ENVIRON
Engineers of North Carolina

July 27, 2017

Via Electronic Mail

Javier Pérez-Maldonado
NYSDEC
Division of Environmental Remediation
625 Broadway
Albany, NY 12233

RE: REVISED GRADING PLAN: REMEDIAL ACTION WORK PLAN
SUN CHEMICAL, SITE #C243024
441 TOMPKINS AVENUE, STATEN ISLAND, NEW YORK

Dear Mr. Pérez:

ENVIRON Engineers of North Carolina, PC (EENC) has prepared the enclosed revised grading plan and supporting engineering calculations on behalf of Sun Chemical Corporation (Sun Chemical) as an additional minor addendum to the approved Remedial Action Work Plan to address post-remedial grading on Lots 12 and 54 at the above-captioned site. For completeness, this revised document supersedes those addenda submitted on May 12, June 2, and July 17, 2017 and addresses comments received from NYSDEC on May 17, 2017 and discussed during our July 6, 2017 site meeting. Last, this revised document makes certain corrections based on comments you provided on July 26, 2017 to the version you received dated July 24, 2017.

Environ Engineers of
North Carolina, PC
101 Carnegie Center
Suite 200
Princeton, NJ 08540
USA

T +1 609 452 9000
F +1 609 452 0284

As you are aware, the depth of soil removal in the general central and higher portion of Lot 12 of the above referenced site resulted in changes to site topography greater than those anticipated when the RAWP, and the grading plan contained therein as Plate 11, was developed. Accordingly, revisions to that grading plan were discussed with, and requested by, NYSDEC during discussions earlier in 2017 about the overall remediation program. That grading plan, most recently submitted on June 2, 2017, was approved by NYSDEC on June 17, 2017. However, during and prior to a July 6, 2017 site inspection and meeting, NYSDEC issued additional comments to the overall site grading, including for areas outside those addressed in the June 2, 2017 grading plan. The June 2, 2017 grading plan was therefore updated to reflect additional regrading and site-restoration activities that, in summary, comprise the following three primary actions:

1. AOC 2 Berm: A berm had previously been approved along the northern portion of AOC 2 to better manage post-remedial storm water flow. The attached plan modifies that berm to be in closer proximity to the eastern property boundary, further limiting the storm water flow that can drain off of the site and directing the storm water flow in the westerly direction, towards the existing interceptor trench.

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2. Cap Area C: An extension of the drainage swale in Cap Area C.1 (Cap Area C on the previous plan) is proposed (see "Cap Area C.2") to connect Cap Area C.1 to the southern/upgradient end of the interceptor trench. This modification will further limit potential erosion at the toe of the slope resulting from large storm events. Construction of Cap Area C.2 will conform to Detail #5 in the attached drawings.
3. Cap Area D: This capping area was added to address DEC's erosion concerns regarding the sloped exposed soil area west of the retaining wall, and consists of extending the current riprap cover adjacent to that wall northward for additional erosion protection. As shown, the riprap capping in Cap Area D will terminate at the proposed swale in Cap Areas C.1 and C.2. These modifications will supplement the previously proposed / approved addition of seeding and the coconut-fiber erosion control blanket to the south of Cap Area B.1.

As part of the ongoing site restoration, we are interested in completing delivery and placement of certified clean and stone armoring, and would therefore appreciate NYSDEC's expeditious review and approval of the attached amended grading plan and stone armoring proposal.

If you have questions about the specific grading proposal, please do not hesitate to contact me or Bill Kraft and Jose Sananes at Ramboll Environ.

Sincerely,

Russell S. Kemp, P.E.
President
Environ Engineers of North Carolina, PC

William Kraft
Principal Consultant
Ramboll Environ

Jose Sananes, P.E.
Principal Consultant
Ramboll Environ

RSK:WDK:JS/cln
21-16443A\PRIN_WP\44253v1

cc: G. Andrzejewski
J. Brown, NYSDEC
W. Faure, Esq.
J. Kenney, NYSDOH

ENVIRON
Engineers of North Carolina

G. Walker
T. Wolff, Esq.

ENVIRON
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DESIGN CALCULATIONS
PROPOSED SLOPE ARMORING DESIGN

PROJECT NAME:	Sun Chemical Rosebank		
PROJECT NUMBER:	2116443A		
CALCULATIONS BY:	June Yeung, PhD	Date:	July 26, 2017
REVIEWED BY:	Jose Sananes, PE	Date:	July 26, 2017
APPROVED BY:	Russell Kemp, PE	Date:	July 27, 2017

1. PROBLEM STATEMENT

The central portion of the site, which grades from approximately elevation 49 ft to elevation 36 ft from west to east, is to be capped with two feet of certified clean fill (i.e., quarried) material. The proposed grading plan was evaluated to: (a) assess the need for slope armoring; and (b) specify the type and dimensions of the proposed surface materials.

2. OBJECTIVES

Attachment A shows the site layout and proposed capping plan. Specific design objectives are as follows:

- **Condition 1.** The proposed fill material for Cap Area B.1 is ASTM #10 aggregate. Conservative calculations were performed to determine whether this material provides a stable surface that would adequately resist erosion by sheetflow or if armoring is warranted. The area encompasses approximately 50,400 SF and has a maximum slope of approximately 10%.
- **Condition 2.** The proposed fill material for Cap Area A.1 is ASTM #10 aggregate. The area encompasses approximately 7,600 SF and has a maximum slope of approximately 2.7%, which is relatively flat. Calculations were performed to confirm that the ASTM #10 aggregate would provide a sufficiently stable surface that would adequately resist erosion by sheetflow.
- **Condition 3.** The proposed grading within the capping footprint results in channelized flow along the southern side of Cap Area B.1, where the proposed cap grades to match existing grades (Cap Area C.1). The resulting average in-channel slope will be approximately 8%. This channel was extended towards the existing interceptor trench via Cap Area C.2. Conservative calculations were performed to design the armor stone needed along the channel to limit erosion.
- **Condition 4.** The area between Cap Area B.1 and the interceptor trench, but excluding Cap Area A.1, consists of ASTM #10 aggregate. Calculations were performed to determine whether this aggregate provides a stable surface that would adequately resist erosion by sheetflow or if armoring is warranted. The area encompasses 13,215 SF and has a maximum slope of approximately 20%.

The capping plan provided in **Attachment A** shows that riprap stone is proposed in Cap Area D, which is situated upslope of the existing retaining wall. As shown in the plan, the southern portion of this slope is currently lined with riprap stone with a median diameter of approximately 8 inches. As part of the site improvements, similar riprap stone will be placed over Cap Area D and extend northward towards Cap Area C.1.

3. AVAILABLE DATA

- Proposed grading plan prepared by Ramboll Environ and dated July 20, 2017 (**Attachment A**)
- Topographic survey (conducted on 02/08/2017 by Control Point Associates, Inc.), shown as the base map on the proposed grading plan provided in **Attachment A**.
- Typical sieve analysis for ASTM #10 stone dated April 28, 2017 from Fanwood Crushed Stone Co in Watchung, New Jersey provided in **Attachment B**.

4. APPROACH

The analyses for the four conditions involve comparing shear stresses induced by the anticipated runoff on the slope or channel surface with the maximum allowable shear stresses that the slope or channel surface can withstand. For Conditions 1, 2, and 4, empirical data from the Bureau of Reclamation research (Fortier and Scobey, 1926) were used as a basis for maximum allowable shear stress. A modified version of Manning's Equation was used to estimate the sheetflow depth across the slope surface, which allows for the calculation of the anticipated shear stress in Conditions 1, 2, and 4. For Condition 3, the iterative procedures described in the Federal Highway Administration's HEC No. 15 manual (*Design of Roadside Channels with Flexible Linings*) were used to define the median diameter (D50) of the armor stone required to limit erosion of the channel.

Consistent with the New York State Standards and Specifications for Erosion and Sediment Control (NYSDEC, November 2016), a 25-year, 24-hour storm was used in these analyses. The peak rain intensity for the design storm was estimated by taking the rainfall total in the 25-year, 24-hour storm from the TR-55 database, converting this rainfall total to rain intensity from the Type II rainfall distribution, and using the maximum rain intensity from this storm in the calculations.

5. ANALYSIS AND ASSUMPTIONS

5.1 Condition 1 (Cap Area B.1)

For ease of analysis, Cap Area B.1 was assumed to have a uniform slope equal to the maximum slope within the area (i.e., approximately 10%). The drainage area was estimated to be the footprint of Cap Area B.1. The rational method (**Equation 1**) was used to determine the maximum anticipated runoff on the slope using the peak rain intensity (I) from the 25-year storm, the estimated drainage area (A), and a conservative runoff coefficient (C) of 0.9. The computed runoff was then used as input for **Equation 2**, which is a modified form of the Manning's Equation that can be used to compute sheetflow depth (y) based on estimated runoff (Q), slope width (w), surface roughness coefficient (n), and slope of the drainage area (S). Finally, the computed sheetflow depth (y) and the surface slope (S) were used in **Equation 3** to determine the anticipated shear stress induced on the slope surface by the sheetflow. This anticipated shear stress was then compared against the maximum allowable shear stress of the proposed capping material (ASTM #10, which was approximated as sandy loam or silt loam) to determine whether the slope surface can resist the anticipated shear stress during the peak of the 25-year storm or if armor stone for slope protection was required.

$$Q = CIA \qquad \textbf{Equation 1}$$

where:
C is the cover factor
I is the rain intensity

A is the drainage area

$$y = \left[\frac{qn}{1.49S^{0.5}}\right]^{\frac{3}{5}}$$ **Equation 2**

where:
y is the flow depth (in feet)
q is the unit width flow rate (Q/W, the total flow rate, in ft^3/s, divided by the slope width, in ft)
n is the surface roughness coefficient
S is the surface slope (ft/ft)

$$\tau_0 = \gamma y S$$ **Equation 3**

where:
τ_0 is the shear stress experienced by the land surface
γ is the specific weight of water (62.4 lb/ft^2)
Y is the flow depth, computed from **Equation 2**
S is the surface slope (ft/ft)

As presented in **Attachment C**, the peak runoff during the 25-year storm was estimated to be 5.07 cfs, based on a drainage area of approximately 50,400 ft^2, a peak rain intensity of 4.87 inches/hour (see Condition 3 calculations below), and a conservative runoff coefficient of 0.9. The corresponding maximum anticipated shear stress induced by the sheetflow on the slope surface (i.e., ASTM #10 material) was determined to be approximately 0.12 lb/ft^2. This anticipated shear stress exceeds maximum allowable shear stresses for both a sandy loam surface (0.075 lb/ft^2) and a silt loam surface (0.11 lb/ft^2), based on empirical data from the Bureau of Reclamation research (Fortier and Scobey, 1926). Therefore, armoring consisting of a fine gravel, which should provide an allowable shear stress of 0.32 lb/ft^2 (based on the table in **Attachment C**), is needed to protect Cap Area B.1 from erosional damage during a 25-year storm. ASTM #7 or #67 stone should be an appropriate armor stone; the gradations of these materials are provided below. This slope armoring should also be able to resist the anticipated shear stresses from the 100-year storm (0.15 lb/ft^2). While the minimum required thickness per the Blue Book is 1.5 times the D50 of the selected stone (i.e., ASTM #7 or #67 stone, both with D50 of 3/8 inch), considering the required stone size and implementability, the minimum specified thickness was 3 inches.[1]

ASTM #67:

Sieve Size	Percent Passing
1”	100
¾”	90-100
½”	-
3/8”	20-55
No. 4	0-10
No. 8	0-5

[1] Note that Detail 3 in Attachment A depicts ASTM #5 stone armoring instead of ASTM #7 or 67 because the remediation contractor inadvertently had ASTM#5 delivered instead. This alternate stone aggregate is acceptable because it is coarser than ASTM #7 or 67, which is the minimum required stone size for armoring.

ASTM #7:	Sieve Size	Percent Passing
	¾"	100
	½"	90-100
	3/8"	40-70
	No. 4	0-15
	No. 8	0-5

5.2 Condition 2 (Cap Area A.1)

Cap Area A.1 is relatively flat, with a maximum slope of approximately 2.7% and is to be capped with ASTM #10 aggregate. To confirm potential armoring requirements, the same assumptions that were used for Cap Area B.1 (Condition 1) were conservatively assumed, with the exception of the maximum slope and slope width. The surface slope was adjusted to 2.7% and the slope width was reduced to 90 feet to reflect Cap Area A.1 conditions. The drainage area was assumed to be 50% of the drainage area for Cap Area B.1.

As presented in **Attachment D,** the resulting computed anticipated shear stress was 0.04 lb/ft^2, which is less than the allowable shear stress for the ASTM #10 aggregate (estimated to range from 0.075 lb/ft^2 to 0.11 lb/ft^2; refer to **Section 5.2**). This conservative analysis confirms that the proposed cap materials for Cap Area A.1 should be able to withstand the anticipated shear stresses from sheetflow. Thus, additional armoring is not necessary.

5.3 Condition 3 (Cap Areas C.1 and C.2)

Based on the site topography, the approximate drainage area for the channel (i.e., Cap Areas C.1 and C.2) was estimated by EENC to be 17,000 square feet (refer to **Figure 1**). The average in-channel slope for Cap Area C.1 is approximately 8%, and the steepest channel side slopes were estimated by EENC to be 2H:1V. The average in-channel slope for Cap Area C.2 is approximately 3%, and the steepest channel side slopes were estimated by EENC to be 3H:1V. The proposed grading plan and details are provided in **Attachment A**.

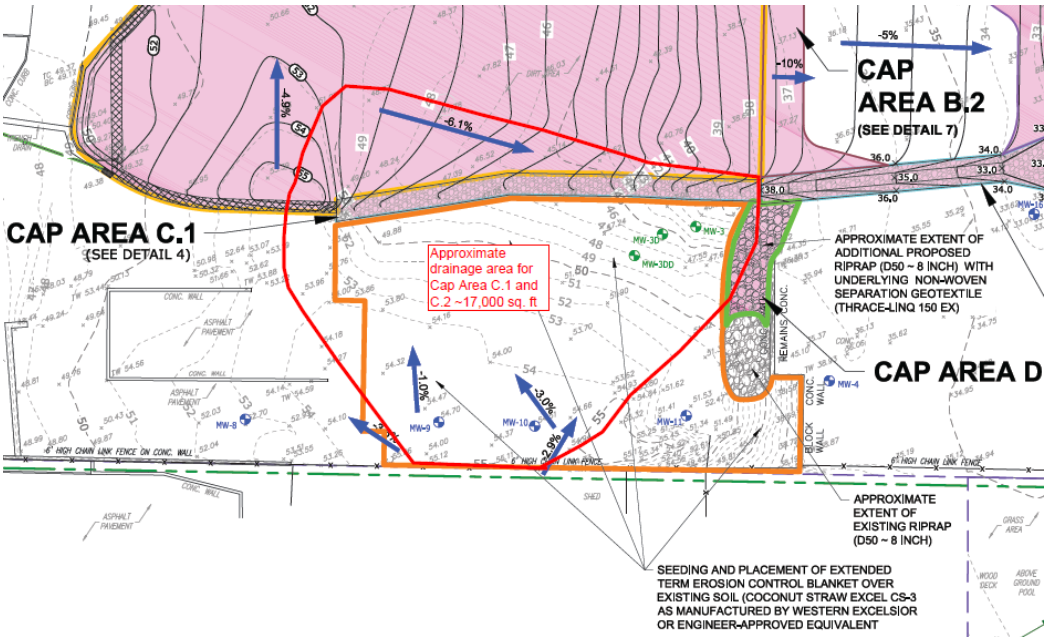


Figure 1. Approximate drainage area for Cap Area C.1 and C.2 channel (arrows depict approximate stormwater runoff flow direction).

The rational method (**Equation 1**) was used to determine the maximum anticipated runoff (Q) within the drainage area using the peak rain intensity (I) from the 25-year storm, the estimated drainage area (A), and a conservative runoff coefficient (C) of 0.9. Consistent with the New York State Standards and Specifications for Erosion and Sediment Control (NYSDEC, November 2016), a 25-year, 24-hour storm was used in the analysis. The peak rain intensity for the design storm was estimated by taking the rainfall total in the 25-year, 24-hour storm from the TR-55 database, converting this rainfall total to rain intensity from the Type II rainfall distribution, and using the maximum rain intensity from this storm in the calculations. The anticipated runoff was estimated to be 1.71 cfs (refer to **Figure 2**).

Rational Method		
Drainage Area	ft^2	17014
Rain intensity	in/hour	4.872
C factor		0.9
Computed Q	ft^3/s	1.71

Design Storm	Type II distribution	
	24-hour Rainfall	Peak
Year	Amount (in)	Intensity
2	3.39	
5	4.27	
10	5.09	
25	6.41	4.872
50	7.64	5.8
100	9.12	6.931

Figure 2. Design flow calculation

The iterative procedures described in the Federal Highway Administration's HEC No. 15 manual (*Design of Roadside Channels with Flexible Linings*) were used to define the median diameter (D50) of the armor stone required to limit channel erosion. As presented in **Attachment E,** the channel in Cap Area C.1 was represented as trapezoidal, with a bottom width of 2 ft and a conservative side slope estimate of 2H:1V. Given this channel configuration, the minimum D50 for the armor stone lining was computed to be 0.7 inches, which can be achieved with ASTM #5 stone, which has a D50 of 0.75 inches.

ASTM #5:	Sieve Size	Percent Passing
	1.5"	100
	1"	90-100
	¾"	20-55
	½"	0-10
	3/8"	0-5

In addition to quantifying the minimum stone size that is required to prevent channel erosion, the extent of stone armoring was also calculated. Considering a 0.3-ft freeboard, the top width of the design flow within the trapezoidal channel was calculated to be 8 ft. Based on these calculations and as shown in the Design Drawings for Cap Area C.1, stone with a D50 of at least 0.7 inches is required along the channel alignment for a minimum width of 8 ft. While the minimum required thickness per the Blue Book is 1.5 times the D50 of the selected stone (i.e., ASTM #5 stone), considering the required stone size and implementability, the minimum specified thickness was 3 inches.

As shown in **Figure 1**, Cap Area C.2 is to be constructed downstream of Cap Area C.1 and will serve to convey the stormwater runoff to the interceptor trench along the eastern portion of the property. The drainage area for Cap Area C.2 is approximately the same as for Cap Area C.1.[2] Since Cap Area C.2 is proposed in a flatter area of the Site, and there are no particular horizontal constraints, shallower channel side slopes (3H:1V), a wider channel bottom (4 ft) are proposed. Thus, the minimum stone lining requirement would be the same as that for Cap Area C.1 (i.e., ASTM #5 stone). Since these channel specifications are consistent with the minimum requirements for Cap Area C.1, additional calculations are not provided for Cap Area C.2.

The New York Blue Book's *Standard and Specifications for Rock Outlet Protection* (**Attachment F**) was used to design the riprap apron that would be needed at the discharge point of Cap Area C.2. These specifications require the classification of the anticipated tailwater condition. For Cap Area C.2, minimum tailwater was assumed, since the channel and outlet configuration can be described as open channel flow with discharge to an unconfined section.

The channel was conservatively represented as trapezoidal, with a bottom width of 2 ft, 2H:1V side slopes, flowing 0.19 ft deep (i.e., the configuration of Cap Area C.1 as opposed to Cap Area C.2). Based on the continuity equation and in accordance with the Blue Book (**Equation 4**), the average flow velocity was estimated to be 3.9 feet per second. Using **Equation 5**, the computed equivalent discharge for this flow regime was 0.1 cubic feet per second. Considering the anticipated flow depth (0.19 ft) and discharge (0.1 cfs), the median diameter (D50) for the rip-rap apron was conservatively estimated to be 2.4 inches, using **Figure 5B.12** (Outlet Protection Design – Minimum Tailwater Condition) of the Blue Book. While the minimum required apron thickness per the Blue Book is 1.5 times the D50 of the selected stone (i.e., ASTM

[2] Note that, while the proposed stone armoring in Cap Area D is adjacent to the channel in Cap Area C.1, stormwater runoff from Cap Area D will not drain into the channel, based on the local topography.

#1 stone), considering the required stone size, the minimum specified thickness was 5 inches. The minimum length and width of the apron were computed to be 6 ft and 8 ft, respectively. As shown in the proposed capping plan in **Attachment A**, the proposed apron dimensions exceed these minimum requirements. The gradation of the ASTM #1 stone, which has a D50 of 2.5 inches, is provided below.

ASTM #1:	Sieve Size	Percent Passing
	4"	100
	3.5"	90-100
	2.5"	25 to 60
	1.5"	0-15
	¾"	0-5

$$Q = VA \qquad \textbf{Equation 4}$$

where:
V = flow velocity
A = cross sectional flow area

$$Q_{equivalent} = \frac{\pi d^2}{4} V \qquad \textbf{Equation 5}$$

where:
$Q_{equivalent}$ = equivalent discharge defined in the *Standard and Specifications for Rock Outlet Protection*
d = flow depth

For ease of construction, it was decided to apply the stone lining requirements for the riprap apron to Cap Area C.2 (i.e., use the larger ASTM #1 stone instead of ASTM #5 stone).

5.4 Condition 4

The area between Cap Area B.1 and the interceptor trench, but excluding Cap Area A.1 (which is discussed above), was evaluated to ensure that the ASTM #10 surface cover materials would provide sufficient erosion protection. Proposed slopes vary in this portion of the Site, from 20% to less than 5%. To determine surface armoring requirements, similar calculations were performed as for Conditions 1 and 2. In the Condition 4 calculations, however, the slope was varied in order to find the minimum slope that would allow the ASTM #10 cover materials to be stable without additional surface armoring.

As presented in **Attachment G**, the drainage area was assumed to be the entirety of Cap Area B.1, and the slope width was conservatively estimated to be 120 feet. Other design parameters were identical to those used in the Condition 2 and 3 calculations. Based on this evaluation, slopes steeper than 5% will require armoring with ASTM #7 or ASTM #67 stone (D50 of 3/8") for erosion protection. The minimum thickness of the stone armor layer should be two times the D50 or 3-inches minimum, whichever is greater.[3] The areas with slopes steeper than 5% are located between Cap Area A.1 and the interceptor trench (i.e., Cap Area A.2) and to the east of Cap Area B.1 (i.e., Cap Area B.2).

[3] See footnote #1.

The suitability of the proposed armoring for the steepest slope in this area (i.e., 20%) was evaluated using the same approach. The calculations, provided in **Attachment H,** concluded that the proposed ASTM #7 or ASTM #67 stone can sufficiently withstand the anticipated shear stresses.

6. SUMMARY AND CONCLUSIONS

The central portion of the site, which grades from approximately elevation 49 ft to elevation 36 ft from west to east (approximately 10% maximum slope), is to be capped with two feet of material (refer to **Figure 1**). The proposed cap configuration was evaluated to: (a) assess the need for armoring; and (b) specify the type and size of the proposed surface materials. Consistent with the New York State Standards and Specifications for Erosion and Sediment Control (NYSDEC, November 2016), a 25-year, 24-hour storm was used in the analysis. The evaluation was performed using the rational method and compared anticipated shear stresses with maximum allowable shear stresses to determine armoring requirements.

Based on this analysis, the minimum armoring requirements for the proposed cap will comprise of the following elements, which are depicted in **Figure 1**:

- No armoring is required for Cap Area A.1, which is to be covered with ASTM #10 stone.
- The proposed soil cap in Cap Area B.1 (ASTM No. #10) will be armored with a 3-inch layer of ASTM #7 or #67 stone (i.e., Condition 2).
- Slopes steeper than 5% in the area between Cap Area B.1 and the interceptor trench (i.e., Cap Areas A.2 and B.2) will be armored with a 3-inch layer of ASTM #7 or #67 stone.
- The channel (Cap Area C.1) along the southern side of Cap Area B.1 (i.e., Condition 3), where the proposed cap grades to match existing grades, will have a base width of 2 ft, a top width of 8 ft, and will be lined with 3 inches of ASTM #5 stone, which has a D50 greater than 0.7 inches.
- A slightly wider channel (Cap Area C.2) is to be constructed downstream of Cap Area C.1. This channel will have a base width of 4 ft, a side slope of 3H:1V, and will be lined with a minimum of 5 inches of ASTM #1 stone, which has a D50 greater than 2.4 inches.
- A riprap apron will be required at the channel C.2 discharge point. The apron will have a length of 6 ft, a width of 8 ft, and will be lined with 5 inches of a ASTM #1 stone, which has a D50 greater than 2.4 inches.

Additionally, in Cap Area D, riprap stone similar to the stone that is currently lining a southern portion of this slope above the retaining wall (D50 of approximately 8 inches) is proposed to extend northward towards Cap Area C.1.

7. REFERENCES

Federal Highway Administration. Hydraulic Engineering Circular (HEC) No. 15, Design of Roadside Channels with Flexible Linings. September 2005.

Fortier, S. and F. C. Scobey, 1926. Permissible canal velocities. Trans. ASCE, Volume 89, paper No. 1588.

New York Department of Environmental Conservation. New York State Standards and Specifications for Erosion and Sediment Control (“Blue Book”). November 2016.

TOMPKINS AVENUE
(70' WIDE)
(TITLE VESTED ON 11-20-81)
TWO-WAY TRAFFIC

(VARIABLE WIDTH)
(TITLE VESTED ON 7-28-89)
ONE-WAY TRAFFIC

CAP AREA A.1
(SEE DETAIL 2)

CAP AREA B.1
(SEE DETAIL 3)

LOT 12

CAP AREA A.2
(SEE DETAIL 7)

CAP AREA B.2
(SEE DETAIL 7)

CAP AREA C.1
(SEE DETAIL 4)

CAP AREA D

CAP AREA C.2
RIPRAP SWALE
(SEE DETAIL 5)

PROTECT EXISTING VEGETATION

APPROX. LOC. U.S. GAS LINE (NOT FIELD VERIFIED)

DRY WELL (SUBSURFACE)

APPROXIMATE EXTENT OF ADDITIONAL PROPOSED RIPRAP (D50 ~ 8 INCH) WITH UNDERLYING NON-WOVEN SEPARATION GEOTEXTILE (THRACE-LINQ 150 EX)

APPROXIMATE EXTENT OF EXISTING RIPRAP (D50 ~ 8 INCH)

SEEDING AND PLACEMENT OF EXTENDED TERM EROSION CONTROL BLANKET OVER EXISTING SOIL (COCONUT STRAW EXCEL CS-3 AS MANUFACTURED BY WESTERN EXCELSIOR OR ENGINEER-APPROVED EQUIVALENT

LOT 54

BUTLER PLACE
(50' WIDE)
TWO-WAY TRAFFIC

KALTENMI LANE

TILSON PLACE
(VARIABLE WIDTH)
TWO-WAY TRAFFIC

ST. MARY'S AVENUE

LEGEND

- APPROX. PROPERTY BOUNDARY
- LOT BOUNDARY
- EXISTING ELEVATION CONTOUR
- PROPOSED ELEVATION CONTOUR
- FENCE
- FIRE LOOP
- GAS LINE
- SEWER/STORMWATER LINE - TO REMAIN
- EXISTING MONITORING WELL - TO REMAIN
- INTERCEPTOR CHANNEL (INSTALLED FEBRUARY - MARCH 2011)
- EXISTING PERIMETER TRENCH
- CAP AREA A.1 (7,558 SQ. FT.)- ASTM #10 COVER (DETAIL 2)
- CAP AREA A.2 (4,000 SQ. FT.)- ASTM #5 COVER (DETAIL 7)
- CAP AREA B.1 (50,613 SQ. FT.) - ASTM #5 COVER (DETAIL 3)
- CAP AREA B.2 (1,870 SQ. FT.) - ASTM #5 COVER (DETAIL 7)
- CAP AREA C.1 (1,260 SQ. FT.) - ASTM #5 COVER (DETAIL 4)
- CAP AREA C.2 (1,240 SQ. FT.) - ASTM #1 COVER (DETAIL 5)
- CAP AREA D (700 SQ. FT.) - 8" RIP RAP (DETAIL 6)
- AREA OF EROSION CONTROL BLANKET
- -3.3% APPROXIMATE FLOW DIRECTION AND AVERAGE SLOPES
- AREA OF PROPOSED STONE PLACEMENT (SEE DETAILS FOR APPROPRIATE STONE SIZES IN EACH AREA)

MEDIAN DIAMETER (D50) OF STONE AGGREGATE	
ASTM #5	3/4"
ASTM #1	2 1/2"

SOURCES:
1. PAVED AREA NORTH AND WEST OF CAPPING AREA: BASEMAP PROVIDED BY CONTROL POINT ASSOCIATES, INC. ENTITLED "BOUNDARY AND TOPOGRAPHIC SURVEY", DATED 9/12/2008 AND REVISED 3/29/2012.
2. CAPPING AREA SOUTH AND EAST OF PAVED AREA: TOPOGRAPHIC SURVEY BY DPK CONSULTING ENTITLED "TOPOGRAPHIC CONDITIONS QA/QC", DATED 02/08/2017.

30 0 30 60
SCALE IN FEET

DATE	DR.	CH.	REVISION
07/20/2017	DLB	JS	REMOVED DETAILS; ADDED EXISTING RIPRAP & CAP AREA D. REVISED EROSION BLANKET. ADDED RIPRAP SWALE. REMOVED COVER DESIGNATION HATCHES, RE-CALCULATED CAP AREAS
06/29/2017	BSC	JS	REVISED GRADING PLAN, ADDED DETAIL.
01/12/2017	TSP	JS	UPDATED ALL EXCAVATION AREAS, REVISED ID FOR PROP CONF. SAMPLES.
03/25/2015	TSP	JS	ADDED EXCAVATION AREAS (RW1, RW2 & RW3).
01/29/2015	MSB	JS	ADDED WELLS (3BR, 15, 15D, 16, 17, & 18).
06/12/2014	BJK	JS	IDENTIFIED TREES TO PRESERVE AND EDITS TO PROPOSED GRADING

PROPOSED CAPPING PLAN

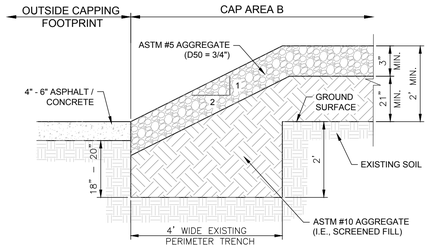
RAMBOLL ENVIRON

SUN CHEMICAL CORPORATION-
ROSEBANK FACILITY
441 TOMPKINS AVE.
STATEN ISLAND, NY

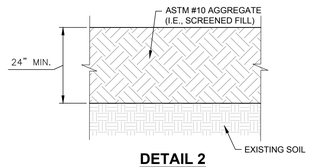
PREPARED BY: JS/TA/JY	DATE: 05/20/2014
DRAFTED BY: BSC/DLB	SCALE: AS SHOWN
APPROVED BY: JS	PROJECT: 2116443A

PLATE 1

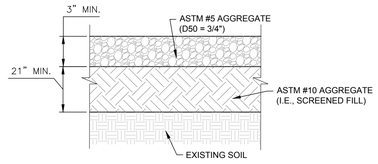
MBLED 7/20/17 [CAPPING PLAN_2116443]
F:\2116443_SUN CHEMICAL ROSEBANK_WIP_DRAFT



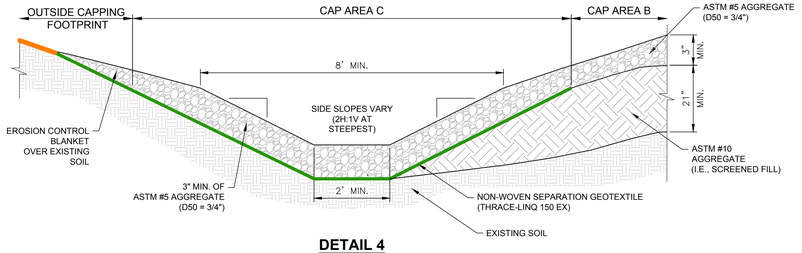
DETAIL 1
CAP TRANSITION OVER EXISTING PERIMETER TRENCH DETAIL
1" = 2'



DETAIL 2
CAP AREA A.1
TYPICAL CROSS SECTION
1" = 2'



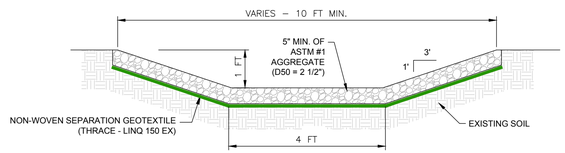
DETAIL 3
CAP AREA B.1
TYPICAL CROSS SECTION
1" = 2'



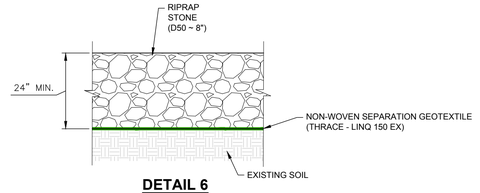
DETAIL 4
CAP AREA C.1 CHANNEL
TYPICAL CROSS SECTION
1" = 2'

NOTE:

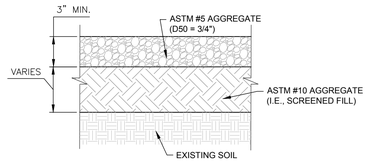
1. SEE DETAIL 5 FOR RIPRAP APRON..



DETAIL 5
RIPRAP SWALE FOR CAP AREA C.2
1" = 2'



DETAIL 6
CAP AREA D
TYPICAL CROSS SECTION
1" = 2'



DETAIL 7
CAP AREAS A.2 AND B.2
TYPICAL CROSS SECTION
1" = 2'

DATE	DR.	CH.	REVISION
07/20/2017	TSP	JS	UPDATED DETAIL 5 AND ADDED DETAIL 6 & 7
07/12/2017	DLB	JS	ADDED DETAILS 3 & 4
06/29/2017	BSC	JS	REVISED GRADING PLAN, ADDED DETAIL.

PROPOSED CAPPING PLAN DETAILS

SUN CHEMICAL CORPORATION-
ROSEBANK FACILITY
441 TOMPKINS AVE.
STATEN ISLAND, NY

RAMBOLL ENVIRON

PREPARED BY: JS/TAJ/Y	DATE: 5/20/2014
DRAFTED BY: BSC/DLB	SCALE: AS SHOWN
APPROVED BY: JS	PROJECT: 2116443A

PLATE
2

MBLD 7/21/17 [CAPPING_DETAILS_2116443]
F:\2116443_SUN CHEMICAL ROSEBANK_WIP_DRAFT

Attachment B. Typical sieve analysis for ASTM #10 stone

F A N W O O D C R U S H E D S T O N E CO.
W A T C H U N G, N.J.

CONTRACTOR: ENR CONTRACTING
FAX NUMBER:

ATTN: JOHN GRELIS

PROJECT : STATEN ISLAND

DATE : 04/28/17 **Sales Representative:** Terry Starr

MATERIAL : **SCREENED FILL**

T Y P I C A L S I E V E A N A L Y S I S

SIEVE SIZE	PER CENT PASSING.	NJ.DOT SPECS. # 10
3/8"	100	100
#4	96	85 - 100
#8	62	N/A
# 16	38	N/A
# 30	26	N/A
# 50	20	N/A
# 100	15	10 - 30
# 200	12	N/A

THE SIEVE ANALYSIS SHOWN IS TYPICAL OF : SCREENED FILL AGGREGATE AS PRODUCED AT FANWOOD CRUSHED STONE, WATCHUNG, NJ AND PROPOSED FOR USE ON THE ABOVE PROJECT. THE SIEVE ANALYSIS COMPLIES WITH THE APPROPRIATE SPECIFICATIONS.

Attachment C. Condition 1 Calculations (Cap Area B)

Rational Method (Equation 1)

Drainage Area	ft^2	50400	
Rain intensity	in/hour	4.872	25-year storm
C factor		0.9	
Computed Q	ft^3/s	5.07	25 year storm

Modified Manning's Formula and Shear Stress (Equations 4 and 5)

Slope width	ft	150	Conservative
Max slope	ft/ft	0.1	
n		0.02	Silt loam or sandy loam
Computed q	ft^2/s	0.03	
Computed sheetflow depth, y	ft	0.02	Equation 4
Computed anticipated shear stress	lb/ft^2	0.12	Equation 5
Max allowable shear stress for sandy loam	lb/ft^2	0.08	See Table 5-2
Max allowable shear stress for silt loam	lb/ft^2	0.11	See Table 5-2
Max allowable shear stress for fine gravel	lb/ft^2	0.32	See Table 5-2

Design Storm

Year	24-hour Rainfall Amount (in)	Peak Intensity	
25	6.41	4.872	
50	7.64	5.8	
100	9.12	6.931	

Table 5-2. Maximum Permissible Velocities and Corresponding Unit Tractive Force (Shear Stress) (U.S. Bureau of Reclamation research, Fortier and Scobey 1926)

Material	n	Clear Water (diversion structures) V (ft/sec)	Clear Water (diversion structures) τ_o (lb/ft^2)	Water Transporting Colloidal Silts (on site and down slope) V (ft/sec)	Water Transporting Colloidal Silts (on site and down slope) τ_o (lb/ft^2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sandy loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when noncolloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Note:
- an increase in velocity of 0.5 ft/sec can be added to these values when the depth of water is greater than 3 ft.
- a decrease in velocity of 0.5 ft/sec should subtracted then the water contains very coarse suspended sediments.
- for high and infrequent discharges of short duration, up to 30% increase in velocity can be added

Attachment D. Condition 2 Calculations (Cap Area A)

Rational Method

Drainage Area	ft^2	25200	Assumed to be 50% of the drainage area for Cap Area B
Rain intensity	in/hour	4.872	25-year storm
C factor		0.9	Fraction of rain falling within drainage area that will run off
Computed Q	ft^3/s	2.54	25 year storm

Modified Manning's Formula and Shear Stress

Slope width	ft	90	
Max slope	ft/ft	0.027	
n		0.02	Silt loam or sandy loam
Computed q	ft^2/s	0.03	
Computed sheetflow depth, y	ft	0.03	Equation 4
Computed anticipated shear stress	lb/ft^2	0.04	Equation 5
Max allowable shear stress for sandy loam	lb/ft^2	0.08	See Table 5-2
Max allowable shear stress for silt loam	lb/ft^2	0.11	See Table 5-2

Table 5-2. Maximum Permissible Velocities and Corresponding Unit Tractive Force (Shear Stress) (U.S. Bureau of Reclamation research, Fortier and Scobey 1926)

Material	n	Clear Water (diversion structures) V (ft/sec)	Clear Water (diversion structures) τ_o (lb/ft^2)	Water Transporting Colloidal Silts (on site and down slope) V (ft/sec)	Water Transporting Colloidal Silts (on site and down slope) τ_o (lb/ft^2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sandy loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when noncolloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Note:
- an increase in velocity of 0.5 ft/sec can be added to these values when the depth of water is greater than 3 ft.
- a decrease in velocity of 0.5 ft/sec should subtracted then the water contains very coarse suspended sediments.
- for high and infrequent discharges of short duration, up to 30% increase in velocity can be added

Figure 5-1 is another guidance illustration showing SCS data (USDA 1977). This figure differentiates between "sediment-free" and "sediment-laden" flow.

ATTACHMENT E. CONDITION 1 CHANNEL STONE LINING (CAP AREA C)

These calculations are performed in accordance with the iterative procedures described in the Federal Highway Administration Hydraulic Engineering Circular No. 15 (Third Edition) Manual, "Design of Roadside Channels with Flexible Linings."

INPUT PARAMETERS

Step 1. Input channel geometric parameters.

Bottom Width, B	ft	2	Conservative
Design Flow, Q	cfs	1.71	Computed with 25-year storm using Rational Method
Channel Side Slope, Z		2	Conservative; steepest segment
In-Channel Slope, So	ft/ft	0.15	Conservative; steepest segment; the average slope is 8% across the entire channel

Step 2. Input initial trial riprap D50.

Trial D50	in	0.7
	ft	0.06

Step 3. Input initial trial depth.

Trial Depth, d	ft	0.185

COMPUTATIONS

Use the geometric properties of a trapezoid to compute the maximum and average flow depths.

Area, A	sq. ft	0.44
Wetted Perimeter, P	ft	2.83
Hydraulic Radius, R	ft	0.16
Top Width, T	ft	2.74
Average Flow Depth, d_a	ft	0.16

Step 4. Compute the relative depth ratio.

Relative Depth Ratio		2.74

Compute Manning's n with Eqn 6.1:

Manning's n		0.043

Compute Manning's n with Eqn 6.2:

d_a	ft	0.16
D50	ft	0.06
T	ft	2.74
Flow velocity	ft/s	3.91
g	ft/s^3	32.2
Fr		1.721
b		0.453
f(CG)		0.276
f(REG)		24.883
f(Fr)		1.014
Manning's n		0.028

Step 5. Computed discharge using Manning's Equation:

Discharge, Q	cfs	1.72	**Ok, within 5% of design discharge**

Step 6. Compute the particle Reynolds number using Equation 6.6 and determine the Shields parameter and Safety Factor values from Table 6.1.

Shear Velocity, v*	fps	0.95	
Reynolds Number, Re		4.53E+03	Ok

From Table 6.1, based on computed values of v* and Re above:

Shields Parameter, F*		4.70E-02
Safety Factor, SF		1.50E-01

If the channel slope is less than 5%, compute the required D50 with Equation 6.8.

Computed D50	**ft**	**0.05**	
	in	**0.65**	Ok

If the maximum channel slope is greater than 5% and less than 10%, also compute the required D50 with Equation 6.11 to make sure the proposed stone size is acceptable. If the maximum channel slope is greater than 10%, use Equation 11.

Input

Z		2	
ᵞ_s (specific weight of stone)	lb/ft^3	165	
ᵞ_s (specific weight of water)	lb/ft^3	62.4	
Maximum flow depth (ft)		1.85E-01	
Channel slope	ft/ft	0.15	
Φ (riprap angle of repose)		37.5	<- typical value from [1] for very angular stone
F*		4.70E-02	
D50	ft	0.06	
alpha (angle of the channel bottom slope)	degrees	8.53	
SF		1.50E-01	

Computations

SG (specific gravity of rock)		2.64	
θ (angle of the channel side slope)	degree	26.57	
τ_d (bottom shear stress)	lb/ft^2	1.73	
K_1		0.80	
τ_s (side slope shear stress)	lb/ft^2	1.39	
ᵑ (stability number)		4.94	
β		68.76	
Δ		0.92	
D50	ft	0.05	
D50	in	0.59	Ok

Conclusion

To be conservative, a stone aggregate with a minimum D50 of 0.7 inches will be used to line the entire channel. This corresponds to a ASTM No. 5 stone.

STANDARD AND SPECIFICATIONS FOR ROCK OUTLET PROTECTION

Definition

A section of rock protection placed at the outlet end of the culverts, conduits, or channels.

Purpose

The purpose of the rock outlet protection is to reduce the depth, velocity, and energy of water, such that the flow will not erode the receiving downstream reach.

Scope

This standard applies to the planning, design, and construction of rock riprap and gabions for protection of downstream areas. It does not apply to rock lining of channels or streams.

Conditions Where Practice Applies

This practice applies where discharge velocities and energies at the outlets of culverts, conduits, or channels are sufficient to erode the next downstream reach. This applies to:

1. Culvert outlets of all types.

2. Pipe conduits from all sediment basins, dry storm water ponds, and permanent type ponds.

3. New channels constructed as outlets for culverts and conduits.

Design Criteria

The design of rock outlet protection depends entirely on the location. Pipe outlet at the top of cuts or on slopes steeper than 10 percent, cannot be protected by rock aprons or riprap sections due to re-concentration of flows and high velocities encountered after the flow leaves the apron.

Many counties and state agencies have regulations and design procedures already established for dimensions, type and size of materials, and locations where outlet protection is required. Where these requirements exist, they shall be followed.

Tailwater Depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. If the tailwater depth is less than half the diameter of the outlet pipe, and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a Minimum Tailwater Condition; see Figure 5B.12 on page 5B.25 as an example. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a Maximum Tailwater Condition; see Figure 5B.13 on page 5B.26 as an example. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition; see Figure 5B.12 on page 5B.25 as an example.

Apron Size

The apron length and width shall be determined from the curves according to the tailwater conditions:

Minimum Tailwater – Use Figure 5B.12 on page 5B.25
Maximum Tailwater – Use Figure 5B.13 on page 5B.26

If the pipe discharges directly into a well defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less.

The upstream end of the apron, adjacent to the pipe, shall have a width two (2) times the diameter of the outlet pipe, or conform to pipe end section if used.

Bottom Grade

The outlet protection apron shall be constructed with no slope along its length. There shall be no overfall at the end of the apron. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground.

Alignment

The outlet protection apron shall be located so that there are no bends in the horizontal alignment.

Materials

The outlet protection may be done using rock riprap, grouted riprap, or gabions.

Riprap shall be composed of a well-graded mixture of stone size so that 50 percent of the pieces, by weight, shall be larger than the d_{50} size determined by using the charts. A well-graded mixture, as used herein, is defined as a mixture composed primarily of larger stone sizes, but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

Thickness

The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter for d_{50} of 15 inches or less; and 1.2 times the maximum stone size for d_{50} greater than 15 inches. The following chart lists some examples:

D_{50} (inches)	d_{max} (inches)	Minimum Blanket Thickness (inches)
4	6	9
6	9	14
9	14	20
12	18	27
15	22	32
18	27	32
21	32	38
24	36	43

Stone Quality

Stone for riprap shall consist of field stone or rough unhewn quarry stone. The stone shall be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5.

Recycled concrete equivalent may be used provided it has a density of at least 150 pounds per cubic foot, and does not have any exposed steel or reinforcing bars.

Filter

A filter is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into and through the riprap. Riprap shall have a filter placed under it in all cases.

A filter can be of two general forms: a gravel layer or a plastic filter cloth. The plastic filter cloth can be woven or non-woven monofilament yarns, and shall meet these base requirements: thickness 20-60 mils, grab strength 90-120 lbs; and shall conform to ASTM D-1777 and ASTM D-1682.

Gravel filter blanket, when used, shall be designed by comparing particle sizes of the overlying material and the base material. Design criteria are available in Standard and Specification for Riprap Slope Protection on page 5B.57.

Gabions

Gabions shall be made of hexagonal triple twist mesh with heavily galvanized steel wire. The maximum linear dimension of the mesh opening shall not exceed 4 ½ inches and the area of the mesh opening shall not exceed 10 square inches.

Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the construction site into a rectangular basket of the specified sizes. Gabions shall be of single unit construction and shall be installed according to manufacturers recommendations.

The area on which the gabion is to be installed shall be graded as shown on the drawings. Foundation conditions shall be the same as for placing rock riprap, and filter cloth shall be placed under all gabions. Where necessary, key, or tie, the structure into the bank to prevent undermining of the main gabion structure.

Maintenance

Once a riprap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows for evidence of scour beneath the riprap or for dislodged stones. Repairs should be made immediately.

Design Procedure

1. Investigate the downstream channel to assure that nonerosive velocities can be maintained.

2. Determine the tailwater condition at the outlet to establish which curve to use.
3. Enter the appropriate chart with the design discharge to

determine the riprap size and apron length required. It is noted that references to pipe diameters in the charts are based on full flow. For other than full pipe flow, the parameters of depth of flow and velocity must be used to adjust the design discharges.

4. Calculate apron width at the downstream end if a flare section is to be employed.

Examples

Example 1: Pipe Flow (full) with discharge to unconfined section.

Given: A circular conduit flowing full.

Q = 280 cfs, diam. = 66 in., tailwater (surface) is 2 ft. above pipe invert (minimum tailwater condition).

Find: Read d_{50} = 1.2 and apron length (L_a) = 38 ft.

Apron width = diam. + L_a = 5.5 + 38 = 43.5 ft.

Use: d_{50} = 15", d_{max} = 22", blanket thickness = 32"

Example 2: Box Flow (partial) with high tailwater

Given: A box conduit discharging under partial flow conditions. A concrete box 5.5 ft. x 10 ft. flowing 5.0 ft. deep,

Q = 600 cfs and tailwater surface is 5 ft. above invert (max. tailwater condition).

Since this is not full pipe and does not directly fit the nomograph assumptions of Figure 7B.13 substitute depth as the diameter, to find a discharge equal to full pipe flow for that diameter, in this case 60 inches.

Since, $Q = AV$ and $A = \frac{\pi D^2}{4}$

First, compute velocity:

V = (Q/A) = (600/(5) (10)) = 12 fps

Then substituting:

$$Q = \frac{\pi D^2}{4} \times V = \frac{3.14\ (5\ ft)^2}{4} \times 12\ fps = 236\ cfs$$

At the intersection of the curve d = 60 in. and Q = 236 cfs, read d_{50} = 0.4 ft.

Then reading the d = 60 in. curve, read apron length (L_a) = 40 ft.

Apron width, W = conduit width + (6.4)(L_a) = 10 + (0.4) (40) = 26 ft.

Example 3: Open Channel Flow with Discharge to Unconfined Section

Given: A trapezoidal concrete channel 5 ft. wide with 2:1 side slopes is flowing 2 ft. deep, Q = 180 cfs (velocity = 10 fps) and the tailwater surface downstream is 0.8 ft. (minimum tailwater condition).

Find: Using similar principles as Example 2, compute equivalent discharge for a 2 foot, using depth as a diameter, circular pipe flowing full at 10 feet per second.

Velocity:

$$Q = \frac{\pi\ (2ft)^2}{4} \times 10\ fps = 31.4\ cfs$$

At intersection of the curve, d = 24 in. and Q = 32 cfs, read d_{50} = 0.6 ft.

Then reading the d = 24 in. curve, read apron length (L_a) = 20 ft.

Apron width, W = bottom width of channel + L_a = 5 + 20 = 25 ft.

Example 4: Pipe flow (partial) with discharge to a confined section

Given: A 48 in. pipe is discharging with a depth of 3 ft. Q = 100 cfs, and discharge velocity of 10 fps (established from partial flow analysis) to a confined trapezoidal channel with a 2 ft. bottom, 2:1 side slopes, n = .04, and grade of 0.6%.

Calculation of the downstream channel (by Manning's Equation) indicates a normal depth of 3.1 ft. and normal velocity of 3.9 fps.

Since the receiving channel is confined, the maximum tailwater condition controls.

Find: discharge using previous principles:

$$Q = \frac{\pi\ (3ft)^2}{4} \times 10\ fps = 71\ cfs$$

At the intersection of d = 36 in. and Q = 71 cfs, read d_{50} = 0.3 ft.

Reading the d = 36" curve, read apron length (L_a) = 30 ft.

Since the maximum flow depth in this reach is 3.1 ft., that is the minimum depth of riprap to be maintained for the entire length.

Construction Specifications

1. The subgrade for the filter, riprap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

2. The rock or gravel shall conform to the specified grading limits when installed respectively in the riprap or filter.

3. Filter cloth shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of cloth over the damaged part or by completely replacing the cloth. All overlaps, whether for repairs or for joining two pieces of cloth shall be a minimum of one foot.

4. Stone for the riprap or gabion outlets may be placed by equipment. Both shall each be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for riprap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogenous with the smaller stones and spalls filling the voids between the larger stones. Riprap shall be placed in a manner to prevent damage to the filter blanket or filter cloth. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

Figure 5B.12
Outlet Protection Design—Minimum Tailwater Condition
(Design of Outlet Protection from a Round Pipe Flowing Full, Minimum Tailwater Condition: $T_w < 0.5D_o$) (USDA - NRCS)

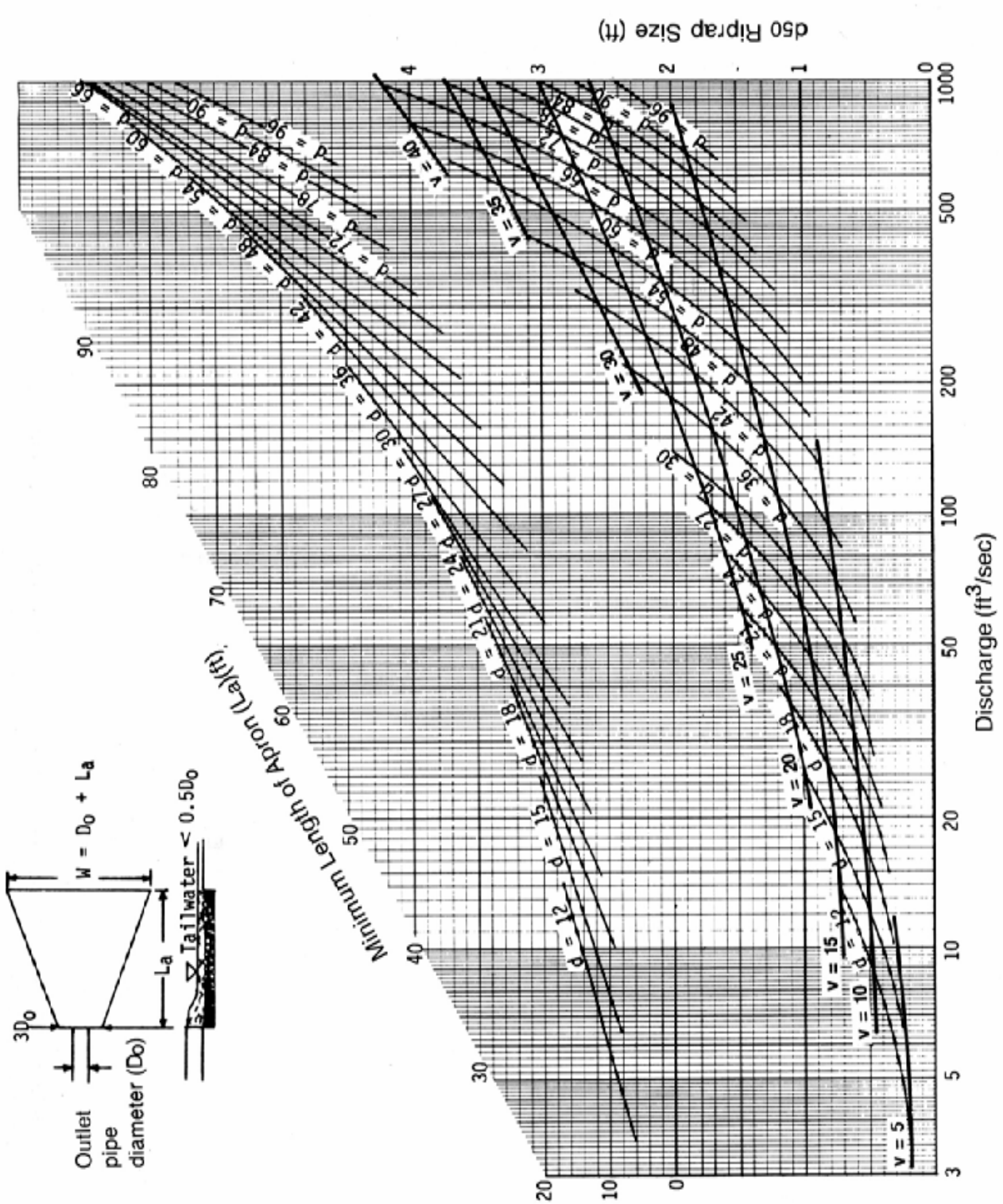


Figure 5B.13
Outlet Protection Design—Maximum Tailwater Condition
(Design of Outlet Protection from a Round Pipe Flowing Full, Maximum Tailwater Condition: $T_w \geq 0.5D_o$) (USDA - NRCS)

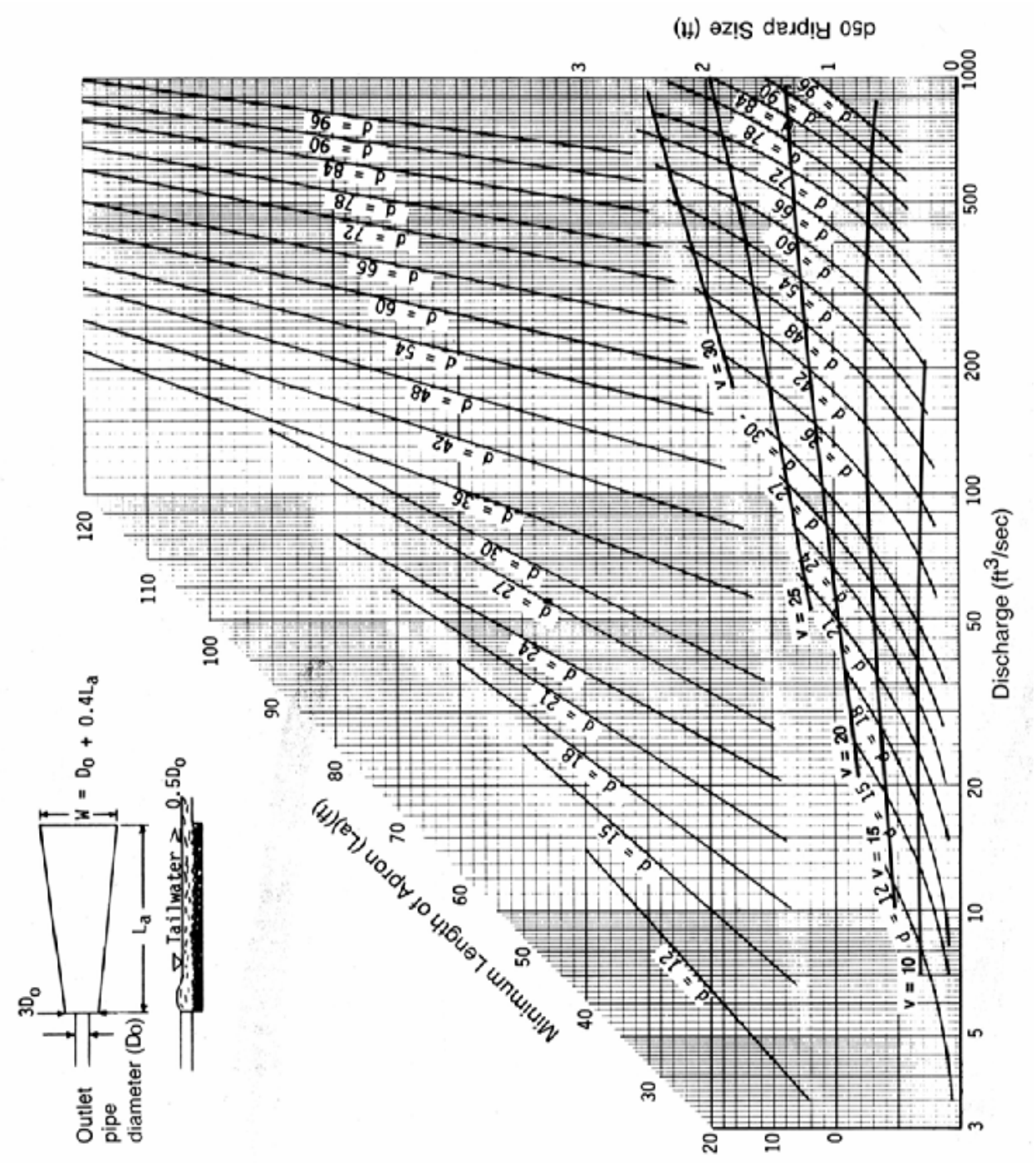


Figure 5B.14
Riprap Outlet Protection Detail (1)

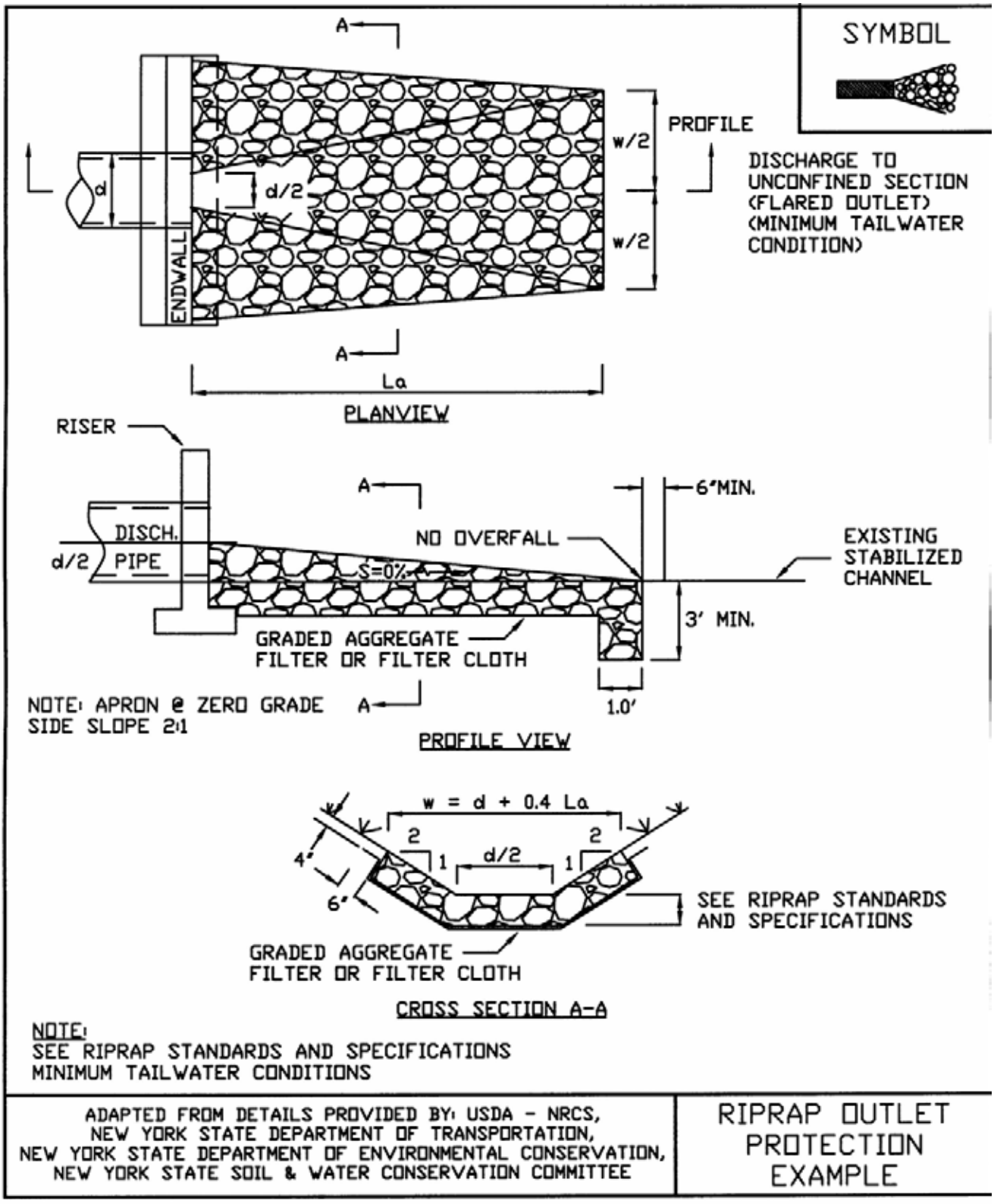


Figure 5B.15
Riprap Outlet Protection Detail (2)

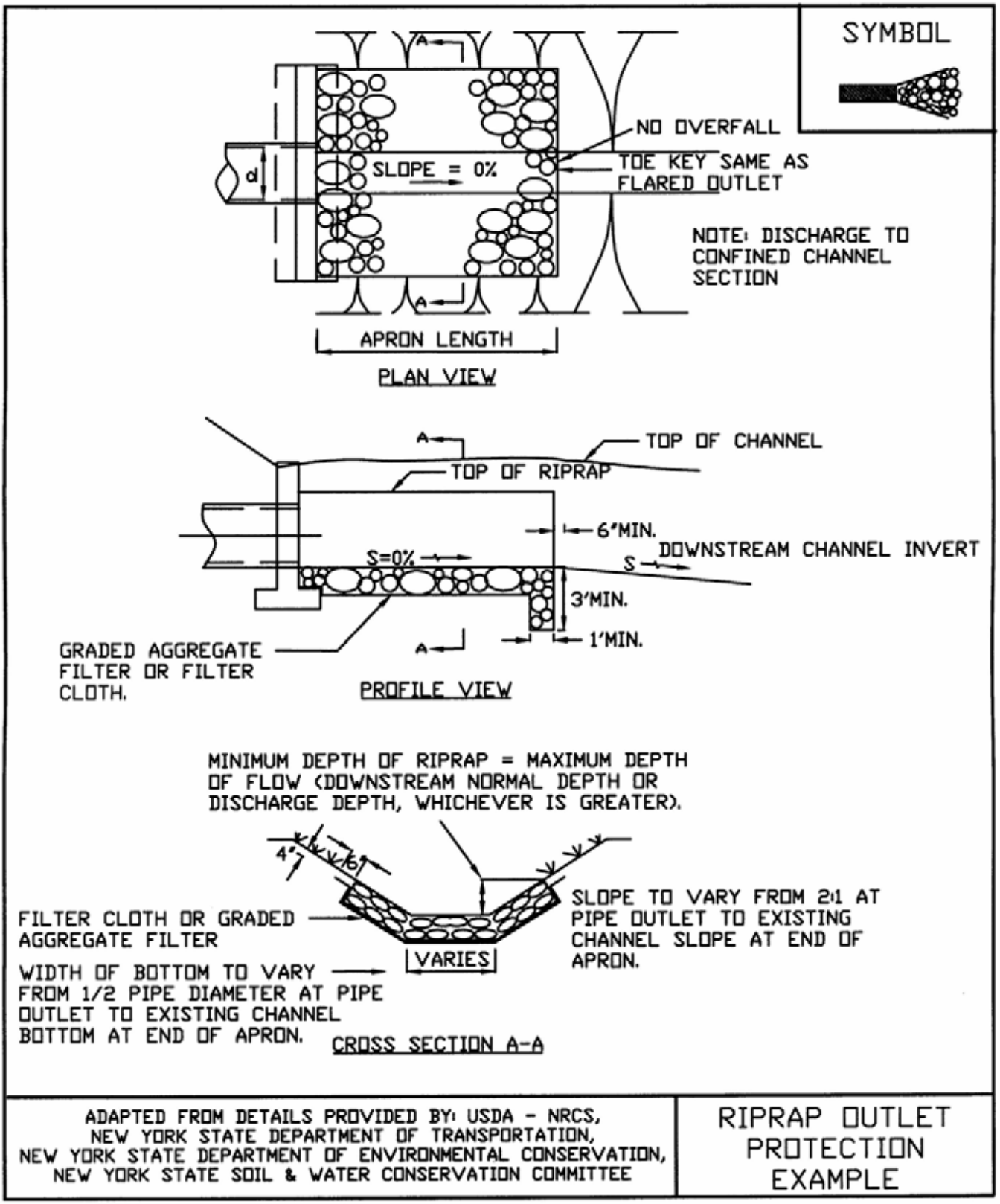
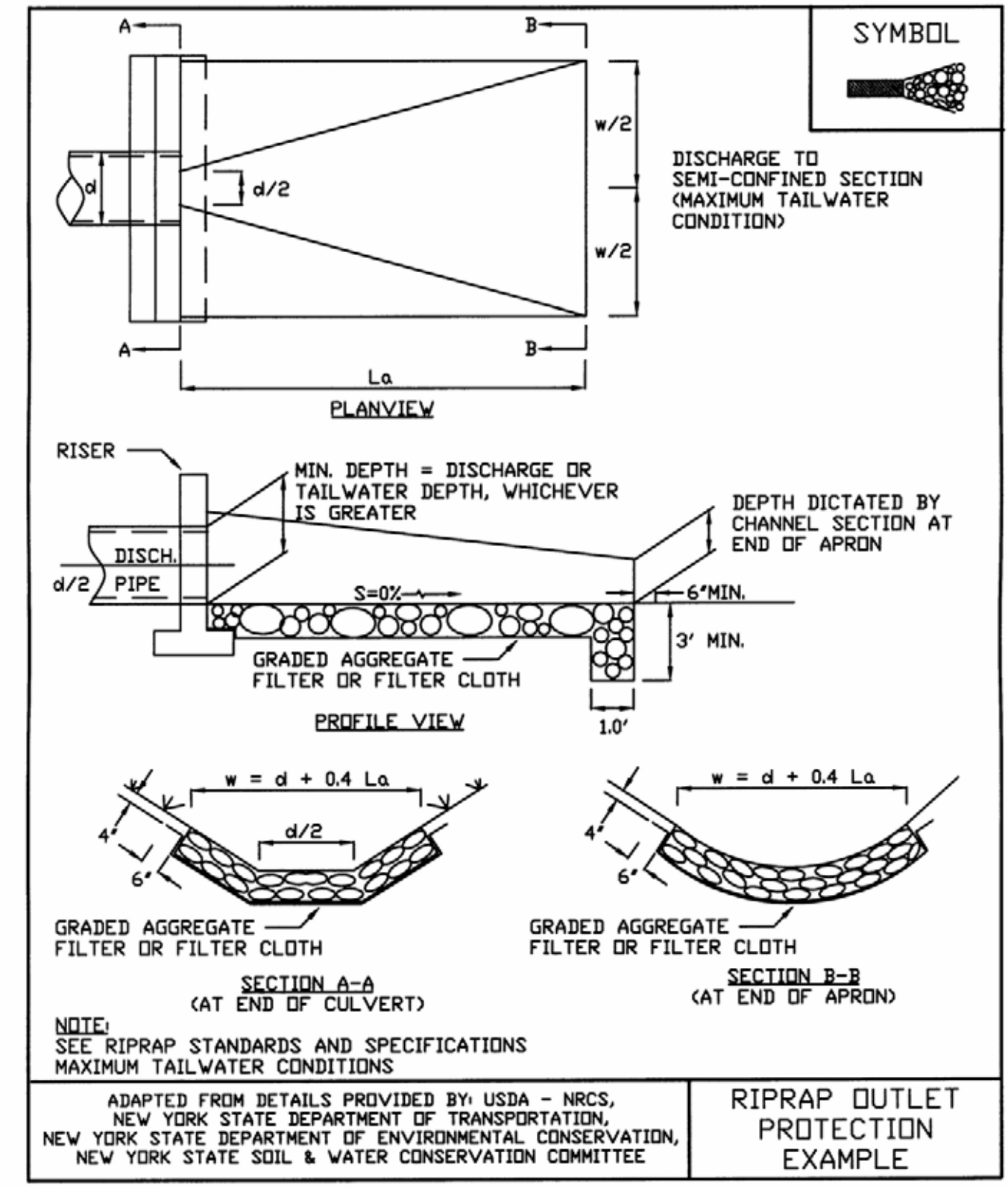


Figure 5B.16
Riprap Outlet Protection Detail (3)



Attachment G. Condition 4 Calculations (Downslope of Cap Area B)

Rational Method

Drainage Area	ft^2	50613	Assumed to be 100% of the drainage area for Cap Area B
Rain intensity	in/hour	4.872	25-year storm
C factor		0.9	fraction of rain falling within drainage area that will run off
Computed Q	ft^3/s	5.09	25 year storm

Modified Manning's Formula and Shear Stress

Slope width	ft	180	
Max slope	ft/ft	0.05	
n		0.02	Silt loam or sandy loam
Computed q	ft^2/s	0.03	
Computed sheetflow depth, y	ft	0.02	
Computed anticipated shear stress	lb/ft^2	0.07	
Max allowable shear stress for sandy loam	lb/ft^2	0.08	
Max allowable shear stress for silt loam	lb/ft^2	0.11	
Max allowable shear stress for fine gravel	lb/ft^2	0.32	See Table 5-2

Table 5-2. Maximum Permissible Velocities and Corresponding Unit Tractive Force (Shear Stress) (U.S. Bureau of Reclamation research, Fortier and Scobey 1926)

Material	n	Clear Water (diversion structures) V (ft/sec)	Clear Water (diversion structures) τ_o (lb/ft^2)	Water Transporting Colloidal Silts (on site and down slope) V (ft/sec)	Water Transporting Colloidal Silts (on site and down slope) τ_o (lb/ft^2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sandy loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when noncolloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Note:
- an increase in velocity of 0.5 ft/sec can be added to these values when the depth of water is greater than 3 ft.
- a decrease in velocity of 0.5 ft/sec should subtracted then the water contains very coarse suspended sediments.
- for high and infrequent discharges of short duration, up to 30% increase in velocity can be added

Figure 5-1 is another guidance illustration showing SCS data (USDA 1977). This figure differentiates between "sediment-free" and "sediment-laden" flow.

Attachment H. Condition 4 Calculations (Downslope of Cap Area B)

Rational Method

Drainage Area	ft^2	50613	Assumed to be 100% of the drainage area for Cap Area B
Rain intensity	in/hour	4.872	25-year storm
C factor		0.9	fraction of rain falling within drainage area that will run off
Computed Q	ft^3/s	5.09	25 year storm

Modified Manning's Formula and Shear Stress

Slope width	ft	180	
Max slope	ft/ft	0.2	
n		0.02	Silt loam or sandy loam
Computed q	ft^2/s	0.03	
Computed sheetflow depth, y	ft	0.01	
Computed anticipated shear stress	lb/ft^2	0.18	
Max allowable shear stress for sandy loam	lb/ft^2	0.08	
Max allowable shear stress for silt loam	lb/ft^2	0.11	
Max allowable shear stress for fine gravel	lb/ft^2	0.32	See Table 5-2

Table 5-2. Maximum Permissible Velocities and Corresponding Unit Tractive Force (Shear Stress) (U.S. Bureau of Reclamation research, Fortier and Scobey 1926)

Material	n	Clear Water (diversion structures) V (ft/sec)	Clear Water (diversion structures) τ_o (lb/ft^2)	Water Transporting Colloidal Silts (on site and down slope) V (ft/sec)	Water Transporting Colloidal Silts (on site and down slope) τ_o (lb/ft^2)
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Sandy loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when noncolloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Note:
- an increase in velocity of 0.5 ft/sec can be added to these values when the depth of water is greater than 3 ft.
- a decrease in velocity of 0.5 ft/sec should subtracted then the water contains very coarse suspended sediments.
- for high and infrequent discharges of short duration, up to 30% increase in velocity can be added

Figure 5-1 is another guidance illustration showing SCS data (USDA 1977). This figure differentiates between "sediment-free" and "sediment-laden" flow.