuel locations. Unless alternative fuel is provided, gas services are not signed on Specific Service signs per the Supplemental Sign Policy. The Authority will provide the approved legend for alternative fuel signing.
6. Similar to General Service signing, Specific Service signing should only be provided at locations where the road user can return to the freeway and continue in the same direction of travel. This guideline is relevant to certain interchanges along the Parkway.

7.4.2.4. Toll Plaza Signs

Road users expect to encounter similar conditions in similar situations, e.g. when approaching toll plazas. Because different toll plazas have different layouts, driver expectations may be violated. The goal of the Authority is to provide consistent signing to support driver expectancy and to encourage drivers to make decisions in advance, reducing the potential for erratic movements.

Diagrammatic Signs: It is the Authority's practice to provide diagrammatic signs in advance of mainline barrier toll plazas where the toll plaza includes Express E ZPass lanes and there is an option lane configuration as defined in MUTCD Section 2E.20. Diagrammatic signs shall not be used when there is not an option lane. The diagrammatic sign provides notice well in advance of the impending toll plaza to properly channelize traffic. Diagrammatic signs shall be mounted overhead and shall be located two miles and one mile in advance of toll plazas utilizing Express E-ZPass.

Advance Toll Warning Signs: Advance toll warning signs (TPW- series and W(NJTA)9 6 series) provide notice in advance of a downstream mainline or ramp toll plaza. Mainline signs should be placed ¼ mile and ½ mile in advance of the plaza, with additional advance signs at 1 mile and 2 miles if spacing permits and diagrammatic signs are not used. Ramp signs are located as described in Subsection 7.4.2 (NJTA Signs).

Toll Regulatory Signs: Standardized toll regulatory signs (TPR- series) are located as described in Subsection 7.4.2 (NJTA Signs). The Lane Designation Sign on the Parkway, showing the types of toll collection present at the plaza, is to be ground mounted and placed approximately 1000 feet from the toll plaza.

Toll Canopy Signs: Toll canopy signs are mounted on the toll plaza above each toll lane with messages that can be changed to indicate the accepted payment method(s) in that lane. The design requirements are provided by the Authority.

7.4.2.5. **Lane Reductions and Drops**

Lane Reduction: When a lane ends between interchanges, the Parkway typically follows the sign sequence noted in Section 2C.42 of the MUTCD:

1. W9-1 – Right (Left) Lane Ends
2. W9-2 – Lane Ends Merge Left (Right)
3. W4-2 – Lane Ends

The Turnpike follows the sign sequence shown in Exhibit 7-6, which may be used on the Parkway where determined by the Authority:

1. W(NJTA)9-1 – Right (Left) Lane Ends X Feet
2. W(NJTA)9-2 – Lane Ends Merge
3. W4-2 – Lane Ends

Where the required sign spacing cannot be achieved on the Parkway, the W9 2 sign may be eliminated from the sequence. The W9-1 or W(NJTA)9 1 is typically located 1,500 feet in advance of the taper but may be moved based on site-specific conditions. When the W9 1 sign is used on the Parkway, a distance plaque (W16 2 or W16 3 series) should be mounted below the W9 1 to indicate the distance to the lane reduction.

Lane Drop: When a travel lane becomes the exit lane at an interchange, Exhibit 7-7 indicates the specific signs and the required sign spacing. Option lane drops are similar, except signs are modified to reflect that traffic in the rightmost through lane has the option of continuing on the mainline or exiting. When the lane drop is for an auxiliary lane less than 1 mile in length, the 1-mile advance guide sign is omitted. Signing is similar for a left exit except the Left Exit Number Plaque (MUTCD sign E1 5bP) is used.

The Exit Only panels are the E11 1 series found in the MUTCD. The only required sign in addition to the exit guide signs is the W(NJTA)9 7 series (Exit Only) sign.

7.4.2.6. **Highway Advisory Radio (GS-HAR) Signs**

These signs are designed with two beacons located directly above the sign panel as shown on Standard Drawing SL 26, centered on the sign posts. The sign posts are to extend above the top of the sign so that the beacons can be mounted on the posts. The beacons are activated by the Authority when the radio station(s) listed are broadcasting advisories relevant to drivers reading the sign. A visor is provided above each beacon to maintain visibility by shielding the lens from sunlight. Beacons and associated electrical items are to conform to Sections 606 and 918.24 of the Authority's Specifications and Sections 4L.01 and 4L.03 of the MUTCD. When activated, the beacons are to flash alternately as described in the MUTCD.

7.4.2.7. **Use of NJDOT Signs**

Certain signs from the New Jersey Department of Transportation (NJDOT) are used on the Turnpike and Parkway to convey regulations of the State of New Jersey:

1. The Fines Doubled (R(NJ)2 7a) sign is posted at the beginning of every 65 mph speed zone.
2. The No Litter (R(NJ)5 12) sign may be posted at Service Areas and other facilities (such as Park and Ride lots) where patrons may exit their vehicles.
3. No Stopping or Standing (R(NJ)7 4 series) signs are posted where parking or standing is prohibited and the Authority determines that signing is warranted to discourage these activities. The R(NJ)7 4L and 7 4R signs are posted at the beginning and end of restrictions, and the R(NJ)7 4X sign is posted within the restriction.
4. The Reserved Parking Penalty (R(NJ)7 8a) sign shall be posted below each Reserved Parking (R(NJ)7 8) sign.

7.4.3. **Contract Signs**

Contract signs are the fixed-message signs, such as guide signs, that have not been standardized by the Authority and are designed on a location-by-location basis. The timely display of information on contract signs when exiting the limited access facility provides the road user with critical information to make a decision without being confused. Contract signs are generally located as shown in Exhibit 7-2 through Exhibit 7-7 with messages as outlined below.

In order to provide for the proper spacing between signs and to provide consistent information to the motoring public, a standard sequence and spacing is desirable when exiting and entering a limited access facility. Guide signs, including supplemental guide signs, should be located a minimum of 800 feet apart in urban areas to maintain adequate visibility to each sign. In rural areas and wherever practical, this minimum spacing should be exceeded.

No more than two destinations should be included on the guide sign sequence in advance of an exit, with the same destinations and order on all signs in the same direction. When multiple destinations are used for a single exit ramp, the closest destination is listed first. When multiple destinations are used for consecutive exit ramps or for a Collector-Distributor (C-D) roadway with multiple exits, the destination for the first exit reached by traffic is listed first.

Note that on the Garden State Parkway, some interchanges are built as partial interchanges with certain movements missing or added in one or both directions. Therefore, guide signs in opposite directions for the same interchange may include different destinations.

7.4.3.1. **Mainline Signing**

Advance Guide Signs: Advance Guide Signs give notice well in advance of the exit point. Their purpose is to inform the drivers of navigational information such as the exit number, the mileage to the exit and the major destinations of interest near the interchange. The names of major destinations to be shown on these signs will be provided by the Authority.

Advance Guide Signs are desirably located at 2 miles, 1 mile and ½ mile in advance of the theoretical exit gore. Locations may be adjusted up to ¼ mile as necessary based on site-specific field conditions including, but not limited to:

1. Locations of existing sign structures
2. Spacing between interchanges
3. Sight distance to the proposed sign location
4. Locations of mainline barrier toll plazas

All three Advance Guide Signs should be provided, but it may not be possible to provide all three signs in constrained locations on the Parkway. The Authority shall approve omission of an Advance Guide Sign based on engineering judgment or a site-specific engineering study. For interchanges with heavy traffic splits or in areas with closely spaced interchanges, it may be desirable to provide additional Advance Guide Signs (e.g., at both ½ mile and ¼ mile in advance). The distance shall be rounded to the nearest ¼ mile.

Advance Guide Signs on mainline roadways are located based on the number of roadway lanes:

1. When the roadway has two lanes in one direction, signs are ground mounted unless there is an adjacent same-direction roadway with an overhead sign at the same location.
2. When the roadway has three lanes in one direction, signs shall be placed overhead on a cantilever or span type structure.
3. When the roadway has four or more lanes in one direction, signs shall be placed overhead on a span type structure only.

At the discretion of the Authority, a butterfly type structure may be used in the median where same-direction roadways are adjacent, such as in the Dual-Dual section of the Turnpike or the Express-Local sections of the Turnpike and Parkway.

The layout of Advance Guide Signs on the Turnpike and Parkway shall follow the MUTCD. All Advance Guide Signs shall contain a distance message at the bottom as well as an exit number plaque. The design and application of exit number plaques shall be according to Section 2E.31 of the MUTCD.

<u>Exit Direction Signs:</u> The Exit Direction Sign repeats the information that was shown on the Advance Guide Signs for the next exit, except in place of the mileage, there is a directional arrow. The layout of Exit Direction Signs on the Turnpike and Parkway shall follow the MUTCD, including use of an exit number plaque. This sign is mounted overhead above the deceleration lane(s) at the theoretical exit gore. If there is an overpass close to the theoretical exit gore that may obscure visibility to the Exit Direction Sign, it may be mounted on a sign structure on the near (upstream) side of the overpass.

<u>Pull-Through Signs / Next Exit Supplemental Signs:</u> NJTA Signs in the E(NJTA)6 3 series direct through traffic. The Next Exit supplemental sign, shown in Figure 2E 23 of the MUTCD, informs the driver of the mileage to the next exit. These signs are located on the same sign structure as the Exit Direction Sign and are mounted over the through lanes.

<u>Exit Gore Signs:</u> MUTCD sign E1 5a indicates the exiting point or place of departure from the main roadway. It is ground-mounted within the gore area at the exit.

7.4.3.2. **Interchange Signing**

<u>Toll Plaza – Entry Signs:</u> NJTA Signs in the E(NJTA)6 1 and E(NJTA)6 2 series are located at the entrance ramp split, directing entering traffic to either the

northbound or southbound roadways. These signs are generally located on an overhead sign structure over the theoretical gore (painted nose). The names of major destinations to be shown on these signs will be provided by the Authority.

On the Dual-Dual section of the Turnpike and as directed by the Authority on the Express-Local section of the Parkway, the signs located at the ramp split for the Inner and Outer Roadways are HCMS mounted on overhead sign structures over the theoretical gore (painted nose).

Toll Plaza – Exit Signs: Contract signing for local roads or state highways shall be consistent with the MUTCD. The details for Interstate, U.S., State and County highway route markers and cardinal direction auxiliary signs are to conform to the MUTCD.

7.4.4. Variable Speed Limit Signs (VSLS)

Variable Speed Limit Signs (VSLS) are generally located every two to three miles above each roadway, co-located with Variable Message Signs (VMS). VSLS and VMS locations have been determined by the Authority based on factors including interchange locations, distance between successive interchanges or ramps, sight distance and distance between VSLS / VMS installations. VSLS and VMS inform traffic of the speed limit and of any adverse road conditions upon entering the freeway and in advance of decision points where traffic may leave the freeway.

7.4.5. Variable Message Signs (VMS)

Variable Message Signs (VMS) are typically installed on overhead sign structures, including span, cantilever and butterfly type structures. When directed to investigate the need for VMS on a project by the Authority, the Engineer shall analyze the following factors to determine if VMS are warranted on a project:

1. Intended purpose of the sign – Serve the general traveling public, special event, upcoming construction, etc.
2. Type of information to be displayed – One message to be blanked out, a few select messages needing limited lines, or a wide range of possible messages. This will determine if a character, line or full matrix VMS is necessary.
3. Type of technology to be used – To be coordinated with the Authority, which may affect sign location.
4. Special project-specific considerations

The Engineer shall submit the recommendation as part of Preliminary Design, for Authority approval, before performing location analysis.

When a VMS is warranted, using the data and information collected above, and approved by the Authority, site selection is now possible. The Engineer shall perform location analysis for each VMS accounting for the guidance provided in

Section 2L.06 of the MUTCD as well as the following considerations (at a minimum):

1. The minimum distance on a freeway that a VMS should be placed prior to an access point (such as an Interchange) or other decision point is one mile.
2. VMS on freeways or expressways with speeds of 55 mph or greater should be located on horizontal tangents with a minimum of 1,000 feet of clear sight distance.
3. The ideal vertical grade should be 1% or less, and VMS should not be placed along grades exceeding 4%. An upgrade is preferable to a downgrade.
4. VMS should not compete with other existing signs or interfere with traffic control devices. The Engineer must take inventory of all signs and traffic control devices along a roadway segment to properly place the VMS. On a freeway, the minimum distance between Type I guide signs and a VMS should be 800 feet.
5. Identifying existing power feeders along a roadway segment helps the Engineer understand how difficult it might be to power a potential VMS site. It is desirable to locate the VMS and existing electrical service as close together as possible. All power service locations require approval from the utility company prior to installation. Where existing electrical power is not available in a proposed location, see Section 7 (Lighting and Power Distribution Systems) of this Manual for more information on design.
6. Installation costs should also be considered, taking into account the other factors above.

Coordination with the Authority during the design process, as described in Subsection 7.9, is required to receive approval for VMS location. Section 9 (ITS and Communication Systems) of this Manual will contain further information regarding sign technology, power, and communication systems.

7.4.6. Hybrid Changeable Message Signs (HCMS)

As described in Subsection 7.2.4.3, Hybrid Changeable Message Signs (HCMS) are located on sign structures over the theoretical gore (painted nose) of all major points of driver decision, where the choice of either alternate would enable the driver to reach the same destination. HCMS may be located at:

1. Entrance ramp splits to Inner and Outer or Express and Local Roadways
2. Service Area entrance ramp splits
3. In advance of any permanent or temporary mainline bifurcation

In the case of a temporary mainline split, HCMS are to be used for two-mile and one-mile advance warning signs as well as at the split itself.

EXHIBIT 7-1 – ADVISORY SPEED SIGNING FOR AN EXIT RAMP (MUTCD FIGURE 2C-3)

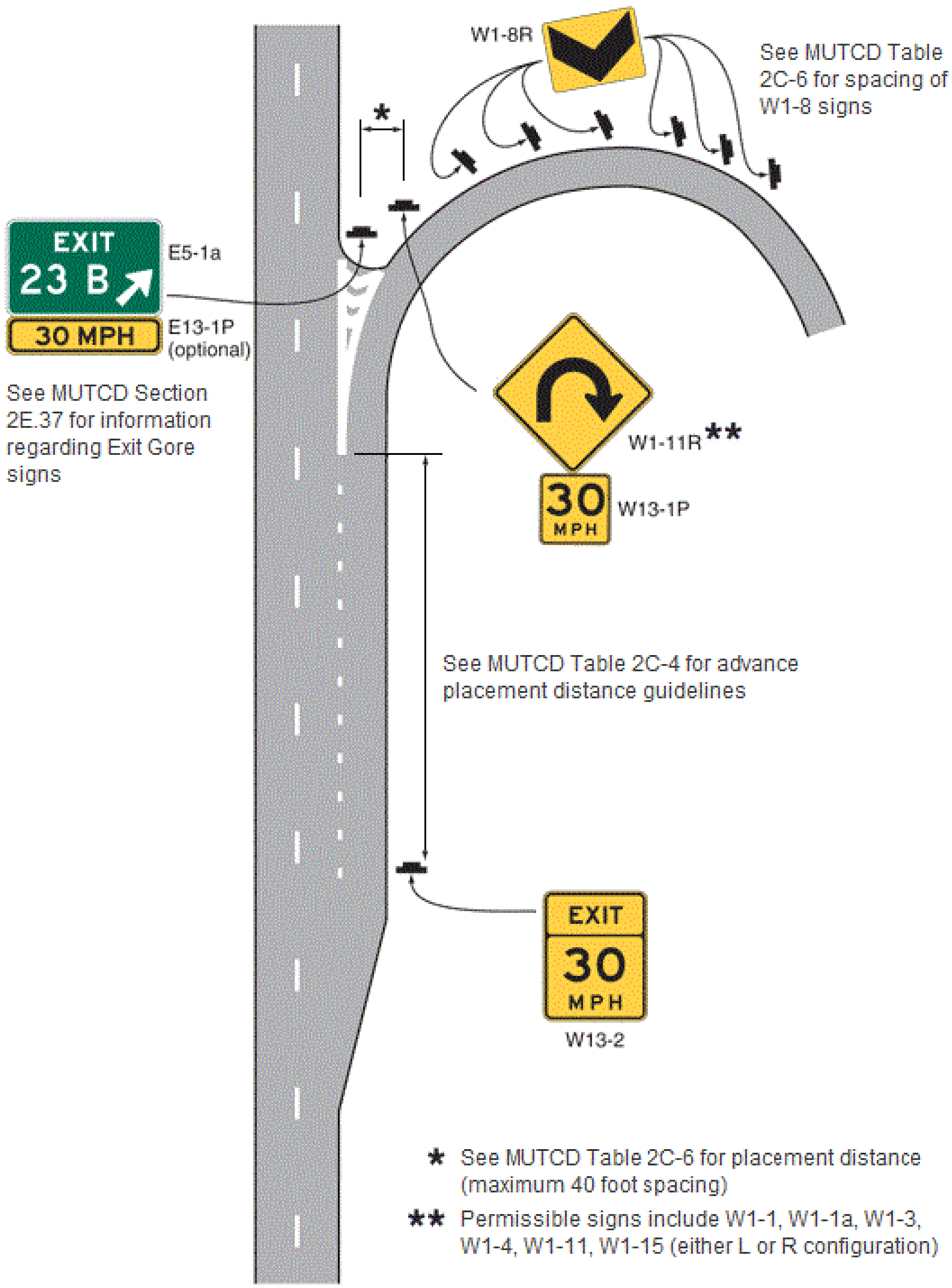
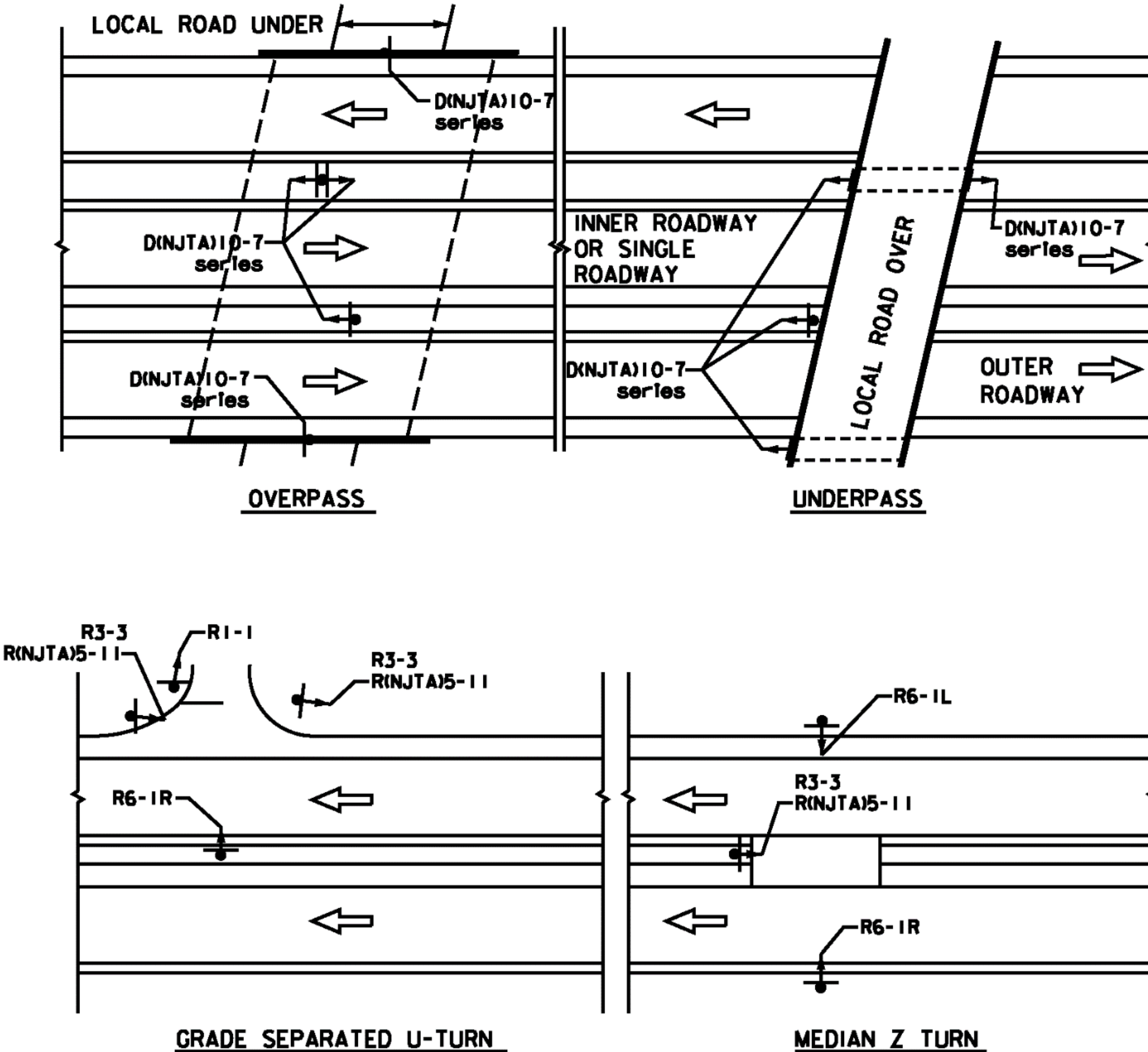
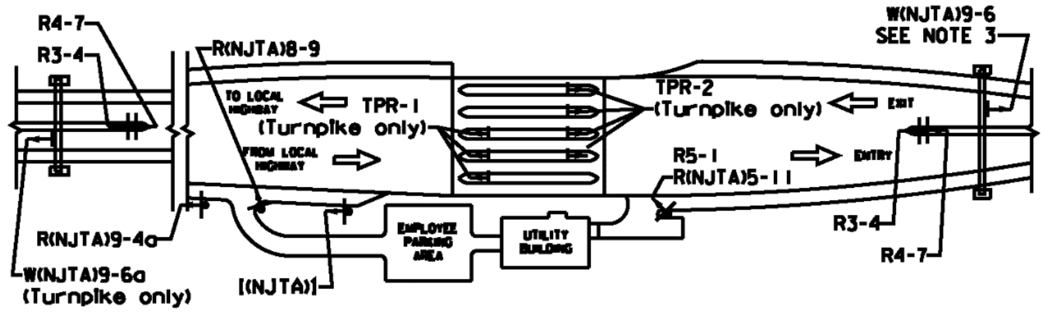


EXHIBIT 7-2 – SIGN LOCATION PLAN – LOCAL ROAD CROSSINGS AND MEDIAN CROSSINGS

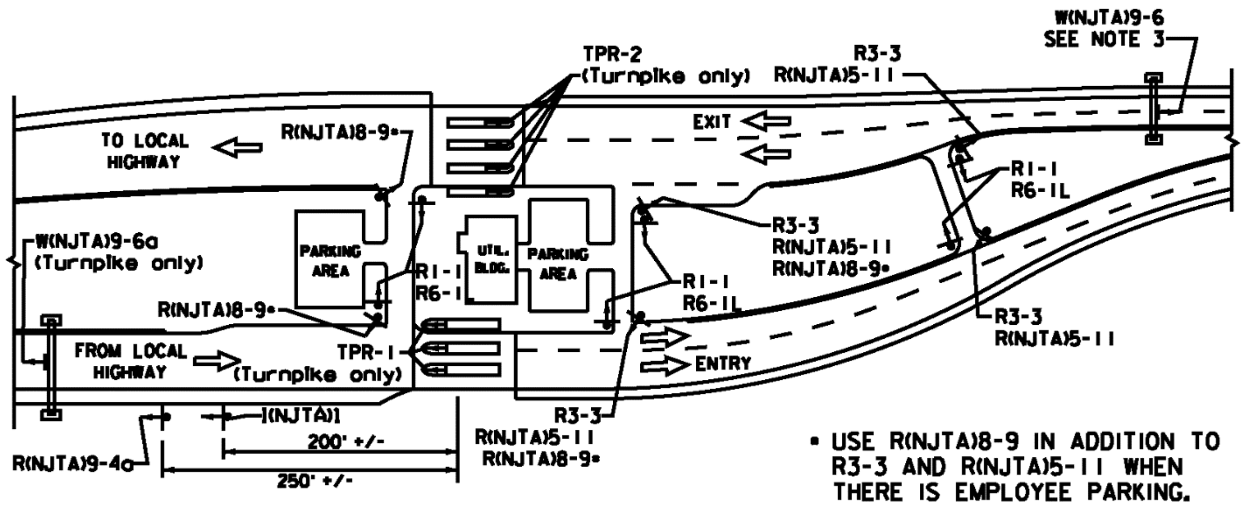


NOTE: For delineator locations, see the DE Standard Drawings.

EXHIBIT 7 -3 SIGN LOCATION PLAN – TOLL PLAZAS AND LOCAL ROADS AT INTERCHANGES



STANDARD INTERCHANGE TOLL PLAZA

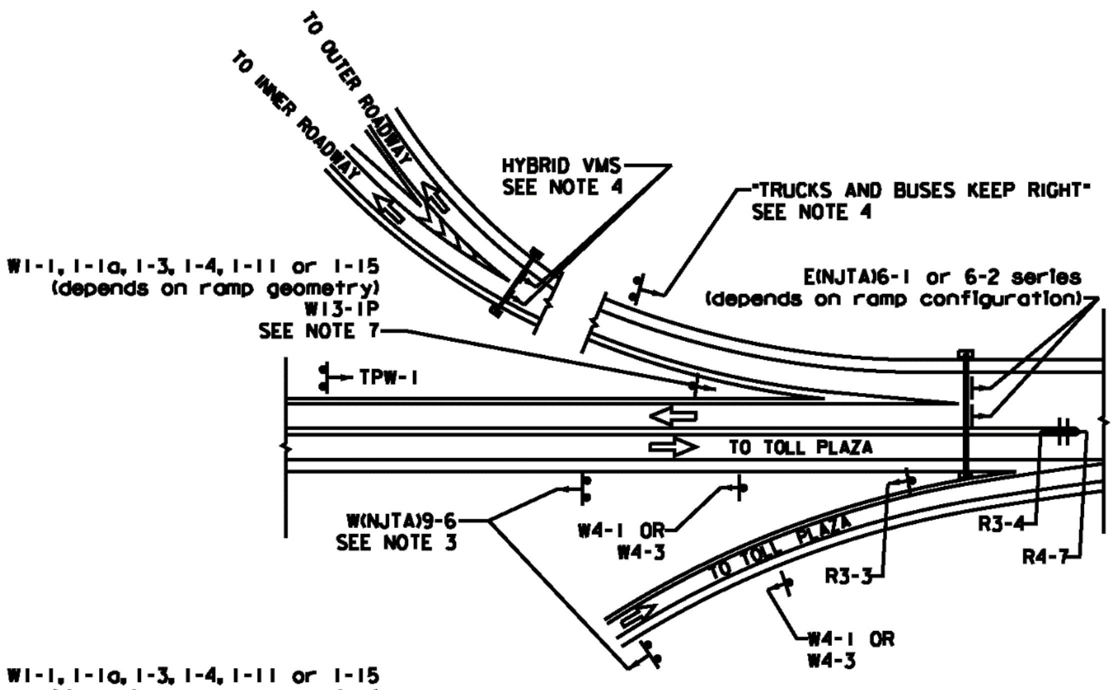


SPLIT INTERCHANGE TOLL PLAZA

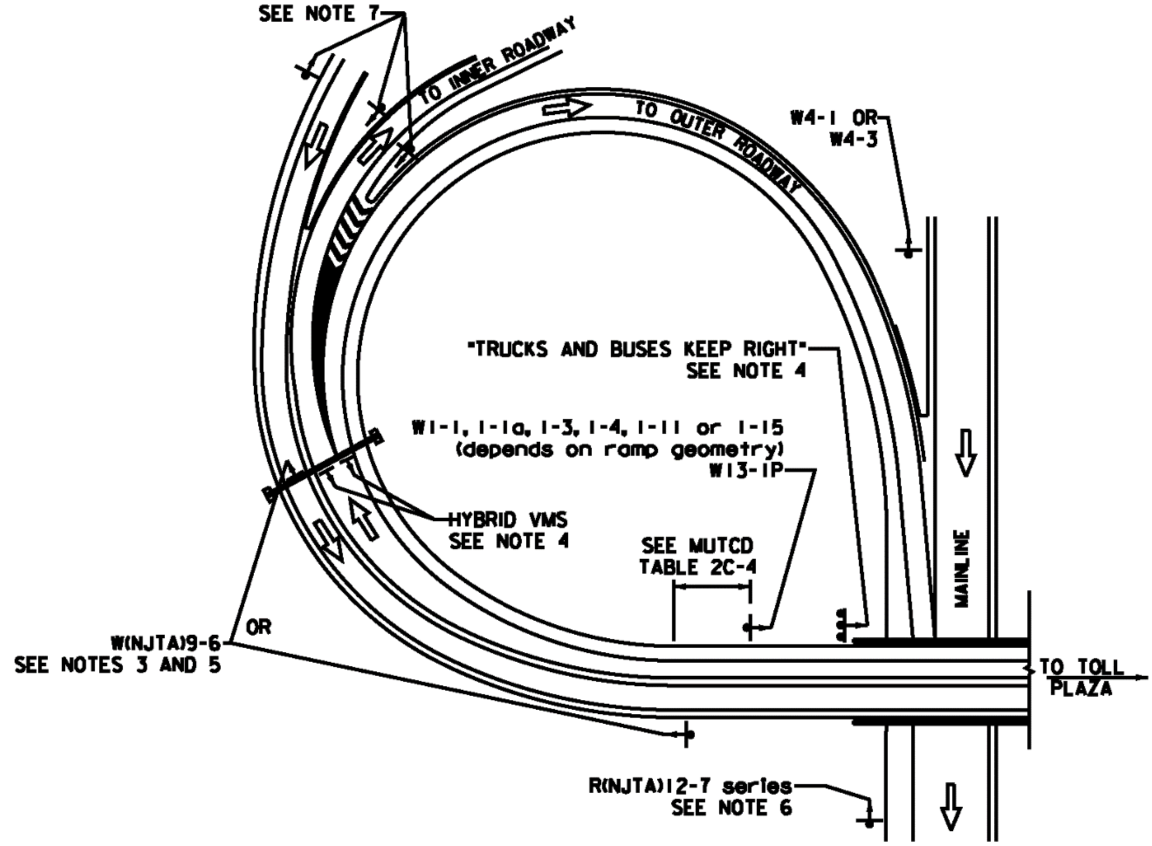
NOTES FOR SIGN LOCATION PLANS (EXHIBITS 6-3 AND 6-4):

1. All overhead sign structures, whether butterfly, cantilever or span type, shall be placed so as to be a minimum of 30' in front of any lighting standard.
2. For delineator locations, see the DE Standard Drawings.
3. W(NJTA)9-6 only to be used when directed by the Authority.
4. Optimize sight distance to Hybrid VMS. Use "Trucks and Buses Keep Right" sign only with approval from the Authority if necessary due to Hybrid VMS location.
5. Optional location, preferably on overhead sign structure, ground mounted if appropriate or necessary.
6. Use R(NJTA)12-7a or 12-7d when there are 3 lanes in the roadway, and use R(NJTA)12-7b, 12-7c or 12-7e when there are 4 lanes in the roadway, depending on applicable restrictions.
7. See Exhibit 6-9 for locating warning signs and chevrons on curved ramps. Where shown, warning signs are posted on the left side of the ramp to which they apply.

EXHIBIT 7 -4 SING LOCATION PLAN – TURNPIKE DUAL – DUAL INTERCHANGE RAMPS

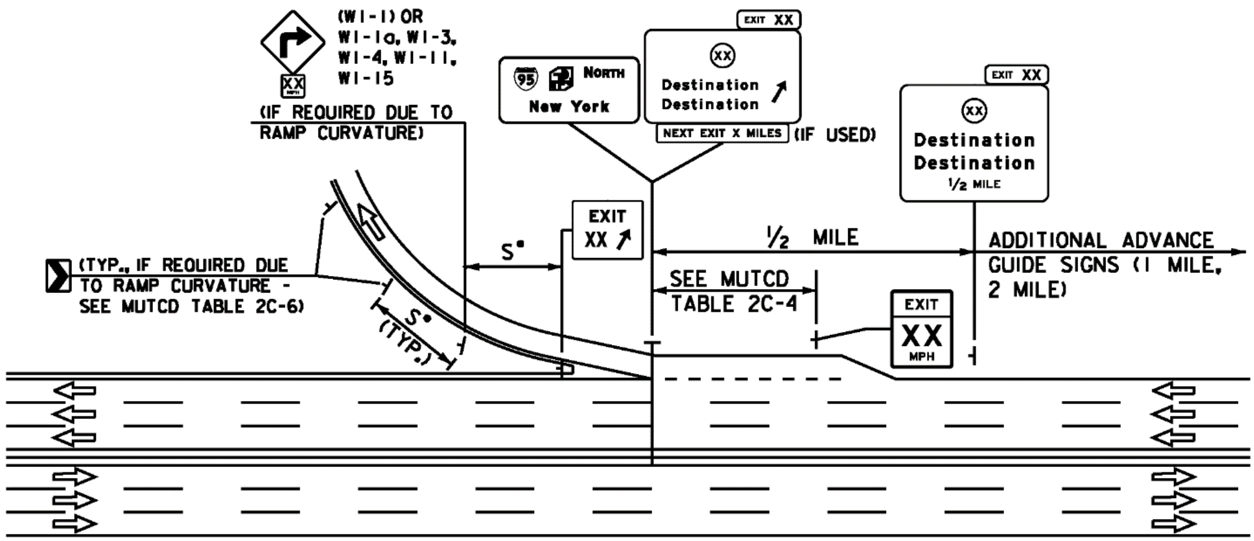


SEE EXHIBIT 6-3 FOR NOTES.



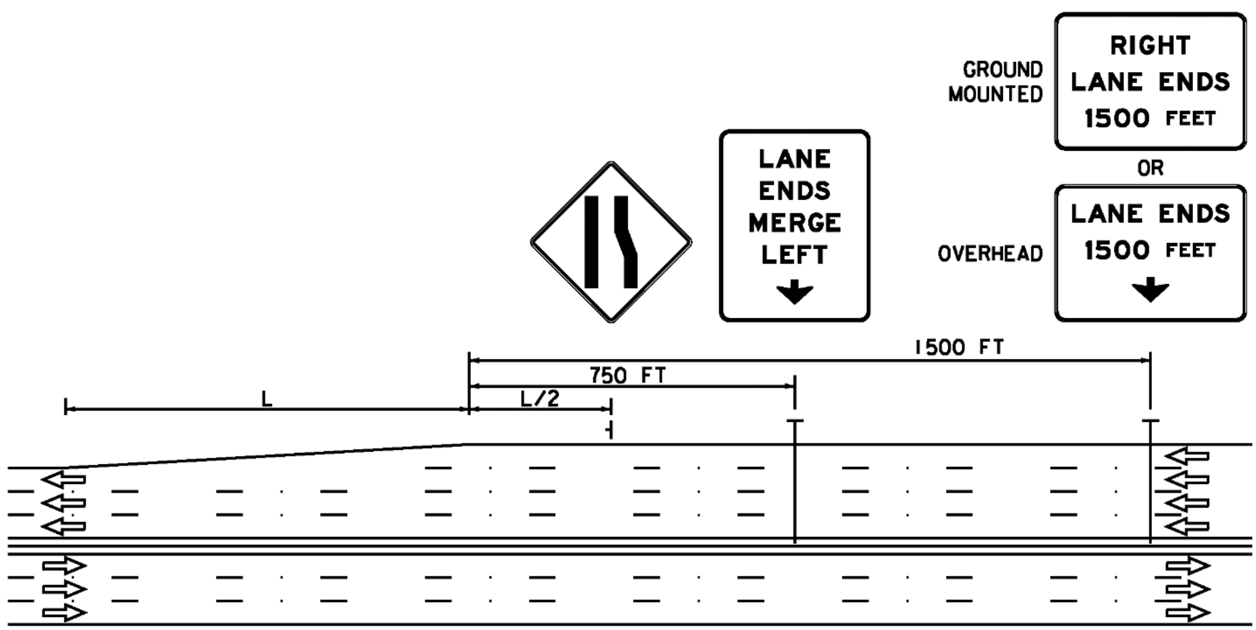
SEE EXHIBIT 6-3 FOR NOTES.

EXHIBIT 7- 5 – SIGN LOCATION PLAN – EXIT RAMPS



*NOTE: S IS DETERMINED ACCORDING TO MUTCD TABLE 2C-6.

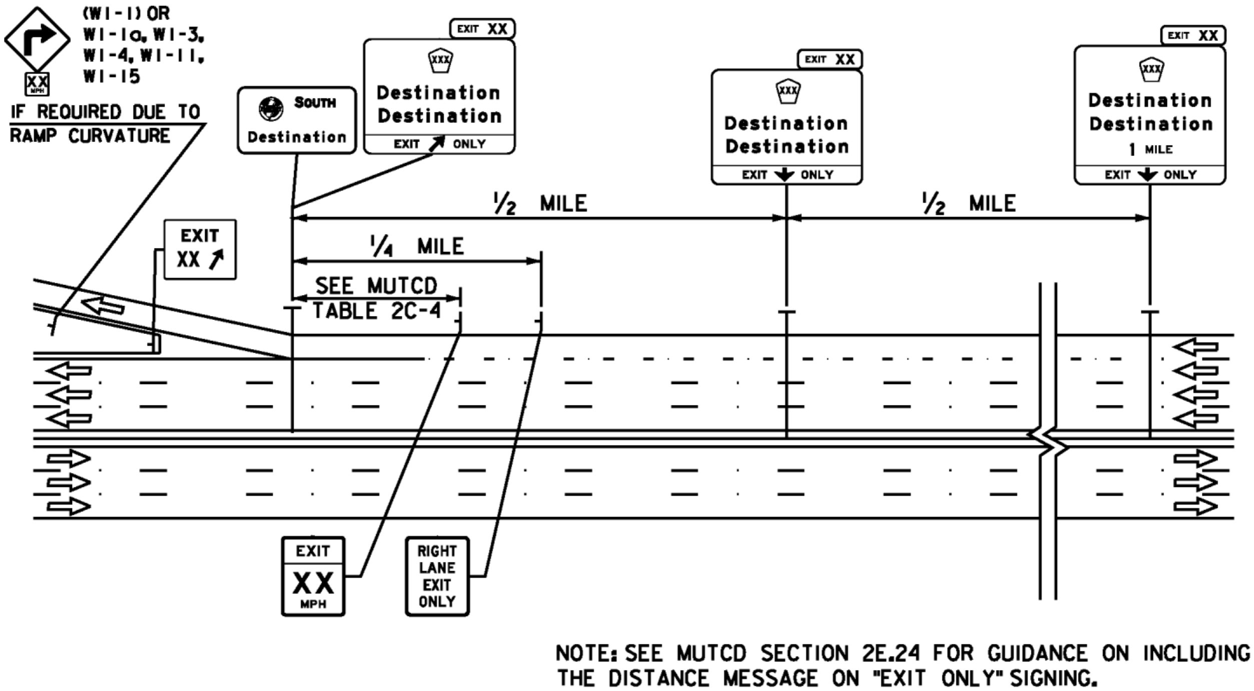
EXHIBIT 7-7 LANE REDUCTION SIGNING



L = TAPER LENGTH

TURNPIKE - SEE SECTION 1A, EXHIBIT 1A-38 (LANE DROP CONFIGURATION)
PARKWAY - SEE SECTION 1B, EXHIBIT 1B-10 (MINIMUM TAPER LENGTH WHEN REDUCING ROADWAY WIDTH). ALSO SEE SECTION 6.4.2.5 FOR USE OF MUTCD SECTION 2C.42 SIGN SEQUENCE.

EXHIBIT 7 -7 - LANE DROP SIGNING



7.5. PANELS

Wherever feasible, overhead signs should be supported on separate sign supports and not on overcrossing structures. If necessary, the use of an overcrossing structure for supporting an overhead sign is considered on a site-specific basis, based on an engineering review of structural loading, costs and available options in consultation with Authority representatives.

Design guidelines for sign hangers are covered in Section 3 (Structures Design) of this Manual.

7.5.1. Sign Text – Alphabet and Sign Layout

7.5.1.1. Standard Alphabets

All message characters for the guide signs and the standard signs on this project are to conform to the shapes of the standard upper case and lower case alphabets shown in the most recent edition of the FHWA Standard Highway Signs and Markings that accompanies the MUTCD. Sign lettering shall be in upper case letters of the type approved by FHWA, except that lower case lettering with initial upper case shall be used for destination names and as otherwise required by the MUTCD.

Letter heights for the various lines of copy on signs other than those classified as NJTA signs are to follow Table 2E 2 of the MUTCD. In general, the criterion used for determining sign visibility is that the sign can be seen from 30 feet away per 1 inch of letter height. This criterion should be considered when placing overhead sign panels where the line of sight to that panel may be obstructed by some object (e.g. a structure over the mainline) between the observer and the sign.

Word lengths can be computed manually using the letter spacing tables found in the FHWA Standard Highway Signs and Markings, but computers can greatly simplify the process. Several companies offer software capable of graphically laying out sign faces, including standard lettering, and producing scale drawings. However, the computer output should be manually verified to ensure the proper word lengths and spacings are used.

7.5.1.2. **Spacing and Margins**

The requirements and guidelines presented in this section are based on a combination of requirements and guidelines in the MUTCD and accepted industry practice in sign design and layout.

Interline spacing should be approximately ¾ of the average of the upper case letter heights in adjacent lines. Spacing between a route marker and the line of text below should be equal to ¾ the height of the numeral in the route marker. The same spacing should be followed for an upward sloping (Type A or B) arrow.

Spacing to the inside edge of the left and right borders should be no less than the height of the largest letter on the sign and shall be adjusted so that the overall sign panel width will be a multiple of 6 inches. Spacing to the inside edge of the top and bottom borders should be approximately equal to the average of the letter and/or numeral height of the adjacent line of text. When a down arrow is part of the last line of text, spacing to the bottom border should be equal to the average of the arrow and letter height. If an arrow is the only item in the last line, spacing shall be measured from the lowest point of the arrow and shall be the same as the spacing at the top of the sign.

Each line of copy should be centered within the sign borders. When an arrow appears on the side of the panel, all text should be centered on the longest line of text, offset by the arrow. The route markers above the text remain centered within the sign borders and are not centered on the longest line of text.

If two or more route markers are in the same line of text they shall be optically centered on the sign. The horizontal spacing between route markers should be no less than the width of the largest route marker and 24 inches minimum.

Flat aluminum sheets have a standard dimension of 4 feet by 8 feet. It is helpful to adjust sign height or width by 6 inches to avoid trimming or splicing.

7.5.1.3. **Border Type and Size**

The MUTCD states that all signs must have a border of the same color as the legend, at or just inside the edge. General rules:

1. Dark border on light background (negative contrast) = border will be inset
2. Light border on dark background (positive contrast) = border flush with edge of panel
3. Border width should not exceed stroke width of the major lettering of the sign
4. Inset shall equal border width or ⅛ inch less than border width

Border widths for guide signs should follow the guidance given in MUTCD Section 2E.16. For other signs, border widths should follow the guidance given in MUTCD Section 2A.14.

Borders flush with the edge of panel should be at least ¾ inch in width. When borders are made with encapsulated lens reflective sheeting, cutting widths of less than ¾ of an inch damages too many of the sheeting cells, causing premature darkening of the borders.

7.5.1.4. **Corner Radii**

The MUTCD states that the corners of all borders shall be rounded, except for STOP signs. General rules:

1. On large signs, corner radius is approximately ⅛ of the minimum dimension of the sign panel
2. On small signs (50 square feet max.), corner radius should not exceed the height of the major copy of the sign
3. Corner radius should not exceed 12 inches on any sign
4. A corner radius larger than 3 inches shall be rounded to a 3-inch increment
5. The corner radius applies to the outside of the border plus the inset (if any)

Where practical, the corners of the signs shall be rounded as well. Rounded sign panels are more easily handled, less likely to be bent before installation and less likely to cause injuries while being handled.

7.5.1.5. Arrows and Route Markers

The standard arrows to be used on guide sign panels are as shown in the MUTCD. Interstate and U.S. route markers shall conform to the MUTCD. Turnpike and Parkway markers are sized equivalently to other route markers on the same sign panel. The construction drawings shall give both overall marker and lettering sizes, and refer to the MUTCD and SL Standard Drawings for details.

The statewide system of "500-series" County Routes in New Jersey (numbered between 501 and 585) shall be signed by number on guide signs. The Authority does not sign for other county routes.

7.5.2. Mounting Heights and Clearances

The vertical mounting heights and lateral clearances required for ground-mounted sign panels are as described in Section 3 of this Manual.

7.6. CONSIDERATION FOR SIGN PANEL LIGHTING

Requirements for lighting associated with the illumination of sign panels are discussed in Section 7 (Lighting and Power Distribution Systems) of this Manual. Details, if applicable, are found on the E Standard Drawings.

7.7. STRIPING

Striping of Authority roadways is to be done in accordance with the PM Standard Drawings. For mainline striping, the Authority uses 10-foot stripes with 30-foot gaps on the Parkway and 25-foot stripes with 25-foot gaps on the Turnpike. Further details relating to striping materials are found in the Authority's Specifications.

Open-road tolling lanes and toll plaza lanes that segregate traffic based on payment method are not considered preferential lanes (as defined in Chapter 3D of the MUTCD). A single white solid line is used between open-road tolling lanes, extending through the entire toll collection area, to encourage traffic to stay in the same lane.

7.8. DELINEATORS

7.8.1. Delineator Spacing

On Authority roadways, delineators are spaced halfway between and in line with integer mile and tenth-mile markers (approximately 264 feet from consecutive signs) on mainline tangent sections. In the absence of mile markers, delineators are spaced at every 1/20 mile (264 feet). Some adjustment of this spacing may be necessary in order to meet the milepost identification of bridges along the Turnpike and Parkway or to accommodate structure locations.

Delineator spacing (S) on curves with radii 1,000 feet or less is given in Table 3F 1 of the MUTCD. On ramp tangents and curves with radii greater than 1,000 feet, the spacing between delineators is 100 feet. On mainline curves with radii greater than 1,000 feet, the delineator spacing (S) is calculated based on the curve radius (R) using the formula presented in Table 3F-1:

On Authority roadways, delineators are spaced halfway between and in line with integer mile and tenth-mile markers (approximately 264 feet from consecutive signs) on mainline tangent sections. In the absence of mile markers, delineators are spaced at every $^{1}/_{20}$ mile (264 feet). Some adjustment of this spacing may be necessary in order to meet the milepost identification of bridges along the Turnpike and Parkway or to accommodate structure locations.

Delineator spacing (S) on curves with radii 1,000 feet or less is given in Table 3F-1 of the MUTCD. On ramp tangents and curves with radii greater than 1,000 feet, the spacing between delineators is 100 feet. On mainline curves with radii greater than 1,000 feet, the delineator spacing (S) is calculated based on the curve radius (R) using the formula presented in Table 3F-1:

$$S = 3\sqrt{R - 50}$$

In advance of or beyond a mainline or ramp curve, and proceeding away from the end of the curve, the spacing of the first delineator should be 2S, the second should be 3S, and the third should be 6S, not to exceed the spacings given above.

Delineation for U-turn roadways and median crossover roadways begins 25 feet from the mainline. Delineator spacing follows the spacing for ramps given above.

In advance of or beyond a mainline or ramp curve, and proceeding away from the end of the curve, the spacing of the first delineator should be 2S, the second should be 3S, and the third should be 6S, not to exceed the spacings given above.

Delineation for U-turn roadways and median crossover roadways begins 25 feet from the mainline. Delineator spacing follows the spacing for ramps given above.

7.8.2. **Guide Rail Delineation**

Where guide rail is located within 7 feet of the edge of pavement, delineators may be mounted either to the guide rail posts or on separate posts immediately behind the guide rail, maintaining a minimum vertical clearance of 4 feet to the near edge of the travel lanes. Mounting details are included in the DE Standard Drawings. Delineators are not to be mounted on the face of the guide rail. Where delineators are mounted on separate posts, the posts are to be in line with and driven into the same impervious surface as the guide rail posts, and the required location may be shifted as necessary to avoid the guide rail posts.

When guide rail is located 7 feet or more from the edge of pavement, delineators are to be located along the edge of pavement instead of along the line of the guide rail. This avoids the visual clutter and potential confusion of having two parallel series of delineators in proximity or of having the delineators too far from the edge of roadway.

7.8.3. Types of Delineators

The various types of delineators are shown in the DE Standard Drawings. There are three colors of delineators:

1. W – White (Crystal)
2. Y – Yellow (Amber)
3. R – Red

The three delineator colors are to be used as described in the MUTCD and in the additional cases described below:

1. White delineators are used along both sides of grade-separated and at-grade U-turn roadways.
2. White delineators are used between same-direction parallel roadways that are separated by less than 8 feet between edges of pavement. When the separation between edges of pavement is 8 feet or greater, yellow delineators are used on the left of each roadway and white delineators are used on the right.
3. Along bridges or walls, red delineators are used at the approach ends and yellow delineators are used at the trailing ends where snow plow operations might deposit snow on a lower roadway. These delineators may be located on the left, right or both sides of the roadway.

Note that when Chevron Alignment (W1 8) signs are used, delineators are not installed along the roadside. If guide rail or barrier is present, delineators may be still installed along the guide rail or barrier according to the Authority's Specifications and Subsection 7.8.2 of this Manual.

In addition to the normal delineator shape, there are three types of special delineators used on Authority roadways. The types and applications of these special delineators are as shown on the DE Standard Drawings. The delineator color is in accordance with the MUTCD based on its location.

7.9. Design Procedures

The format for plan submission for contracts containing signing, delineation and pavement marking plans generally conforms to Section 3 (Submission Requirements) of the Procedures Manual. Following is a description of the requirements of the various plan submissions.

1. Preliminary Design: A preliminary layout at either 1"=100' or 1"=200' scale should show the tentative location of all major signs, the type of mounting and the proposed sign text. The layout should also show proposed locations of VSLS, VMS and HCMS. Mileposts and any other signing considered critical at this preliminary stage should likewise be shown. Delineation and pavement markings are not required at this phase. Warrant analysis for VMS shall be included if necessary.
2. Phase "A" Submission: If no preliminary design was submitted, the Phase "A" submission shall be as outlined under Preliminary Design. The Phase "A" submission includes a complete layout of striping and preliminary feasibility of VMS locations.
3. Phase "B" Submission: The Phase "B" submission should be presented in final plan format and the preliminary signing layout must be approved prior to the Phase "B" submission. As a minimum, the Phase "B" submission must include the following:
    a. Complete layout of all signing with sign structure elevations showing roadway lane widths and striping (including temporary signing, if required)
    b. All sign messages sized and panels detailed (sign text data sheet and sign tabulation)
    c. Striping in gore areas
    d. Delineator layout
    e. Power service location noted
    f. Preliminary Engineer's Estimate
    g. Overhead sign foundation details (soil bearing, pile, etc.)
    h. Plans of approved VMS locations
4. Phase "C" Submission: The Phase "C" submission should be 95 percent complete, including construction details, specifications and an Engineer's Estimate. Quantity calculations should also be submitted.
5. Phase "D" Submission: To include final plans, specifications and estimate.

7.10. Plan Preparation

7.10.1. General

The details of plan preparation for contracts containing signing, delineation, and pavement striping shall conform with Section 6 (Roadway Plan Preparation) of the Procedures Manual.

7.10.2. Contract Plan Format

Signing plans shall appear in the following order, within the overall contract plan format as outlined in Section 6 of the Procedures Manual:

1. Signing Plans
2. Sign Text Data Sheet
3. Sign Panel Tabulation
4. Sign Post Tabulation
5. Hybrid Changeable Message Sign Text Sheet (if applicable)
6. Sign Panel Layouts
7. Temporary Guide Signs
8. Design Data
9. Sign Structure Elevations

Plans shall be numbered consecutively.

7.10.3. Contract Plan Content

The following is a brief description of the information to be shown on the finalized signing plans within the contract drawings.

1. Signing Plans
   a. 1”=30’ or 50’ scale plans showing proposed roadways as screened – these plans are preferably screened copies of the pavement plans
   b. Screened base, which should show all drainage and guide rail
   c. Standard title box showing “Signing Plan - X -”
   d. Match Lines by “Signing Plan” number
   e. Complete signing layout with symbols for sign numbers and mounting type as shown on the legend
   f. Delineator layout with appropriate callouts
   g. Pavement stripes with appropriate callouts
2. Sign Text Data Sheet – This sheet should give in tabulation form the following information (see Sample Design Plans):
   a. Contract sign number
   b. Number required
   c. Legend (sign message)
   d. Sign Panel, showing:
      1) Size – width and height
      2) Copy – color and finish
      3) Background – color and finish
      4) Stringers – number and size

e. Post Supports, showing:
   1) Number
   2) Material
   3) Size

f. Remarks

3. Sign Panel Tabulation – This information may be included in a separate tabulation on the last Sign Text Data Sheet. For each sign panel pay item, the tabulation should include (see Sample Design Plans):

   a. NJTA Sign Number
   b. Contract Sign Number
   c. Number Required
   d. Total Area
   e. Remarks

4. Sign Post Tabulation – Should be included with the Sign Panel Tabulation. The tabulation should include (see Sample Design Plans):

   a. NJTA Sign Number
   b. Contract Sign Number
   c. Number of Signs Required
   d. Number of Signs Requiring Posts
   e. Number of Posts per Sign
   f. Total Length of Various Sign Post Pay Items
   g. Remarks

5. Hybrid Changeable Message Sign Text Sheet – A tabulation showing messages for each drum face of an HCMS. This sheet is omitted if there are no HCMS.

6. Sign Panel Layouts – These sheets give a detailed layout of each sign shown on the sign text data sheet including sign size, message size spacing and arrow location.

7. Temporary Guide Signs – This sheet would show details for all temporary guide signs, if required. See Section 9 of this Manual for other temporary signs used in traffic control during construction.

8. Design Data – This sheet would include detailed design data such as sign foundation dimensions and reinforcing bar requirements, pile layouts and dimensions for span, cantilever and butterfly type structures (see Exhibit 7-8).

9. Sign Structure Elevations – This sheet would show elevation views of all sign structures including all dimensions required for the structure and the panels located thereon (see Section 3, Exhibits 3 404 through 3 412)

The Signing Plans should include some method by which the Contractor can determine post heights for fabrication, such as reference drawings of cross sections or grading plans (see Sample Design Plans).

Exhibit 7-8 – Structures Data Form

TYPICAL SIGN FOUNDATION DATA FORM •

SIGN STRUCTURE NO.	DIMENSIONS							REINFORCING BARS (Total for each footing)							PILES ••		
	A	B	C	D	E	F	G	Bars A	Bars B	Bars C	Bars D	Bars E	Bars F	Bars G	No.	Batter	Act. Length
Each Ftg.								•••									

• See Standard Drawings for location of dimensions and reinforcing bars.
•• When piles are required, a pile plan showing their placement should be included in plans.
••• Give either the size and number of bars or the size and spacing of bars.

TYPICAL OVERHEAD SIGN STRUCTURE DATA FORMS

CANTILEVER TYPES •

SIGN STRUCTURE NO.	LOCATION	STRUCTURE TYPE		COLUMN HEIGHT	SPAN LENGTH	PANELS	
		Cant.	Bfly.			No.	Length

• See Standard Drawings for details.

SPAN TYPES ••

SIGN STRUCTURE NO.	LOCATION	END FRAME HEIGHT	SPAN LENGTH	SPAN SECTION ARRANGEMENT		
				Left	Center	Right

•• See Standard Drawings for details.

Section 8 - LIGHTING AND POWER DISTRIBUTION SYSTEMS

8.1. GENERAL

8.1.1. Introduction

Construction projects on the New Jersey Turnpike (Turnpike) and Garden State Parkway (Parkway) will likely impact or require the construction of Lighting and Power Distribution Systems.

These systems may include, but are not limited to, lighting installations for new roadways, bridges, toll plazas, signs, parking areas, maintenance facilities, and storage yards, and/or modifications to various existing systems throughout the Authority roadways. They also include installation of power to non-lighting equipment, such as traffic counting equipment, weather stations, Variable Message Signs (VMS), Hybrid Changeable Message Signs (HCMS), and Changeable Message Signs (CMS), lane use signs, warning lights, cameras, and other Intelligent Traffic Systems (ITS) devices that require power.

This Section is not meant to describe the installation of specific ITS Systems equipment, or installation of communications systems such as fiber, telephone, and radio transmission. See Section 9 (ITS and Communications Systems) of this Manual for a discussion of installation for these systems. See also Section 8 (Utility Installations, Relocations and Adjustments) of the Procedures Manual for a discussion of Utility Installations.

Installation of raceway systems to be utilized for Communications Systems shall be designed as described in this section, and as modified by Section 9 (ITS and Communications Systems) of this Manual.

For installation of Toll Plaza Systems, and power and lighting systems installed within Authority buildings, see Section 12 (Facility Buildings/Toll Plazas) of this Manual.

All traffic signal systems shall be designed and constructed in accordance with the requirements of the New Jersey Department of Transportation, as amended by local requirements of the signal owner or maintainer.

This Section is not intended to be a design handbook, but rather a guideline covering the Authority's current standards for system design and preparation of contract documents. It is essential that the basic criteria covered in this Manual be followed as closely as possible by the electrical engineering staff of each Engineer in order to achieve uniform and consistent Lighting and Power Distribution Systems throughout Authority facilities.

Satisfying these criteria will necessitate sound judgment and good engineering practice on the part of the Engineer. Where designs deviate from these basic criteria, the Engineer shall secure written approval from the Authority. See Subsection 8.1.3. for more information on this subject.

Lists of items or descriptions included in this Section to illustrate various concepts shall not be interpreted as being all inclusive. Due to the varied nature of the Authority's Facilities, many exceptional cases may be encountered.

Where information shown on or contained within the Current Standard Drawings or Standard Specifications differs from the direction given in this Section, the Engineer shall submit a written letter to the Authority asking for clarification before commencing design of the item in question. This procedure has been put in place to prevent confusion during the various project reviews, and to prevent different interpretations of the relevant design requirements after design has been completed.

The Engineer should feel free, at any time, to contact the Authority to receive consultation on extraordinary issues or interpretations of this Section prior to design or submission.

8.1.2. Codes and Standards

All Lighting and Power Distribution Systems shall be installed in compliance with the National Electrical Code (hereafter referred to as the NEC). The version used shall be the same version adopted by the state of New Jersey Department of Community Affairs Division of Codes and Standards (hereafter referred to as the DCA) for use on all new construction projects statewide.

Roadway and other lighting systems shall be designed utilizing light emitting diode (LED) type luminaires in accordance with the procedures found in AASHTO Publication GL *Roadway Lighting Design Guide,* latest edition and the other reference publications listed below. Power Distribution Systems shall be designed in accordance with standard industry practice, codes, and sound engineering judgment. This Section lists design and plan preparation requirements that are specific to the needs of the Authority. In case of any discrepancies between any other design guide and this Section, the direction given in this Section shall govern. Submitted designs will be reviewed according to the requirements of this Section and the other recommended practices in the reference publications. It is the Engineer's responsibility to coordinate with the New Jersey Department of Community Affairs (DCA) to determine if the DCA's involvement is required.

Where Authority-sponsored projects disrupt, modify, or install Lighting or Power Distribution systems for other stakeholders, other codes and standards may apply. The Engineer shall determine at the start of the project any additional codes and/or standards, and Design Manuals which may apply, and shall submit a summary of the findings for the Phase "A" Submission prior to any actual system design. If the various stakeholders do not dictate an alternate method for design or construction, the procedures and criteria listed herein shall apply.

8.1.3. Alternate Equipment and Modification of Design Criteria

The Engineer shall be responsible for the design of the Lighting and Power Distribution Systems and preparation of the Plans and Specifications.

Standard electrical equipment is pre-approved by the Authority on an on-going basis, and the approved manufacturer, model, and drawing numbers are noted for these items in the Qualified Products List. The Engineer shall use, to the greatest extent possible, these standard components when developing system designs.

When, in the opinion of the Engineer, criteria outlined in this Section cannot be achieved using standard equipment due to unique physical or geometric conditions or other limiting factors, the Engineer shall solicit the opinion of the Authority. In such cases, the Engineer shall submit a comprehensive analysis of design parameters, including supporting calculations and related data, for approval. Where approved, the Engineer shall write supplemental specifications, if necessary, for project-specific installations to ensure that project constraints are adequately addressed.

The Authority shall have final approval of all special inquiries made by Engineers in the course of seeking approval for substitute or alternative equipment proposed for use on Authority projects, whether proposed by the Engineer or the Contractor.

When, in the opinion of the Engineer and according to sound engineering judgment, it is not possible to meet the lighting, power, or electrical design criteria outlined in this Section with any type of equipment due to unique limiting factors, and/or the Engineer believes that the procedures and criteria in this Section should be amended for a specific project, the Engineer shall request a modification of design criteria. Requests for modifications to criteria shall indicate the exact requirements to be waived and shall include a description of the underlying engineering analysis. All requests for modification shall be prepared, submitted, and approved as described in Section 3 (Submission Requirements) of the Procedures Manual as part of the Phase "A" Submission.

Approval of non-standard equipment or modifications to design criteria on one project or portion of a project shall not be interpreted as a mandate for similar waiver of Authority standards in other project locations without separate requests submitted in accordance with the above procedures.

The implementation of all non-standard electrical equipment that is permitted by the Authority as part of system design shall be reviewed and approved by the Engineer prior to Contractor's order, fabrication, or use of such equipment.

8.1.4. Reference Publications

The following publications have been referenced in developing this Section for Lighting and Power Distribution Systems and shall serve as a reference to design information that is not specifically included in this Manual. Unless otherwise noted, all publications in this Manual shall refer to the latest edition.

- *Roadway Lighting Design Guide.* AASHTO Publication GL, American Association of State Highway and Transportation Officials (AASHTO).
- *Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting.* Publication Number RP-8, Illuminating Engineering Society (IES) and American National Standards Institute (ANSI).
- *FHWA Lighting Handbook. Federal Highway Administration (FHWA).*
- *Standard Specifications. New Jersey Turnpike Authority.*
- *Current Standard Drawings. New Jersey Turnpike Authority.*
- *NJTA Qualified Products List (QPL). New Jersey Turnpike Authority*
- *National Electrical Code. Publication Number NFPA 70, National Fire Protection Association (NFPA).*
- *NJDOT Roadway Design Manual. New Jersey Department of Transportation*
- *The National Electrical Safety Code (NESC). Publication C2, Institute of Electrical and Electronics Engineers Standards Association (IEEE SA).*
- *A Policy on Geometric Design of Highways and Streets. American Association of State Highway and Transportation Officials (AASHTO).*

8.2. LIGHTING SYSTEMS DESIGN

Lighting systems for Authority projects will be constructed using the Contract Documents (Plans and Specifications) prepared by various Engineers. The purpose of this Subsection, therefore, is to provide the Engineers with general guidelines for the design and preparation of contract documents for Lighting systems, to achieve uniform lighting installations between projects.

The Engineer shall advance a lighting design utilizing the following standard process, which is described in detail in this Subsection:

STEP 1 – A Lighting Warrant Analysis shall be performed to assess the need for and requirements of lighting within the project limits. The Lighting Warrant Analysis shall indicate all lighting systems (see below) that may need to be installed.

STEP 2 – Using the results of the completed Lighting Warrant Analysis, the Engineer shall determine the specific areas throughout the project that are required to be lighted. Boundaries indicating where lighting shall conform to applicable design standards shall be defined, and the resulting Design Areas shall be used as the basis for lighting calculations. The Engineer shall then determine the design criteria to be used in completing the design.

STEP 3 – The specific type(s) of lighting system equipment to be installed shall be determined. Larger projects may require multiple lighting systems.

STEP 4 – Lighting Calculations shall be performed to determine proper location of lighting equipment.

STEP 5 – The Lighting Plans and Details shall be developed to the Authority's standard requirements.

8.2.1. Lighting Warrant Analysis

This Subsection details the requirements for determining where fixed lighting systems are required to be installed for new construction projects.

A Lighting Warrant Analysis shall be performed prior to any design for each project in order to determine if and where lighting is required for the project. The Lighting Warrant Analysis shall be used to determine where new lighting is to be installed and where existing lighting shall remain. If the warrant analysis indicates that existing lighting systems or lighting equipment is no longer warranted, this equipment shall be removed as part of the project work.

The warrant analysis shall be provided for all projects, including those projects that modify existing lighting systems, and shall include the following, where applicable for each project:

1. Determination of the need for any Complete Freeway Lighting.
2. Determination of the recommended roadway lighting system for each interchange: Complete Interchange Lighting, or Partial Interchange Lighting.
3. Determination of the recommended roadway lighting system for Toll Plazas, Parking Facilities, and/or Storage Areas.
4. Areas where existing roadway lighting is no longer warranted and will be removed.
5. Determination of the need for other lighting systems, including but not limited to Underbridge Lighting, Roadway Tunnel Lighting, Sign Lighting, Aviation Obstruction Lighting, and/or Navigation Lighting.
6. Indication of specific areas of the project (hereafter referred to as Design Areas) that will be lighted, and those in which lighting is not required,

including roadway stationing if available (See Subsection 8.2.2 for more information).

7. Indication of areas outside Authority jurisdiction that will be lighted by systems that will be owned or maintained by the Authority.
8. Indication of areas outside Authority jurisdiction that will be lighted with non-Authority-owned systems but that are being designed and constructed by the Authority, including relevant warrant analysis and design criteria.
9. Any special project considerations or additional lighting systems required for the project.

The completed warrant analysis shall be submitted concurrently with the Conceptual Illumination Design Plans and shall be included with the Phase "A" Submission. The Phase "B" lighting system design shall not be advanced prior to the Authority's approval of the Engineer's recommendations for lighting system type and extent.

8.2.1.1. **Roadway Lighting**

Roadway lighting shall be interpreted to include all lighting on areas that are considered "traveled way", that is, areas that carry public vehicular traffic from an origin to a destination.

Roadway lighting shall not be considered warranted solely because it is currently installed on an Authority roadway, ramp, or facility. A separate warrant analysis and any required studies shall be performed for all roadways, ramps, interchanges, and other facilities within project limits as described in Sections 2.6 and 3.2 of AASHTO GL.

The Roadway Lighting Warrant Analysis shall be performed as described in AASHTO GL *Roadway Lighting Design Guide,* and as excerpted below, with the following Authority-specific requirements:

Continuous Freeway Lighting (CFL)

Continuous Freeway Lighting is a "lighting system [which] provides relatively uniform lighting on all main lanes and direct connections, and complete interchange lighting of all interchanges within the section" (AASHTO GL).

Continuous Freeway Lighting shall be considered warranted only for sections of freeway "where the ratio of night to day crash rate is at least 2.0 times the statewide average for all unlit similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate", (Case CFL-4 of AASHTO GL) or where required by special project considerations and approved by the Authority.

Complete Interchange Lighting (CIL)

Complete Interchange Lighting is "a lighting system that provides relatively uniform lighting within the limits of the interchange, including main lanes, direct connections, ramp terminals, underpasses, and frontage roads or crossroad intersections" (AASHTO GL).

If any one of the following conditions (in Exhibit 8-1 below) are met, Continuous Interchange Lighting shall be considered warranted and shall be installed for the interchange under consideration.

Exhibit 8-1 Warranting Conditions for Complete Interchange Lighting

Case	Warranting Conditions
CIL-1	Where the total current Average Daily Traffic (ADT) ramp traffic entering and leaving the freeway within the interchange areas exceeds 10,000 for urban conditions, 8,000 for suburban conditions, or 5,000 for rural conditions.
CIL-2	Where the current ADT on the crossroads exceeds 10,000 for urban conditions, 8,000 for suburban conditions, or 5,000 for rural conditions.
CIL-3	Where existing substantial commercial or industrial development that is lighted during hours of darkness is located in the immediate vicinity of the interchange, or where the crossroads approach legs are lighted for 0.5 mile or more on each side of the interchange.
CIL-4	Where the ratio of night to day crash rate within the interchange area is at least 1.5 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate.

Reprinted from Table 3-3 in *Roadway Lighting Design Guide*, AASHTO GL, American Association of State Highway and Transportation Officials. Refer to *A Policy on Geometric Design of Highways and Streets* for roadway classifications.

Where Complete Interchange Lighting is warranted, the following roadways shall be lighted:

1. Deceleration lanes on the freeway mainline
2. Acceleration lanes on the freeway mainline
3. Ramps and Direct Connections – continuous lighting from the connection to the freeway mainline through their termini at the limits of Authority jurisdiction
4. All Toll Plaza areas within the interchange under consideration
5. Other areas as required by special project considerations

Continuous lighting of the mainline lanes throughout the area of the interchange shall not be provided unless Continuous Freeway Lighting is warranted (see above) or because of other project-specific considerations.

For areas of the mainline to be lighted in the areas of deceleration and acceleration lanes, and merge/diverge/weaving areas, see Subsection 8.2.2.

Partial Interchange Lighting (PIL)

Partial Interchange Lighting is "a system that provides illumination only of decision-making areas of roadways including acceleration and deceleration lanes, ramp terminals, crossroads at frontage road or ramp intersections, other areas of nighttime hazard" (AASHTO GL).

If Continuous Interchange Lighting is not warranted according to the criteria above, and Case PIL-1, PIL-2, or PIL-3 is met according to Exhibit 8-2 below, Partial Interchange Lighting shall be considered warranted and shall be installed for the interchange under consideration:

Exhibit 8-2 Warranting Conditions for Partial Interchange Lighting **Case**	**Warranting Conditions**
PIL-1	Where the total current ADT ramp traffic entering and leaving the freeway within the interchange areas exceeds 5,000 for urban conditions, 3,000 for suburban conditions, or 1,000 for rural conditions.
PIL-2	Where the current ADT on the freeway through traffic lanes exceeds 25,000 for urban conditions, 20,000 for suburban conditions, or 10,000 for rural conditions.
PIL-3	Where the ratio of night to day crash rate within the interchange area is at least 1.25 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. Where crash data are not available, rate comparison may be used as a general guideline for crash severity.

Reprinted from Table 3-4 in Roadway Lighting Design Guide, AASHTO GL, American Association of State Highway and Transportation Officials. Refer to A Policy on Geometric Design of Highways and Streets for roadway classifications.

Where Partial Interchange Lighting is warranted, the following roadways shall be lighted:

1. Deceleration lanes on the freeway mainline
2. Acceleration lanes on the freeway mainline
3. Ramps terminals
4. Toll Plaza Merge Areas within the interchange under consideration
5. Merge Areas / Lane Drops
6. Decision Points

7. Other areas of nighttime hazard
8. Other areas as required by special project considerations

Bridge Lighting

Continuous roadway lighting shall be considered warranted on long-span bridges (total bridge length in excess of 300 feet) only where both shoulders are substandard. Lighting equipment on existing bridges that have at least one adequate shoulder or are being widened to have at least one adequate shoulder, shall be removed as a result of project work.

Roadway lighting shall be provided on short-span bridges (total bridge length less than 300 feet) only where required by other warrants in this Section – for example, where short-span bridges occur in an interchange where complete interchange lighting is warranted.

Lighting of bridges and overpasses shall be at the same level as the adjoining roadways.

Toll Plaza Merge Areas

All Toll Plaza Merge Areas shall be lighted.

U-Turn and Restricted Access Roadways

Lighting shall not be provided unless directed by the Authority.

Service Area Roadways

Lighting on ramps to and from service areas, including acceleration lanes, deceleration lanes, and direct connections shall be considered warranted, and shall be installed.

Merge/Diverge Areas

Lighting shall be considered warranted and shall be installed for all merge, weaving, and diverge areas where two major roadways either come together or split. Required lighting of merge and diverge areas shall not be interpreted to warrant installation of lighting on every lane drop and lane add on the mainline, where other warrants in this Section are not met. The Engineer shall analyze the requirements for lighting where lanes are added/ dropped as described below in the discussion of Special Project Considerations.

Lighting on Roadways of other jurisdictions

Authority-maintained lighting shall be provided on roadways outside Authority jurisdiction only where directed or approved in advance by the

Authority. Typical situations where lighting on roadways of other jurisdictions may be directed are:

1. On bridges, where the Authority roadway passes over or under a local roadway
2. For safety, where an Authority facility is frequently used by pedestrians
3. Where, by prior agreement, the Authority assumes maintenance of a system as a condition of construction
4. At certain signalized intersections

The Engineer shall coordinate with the Authority to determine the need for any lighting on roadways of other jurisdictions and indicate the resolution of this coordination as part of the Phase “A” Submission.

Areas outside Authority jurisdiction

A separate warrant analysis shall be performed on all areas outside Authority jurisdiction where lighting may be installed as a result of project work. Warrant analyses for lighting for roadways and areas under NJDOT jurisdiction shall be performed in accordance with the NJDOT Roadway Design Manual. Warrant analyses for local roadways under other jurisdictions, including roadways passing under or over Authority structures shall be performed as per the requirements of the local jurisdiction.

Special Project Considerations

The Engineer shall assess the need for lighting under special roadway conditions or facilities and provide them in the Lighting Warrant Analysis for review and determination by the Authority. The Engineer shall provide supporting documentation for warranting the special condition in the analysis in order for the Authority to make an informed decision.

Examples where lighting may be warranted with unique project-specific considerations include:

1. Roadways with non-standard geometry or visibility concerns
2. Roadways with high nighttime crash rates
3. Areas with excessive merging, weaving, or short sight distances
4. Areas with significant pedestrian traffic
5. Areas where engineering judgment requires adaptation/transition lighting to be installed to prevent unnecessarily abrupt or frequent transitions between lighted and unlighted areas, or areas of different brightness (See AASHTO GL)
6. Areas where lighting is required to transition to lighting systems maintained by other jurisdictions (See AASHTO GL-6)

8.2.1.2. **Underbridge Lighting**

Underbridge Lighting shall be provided only where roadway lighting is required by other warrants in this Section, but proper lighting levels and uniformity cannot be achieved with ground-mounted lighting standards. This is often due to project-specific geometric considerations such as length of overpass, or orientation of structures relative to various roadways.

8.2.1.3. **Sign Lighting**

Sign Lighting shall not be provided for any new signs (span, butterfly, cantilever, ground, or bridge-mounted) on the Authority roadways, unless warranted based on the conditions below.

Where existing sign lighting or sign panels are to be replaced, sign panels shall be replaced with new retroreflective sheeting in accordance with the Standard Specifications. Where proposed conditions do not warrant sign lighting, the existing sign lighting shall be removed, including structural supports.

The Engineer shall list the design criteria to be used for all sign lighting calculations in the Phase "A" submission and submit the calculations in the Phase "B" submission.

The following are the overhead sign lighting warranting conditions:

1. Tangent sight distance is less than 1200 feet due to horizontal or vertical curve or other sight obstruction.
2. Areas with high occurrence of fog as identified by Operations.
3. The sign is for a left exit and is the last sign, nearest the gore area when exiting the mainline, in any series of signs approaching the exit.
4. The sign is an Exit Direction Sign, as defined in the Design Manual Subsection 7.4.3.1, and is the last sign prior to exiting the roadway. See Exhibit 7-5 of Design Manual Section 7.
5. The penultimate, overhead advance warning or guide sign on approach to a mainline barrier toll plaza where the final sign in the sequence is the Exit Direction sign to that plaza. Lighting for this penultimate sign is warranted if located less than one-half mile from the bifurcation.
6. Other guide signs where directed by the Authority.

When sign lighting is warranted, the Engineer shall perform calculations as set forth in the current edition of the AASHTO Roadway Lighting Design Guide Publication. The Engineer shall list the design criteria to be used for all sign lighting calculations in the Phase "A" submission and submit the calculations in the Phase "B" submission.

Where Hybrid Changeable Message Signs (HCMS) are installed, separate sign lighting shall not be designed or provided for any static message signs on the same structure.

Where a static message sign is installed on a Variable Message Sign (VMS) structure, separate sign lighting shall not be provided for the static message sign.

8.2.1.4. **Roadway Tunnel Lighting**

A warrant analysis for Roadway Tunnel Lighting shall be prepared in accordance with the ANSI/IES Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting Publication RP-8. RP-8 characterizes a tunnel as, "A structure over a roadway that restricts the normal daytime illumination of a roadway section such that the driver's vision is substantially diminished."

Where tunnel lighting is warranted, supplemental daytime lighting shall be required as directed in RP-8. Nighttime light levels in the tunnel shall be in accordance with RP-8 Tunnel Lighting Recommendations.

8.2.1.5. **Parking Lot Lighting**

Parking Lot Lighting shall be considered warranted and shall be installed for all parking lots on Authority property, unless directed otherwise by the Authority.

8.2.1.6. **Storage Facilities and Maintenance Yards Lighting**

Lighting shall be installed only where directed by the Authority

8.2.1.7. **Aesthetic Lighting**

Aesthetic lighting, which is lighting that is meant to be Architectural and not used to illuminate any site, roadway, or facility for safety concerns, shall be installed only where directed by the Authority.

8.2.1.8. **Navigation and Aviation Obstruction Lighting**

Navigation Lighting, including channel and fender lights, shall be provided on bridge structures with navigable channels as required by the United States Coast Guard or other Federal or Local Regulations.

Aviation Obstruction Lighting, including aviation obstruction beacons shall be installed as required by the Federal Aviation Administration. It shall be noted that certain Authority facilities are within airport glide slopes and may require special treatment to ensure that fixed lighting equipment does not project into restricted air space. Coordinate design and approvals with the local Flight Standards District Offices (FSDO), United States Department of Transportation, Federal Aviation Administration.

8.2.2. Required Area of Illumination

Once the Lighting Warrant Analysis has been completed, the Engineer shall determine the specific project areas that are required to be illuminated. This Subsection is intended to show the methods used to determine the required areas of illumination (denoted as Design Areas hereafter in this Section), where lighting must meet the applicable design criteria. Boundaries shall be defined between the required Design Area(s), and areas where lighting levels will not be analyzed and/or no lighting is required. Lighting levels shall be analyzed only for the Design Areas, as detailed in this Subsection.

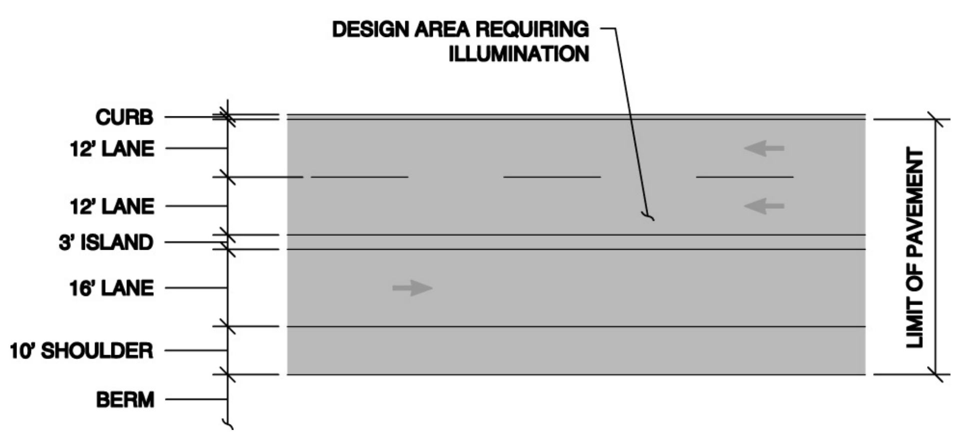
The lighting system shall be designed to efficiently and properly illuminate only those areas that require lighting as defined herein. Care shall be taken to minimize spill light into areas that do not require illumination, including both areas inside and outside Authority jurisdiction, unless otherwise directed.

Lighting on all residential areas shall be kept to an absolute minimum. A maximum point illumination level of 0.1 foot-candles on any residential properties shall be strictly enforced, unless otherwise authorized by the Authority (see Subsection 8.1.3. above). The Engineer shall use appropriate luminaire selection and location to minimize spill light. The use of shielding elements to control glare or light trespass shall not be permitted without prior approval from the Authority. Requests and justification shall be made in the Phase "A" Lighting Report.

8.2.2.1. Continuous Lighting on Roadways

Continuous lighting on roadways, freeways, ramps, and direct connections, where warranted to be installed, shall be provided from pavement edge to pavement edge. The Design Area shall include all shoulders, medians, curbs, and islands as shown for a typical roadway section in Exhibit 8-3 below:

Exhibit 8-3 Required Design Area for Typical Ramp



Where lighting is required only on certain portions of the roadway, such as the case of acceleration or deceleration lanes, the other requirements of this Subsection shall apply.

8.2.2.2. **Deceleration Lanes**

Deceleration Lane lighting, where warranted, shall be installed in advance of the striped gore for the predetermined safe stopping distance as listed in Exhibit 8-6, and continued to a point 50 feet beyond the physical gore. The Design Area shall include the deceleration lane(s) and shoulder, as well as the two adjacent mainline lanes. Deceleration lane lighting may be extended to accommodate project-specific considerations where directed by or approved in advance by the Authority. Deceleration Lane lighting is shown in Exhibit 8-4 and Exhibit 8-5, where the Safe Stopping Distance is referenced from Exhibit 8-6:

Exhibit 8-4 Required Design Area for Deceleration Lane

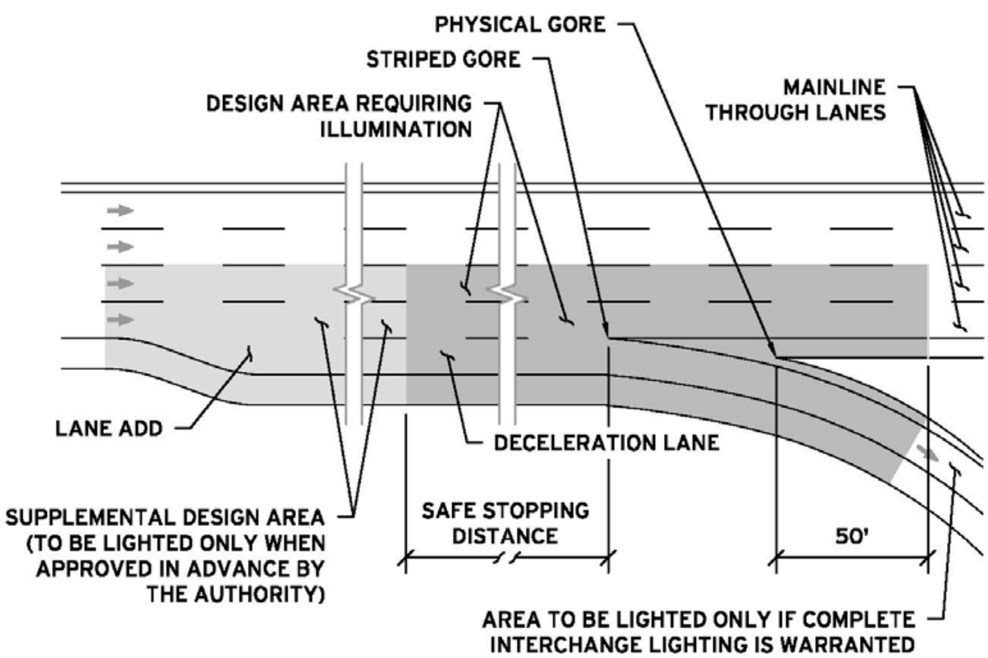
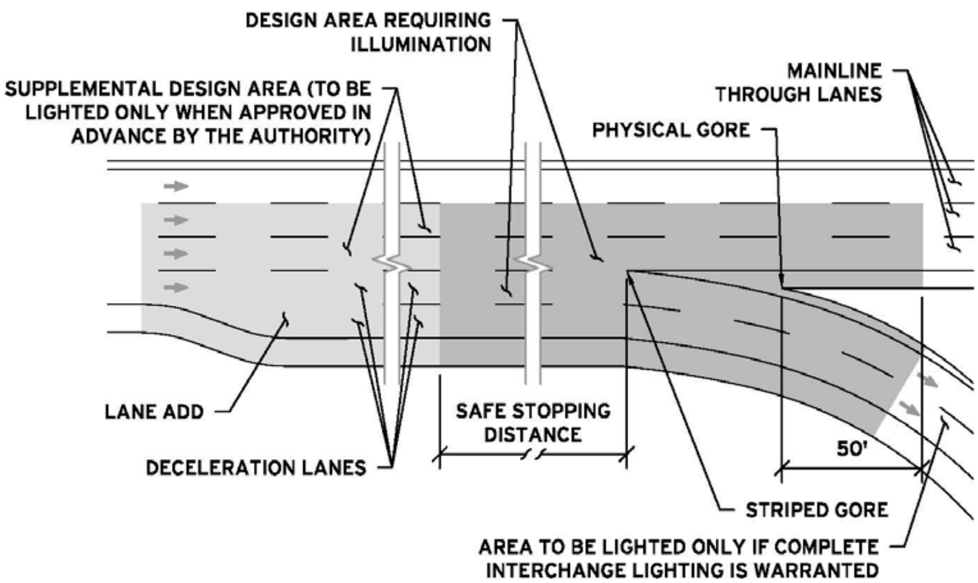


Exhibit 8-5 Required Design Area for Multiple Deceleration Lanes



The minimum safe stopping distance that requires lighting, as measured from the physical gore, is listed in Exhibit 8-6.

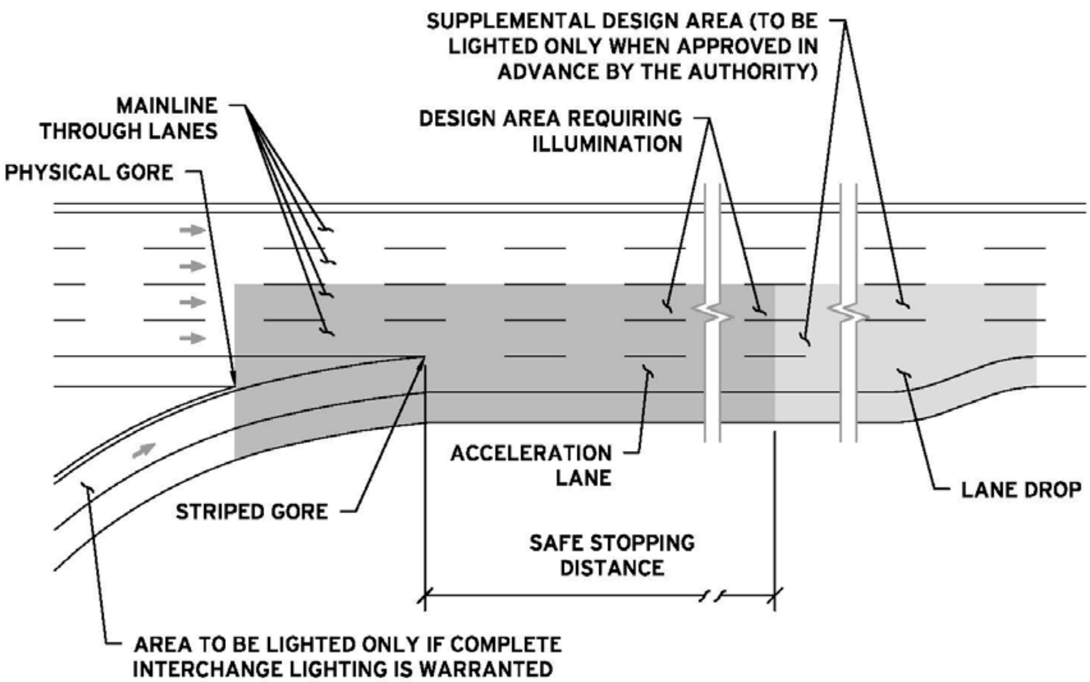
Exhibit 8-6 Table of Minimum Safe Stopping Distances That Requires Lighting

Design Speed Limit	Safe Stopping Distance
35 MPH	250 Feet
40 MPH	325 Feet
45 MPH	400 Feet
50 MPH	475 Feet
55 MPH	550 Feet
60 MPH	640 Feet
65 MPH	735 Feet
70 MPH	835 Feet

8.2.2.3. Acceleration Lanes

The Design Area for Acceleration Lane lighting, where warranted, shall start from the physical gore and continue for a predetermined safe stopping distance as listed in Exhibit 8-6. The Design Area shall include the acceleration lane(s) and shoulder, as well as the two adjacent mainline lanes. Acceleration lane lighting may be extended to accommodate project-specific considerations where directed or approved in advance by the Authority. Acceleration Lane lighting is shown in Exhibit 8-7, where the Safe Stopping Distance is referenced from Exhibit 8-6:

Exhibit 8-7 Required Design Area for Acceleration Lane



The minimum safe stopping distance that requires lighting, as measured from the convergence of the acceleration lane and mainline lanes (Striped Gore), is listed in **Exhibit 8-6**:

8.2.2.4. Merge, Weaving, and Diverge Areas

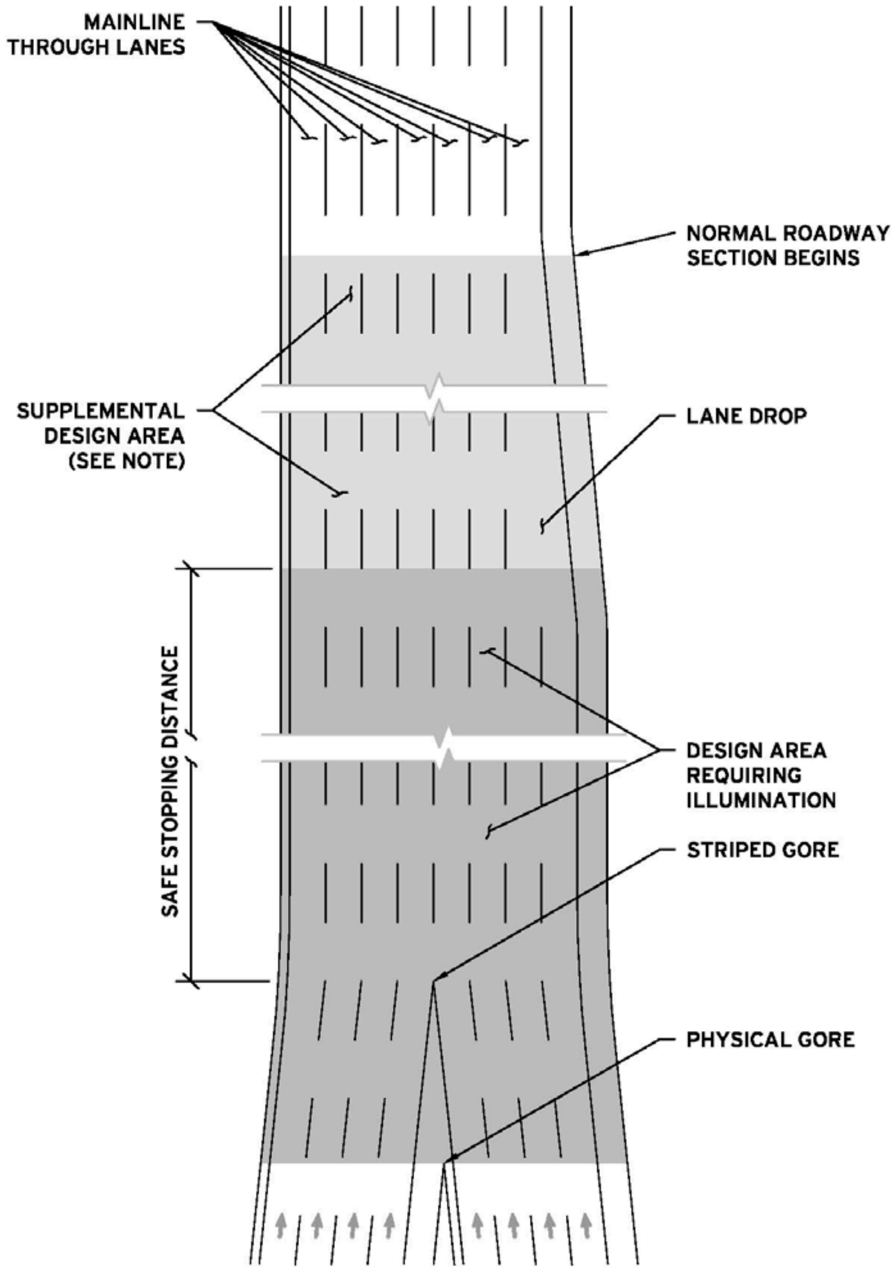
Design Areas for merge, diverge, and weaving areas, where lighting is warranted, shall be as shown in Exhibit 8-8 and Exhibit 8-9.

The Design Area for merge and weaving areas shall include all paved area starting from the point of the physical gore, to the striped gore, and continuing for a predetermined safe stopping distance (from the table in Exhibit 8-6). If lane drops occur beyond the minimum merge area, the

Design Area may be extended to the location where all lane drops have occurred, if directed or approved in advance by the Authority.

The Design Area for diverge areas shall include all paved area starting from a point located a safe stopping distance (from the table in Exhibit 8-6) from the striped gore and continuing to 50 feet beyond the physical gore. If lanes are added in advance of the minimum diverge area for purposes of allowing proper weaving distance prior to the decision point, the Design Area may be extended to a location where the first lane is added if directed or approved in advance by the Authority.

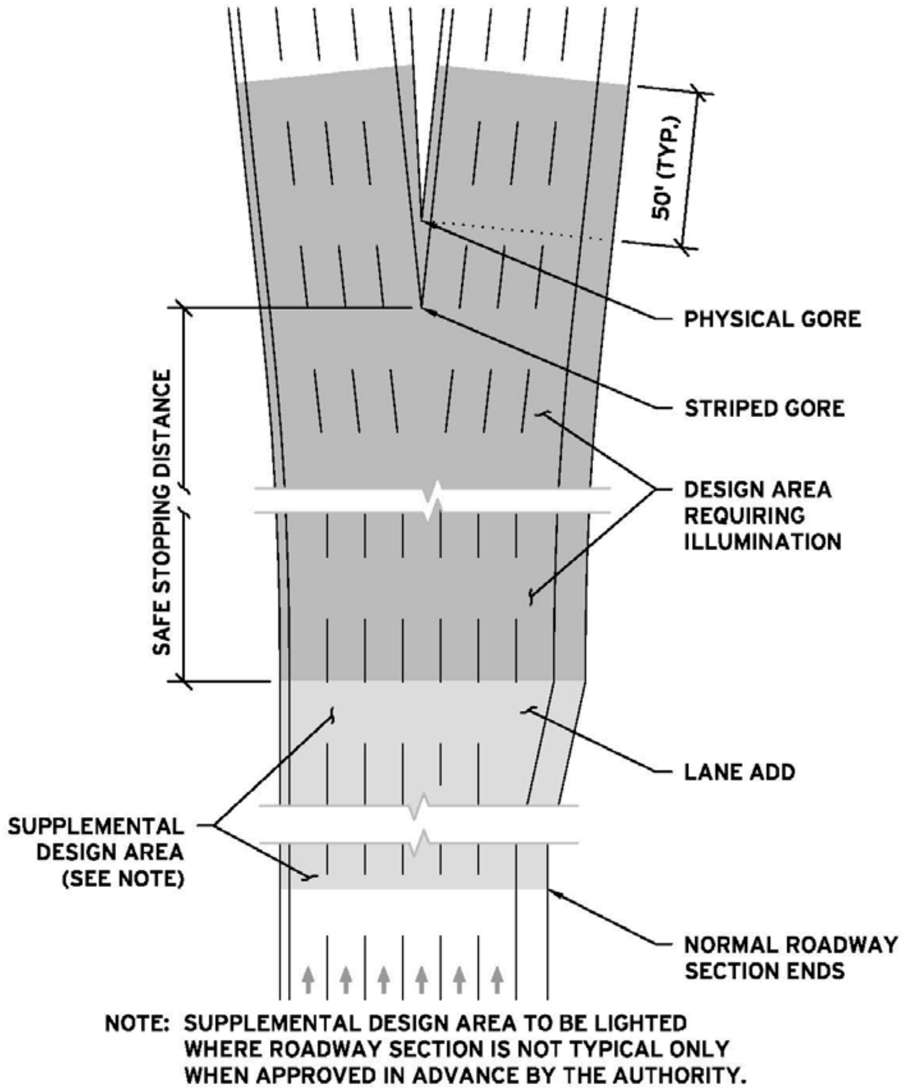
Exhibit 8-8 Required Design Area for Merge/Weaving Area



NOTE: SUPPLEMENTAL DESIGN AREA TO BE LIGHTED WHERE ROADWAY SECTION IS NOT TYPICAL ONLY WHEN APPROVED IN ADVANCE BY THE AUTHORITY.

The Design Area for diverge areas shall include all paved area starting from a point located a safe stopping distance (from the table in Exhibit 8-6) from the striped gore and continuing to 50 feet beyond the physical gore. If lanes are added in advance of the minimum diverge area for purposes of allowing proper weaving distance prior to the decision point, the Design Area may be extended to a location where the first lane is added if directed, or approved in advance by the Authority.

Exhibit 8-9 Required Design Area for Diverge Area



8.2.2.5. Ramp Termini

Ramp terminus lighting, where required, shall be installed where the ramps connect with local roads, intersections, or other freeways. Because of the diversity of the geometries of the various ramp terminals across the Authority roadways, the Engineer shall use judgment to determine the necessary Design Area. Any transition lighting necessary to visually connect the Authority's lighting system with the lighting system of another jurisdiction shall be included in the Design Area.

Examples of typical ramp terminus treatments are shown below in

Exhibit 8-10 and Exhibit 8-11 for reference:

Exhibit 8-10 Required Design Area for Typical Ramp Terminus

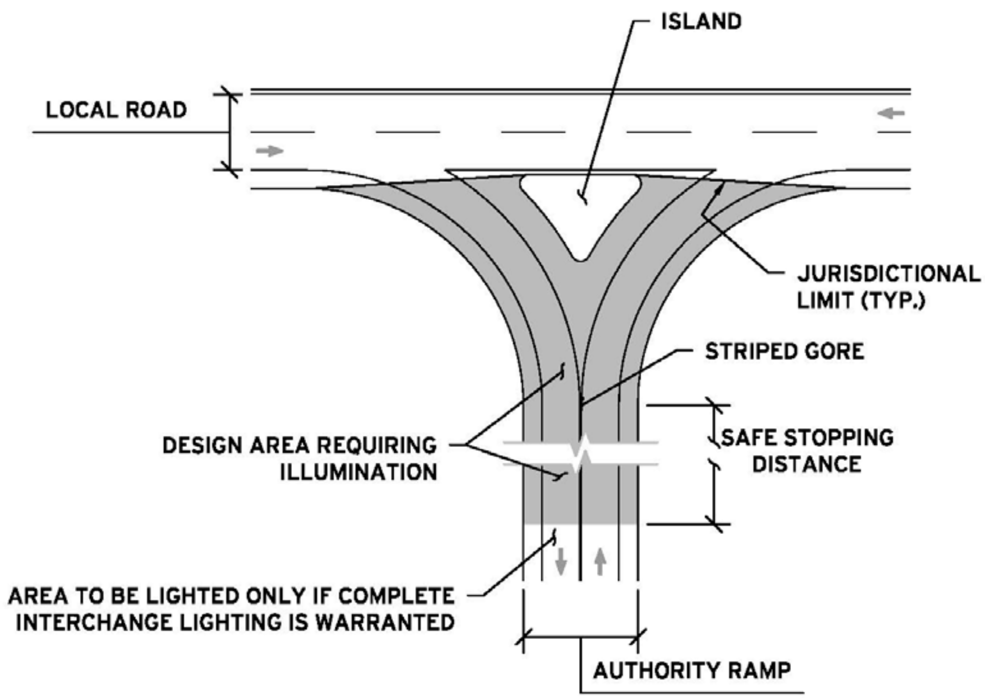
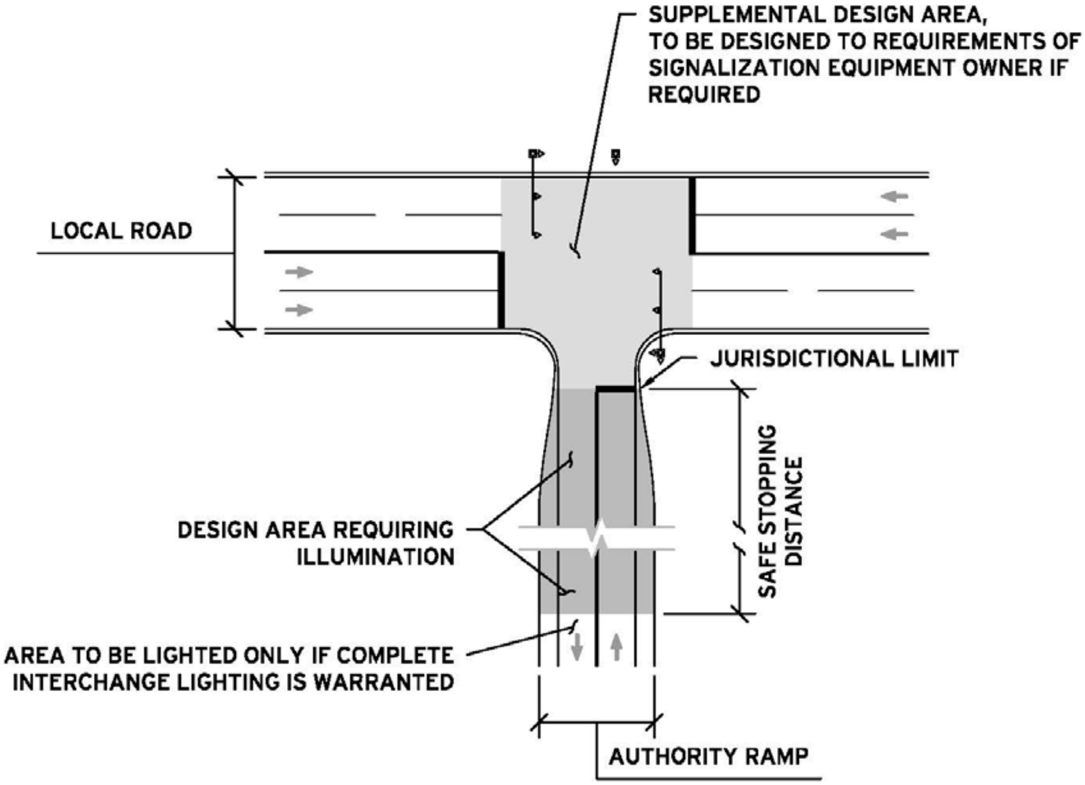


Exhibit 8-11 Required Design Area for Ramp Terminus at Signalized Intersection



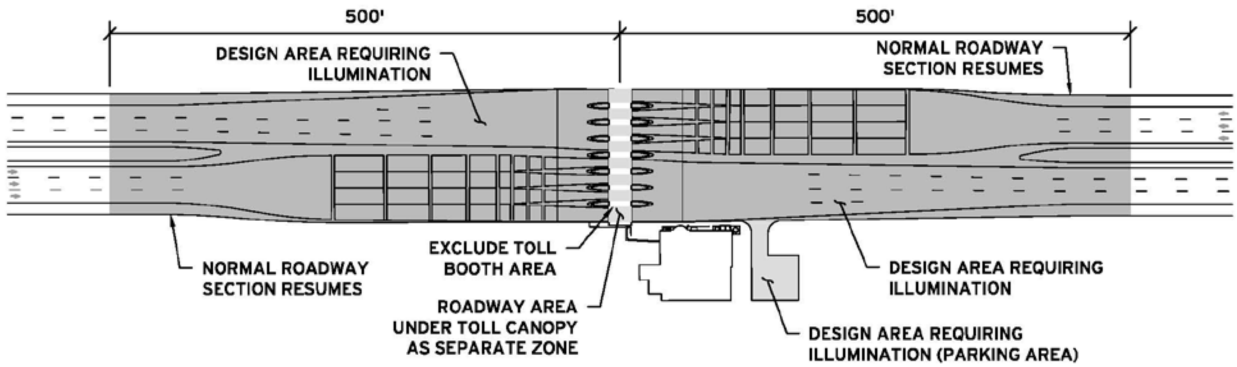
8.2.2.6. **Toll Plaza Merge Areas**

Toll Plaza Merge Areas (as defined below) shall be continuously lighted from pavement edge to pavement edge, including all shoulders, where required by the Lighting Warrant Analysis. The Design Area for Toll Plaza Merge Areas shall include all islands, dividers, and other obstructions, but shall not include the area immediately below the Toll Plaza Canopy, which shall be defined as a separate zone in the same file. The Toll Plaza Canopy shall be modeled as a solid obstruction at the height of the lowest clearance, just above the mounting height of the Toll Plaza Canopy luminaires. All additional Toll Plaza areas, including Parking, Maintenance, and Storage Facilities shall be analyzed as separate zones in the same Toll Plaza calculation file. Include all contributing lighting from roadway, parking, storage areas, as well as under toll or fuel canopies.

The area under the toll canopy shall be the defined as all roadway area under the toll canopy. This area excludes Toll Islands. This may be achieved by assigning a zone to each lane and combining them as one area. Toll booths shall be approximated and modeled as a solid obstruction. Any calculations for a Toll Plaza Canopy shall also include the toll plaza approach luminaires within 160' of the canopy.

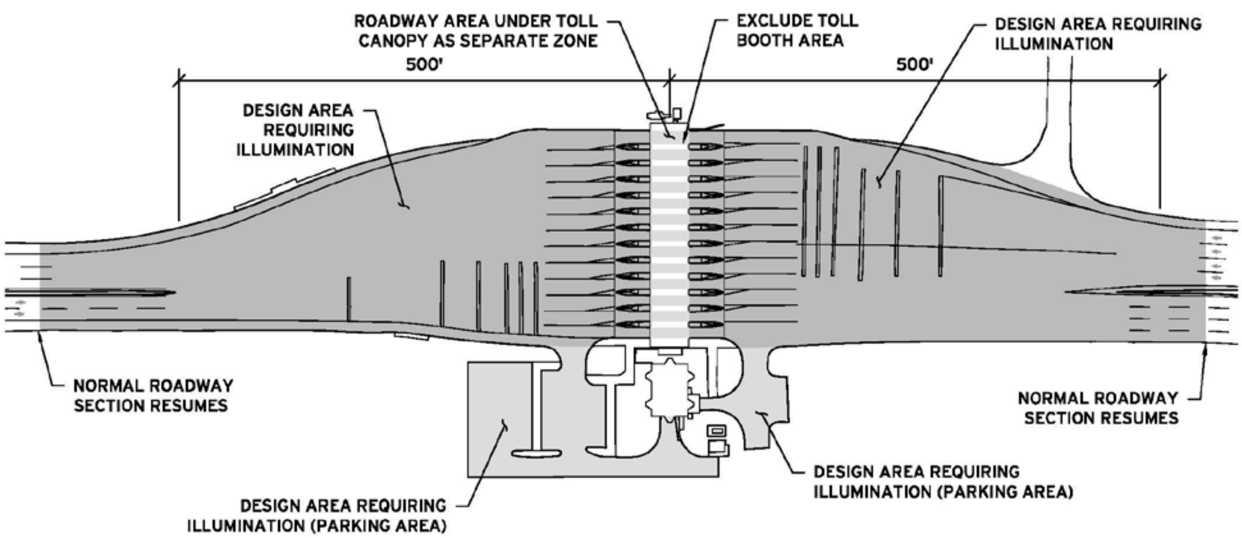
The Toll Plaza Merge Area shall be defined as the greater of the two following areas:

Exhibit 8-12 Small Toll Plaza Design Area



The paved area between points located 500 feet on either side of the Toll Plaza centerline as shown above in Exhibit 8-12, or

Exhibit 8-13 Large Toll Plaza Design Area

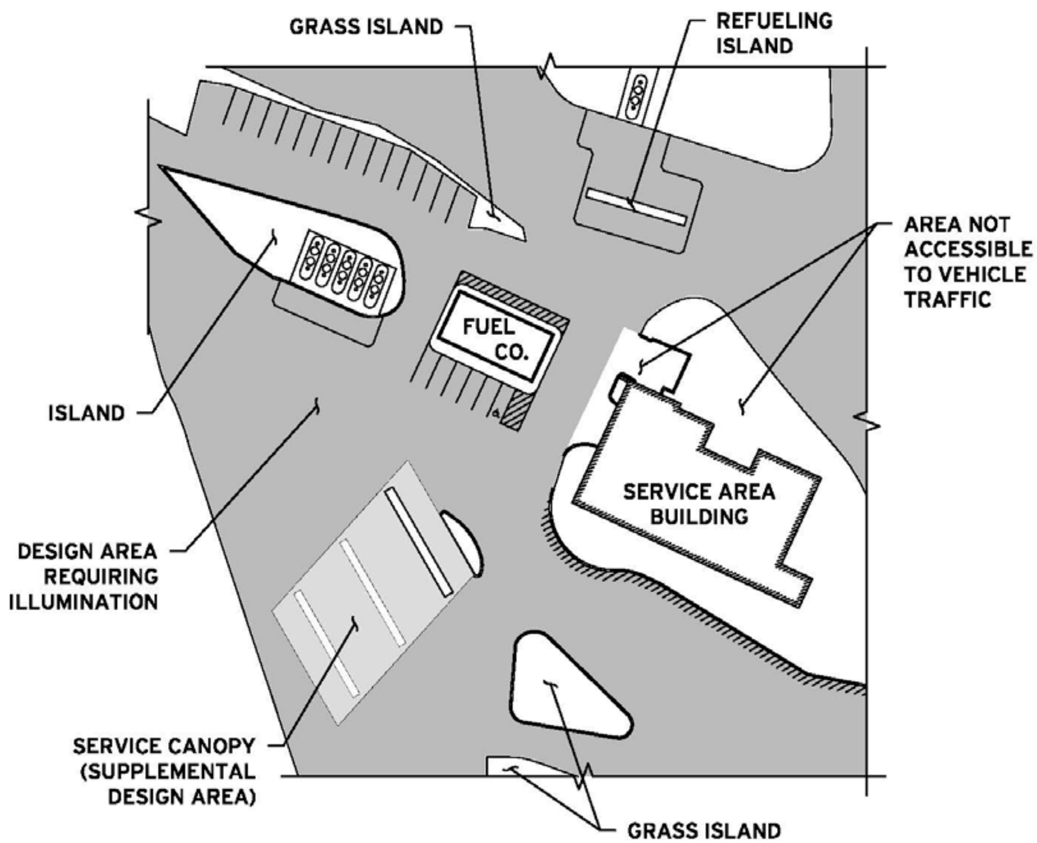


The paved area on both sides of the toll plaza that is located between the limits of typical a roadway section as shown above in Exhibit 8-13.

8.2.2.7. **Parking / Maintenance / Storage Facilities**

The Design Area for Parking, Maintenance, and Storage areas, where lighting is warranted, shall include all paved area that is accessible by vehicular traffic. Channelizing devices, buildings, islands, service canopies, maintenance buildings, etc. shall be excluded from the Design Area in order to reduce unnecessary light spill and improve overall system efficiency. Areas with any expected pedestrian traffic should be included in the Design Area to ensure maximum safety. Where Fuel Canopies exist, the canopy shall be modeled as a solid obstruction similar to that of the Toll Canopy and excluded from the Design Area. The Fuel Canopy luminaires shall be included in the calculations, and the area below the Fuel Canopy shall be a supplemental Design Area, as a single calculation zone. A typical parking area is shown in Exhibit 8-14, below:

Exhibit 8-14 Typical Design Area for Parking Facility



8.2.2.8. **Roadway Tunnels**

The Design Area for Roadway Tunnels, including Adaptation, Transition, and Interior Zones, shall be as defined and described in *ANSI/IES Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting*, Illuminating Engineering Society of North America Publication RP-8.

8.2.3. Lighting Design Criteria

Once the required areas of illumination (Design Areas) are determined, the appropriate lighting design criteria shall be designated for each area.

The Authority utilizes an Illuminance method for the design of all lighting systems, except as required by the ANSI/IES publications for Roadway Tunnels. Illuminance levels shall be in accordance with the following criteria, shown below in Exhibit 8-15:

Exhibit 8-15 Table of Illumination and Uniformity Requirements

Usage Classification	Minimum Average Maintained Illuminance (foot-candles)	Maximum Average Maintained Illuminance (foot-candles)	Minimum Point Illuminance (foot-candles)	Maximum Uniformity Ratio (Avg./Min.)[1]
Mainline Roadways and Ramps	0.70	0.85	0.20	4.0:1
Gore Areas (Mainline Roadways and Ramps)	0.70	0.85	0.20	4.0:1
Toll Plaza Merge Area	2.30	2.50	0.60	4.0:1
Toll Plaza Lanes (Area below Canopy)	15.00	20.00	10.00	1.5:1
Major Long Bridges	0.70	0.85	0.20	4.0:1
Service Areas/Parking Areas	1.75	2.25	0.50	4.0:1
Roadway Tunnels	See ANSI/IES RP-8, Tunnel Lighting			
Other Areas	See the IES Lighting Handbook			
Footnotes: [1] Higher uniformity values will be acceptable for elevated ramps near highmast poles, when approved in advance by the Authority				

Light levels for the Toll Plaza Merge Area shall be as listed in Exhibit 8-15 above and shall transition to the light levels of the adjacent roadways near the limits of the merge area.

Toll plaza lanes shall be illuminated on all plazas to the requirements shown. The calculation zone shall be the roadway surface coincident with the projection of the toll plaza canopy onto the roadway surface.

Outside Authority jurisdiction, illuminance levels and appropriate uniformity requirements for roadways and parking areas shall be as determined by the owner of each property or facility. Lighting levels on all local/county/state-owned roadways shall be designed in accordance with the standards of the local jurisdiction. In the absence of local authority criteria, the lighting shall conform to current NJDOT design criteria, unless otherwise directed by the Authority. At the jurisdictional limits of Authority right of way, all Authority-owned lighting systems shall be designed to transition appropriately to the light levels of the adjacent lighting system, if such system exists.

All lighting calculations shall be performed utilizing a Combined Light Loss Factor (also referred to as Maintenance Factor) to account for diminished light output due to LED degradation, equipment tolerances, and dirt accumulation. Light Loss Factors shall be as shown below in Exhibit 8-16 for all projects:

Exhibit 8-16 Table of Light Loss Factors

Facility	Light Loss Factor
Authority Roadways	0.85
Other Authority Facilities	0.85
Other Authority Facilities Considered Dirty[1]	0.80
Local, County, and State (NJDOT) Roadways	Per NJDOT requirements
Other Areas outside Authority jurisdiction	Per property owner
[1] Area shall be considered “dirty” if environmental factors (i.e., soot, exhaust, dirt, etc.) are expected to accelerate depreciation of lamp lumen output relative to an average installation.	

To prevent need to redesign lighting systems, Light Loss Factors shall be determined in advance of, and included with the Phase “A” Submission for review by the Authority. See Subsection 8.6.1 for more information.

8.2.4. Selection of Roadway Lighting System

After the various Design Areas and Design Criteria have been determined, the Engineer shall identify the type(s) of Roadway Lighting System(s) to be used on the project. This Subsection details the selection of the Roadway Lighting System only. For information regarding types of equipment installed for other lighting systems, see Subsection 8.3.

Refer to the Current Standard Drawings and Specifications, and the Authority’s website for references of specific photometric and material requirements, and the Qualified Products List for currently approved model numbers for each type of fixture as noted below.

8.2.4.1. **Approved Roadway Lighting Systems**

The Authority currently utilizes and maintains three (3) major types of roadway lighting systems. These systems are designated below, with brief descriptions of the major system features:

a. Pole-Top Cutoff Lighting System – The Pole-Top Cutoff Lighting System utilizes a range of LED luminaires (LP1 through LP9) that are designed to be mounted on poles without the traditional bracket arms. Nominal mounting heights are either 26 or 40 feet and shall be determined based on the criteria listed in Subsection 8.3.1. Horizontal or vertical tenon adapters are installed on the top of each pole, and the luminaire is installed and attached. The Type LP luminaire is preferred by the Authority because maintenance can be performed without the need to shut lanes if the lighting design places luminaires above full-width accessible shoulders. It is preferred to mount luminaires at zero (0) degrees tilt, but some luminaire tilts may be accepted as described in Subsection 8.2.4.2. It is the Engineer's responsibility to validate that the luminaire used is capable of tilting while mounted on a standard tenon adapter. The Engineer shall provide project-specific details where special mounting adapters are required.

b. Mast Arm Lighting System – The Mast Arm Lighting System utilizes a range of LED luminaires (LP1 through LP9), mounted on either 8- or 15-foot bracket arms. Nominal mounting heights are either 26 or 40 feet for new installations (30 or 40 feet for retrofit installations on the Turnpike, see Subsection 8.3.1).

c. Mast Arm Lighting System – The Mast Arm Lighting System utilizes a range of LED luminaires (LP1 through LP9), mounted on either 8- or 15-foot bracket arms. Nominal mounting heights are either 26 or 40 feet for new installations (30 or 40 feet for retrofit installations on the Turnpike, see 8.3.1).

8.2.4.2. **Selection of System**

1. For each project, the Engineer shall perform an analysis of project areas and propose the Roadway Lighting System(s) to be installed. The systems should be considered in the following order, which is ranked according to Authority preference:

    a. Pole-Top Cutoff System shall be considered the preferred Roadway Lighting System on the Authority roadways. Pole-Top Cutoff Systems have been installed on roadways and toll plazas as wide as 10 lanes with optimal results, and shall be used for all installations, unless the Engineer can demonstrate that Authority Lighting Design Criteria cannot be met. All Pole-Top lighting shall be evaluated with no tilt (0°) first. If the Engineer demonstrates that it is not possible to meet the criteria with all zero tilt luminaires, the Engineer may then consider a maximum of five degrees (5°) tilt only where necessary and bring this to the attention of the Authority in the lighting report.

b. Where no other luminaires or arrangements meet the illumination criteria, Pole-Top Luminaires with tilt angles greater than five degrees (5°) may be considered. The Engineer shall make certain that the glare produced by this type of luminaire is properly controlled. Visors and special optical systems may be considered for such applications.

c. The Mast Arm Lighting System shall be installed only where directed or approved by the Authority to replace or modify existing Conventional lighting systems that are not slated for complete system replacement.

d. Highmast Lighting Systems may be considered for large, complete interchange lighting systems. A highmast system may offer distinct illumination and economic advantages over the other system types. However, because many Authority roadways are near residential developments and areas with sensitive environmental impacts, it may not be feasible to utilize this system. It is the Engineer's responsibility to demonstrate the economic advantage and evaluate the environmental impact of a highmast lighting system to be considered. It is also the Engineer's responsibility to assess the ambient lighting conditions in the areas adjacent to the Design Area to determine potential light trespass impacts. The location and surrounding ambient light levels will be taken into consideration for design acceptance by the Authority.

2. Multiple different roadway lighting systems shall not be installed concurrently in the same project locations, unless approved in advance by the Authority. The Engineer shall make every effort to minimize the number of systems and the number of equipment types used at each project location. The only exception to this direction is that Highmast lighting standards shall be permitted to be installed in the same project areas as other lighting equipment to

realize the efficiency gained by these poles when they cannot be used on all areas of a project.

3. Any existing or proposed roadway lighting system and/or equipment that impacts the roadway lighting system under determination shall be considered in the analysis, discussion, recommendations, and calculations.

4. Where projects are performed at locations where existing lighting systems need to be modified in part due to modified proposed geometry or other construction requirements, the Engineer shall consider replacement of all relevant lighting equipment to meet current Authority standards. If replacement is not cost-feasible or does not offer any material benefit to the Authority, the Engineer shall recommend the exact extent to which lighting equipment shall be removed and replaced.

   New installations (for example, where all lighting on the ramps from an existing toll plaza to the circuits' terminations on the Turnpike mainline are replaced) shall conform to the current standards of the Authority. If only a small portion of an existing approved lighting system (see Subsection 8.2.4.1 for a list of approved systems) needs to be modified, (for example, where several poles are replaced in the middle of a run of existing poles) the new design shall match the standards of the existing installation. See Subsection 8.3.1 for more information regarding types of poles to be used when modifying certain existing lighting installations on the Turnpike.

5. Where multiple types of lighting systems are considered, the Engineer shall perform an analysis of the environmental impacts of each system, especially to residential areas and property, sensitive environmental areas (wetlands, waterways, etc.), and glare / light pollution shall be investigated and detailed in the Phase "A" report. The lighting system with the least amount of environmental impacts should be used if no lighting system evaluated is free of environmental impacts and stated as such in the report. This cost-benefit analysis shall take into consideration maintenance cost, installation cost, and energy usage, and shall be used in making a recommendation of proposed Roadway Lighting System. The cost-benefit analysis shall be included in the Phase "A" report.

6. Wood pole systems shall not be allowed, except for temporary construction lighting.

7. Where existing wood pole, non-standard floodlighting, or legacy systems (including systems using standard poles but non-standard fixtures such as offset or vertical lighting luminaires) are encountered during improvement projects, they shall be replaced or upgraded to meet the Authority's current standards of construction, including associated power and distribution systems or other components. This requirement shall supersede the direction given elsewhere in this Section.

8.2.5. Design Considerations

In the design of lighting systems, the level of light and the effect of glare should be primary concerns. A glare-free environment shall not be compromised in the interest of economy, nor shall higher light levels be permitted where not required by this Manual. Special attention shall be exercised to ensure cutoff type luminaires are utilized to the maximum extent possible, that luminaire tilts are minimized, and that consideration to control glare is given to all design applications.

The Engineer shall work to ensure that all lighting designs meet the following basic criteria in order to achieve a superior and economical roadway lighting system. These criteria are presented in order of the Authority's preference (Number 1 being the most important). Where it is not possible to satisfy all criteria for the entire installation due to project-specific constraints, the Engineer shall utilize this ranked list to make decisions regarding tradeoffs between various project elements. Where any of the following criteria cannot be met for a given installation, the Engineer shall include a discussion in the appropriate Phase Submission report, for final approval by the Authority.

1. Placement – Safe placement of light poles and equipment. Safety for the public and maintenance shall take priority.
2. Uniform Lighting – The Engineer shall ensure a uniform distribution of lighting intensities that fall within Authority Design Criteria and shall achieve this throughout the entire system unless specific Design Criteria have been modified through the process described in Subsection 8.1.3.
3. Responsible Installation – The Engineer shall utilize the most environmentally-friendly solutions that reduce light pollution.
4. Planned Maintenance – The Engineer shall choose equipment locations that require the least amount of preventative and periodic maintenance in terms of manpower and cost. Equipment locations selected shall be easily accessible for maintenance.

5. Economical Installation – The Engineer shall optimize initial construction costs and ongoing power consumption costs for the entire system.

6. Aesthetically Pleasing – The Engineer shall provide an installation that is pleasing and symmetrical in appearance to passing motorists. Lighting installations should not look out of place or be visually objectionable to a public patron who is not trained in the specifics of lighting design and may not know the engineering reasons why certain options may be preferable if aesthetics is not a consideration. In general, lighting standards shall be aligned or evenly staggered, with relatively uniform height to achieve an acceptable aesthetic appearance. See Subsection 8.3.1 for typical lighting standard arrangements that meet these aesthetic requirements.

It is understood that creating a lighting system design that is compliant with all the above criteria is sometimes difficult and will require tradeoffs. It will require some judgment on the part of the Engineer to draw an appropriate balance. The Engineer should take this into consideration when determining the required lighting system design.

8.2.6. **Lighting Calculation Method**

This Subsection lists the specific requirements to be used when performing illuminance calculations for Authority projects. These methods are used for most roadway, site, underpass, and other lighting systems. For details of the luminance calculation methods required for certain Tunnel and Sign Lighting installations, see the *Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting* (ANSI/IES Publication RP-8)

Calculations shall be submitted for all areas where Roadway Lighting is warranted, including but not limited to, Roadways, Tunnels, Underbridge, Signs, and where lighting is required as a result of or in conjunction with Aesthetic Lighting.

8.2.6.1. **Software and Setup**

1. All illuminance calculations shall be performed using the Acuity Lighting Brands, Inc. lighting calculation software called Visual™ Professional Edition, latest version. This is an industry-standard program used for review of lighting calculations. The alternate program for illuminance calculations is AGi32, by Lighting Analysts, latest version. The Engineer may not propose use of an alternate lighting calculation program.

2. The Visual™ lighting software may be used for luminance calculations, as is required for such installations as Sign Lighting. The acceptable alternative is AGi32 for Sign Lighting. Tunnel Lighting, specifically, shall use only AGi32 for luminance calculations. Tunnel

luminance calculations shall be performed in candelas per meter-squared (cd/m²).

3. The Engineer shall import the most recent proposed roadway geometry and topographical information into the calculation software and shall use this as a basis for all calculations. At a minimum, stationing, striping, and utilities shall also be shown. All structures and obstructions which may impact light levels shall be shown, as well as all existing lighting standards that will remain after construction.

4. For complex interchanges, the Engineer shall use three-dimensional modeling and/or creation of obstructions and surfaces within the file to model the effects of bridges, grade-separations, and/or other structures which may interfere with ideal lighting conditions. It shall be permissible to approximate areas of variable grade with multiple stepped "flat" calculation zones, each of as large a size as possible, provided that the method used does not introduce a significant error into the calculations.

5. To reduce coordination and possibility of cross-referencing errors between multiple lighting calculation files, the calculations shall be performed in a single lighting file. If the Engineer desires to utilize more than one file for calculations, a request shall be made to the Authority during the Phase "A" Submission. The request shall state the engineering reasons why multiple files are required and shall be reviewed at the time of the Phase "A" Submission. Any calculations submitted as multiple files without an approved request shall be returned without further review, and resubmission will be required.

6. All calculations shall be performed in U.S. Customary units (lumens, feet, foot-candles).

8.2.6.2. **Calculation Zones**

1. Calculations zones shall be defined to be coincident with the lighting Design Area, (See Subsection 8.2.2 for determination of Design Areas). Calculation zones shall be constructed using the Polygon method and shall closely match all curved geometry of the base drawing to ensure that no calculation points are unintentionally omitted. Each section or Design Area shall be analyzed using a separate calculation zone, and multiple calculation zones shall be allowed for each Design Area. Use of statistical zones shall not be permitted. Calculation zones shall be defined as large as possible given the above criteria for ease of design and review. When

geometry requires smaller separate calculation zones that make up a larger area, those smaller zones shall be combined to create a single calculation zone. Adjacent calculation zones may not have gaps between them and should not overlap.

2. To facilitate review of the calculations, calculation zones shall be named to match the area being calculated, or roadway station points. Multiple colors shall be used to differentiate between zones. Minimum and maximum values shall be displayed in a different color than the main calculation zone points.

3. Calculation zone accuracy shall be set to hundredths (double-digit decimal “0.00” accuracy). Point spacing for all calculation zones shall be 5 feet transversely and longitudinally for roadways and parking facilities. Point spacing for Sign Lighting shall be 1 foot transversely and longitudinally. Point spacing for Pedestrian Walkways and other pedestrian areas shall be 2 feet transversely and longitudinally.

4. Calculation zones shall be defined for all residential lots and shall be named “Residential Area”. Lighting levels in these areas shall be kept to a maximum point illuminance of 0.10 foot-candles (see Subsection 8.2.2). If more than one residential area exists, or if residential areas are separated such that they cannot be defined as one calculation zone, then each residential area shall be numbered logically following “Residential Area 1”, “Residential Area 2”, etc.

5. Masking or deletion of individual calculation points shall not be permitted other than the exceptions listed here.

    a. Masks will be allowed for large parking areas – for example, an area mask is required to exclude a grass island, an area inaccessible to traffic, or a building from the overall calculation zone.

    b. In the case of retrofit lighting in which the pole locations are fixed/re-used (no new or relocated light poles), up to six (6) calculation points may be individually masked when within four (4) feet of the edge of a shoulder and two (2) feet of the edge of a roadway where no shoulder is present. The Engineer shall include the number of masked points and their location in the calculation output and accompanying phase report along with explanation of methods attempted prior to masking points.

6. All Toll Plaza calculation zones shall be defined in a single file to include all contributing lights including those under the canopy. The zones shall be defined to the Design Areas in Subsection 8.2.2.6. A separate zone shall be the roadway under the canopy, so all lighting contribution is calculated.
7. Toll plaza obstructions such as Toll Booths and toll island bumper blocks shall be approximated in 3D as solid obstructions in the calculation software for more accurate results in and around the Toll Plaza.

8.2.6.3. **Luminaires and Photometrics**

1. Luminaire definitions shall be created using the .IES photometric files for the specific luminaire catalog number of an Authority approved luminaire indicated in the Qualified Products List, and as otherwise directed by the Authority. Photometric data used shall be the most recent version of unaltered IES files from the manufacturer's website. No substitutions will be accepted without prior direction from The Authority.
2. IES photometric files used in calculations for existing and/or proposed non-Authority or non-standard equipment shall be as per the manufacturer's direction for the specific equipment. Manufacturer, fixture type, and photometrics shall be determined by field investigation, review of As-Built plans, coordination with equipment owner, or similar method. "Approximate" or altered photometrics files will not be accepted.
3. Tilt values and optical rotations in the luminaire definition shall be set to zero degrees (0°) to the illuminated surface in the luminaire definition. All tilts shall be applied to the individual luminaires/light standards.
4. Mounting height of luminaires shall be the actual mounting height as shown in the Current Standard Drawings, rounded to the nearest foot to simplify data entry.
5. Symbols in the Luminaire Schedule shall be defined accurately and scaled to the examples in the Current Standard Drawings and Sample Plans.
6. Luminaires/Lighting Standards shall be laid out in accordance with the details shown on the Current Standard Drawings and to match the design considerations listed in Subsection 8.2.4.

7. The Engineer shall ensure that the location and types of luminaires and lighting standards are consistent between all calculations files and the plans developed for construction of the lighting system.

8. All light sources within three (3) mounting heights of any calculation zone shall be included in the calculations. This includes utility, site, and other lighting that is not on Authority property. For example, if a utility light on a 40-foot pole is near Authority property, it shall be included in the design as a contributing light source if it lies within 3 x 40 = 120 feet of any calculation zone. Where luminaire information is not available for a contributing source, a conservative approximation should be used.

9. All initial LED lumen values imported from their respective IES photometric file shall remain as imported. IES files should not be edited prior to importing for calculations, and initial lumen values may not be changed.

10. Exhibit 8-17 below is a table to be utilized for initial lamp lumens of existing or retrofit High Pressure Sodium (HPS) lamps that may be required in calculations. These values shall be used when defining existing or retrofit light sources within the calculation software , even if the .IES photometric files are imported with different (manufacturer specified) values. Only clear lamps shall be utilized to evaluate HPS luminaires.

Exhibit 8-17 Lamp Types, Wattages, Lumens, and Rated Life

Lamp Type	Lamp Watts	Initial Lumens	Rated Hours
High Pressure Sodium (HPS)	70	6,400	24,000
	100	9,500	24,000
	150	16,000	24,000
	200	22,000	24,000
	250	27,500	24,000
	310	37,000	24,000
	400	50,000	24,000
	1000	140,000	24,000
The Light Loss Factor for all HPS luminaires shall be 0.75.			

8.2.6.4. **Additional Considerations**

Calculations shall be provided for all major stages of construction, wherever the traveled way is out of the normal traveled way or location of existing or temporary lighting changes until permanent lighting is installed and operational.

In the case of retrofit lighting in which the pole locations are fixed/re-used (no new or relocated light poles), average illumination levels may exceed the criteria in this manual. For this type of retrofit lighting the threshold for the maximum allowed average illumination level is 1.2 foot-candles. This information shall be emphasized in the Phase "A" Conceptual Design Submission.

8.3. LIGHTING EQUIPMENT AND MATERIALS

8.3.1. Roadway Lighting Standards

8.3.1.1. **Light Pole Type and Construction**

Except for Highmast Lighting Systems, ground-mounted lighting standards typically mounted on precast concrete bases or Junction Box Foundations via breakaway transformer bases shall be aluminum alloy, equipped with single, double, or triple tenon luminaire mounting adapters. Bridge/wall/structure-mounted lighting standards shall be steel, equipped with single or double tenon luminaire mounting adapters as shown on the Current Standard Drawings, and mounted via shoe bases. In some existing and retrofit Turnpike installations, lighting standards may be a shoe base mounted via parapet bracket to the side of the parapet. See Current Standard Drawings for details.

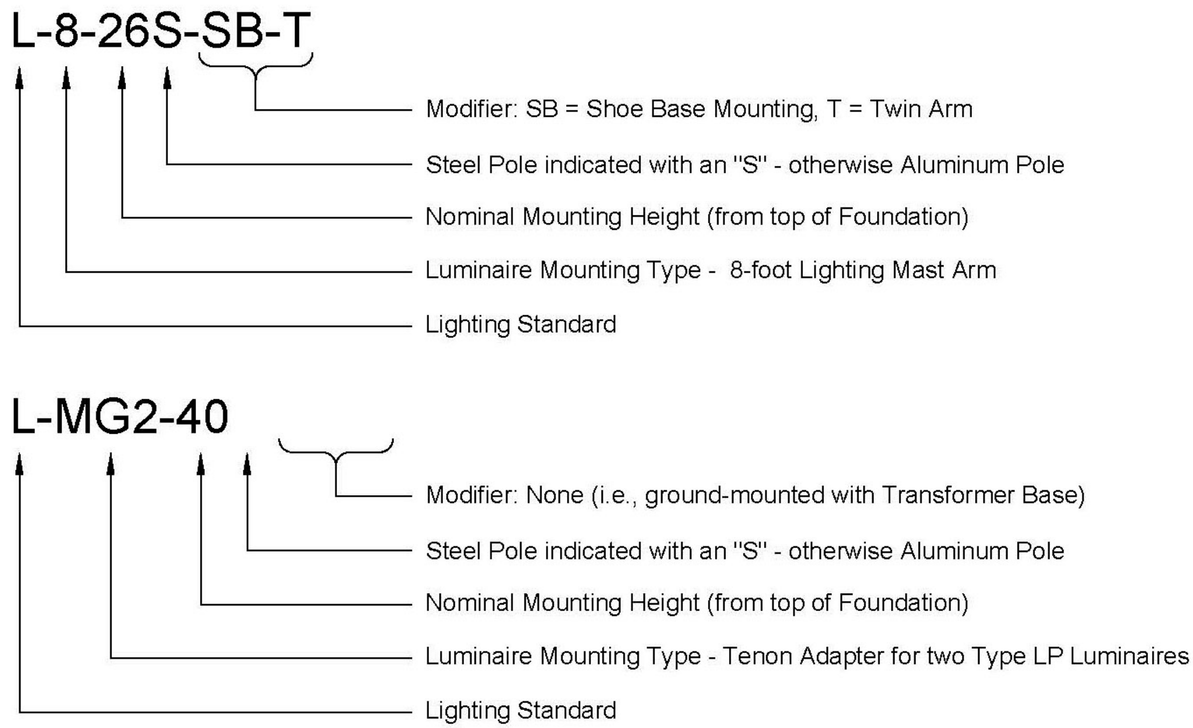
All light poles shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. See Section 3 (Structures) of this Manual, and specific information on the Current Standard Drawings for more information.

For specific types, descriptions, and dimensional details of approved Lighting Standards, refer to the Current Standard Drawings.

Legacy roadway lighting designs utilized 30 and 40-foot poles of a design that differs from current approved standard light poles. Those poles are designated with numeric types – i.e. "Type 1", "Type 2", "Type 3", etc. that are standardized. These pole types shall not be used in proposed designs unless approved by the Authority. They are provided as a reference for LED Retrofit projects.

Approved standard light pole types are featured on Standard Electrical "E" Drawings. The 26- and 40-foot nominal mounting height lighting standards shall be used in various configurations on all new construction projects unless noted otherwise. Pole designations are a coded system shown below in Exhibit 8-18. See Current Standard Drawings for the list of pole types and modifiers.

Exhibit 8-18 Lighting Standard Designation Method



LIGHTING STANDARD DESIGNATION FOR ALL CURRENT AND FUTURE DESIGNS

The light poles shown on the Current Standard Drawings shall be used on all new projects with the following exceptions:

1. Where directed by The Authority
2. Where three (3) poles or fewer are being replaced.
3. A partial installation that may result in an objectionable aesthetic appearance due to a predominant number of existing legacy Turnpike poles.

In each of the exceptions, Engineers shall provide their recommended light type and include all relevant documentation for approval.

Legacy light poles shall be considered non-standard. Legacy and other non-standard poles are approved for use by the Authority according to other requirements in this Section, the poles shall be designated with the Modifier “NS1”, “NS2”, etc. for each type of non-standard pole used on a project. The details and model number information for all non-standard poles shall be clearly shown in the Plans. For example, a painted steel Architectural parking lot lighting pole with 20-foot height and 4-foot arm would be designated “L-4-20-NS1.” A pole of the same construction, but with 25-foot height would be “L-4-25-NS1”. A twin arm pole would be “L-4-25-NS1-T”, etc.

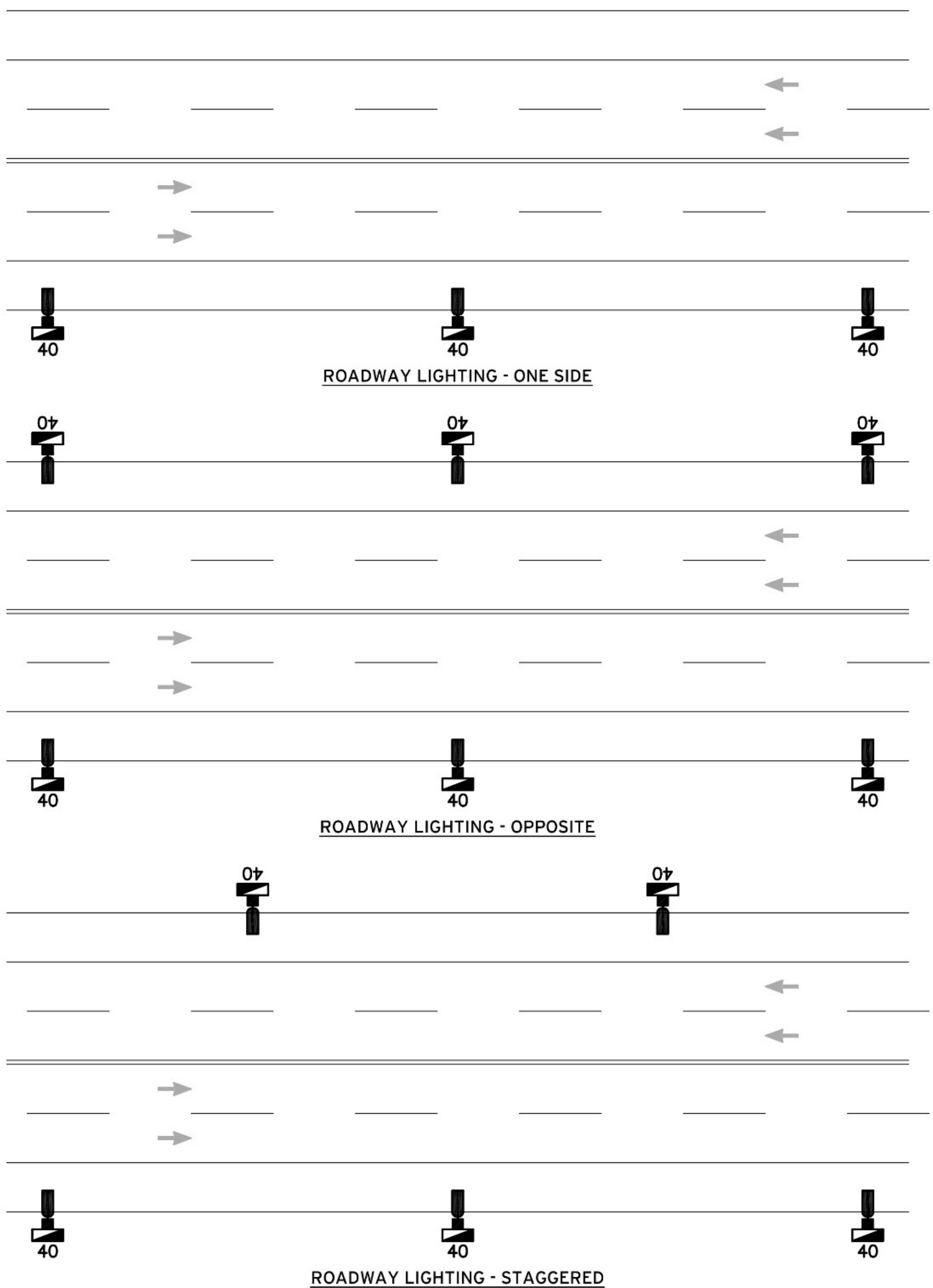
For pole-top cutoff lighting installations, “L-MG” type lighting standards with 40-foot nominal mounting heights shall be used for mainline roadway illumination. 40-foot poles with Type LP4 through LP6 luminaires shall be considered for use first, in order to yield a more efficient design. Type LP7 and LP8 fixtures shall be used only for very wide roadways or where the Illumination Design Criteria is greater than 1.0 foot-candles.

8.3.1.2. **Light Pole Arrangement**

Type, arrangement and location of lighting standards to be used in various areas shall conform to the following design criteria:

1. Lighting standards shall be arranged in one of the following three (3) methods; one-sided, opposite, staggered. Installation of Lighting Standard on a median barrier shall require prior approval by the Authority. An illustration of these arrangements follows in Exhibit 8-19. Selection of the method shall be based on the engineering analyses shown to produce the most effective and economical lighting system. The Engineer shall analyze both installation methods to determine the recommended scenario and shall describe the analysis as part of the submission report. Except where non-symmetrical geometry is encountered, lighting shall be evenly spaced and staggered to yield a pleasing visual appearance. See Subsection 8.2.5 for more information regarding aesthetic treatment of lighting installations.

Exhibit 8-19 Typical Roadway Lighting Standard Arrangements



2. Avoid placing 40-foot lighting standards within 60 feet of a physical gore, ramp, taper, or other roadway geometry where the pole may block the entire ramp or roadway if it were to fall. Use of 40-foot lighting standards in these locations may only be permitted if the Engineer demonstrates that no combination of 26-foot poles is For pole-top cutoff lighting designs using 26-foot poles, Type LP1 or LP2

fixtures shall be permitted on roadways up to 48 feet wide, provided that the Design Criteria is satisfied and the Engineer can justify their use in lieu of 40-foot poles because of specific project-related constraints, efficiencies, or impacts to non-Authority property. 26-foot lighting standards shall be used on ramps and within 60 feet of a physical gore, ramp, taper, or other roadway geometry that could be blocked by a 40-foot pole if it were to fall.

3. Mast arm lighting system installations shall require pre-approval or direction from the Authority. Lighting standards with 26-foot nominal mounting heights (and 30 foot heights where retrofit poles are specifically approved) shall be used for ramps and within 60 feet of a physical gore, ramp, taper or other roadway geometry that could be blocked by a 40-foot pole if it were to fall. 40-foot poles shall be used for mainline roadway illumination. All mast arm lighting shall be equipped with approved luminaires from the Qualified Products List.

4. Bridge-mounted or parapet-mounted lighting standards shall be 26-foot nominal mounting height. 40-foot poles may only be bridge-mounted or parapet-mounted where the Engineer demonstrates that 26-foot poles cannot light the ramp or roadway within the criteria. For ramp lighting over another roadway, pole installation on the bridge shall be avoided. In any case where the design criteria cannot be met with 26’ poles off the bridge, the preference is to place the least number of 26’ poles on the bridge structure as necessary to meet the required criteria. The 26’ poles in this case shall be mounted nearest to the ends of the bridge or bridge support. Use of 40’ poles on elevated structures or over another roadway shall require approval from the Authority.

5. Lighting standards shall be located along the wide shoulder (10 ft. and 12 ft.) edge of all ramps and mainline roadways in order to facilitate maintenance and re-lamping. In very wide gore areas, however, it shall be permissible to install a small number of supplementary lighting standards along the opposite shoulder in order to achieve illuminance requirements.

6. When a lighting standard is to be located within the vicinity of an exit gore area, a minimum of 50 ft. clearance should be provided beyond the physical bullnose.

7. Lighting standards adjacent to overpasses shall be located to avoid glare affecting traffic on overpasses. Additionally, light cutoff angles produced by structural members should be analyzed when locating such lighting standards. Preferably, the lighting standards should be located equidistant from overpass structures. If this cannot be achieved, a minimum clearance of 35 feet (for 26-foot poles) and 50 feet (for 40-foot poles) shall be provided from the face of parapet of a typical overpass (with standard minimum vertical clearance).

8. Lighting standards adjacent to overhead sign structures should be located equidistant from such structures, if feasible, otherwise minimum clearance requirements set forth for the overpass structures shall be provided.

9. Opposite lighting standard arrangements (see Exhibit 8-19) shall be used in toll plaza areas, except at certain narrow toll plazas where required illuminance levels and uniformity ratios can effectively be achieved by one-sided arrangement. Lighting from the median or median barrier will not be approved.

10. Ground-mounted lighting standards shall be installed on concrete bases or Junction Box Foundations. Junction box foundations shall be used in lieu of junction boxes and separate concrete bases wherever feasible, while maintaining a standard setback of 3`-6” measured from the edge of pavement to centerline of the lighting standard. Each lighting standard installed on a concrete base shall be provided with a concrete junction box adjacent thereto for cable splicing unless another junction box within the proximity of the lighting standard (up to 50 feet away) can be used for this purpose.

11. Lighting standards on bridge structures shall be located at or as near as possible to piers or abutments to reduce undesirable vibration. Mid-span locations must be avoided whenever possible. See Section 3 (Structures Design) of this Manual for specific locations where lighting standards are allowed. All bridge-mounted light standard mounts shall be capable of supporting all standard Authority poles, up to a height of 40 feet.

12. Lighting Standards shall be installed such that they are located not closer than 20 feet to primary or secondary utility power lines or communication facilities that are mounted to wood or other utility poles. The Engineer shall take into consideration the requirements

of the National Electrical Safety Code when designing lighting systems in the vicinity of power distribution lines. Additionally, the Design shall take into consideration the likelihood of pole knockdowns by vehicle impact and ensure that no other critical facility may be rendered inoperable in the event of an accident.

13. The number of various lighting standard assemblies and fixture optics shall be kept to a minimum on each project, for ease of maintenance. Runs of adjacent lighting standards shall be of the same type or fixture. The Engineer shall not alternate lighting standards types, luminaires, or wattages, or install small quantities of non-matching lighting standards in a string of otherwise identical poles. If the Engineer feels there is a valid engineering reason why such a design is required in lieu of other, more standardized designs, the Engineer shall present this reasoning to the Authority for approval.

14. Lighting standards located within the roadway clear zone shall be shielded by guide rail, as warranted, in accordance with Section 4 (Guide Rail / Median Barrier / Attenuator Design) of this Manual and the GR Standard Drawings.

8.3.2. **Roadway Lighting Luminaires**

Various types of luminaires to be used for roadway lighting systems shall be as listed in the Qualified Products List.

1. All standard luminaires are designated by a one- or two-digit letter-number combination, i.e., “Type LPx”, “Type LHx”, or “Type LWx” independent of fixture wattage, which shall be shown separately on the Plans. Where non-standard luminaires are approved for use by the Authority according to other requirements in this Section, the luminaires shall be designated as Type “N1”, “N2”, etc. for each type of non-standard luminaire used on a project. The details and model number information for all non-standard poles shall be clearly shown in the Plans. For example, an Architectural parking lot lighting fixture with a wide symmetric light distribution would be designated “Type N1”. A fixture of the same construction, but with an asymmetric light distribution would be designated “Type N2”. A fixture of different construction used on the same project would be “Type N3”, etc.

Descriptions on the use of each type of standard luminaire follow. Where multiple photometrics are approved for use in a given installation (for example, when choosing between the LP3 and LP4 fixtures), the Engineer shall perform calculations for each type to determine the optimal solution for the given Design Area.

LED Pole-Top luminaires (Type LP) to be used for general roadway, toll plaza, and parking area illumination shall be as listed in the Qualified Products List.

2. Special architectural type luminaires may be utilized, as approved by the Authority, for Service Area applications.

The following chart in Exhibit 8-20 summarizes the photometrics that shall be used for designs on both the Authority roadways, and gives recommendations where and how each type of luminaire should be used. Because of the variety of project geometrics, it is expected that these recommendations may need to be adapted for some projects. The Engineer shall perform calculations using the guidelines below to determine the optimal lighting equipment and layout based on the other parameters and requirements of this Section.

Exhibit 8-20 Type LP Luminaire Installation Guidelines

Additional luminaire requirements shall be as described elsewhere in this Section.

Type	Luminaire Optics Type (As defined by IES)	Nominal Mounting Height	Recommended Use
LP1	Medium Roadway	26’	Design Areas up to 48’ in width
LP2	Narrow Roadway	26’	Design Areas up to 48’ in width
LP3	Medium Roadway	26’ or 40’	Design Areas up to 60’ in width
LP4	Narrow Roadway	40’	Design Areas up to 60’ in width
LP5	Wide Roadway	40’	Design Areas 48’ or wider
LP6	Wide Roadway	40’	Design Areas 48’ or wider
LP7	Wide Roadway	40’	Design Areas 60’ or wider
LP8	Forward Throw	40’	Toll plazas and special geometry [1]
LP9	Forward Throw	26’ or 40’	Special geometry [1]
[1] Luminaire to be used in areas of non-standard geometry, varying widths, or transitions between light levels, and where other approved fixtures do not work			

Additional luminaire requirements shall be as described elsewhere in this Section, Standard Specifications Division 900.

8.3.3. Highmast and Floodlighting Systems

1. Highmast Lighting systems shall utilize 80- to 100-foot-high galvanized steel towers equipped with four (4) to eight (8) LH1, LH2, or LH3 luminaires as listed in the Qualified Products List, as outlined in the Standard Specifications, or as otherwise approved by the Authority. The number and types of fixtures provided on a given project shall be kept to a minimum.
2. Highmast Lighting Standards shall be located free of the clear zone (usually 30 feet on most roadways) or protected by physical obstruction or a raised foundation.
3. Unless otherwise directed, all Highmast poles shall be designed with lowering devices, a bottom-latching chain assembly, lightning protection system, proper Equipment Grounding Conductor (EGC), guide rollers to prevent swaying while the luminaires are being lowered, and a method to safely prevent the ring assembly from rotating or moving unexpectedly when lowered for maintenance.
4. Proper aiming of each fixture, including orientation angle, tilt angle, and appropriate reference angle information, shall be included in the plans for all Highmast Lighting Systems.
5. The Engineer shall provide specific details for all High Mast foundations.
6. It is the Engineer’s responsibility to ensure the High Mast Luminaires used in the design dimensionally fit on the head ring and correct optics options are used.

8.3.4. Standby Generator Backup

Where installed at toll plazas or facilities, all new roadway lighting systems shall be connected to circuits that are backed up by generator in the case of a loss of normal electrical service. In the event of a power failure, all toll plaza and interchange lighting shall remain functional. The Engineer is responsible to field-verify and validate the capacity of the generator.

Lighting systems powered by remote standalone load centers do not require generator backup, unless otherwise directed.

Engineers shall verify the preferred fuel type appropriate for the installation and location of all new standby generators with the Authority. All generators shall be factory certified to meet all United States EPA emissions requirements so that stack testing will not be necessary.

Generators shall not be installed in parallel. In the case where there may be a need for parallel generator installation, the Engineer shall evaluate the differences between single vs multiple generators based on load requirements, space, size, and cost, etc. The Engineer shall submit the findings to the Authority for review and further direction.

The Engineer shall design and coordinate raceways such that Building Management System (BMS) communication cables may connect the BMS to a generator or UPS.

Generators shall include a load bank in the design, sized as recommended by the generator manufacturer. The Engineer shall evaluate and specify load bank mounting type to assure a cost and space efficient design, guided by the constraints of the site and project. Load banks shall be provided with automatic load control to assure the generator manufacturer's minimum recommended load is maintained at all times.

See 8.4.2.1 for more information regarding generators, load centers, BMS monitoring equipment, and transfer switches.

8.3.5. **Underbridge Lighting**

The intention of underbridge lighting is not to accent the roadways beneath structures, but rather to provide adequate illumination and to achieve continuity of lighting throughout the roadway. Therefore, underbridge lighting shall only be required where, due to structural limitations such as the width, skew and minimum clearance, adequate illumination cannot be accomplished by means of ground-mounted lighting standards outside the limits of the structure.

Underbridge lighting luminaires shall be LED Type LW (See QPL) and shall be installed on bridge piers or abutments or supported by structural members, as required.

Mounting height shall be as required for proper illumination of the roadway, and as follows:

1. Luminaires on piers or abutments: 15 ft. minimum from roadway surface to bottom of luminaire
2. Type-LS Luminaires on structural members: Bottom of luminaire in line with bottom of adjacent stringer flange.

Luminaire setback (light center to pavement edge distance) shall be as per the following minimum requirements:

1. Type-LW Luminaires on piers or abutments: Face of pier or abutment to pavement edge.
2. Type-LS Luminaires on structural members: 3 ft. beyond pavement edge over shoulder.

Engineers shall use the lowest wattage LED luminaire to meet Authority design criteria.

Photometric requirements shall be as listed in the QPL and Specifications.

For installations requiring luminaires mounted to structural members, the Engineer shall ensure that the location of the luminaires, and the mounting detail does not block the light output to the roadway. Additional modeling may be required to determine this for installations between tightly spaced stringers.

Bird deterrent shall be required for all underbridge lighting, including junction boxes and conduits larger than 1”. The Engineer shall coordinate bird deterrent method with luminaire installations. The attachment of bird deterrent must be approved by the manufacturer. Failure to install bird deterrent to manufacturer direction may lead to improper cooling or lack of cooling due to restricted air flow. If a manufacturer has a specific bird deterrent as an option or accessory for their luminaires, it should be considered over alternative methods.

8.3.6. Toll Plaza Lighting

Toll Plaza Lighting Systems shall conform to the requirements of the other lighting systems described in this Section. The Engineer shall not utilize non-standard lighting systems for toll plazas. All lighting shall be from the right shoulder with proper setback for the plaza conditions, and one-sided wherever possible. Lighting from the median or median barrier will not be approved.

8.3.7. Roadway Tunnel Lighting

Owing to the specialized nature of tunnel lighting, non-standard luminaires and installation methods may be required. The Engineer shall utilize Authority standard luminaires, equipment, mounting, and construction methods wherever possible for tunnel lighting installations. Where it is necessary to utilize non-standard items, the Engineer shall make recommendations of equipment to be installed, and proper installation methods, in accordance with Subsection 8.1.3.

If possible, location of luminaires and mounting shall be as described above for underbridge lighting. All conduits and equipment shall be installed to minimize likelihood of vehicle impact, to facilitate maintenance, and to keep a high level of system uptime.

8.3.8. Maintenance Area/Storage Area Lighting

Storage Facility and Maintenance Yard Lighting shall be constructed of Pole-Top Cutoff Lighting Systems. The Engineer shall weigh the various systems and equipment that can be installed and make recommendations based on engineering judgment.

8.3.9. Parking Lot Lighting

Parking Lot Lighting systems, including the lighting at Service Areas, may require the use of special Architectural fixtures and poles. The Engineer shall contact the Authority for specific design requirements, prior to design.

8.3.10. Temporary Roadway Lighting

Design and construction sequence of the roadway lighting system should be arranged so that the permanent lighting installations will be completed and in operation when the new roadways are opened to traffic. If this cannot be accomplished, temporary lighting should be provided for these roadways. All installations which are required to be removed at the end of the construction should be of temporary nature. Temporary roadways such as crossovers and other detours shall be lit to the same criteria as a permanent roadway.

Illumination levels and uniformity requirements for temporary lighting systems shall be as prescribed above for permanent lighting systems. A temporary lighting system is expected to produce a level of illumination equal to that of a permanent system. However, physical arrangements and equipment criteria are modified to enable an abbreviated and less costly installation. Maintainability, constructability, and safety considerations should not be compromised in temporary lighting systems.

The following general criteria are provided for temporary lighting systems. Unless otherwise stated below, criteria relating to permanent lighting systems apply for the design of temporary systems.

1. Screw-type bases or other above-ground bases may be used with lighting standard installations in lieu of concrete bases and Junction Box Foundations where protected from vehicle impact.
2. Wood poles with Type LP luminaires with pole-mounted tenons may be used for roadway lighting applications.
3. Wood poles with Type LP8 or Type LP9 LED luminaires may be used for roadway lighting applications and in areas where a large setback is necessary to clear construction activity Wood poles with HPS floodlighting type luminaires may be used for area lighting applications.
4. Wood poles with Type LP LED luminaires may be used for area lighting applications.
5. Each temporary lighting standard and wood pole location shall be properly bonded to the system ground. All temporary distribution wiring (multiconductor direct burial, aerial cable or individual wiring in conduit) shall incorporate a separate equipment ground conductor to provide a continuous ground throughout the entire circuit.

6. Lighting standard identification tags, as shown on the Current Standard Drawings, will not be required for temporary installations. However, an approved weatherproof write-on-type-tag should be installed at each temporary location indicating circuit number and phase connection.

7. Lighting standards and equipment shall be set back from edge of roadway in accordance with the requirements of the Current Standard Drawings when construction activity will not be expected to conflict or interfere.
8. When a project requires a temporary condition not specifically detailed in the contract plans, the Engineer shall provide clear direction to the contractor for the scope of work and clearly identify the measurement and payment for the work.

8.3.11. **Sign Lighting**

Sign lighting where required, shall be Type LS LED luminaires as listed in the Qualified Products List. Installation requirements shall conform to the Current Standard Drawings. The Contract Plans shall also include the following additional information:

1. Luminaire arrangement for each sign panel, based the tabulation included in the Current Standard Drawings, shall be coordinated with, and shown on the Structural Elevations for each illuminated overhead sign structure.

2. Circuit provisions for each sign structure or bridge-mounted sign, either from roadway lighting circuitry (group controlled) or from a local utility (24-hour service), shall be shown on the Roadway Lighting Plans. Sign lighting luminaires shall alternate circuit phases.

3. Relocation of Sign Lighting where existing sign panels are replaced with new panels, and the new panel is of a different dimension than the old panel.

8.3.12. **Navigation and Aviation Obstruction Lighting**

The Engineer shall select appropriate Navigation and Aviation Obstruction Lighting equipment per the requirements set forth by the governing authorities (see Subsection 8.1.2.) and shall utilize this equipment in the design. Fixtures that utilize long-life light-emitting diode (LED) sources are required. All Navigation and Aviation Obstruction Lighting shall be equipped with bird deterrent as recommended by the manufacturer.

All Navigation Lighting shall be solar powered, operate on a 24-hour/day basis, meet USCG visibility requirement, and will have autonomy of at least 10 days if the light has a self-contained power system (per 33 CFR § 66.01-11 (a)(7)). Batteries shall be sized accordingly. Remote monitoring is not required. This includes both channel and fender lighting. See Standard Specifications and Qualified Products List for details on equipment. Only those lights and systems listed in the Qualified Products List shall be accepted.

All fender-mounted units shall be either independent with built-in solar panels or grouped such that all the lights on each side of a channel are independent of each other. In shaded areas (under bridges, etc.), a separate solar panel battery charging unit should be mounted nearby in a location to meet manufacturer location and orientation requirements to charge batteries.

Snow shields may be installed on parapet to shield solar panels from plowed snow and other debris, with signage for snowplow drivers to slow down. Where snow shields are installed, the Engineer shall coordinate snow shield location and height such that the shield does not block the solar panel from the sun. All other aspects of Aviation Obstruction Lighting shall be located and installed per FAA direction.

8.3.13. Lighting Standard Bases and Junction Box Foundations

Construction methods and typical installation details for standard concrete bases, Junction Box Foundations, junction boxes, and roadway lighting manholes shall be in accordance with Standard Specifications and Current Standard Drawings. All other special details required for the Project shall be prepared by the Engineer.

While it is recognized that many existing Parkway lighting systems have the Junction Box Foundations oriented with the boxes closer to the road, all new JBF installations shall be oriented with the pole closer to the roadway on all Authority projects.

Junction Box Foundations shall be used wherever possible. Concrete Light Standard Bases with separate Type C or Type D Junction Box shall be used only where specific right of way or project constraints prevent the installation of Junction Box Foundations.

Junction box and Junction Box Foundations shall not be installed in areas where the grade is greater than 4:1. Junction boxes and junction box foundation locations shall be investigated to determine if grading is required, or slopes are too steep (greater than 4:1) for installation. Engineers are to review existing and proposed grading in the area of each junction box. The Engineer shall determine the type of erosion control around all boxes on slopes and include it in the plans. Standard guiderail offset, grading, and berm dimensional requirements shall be as directed in the Standard Drawings.

Additional requirements for underground junction boxes, handholes, and manholes may be found in Subsection 8.4.4.1.

8.4. POWER DISTRIBUTION SYSTEM DESIGN

8.4.1. General

The Power Distribution System includes all underground and above ground conduits, boxes, manholes, and foundations, wiring, and power distribution equipment necessary to provide the various lighting and other electrical systems with power. All Power Distribution Systems, as well as all raceways shall be designed in accordance with the NEC and the guidance of this Subsection.

8.4.2. Electric Service

8.4.2.1. General

Secondary electrical service shall be obtained from the local utility company and utilized for the complete lighting system in each area. The Engineer shall coordinate with the utility company on behalf of the Authority to obtain new, modified, and upgraded utility services as project may require. The Engineer shall identify utility company specific requirements regarding equipment and materials between the utility service drop and the meter, and include them in their design. Utility service drops shall be located to minimize interference with other project work and as required below in Subsection 8.4.3. The Engineer shall also make every attempt to locate load centers, select voltages and coordinate with the utility company to minimize costs and the extents of Authority maintenance on all new utility services. Coordination shall be as described in Section 8 (Utilities) of the Procedures Manual.

Standard services available from the local utility companies are:

1. 3-phase 4-wire Secondary Service at 208Y/120V or 480Y/277V.
2. Single-phase 3-wire Secondary Service at 240V/120V or 480V/240V.

Certain older installations on the Turnpike may utilize three-phase 460Y/265V services. The Engineer shall perform all calculations using the 480Y/277V service but shall note the 460Y/265V installation methods in the plans accordingly in cases where 460Y/265V services are used.

1. Primary Service: 4,160Y/2,400V and 13,200Y/7,620V.

4,160 Volt service should be used, except in those restricted areas where only 13,200 Volt service is available. This matter should be checked with the utility company.

All new roadway lighting power distribution systems shall be equipped with a manual transfer switch with integrated external generator docking station (MTS-DS) for connection of a portable generator. An MTS-DS shall also be installed at lighting systems where a manual transfer switch is to be replaced. Where an existing manual transfer switch is to remain, an external generator docking station (GDS) shall be installed if one does not already exist.

All transfer switches shall be sized appropriately for the incoming utility service and designed in accordance with the NEC, in particular NEC Article 250.30, Grounding Separately Derived Alternating-Current Systems. In cases where an existing transfer switch installation does not meet the requirements of NEC Article 250.30 the Designer shall document the non-compliant installation via a memo with a proposed solution to make the installation comply with the NEC and submit the memo to the Authority for review and approval.

See the Standard Specifications, Division 900, and Qualified Products List for specifications and model numbers for the MTS-DS and GDS.

8.4.2.2. **Building/Facilities Electrical Services**

At Where service transformation is required, an outdoor transformer shall be installed near the external load center within the immediate vicinity of the building. It is the Engineer's responsibility to properly size the transformer and to develop necessary installation details. New roadway lighting distribution panels and load centers shall be located in free-standing outdoor enclosures including at toll plaza utility buildings.

8.4.2.3. **Services Not Located at Buildings**

In areas where the existing roadway lighting and associated facilities are being modified and/or expanded, the existing load centers are generally located in the interchange Utility Buildings or outdoor transformer stations. Circuitry originating at these existing load centers shall be used for the modified and/or expanded lighting facilities, to the maximum extent possible.

Where new electric service is required, the Engineer shall use existing metered services where economically possible. The Engineer shall contact the Authority for a list of nearby service locations. For instances where the available voltage differs between proposed metered service and the required voltage, the Engineer shall utilize a transformer or coordinate a new service drop with the correct voltage for the application.

Where lighting loads and the physical limits of circuitry prohibit the utilization of existing load centers, new outdoor type load centers shall be provided as described in Subsection 8.5.3.

Transformation for standalone load centers shall be by utility transformer, either pad-mounted near the load center, or mounted on the pole nearest the load center installation. Load center voltage preference shall be 480Y/277V, 3-Phase, 4-Wire. If it is determined that 480Y/277V service is not available nearby, the Engineer shall refer to Subsection 8.4.2.4 Utilized Voltage for the service preferences listed by load type.

8.4.2.4. **Utilized Voltage**

Utilized voltage for various facilities shall be as directed in this manual. Any deviation shall require written authorization from The Authority.

Voltages for building lighting and equipment shall be 208Y/120V 3-phase, 4-wire. Building HVAC and certain lighting loads shall be 480Y/277V 3-phase, 4-wire. The preferred Roadway Lighting operating voltage is 480Y/277V, 3-phase, 4-wire. Where 480Y/277V cannot be obtained, either 240V/480V, single-phase, 3-wire or 120V/240V, single-phase, 3-wire may be utilized. All high mast lighting shall be 480Y/277V, 3-phase, 4-wire. Overhead sign structures with fixed message signs and underbridge lighting shall be connected to roadway lighting circuits, where available. Engineer shall determine voltage for standalone installations based on availability of service, with 480Y/277V, 3-phase, 4-wire preferred.

Any 24-hour service required shall either be obtained from the building electrical distribution panel or from a separate utility connection.

8.4.3. Circuitry and Voltage Drop

1. Minimum size of cable for roadway lighting circuits shall be #4 AWG, and maximum shall be #4/0 AWG. Other standard sizes, such as #1/0 AWG, and #2/0 AWG shall be used as required, but it is recommended that variations in cable sizes be kept to a minimum in each project. Parallel feeders shall not be installed for lighting systems. Where ampacity allows, #6 AWG wiring is permitted to be installed between the main lighting feeder and various equipment, such as sign lighting, variable message signs, or various other ITS devices.
2. On the Turnpike and where possible on the Parkway, the Power Distribution system for roadway lighting and other roadway equipment shall be fed from a single load center installation, which is generally to be located outside and within proximity to an Authority-owned building (Utility, Toll Plaza, Police Barracks, Service Area, Maintenance Shop, etc.).
3. In very large areas, additional (auxiliary) standalone load center installations may prove to be more economical than running extremely long circuits

requiring large size cables. Secondary service should be obtained locally from the utility.

4. Where smaller projects require installation or modification of roadway electrical systems and power is not available from a nearby building, a standalone load center shall be installed, and secondary service obtained from the utility locally. Effort shall be taken to minimize the number or standalone load centers, and therefore ongoing maintenance and cost.

5. Engineers shall prepare a cost-benefit analysis when proposing more than one standalone load center in a given project, to be submitted for review at the time of the Phase “A” Submission.

6. Standalone load centers shall be installed as shown in the Current Standard Drawings, and as described below under Utility Services.

7. All lighting systems shall be group controlled by means of a photoelectric control device dedicated for use by the system. The photoelectric control shall be located where it is easily maintained and facing North where possible for optimal operation. The photoelectric control shall be wired to control a single contactor that feeds a separate roadway lighting panelboard. Individual circuits shall not be controlled by the photocell. The photocell shall be located such that it is not affected by light sources in the vicinity of the lighting control equipment, to ensure continuous reliable nighttime operation of the lighting system.

8. Where 24-hour continuous-on circuits are required for equipment that is in an area served by a Roadway Lighting System, the 24-hour circuits shall be powered from the same utility room or load center, and the power shall be taken from a circuit located “upstream” of the Roadway Lighting contactor.

9. For three-phase systems, each branch circuit shall be 3-phase, 4-wire with dedicated neutral conductors. Luminaires shall be connected to alternate phases of the same circuit. For single-phase systems, each circuit shall be 2-leg, 3-wire with a dedicated neutral. Luminaires shall be connected to alternate legs of the same circuit and respective neutral conductor. Phase-to-Phase installations shall not be allowed and shall be utilized only where approved in advance by the Authority.

10. All neutral conductors shall be labeled as “CKT-Phase-NX”, where “CKT” is the circuit number associated with the neutral. The “N” in -Phase-NX” does not change and denotes that it is the neutral phase, and the “X” in “-Phase-NX” is the phase the neutral is associated with.

11. Each luminaire shall be individually protected by means of a fused cable connector kit, as indicated on the Current Standard Drawings.

12. For both single- and three-phase systems, the roadway lighting branch circuits shall be designed for a maximum current of 35 Amps and shall be provided with a 50 Amp trip capacity circuit breaker. For circuits where 35 Amp capacity is insufficient, the maximum current may be increased to 50 Amps, and the circuit breaker trip increased to 70 Amps. Breaker trip currents shall be sized in accordance with the NEC. 30A circuit breakers shall be allowed in smaller installations to reduce wire size. Roadway Lighting circuits shall be limited to no more than 20 luminaires per branch circuit. Where an existing panelboard or existing roadway lighting wiring is anticipated to be replaced, the proposed design shall utilize single pole branch circuit breakers with dedicated neutrals.
13. Lighting circuits shall be designed for a maximum of 3% voltage drop between the circuit breaker in the lighting panel to the terminal points on the luminaire (including the future lighting extensions, where required) calculated between the phase and neutral. All circuit breakers for area lighting circuits in the panelboard shall be of the single pole type.

Final voltage drop calculations shall be based on amperage values of all actual equipment used on each phase for each circuit length between all lighting equipment and other loads, etc., utilizing AC resistance for uncoated copper conductor as listed in NEC Chapter 9 (Table 9). To simplify calculations, up to fifty (50) feet of #10 AWG fixture wire between the feeder and luminaires shall be permitted to be omitted from the voltage drop calculations. The Equipment Grounding Conductor (EGC) shall be sized proportionately to the phase and neutral conductors based on the voltage drop calculations, in accordance with the NEC.

All single-phase and three-phase systems shall be analyzed using a single-phase method utilizing the Authority’s Standard Voltage Drop Computation Form. An electronic version of the Excel Spreadsheet is available on the Authority’s website. Each leg/phase of the circuit shall be analyzed separately. A sample completed form and sketch are shown following in Exhibit 8-21.

Voltage drop calculations shall include all existing equipment to remain in place for the final design. It shall not be sufficient to analyze the voltage drop for new equipment only unless the entire circuit is new.

Exhibit 8-21 Sample Voltage Drop Calculation Forms 1 and 2

New Jersey Turnpike Authority
Standard Voltage Drop Computation Form 1 - Calculations

XYZ Engineering Company		**Made by**	**Date**	**CIRCUIT # 3**
100 Main Street		M. Nesmith	1/2/2003	**PHASE # B**
Hackensack, NJ 07601		**Checked by**	**Date**	**VOLTAGE # 277 V**
Contract No:	**T300.019**	D. Jones	1/3/2003	
Name:	**Interchange 19 Reconstruction**	**Backchecked by**	**Date**	**Sheet Number**
		P. Tork	1/5/2003	**1 of 2**

Instructions:

Calculations shall be performed for each circuit branch separately, including all existing lamps and loads, if any are connected to the circuit. Select worst case branch voltage drop to determine total circuit voltage drop. DO NOT TOTAL ALL DROPS. Use NEC Chapter 9, Table 9 to determine appropriate resistance values, taking into account overall circuit Power Factor as described in the footnotes to the Table. Use additional forms if required for long circuits. Complete one complete set of forms for each circuit and phase.

Section	From	To	Current	Distance	Ohms/K ft	Z=2xLx0.001xΩ	Vd=IxZ
			I	L	Ω	Z	Vd
BRANCH A							
1	Panel	JB1	8.77	500	0.2	0.20	1.754
2	JB1	1-3-B	3.51	700	0.2	0.28	0.983
3	1-3-B	4-3-B	2.34	250	0.2	0.10	0.234
4	4-3-B	7-3-B	1.17	250	0.2	0.10	0.117
						TOTAL	3.088
BRANCH B							
1	Panel	JB1	8.77	500	0.2	0.20	1.754
2	JB1	10-3-B	5.26	400	0.2	0.16	0.842
3	10-3-B	JB2	4.09	300	0.2	0.12	0.491
4	JB2	13-3-B	2.34	300	0.2	0.12	0.281
5	13-3-B	16-3-B	1.17	200	0.2	0.08	0.094
						TOTAL	3.461
BRANCH C							
1	Panel	JB1	8.77	500	0.2	0.20	1.754
2	JB1	10-3-B	5.26	400	0.2	0.16	0.842
3	10-3-B	JB2	4.09	300	0.2	0.12	0.491
4	JB2	19-3-B	1.75	100	0.2	0.04	0.070
						TOTAL	3.156

Worst Case Branch: B

% Vd = 3.461 V / 277 V = 1.25% is less than 3%

Comments: (To be filled in by Engineer)

All wires selected to be #2 AWG in steel conduit (Z=0.20 Ω per 1000 ft - per NEC Chapter 9, Table 9), Power Factor assumed to be 0.96.

New Jersey Turnpike Authority

Standard Voltage Drop Computation Form 2 - Sketch and Details

XYZ Engineering Company		**Made by**	**Date**	**CIRCUIT # 3**
100 Main Street		M. Nesmith	1/2/2003	**PHASE # B**
Hackensack, NJ 07601		**Checked by**	**Date**	**VOLTAGE # 277 V**
Contract No:	**T300.019**	D. Jones	1/3/2003	
Name:	**Interchange 19 Reconstruction**	**Backchecked by**	**Date**	**Sheet Number**
		P. Tork	1/5/2003	**2 of 2**

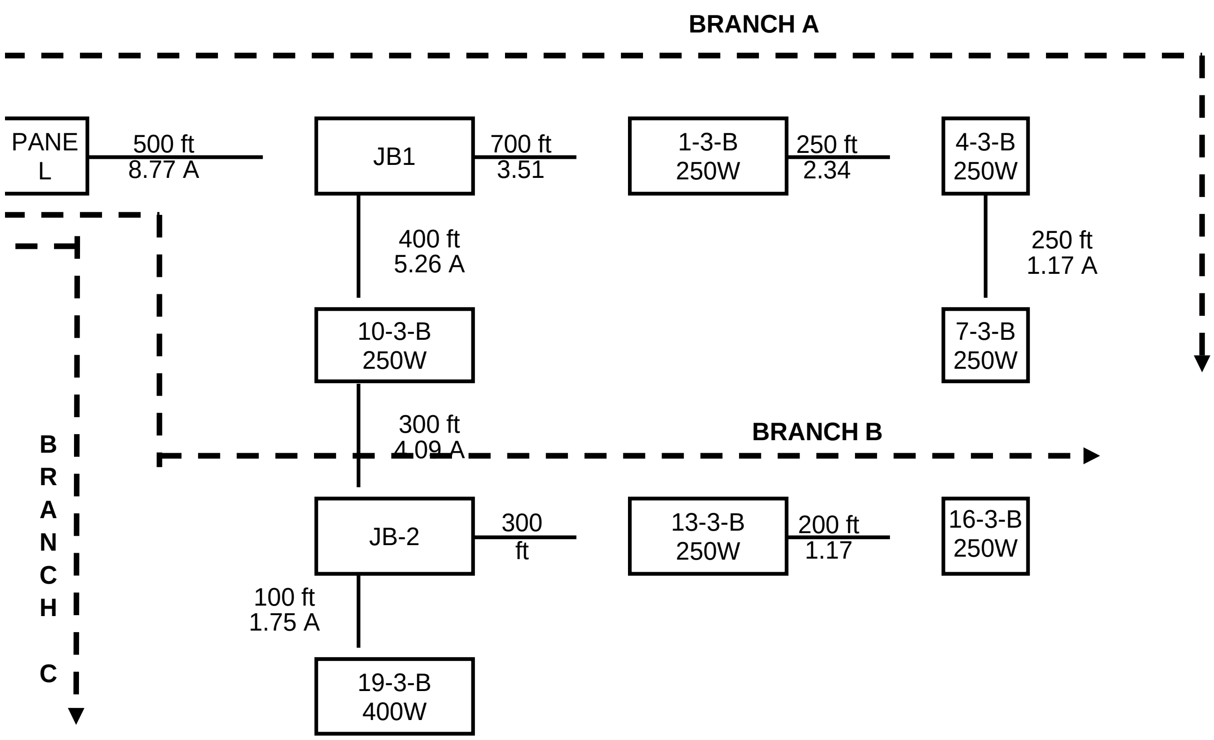
Circuit Information

Load Center Location	Plaza Utility Building	**Voltage:**	277 V
Total Load (kW):	1.9 kW	**Phase and # Wires**	Three Phase, 4-Wire
Wire Size:	#2 AWG	**Conduit Type:**	RMC Steel

Luminaire Quantities:	**Watts**	**Quantity**	**Watts**	**Quantity**		
	250	6				
	400	1				

Instructions:

Show a sketch of the circuit below. Do not include any #10 AWG fixture wire.



Comments: (To be filled in by Engineer)

All wire for this circuit is #2 AWG

14. A dedicated neutral conductor shall be installed for each circuit that is being individually controlled by its own overcurrent protection device. Unless otherwise directed, all circuit phases shall terminate at the last connection and do not need to be extended to the last junction box or junction box foundation.
15. Arc Flash calculations for incident energy availability shall be provided for all new electrical equipment operating at 50V or higher, in accordance with IEEE 1584 and NFPA 70E. Labels indicating arc flash incident energy levels and appropriate PPE shall be required for all new electrical equipment.
16. All feeder phase conductors shall be terminated at the last device they feed. It is not required to extend phase conductors to the last junction box.
17. In all toll plazas or roadways where additional future widening is contemplated, the locations of underground conduits, junction boxes, manholes, and power distribution equipment should be beyond the limits of the future widening, where possible and approved by the Authority. Lighting standards, however, should be installed along the present edge of the pavement.
18. Where multiple circuit feeders are installed in one conduit, the conductor ampacities shall be derated in accordance with the NEC.
19. LED Luminaire input wattages shall be as published by the manufacturer and obtained from the latest catalog specifications for the luminaire used.
20. It is the Engineer’s responsibility to ensure all circuit breakers are sized in full compliance with the NEC. If a design based on Authority Standards has a condition which violates code, the Engineer is obligated to address the exception so that it complies with code.
21. Circuit breakers supplying transformers shall be sized to account for transformer magnetization current.

8.4.4. Raceway Systems Design

8.4.4.1. Underground Junction Boxes, Handholes, and Manholes

1. To facilitate cable pulling and splicing where a junction box foundation is not used, a junction box or manhole shall be installed adjacent to each lighting standard base, highmast tower, illuminated sign structure pedestal, bridge-mounted sign, underbridge lighting system, and at each end of conduit crossings under roadways. The location of conduit crossings shall be so arranged that the junction boxes or manholes at such crossings can also be used as service points to the above-noted facilities.

2. Junction boxes shall be installed at the end of spare conduit runs in barriers, walls, and structures, and at the point nearest the wingwall, for future continuation of the conduit.
3. Junction boxes and Junction Box Foundations shall be installed within a maximum pulling distance of 250 feet.
4. Standard junction boxes are designed to carry a maximum of three (3) 3” in-line conduits. Manholes should be used in lieu of junction boxes whenever there are more than three (3) in-line conduit runs, or where angled pulls require a larger box (as dictated by the requirements of the NEC).
5. In special cases where the number of circuits and cable sizes involved are in excess of the standard manhole capacity, larger manholes of an approved design should be used. Large size manholes may be of cast-in-place type, and the Engineer shall provide a design in the plans.
6. Type D Junction Boxes shall be used in all barriers and parapets as shown in the Current Standard Drawings. Alternate designs will not be accepted.
7. Type C Junction Boxes shall be used for all roadway lighting installations in paved or grass areas.
8. Installation of Junction Boxes in the roadway, shoulder, or other travelled way is strictly prohibited.

8.4.4.2. **Conduits and Raceways**

1. All conduits shall have minimum of 24” burial depth below grade. Where 24” depth cannot be achieved, NEC guidelines for minimum cover requirements shall be followed.
2. Separate conduit raceways shall be provided for each roadway lighting circuit. In certain cases where small size wiring is required, cables for two or more circuits may be installed in the same conduit.
3. Wherever practical, wiring for 24-hour circuits shall be contained in a conduit dedicated to this use. However, 24-hour circuits shall be permitted to pass through junction boxes for Roadway Lighting or other systems, provided the insulation on all cables is rated for the maximum voltage present in the box.
4. At all locations where conduits pass under an active roadway, driveway, or parking area, a spare conduit shall be provided in addition to all conduits required for the initial system installation. At

major main feeder crossings, two spare conduits are recommended. One spare conduit, in addition to the active conduit, should be provided on all bridge and wall structures, even those structures which do not require installation of wiring or cables at the time the structures are constructed.

5. At any conduit crossing under a roadway that requires directional drilling, the Engineer shall ensure that there is enough room on both ends for a safely accessible appropriately sized drill pit and equipment based on the number, depth, and size of ducts to be installed.

6. Unless otherwise directed by the Authority, all existing transite conduit (or any other asbestos duct or duct bank) shall not be reused for any design and shall be called out to be abandoned in place and have tracer wire installed. See Specifications for procedures regarding transite conduit including the installation of tracer wire.

7. Conduits shall be provided in barriers, walls, and bridge parapets as outlined in this subsection. Conduits shall be placed in accordance with details shown on Authority Current Standard Drawings BR-7 and BR-15. More specifically:

   Bridges carrying mainline or ramp roadways

   - Bridge parapets adjacent to the right shoulder(s) on structures carrying mainline roadways shall be provided with two 3" diameter (nom.) conduits.
   - One bridge parapet on structures carrying entry/exit ramp roadways shall be provided with two 3" diameter (nom.) conduits. The conduits shall be located in the parapet which supports the ramp roadway lighting, if applicable. There is no preference as to which parapet the conduit shall be located in for these structures which do not have roadway lighting.
   - These conduits shall only be used to support circuits that power lighting and/or electrical appurtenances located directly on that bridge as required by current or future design. Conduits designated for future use or are not utilized past the end of a structure shall be terminated and capped in the embankment a minimum of 10 feet past the end of the wingwall and/or approach slab within a junction box.

- A single 3” diameter (nom.) conduit shall be installed in one of the two bridge parapets on dedicated “Official Use Only” U-turn structures. It is preferred that the conduit be located in the parapet adjacent to the inside radius of these structures which are configured into a “U” type alignment. There is no preference as to which parapet the conduit shall be located in for these structures which are configured into an “S” type alignment.

Retaining Walls

- Retaining walls that are continuous with bridges carrying mainline and/or ramp roadways shall be provided with conduits in parapet(s) to match the conduits in the adjacent bridge parapet(s). These conduits shall be continuous with the conduits in the adjacent structure parapet(s). Free standing retaining wall parapets that are not continuous with bridges carrying turnpike mainline and/or ramp roadways and supporting roadways that do not require lighting or ITS facilities shall not be provided with conduits. Conduits located along retaining wall alignments shall be placed in the embankment under the roadway shoulder pavement only where required by design for roadway lighting or ITS systems.
- Conduits designated for future use which are not connected past the end of a retaining wall structure shall be terminated and capped in the embankment a minimum of 10 feet past the end of the retaining wall.

8. All local road structures over Authority roadways shall have provisions for two (2) 3” conduits, to be located in either parapet. The conduit is to be a provision for future lighting or utility work. More specifically:

Bridges not carrying mainline or ramp roadways

- One of the bridge parapets on structures carrying local roadways over mainline or ramp roadways shall be provided with two 3” diameter (nom.) conduits. The conduits shall be located in the parapet which supports the local roadway lighting, if applicable. For two-direction bridges, there is no preference as to which parapet the conduit shall be located in for structures which do not have roadway lighting. For one-direction bridges, preference shall be given to the parapet adjacent to the larger roadway shoulder or sidewalk. Additional conduits may be required as per local road owner criteria, and as approved by the Authority. The provisions of Bullet 3 under "Bridges carrying mainline or ramp roadways" above do not apply for local road bridges. Additional conduits which are required for these structures by local road owners shall be located in the structure parapet, if practical.

All conduit transitions at expansion joints shall be Bridge/Wall Expansion/Deflection installations. These transition installations are detailed in the Current Standard Drawings. All transitions from bridge wingwalls into ground shall use a standard Expansion/Deflection fitting for each conduit.

9. All local road structures over Authority roadways shall have provisions for two (2) 3" conduits, to be located in either parapet. The conduit is to be a provision for future lighting or utility work. The Authority should be contacted for updated information on this matter.

10. Underground handholes, manholes, junction boxes, and other structures carrying electrical wiring shall be drained by connecting a 2" minimum perforated PVC pipe to the nearest drainage inlet. Care shall be taken to ensure that the inlet invert is below the bottom of the box or manhole to prevent water from flowing through the electrical raceway system. A removable screen or filter fabric shall be installed to prevent sediment from entering the drainpipe. Pipe installation shall be shown on the drainage plans and shall be noted on the Electrical and/or Roadway Lighting Plans. Where electrical equipment is installed in areas without drainage systems, the Engineer shall assess whether supplementary drainage is required for the electrical installation, considering the height of the water table, soil material, etc.

11. Unless installed in an environmentally controlled space with no likelihood of water entering the conduit system, conduits shall enter all exposed cabinets from the bottom, or on the sides within 2" of the bottom of the cabinet. Under no circumstances shall conduits be allowed to enter the tops of any exterior, or tunnel-mounted cabinets containing electrical equipment. Where cabinets are installed in or near flood-prone areas, they shall be installed such that they are above the design flood elevation. Cabinet location outside such an area, higher cabinet placement, taller concrete pads, and elevated equipment platforms are examples of acceptable cabinet placements.

12. Wireways shall be used in installations wherever practical to minimize the number of conduits necessary. Where communications and power raceways are required to connect multiple equipment enclosures, a partitioned wireway shall be permitted. The partition shall be mechanically attached to the wireway such that its watertightness is not compromised.

13. The entire raceway system shall be grounded and bonded in accordance with the NEC. A separate equipment grounding conductor shall be sized per the NEC and installed in all raceways so that the fault current path is not dependent on mechanical connections such as couplings and fittings.

14. Concrete-encased duct banks shall be installed as shown in the Current Standard Drawings, where more than 3 conduits are installed in one trench under a paved surface. Additionally, concrete-encasement should be considered as an option by the Engineer for high-importance, low-downtime raceway facilities where they might be easily interrupted by construction or other normal operations, or where minimum cover requirements cannot be met due to conflicts with other utilities or sub-surface structures. Where concrete-encased duct banks are installed, at least 50% spare conduits shall be provided, in accordance with the other requirements of this Manual.

15. The Engineer shall perform conduit fill calculations for each raceway, ensuring that no conduits are overfilled as per the requirements of the NEC. Actual cable diameters shall be used in these calculations. Where there is a likelihood of future additional wiring to be installed in any conduit, spare capacity shall be maintained in the conduit. While not required for plan review as part of the Phased Submissions, conduit fill calculations shall be submitted for review if requested by the Authority.

16. Ducts are to be provided at all Authority structures for the future installation of communications cables unless otherwise directed. The Engineer shall contact the Authority for the current appropriate number and location of the conduits. Underground conduits for communications cables are also to be provided from each abutment backwall to an appropriate location. Typical installations may be found in the Current Standard Drawings. These installations must be verified as current or modified appropriately.

17. To prevent vehicle impact, where conduits are provided running under bridge structures and/or attached to stringers, no part of the

conduits or attachment method shall protrude below the lowest point of any stringer.

18. Where raceways are installed for bridge-mounted applications or other structures, no welding of conduit supports to structural steel members will be permitted. Where possible, all conduits and raceways shall be mounted by clamped or other non-invasive installation. All drilling and modification to existing and proposed steel or concrete structures necessary to mount raceway systems shall be designed and detailed by the Engineer and included as part of the design.

19. All underground conduit entrances or conduits that transition to or from underground into junction boxes, equipment enclosures, manholes, handholes, or otherwise shall be installed with rodent blocking materials consisting of copper mesh and expandable foam, as detailed in the Current Standard Drawings and Standard Specifications. Only approved rodent blocking materials may be used. Use of duct seal is prohibited for this purpose.

8.4.5. Temporary Power Distribution Systems

Where possible, new power distribution systems shall be designed to minimize the need for temporary facilities during construction. However, where temporary power distribution systems are required, either to facilitate construction activities or to power roadway or other electrical equipment during construction, the following requirements shall be taken into consideration, in addition to the requirements listed above for permanent installations:

1. Multi-cable rated for 600V and suitable for direct burial use shall be permitted for underground installations between temporary lighting standard and wood pole locations. Wiring may be installed in rigid metallic or non-metallic conduit, as appropriate when deemed necessary due to the staging or methods of construction employed in the vicinity of temporary underground wiring.

2. Overhead wiring installations, including self-supporting aerial messenger cables, will be permitted for use with temporary roadway and area lighting systems on a case-by-case basis with prior approval by the Authority. The Engineer shall certify that said overhead wiring system will not interfere with the contractor’s construction operations, especially those requiring heavy equipment.

3. Temporary wiring systems provided on bridges or other structures shall be installed in rigid metallic or non-metallic conduit, as appropriate and properly supported or attached to the structure by means of approved conduit support hangers, clamps, and hardware. Self-supporting open-air wiring installations will not be permitted.

4. All wiring installed in conduits underground or on structures should be maintainable and conduit systems shall incorporate a means of pulling cable at maximum 250 ft. intervals. This may be accomplished by using various devices which may include temporary junction boxes, handholes, lighting standard transformer bases, conduit pulling fittings, or other re-enterable equipment. Access to pulling points should be unrestricted.

5. All wiring splices shall be in junction boxes, handholes, etc. and shall be made using wiring connector kits as shown on Current Standard Drawings.

6. Temporary distribution circuitry shall be designed to maintain a maximum voltage drop of 3% between line and neutral conductors. Existing multiple-wire circuits should be utilized wherever possible. However, a careful analysis shall be performed to determine the influence of temporary facilities connected to existing circuitry. All multi-phase circuits shall be properly balanced. In the event existing circuitry will not support additional temporary loads, a temporary load center with separate utility service may

be utilized. An analysis of additional loading on existing circuits, and the possible need for temporary load centers shall be included in the Phase "A" Submittal package.

8.5. Power Distribution Equipment and Material

8.5.1. Conduits, Cabinets, Wireways, Hangers, and Fittings

The Various types of conduits to be used shall be as specified in the Standard Specifications, shown on the Current Standard Drawings and further prescribed hereinafter.

1. In general, nonmetallic PVC Schedule 80 conduit shall be used for installations under paved roadways, ramps, and parking areas. PVC Schedule 40 conduit shall be used in all underground installations where vehicular traffic is not expected.
2. With the exception of conduits on buildings away from roadways, conduits installed on concrete, steel, or other exterior structures, and in any location that is not environmentally controlled shall be PVC-coated rigid metallic conduit (PCRMC). All attachment hardware, hangers, and support struts shall be stainless steel or PVC-coated rigid galvanized steel. In order to minimize corrosion and prevent damage where conduits transition from an underground distribution system to a structure that is exposed to the air, a section of PVC-coated galvanized rigid steel conduit at least five feet in length shall be installed from 3 feet above grade to at least 2 feet below grade. This PVC-coated RMC shall then be coupled to a PVC conduit via a PVC-coated expansion/deflection fitting at a minimum of 2 feet below grade to continue its run to the nearest underground junction box or manhole. A continuous insulated, impregnated solid color green equipment grounding conductor shall be provided in all conduits. Conduits on exterior of buildings away from roadways shall be galvanized rigid steel (RMC), using only stainless steel attachment hardware.
3. Conduits on aluminum structures shall be fabricated of PCRMC and shall be mounted using stainless steel hardware with insulation bushings or nylon washers to prevent the effects of dissimilar metals.
4. PVC-coated galvanized rigid steel conduit and hardware shall be used on all structures that are exposed to corrosive areas, especially on bridge structures over bodies of saltwater. PVC-coated conduit shall also be used in all damp locations, and where conduits are cast in concrete. Conduit that makes the transition from the concrete to the open air shall be stainless steel. A detail shall be provided for all such installations in the plans.

5. Fiberglass reinforced (FRE) conduits shall be permitted to be installed under bridge structures and for cast-in-concrete installations. Adequate equipment grounding shall be provided in all installations.
6. PVC-coated galvanized rigid steel conduit and rigid metallic conduit shall not be used underground except as noted above for transition from underground to above grade.
7. PVC Schedule 40 or 80 shall not be used in any exposed installation and shall not be permitted to be exposed to sunlight.
8. Electrical metallic tubing (EMT) shall be used only in environmentally controlled, finished portions of buildings. EMT shall not be installed in any areas that are damp or that may be exposed to water.
9. All flexible conduit installations shall be Liquid-tight Flexible Metallic Conduit (LFMC). LFMC shall be limited to three (3) feet maximum where required to make complex bends, or where required to allow for flexibility in movement. Expansion/compression fittings shall be used instead of flexible conduit wherever the degree of expansion is within the allowable tolerances of these fittings. All flexible conduit shall be supported within 12 inches of every fitting and in accordance with the NEC.
10. Flexible metallic conduit shall not be used where rigid metallic conduit can be installed.
11. All conduits for roadway lighting distribution circuits, unless otherwise indicated on the Current Standard Drawings and/or prescribed herein, shall be three-inch (3”) size. Two-inch (2”) conduit may be used for lighting standards at the end of a circuit where no future expansion is anticipated and approved by the Authority. Duct banks at toll plazas or other Authority facilities for installation of multiple power and communication cables shall be minimum four-inch (4”) size.
12. Cable duct will not be permitted for use in any Roadway Electrical installations. Certain typical details regarding conduit installations are included in the Current Standard Drawings and shall be utilized wherever possible on each project.
13. Fittings used shall be of the same material as the conduit they are attached to.
14. All wireways and enclosures shall be constructed of Type 304 stainless steel and provided with a NEMA 3R rating, as indicated on the plans and in the specifications. The Engineer shall indicate the appropriate enclosure rating for the purpose, location, and conditions where it is installed. Details of mounting shall be included that show mounting without compromising the

NEMA rating of the wireway or cabinet. Where it is likely that water could collect in a NEMA 3R wireway or enclosure, a breather/drain shall be installed in the bottom such that insects cannot enter and sized so that it will not easily be clogged. NEMA 4X wireways and cabinets may be used where determined necessary by the Engineer, and shall be constructed of Type 304 stainless steel. All mounting and installation methods shall be such that they do not compromise the rating of the enclosure. See the Standard Specifications, Division 900 Material Specifications, and the Qualified Products List for details on acceptable wireway and enclosure materials.

15. Conduit shall not enter the top of any cabinet or wireway. See Subsection 8.4.4.2.
16. Unless otherwise approved, minimum size of conduit underground shall be 2" and minimum size of all other conduits shall conform to the Standard Specifications.
17. Compression fittings shall not be allowed, except in buildings for EMT installations, where permitted as described above.
18. Conduits shall be shown running either parallel or perpendicular to key structural elements and shall be installed with at least 1" clear between the conduit and structure to allow for drainage and to prevent debris accumulation.
19. Conduits for underbridge and other structure lighting systems shall be surface mounted unless shown otherwise in the Standard Details or Specifications.
20. All cabinets and equipment mounted on sign structure pedestals, bridge abutments, or in other installations near active roadway shall be mounted to prevent snow accumulation and allow access during plowing operations. In most cases, this requirement can be met by placing all equipment on the backside or "downstream" side of the structure.
21. The minimum allowable diameter for HDPE directionally drilled under the mainline roadway is 4". Minimum allowable diameter for HDPE directionally drilled under ramp roadways is 3".

8.5.2. **Cables and Wires**

1. All multiple lighting, power, primary, and secondary cables, including neutrals, shall be single conductor, stranded copper, and type as in the Specifications and QPL. All cables shall be sized in accordance with the NEC with continuous factory-impregnated solid color-coding as specified in the Standard Specifications and Qualified Products List. Painted stripes shall not be permitted.

2. Equipment grounding conductor to be used in conjunction with roadway electrical and associated circuits shall be bare, stranded and tinned/coated copper, as specified in the Standard Specifications and/or shown on the Current Standard Drawings. Equipment grounding conductor to be used in circuits within building and between panels shall be insulated and continuously colored green.
3. Splices, including in-line connections, for roadway lighting cables shall be made by means of resin-encapsulated splice kits as shown in Current Standard Drawings and specified in the Qualified Products List and Division 900 Material Specifications.
4. Cables and wiring required for Communications Systems, where not included in the Standard Specifications or Current Standard Drawings, shall be the type as indicated on the plans. All cables to be utilized in outdoor installations, whether above or underground, shall be rated to be chemical-proof, oil-proof, UV-resistant, and capable of being continuously submersed in water.
5. Cables to be installed in confined spaces or roadway tunnels shall be low-smoke zero-halogen type (Type LSZH). The Engineer shall specifically call out this type of cable on the Plan where intended to use. Pay item and cost estimate shall be updated accordingly.
6. Connection between solar panels and Navigation Lights shall be via SOOW cable installed close to handrails and located to minimize potential damage or trip hazards. Installations requiring high degree of cable flexibility, including cables that are required to move for equipment operation, shall utilize cables specifically designed for that purpose.
7. A complete specification for all non-standard cables, including relevant industry testing standards and material certifications, shall be clearly indicated on the Plans for ease of future replacement. The Supplementary Specification shall be utilized only for additional / supplemental material and payment information.
8. A requirement shall be added to all contract drawings stating that a nylon pull cord shall be installed with all wiring and in all empty conduits to facilitate the future installation of additional wiring.

8.5.3. **Standalone Load Centers**

1. The load center installation shall consist of the roadway lighting panelboard, Surge Protective Device (SPD), remote control switch, contactors, relays, photoelectric bypass switch, control switches, etc. All this equipment shall be furnished without enclosures and installed in a free-standing cabinet

according to the details on the Current Standard Drawings. The bottom of the cabinet shall be used as the wiring section.

2. Standalone load centers for standard voltages and loads shall be installed in accordance with the Current Standard Drawings. The Type F three-phase load center shall be used for 480Y/277V lighting distribution systems on the Authority roadways. Where other project considerations require standalone power, don't require 480Y/277V power, with no lighting loads, and no loads exceeding 30 kW, the Type G single-phase load center shall be used for 120V/240V and 240/280 Volt single-phase, and 208Y/120V three-phase installations.
3. See Standard Specifications and Qualified Products List for acceptable SPD models. SPD shall be placed within the load center such that wiring lengths to and from the SPD are minimized.

8.6. DESIGN SUBMISSION REQUIREMENTS

The format for plan submission for roadway lighting shall conform to applicable requirements of Section 3 (Submission Requirements) of the Procedures Manual, and as described in Subsection 8.7.

Following is a description of the requirements for the various plan submissions for Roadway Lighting and Power Distribution Systems.

8.6.1. Phase "A" Conceptual Design Submission

The intent of the Phase "A" Submission is to create a set of documents that indicates the Engineer's Design Approach. Review of these documents by the Authority will verify that the Engineer is proceeding with design in a manner that is consistent with other Authority projects and shall be completed prior to the advancement of the final design and plan preparation.

The Phase "A" conceptual lighting submission shall contain the following:

1. Conceptual Illumination Design Plans (in 1" = 30' scale) shall be included to review the Engineer's intent for system design. The following information shall be shown, where applicable:
    a. Proposed roadway alignment, including striping, which is necessary to develop proper Design Areas
    b. Existing and proposed load center(s)
    c. All existing lighting equipment, properly labeled in accordance with Subsection 8.7.1.3.
    d. Jurisdictional limits of Authority maintenance, and required area of illumination (Design Areas) shown hatched or shaded

e. Design Areas for any additional lighting systems present in the project, especially those that may require coordination with the Authority-owned lighting system(s)

f. Design Criteria for each Design Area, including minimum and maximum value for Average Illuminance, maximum Uniformity ratio, and Light Loss Factor to be used in the calculations.

g. Right of Way boundaries

h. Signalized traffic intersections

i. Location of all proposed sign structures, and whether or not they require sign lighting

j. Location of all ITS and other roadway devices that require power, such as cameras, HCMS, VMS signs, weather stations, etc.

k. Other information which the Engineer feels is relevant for a proper review of design intent

l. Specific locations of proposed lighting equipment shall not be shown

2. A preliminary lighting key plan prepared on 1" = 100' maximum scale screened highway plans. The Preliminary Lighting Key Plan shall show all the same information as the Conceptual Illumination Design Plans, but at a smaller scale that allows for review of the design intent for the entire lighting system at a glance. The following additional information shall be shown.

   a. Preliminary routing of proposed circuit runs, properly labeled in accordance with Subsection 8.7.1.3., for the entire Project.

3. A Phase “A” Report including the following:

   a. Overall relevant information to acclimate a reviewer to the project.

   b. A list of all applicable codes, regulations, and design guides

   c. Completed Lighting Warrant Analysis, as described in Subsection 8.2.1

   d. Discussion and selection of the type of Roadway Lighting System (Pole-Top cutoff, Conventional, Highmast, etc.) to be used for the design, including cost benefit analysis (see Subsection 8.2.4.2), and all applicable design criteria.

   e. Discussion of the need for “Retrofit” type lighting standards, if applicable to the project

f. Discussion of design intent for all electrical and communications systems necessary for equipment located within the project limits.

g. Discussion additional lighting systems required in the Project and applicable design criteria.

h. Results of the field-visit condition assessment of all existing equipment to remain and recommendations for replacement based on condition.

i. Cost benefit analysis of locations of new utility services and standalone load centers

j. Analysis and need for temporary load centers for construction.

4. All requests for modification of Design Criteria. See Subsection 8.1.3.

5. A complete list of the relevant As-Built contracts, detailing the construction history of the existing lighting system installation.

The Phase “A” Submission shall be approved by the Authority prior to the preparation of lighting calculations or final plan documents.

8.6.2. Phase “B” Submission

The Phase “B” submission shall be presented in final plan format and is intended to provide plans that show locations of lighting, electrical, and ITS devices only, along with the companion initial lighting calculations. **Power and communications distribution systems shall not be designed or included until lighting calculations, and locations of end devices, have been reviewed and approved.**

The Phase “B” Submission, at a minimum, must include the following:

1. A of all Design Criteria modifications that have been approved by the Authority.

2. Conceptual Illumination Design Plans, as described in the Phase “A” Submission Requirements, updated to address all review comments.

3. Lighting Plans, in final plan format, and Lighting Key Plan showing the following:

    a. Proposed roadway alignment, including striping

    b. Existing and proposed load center(s)

    c. All existing lighting equipment, properly labeled in accordance with Subsection 8.7.1.3. as based on As-Built plans and field verification

    d. All lighting standards, highmast or floodlighting towers properly plotted by stationing and fully identified by Authority standard symbols and callouts in accordance with Subsection 8.7

e. Underbridge where required, with symbols shown in accordance with Subsection 8.7

f. Navigation and/or aviation lighting luminaires, where required

g. All overhead sign structures, coordinated with lighting facilities, and bridge-mounted signs

h. Location of all ITS and other electrical devices, identified by Authority standard symbols, coordinated with lighting and structural facilities

i. Locations of new/modified electrical and communications services, along with connections to utilities

4. Preliminary Schedule of Light Standards

5. Electrical/Communications plans for non-lighting systems, in final plan format, showing installation of end devices only. Power circuitry and communications distribution do not need to be shown.

6. Full-size color prints in 1” = 30’ scale showing “Preliminary” Lighting Calculations for all lighting systems, including underbridge, sign, and tunnel lighting systems. Lighting calculations shall show alignment, striping, proposed light locations, existing light locations that will remain, calculation zones, and appropriate light value statistics. Light levels shall be legible for each point.

7. “Preliminary” Lighting Calculations – Two (2) CDs of the electronic calculation file(s), including all relevant photometric files and other supporting information, which may be read by the two most recent versions of the Windows operating system.

8. “Preliminary” Lighting Calculations – The electronic calculation file(s) used for the design, including all relevant photometric files and other supporting information. The electronic files may be transmitted electronically, included via two (2) CDs, or two (2) thumb drives. Any of which may be read by the two most recent versions of the Windows operating system.

9. Phase “B” Report consisting of a status update and summary of major design points and a discussion of the alternatives analyzed and design chosen. Changes from the Phase “A” Submission shall be clearly indicated with engineering analysis and discussion. The report shall also discuss coordination efforts with all utility companies regarding new/modified services and location of electrical and communication facilities.

8.6.3. Pre-Phase "C" Submission

The Pre-Phase "C" submission shall be submitted at least 4 weeks prior to the Phase "C" Submission deadline to allow appropriate time to review and include all necessary changes in the Phase "C" Submission.

The Pre-Phase "C" submission, at a minimum, must include the following:

1. Completed Sheet of General Notes, Legends, and Abbreviations
2. Completed Lighting Plans, in final plan format, and Completed Lighting Key Plan showing all information required for the Phase "B" submission, with the addition of the following information:
    a. Complete roadway lighting layout and circuitry
    b. Load center(s), electric service locations, sign feeders, etc.
3. Electrical/Communications Plans showing complete installations, including all devices, equipment, and power and communications distribution systems.
4. Temporary Lighting Plans showing lighting work required in order to maintain illumination on all active roadways throughout the duration of the project.
5. Staging Plans that show the sequence of construction. If separate staging plans are not required, staging notes shall be included elsewhere in the Plans.
6. Miscellaneous construction details, which are not covered by Current Standard Drawings. It should be noted that submission of such details at the Pre-Phase "C" stage may reduce the possibility of time-consuming corrections in the Phase "C" submission.
7. A list of required Current Standard Drawings to be used on the project.
8. Any reference plans to be included in the project.
9. Final Schedule of Light Standards and all applicable Wiring Diagrams.
10. Full-size color prints in 1" = 30' scale showing "Final" Lighting Calculations for all lighting systems, including underbridge, sign, and tunnel lighting systems. Lighting calculations shall show alignment, striping, proposed light locations, existing light locations that will remain, calculation zones, and appropriate light value statistics. Light levels shall be legible for each point.
11. "Final" Lighting Calculations – The electronic calculation file(s) used for the design, including all relevant photometric files and other supporting information. The electronic files may be delivered via two (2) CDs, or two (2)

USB flash drives, any of which may be read by the two most recent versions of the Windows operating system.

12. Load, circuitry, voltage drop computations, in standard Authority format.
13. Arc Flash documentation in accordance with IEEE 1584, see the Specifications.
14. Preliminary construction cost estimate.
15. Pre-Phase “C” Report consisting of a summary of major design points focusing on any changes from the Phase “B” submission.

The Pre-Phase “C” Submission shall address all comments made during the review of the Phase “B” submission.

8.6.4. Phase “C” Submission

The Phase “C” submission shall be essentially complete, including all items listed above for the Pre-Phase “C” Submission in addition to the Supplemental Specifications and an Engineer’s Estimate. With this submission, all final design and quantity computations shall also be submitted. Copies of approved service requests and agreements with all utility companies shall be submitted for record purposes.

The Phase “C” Submission shall address all comments made in review of the Pre-Phase “C” Submission.

Submission of calculations shall generally not be required. However, if changes are made to the calculations submitted for the Pre-Phase “C” Submission, the Engineer shall resubmit a “record” set of calculations that matches the Phase “C” Submission.

8.6.5. Phase “D” Submission

The Phase “D” submission shall include the final Plans, Specifications and Engineer's Estimate, all incorporated with the Phase “C” review comments.

8.7. Preparation of Contract Documents

8.7.1. Plans

8.7.1.1. Required Plans

1. Plan preparation for either separate roadway lighting contracts or composite construction contracts containing roadway lighting shall conform to applicable requirements of Section 6 (Roadway Plan Preparation) of the Procedures Manual.
2. Contract plans shall generally consist of the following sheets, consecutively numbered:

a. Title Sheet: This sheet is required for separate roadway lighting contracts, not for composite contracts.

b. Legend, Notations and General Notes (may be more than one sheet): Legend and notations shall be prepared from the information provided as shown in Subsection 8.7.1.3. covering all installations under the Contract.

c. Table of Quantities: A separate sheet is not required for composite contracts, and this sheet may be combined in the Legend, Notations and General Notes sheet for small standalone roadway lighting contracts.

d. Plan Reference Sheets: This sheet shall also include load center location(s) and all major structures. Plan Reference Sheets may be combined with Lighting Key Plan.

e. Lighting Plans: Base plans shall be screened (subdued or gray) 1” = 30’ scale Roadway plans (complete with bridge structures, guide rail and drainage) to serve as background for roadway lighting work. Numbering of roadway/site lighting plans shall coincide with numbering of the Roadway plans (i.e., the same areas of the project shall be shown on Roadway Lighting Plan 4 and Roadway Plan 4). Sheets with no roadway lighting work shall be included and noted as “No Work This Sheet”. In the case where there are multiple consecutive sheets with no electrical or lighting work, a note may be added to the adjacent sheets and the sheets with no work omitted. For example: “Plans 5 through 10 require no roadway lighting work and have been omitted for clarity”.

   To allow for distinction between geometry and proposed electrical and communications equipment, all roadway lighting plans shall show new roadway lighting installation in thick, bold line, existing roadway lighting equipment to remain or to be removed in a thin, solid line, and all roadway geometry, striping, utility, drainage, and other topographical information in screened linework. Any existing topographical information which shows the features to be removed (i.e., not included in the final configuration) shall be omitted from the plans unless specifically required for temporary or staging plans. New, existing, and reference information shall be able to be determined at a glance using this approach.

Lighting Plans for roadway projects shall be titled "Roadway Lighting Plans," and lighting plans for other projects shall be titled "Site Lighting Plans.

All lighting facilities shall be properly plotted by stationing and fully identified by appropriate legend and notations. Luminaire station, offset, and tilt values shall be clearly noted. Notes shall be included on each sheet for cross-referencing and prescribing certain special installations, as required.

All existing facilities shall be shown on the Lighting Plans using the correct symbols (see Subsection 8.7.1.3). If required due to amount of work and for clarity of the proposed system, separate Removal Plans shall be permitted with prior approval from the Authority.

f. Lighting Key Plan(s): Plan(s) showing overall "final" view of installation, including all existing lighting connected to the final system. Plans shall be prepared to same standards as Lighting Plans, only at larger scale (1" = 100' scale maximum). Lighting standard designations and circuit routing and designations, including all 24-hour power circuits, shall be clearly shown. Locations of all equipment, including load centers, sign structures, ITS devices, and other powered devices, shall be shown.

g. Electrical / Communications Plans (if required): Plans shall show all required information to install all non-lighting devices in the project. Plans shall include a scaled geometry, all relevant topographical information, and shall generally be prepared in accordance with the criteria for Lighting Plans. Typical equipment which may require Electrical/ Communication Plans are variable/changeable message signs, ITS devices, refer to Section 9 (ITS and Communication Systems) of this Manual for additional criteria, cameras, etc. Plans shall be required only if the areas of work are not coincident with the areas covered by the Lighting Plans.

h. Staging Plans / Sequence of Construction (if required): These sheets shall also include the temporary lighting facilities and required revisions and/or removal of existing roadway lighting facilities. Plan preparation shall be as described for Lighting Plans, above.

i. General Construction Details: These sheets shall include all required construction details which are not covered in the Current Standard Drawings. With the exception of one-line, wiring, and riser diagrams, all details shall be drawn to scale on accurate base plans. Drawings of installations that rely on accurate dimensioning will be rejected and resubmission required if submitted in a “not-to-scale” format.

j. Roadway Lighting Load Center(s) and Wiring Diagrams(s). These sheets shall clearly identify the associated work by others and all existing equipment and/or wiring being reused or removed in conjunction with the proposed work.

k. Schedule of Lighting Standards and Luminaires: These sheets shall include a schedule for each circuit showing all proposed, existing and removed lighting facilities with final loads and phase balancing. The format of the Schedule shall be as shown below in Exhibit 8-22, which has been filled in for a “typical” new three-phase circuit. See the Sample Plans for more information.

   Where single-phase circuits are used, the “Phase A”, “Phase B” and “Phase C” columns shall be replaced with columns that read “Leg A” and “Leg B” to show proper balancing of the circuit. The format as shown below may also be modified to accommodate special circumstances and projects, but should, at a minimum, include all the information shown on the sample.

Exhibit 8-22 Schedule of Lighting Standards and Luminaires

CIRCUIT No.1					
LIGHTING STANDARD OR LUMINAIRE No.	LIGHTING STANDARD TYPE	LUMINAIRE		BASE OR JBF TYPE	REMARKS
		TYPE	LAMP WATTS		
1–1–A	L–MG–40–SB	LP2	166	PLB	
2–1–B	L–MG–40–SB	LP2	166	PLB	
3–1–C	L–MG–40–M	LP2	166	CB–M	
4–1–A	L–MG–40–M	LP2	166	CB–M	
5–1–B	L–MG–40	LP3	238	JBF	
6–1–C	L–MG–40	LP2	166	JBF	
7–1–A	L–MG–40	LP2	166	JBF	
8–1–B	L–MG2–40	LP4	238	JBF	
9–1–C		LP4	238		
UB3–1–A	–––	LW1	63	–––	
		TOTALS	1773		

SIGN LIGHTING SUMMARY						
STRUCTURE	QUANTITY OF LUMINAIRES	LOAD (kW)				
		øA	øB	øC	TOTAL	
STR. 091.36A	5	0.580	0.290	0.580	1.450	
STR. 091.38	2	–	0.290	0.290	0.580	
	TOTAL	0.580	0.580	0.870	2.030	

CONNECTED LOAD (KW)					
–	øA	øB	øC	TOTAL	
ROADWAY LIGHTING	0.498	0.642	0.570	1.710	
UNDERBRIDGE LIGHTING	0.063	–	–	0.063	
SIGN LIGHTING	0.580	0.580	0.870	2.030	
OTHER	–	–	–	–	
TOTALS	1.141	1.222	1.440	3.803	
					LOAD (kW)
TOTAL EXISTING LOAD					0
TOTAL CHANGE IN LOAD					+ 3.803
TOTAL FINAL LOAD					3.803

l. Current Standard Drawings: All required electrical and associated Current Standard Drawings.

m. Reference Drawings: As-Built drawings related to existing roadway lighting and associated facilities. Each Reference Drawing must be referred to by specific note in the construction plans.

8.7.1.2. **Additional Plan Requirements**

1. Manufacturer model numbers, where included in the Plans, shall be included only once to prevent errors and inconsistencies.
2. All luminaire tilt and orientation angles other than zero (0) degrees shall be clearly shown on the Lighting Plans and Details.
3. Luminaires shall be numbered such that each circuit starts at luminaire number 1. Continuous numbering for each load center and interchange shall not be utilized.
4. Existing Authority-owned equipment (lights, conduits, wires, etc.) shall be shown on all plans using proper symbols and callouts for all areas where a Contractor could disturb as a result of construction activities, or where the Contractor is required to maintain the facilities for the duration of the Contract. It shall not be sufficient to include only notes where a Contractor is required to maintain existing facilities that are not clearly indicated on the Plans.

8.7.1.3. **Standard Legends and Symbols**

The Engineer shall develop a contract-specific legend for use on each project by selecting standard Authority symbols from the Standard Electrical Legends available on the Authority’s website.

Any additional symbolism and/or notations required for special cases shall be reviewed by the Authority before being included by the Engineer to ensure consistency between the various construction contracts.

Topographical mapping typically is created using a single symbol for all lighting poles. The Engineer shall field-verify all installations and modify the lighting and electrical symbols shown for all Plans (including those of other design disciplines and all topographical files) using the Authority’s standard symbols for existing electrical and lighting equipment. This process shall both reduce confusion during construction and shall serve to ensure that all existing lighting systems are shown correctly on the Plans.

8.7.2. **Specifications**

Construction of roadway lighting systems and associated electrical facilities shall conform to the following:

1. Standard Specifications.

    a. Section 601 - Common Electrical Provisions

    b. Section 602 – Power Distribution

    c. Section 603 – Lighting

    d. Section 604 – Communications

2. Supplementary Specifications.

    Specifications for additional items which are not covered in the Standard Specifications to be prepared by the Engineer shall be as follows:

    a. Specifications shall follow the format set forth in the Standard Specifications and shall be brief and precise.

    b. Equipment and materials shall be specified to conform to Federal Specifications, ASTM, NEMA, ANSI, ICEA, etc., or to be equal to a particular brand product.

    c. When brand names are used, a brief description of the equipment or material, including type, model, catalog number, etc. shall be specified. For major items, more than one brand name should be specified as acceptable, unless otherwise directed by the Authority.

    d. Lump sum items shall be kept to a minimum in order to facilitate a more accurate estimate of cost, and to more easily negotiate field changes.

Section 9 - ITS AND COMMUNICATION SYSTEMS

Note to Designers:

Contact your Authority Project Manager for project-specific design criteria.

Section 10 - Traffic Control During Construction

10.1. Introduction

This Section, along with the Standard Drawings and Sample Plans, and the Manual For Traffic Control In Work Zones, have been prepared to provide Engineers with general guidelines and examples of the desirable applications for typical situations requiring lane and shoulder closures and/or lane shifts. This information may be used along with the current Manual on Uniform Traffic Control Devices (MUTCD) Part VI to prepare more detailed and site specific Traffic Control Plans that will enable a contractor to construct the project with adequate consideration of safety to motorists, pedestrians and construction workers.

Engineers should not refer to or use the Standard Drawings without proper evaluation of the specific site constraints and construction procedures required to construct the project. Traffic Control Plans should be prepared in accordance with the current Sample Plans. The Traffic Control methods established for each project should be consistent with the general provisions of this Section and should be based on good safety practices, engineering judgment, the speed and volume of traffic, the duration of the operation, the exposure to potential hazards, sight distance constraints and the physical features of the roadway including horizontal alignment, vertical alignment and the presence of interchanges and driveways. All final Maintenance and Protection of Traffic Plans must meet the approval of the Authority's appropriate Operations Department.

10.2. General

The first two sheets of the Maintenance and Protection of Traffic Plans should be as shown on the Sample Plan, as appropriately modified for individual project needs. These sheets contain a standard legend of typical traffic control devices, general traffic control notes, an escape ramp detail, a typical section for placement of construction barrier, a table showing recommended spacing of the channeling devices and a table showing recommended sight distances to the beginning of the channel tapers. The legend and general traffic control notes should be reviewed and modified to include other project specific symbols and notes as necessary for each project. The Sample Plans can also be modified to include other project specific information necessary to adequately address traffic control needs. Where required for clarification, sectional views showing the placement of traffic control devices adjacent to the traveled way and the work site should be provided. The Authority's Standard Drawings may never be revised by an Engineer.

Additional Traffic Control Plans should follow the first two (2) standard sheets. These additional plans should be included to show plan views of project specific work sites when those locations need to be represented or where design features of traffic control devices (such as the type of precast construction barrier) or temporary pavement markings need to be indicated. The scale of the Traffic Control Plans should be selected so that the optimum amount of information is shown on a minimum number of plan sheets. The Traffic Control Plans should include a tabulation of the channelization devices needed for the project.

The Engineer shall note any recommendations that conflict with the Authority's Traffic Manual and provide justification for the Authority's appropriate Operations Department approval.

As a minimum, Traffic Control Plans should include the following items:

1. Required lane widths for each staging plan
2. Grading, drainage and utilities for temporary roadways and crossovers
3. Detours with respective detour signing
4. Temporary drainage associated with traffic staging
5. Temporary staging for drainage and other utilities
6. Temporary traffic signals and associated signal phasing design, if necessary
7. Advance warning signing for each staging plan
8. Traffic control and safety devices that are necessary for each stage of construction
9. Township and county
10. Graphic scale and north arrow
11. Allowable working hours
12. Accommodation for Pedestrian traffic (i.e. locations of temporary sidewalks)
13. Appropriate use of temporary / permanent barriers and end treatments
14. Appropriate plans and specifications to address safety concerns
15. Requirements of the State Police and/or local law enforcement

10.3. MAINTENANCE AND PROTECTION OF TRAFFIC PLANS

Maintenance and Protection of Traffic Plans should be utilized when a staging or sequence of construction needs to be specified. Notes pertaining to the various stages of construction should be included on these plans. The notes should thoroughly describe each phase of construction in the sequence to be performed.

The Legend on the Sample Plans shall be modified to show symbols for the work to be performed during each stage of construction and for work completed while construction is being performed during subsequent stages. When temporary pavement areas are required, a typical section shall be provided.

During all phases of paving, staging should provide for no exposure to drop-offs and uneven pavement adjacent to and between travel lanes.

To improve the riding quality of new bituminous concrete pavements, wherever possible, the top layer of the bituminous concrete surface course should be paved as a single stage of construction for the full width of the traveled way, shoulder and auxiliary lanes. Therefore, development of the Traffic Control Plans for projects involving paving operations should specify a Construction Sequence in which work progresses up to the bottom of the top layer of the surface course. The top layer shall be shown as the final paving stage.

Engineers shall not have traffic riding on Unbound Paving Materials. The appropriate striping shall be in place on all open roadways.

10.4. TRAFFIC IMPACT REPORT

As part of the development of the Traffic Control Plans, the Engineer shall conduct an analysis of construction related impacts. For construction on roadways other than the New Jersey Turnpike or Garden State Parkway, the findings should be presented in a detailed Traffic Impact Report that addresses the following items:

1. The existing traffic volumes and capacity data on the roads likely to be substantially impacted.
2. The projected traffic data at the start of construction including nearby highway construction projects as well as private construction projects.
3. The potential impacts of the construction on traffic through the project and along any detours.
4. The potential impacts to existing adjacent property, including shopping centers and sports facilities.
5. Recommendations for traffic impact mitigation, e.g., nighttime work, restricted hours of operation, number of lanes available for traffic, width of lanes, requirement for alternating traffic, staging requirements, public information program, and transportation demand management strategies such as park and rides, shuttle buses, flextime, etc.

During the Summer season, as defined in the Authority's Lane Closure and Shoulder Closure Tables, the Garden State Parkway experiences increased traffic volume, especially south of Interchanges 127-129. Due to this regular occurrence, the Authority generally requires a Traffic Impact Report to be submitted and approved for a proposed installation of a long-term lane shift that would be in place during the Summer season. The report must include quantitative analyses and observations of mainline operations and operations of any ramp within 1,000 feet of the work zone following the methodology of the latest edition of the Highway Capacity Manual (HCM), demonstrating that any adverse impacts caused by the lane shift, including queues along exit ramps, will be limited to the satisfaction of the Authority.

There are limited exceptions to the requirement to submit a Traffic Impact Report for long-term lane shifts to be installed on the Parkway during the Summer season. The flow chart in Exhibit

10-7 describes the circumstances under which a report would not be required, including work zone location, configuration and traffic volumes. Exhibit 10-8 shows the threshold volumes above which a report will be required for each Garden State Parkway segment. Note that even if a Traffic Impact Report is not required, the Authority still may limit construction activity within the lane shift during peak periods. In that circumstance, the Authority's Operations Department will provide a list of restricted work hours.

The Authority's appropriate Operations Department shall be consulted during the development of the Traffic Impact Report through the Authority's Project Manager. The Authority's appropriate Operations Department will provide the Engineer with the permissible New Jersey Turnpike and Garden State Parkway lane and roadway closing hours for a project.

10.5. Development of Traffic Control Plan…

Design Parameters

The Authority recognizes the need to effectively and efficiently manage traffic through construction projects in order to reduce congestion, maintain high standards of safety for workers, pedestrians and motorists, and minimize impacts to the local community both business and residential.

On the New Jersey Turnpike and Garden State Parkway, congestion is mitigated through the use of their lane reduction tables. Any lane or roadway closings outside the allowable times will not be considered, unless the Engineer proposes a method to mitigate the speed differential risk, including but not limited to a traffic queue warning system. The Engineer shall also evaluate ramp construction to determine and mitigate any truck overturn risk.

To this end, the scoping, design, scheduling and construction of projects should be accomplished in a manner that will provide standards of safety for workers and the traveling public, minimize congestion and community impacts by maintaining levels of service close to preconstruction levels and provide the contractor with adequate access to the roadway to complete the work efficiently, while meeting the quality requirements of the contract.

In order to achieve these objectives, an Engineer shall utilize the Authority's Road User Cost Manual and the appropriate Traffic Manual to evaluate potential alternatives, in terms of cost to the traveling public, as directed by the Authority's Project Manager. All projects should be designed to minimize road user cost impacts. This may be accomplished through a variety of means including, but not limited to, reduced daytime construction hours, nighttime operations, detours, diversionary roads, crossovers, the use of shoulders as travel lanes, temporary roads and bridges, alternating traffic patterns, non-traditional methods of completing the work, and using faster setting materials. The incorporation of design elements to ease traffic impacts during future construction should also be considered. These could include wider lanes, shoulders or right of way, full depth shoulders, removable sidewalks on bridges, and other alternatives.

The basic safety principles governing the design of permanent roadways and roadsides should also govern the design of construction, maintenance and utility work sites. The goal shall be to safely route traffic through these areas with geometrics and traffic control devices, as nearly as possible, comparable to those for normal highway situations, with the design speed that is specified by the Authority's appropriate Operations Department. The following items should be considered in determining the overall approach to project specific traffic control:

1. Regarding hours of operation or lane restrictions, consideration should be given to the location of the project and calendar of events. Unless there are valid reasons to the contrary, travel lanes should not be reduced in number or width, nor work be permitted to interfere with traffic, on weekends, holidays (including the PM peak the day before and the AM peak the day after) and days of special events of major traffic generators near the project site, such as the Meadowlands Complex, Garden State Arts Center, shore areas during the summer, etc.

2. Through the Authority's Project Manager, discuss the project with the Authority's appropriate Operations Department to determine the number of lanes which can be closed during the day, during the night, or on weekends. Incorporate seasonal variations into the analysis. Through the Authority's Project Manager, the Engineer shall contact the Authority's appropriate Operations Department, which has jurisdiction and ask what lane or road closings they will allow and discuss independent findings with them. With concurrence from the responsible Operations Department, define the allowable lane closing periods.

3. Provide minimum lane widths of 11 feet for all lane shifts and diversionary roads, except where existing lane widths are 10 feet.

4. Determine if detour routes are available. If potential detour routes exist, determine if their use would enhance the constructability of the project.

5. Determine if shoulders or temporary pavements can be used by traffic. Shoulders may require reconstruction prior to placing traffic on them. Short temporary roads may provide access to other existing roads making a detour possible.

6. Determine if guide rail has to be removed or relocated. If removal of guide rail reveals a blunt end then temporary impact attenuators should be provided.

7. Determine if temporary signals are required.

8. Determine if there are any reasons why a construction project should be substantially accelerated when under construction. If there are reasons for an accelerated construction process, discuss proposed methods of implementation with the Authority's project manager to determine the details of the acceleration (i.e. number of crews required, hours of work).

9. Using the Roadway Plans, determine the duration of the various construction operations required to build the project. Using this information, determine if lane closings can be

set up and broken down over one work shift (8 hours±), over the weekend (Friday night to Monday morning), or must lane closings be maintained for longer continuous durations. Lane closings beyond the times specified in the Lane Reduction Tables are not permitted without the prior approval of the Authority's appropriate Operations Department. All of the above may apply. For New Jersey Turnpike and Garden State Parkway projects, the permissible lane closing hours are specified in the appropriate Traffic Control Manual.

10. Determine whether or not Movable Construction Barrier should be used. Refer to Subsection 10.9.

11. Review the guidelines for nighttime construction described in Subsection 10.10.

12. Review the time allowed for the staging of paving operations. Provide the appropriate amount of time for sufficient curing, deck patching, cooling asphalt pavement, placement of pavement markers and striping as necessary.

10.6. TEMPORARY TRAFFIC STRIPED AND TRAFFIC MARKINGS

The Authority's policy on temporary traffic stripes and traffic markings is as follows:

1. Traffic paint (latex or alkyd) shall be used when traffic stripes or traffic markings are required on intermediate pavement layers that need to be opened to traffic due to stage construction. The traffic stripes shall be calculated in linear feet for each 6 inch width of actual stripe (gaps are not counted) under the item TEMPORARY PAVEMENT STRIPING. Diagonal gore lines, crosswalks, and stop lines shall be calculated in linear feet for each 6 inch width of actual stripe under the item TEMPORARY PAVEMENT STRIPING (Linear Foot). Words, arrows and other pavement symbols shall be calculated in square feet under the supplementary item TEMPORARY PAVEMENT MARKINGS, SYMBOLS (Square Foot). Where lane shifts are necessary on the intermediate layers or on existing pavements not being repaved, and temporary striping will remain in place less than three (3) months, removable pavement marking tape or temporary pavement markers shall be specified and calculated accordingly. The placement of temporary pavement markers shall be in accordance with the Sample Plans.

2. Long life traffic stripes or traffic markings may be considered for stage construction, detours, and diversionary roads on those occasions when it can be justified based on cost considerations, site conditions, or length of time when the stripes or markings will be in place.

10.7. LANE AND ROADWAY CLOSURES

10.7.1. Lane Closures

The Engineer should modify the Sample Plans to provide a table showing specific restrictions placed on travel lanes, durations of closures and hours when work may be performed, including holidays and weekends. The permissible lane and roadway closing times for the Turnpike and Parkway will be specified by the Operations Department. The closures and lane restrictions on other roadways shall be evaluated in the Traffic Impact Report, refer to Subsection 10.4. The following table is provided as an example of the form of presentation of this information:

Roadway Route Designation and Direction	Type of Closure	Monday thru Thursday	Friday	Saturday	Sunday
	No Closure				
	One Lane Closure				
	Two Lane Closures				
	Full Closures (indicate duration and type of operation)				

Mobile lane closures shall only be permitted for the types of work specified in the Standard Drawings.

10.7.2. Traffic Slowdowns

Total roadway closures (i.e. all lanes, single direction or two directions) required for the erection of overhead sign structures, cantilevered sign structures or bridge steel shall be performed in accordance with the following:

1. The use of roadway closures shall be specifically addressed in the Traffic Impact Report, refer to Subsection 10.4, and shall be considered only after detours have been determined to be unavailable or unfeasible.
2. Slowdowns shall be approved by the Authority’s appropriate Operations Department.
3. Slowdowns shall be performed during non-peak hours and with prior approval of the Resident Engineer concerning the timing and method of operation.
4. Nighttime construction for the erection of the various structure types is preferred, refer to Subsection 10.10.
5. The erection of overhead and cantilever sign support structures shall be done only when overhead electric lines, if there are any within 100 feet, have been de-energized.
6. Slowdowns shall be initiated with a slow down of traffic approximately 1/2 mile in advance of the work area.

7. Slowdowns, whether single direction or two directions, shall be limited to 5 minute intervals. At the end of each 5-minute interval, the work must stop, and traffic allowed to pass. After traffic has cleared, the roadway may again be closed for another maximum 5 minute interval, repeating the same procedure, and work may resume. Continue this procedure until all work over the roadway is complete. Slowdowns in excess of 5 minutes may occur when no other option exists, and they require special coordination with the appropriate Authority Operations Department and the State Police.

10.7.3. Roadway Closures

The use of roadway closures for specific work shall be approved by the Authority's appropriate Operations Department during the design phase of a project. The actual date and time of a roadway closure will not be determined during design.

10.7.4. Center/Interior Lane Closures

Existing roadway facilities with three or more lanes in each direction often require the closure of interior lanes to perform construction activities. The Standard Drawings provide the methods for maintaining traffic during construction in an interior lane. In addition to the Standard Drawings, specific project/site conditions should be evaluated when determining the appropriate details to use. Generally, center lane closings on the New Jersey Turnpike and Garden State Parkway are to be avoided to the greatest extent possible.

10.7.5. Alternate Traffic Routes on Projects Involving Local Road Construction

10.7.5.1. General

Alternate traffic routes located where high approach speeds are anticipated should be of a high-type design. Transition lengths, curve radii, superelevation and other design features should be consistent with the design speed of traffic that will be entering the alternate traffic route.

10.7.5.2. Diversionary Roads

If a temporary roadway is to be constructed on Authority right of way or easement as part of the contract to carry traffic around a construction site it should be referred to as a "diversionary road" and not an official detour. It is desirable that diversionary roads used for construction zone traffic control have the same design speed and cross section as the existing roadway. The minimum design speed of the diversionary road shall be 20 mph less than the design speed of the existing roadway.

10.7.5.3. Detours

The Authority is required to obtain County or Municipal permission to close, or otherwise impact roads or streets because of construction. It is the Authority's policy to meet with the proper authorities and to obtain their permission and cooperation beforehand and obtain approval during Phase “B”.

An official detour exists whenever, as a result of roadway construction, existing roadways are to be closed temporarily and it becomes necessary to reroute Authority, State, Municipal or County Road traffic over other existing streets or roads to maintain the normal flow of pedestrian and vehicular traffic.

The roads or streets to be used for the detour shall be examined to make sure they are acceptable from the standpoint of condition, safety, necessary signing, lighting and repair. A detour map, together with recommendations for signing, repair, limitations, if any, should be prepared and submitted as part of the project design. Approval of the project makes the detour "legal". By State Statute, the Authority is required to obtain prior permission to improve Municipal streets.

The Authority is responsible for all of these arrangements. Should situations of this type exist which are not being handled as described, the Authority's project manager should immediately be contacted so that proper action can be taken. Provisions shall be made for videotaping the detour road(s) before and after construction.

10.7.5.4. Haul Roads

A Contractor may use the local roads to transport materials for the construction project. Haul roads are not considered detours. Municipalities may not levy charges against the haul vehicles if they are licensed to travel on any road in the State, but they can place limitations if weight restrictions exist. The Engineer shall investigate for such restrictions during the course of the design, as long as they meet all existing regulations.

10.7.6. Traffic Shifts

10.7.6.1. Clear Zone

In the absence of protective roadside devices for lane shifts or any traffic pattern that alters the existing clear zone, the clear zone shall be maintained and conform to the requirements set forth in Section 4 (Guide Rail / Median Barrier / Attenuator Design).

10.7.6.2. Shoulder Condition Evaluation

Existing shoulder pavement shall be evaluated to determine if it is suitable for use by traffic. Above average heavy vehicle percentages shall be used for any design calculations. Pavement cores may be required to determine asphalt properties for the evaluation. All drainage systems shall be inspected and repairs/retrofits identified as required. Cross-slope of shoulders shall be determined and modifications to the cross slope shall be recommended as required.

10.7.6.3. Temporary Shoulders

Temporary shoulders shall be constructed within the limits of traffic shifts when the shoulder width is reduced to less than 2’-0” at locations where roadside protective devices are not present.

10.7.6.4. Rumble Strips

Longitudinal rumble strips shall be reconstructed but need not be present prior to returning traffic to the original alignment.

10.8. Precast Concrete Construction Barrier

10.8.1. Introduction

In general, Precast Concrete Construction Barrier (PCCB) should be installed only if it is clear that the barrier offers the least hazard potential. Elimination of the warranting obstruction should always be the first alternative considered. Limiting excavations to that which can be backfilled during the same work shift or covering minor excavations are practical examples of how obstructions, commonly encountered during construction, can be eliminated. In some cases, a detour may be the most practical solution, especially on projects that would require large quantities of construction barrier.

There may be situations where there is not a clear choice as to whether or not a construction barrier is warranted or where site conditions or construction operations will exclude the use of a construction barrier even though one is warranted. The Engineer should constantly be on the lookout for situations where the site conditions and/or the operational characteristics of the road such as adverse geometrics, high operating speed and high traffic volume, will make the use of construction barrier appropriate even though not specifically required by the warrants shown in Subsection 10.8.2. Such cases should be evaluated on an individual basis and, in the final analysis, must usually be resolved by engineering judgment. In such cases, adequate documentation should be included in the job file so that whatever action is taken, it cannot be misconstrued as being arbitrary.

10.8.2. Warrants

The following guidelines are to be used to establish warrants for using PCCB when developing Traffic Control Plans. Three factors must be considered in determining if an obstruction warrants a construction barrier:

1. The physical characteristics of the obstruction.
2. The distance from the traveled way to the obstruction.
3. How long the obstruction will exist.

For an obstruction to warrant a construction barrier, all three of these criteria must indicate that a barrier is needed.

Physical Characteristics: A warranting obstruction is defined as a non-traversable roadside or a fixed object that is located within the clear zone and whose physical characteristics are such that injuries resulting from an impact with the obstruction would probably be more severe than injuries resulting from an impact with construction barrier.

Also, other examples of using PCCB to protect patron vehicles from warranting obstructions are:

1. To protect traffic from entering work areas such as excavations.
2. To protect construction such as falsework for bridges and other exposed objects.
3. To separate two-lane, two-way traffic on one roadway of a normally divided roadway. Whenever two-way traffic is to be maintained on one side of a normally divided highway, opposing traffic shall be separated as follows and such separation shall be shown on the Traffic Control Plan.

   Where the two-lane, two-way, one-side arrangement is used, the Traffic Control Plans shall include the above provisions for the separation of opposing traffic except:

   a. Transition Zones - Positive Barrier (PCCB or approved alternate), with a buffer area equal to the maximum deflection limit of the proposed barrier.
   b. Between Transitions - Positive Barrier, as described in A above or by delineation devices as deemed appropriate by the Operations Department.
   c. Striping and complimentary signing shall be used in conjunction with A and B above.

Duration of Existence: PCCB is warranted if an obstruction will remain within the clear zone for more than one work shift.

10.8.3. Applications

Precast Concrete Construction Barrier, Alternates A and B are the only barrier types approved for use on construction projects.

Alternates A or B may be used at all locations where Joint Class A, B, or C are specified; Alternate B must be used where Joint Class D is specified. Refer to the Standard Drawings for details on the alternate barrier types.

When PCCB is specified, the joint class and limits for the barrier should be indicated on the Traffic Control Plans based on the minimum clear area available behind the barrier as noted in Table 10.8-1. Joint Class B shall not be used as median barrier (traffic on both sides of the barrier) and may only be used to shield traffic on one side of the barrier, with the steel box beam stiffening always attached to the non-traffic side of the barrier. The applicable joint class of PCCB shall be provided when construction barrier is to be used as bridge parapet based on the width of the shelf provided for the required minimum clear area of the joint class**.**

The following chart summarizes the respective joint treatments:

Table 10.8-1 PCCB Joint Treatment

Joint Class	Minimum Clear Area Behind PCCB	Joint Treatment
A	39 inches	Connection key and barrier end sections fully pinned
B	33 inches	Connection key and non-shrink grout at every joint; 6-inch x 6-inch steel box beam spanning each joint; and barrier end sections fully pinned
C	12 inches	Connection key and non-shrink grout at every joint; traffic side of all barrier sections pinned; and barrier end sections fully pinned
D	0 inches	Connection key and non-shrink grout at every joint; and bolt every anchor pocket hole in every barrier section

Anchoring PCCB to a bridge deck that is High Performance Concrete (HPC) or has a Latex Modified Concrete (LMC) overlay undermines the effectiveness of the HPC or LMC. In addition, the extra costs associated with placement of HPC or LMC make it especially undesirable to lessen its effectiveness by drilling holes through it. The Engineer is advised to investigate alternatives in order to eliminate the need for anchoring barrier on bridge decks, when possible, so as not to compromise the benefits of the HPC or LMC overlay.

Where different joint classifications are required within a section of barrier, the controlling joint class shall extend beyond the area required for limited deflection as noted in table:

Table 10.8-2 PCCB - Transition Between Joint Classes

PCCB - Transition Between Joint Classes	
Joint Class Transition	**Transition Requirements**
D to C	Extend one complete barrier section of Joint Class D beyond the work area requiring limited deflection.
D to B D to A	Extend one complete barrier section of Joint Class D beyond the work area requiring limited deflection and pin the first hole of the Joint Class A or B barrier section on the traffic side of the PCCB.
C to B C to A	Extend one complete barrier section of Joint Class C beyond the work area requiring limited deflection and pin the first hole of the Joint Class A or B barrier section on the traffic side of the PCCB.
B to A	Extend Joint Class B box beam stiffing for 50 ft. minimum beyond the work area requiring limited deflection.

PCCB shall not be installed on side slopes steeper than 10H:1V. The approach end shall either be flared at 20:1 on both the New Jersey Turnpike and Garden State Parkway beyond the clear distance or, when terminated within the clear zone, the approach end of the barrier shall be shielded with an appropriate attenuator system. PCCB shall be placed on a traversable surface, preferably paved. The deflection area behind a barrier shall be able to bear traffic and shall be free from obstructions. When barrier is used as parapet protection the integrity of the surface should be evaluated to ensure adequacy of the barrier anchorage to provide the width of the shelf behind the barrier to accommodate the barrier movement.

Construction barrier systems other than the Authority's standard PCCB may be considered and approved by the Authority on a project-by-project basis. Consideration of an alternative barrier system requires that the barrier satisfactorily demonstrated MASH TL-3 compliance; sources for alternative type barriers include:

https://www.roadsidepooledfund.org/mash-implementation/search/
https://mwrsf.unl.edu/researchhub.php

Contract documents shall include all appropriate details for installation of the alternative barrier system conforming to the conditions under which it received MASH compliance. If an alternative barrier system is identified, the contract documents shall include the maximum deflection per MASH testing for the specified barrier system.

The approach length of need (L.O.N.) is the minimum length of construction barrier required in front of the warranting obstruction to shield the hazard effectively. See Exhibit 10-1 for instructions on how to determine the L.O.N. for PCCB.

EXHIBIT 10 -1 LENGTH OF NEED OF PRECAST CONCRETE CONSTRUCTION BARRIER

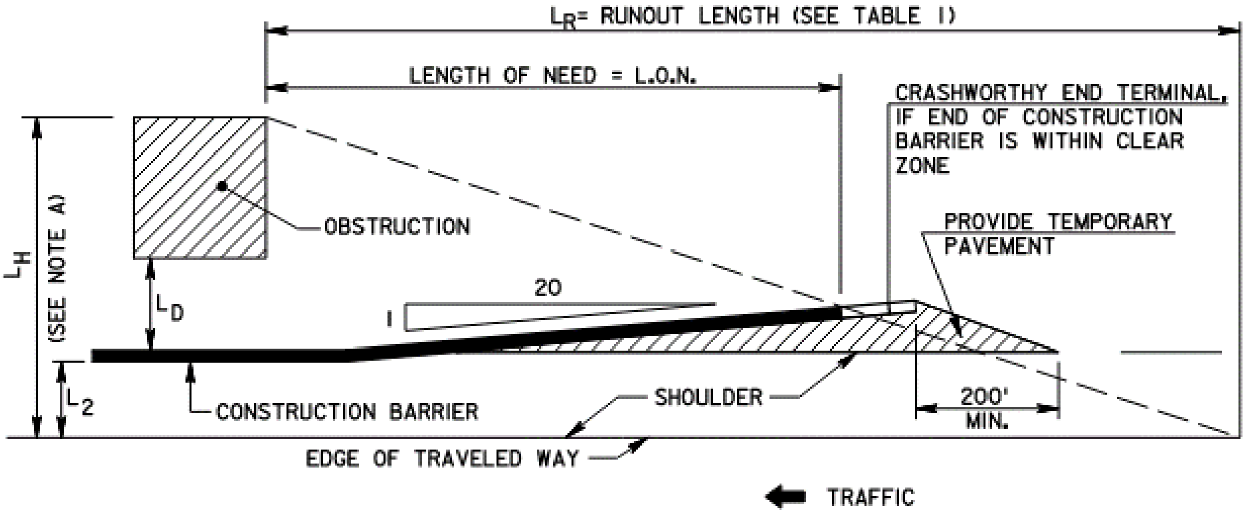


TABLE - I				
	TRAFFIC VOLUME (A.D.T.)			
	OVER 6,000	2,000-6,000	800-2,000	UNDER 800
DESIGN SPEED (M.P.H.)	L_R	L_R	L_R	L_R
70	480	440	400	360
60	400	360	330	300
50	320	290	260	240
40	240	220	200	180
30	170	160	140	130

NOTE A. IF OBSTRUCTION EXTENDS BEYOND CLEAR ZONE, MAKE L_H EQUAL TO CLEAR ZONE EXCEPT IF OBSTRUCTION IS A CRITICAL SLOPE, SEE EXHIBIT 4-7.

NOTE B. IF ROADWAY IS CURVED, DRAW LAYOUT TO SCALE AND OBTAIN L.O.N. DIRECTLY BY SCALING FROM DRAWING.

NOTE C. IF BARRIER END IS PARALLEL TO ROADWAY (NO FLARE), THEN CHANGE "1/20" IN FORMULA TO "0".

NOTE D. SEPARATION BETWEEN BARRIER TO OBSTRUCTION, $L_D \geq$ MAXIMUM BARRIER DEFLECTION.

EXAMPLE

$$\text{L.O.N.} = \frac{L_H - L_2}{\frac{1}{20} + \frac{L_H}{L_R}}$$

L_2 = 15'
L_H = 25'
L_R = 480'

$$\text{L.O.N.} = \frac{25 - 15}{\frac{1}{20} + \frac{25}{480}}$$

DESIGN SPEED = 70 MPH
ADT = 26,000

L.O.N. = 98.0

10.9. MOVEABLE CONSTRUCTION BARRIER

10.9.1. Warrants

The following guidelines are to be used to establish the warrants for using Moveable Precast Concrete Construction Barrier to achieve an efficient and effective Traffic Control Plan. Moveable barrier will provide additional traffic capacity lanes for accommodation of both AM and PM peak traffic, a safe and expeditious means of expanding the Contractor's work area (all work is done using positive separation), or the opportunity to stage projects in a more efficient method.

Moveable barrier should be a type that can be quickly moved laterally from 4 feet to 18 feet in one continuous operation. The daytime movement of moveable barrier can only be accomplished by means of a traffic slowdown. Therefore, the time required to relocate moveable barrier could preclude its use. The decision to use a moveable barrier system shall be approved by the appropriate Operations Department with capacity, safety and economics as the guidelines and should include the following considerations:

1. Additional traffic lane capacity can be gained during peak hour traffic periods.
2. Additional contractor working area can be gained during off peak hours and substantially reduce construction time.
3. Construction time can be shortened either through staging or increased productivity by the contractor.
4. Timing required to set up staging can be kept to a minimum.
5. Construction sites with limited work zones in urban or restricted areas where frequent day or nighttime lane closures will be required.
6. Their use will provide a greater degree of safety for motorists.
7. Projects which are located in non-attainment areas and have Clean Air Issues require a reduction in emissions.

10.9.2. Applications

When developing the Traffic Control Plan, the use of moveable barrier systems should be limited to projects where a greater benefit can be attained than if standard methods and equipment were used. Listed below are types of projects where it would be a viable option for use.

1. Widening or reconstruction projects on highways or expressways with high peak hour traffic volumes (i.e. 50,000 AADT and greater for four lane facilities and 90,000 AADT and greater for 6 lane facilities).

2. Projects where a reversible traffic lane would be beneficial during peak traffic durations and which would allow for better staging.
3. Median and shoulder reconstruction projects. Examples include shoulder/median improvements or widenings, such as a new permanent concrete barrier being installed. Moveable barrier is especially beneficial when the size of the work zone is either very restricted or if repeated lane closures are anticipated.
4. For resurfacing projects by closing one side of a divided highway and creating opposing traffic lanes on the open side of the road, a contractor can resurface one side of the roadway at night without interference from traffic.
5. For Reconstruction of parallel structures where the design of a reversible lane to increase the capacity of one structure while closing down the other.
6. Alternate routes do not have excess capacity for suitable detour.
7. Alternate routes do not exist.

10.9.3. Safety and Cost Consideration

In construction projects, moveable barrier generally is used to open traffic lanes during peak traffic periods and close the lanes during off peak periods to allow improved access to the work zone. In this application, the moveable barrier has the unique ability to provide continuous positive protection before, during and after the opening and closing of traffic lanes. Once these barriers are on the road, it takes significantly less time to shift barrier than it does by using traditional methods. Moveable Barrier allows greater work zone access for a contractor and increases productivity. A determination should be made by the Engineer that this feature and resulting increased worker safety makes the use of a moveable barrier system a viable alternative to conventional traffic control devices. Its use should be clearly described in the Traffic Control Plan.

When considering this product the Engineer should also prepare a cost comparison of the moveable barrier and the next best alternative. The following items should be considered:

1. Cost of the moveable barrier. The Engineer should work with the supplier to determine operational costs and a lease price to contractors.
2. The next best alternative and its cost.
3. The savings in time for the project’s schedule should also be considered with the overall savings.
4. Consideration for congestion and clean air issues where a reduction in emissions is required.

Use of moveable barrier should take into consideration access to interchanges, service areas, maintenance facilities, emergency access points, etc., where access must be maintained during construction.

When using moveable barrier, consideration for additional wide load signing on the Traffic Control Plans may be appropriate. If the barrier is used to reverse traffic flow and there is a single lane in one direction, it shall not be less than 11 feet.

Moveable barrier shall only be used on tangent sections and flat curves where an angle of impact of not more than seven degrees exists and where an allowable movement of the barrier, when hit, of 1 ½ feet is acceptable. Moveable barrier can be used on the following sharp curves where an allowable movement of the barrier, when hit, of 5 feet is acceptable:

Number of Lanes	5 ft Deflection where Radius is less than
1	500 feet
2	900 feet
3	1,300 feet

Approved attenuators, as identified on the Authority's website, must be used with moveable barrier to shield the approach ends of the barrier. Where possible, the barriers may be tucked behind conventional concrete barrier curb.

10.10. NIGHTTIME CONSTRUCTION

In keeping with the Authority's policy of delivering a safe, reliable and affordable transportation system and to alleviate traffic congestion and improve air quality, it is proposed that any activity that requires the temporary closing of traffic lanes which results in a sufficient degradation of the highway level of service, should be performed at night provided that the requirements of the Authority's Traffic Control Manuals are met. Excluded will be emergency operations such as locations where safety conditions preclude nighttime work, locations where existing municipal ordinances have been enacted that prohibit nighttime work, or locations where the traffic volumes are such that the work activity can be accomplished during the day without significant negative impacts.

It is the intent of the Authority to perform construction activities at night that would otherwise cause unacceptable negative impact on traffic flow. It is recognized that there are certain influencing factors that must be reviewed when considering whether or not to perform nighttime work.

The decision to perform nighttime work will be determined during the scoping process, but the final approval for nighttime construction should be made by the Authority's project manager, with the approval of the appropriate Operations Department. The following guidelines are to be used for establishing the warrants for nighttime work outside of the Authority's right of way.

1. The conditions listed below must be met before nighttime work can be performed:

a. Compliance with local noise restriction ordinances.

b. The Authority has obtained local government approval for nighttime work within the project limits. (Inform local government of what type of work will be taking place.)

c. Work zone safety must not be compromised by nighttime construction activities.

d. The quality of construction work must not be compromised by nighttime work.

2. Some factors that may eliminate the need for nighttime work:

    a. A shoulder which may be used in place of the lane to be closed.

    b. A viable detour is available.

    c. Operations Department staff and the Traffic Impact Report indicate that a lane closure during the day would not cause a significant impact.

3. Projects that may require both day and nighttime construction operations are as follows:

    a. Projects where the location has specific seasonal requirements (such as shore routes during the summer, major shopping centers at the Holiday Season, sports facilities, etc.).

    b. Projects where the work required has specific temperature or environmental constraints.

    c. Projects with accelerated construction schedules.

10.11. CONSTRUCTION DETAILS

Construction details should be provided for any traffic control device not adequately covered by the Standard Drawings.

10.11.1. Temporary Attenuators

Temporary attenuators in construction zones shall not be placed on side slopes steeper than 5%, or on islands, curbs, platforms, etc. greater than 4 inches in height. The Engineer should refer to Subsection 10.17 for information on the selection and design of the Inertial Barrier Systems. Alternate systems currently approved by the Authority are provided on the Authority’s website. The Engineer must provide design specific information such as the required number of bays or modules for each location. For Inertial Barrier systems, a layout of the modules, including the weight of each module shall be included as a construction detail in the contract plans.

10.11.2. Signs

10.11.2.1. General

1. Any construction sign not depicted on the Standard Drawings shall be shown in detail.
2. All signs should be sized relative to the posted speed limit (consult the FHWA Manual on Uniform Traffic Control Devices and the Standard Drawings).
3. Determine if specific site conditions require special supplemental signing. The use of variable message boards should be considered and approved by the Authority's Operations Department.
4. For work zones that are not depicted in the plans or Standard Drawings:
   a. Related Standard Drawings and Part 6 of the MUTCD, particularly Chapter 6H (Typical Applications), shall be used as a guide to establish the minimum provisions for sign placement.
   b. The Authority's Operations Department shall be consulted for a determination of work zone treatment.
   c. The specific locations of signs for each work zone shall be depicted in plans and approved by the Engineer.
   d. Traffic control signs for work zones that encompass an on- or off-ramp may require plan-specific locations in lieu of a field determination due to the complexity of the work zone closure.

10.11.2.2. Tables for Construction Signs

In order to estimate the required quantity of signs in square feet, the Engineer should prepare a summary of signs for the project. This summary of construction signs shall be shown on a table, and included on the first sheet of the Traffic Control Plans. An example of a completed table listing the sign designation, quantity and area in square feet is shown in the Sample Plans.

10.11.3. Guide Rail

Guide rail in construction zones shall not be installed on side slopes steeper than 10H:1V.

10.12. UTILITIES

Utility relocations that affect staging or traffic control should be clearly identified on the Traffic Control Plans. This information should include both temporary and permanent relocation work.

Notes pertinent to the relocations should be provided on the applicable staging plan(s) and/or traffic control plan(s). In addition, the Engineer should review the need for general utility notes to be added.

10.13. Quantities

Quantities should be estimated based upon actual requirements shown on the plans.

For quantity purposes, the number of units or linear feet of traffic control devices and signs should be the maximum quantity required to be in use at any one time. Construction signs should be tabulated by sign designation and quantity, refer to Subsection 10.11.2. Signs indicating speed limits or speed reductions shall be included.

Temporary pavement to be used for traffic control shall be measured and paid for under the various pavement pay items in the Proposal. Quantities for the removal of temporary pavement must also be included.

10.14. Installation and Removal Sequence for Work Zone Traffic Control

The manner in which traffic control schemes are installed and removed may affect safety and traffic flow. The following is a suggested guideline describing the proper installation and removal sequence for work zone traffic control schemes:

1. Required advance warning signs should be installed first so that protection is provided when channelizing devices are installed near the work area. If work zone signing is necessary for both directions of travel, sign installation should begin with the advance warning sign located furthermost in advance of the work area and on the side of the roadway opposite the work area. Sign installation should proceed down the roadway toward the work area. After the necessary signs are erected on the side of the roadway opposite the work area, sign installation may begin for the other direction of travel, beginning with the sign furthermost from the work area. In the process of installing the work zone signing, existing signs with conflicting messages shall be completely covered, removed or modified.

2. If the work area is such that flagging operations are necessary, the flaggers may begin flagging operations after the advance warning signs are in place. Otherwise, the installation of channelizing devices at the work area can begin after the placement of the advance warning signs. These devices should also be installed in the direction of travel starting with the device furthermost in advance of the work area.

3. A shadow vehicle with a truck-mounted attenuator should be placed between approaching traffic and the workers who are installing channelizing devices around the work area. After the channelizing devices are installed, the vehicle may be removed or moved inside the work area and the work may begin.

4. After work is completed and the work zone restored to normal operations, the work zone traffic control scheme may be dismantled. The removal of the traffic control scheme should be carried out in reverse order from the installation procedure. The channelizing devices which surround the work site should be removed first, followed by flaggers that may have been used. The work area signing may then be removed and normal traffic patterns restored.

10.15. Maintenance and Protection of Traffic Plan…

Submission Requirements

10.15.1. Phase "A" Submission

Conceptual Construction Sequence Plans should be prepared at either 1"=100' or 1"=200' scale to show the overall approach to constructing the project. The plans should show existing and proposed roadways with a brief explanation of the construction sequence, including any detours.

10.15.2. Phase "B" Submission

Investigate project site specific conditions and Prepare Preliminary Maintenance and Protection of Traffic Plans:

1. Visit project site and note locations of the following:
    a. Horizontal and vertical sight distance restrictions due to existing roadway conditions (i.e. roadside vegetation, adjacent property usage, overpass bridge structures, sign structures, barrier curb, guide rail and/or horizontal and vertical geometry).
    b. Expected pedestrian activity, crosswalks, parks, schools, universities, bus routes, school bus routes, bus stops, emergency vehicle access routes, churches, stadiums, and/or shopping and industrial areas. When a park is located within the project limits, obtain a calendar of events and the name, address and phone number of the individual to contact for coordination of construction staging. Also obtain a calendar of major traffic generating events from the Authority's appropriate Operations Department where applicable.
    c. Existing emergency facilities for fire, rescue and/or police; where traffic signals exist, note if they are equipped with an optically controlled emergency vehicle detection system or a pre-empted system to provide for clearance of adjacent railroad crossings.
    d. Look for alternate routes which can be used as detour routes or congestion relief.
2. Review of Existing Information

a. Review as-built plans and/or collect field data necessary to determine the horizontal and vertical sight distances of the existing roadway throughout the project limits including 1,000 feet beyond each terminus.

b. For roadways outside of the Authority's right of way, obtain existing peak-hour traffic counts from the agencies with jurisdiction, with vehicle classification and 24-hour ATR traffic counts. Use this data to support decisions regarding minimum lanes to be maintained, detour requirements and work hours.

c. Review existing crash information to determine if any specific type of vehicle crashes may affect the proposed staging plans.

d. Determine if the traffic flow within the project area has any seasonal characteristics such as shore route, Holiday shopping route, etc.

e. Determine the agencies which have jurisdiction over the project area and potential detour routes.

3. Prepare Roadway plans in accordance with Section 3 (Submission Requirements) of the Procedures Manual. Note features that will affect traffic control such as number of lanes and lane widths, existing shoulder widths and pavement thickness, merge and weave requirements for ramps, lateral clearance restrictions, vertical and horizontal clearances at structures, structural widths (i.e., parapet to parapet, abutment to abutment, stringer spacing, etc.) and the location of major utilities, including the effect on their future maintenance.

4. Prepare Maintenance and Protection of Traffic Plans to show the overall approach to the required stages of construction of the project considering site specific conditions and work to be accomplished. Identify issues, constraints and time frames associated with the various stages to be studied in greater detail during Phase "C". If a project requires the relocation of utilities, the staging plans shall take into account any staging requirements necessary for such relocations.

5. Prepare a Traffic Impact Report as discussed in Subsection 10.4.

6. Contact and coordinate with appropriate State, County and Local Authorities (i.e. New Jersey Department of Transportation, South Jersey Transportation Authority, etc.) to obtain the required permits needed to enter upon lands under their jurisdiction. This coordination effort should include, but not be limited to:

a. Permits required and fees.

b. Authority's Traffic Control Plan Standards.

c. Insurance requirements.

d. Materials specifications.

e. Agreements between Agencies to perform certain types of work.

10.15.3. Phase "C" Submission

Prepare Final Maintenance and Protection of Traffic Plans:

1. Perform field visits and collect additional field data as necessary during the development of the Final Traffic Control Plans and Staging Plans.
2. The first two sheets of the Maintenance and Protection of Traffic Plans should be as shown on the Sample Plans, modified to address project site specific conditions. These sheets should contain General Notes, a Standard Legend of typical traffic control devices and a table showing recommended spacing of the channeling devices if project specific traffic control plans have been added to the contract plans.
3. Review the Standard Drawings, select details applicable to the project and modify to reflect the specific site constraints and construction procedures required to construct the project.
4. Review the Legend and modify to include other project specific symbols as necessary for traffic control.
5. Review the need for travel lane restrictions.
6. Review hours of operations or lane restrictions determined in the Preliminary Submission. Consideration should be given to the location of the project, calendar of events, etc.
7. Review the Traffic Control Detail General Notes and select the notes applicable to the project. Additional project specific notes should be added as necessary. The notes should include but not be limited to:
    a) specific restrictions placed on travel lanes,
    b) durations of closures,
    c) hours when work may be performed (include holidays and weekend hours),
    d) number of lanes of unobstructed traffic to be maintained in each direction,
    e) staging of traffic signals,
    f) temporary drainage,

g) allowable minimum widths of traveled way and if detour routes have to be established for over width vehicles,

h) number of lanes to be open to traffic,

i) diversionary routes with any restrictions,

j) traffic lanes or patterns to be maintained during construction for local roads affected by construction,

k) contractor's access and staging areas,

l) provisions for maintaining access to driveways,

m) signing for temporary access driveways to commercial developments.

8. The Sample Plans shall be modified to include other project specific information necessary to adequately address traffic control needs as follows:

   a) Where required for clarification, sectional views showing the placement of traffic control devices, such as construction barrier, adjacent to the traveled way and the work site shall be provided.

   b) When ramps or jughandles are to be reconstructed, consideration should be given to the effect that the work will have on traffic patterns or flow. Traffic Timing Plans for traffic signals may have to be altered. It is desirable that local government or the New Jersey Department of Transportation assume the maintenance of these facilities at the completion of construction.

   c) The need for a detour route should be considered if a ramp or jughandle is to be closed for construction. Also, where work is to be performed on a ramp or jughandle whose width is less than 14 feet, that ramp or jughandle should be closed while the work is being done or if the ramp cannot be closed, a temporary ramp widening may be required. When reconstructing a shoulder, consider the use of a temporary traffic shift to provide a buffer between the work zone and the traveling public.

9. Following the first two (2) sheets, prepare additional Maintenance and Protection of Traffic Plans to show plan views of project specific work sites when these locations need to be represented or where design features of traffic control devices or temporary pavement markings need to be indicated. Issues to address on the plans should include but are not limited to those listed in Item 7 above. These plans should contain notes pertaining to the various stages of construction that thoroughly describe each phase of

construction in the sequence to be performed. In addition, utility relocations that affect the staging of construction should be clearly identified within the sequence of work.

10. When temporary pavement areas are required, a typical section should be provided.
11. Prepare and include in the Maintenance and Protection of Traffic Plans the method of removal of surface water runoff during each stage of construction.
12. Review the construction staging to determine any seasonal constraints due to weather (i.e. snow removal etc).
13. Determine the constructability of the construction staging by reviewing the sequencing of work and methods of construction.
14. When staging the successive passes of resurfacing, consideration should be given to the location of the longitudinal pavement edge. Avoid placement of these edges within the wheel path.
15. Determine if underground work (i.e. new storm drains, pipelines, gas, electric, etc.) is sequenced to coincide with or enhance construction phasing, and that this work will meet traffic control constraints for lanes, etc. (i.e. check limits on applying a back slope in trenches when calculating lateral clearances. Also check if sheeting or a trench box will be required. Standard segment lengths of pipe should also be considered.)
16. If required, prepare temporary traffic signal plans, details and traffic signal timing plans associated with the staged installation of new signals.
17. Prepare construction details for any traffic control device not adequately covered in the Standard Drawings such as the following:
    a) Details for all temporary barriers and crash cushions to be utilized on the project, refer to Subsection 10.11.
    b) Construction signs not depicted in the Standard Drawings.
18. Prepare and include in the Maintenance and Protection of Traffic Plans, a tabulation of the channelization devices needed for the project.
19. Obtain Traffic and Parking restriction ordinances approved by municipalities.
20. Establish a maximum length of lane closure, length of alternating traffic and maximum number of intersections affected.

10.16. QUALITY CONTROL CHECKLIST FOR ENGINEERS

Engineers shall refer to checklist, posted on the Authority's website, throughout the development of the Maintenance and Protection of Traffic Plans and include with the Phase "C" Submission. An explanation is required for any "No's" checked.

10.17. TEMPORARY ATTENUATOR SELECTION

10.17.1. General

Once it has been determined that an attenuator is to be used to prevent errant vehicles from impacting a fixed object, a choice must be made as to which attenuator is best for the particular location under consideration. The attenuators presently recommended for installations on Authority projects are MASH Test Level 3 (TL-3) compliant redirective (non-gating) or non-redirective (gating). Redirective (non-gating) attenuators are designed to redirect a vehicle that impacts at any location along the face of the device. Non-redirective (gating) are designed to capture a vehicle or to allow it to pass through when hit along the face of the device. Temporary attenuators are typically non-redirective arrays due to the ease of installation and cost effectiveness; there are circumstances where redirective attenuators may be the better choice. See Section 4 (Guide Rail / Median Barrier / Attenuator Design) of this Manual for the design parameters associated with attenuators. The Authority maintains a list of approved redirective and non-redirective attenuators on the QPL.

Several factors must be evaluated when determining the appropriate type of attenuator. The number and type of factors to be evaluated precludes the development of a simple, systematic selection procedure. The factors which normally should be considered are briefly discussed below. In many cases, evaluation of the first few items will establish the type of attenuator to be used. When designing an attenuator, take the time to review the design instructions and product limitations in the manufacturer's design manual thoroughly before performing the necessary work. The Engineer shall review the manufacturer's design instructions and product limitations before specifying this product.

10.17.2. Dimensions of the Obstruction

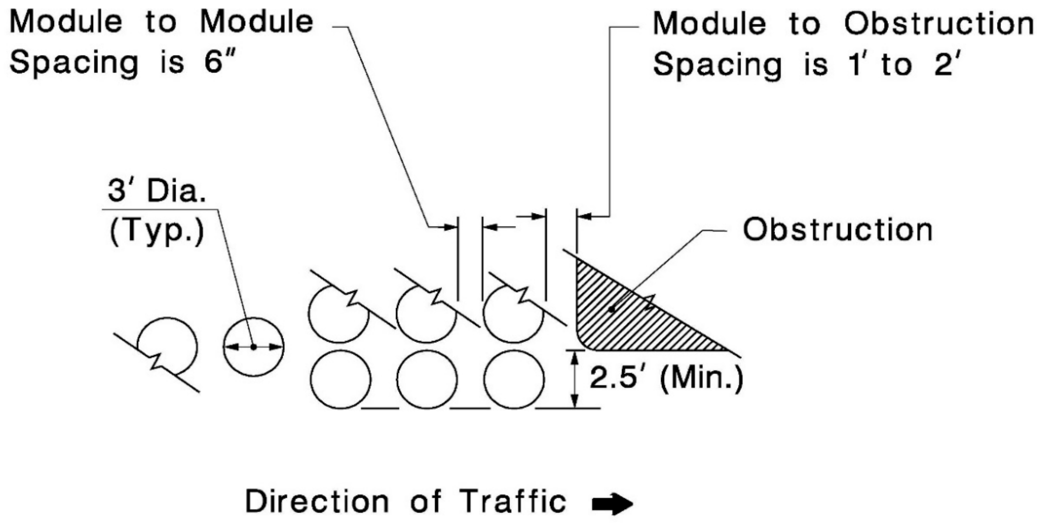
Non-redirective attenuators should be designed to prevent errant vehicles from impacting a fixed object of any width as needed.

10.17.3. Space Requirements

Area occupied by the attenuator:

All attenuators should be installed as directed by the manufacturer of the attenuator and in accordance with the MASH compliant testing. Non-redirective attenuators typically require a wider footprint than redirective attenuators. A general layout for non-redirective attenuators is depicted in Exhibit 10-2. Non-redirective attenuators will have a minimum width of approximately 6.5 feet (two barrels each at 3 feet wide plus a 6-inch space between them).

EXHIBIT 10-2 LAYOUT FOR LAST THREE MODULE ROWS IN NON-REDIRECTIVE ATTENUATORS



NOTE:

A minimum of two modules must be provided in the last three rows.

10.17.4. Geometrics of the Site

The vertical and horizontal alignment, especially curvature of the road and sight distance, are important factors to be considered. Adverse geometrics could contribute to a higher than normal frequency of impacts.

10.17.5. Physical Conditions of the Site

See Section 4 (Guide Rail / Median Barrier / Attenuator Design) of this Manual.

10.17.6. Redirection Characteristics

Non-redirective attenuators shall be designed to capture an errant vehicle to avoid impact with the obstruction. Redirective attenuators shall be designed to redirect an errant vehicle away from the obstruction and back to the travel way.

10.17.7. Installation Requirements

The attenuator system shall be installed as directed by the manufacturer of the attenuator and in accordance with the MASH compliant testing parameters. Refer to the QPL for currently approved temporary attenuators.

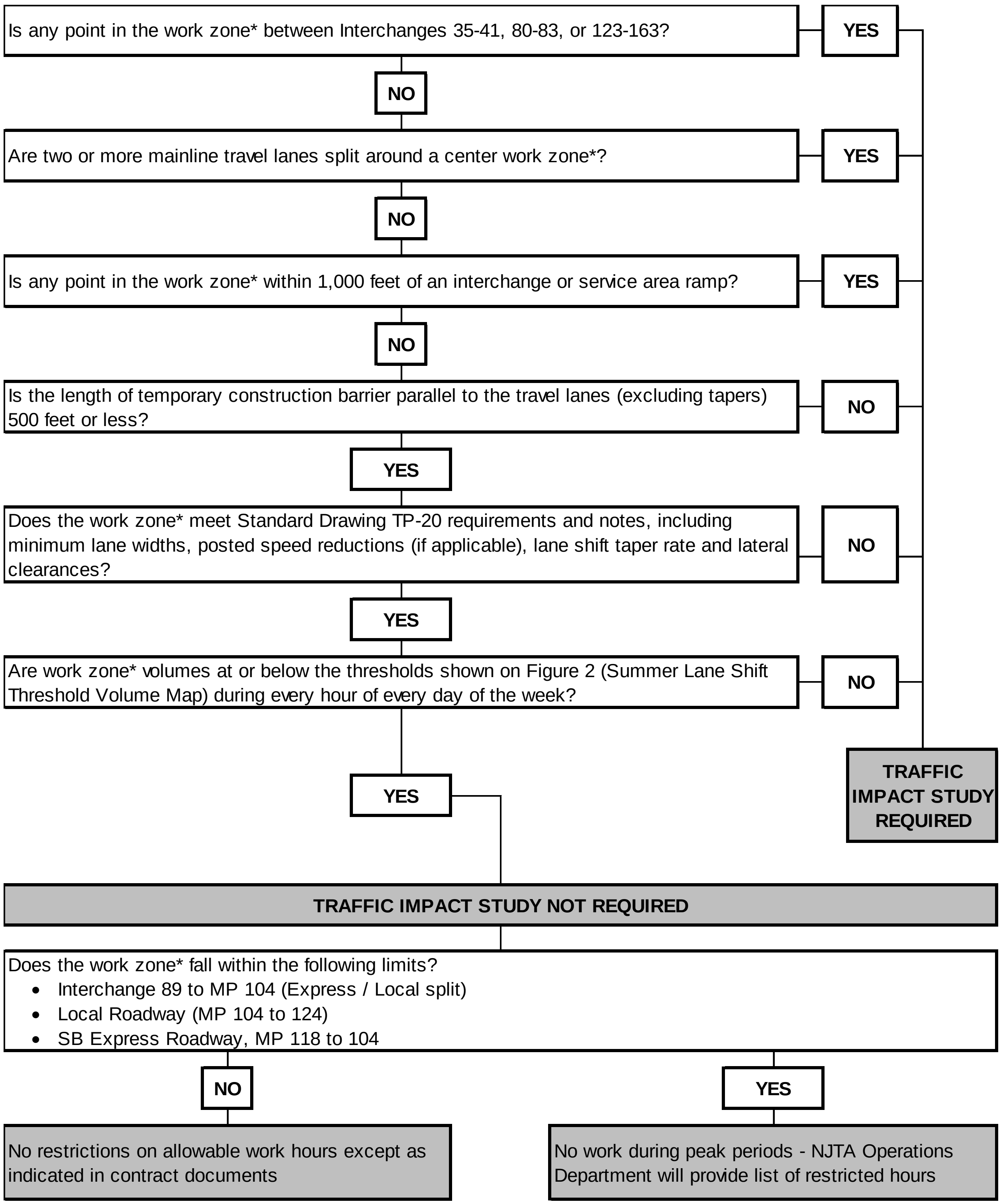
10.17.8. Maintenance

Non-redirective attenuators are particularly susceptible to damage during minor impacts. At locations where nuisance hits may be common or there is a high probability of crashes, attenuators with redirection capabilities should be considered as a means of reducing maintenance requirements.

10.17.9. **Cost**

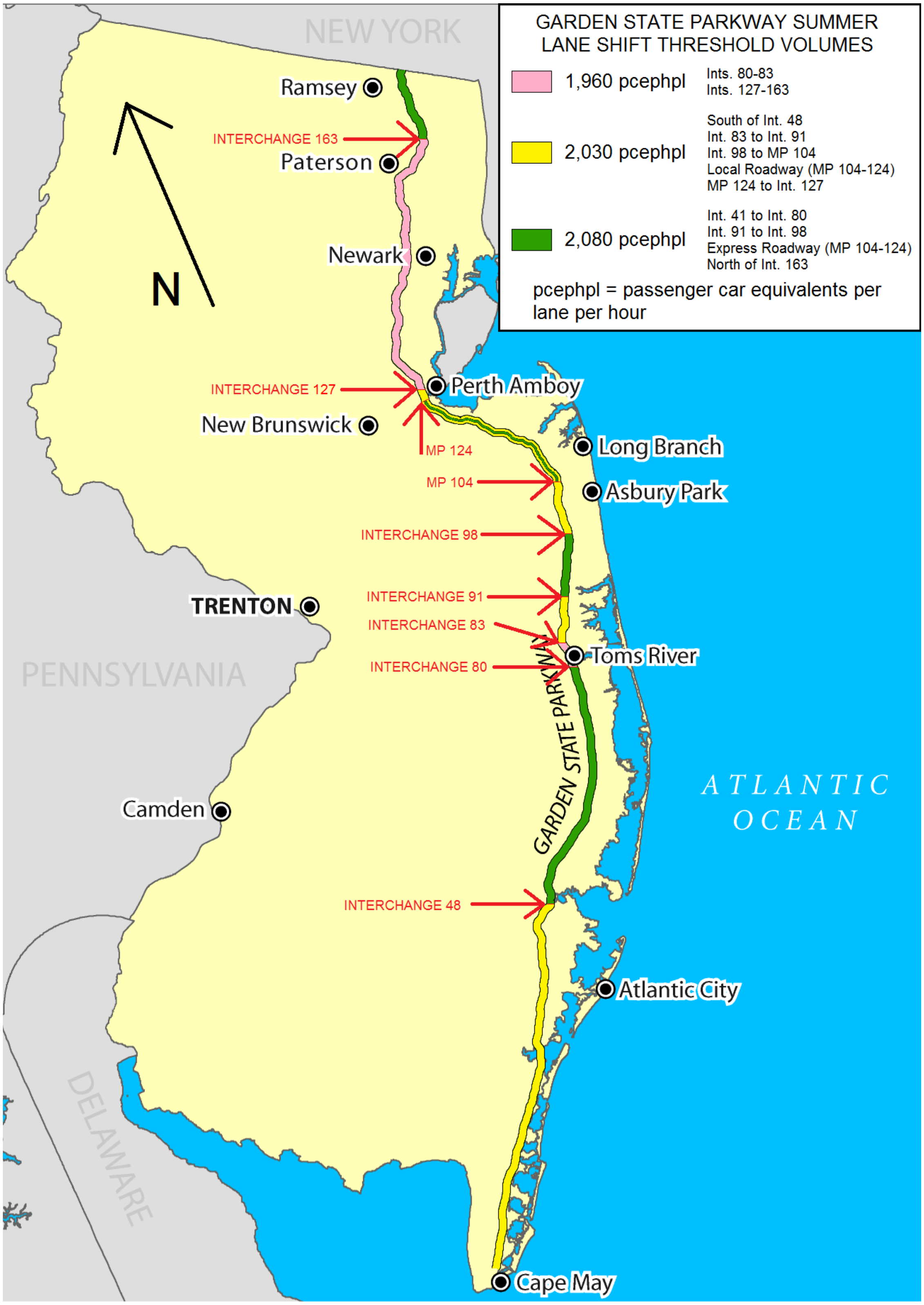
Compare initial costs of approved attenuators. The Engineer should consider reducing the number of unique attenuators used throughout a project design.

EXHIBIT 10 -3 GARDEN STATE PARKWAY SUMMER LANE SHIFT RESTRICTIONS FLOW CHART



* "Work zone" is measured from the beginning of the shoulder closure taper to the last cone or barrier segment in the closure.

EXHIBIT 10 -4 GARDEN STATE PARKWAY SUMMER LANE SHIFT THRESHOLD VOLUME MAP



Section 11 - LANDSCAPING

11.1. INTRODUCTION

During the design and plan preparation for all Authority projects, the Engineer shall exercise due consideration and judgment regarding all factors, including permit requirements that will affect the surrounding landscape and environment, both during and after the construction period.

11.2. DESIGN CONSIDERATIONS AND SPECIFICATION ITEMS

11.2.1. General

On all Authority projects, the right-of-way is to be carefully and completely landscaped to minimize any community intrusion and to maximize the preservation of the existing environment. Where appropriate and possible, while meeting design and safety requirements, existing vegetation within the right of way is to be carefully preserved and made a part of the final landscape design.

Wide medians between roadways may be pleasingly aesthetic, but they may also cause severe impacts on the surrounding area or be cost prohibitive. New design projects that could possibly incorporate wide medians to separate roadways shall be discussed with the Authority's Engineering Department on a case-by-case basis.

All projects must be prepared in accordance with "New Jersey No Net Loss Reforestation Act" (N.J.S.A. 13:1L-14.1 et seq.). If a project will deforest more than ½ acre of land, a Reforestation Plan is required. In addition, if a project will deforest more than one acre of land, it is required that a public forum be held in conjunction with the project's public involvement process. Reforestation Plans shall be submitted for review and comment to the New Jersey Department of Environmental Protection, Division of Parks and Forestry through the Authority's Project Manager.

11.2.2. Clearing and Grubbing

1. In clearing and grubbing for fence installations, the minimum of vegetation is to be removed or disturbed and the removal of major trees is to be avoided. In general, through a woodland, a maximum 8-foot swath may be cleared; through an isolated group of trees a 4-foot swath may be cleared. A fence line should go around isolated trees having a caliper greater than 4 inches. All trees removed shall be cut flush with the ground.

2. In felling trees, care shall be taken to avoid injury to trees and other vegetation that are to remain. Should any damage occur, proper horticultural measures are to be taken to ensure that damaged areas will heal as rapidly as possible.

3. Burning is not permitted. No wood or brush, except tree stumps, shall be buried within the right of way. All wood is to be chipped and either stockpiled in designated areas or spread evenly to a depth of 3 to 4 inches in areas to be reforested. The plans are to designate the area where the chips are to be stockpiled. The Authority's Engineering Department will advise the Engineer in what areas the chips are to be spread. Diseased trees are not to be chipped but are to be removed from the project site.

4. Where excavation or filling will occur in the vicinity of trees which are to remain, either tree walls or tree wells shall be provided and shown on the plans.

   a. Tree Walls - These shall be provided where the existing grade is to be lowered. A minimum number of tree roots shall be removed. Required cuts shall be neatly made and those 1 inch in diameter or greater shall be painted. Roots temporarily exposed to the air shall be kept moist by the use of wet burlap or other suitable materials until again covered by earth.

   b. Tree Wells - Where the existing grade is to be raised, wells shall be provided to prevent shock due to alteration in drainage and airation.

11.2.3. Conservation of Native Plant Materials

1. Native plant material shall not be cleared and grubbed outside of the specific areas to be occupied by new construction, except as necessary to facilitate future maintenance operations within the right of way and as necessary for the installation and maintenance of right of way fencing.

2. Stripped topsoil or any other materials shall not be stored either within or at the edge of native woodland, as equipment working in and around trees can seriously damage tree roots. All materials shall be stockpiled in areas selected especially for that purpose. No topsoil is to be removed from within the Authority's right of way. Topsoil is not to be placed in excess of 4 inches unless directed by the Authority's Engineering Department. Excess topsoil is to be stockpiled within the right of way in an area approved by the Authority's Engineering Department. The Authority's Engineering Department is to be notified of any project in which topsoil is to be imported as generally topsoil should not be imported.

3. Individual trees to remain are to be barricaded to protect them from injury.

4. Provision shall be made to selectively thin native woodland, including the removal of dead and diseased trees. This work, is to be included under the item "Clearing and Grubbing" and the areas clearly defined on the plans.

11.2.4. Drainage Facilities

1. Care shall be taken so that water does not drain into or become ponded in native woodlands. Final plans should be checked against 1”=30’ or 1”=50’ scale mapping to assure this.
2. Water swales are to be sodded rather than paved, wherever possible.
3. Water retention basins shall be provided as necessary to slow down surface water runoff, thus minimizing erosion.
4. Temporary or permanent siltation basins shall be provided as necessary and used during construction in order to avoid the siltation of natural streams or lake beds.
5. Primary surface drainage waterways should be set back at least 60 feet from the edge of roadways and screen planting provided. Small sodded water swales should be used, as much as possible, to convey surface water to the main waterway.
6. It is preferable that small natural waterways be temporarily bridged during construction, rather than being dammed and piped, in order to minimize siltation of the waterway.
7. As an aid to erosion control, soil stabilization matting should be provided in all waterways and around all inlets, catch basins, and at the top and toe of all slopes as directed by the Engineer. Provision for this is to be incorporated into the plans.
8. Where underground water springs come to the surface, the immediate surrounding area shall be covered with a layer of coarse gravel or rip rap.
9. In service areas, surface drainage systems shall be enclosed where practicable, and open ditching shall be avoided.

11.2.5. Grading

1. No slopes shall be greater than 2 on 1. Three on 1 or 4 on 1 slopes shall be used wherever possible.
2. All slopes are to be graded in relation to the natural contours.
3. The work is to be scheduled and conducted to avoid excessive erosion during construction. Temporary erosion and sediment controls shall be provided as necessary, not only for the work conducted within the right of way, but also on haul roads, at borrow pits and at disposal areas outside the right of way.
4. Surface erosion shall be kept to a minimum during construction.

5. Bare areas shall be seeded, sodded or otherwise planted as soon as possible, even if temporary measures are to be used.
6. Crown vetch and birdfoot trefoil should be utilized wherever possible to minimize maintenance. On mainline berms, however, it should be no closer than 5 feet from the edge of shoulder.
7. Where turf is to be maintained by mowing, no areas shall be less than 18 feet in width.
8. Grading and planting shall be provided as near as possible to residential areas to aid in sound and sight buffering.
9. Where existing pavement is to be abandoned in seeded areas, it shall be completely removed if it lies within less than 18 inches of the finished landscaped surface. If such pavement lies more than 18 inches but less than 3 feet below the finished surface, it shall be broken up into pieces no greater than 2 square feet in size and left in place. If it lies below 3 feet of the finished surface, it will not be necessary to break up the abandoned pavement unless other circumstances warrant such treatment.

11.2.6. Service Area

Planting areas shall be provided in parking lots to serve as traffic dividers, and elsewhere in Service Areas as appropriate for aesthetics.

11.3. Landscaping Plan Preparation

11.3.1. By the Engineer

The Engineer shall prepare a separate set of basic plan sheets for the landscaping portion of the project. These sheets are to be provided to the Landscape Architect and shall be to a scale of either 1”=30’ or 1”=50’. This set of drawings shall be included with the Phase “B” submission and show the following:

1. Bar scale and north arrow.
2. Existing topography to remain, i.e. buildings, fences, utility poles, walls, roadways, vegetation, etc.
3. New mainline roadways and ramps, median, shoulders, curb tops and toes of slopes.
4. There is to be no lettering, lines, etc. between the edge of pavement and the top or toe of slope, similarly the outlying wooded or other areas shall be as clean as possible.
5. Bridge structures.

6. Service areas, including access roads, buildings, parking areas, walkways, etc.
7. Waterways, culverts, drainage lines, catchbasins, inlets.
8. Right of way fencing, guide rail, light standards, signs, mileposts, etc.
9. Descriptive notes, dimensions, etc. shall be kept to a minimum number necessary for complete definition.

11.3.2. By the Landscape Architect

All landscape plans shall be prepared by a Certified Landscape Architect licensed to practice in the State of New Jersey and coordinated with the Authority's Engineering Department.

Upon receipt of the set of the copies of the basic plan sheets, the Landscape Architect shall indicate thereon the type and location of new landscaping features and planting, using industry standard symbols.

The Landscape Architect shall also prepare a tabulation of the quantity, type and size of each new planting to be provided, which shall list the proposed plantings on each individual plan sheet. The Table of Quantities in the Plans, the Proposal in the Contract Documents, and the Engineer's Estimate shall also include the pay items for each proposed planting or lump sum landscaping items.

11.4. Preparation of Contract Proposal and Specifications

11.4.1. Proposal

The proposal shall contain specific pay items for each item of work involved in the landscaping operations, as well as specific pay items for work involving erosion and pollution control.

Work involving erosion and sediment control will generally be covered in proposal items pertaining to grading, drainage and landscaping work. However, in the event special items of work are necessary to cover work of an environmental nature, they shall be included in the proposal and supplementary specifications.

11.4.2. Specifications

Division 700 of the Standard Specifications covers the general topics relating to landscaping work. Supplemental specifications will be required to cover any other items of work included in a particular construction contract, as well as provisions for erosion and sediment control.

In addition to items previously mentioned herein, the specifications shall provide for the following with respect to landscaping work and erosion and pollution prevention and control:

1. The Contractor shall take precautions to prevent pollution and siltation of flowing and impounded waters as a result of their operations. The Contractor shall provide such temporary pollution and erosion control measures as are necessary to insure that no adverse pollution or erosion occurs.
2. Erosion control measures shall be applied not only to work conducted within a contract's construction limits, but also to haul roads, borrow pits and disposal areas within the Authority's right of way.
3. The work shall be conducted in such a manner that surfaces are exposed to erosion by the elements for the least time possible. The work shall be prosecuted continuously and diligently to minimize erosion exposure time of surfaces. Should the work be halted or suspended, the Contractor shall take appropriate measures to protect the work during such suspended periods.
4. Should the Contractor fail to properly or adequately control erosion and water pollution, the Authority shall have the right to engage outside assistance to effect such control, at the expense of the Contractor.
5. The Contractor shall coordinate topsoiling and finishing operations with the turf establishment work.
6. In the event that planting season restrictions prohibit seeding and planting operations, the Contractor shall protect the exposed surfaces against erosion.
7. No more seed shall be sown on any one day than can be mulched within 48 hours.
8. Seeding shall be performed at only such times as present and predicted weather conditions are conducive to germination and growth of the seed.
9. Tillage equipment shall be operated generally at right angles to the direction of normal surface drainage.
10. For additional methods and details for erosion control, see Section 4 (Drainage Design) of this Manual.

11.5. MISCELLANEOUS

11.5.1. Disposal of Stumps

The Engineer is to designate areas on the plans where the contractor can dispose of stumps within the Authority's right of way if at all possible. No treed areas are to be cleared for this operation without specific approval from the Authority's Engineering Department.

The disposal areas are to be located outside the slope lines. The stumps are to be covered with at least 3 feet of embankment. Excess excavation may be used for embankment construction if approved by the Resident Engineer.

11.5.2. Disposal of Unsuitable Material

The Authority prefers that on-site areas be provided for the disposal of unsuitable material.

11.5.3. Seed

1. New Jersey Turnpike
   a. Type “A” seed shall be used on permanent slopes flatter than 3H:1V.
   b. Type “B” seed is for temporary applications
   c. Type “C” seed is for high quality lawn areas such as service areas and toll plazas.
   d. Type “L” seed is to be on all slopes steeper than 3H:1V. Wherever Type “L” seed is used, an equal quantity of soil stabilization matting shall be provided.
2. Garden State Parkway
   a. Wildflower seed mixture shall be used on permanent slopes flatter than 3H:1V.
   b. Wildflower seed mixture for steep slopes is to be used on all slopes steeper than 3H:1V. Wherever wildflower seed for steep slopes is used, an equal quantity of soil stabilization matting shall be provided.

Section 12 - Facility Buildings / Toll Plazas

12.1. General

This section addresses the design and construction of the various facility buildings and toll plazas on the New Jersey Turnpike and Garden State Parkway.

The buildings addressed are the maintenance district buildings, utility buildings at the toll plazas, salt storage domes, and other secondary buildings. Providing guidance for the planning and construction of these various buildings shall assist the Authority in standardization of facilities throughout the system.

The toll plaza is a facility built to collect tolls on the New Jersey Turnpike and Garden State Parkway. It typically consists of the toll plaza area formed of islands, toll booths, pavement, tunnel and canopy. Adjacent to the plaza is the utility building which is built to house the toll collectors and equipment necessary to process tolls in a secure environment. For all new plazas, a tunnel usually connects the utility building to the toll booths located on the islands. A parking lot or parking area is typically required for the toll collector's vehicles as well as maintenance or state police vehicles.

Since an Architect is generally employed by the Authority for the design or renovation of the toll building, close design coordination between the Architect and Engineer is required and the limits of responsibility for each must be clearly defined. Many of the design responsibilities are outlined in the following Subsections. A sample "Coordination of Work" is attached at the end of this section. A similar listing shall be developed during Phase "A" of each project as an aid in the coordination of the many contracts that will be prepared.

12.2. Department of Community Affairs Procedures

All buildings and toll plazas must have their design documents submitted to the Department of Community Affairs, Division of Codes and Standards, Bureau of Construction Project Review, commonly identified as the DCA. All portions of habitable buildings, as well as the toll plaza tunnels, stairways, railings, access and egress, toll booths and toll plaza canopies must be designed in conformance with the currently adopted codes.

The adopted Code and Sub-codes for work on Authority facilities are as follows:

Code:	New Jersey Uniform Construction Code, UCC (NJAC 5:23)
Sub-codes:	International Building Code, IBC – New Jersey Edition
	National Electric Code, NEC
	National Standard Plumbing Code, NSPC
	International Mechanical Code, IMC

International Fuel Gas Code, IFGC

Rehabilitation, UCC 5:23-6

Barrier Free, UCC 5:23-7 and ANSI A117.1

Elevator, ASME A17.1

Energy ASHRAE 90.1

In addition to those listed above, other ancillary Sub-codes may be needed for specialized work and construction. The Engineer shall contact the DCA to verify the currently adopted Code and Sub-codes for the work being designed at the time of the design. Currently adopted codes can be found at:

http://www.nj.gov/dca/codes.

Special design standards are required for all renovation, rehabilitation, addition, and change of use projects. The Engineer and Architect shall coordinate with the DCA to determine these requirements during Phase "A" design.

Contract plans, specifications and design calculations for the building and toll plaza work must be submitted to the DCA for review and concurrence to ensure that the documents are in conformance with the codes. The documents must be signed and sealed, as appropriate, by a Professional Engineer or Architect Licensed in the State of New Jersey and should represent the final design, specifications and plans slated for construction. Instructions for submittal of design calculations, specifications and plans, along with the project review application and the fee schedule associated with the reviews can be found under Construction Project Review at:

http://www.state.nj.us/njbusiness/license/permits/construct/forms.shtml

Approval of the submission and any subsequent revisions will result in a release for construction.

The fee to the DCA, for review of the contract documents, will be paid by the Engineer or Architect and reimbursed by the Authority.

12.2.1. DCA Submission Schedule

For most design-bid-build contracts, a complete plan release should be requested. This entails a complete submission of all plans, specifications, design calculations and fees for review by the DCA at one time after the design is complete. Since the portion of the contract affected by DCA procedures must be basically complete for this type of submission, the Phase "C" submission date is the latest date for initial submittal to the DCA. The DCA has a period of 20 working days from the date the submission is accepted to review and comment on the initial submittal. Subsequent submittals for corrections or revisions will be reviewed within a period of 7 working days from the date the subsequent submission is accepted. Several review cycles are often required.

If partial plan releases are requested on projects that require construction of elements before the entire project is designed, such as design-build projects, then each element of submission will have its own 20 working day review period. The fee for the entire project must be submitted with the initial elements along with a schedule of anticipated submission dates for the remainder of elements to be reviewed. The Engineer or Architect shall submit the required record copies and request at least one (1) signed and sealed approved copy from the DCA for record purposes. Once plans are complete, permits shall be coordinated by the Contractor.

If any standard drawings are required to be submitted to the DCA for review, the Authority's Engineering Department will forward signed and sealed copies to the Engineer or Architect upon request.

12.3. FACILITY BUILDINGS

The facility buildings addressed include district maintenance buildings, utility buildings at the toll plazas, salt domes and other secondary types of facility buildings.

12.3.1. District Maintenance Buildings

1. The district maintenance buildings are usually designed and constructed as a separate contract with an Architect as the lead for building design and a Civil Engineer for the site work. The buildings shall comply with the DCA procedures as written in Subsection 12.2.

2. The design of a new district maintenance building shall follow the directions given in Subsection 12.4.5 as an overall planning program for the work to be accomplished.

3. Room sizes, locations, equipment, storage capacity and materials for the building shall be discussed with the representatives of the Authority's Maintenance Division during Phase "A" of the design process so that recommendations can be established before final design and plan preparation.

   The district maintenance building shall be a one story facility with the following rooms and facilities subject to the Authority's Maintenance Department approval:

   - 2 Supervisor's offices
   - Separate Men and Women Restrooms/ Locker Rooms/ Bunk Rooms
   - Lunch Room with cooking facilities
   - Stock & Inventory Room w/ Maintenance Record Clerk office within
   - Mechanic's Room
   - Mechanical Room with Secure Storage Area
   - Network Equipment Room
   - Janitor's Closet

- Garage Bays, number and size to be determined, includes exhaust removal system
- Vehicle Wash Area
- Intercom System
- Other security and communications systems as directed by the Authority

4. Site design for a maintenance building facility shall provide for the below listed items subject to the Authority's Maintenance Department approval:

   - Tire Storage in a separate building (shed)
   - Stand by Generator
   - Tank Storage Area
   - Ground Mounted Exterior Compressors with Interior Air Handling Units Fuel Facilities with Gasboy and Veeder-Root System
   - Security System and Cameras compatible with the most recent approved systems
   - Electric Diesel Heater Power Supply
   - Covered Vehicle Storage Area
   - Parking for Employees and Maintenance Vehicles
   - Provisions for Stockpile Bins

12.3.2. **Utility (Toll) Buildings**

For a complete discussion of the design parameters on the Utility Buildings, refer to Subsection 12.4.5.

12.3.3. **Salt Storage Facilities**

1. These structures are constructed for the purpose of stockpiling de-icing material to be used in the ice and snow control program for the Authority. They are primarily located at the various Maintenance Districts for direct and quick access by maintenance forces throughout the length of the New Jersey Turnpike and Garden State Parkway.

2. The salt storage facilities shall conform to a high quality bulk storage structure as manufactured by Dome Corporation of North America, Saginaw, MI, or an approved equal. The structures shall be mounted on a 12 inch thick reinforced concrete retaining wall approximately 8 feet in height above the ground.

3. The Engineer or Architect shall discuss the parameters of the salt storage facility design and construction with the Authority's Maintenance Department during Phase "A" design to establish the size, storage capacity, number of entrances, electrical facilities and possible site condition aspects of the project.

4. All electrical work in the salt storage facilities shall be performed in conformance with the proper NEC code, the requirements of Subsections 8.4 and 8.5 in this Manual and be subject to review and inspection by the DCA.

12.3.4. Other Buildings

Buildings for purposes other than those indicated above include but are not limited to, small communications shelters required for toll plaza systems, radio and microwave towers, and cellular phone installations. Before beginning design of these structures, the Engineer shall determine the specific requirements of the Authority's Engineering and Technology Administrative Services (TAS) Departments, and prepare a preliminary design memo for the Phase "A" Submission for review by the Authority's Engineering Department.

12.4. Toll Plazas

12.4.1. Geometrics

The toll plaza geometric design criteria presented herein describe the essential standards and policies for the design of a widened or new plaza. The criteria apply to the general type of plazas utilized by the Authority with a toll utility building on one side of a barrier type plaza with or without reversible lanes. Split toll plazas with the toll utility building in the median area between opposite direction roadways will be considered non-standard toll plazas and are to be addressed on an individual basis. The type of plaza to be used on a given project will be dictated by the Authority's Engineering Department.

1. Design Speed

   The design speed for the toll plaza area varies from a stop condition at the booths to the controlling ramp or mainline design speed. Both horizontal and vertical geometry must be compatible with this variable design speed.

2. Horizontal Alignment

   a. Length - The desirable minimum half-length of the toll plaza area is 500 feet from the plaza centerline to either the ramp nose split or normal roadway width. The length of the toll plaza area is dependent upon the geometric controls of the site.

   b. Width - The plaza width is controlled by the number of lanes dictated by the Authority's Engineering Department.

   c. Configuration - Each standard plaza should taper symmetrically from the ramp nose to the end of the concrete toll plaza slab. Equal reverse curves are generally used for plaza edge geometry in order to attain such a taper.

Each split plaza shall be oriented such that the right edge of the lanes approaching the plaza is approximately tangent, thereby permitting traffic to disperse to its left, a more natural pattern. Similarly, the configuration of the lanes leaving the plaza shall also encourage the natural merge left pattern.

3. Vertical Alignment

    a. Grades - An initial negative 0.5 percent grade away from the plaza centerline for about 200 feet is required for all plazas. It is desirable that relatively flat grades (2 percent or less) be held for at least 500 feet in each direction.

    b. Vertical Curves - At the plaza centerline, a vertical curve shall not be used. A 1 percent break in profile shall be designed.

    c. Superelevation - For the limits of the concrete plaza slab (See Pavement below) there is to be a 0.0 percent cross slope. From the edge of the slab there is a transition to a normal ramp cross slope of 1.5 percent in about 100 feet. Care must be taken to investigate edge profiles such that ponding of water is avoided and the profile does not exceed 3 percent. For wide plazas, increased cross slopes may be required.

    d. Clearances - The minimum vertical clearance under the canopy is to be 17 feet 0 inches. Overheight vehicle detectors, if required, shall be set at 13 feet 6 inches above the toll lane pavement. See Subsection 12.4.6.

4. Pavement

    a. Pavement types will be established by the Authority’s Engineering Department. For the initial 500 feet or to the ramp nose, whichever is less, the shoulder pavement, if present, shall be replaced with full depth pavement.

    b. For concrete pavement details, see TI Standard Drawings. For new toll plazas, the approach and exit pavements shall be 10” Thick Portland Cement Concrete Pavement reinforced with #5 bars at 10” o. c., top and bottom, both longitudinally and transversely. The approach pavements shall have 6 slabs at 33’-4” long (200 feet). The exit pavements shall have 3 slabs at 33’-4” long (100 feet). All slabs shall be 16’-6” wide.

       For widening of existing toll plazas, the approach and exit pavements should match the dimensional layout of the adjacent slabs. All new pavement slabs shall be reinforced as noted above.

Care shall be taken during design to prevent interference between vehicle detector loops and reinforcement steel in concrete pavement. The Engineer shall coordinate with the loop manufacturer as designated by the Authority's ETC Department to ensure compliance with all installation guidelines.

5. Plaza Layout
   The standard layout for the toll plazas includes the following parameters, the Standard Drawings TI-1 to TI-7, Exhibit 12 - 4 and Exhibit 12 - 5 at the end of this Section.

   a. 10'-0" lanes widths (normal)

   b. 6'-6" toll island widths

   c. 12'-0" lane widths for each outside lane to allow for oversized or wide loads

   d. Tunnel placed beneath the entire width of plaza and connected to adjacent utility (toll) building basement.

   e. Stairways from island to tunnel placed so that toll collector has to cross only one lane of traffic (maximum) to get to assigned toll booth.

   f. A canopy approximately 40 feet wide that covers all toll plaza lanes and approximately one-half of the outside lanes (as a minimum).

Such items as the number of lanes, future lanes, staircases, parking spaces, toll booth types and E-ZPass lanes will be provided by the Authority's Engineering Department for each toll plaza. Designs shall account for a future plaza widening in all respects, unless directed otherwise by the Authority's Engineering Department. Express E-ZPass lanes shall be designed as mainline roadways.

12.4.2. Toll Booths and DATIM Enclosures

Toll booths for use on the Turnpike shall be manufactured in conformance with the Standard Drawings TB-1 to TB-7. DATIM enclosures (used on Turnpike only) are toll booths that have been designed and manufactured to hold the dual automatic ticket issuing machine (DATIM) at entry lanes designated for the specific purpose of providing toll tickets to patrons. The DATIM enclosure is the same overall size as the standard toll booth but has been modified to hold the DATIM machine and not manned by a toll collector.

Toll booths for use on the Parkway are not the same construction as those used on the Turnpike. [Standard Drawings for Parkway Toll Booths will be published at a later date.] All Parkway toll booths shall be designed and constructed to accept a coin machine of the current design used by the Parkway, as well as blister and violation observation window.

Toll booth construction is usually contracted for separately and installed later by the toll plaza contractor. The toll booths fabricated shall be Industrialized Building Commission (IBC) Certified in conformance with Section 519.03 of the Standard Specifications. The DCA must have the certified plans (shop drawings) submitted to them before there is final approval and release of the interior and exterior building construction for the toll plaza tunnel. This requirement promotes the development of an earlier, separate contract for the toll booths so that toll plaza construction will not be compromised or delayed waiting for toll booth certification.

12.4.3. Tunnels, Islands and Canopies

Details for islands, tunnels and bumper blocks are indicated on Standard Drawings TI-1 to TI-5. These details are applicable to standard and split plazas. Standard (two way) plazas would incorporate Standard Drawing TI-2 for all the islands at the plaza. Unidirectional or split plazas would incorporate Standard Drawing TI-1 for the islands. Plans for previously constructed plazas would be supplied to the Engineer for use in developing contract plans for widened plazas. Island lengths other than present standards may be considered by the Authority's Engineering Department if geometry at the toll plaza may preclude the use of the standard islands.

Depending on the Engineering Agreement, the responsibility for canopy design may lie with either the Engineer or the Architect. Unless specifically requested by the Authority's Engineering Department, canopy design shall require adaptation of earlier canopy designs to match aesthetic appearances. The canopy is usually part of the overall toll plaza contract but may be a separate contract from the tunnel and islands, if so dictated by the Authority's Engineering Department.

The canopy contract (if separate) usually includes other items such as traffic signals, overheight vehicle detectors, canopy lighting, E-Z Pass equipment supports, and roof drains and leaders. The canopy column grillage beam anchorage is included in the canopy contract while the anchor bolts are placed by the plaza contractor. The construction limits of these various items must be clearly shown on the Plans if the canopy is not in the toll plaza contract.

12.4.4. Toll Plaza Contract

The Engineer is responsible for preparing a toll plaza contract which is to include the following items and other items detailed later in this section. This contract may be included as part of a larger contract with the approval of the Authority's Engineering Department. The limits of responsibility are as detailed on Exhibit 11 - 4, Exhibit 11 - 5 and Standard Drawings TI-1 to TI-7. Work generally includes all conduits, pipes, etc. that are embedded in concrete.

1. Excavating, paving, drainage (tunnel pumping if required) and grading (including building site).

2. Tunnel, tunnel doors, islands and concrete plaza slab.
3. Canopy and associated items (unless the canopy is considered for a separate contract)
4. Piles, reinforced with caps for buildings and/or tunnel if required.
5. Conduits with pull wire embedded in tunnel roof, concrete plaza slab and islands and other electrical, communication, and toll equipment as detailed in the Engineering Agreement and described in Subsection 12.4.6.
6. Treadle frames, curb boxes, electric roughing (conduit installation for electric service) and treadle drainage. Treadle frames are required in exit lanes only on the Turnpike and at all lanes on the Parkway.
7. Canopy anchor bolts.
8. Coordination of delivery and installation of toll booths (supplied by toll booth contractor).
9. Equipment

   See Subsection 12.4.6 for Equipment requirements.
10. Utilities
    The utility relocations associated with toll plazas are generally discussed in Section 8 (Utility Installations, Relocations and Adjustments) of the Procedures Manual. The Engineer is responsible for coordinating at least the following relocations with both the Architect and utility company.

    a. Telephone - Service shall be installed to the utility building to a demarcation point (the “Verizon Demark located in the Radio Room. The Engineer shall coordinate with the Authority’s Technology and Administrative Services (TAS) Department to determine a point of contact for the recommended vendor).
    b. Sanitary - If connection to a public system is feasible, the Engineer shall make the necessary provisions. If a septic field or tank is required, the Architect will make the necessary provisions.
    c. Power - The Engineer shall provide the conduits to and make the arrangements for power services to pad mounted transformers outside the utility building. The Architect is responsible for connections from the transformer to the building. Load requirements for the building, the toll booth equipment, the interchange lighting, etc. must both be considered.
    d. Water - The water supply to the utility building is the responsibility of the Engineer if supplied by a utility company. If the supply is from a well, the Architect is to supply the necessary service.

e. Fiber Optic – Connection of backbone cable via lateral to building.

11. Drainage

    As previously indicated, the drainage pattern in the toll plaza area is an important consideration in the development of both the horizontal and vertical geometry. Ponding of water is not permitted in the pavement area. Transverse drainage troughs or slotted drains are not allowed in the toll plaza area. Treadle drains for new construction, as shown on Standard Drawing TI-7, are to be provided in each New Jersey Turnpike exit lane and each Garden State Parkway lane.

12. Lighting

    All lighting associated with a toll plaza is to be provided as outlined in Section 8 (Lighting and Power Distribution Systems) of this Manual.

13. Signing and Striping

    All signing and pavement striping associated with a toll plaza are to be provided as outlined in Section 6 (Signing and Striping) of this Manual and Standard Drawing PM-1. A preliminary striping layout for the plaza should be submitted to the Authority's Engineering Department at Phase "A" as an aid in evaluating the plaza geometry.

14. Maintenance and Protection of Traffic

    Where maintenance and protection of traffic is required for the widening of an existing plaza, as many lanes of traffic as possible must be maintained through the existing plaza. Any scheme requiring closing of existing lanes must be approved by the Authority's Operations Department. The number of lanes required during any stage of construction will be determined by the Authority's Operations Department.

12.4.5. **Utility Building**

1. Architectural design shall be performed by an Architect registered in the State of New Jersey. The Architecture design team including the related building engineering disciplines - such as mechanical, electrical, and plumbing - is usually contracted for separately by the Authority.

2. The architectural design quality and language of the utility building shall become definitive through exploration of multiple schemes, the consideration of existing conditions and direct design coordination with the Authority's Engineering Department. High performance / "green building" design strategies shall be explored where schedule and budget allows.

3. The building site design and preparation is the responsibility of the Engineer. This includes the taking of the necessary borings to be provided

to the Architect. The Engineer is also responsible for the rough grading of the building site. Coordination of the building foundation requirements is necessary at all stages of design. It may be found that the toll plaza contractor should install the piles for the building.

The building design team's responsibilities generally include all areas up to five feet outside the limits of the building with the following additional items being included although outside the five-foot limit.

a. Septic tanks or disposal fields (if required).

b. Oil storage tank.

c. Well and pump and piping (if required).

d. Power transformers.

e. Generators.

Reference is also made to the Exhibit 12 - 2 "Toll Plaza Coordination of Work" included at the end of this Section. The Engineer is responsible for providing sanitary and water utility service from adjacent local roads if it can be justified economically.

4. Materials and finishes considered for the utility building shall be cost effective, durable and low maintenance. Consideration shall be given to materials that are derived from renewable resources and contain a high recycled content. The exterior of new buildings should be comprised of highly durable and long lasting materials such as brick, masonry or pre-cast concrete. Roofing should consist of energy efficient standing seam systems. Glazing systems should consist of "low e" insulated glass. The interior floor finishes should consist of porcelain tile for the lobby and corridor areas and ceramic tile floors and walls in restrooms and locker areas. Office areas, count rooms and swing rooms should have linoleum, cork, or rubber floor coverings. Use of vinyl composition tile is discouraged as a health and environmental hazard and use of carpet is discouraged for maintenance reasons.

5. Interface with the Traveling Public/ Lobby

   In accordance with Authority policies, access to the toll utility buildings is restricted to those persons conducting Authority business. In emergency situations, access may be granted to patrons for use of restroom facilities in the lobby, or other appropriate and supervised reasons. Due to Authority policy, patron entry shall be allowed via a controlled access entry door where the plaza supervisor can securely buzz a patron in. Upon entering the lobby, the patron can then interface with the plaza supervisor via a secure, glazed transaction window. Access beyond the lobby is restricted only to Authority personnel and controlled via another access door. For security reasons, access to and from the tunnel must be through the lobby area of the Utility Building. Amenities such as a drinking fountain, an accessible unisex restroom, a public telephone and, if space permits, vending machines should be located in the lobby.

6. Building Program/Space Allocation

   The standards below are a flexible list of core spatial requirements that are adjusted for each plaza building based on number of employees and special requirements unique to the specific plaza. A utility building for a full interchange shall contain the following rooms for use by the Authority. Room sizes, locations and materials for the building should be discussed with the Authority's Toll, Operations, ETC, TAS and Maintenance Departments during Phase A of the design process so that recommendations can be established prior to final design and plan preparation. The typical size of a plaza utility building is 6000-8000 square feet depending upon the size of the staff at the plaza.

   The plaza level shall contain, subject to Authority's review:

   Public Lobby with Unisex Restroom

   Plaza Supervisor's Office with storage closets

   Counting Room – 30 square feet per count station

   Ticket Room

   Clerk's Office

   Interchange Manager Office

   State Police Office (as required based on location of plaza)

   Break Room with seating and kitchen (30 square feet per person)

   Women's and Men's Lockers (12 square feet per locker)

   Women's and Men's Restrooms

   Janitor's Closet

   Storage Closets

   Loading Dock

Refer to Exhibit 12 - 3 "Utility Building Standard Operational Plan Diagram" at the end of this Section for suggested operational layout of a proposed utility building.

7. Furnishings and Equipment: Furnishings and equipment for the utility building shall be included in the contract documents, unless otherwise indicated by the Authority. These typically include office desks and chairs,

breakroom tables and chairs, lockers, kitchen appliances, safes, file storage units, etc., and should be evaluated during Phase “A” of project development.

8. Depository vaults shall be located in the plaza supervisor office. Deposits are made from the count room, and collection happens within the plaza supervisor office. Special consideration shall be given to the supervisor’s view of the plaza as well as the supervisor’s view to the lobby and count room.
9. Installation of a Building Management System (BAMS) that can communicate over the internet with secure remote access and allows for complete monitoring of building systems is recommended for installation at all buildings.
10. Utility building shall conform to the requirements of Subsection 12.2, DCA Procedures. The review and approval for construction may take 3 months or more and can be separated from the DCA submittal of the tunnel and canopy. The separation of the two elements may provide a better construction scenario if either the building or the toll plaza is on an accelerated construction schedule.

12.4.6. **Toll Plaza System**

This Subsection details the design requirements for the various systems to be installed at each toll plaza location. Due to continuous innovations in technology and the requirements of the Authority’s Engineering, ETC, Internal Security and TAS Departments, designs for many of these systems are continuously changing, however the requirements for each system and basic design criteria detailed below should be utilized unless otherwise directed by the Authority.

The Engineer shall coordinate with the Authority’s Engineering, ETC, Internal Security and TAS Departments to determine the most recent direction, model information, and installation requirements for each of the below Systems, and any additional systems that may be required. This coordination shall occur during the Phase “A” design, and a report shall be put together detailing the requirements and system design intent, including block diagrams of each system, for the Phase “A” Submission. Many of the systems require components to be installed in both the toll plaza booths, tunnel, and utility buildings. The Engineer and Architect shall coordinate accordingly.

1. Power Distribution and UPS System

   All toll plazas shall be provided with backup generator. The backup generator shall be adequately sized to handle all loads of the toll plaza building and toll booth operations, including all roadway lighting and ITS devices fed from the utility building.

All toll plazas shall also be provided with Uninterruptible Power Supply (UPS) systems. This system shall be fed from the Emergency panel, and shall be used to power only the critical loads of toll collection, revenue, and communications systems. To allow for future expansion and reliability of operation, the UPS shall be sized to run at no more than 50% capacity and shall run for at least 30 minutes for all connected loads. Where possible, three-phase redundant “hot-backup” systems shall be installed to ensure maintenance is possible without any power outages to connected equipment. The Engineer shall coordinate with the TAS and ETC Departments to determine if any additional design criteria are required for the UPS installation.

2. E-ZPass™ Toll Collection

An independent System Vendor is separately contracted by the Authority for the purposes of installing and maintaining the E-ZPass™ Toll Collection System. For this reason, unless otherwise directed by the Authority, the Engineer is not responsible for the layout and specification of specific toll collection equipment. The Engineer, however, is responsible for properly designing the toll plaza islands, canopy, booths, tunnels, and power and communication infrastructure to accommodate the E-ZPass™ equipment layout and design that is performed by others.

The Engineer shall coordinate with the Authority’s System Vendor to determine an appropriate delineation of work between the Plaza Contract and the System Vendor. An example table showing delineation of work on a recent contract is shown in Exhibit 11 - 1. The Engineer shall analyze each item, determine if additional items are necessary, and shall confirm all assumptions with the System Vendor. The Engineer shall also coordinate development of the delineation of work with the Coordination of Work between various plaza contracts as shown in Exhibit 12 - 2. The delineation of work shall be shown in the Plaza Contract in a format similar to that shown on Exhibit 12 - 1 and shall be submitted at the Phase “A” Submission for review. The Plaza Contract documents shall be developed according to the delineation criteria, and all work not in the contract shall be shown “by others.”

Items usually installed by the Plaza Contract include treadle frames, antenna mounting brackets, all island boxes and conduits, canopy signs, and Lane Use Signals (see Exhibit 12 - 1 for more information).

The Engineer shall utilize the standard toll equipment layout shown in Standard Drawing XX (to be published at a later date) in order to properly locate the equipment for all low-speed toll lanes. Locations of equipment shall be shown on the plans within the tolerances allowed, but installation shall be shown by others. Continuous paths consisting of conduit, wireway, and raceway shall be provided between the lane equipment and the Lane Equipment Cabinets mounted either in the tunnel and/or booths according to the requirements of Standard Drawing XX (to be published at a later date).

Where aesthetics or structural designs require, the Engineer shall design and include in the Plaza Contract structural mounting frames for antennas, profilers, or other equipment in order to provide a mounting location within the proper tolerances. The Engineer shall coordinate with the Authority's ETC Department to determine the need for, and design of, structural mounting supports.

The Engineer shall contact the Authority's Engineering, TAS, and ETC Departments during the Phase A design to determine any specific requirements for E-ZPass™ systems that may be supplemental to the direction given here.

Unless otherwise directed by the Authority's Engineering Department, the Engineer shall not be required to develop plans for the installation work of the System Vendor. However, the Engineer shall be required to coordinate closely with the System Vendor throughout the duration of design and construction. Coordination is also necessary with the Architect for such items as conduit requirements, mounting, etc.

All installation plans shall be reviewed by the System Vendor, and approval shall be obtained before the Phase "D" Submission.

EXHIBIT 12 – 1 SAMPLE DELINEATION OF TOLL SYSTEM CONSTRUCTION WORK

Description	Furnished	Installed	Connected
Toll Booths With Accessories			
Toll Booth - Manual/E-ZPass	Contractor	Contractor	Contr/NJTA
Toll Booth - Manual/Automatic/E-ZPass	Contractor	Contractor	Contr/NJTA
Toll Recording Room Equipment			
Table	NJTA	NJTA	N/A
Chair	NJTA	NJTA	N/A
Lane Controller Racks	NJTA	NJTA	N/A
Lane Controller Computers	Sys. Vendor	Sys. Vendor	Sys. Vendor
Fiber Lateral to Lane Controller Racks	Adesta	Adesta	Adesta
Lane Controller Power Outlets in Floor	Contractor	Contractor	Contractor
Toll Plaza Signage			
E-ZPass Sign Assemblies	Contractor	Contractor	Contractor

Description	Furnished	Installed	Connected
E-ZPass Sign Panels	Contractor	Contractor	Contractor
Toll Island Advisory Signs	NJTA	NJTA	NJTA
Toll Booth Window Signs	NJTA	NJTA	NJTA
Treadle			
Treadle Frame with filler strip	Contractor	Contractor	N/A
Treadle	Sys. Vendor	Sys. Vendor	Sys. Vendor
Communications Systems			
Telephone Cables	Contractor	Contractor	NJTA
Police Radio Cables	Contractor	Contractor	NJTA
Alarm Cables	Contractor	Contractor	NJTA
CCTV Cables	Contractor	Contractor	NJTA
Communications Systems Equipment	NJTA	NJTA	NJTA
Automatic Toll Collection Equipment			
Automatic Coin Machine	NJTA	NJTA	NJTA
Automatic Toll Lane Gate	NJTA	NJTA	NJTA
ACM Vault	NJTA	NJTA	NJTA
Electronic Toll Collection (ETC) Equipment			
Infrared Light Curtains (Transmitter & Receiver)	Sys. Vendor	Sys. Vendor	Sys. Vendor
AVI Antennas	Sys. Vendor	Sys. Vendor	Sys. Vendor
AVI Reader Cabinet Enclosures	Sys. Vendor	Sys. Vendor	Sys. Vendor
AVI Reader Cabinet Interiors	Sys. Vendor	Sys. Vendor	Sys. Vendor
Lane Equipment Cabinet (LEC) Enclosures (Primary & Secondary)	Contractor	Contractor	Contractor
Lane Equipment Cabinet (LEC) Interiors (Primary & Secondary)	Sys. Vendor	Sys. Vendor	Sys. Vendor
ETC Panels	Contractor	Contractor	Contractor
Patron Feedback Displays with Doppler Radar (PFD)	Sys. Vendor	Sys. Vendor	Sys. Vendor
Bus Height Sensor (Oversized Vehicle Height Detector)	NJTA	NJTA	NJTA
Vehicle Detector Loops	Contractor	Contractor	NJTA
Overhead Vehicle Separators (SICK units)	Sys. Vendor	Sys. Vendor	Sys. Vendor
Violation Enforcement System (VES) Cameras	Sys. Vendor	Sys. Vendor	Sys. Vendor
Violation Enforcement System (VES) Lights	Sys. Vendor	Sys. Vendor	Sys. Vendor
Card readers	Sys. Vendor	Sys. Vendor	Sys. Vendor
Canopy Override Switch Box	Sys. Vendor	Sys. Vendor	Sys. Vendor
Lane Use Signals	Contractor	Contractor	N/A
Ticket Readers	Sys. Vendor	Sys. Vendor	Sys. Vendor
Dual Height Automatic Ticket Issuing Machines (DATIMs)	Sys. Vendor	Sys. Vendor	Sys. Vendor
Wiring to Lane Signals	Contractor	Contractor	Sys. Vendor
Touch Terminals, Receipt Printers	Sys. Vendor	Sys. Vendor	Sys. Vendor
Conduits, Handholes, Junction Boxes in Tunnel	Contractor	Contractor	Contractor
Conduits, Handholes, Junction Boxes in Booth (ETC)	Sys. Vendor	Sys. Vendor	Sys. Vendor
Conduits, Handholes, Junction Boxes in Booth (Power and Comm)	Contractor	Contractor	Contractor
Lightning Protection System	Contractor	Contractor	Contractor
Communications wiring (LEC to booth, island equipment)	Sys. Vendor	Sys. Vendor	Sys. Vendor
ETC Fibers from LEC to Lane Controller Racks	Sys. Vendor	Sys. Vendor	Sys. Vendor
VTDM cameras, equipment, and wiring	Sys. Vendor	Sys. Vendor	Sys. Vendor
VTDM poles, raceways	Contractor	Contractor	N/A

3. Telephone

Telephone systems shall be installed in the booths and/or tunnel as detailed below:

All Parkway Toll Plazas utilize external ("Bell Phone") lines. Some plazas are supplemented with internal ("GSP Phone") lines in addition to the external lines. Terminated phone jacks and cable shall be installed and tested in all rooms and toll booths. The cable shall be home-runned and terminated on a Type 66 communications punch block in the Radio Room. All cables shall be labeled on both ends so cables can be identified in the future.

All Turnpike Toll Plazas utilize external ("Grey Phone") lines. Terminated phone jacks and cable shall be installed and tested in all rooms and toll booths. The cable shall be home-runned and terminated on a Type 66 communications punch block in the Radio Room. All cables shall be labeled on both ends so cables can be identified in the future.

The Engineer shall coordinate with the Authority's TAS Department to determine the exact location of end devices and communications distribution equipment.

4. Ethernet

   Terminated Category 5e Ethernet jacks and cable shall be installed and tested in all rooms and toll booths at all toll plazas on the Parkway and Turnpike. All cables shall be terminated on a Category 5e Patch Panel mounted to a 19 inch open rack. All hardware shall be provided by the Contractor. The Authority's TAS Department will designate the exact quantity and specific locations of these jacks.

5. Intercom

   Intercom stations shall be provided in all booths, and a master intercom station shall be provided in the Toll Plaza Supervisor's office, located in the utility building. Appropriate intercom cabling shall be used to connect the various equipment to ensure a completely operational system.

   The intercom system manufacturer used is the same for both roadways, however specific model numbers differ, as different equipment is installed. The Engineer shall coordinate with the Authority's TAS Department for further direction regarding the intercom system.

   The Plans shall note that all installations of intercom systems shall be performed by a manufacturer-certified installer/maintainer. Notes shall be provided on the Plans indicating that the complete system shall come with a complete on site one-year warranty and must interact with all current intercom systems installed across the various Authority facilities. As the intercom system is viewed as an employee and patron safety issue, the Contractor shall repair any failures that occur within six (6) hours.

6. Police Radio (Parkway only)

   Plazas on the Parkway use a police radio system, which allows toll collectors to monitor the police radio, and contact the police in case of emergency. Police radio stations shall be installed in all manned booths, and appropriate cabling connected to the Police Radio distribution panel in the utility building. Owing to the proprietary nature of the Police Radio system, the Engineer shall contact the Authority's Engineering Department for specific requirements for the installation of this system on all Parkway toll plazas.

7. Plaza Security System

   A comprehensive security system shall be installed for all facilities. The system shall be designed to meet all current Authority requirements, and may interface or connect several of the systems listed in this subsection.

   At toll plazas, the system shall include, at a minimum, installation of a panic button in a location to be determined by the Authority, and installation of a host system in the utility building that is fully integrated with the Authority's other system equipment. Additional components may be required, such as cameras, motion sensors, and/or blue beacons mounted to the top of each toll booth or canopy sign that indicate where the duress alarm was activated.

   For more specific requirements, the Engineer shall coordinate with the Authority's Internal Security and Engineering Departments.

8. Closed-Circuit Television (CCTV)

   CCTV systems shall be provided throughout the toll plaza building and facility to allow the toll plaza supervisor to monitor all areas of the site. Typically, this requires certain fixed cameras mounted in the building aimed at the vault, counting stations, and exits, and pan-tilt-zoom (PTZ) cameras mounted in the hallways, and on site lighting or other poles to allow a clear view of all plaza entry and exit roadways. This camera system is independent of the Traffic Surveillance Cameras provided for the purposes of surveillance of traffic as described below.

   CCTV systems are installed throughout Authority facilities using a single set of equipment that is designed to be interoperable. The Engineer shall design the CCTV system to the requirements as directed by the Authority's TAS Department.

9. Traffic Surveillance Cameras

   The Traffic Surveillance Camera system is designed to allow central Operations personnel a priority view of all critical roadways, and is independent of the facility CCTV system.

The Engineer shall show installation of Traffic Surveillance Cameras at the locations in the project as determined by the Operations Department. Installation of the cameras are often performed by outside vendors, however, at a minimum, it is the responsibility of the Engineer to provide proper poles for mounting and 24-hour power circuits to the locations requested by the Authority's Operations Department.

Technical requirements for the Traffic Surveillance Camera system shall be as directed by the Authority's TAS Department, and all work shall be included in the Plaza Construction Contract.

See Section 9 (ITS and Communication Systems) of this Manual for more information.

10. Video Transaction Data Monitoring (VTDM)

    The VTDM system allows for monitoring of the toll collection activities, and is installed for all Parkway plazas, and on the exit side of Turnpike plazas only. In a typical installation, cameras are installed approximately 200 to 300 feet from the plaza on a light standard or separate pole, and are aimed back at the booths. One camera shall be provided for every four (4) booths at a minimum. Fiber-Optic connection and 24-hour power shall be connected from the cameras, through the lighting or independent raceway systems, back to the ETC hut or ETC room in the utility building.

    The layout of VTDM cameras shall be approved by the Authority's ETC Department during the Phase "B" design. The Engineer shall also determine the delineation of work, if any is required, between the Plaza Contract and the System Vendor, who on occasion installs VTDM systems.

11. Fire Suppression

    Due to the sensitive and revenue-critical nature of the systems installed in the tunnel, the need for a Fire Suppression system should be avoided in the tunnel and booths. According to International Building Code requirements as of the writing of this manual, Fire Suppression systems do not need to be installed in the tunnel, if the following criteria are met:

    a) Each stairwell leads directly to grade.
    b) Exits (stairwells) are located at a distance of no more than 50 feet on center for the length of the tunnel (this equates to every 3rd lane).
    c) The distance from the last stairwell to the end of the tunnel is less than 20 feet.

    The Engineer shall design the tunnel to meet these requirements and avoid the need for Fire Suppression in the tunnel.

12. Fire Detection and Egress

    Fire Detection Systems shall be installed throughout the utility building and tunnel to the requirements of the DCA. Fire Pull stations shall be provided at all tunnel exits, and horn/strobe units shall be included in the tunnel, but specifically designed to sound at minimum allowable volume.

13. Heating, Ventilation, and Air Conditioning (HVAC)

    On the Parkway, HVAC systems are provided as part of the pre-fabricated booth. A chiller is located on the roof of the booth, and supplemental heaters are mounted in various locations inside the booth. All installations shall be as shown on the Standard Drawings (to be published at a later date).

    On the Turnpike, air supply to booths shall be by central duct system. Air supply shall be taken from a clean-air location near the utility building, fed through the tunnel through a large stainless steel duct, and directed to each booth through a Variable Air Volume (VAV) damper, located in the tunnel. Hydronic piping shall be run through the length of the tunnel and connected to heat exchangers for control of temperature. Thermostats shall be provided inside each booth for control. Each booth shall be provided with 2 vents, one located under each counter, and the vents shall be connected by means of a recessed floor pan cast into the island concrete under the booth. Design air volume per booth shall be 400 CFM.

14. Canopy and Overheight Vehicle Detection Systems

    Overheight Vehicle Detection Systems shall not be installed, unless directed otherwise by the Authority's Engineering Department. See Subsection 12.4.1.

    Lane Use Signals ("X-Arrow Signals") shall be utilized on the front canopy fascia of each active toll lane. Lane Use signals shall be incorporated into the design as shown on Standard Drawing XX (to be published at a later date). Mounting shall be through-bolted to canopy fascia. The Plaza Contract shall include all conduit and wiring for the Lane Use Signals, and the wiring shall be coiled and left for termination by the System Vendor at the coordinated location.

    Lane Signs and Sign Lighting shall be designed as directed by the Authority's Engineering Department, and shown on Standard Drawing XX (to be published at a later date).

15. Lightning Protection

    Lightning Protection Systems shall be installed on all Authority buildings and toll plaza canopies. The Lightning Protection System shall be installed by an

Underwriters Laboratories (UL)-certified Master Installer, according to the requirements of National Fire Protection Association Publication NFPA 780. The Lightning Protection System shall be required to be provided with a Master Label certifying the installation before any toll collection equipment is utilized. If construction staging requires installation of the Lightning Protection System in stages, each stage shall be independently certified as compliant before the lanes can be opened.

Because there are many accepted details for the installation of Lightning Protection System devices, please see Standard Drawing XX (to be published at a later date) for details to be utilized at various plazas and buildings.

16. Other Building Systems

Additional systems will likely be required in the utility building, by direction of the Authority's Engineering Department, through coordination with the Operations, Tolls, ETC, TAS, or Maintenance, or Tolls Departments, or because of code requirements. The Engineer and Architect shall perform the necessary coordination to ensure that all requirements are met, and that the toll plaza systems interface adequately to those located within the building, especially where these systems are networked or connected to other Authority facilities.

EXHIBIT 12 – 2 TOLL PLAZA COORDINATION OF WORK

SAMPLE

COORDINATION OF WORK
(To be developed for each toll plaza)

ITEM	BUILD. CONTR.	TOLL PLAZA CONTR.	CANOPY CONTR. **	TOLL BOOTH CONTR.	TOLL EQUIP. CONTR.	REMARKS
1. EXC., GRAD. & PAVING		F & I				Including building site (rough & finish grading).
2. TUNNEL & TOLL ISLAND		F & I				
3. PILES, REINF. CAPS W/DOWELS FOR BLDGS.		F & I				If required.
4. HYDRANTS @ ISLANDS		F & I				Connection in tunnel by building contractor.
5. UTILITY BUILDINGS	F & I					(See extent of tunnel in building contract)
6. SITE WORK AND PAVING		F & I				Verify limits with NJTA.

ITEM	BUILD. CONTR.	TOLL PLAZA CONTR.	CANOPY CONTR. **	TOLL BOOTH CONTR.	TOLL EQUIP. CONTR.	REMARKS
7. SANITARY SEWER	5' from build.	F & I				Public Sewer if avail. Lifting Sta. if necessary by Toll Plaza Contr.
8. SEPTIC TANK OR DISPOSAL FIELD	F & I					If required include lifting Sta. for building sewer.
9. WATER	to 5' from Bldg.	F & I				Well and pump, if required, by plaza contr.
10. FUEL & DIESEL OIL STOR. TANKS (INCL. MASONRY VAULTS)	F & I					Including conc. Pads, piping & backfill to rough grade elev.
11. STORM DRAINAGE	to 5' from Bldg.	F & I				Sump pump if necessary
12. POWER	From pad to Bldg.	F & I				
13. PLAZA & SITE LIGHTING		F & I				Excl. canopies, if there is a canopy contract
14. PLAZA & SITE LIGHT. PHOTO-ELEC. CONTROL	F & I					
15. ALL CONDUITS W/PULL WIRE, EMBEDDED IN CONC. IN TUNNEL & ISLAND		F & I				
16. TREADLE FRAMES & CURB BOXES		F & I				
17. TREADLES					F & I	
18. ELEC. ROUGHING TREADLES		F & I				
19. TREADLE DRAINAGE		F & I				
20. "M" BOXES					F & I	
21. COLLECTION EQUIPMENT ELECTRIC ROUGHING		F & I				
22. CABLE TRAYS AND RACKS	F & I @ Buildings	F & I @ Tunnel				

ITEM	BUILD. CONTR.	TOLL PLAZA CONTR.	CANOPY CONTR. **	TOLL BOOTH CONTR.	TOLL EQUIP. CONTR.	REMARKS
23. FIRE EXTINGUISHERS		F & I				See plaza plan.
24. LANE SIGNALS			F & I			Terminate at block, system vendor will hookup.
25. CANOPY ROOF DRAINS & LEADERS			F & I			To top of tunnel only & hook to drain system.
26. TUNNEL DOORS, GRATING, RAILINGS, LIGHTING FIXTURES & NON-SLIP NOSING AT TUNNEL STAIRS		F & I				Incl. hardware.
27. TOLL BOOTH ANCHORAGE		F & I				
28. CANOPY COLUMN ANCHORAGE		F & I				Anchor bolts only.
29. TELEPHONE SERVICE		F & I				To hookup point outside of Bldg.
30. OUTDOOR TEL. INCL. POWER		F & I				
31. TOLL COLLECTION EQUIPMENT					F & I	
32. GRAY PHONE ROUGHING	F & I @ Bldg.	F & I @ Toll Booths				
33. BELL PHONE ROUGHING	F & I	F & I @ Toll Booths				
34. RADIO PHONE ROUGHING	F & I	F & I @ Toll Booths				
35. GREY PHONE EQUIP.	Rough only @ Bldg.	Rough only @ Tool Booths				Equip. & hookup by NJTA Demarcation point decided during design.
36. BELL PHONE EQUIP.	F & I	F & I				If not provided by Tel. Co. Demarcation point decided during design
37. RADIO PHONE EQUIP.						Separate contract
38. RADIO EQUIPMENT						Separate contract
39. INTERCOM ROUGHING	F & I @ Bldg.	F & I @ Toll Booths				Demarcation point decided during design
40. INTERCOM EQUIPMENT						Separate contract

ITEM	BUILD. CONTR.	TOLL PLAZA CONTR.	CANOPY CONTR. **	TOLL BOOTH CONTR.	TOLL EQUIP. CONTR.	REMARKS
41. CLOSED CIRCUIT TV EQUIP. WIR. & MTG.	F & I					
42. CLOSED CIRC. TV ROUGHING	F & I					
43. ELECT. VEHICLE HT. MONITOR EQ. & WIR.		F & I				Not used unless specifically directed by the Authority's Engineering Department.
44. ELECTR. VEHICLE HT. MONITOR ROUGHING		F & I				Not used unless specifically directed by the Authority's Engineering Department.
45. ROADWAY LTG. DISTR. EQUIPMENT	F & I	F & I* (see remarks)				Conduits by Bldg. Contr. 5' from Bldg. *Remainder in plaza contract.
46. RADIO ANTENNA	F & I					If required
47. TOLL BOOTHS		I		F (Deliv. Only)		
48. TOLL BOOTHS – SLEEVES FOR DUCTS & PIPES		F & I				
49. TOLL BOOTHS – MECH'L HOOKUP	F & I					
50. TOLL BOOTHS – HEATING COIL CONTROLS & WIRING	F & I	F & I (Cond. Only)		120v Power Hookup & M-Block		
51. E-Z PASS EQUIPMENT					F & I	
52. E-Z PASS EQUIPMENT SUPPORTS ON CANOPY			F & I			

** If there is no separate canopy contract, this work is included with toll plaza contract.
F= Furnish I= Install CONTR = Contractor

EXHIBIT 12- 3 UTILITY BUILDING STANDARD OPERATIONAL PLAN DIAGRAM

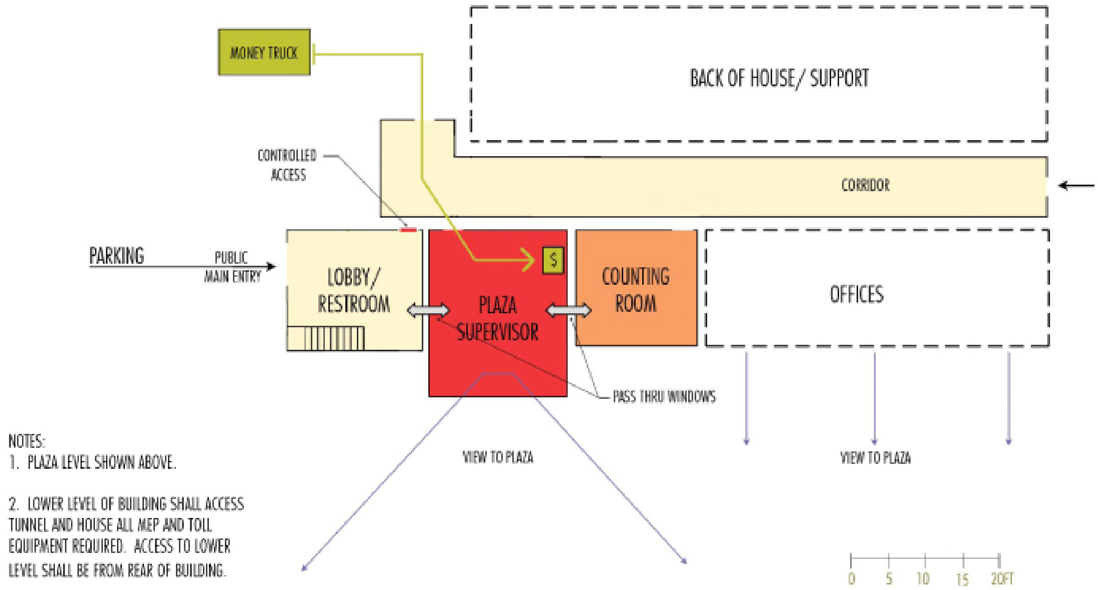
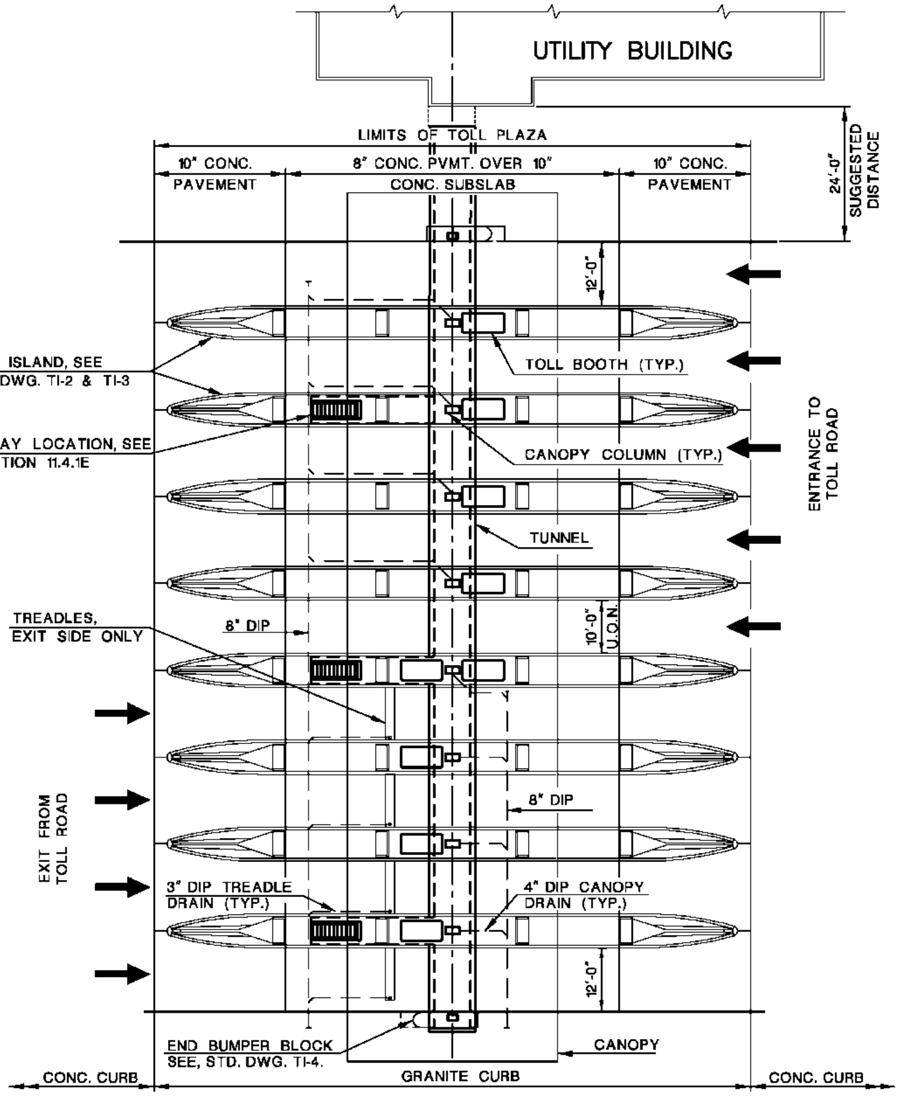


EXHIBIT 12 – 4 TWO WAY TOLL PLAZA LAYOUT



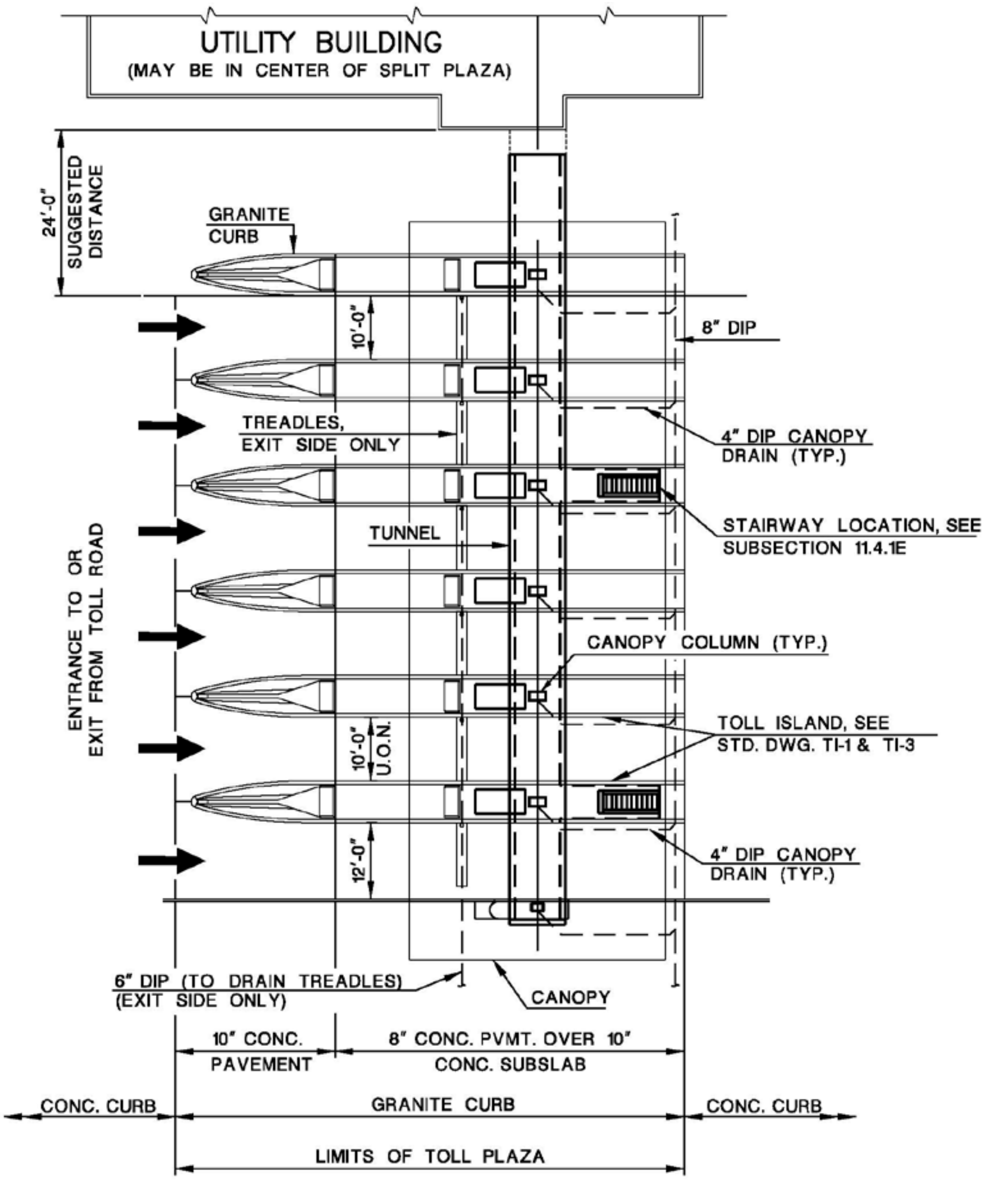
LEGEND:

— — CANOPY & TREADLE DRAINAGE

NOTE:

FOR ADDITIONAL DETAILS SEE, STD. DWGS TI-1 TO TI-7

EXHIBIT 12 – 5 ONE WAY TOLL PLAZA LAYOUT



LEGEND:

— — · CANOPY & TREADLE DRAINAGE

NOTE:

FOR ADDITIONAL DETAILS SEE, STD. DWGS TI-1 TO TI-7

Section 13 - ENVIRONMENTAL ENGINEERING

13.1. INTRODUCTION

The presence of environmental contamination can impact project feasibility, cost, schedules, human health & safety and environmental quality. It is therefore important to identify the presence of contamination early during project development to avoid or minimize involvement and produce predictable schedules and budgets. Any testing for and management of contamination within the project site must be performed in accordance with current NJDEP Site Remediation regulations under N.J.A.C.7:26E, as well as, the NJDEP's Field Sampling Procedures Manual.

This Section provides the Engineer with guidance for conducting environmental investigations during the design process to determine the presence/absence of contamination (Areas of Concern (AOC)), and if contamination is present, to appropriately address AOCs in the construction contract documents.

The extent of the environmental investigation to be undertaken is dependent upon the scope of the project. Projects that do not involve ground intrusive activities will require little, if any, environmental investigation.

13.2. COORDINATING SUBMISSION REQUIREMENTS AND… ENVIRONMENTAL INVESTIGATIONS

13.2.1. General

The Phase Design Submission requirements pertaining to environmental matters are dependent on the results and availability of information produced by progressive stages of the environmental investigation. Initial environmental screening/Preliminary Assessment investigations can help prevent the Authority from impacting or purchasing sites with potential contamination. If acquisition or impact to contaminated property is unavoidable, the results of the environmental investigations will be used to support the right-of-way acquisition process described in Section 9 of the Procedures Manual.

This Section provides the Engineer with a framework for undertaking due diligence and satisfying NJDEP requirements as well as integrating environmental issues into the Authority's design process. This is not intended to be a rigid procedure. The Engineer will develop a cost effective, flexible plan to address NJDEP requirements within the specific context of each project. The Engineer and/or the Environmental Subconsultant must determine the most appropriate approach (i.e., report combinations, combining field investigative requirements, etc.) to maximize the efficiency of project schedules and costs.

It is incumbent upon the Engineer to be fully aware of NJDEP's Licensed Site Remediation Professional (LSRP) Program and its potential implications for design submissions, construction schedules and construction requirements. The Engineer must comply with the LSRP Program requirements as well as any other applicable NJDEP procedural/ guidance requirements.

Historic Fill

The Engineer must be aware of the potential presence of historic fill (as defined in accordance with N.J.A.C. 7:26E 1.8) on project sites. Associated NJDEP requirements and health & safety issues must be addressed during design phases. The initial environmental screening/Preliminary Assessment will provide preliminary information regarding the presence of onsite historic fill. Additionally, geotechnical investigations can provide valuable data for the presence of in-situ historic fill.

Historic fill is presumed contaminated by NJDEP and is potentially present on existing/proposed NJTA Right of Ways. If encountered, the Engineer may be required to design engineering/institutional controls during the design phases to be implemented during construction. All historic fill sampling/ requirements must be undertaken in accordance with N.J.A.C. 7:26E Technical Requirements for Site Remediation and NJDEP's Field Sampling Procedures Manual.

13.2.2. Environmental Screening / Limited Preliminary Assessment (PA)

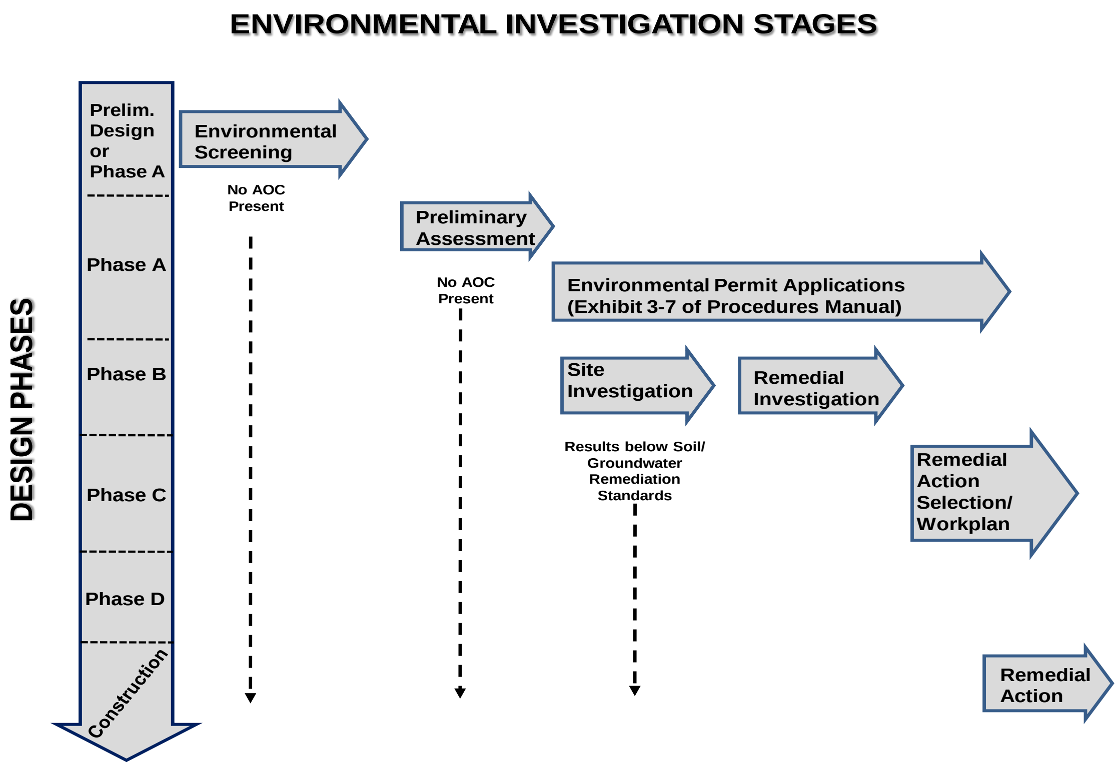
An Environmental Screening/Limited Preliminary Assessment must be conducted to support Preliminary Design. For major projects, the environmental screening is to be performed during preliminary engineering. For projects that do not include a preliminary engineering phase, the environmental screening is to be performed during Phase A of the design process. The investigation is intended to identify AOCs within the project site. At a minimum it should include:

- Review of Federal and State environmental databases (i.e. Environmental Data Report)
- NJDEP Environmental Information Inventory reviews
- NJDEP GIS database searches and NJDEP file reviews
- Review of historic land use information consisting of:
  - aerial photographs
  - city directories
  - Sanborn Fire Insurance Maps (earliest available)
- Review of local municipal files (i.e. health department, tax assessor's office, construction department, etc.)
- Agency Coordination (i.e. NJDEP, USEPA, etc) and OPRA Request

- Review of existing As-Builts and environmental reports
- Site reconnaissance and assessment of risks associated with excavation or other construction related surface/subsurface activities.

Unless directed otherwise by the Authority, soil sampling is not to be undertaken at this phase. The results of the Environmental Screening (ES)/Limited Preliminary Assessment must be provided to the Authority in the form of an Environmental Screening Report (ESR).

EXHIBIT 13 -1



Notes:

1. AOC – Area of Concern
2. Field activities and/or reporting requirements may be combined where appropriate.
3. The Engineer is strongly encouraged to use this diagram in conjunction with the full text of the regulation as published in the New Jersey Administrative Code (N.J.A.C.) 7:26E. The diagram is not suitable substitute for referring to the regulations directly and interpretations of regulations made on the basis of this diagram are the sole responsibility of the Engineer.
4. It is the Engineer's responsibility to determine whether there have been any changes in applicability of this regulation since the date of publication.

Results of the environmental screening investigation shall be documented in the ESR, which includes the following:

- Introduction
- Project description
- Summation/Review of resources utilized
- AOCs identified and justification
- Constraints to surface/subsurface activities
- Conclusions/Sampling recommendations
- Engineer's recommendation for additional investigative action
- Appendix of all resources utilized

The results/findings of the ESR process shall also be reflected in the E.O. 215 Document prepared for the project, if applicable.

13.3. Environmental Investigations Supporting…

Design Submissions

Depending on the results (identification of AOCs) of the ES conducted during Preliminary Design or Phase A, the Engineer will conduct an appropriate Preliminary Assessment (PA); Site Investigation (SI) and/ or Remedial Investigation (RI) in consultation with the Authority. Should an AOC be identified during the ES, the Engineer must conduct a PA/SI and submit the report to the NJTA. Findings outlined in the PA/SI report will determine whether an SI/RI investigation is required.

The results of investigations described below will be used to support design submissions, as appropriate. The Authority will review and comment on environmental submittals (i.e. sampling plans, reports, etc.) associated with SI/RI investigations and if acceptable, authorize environmental investigations to proceed. All documents must be reviewed and approved by the Authority before submittal to the NJDEP.

13.3.1. Preliminary Assessment

If necessary, the Engineer will complete a PA as described under N.J.A.C. 7:26E-3.1 and 3.2.

13.3.2. Site Investigation

If necessary, the Engineer will conduct a SI described under N.J.A.C. 7:26E-3.3 through 3.13. The Engineer will submit a sampling plan to the Authority for review and comment. Soil/groundwater sampling will not be initiated until authorization is given by the Authority to proceed. A SI Report (SIR) will be submitted to the Authority for review and comment prior to NJDEP submission. The Engineer will reflect information contained in the SIR in the Design Submission if applicable.

13.3.3. Remedial Investigation/Remedial Investigation Workplan (RI/RIW)

If necessary, the Engineer will conduct a RI described under N.J.A.C. 7:26E-4.1 through 4.9. The Engineer will submit a Remedial Investigation Workplan (RIW) to the Authority for review and comment prior to NJDEP submission. Soil/groundwater sampling shall not be initiated until authorization is given by the Authority to proceed. The Engineer will incorporate information contained in the RIR within the Design Submission if applicable.

13.4. Environmental Investigations Supporting… Design Phase C and Phase D

If necessary and depending upon the results of the RI/RIW/Remedial Investigation Report (RIR), the Engineer will conduct an appropriate Remedial Action Selection (RAS) and/or Remedial Action Workplan (RAW) in consultation with the Authority. The RAS/RAW will be used to support Phase C and Phase D submissions.

13.4.1. Remedial Action Selection (RAS)

If necessary, the Engineer will coordinate with the Authority to develop, recommend the most appropriate RAS. The RAS process will include a written document outlining potential remedial options and recommendations for review and evaluation by the Authority prior to completion of a RAW, if applicable.

13.4.2. Remedial Action Workplan (RAW)

If necessary, the Engineer will prepare a RAW in accordance with N.J.A.C. 7:26E-5.1 through 5.8. The RAW schedule of activities and reporting requirements will be integrated into and coordinated with the Critical Path Method Progress Schedule for Construction Activities.

13.5. Remedial Action

Depending on the circumstances of a particular project and the specifics of any remedial action determined to be necessary, it may be appropriate to undertake the remedial action in advance of the construction of the project in the form of a separate remedial action contract. The Engineer should discuss the possibility of an advance remedial action contract with the Authority where feasible and appropriate. Otherwise, the remedial action requirements may need to be incorporated into the construction contract documents for the project.

If the Design Consultant is functioning as the LSRP during environmental investigations and design efforts it may be appropriate for the Design Consultant/LSRP to continue functioning in that role during construction. If such a continuation of LSRP services is considered appropriate and/or beneficial to the Authority, the Design Consultant shall so notify the Authority's Project Manager of this recommendation.