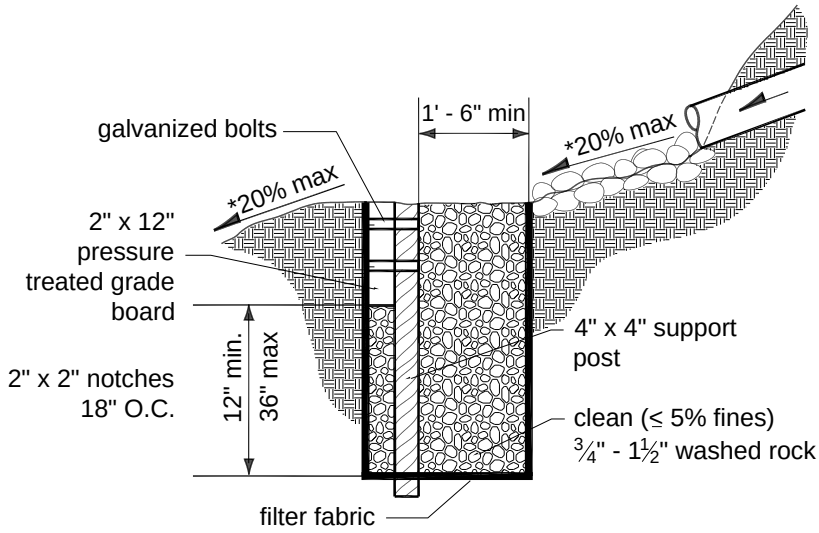
Figure 4.1 – Alternative Flow Dispersal Trench



*15% max for flow control/water quality treatment in rural areas

SECTION A-A
NTS

NOTES:

1. This trench shall be constructed to prevent point discharge and /or erosion.
2. Trenches may be placed no closer than 50 feet to one another (100 feet along flowline).
3. Trench and grade board must be level. Align to follow contours of site.
4. Support post spacing as required by soil conditions to ensure grade board remains level.

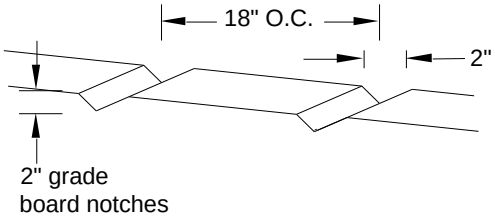
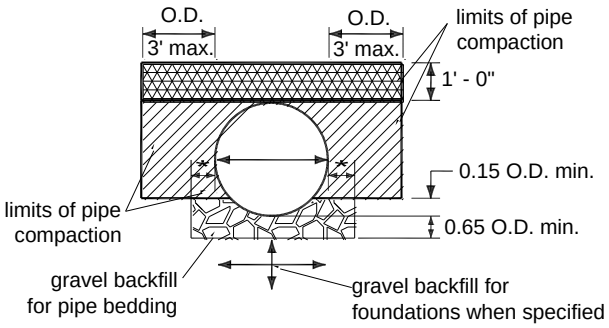
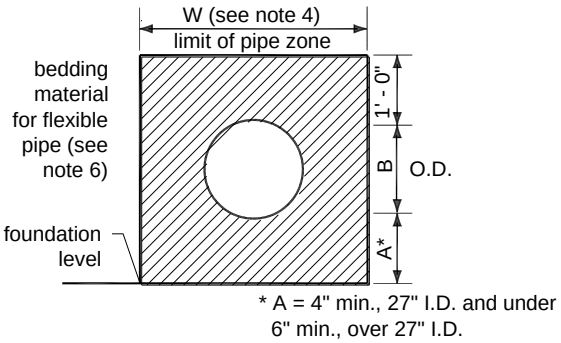


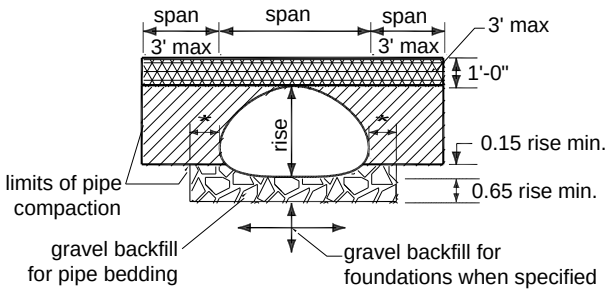
Figure 4.2 – Pipe Compaction Design and Backfill



A. Metal and Concrete Pipe



Bedding for Flexible Pipe



B. Pipe - Installation

Rigid Pipe NOTES:

1. Pipe compaction limits shown on this plan are for pipe construction in an embankment. For pipe construction in a trench, the horizontal limits of the pipe compaction zone shall be the walls of the trench.
2. All steel and aluminum pipe and pipe-arches shall be installed in accordance with design A.
3. Concrete pipe with elliptical reinforcement shall be installed in accordance with design A.
4. Concrete pipe, plain or with circular reinforcement, shall be installed with design A.
5. O.D. is equal to the outside diameter of a pipe or the outside span of pipe-arch. The dimensions shown as O.D. with 3' maximum shall be O.D. until O.D. equals 3'; at which point 3' shall be used.

* 1'-0" for diameters 12" through 42" and spans through 50". 2'-0" for diameters greater than 42" and spans greater than 50".

Flexible Pipe NOTES:

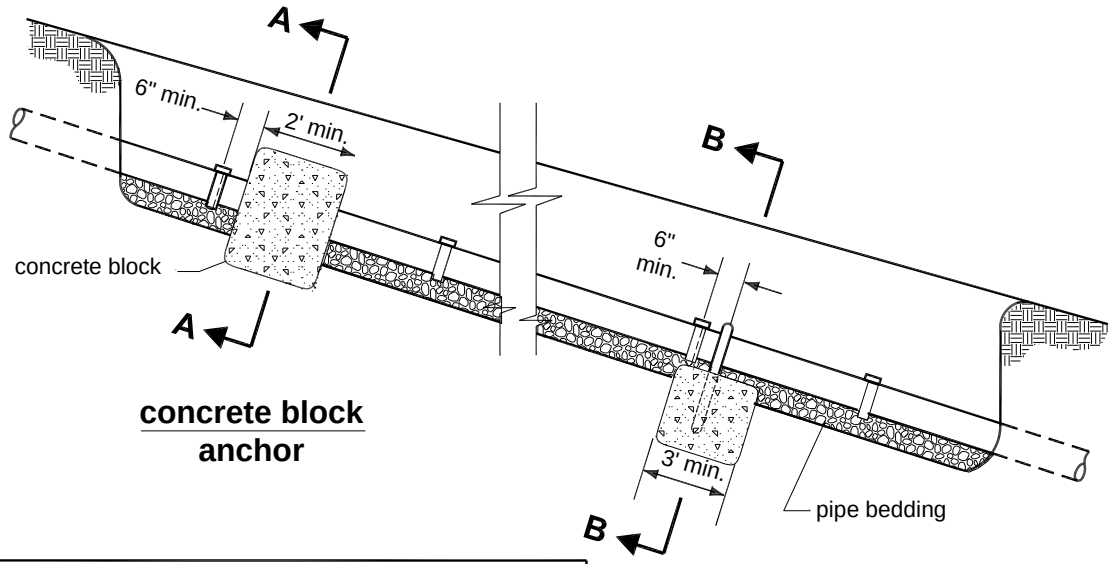
1. Provide uniform support under barrels.
2. Hand tamp under haunches.
3. Compact bedding material to 95% max. density; directly over pipe, hand tamp only.
4. See "Excavation and Preparation of Trench" in sanitary sewers section of the standard WSDOT/APWA specifications for trench width "W" and trenching options. The pipe zone will be the actual trench width. The minimum concrete width shall be $1\frac{1}{2}$ I.D. + 18".
5. Trench backfill shall conform to "Backfilling Sewer Trenches" in the sanitary sewers section of the WSDOT/APWA standard specifications, except that rocks or lumps larger than 1" per foot of pipe diameter shall not be used in the backfill material.
6. See "Bedding Material for Flexible Pipe" in aggregates section of the WSDOT/APWA standard specifications for the material specifications.

Backfill material placed in 0.5' loose layers and compacted to 95% maximum density.

Method B or C compaction (WSDOT/APWA) standard specifications.)

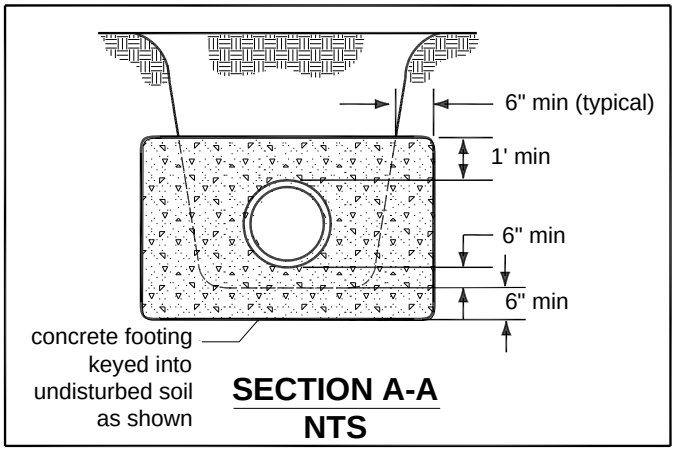
Pipe	Size	Min. dist. between barrels
circular pipe conc., LCPE, CMP (diameter)	12" to 24"	12"
	30" to 96"	diam. / 2
	102" to 180"	48"
pipe - arch metal only (span)	18" to 36"	12"
	43" to 142"	span / 3
	148" to 199"	48"

Figure 4.3 – Pipe Anchor Detail

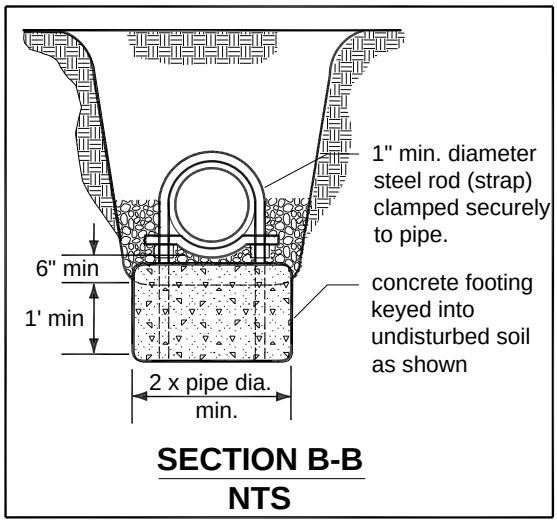


concrete block anchor

strap-footing anchor



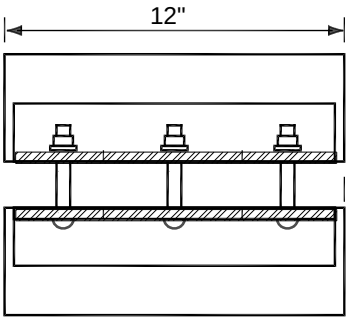
SECTION A-A
NTS



SECTION B-B
NTS

Note: For SWPE, pipe must be free to slide inside a 4' long section of pipe one size diameter larger.

Figure 4.4 – Corrugated Metal Pipe Coupling and/or General Pipe Anchor Assembly



Smooth Coupling Band
for Smooth Pipe

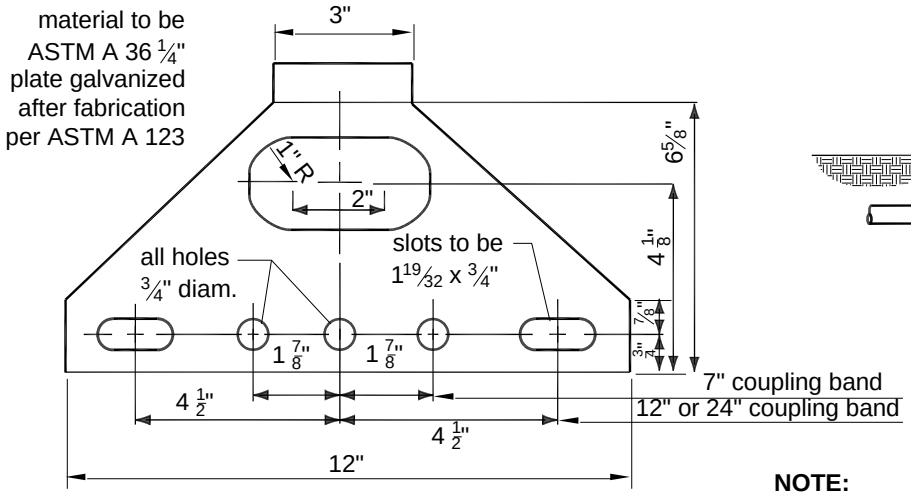
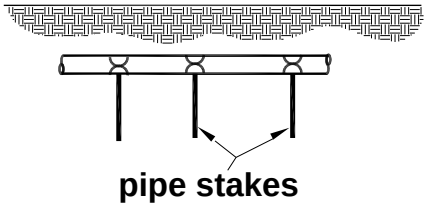
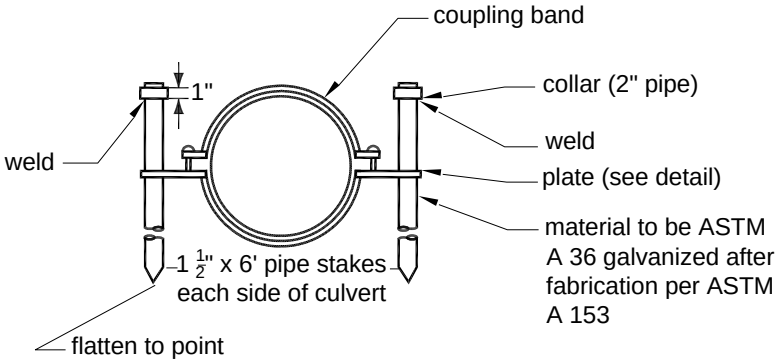


Plate Detail



pipe stakes



Anchor Assembly
Corrugated Metal Pipe

NOTE:

1. The smooth coupling band shall be used in combination with concrete pipe.
2. Concrete pipe without ball and spigot shall not be installed on grades in excess of 20%.
3. The first anchor shall be installed on the first section of the lower end of the pipe and remaining anchors evenly spaced throughout the installation.
4. If the pipe being installed has a manhole or catch basin on the lower end of the pipe, the first pipe anchor may be eliminated.
5. When CMP is used, the anchors may be attached to the coupling bands used to join the pipe as long as the specified spacing is not exceeded.
6. All pipe anchors shall be securely installed before backfilling around the pipe.

Figure 4.5 – Pipe Culvert Discharge Protection

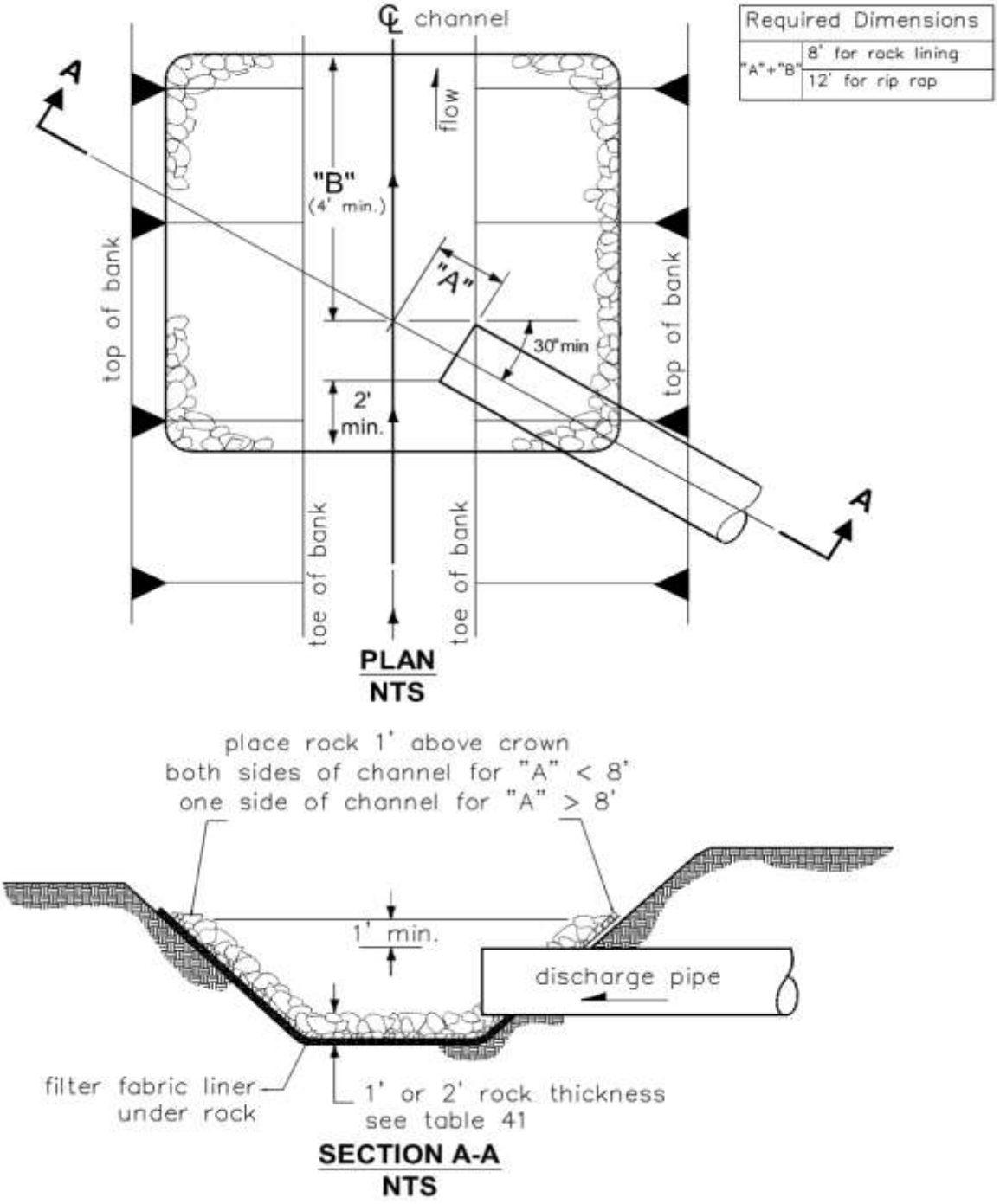
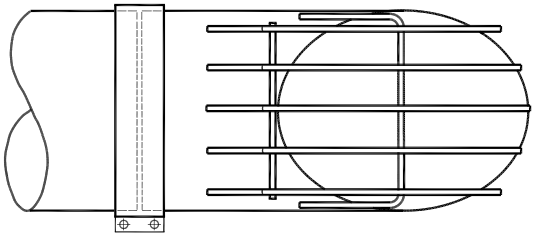


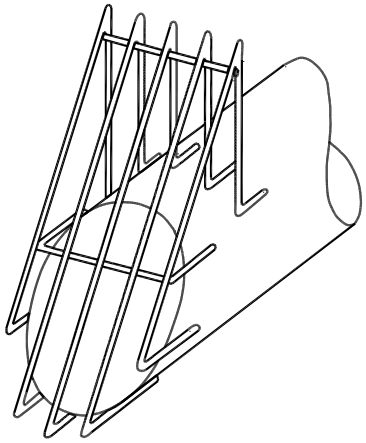
Figure 4.6 – Debris Barrier (Off Road Right-of-Way)

NOTE:

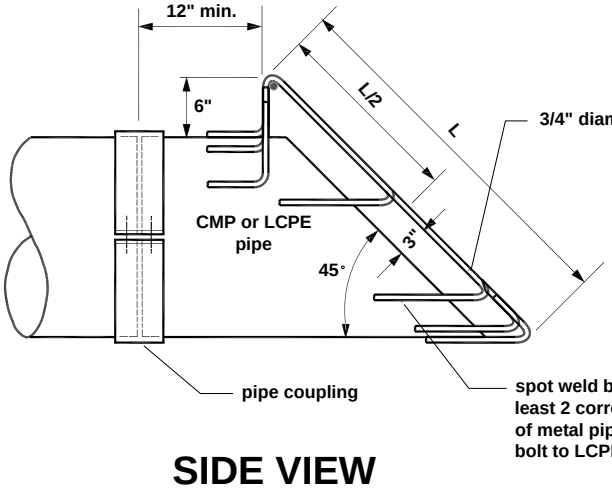
1. This debris barrier is for use outside roadways on pipes 36" dia. and smaller. See Figure 4.2.1.E for debris barriers on pipes projecting from driveway or roadway sideslopes.
2. All steel parts must be galvanized and asphalt coated (treatment 1 or better).
3. LCPE pipe requires bolts to secure debris barrier to pipe.



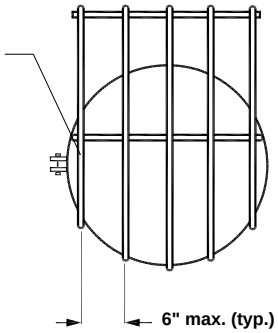
PLAN
NTS



ISOMETRIC
NTS



SIDE VIEW
NTS



END VIEW
NTS

Figure 4.7 – Debris Barrier (In Road Right-of-Way)

NOTES:

1. CMP or LCPE pipe end-section shown; for concrete pipe beveled end section, see KCRS drawing No. 2-001.
2. All steel parts must be galvanized and asphalt coated (treatment 1 or better).

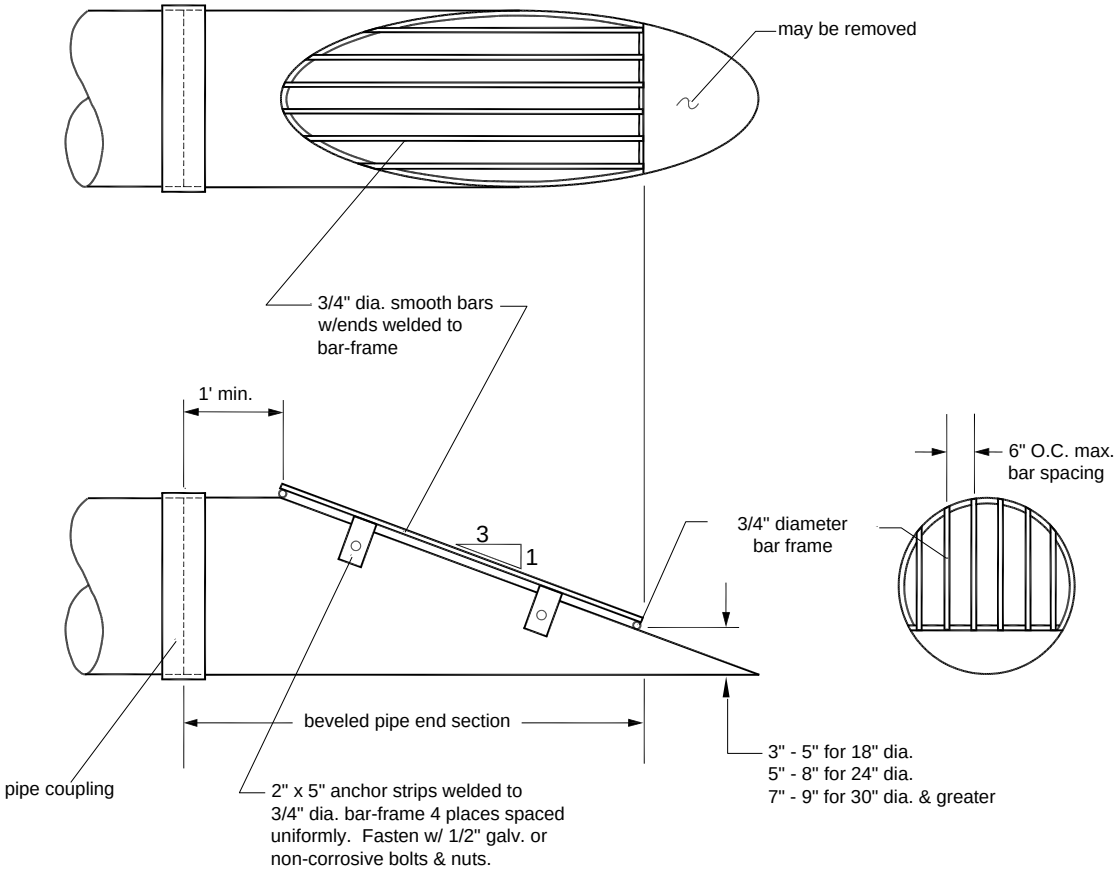
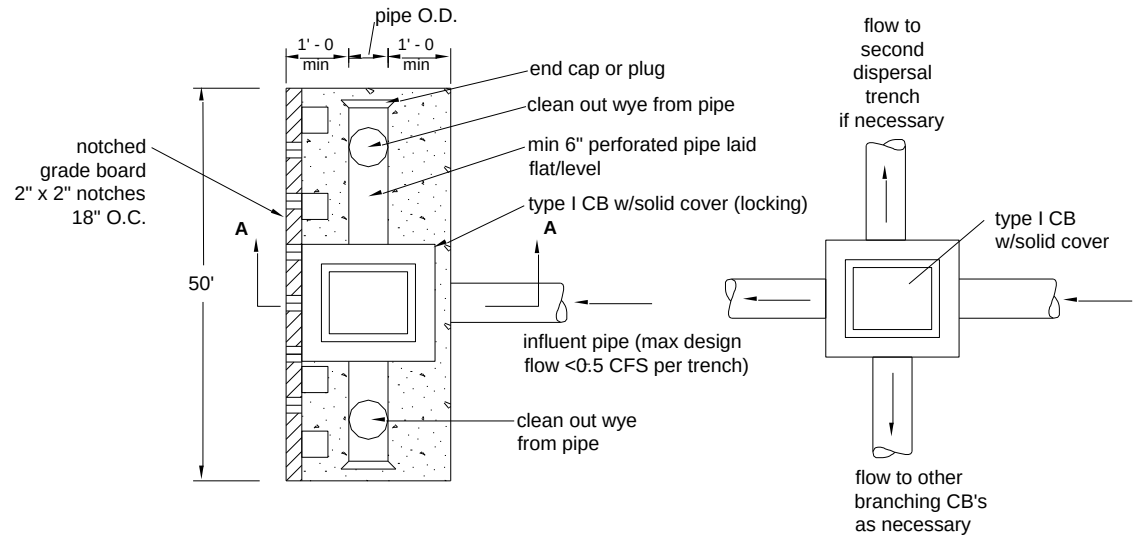
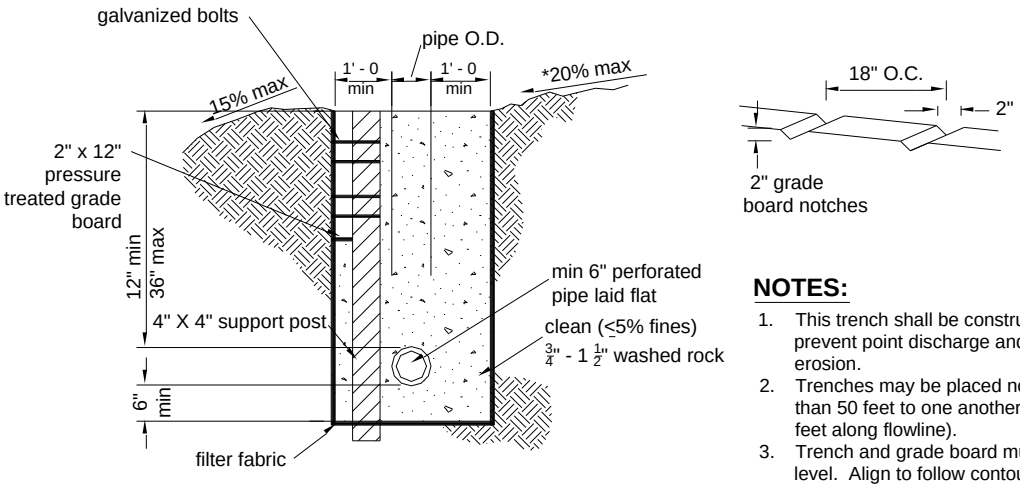


Figure 4.8 – Flow Dispersal Trench



PLAN
NTS



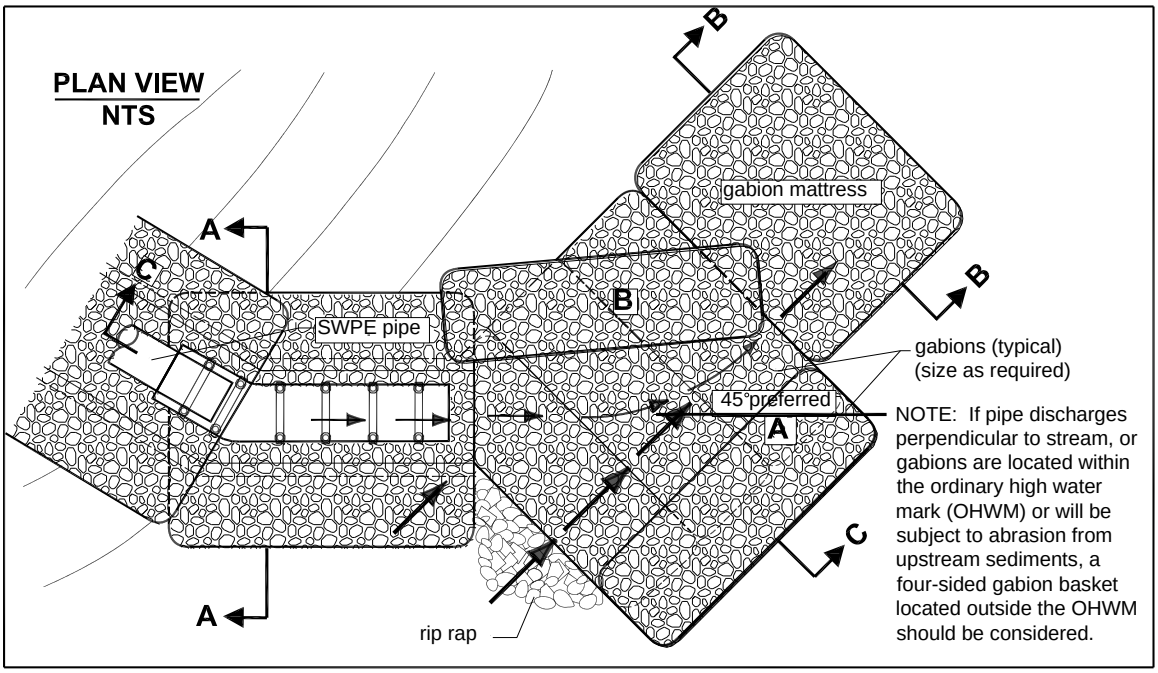
*15% max for flow control/water quality treatment in rural areas.

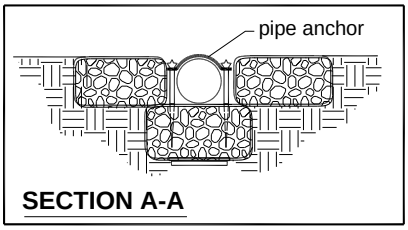
SECTION A-A
NTS

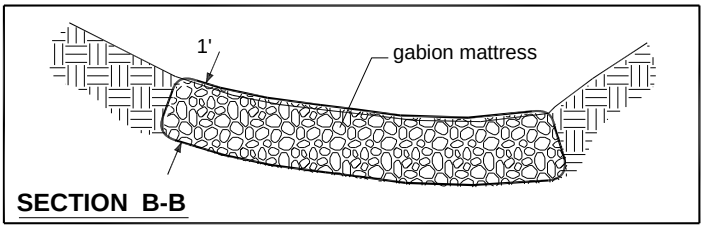
NOTES:

1. This trench shall be constructed to prevent point discharge and/or erosion.
2. Trenches may be placed no closer than 50 feet to one another (100 feet along flowline).
3. Trench and grade board must be level. Align to follow contours of site.
4. Support post spacing as required by soil conditions to ensure grade board remains level.

Figure 4.9 – Gabion Mattress Dissipater Detail







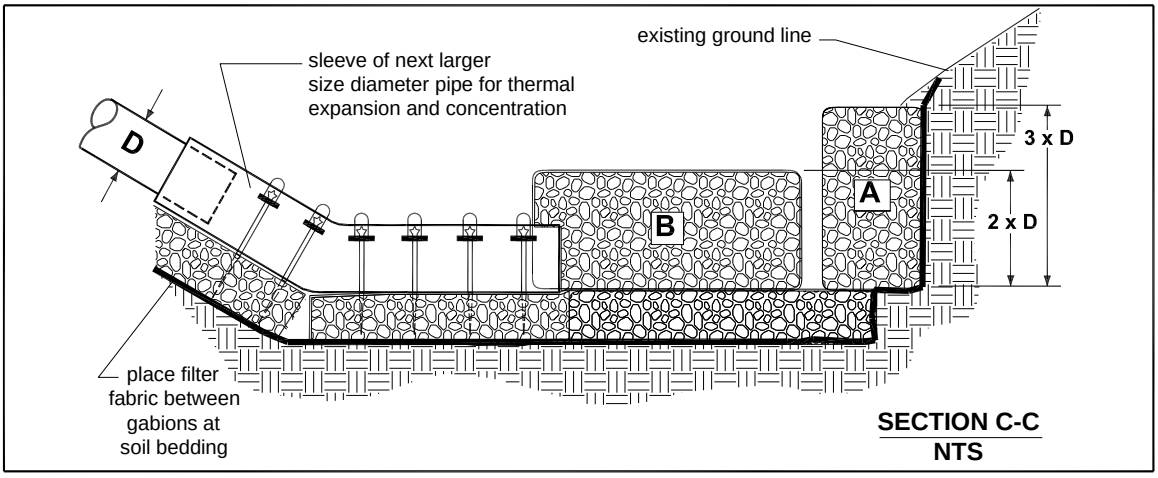


Figure 4.10 – Tee Type Energy Dissipater

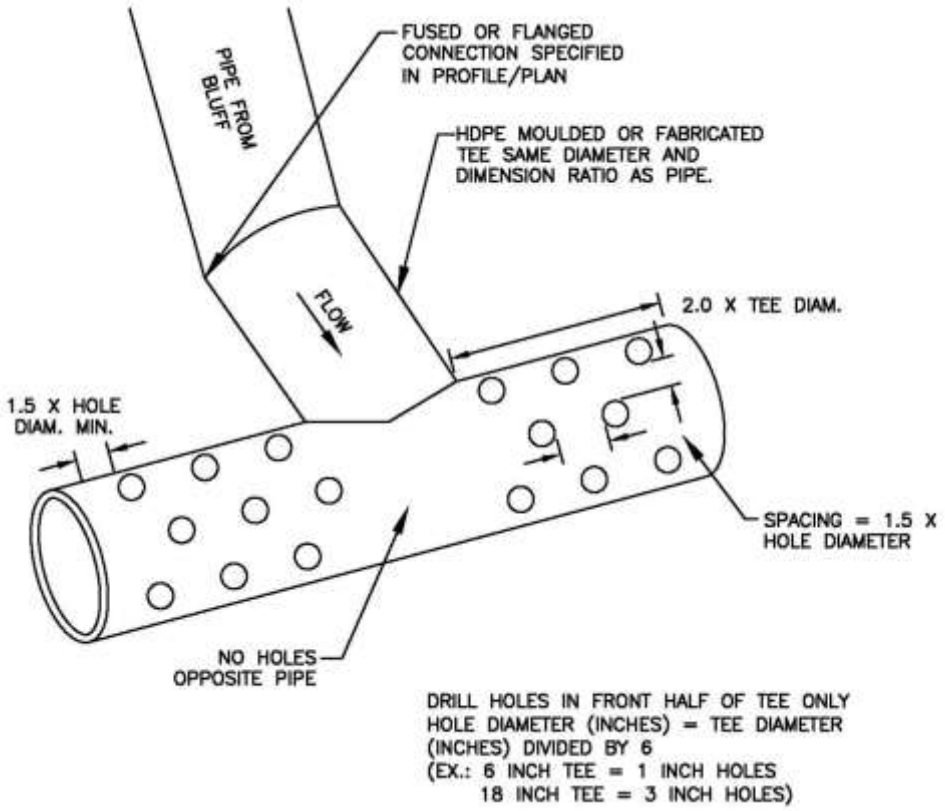
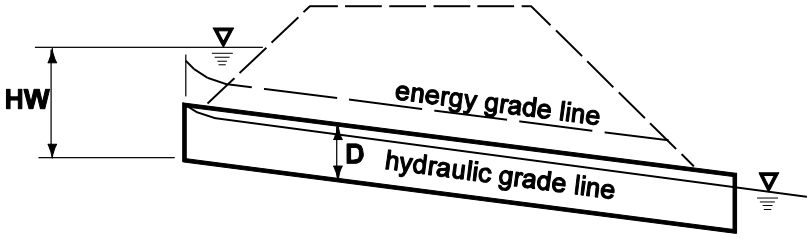
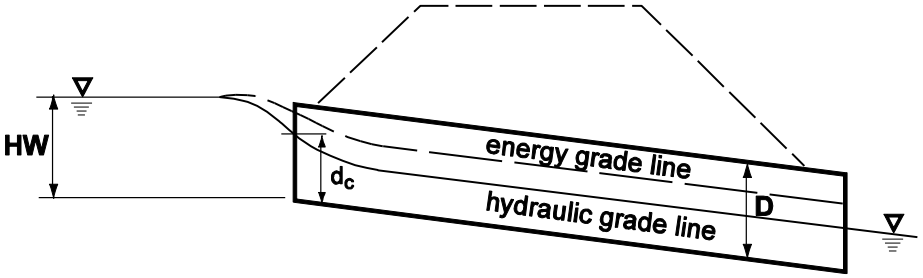


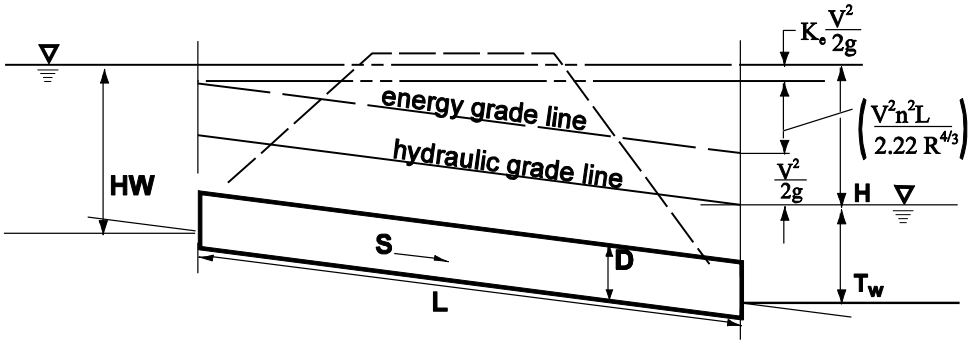
Figure 4.11 – Inlet / Outlet Control Conditions



Inlet Control - Submerged Inlet



Inlet Control - Unsubmerged Inlet



Outlet Control - Submerged Inlet and Outlet

NOTE: See FHWA no. 5 for other possible conditions

Figure 4.12 – Ditches Common Sections

Properties of Ditches								
NO.	Dimensions				Hydraulics			
	Side Slopes	B	H	W	A	WP	R	$R^{(2/3)}$
D-1	--	--	6”	5'-0"	1.84	5.16	0.356	0.502
D-1C	--	--	6”	25'-0"	6.25	25.50	0.245	0.392
D-2A	1.5:1	2’-0”	1’-0”	5'-0"	3.50	5.61	0.624	0.731
B	2:1	2’-0”	1’-0”	6'-0"	4.00	6.47	0.618	0.726
C	3:1	2’-0”	1’-0”	8'-0"	5.00	8.32	0.601	0.712
D-3A	1.5:1	3’-0”	1’-6”	7'-6"	7.88	8.41	0.937	0.957
B	2:1	3’-0”	1’-6”	9'-0"	9.00	9.71	0.927	0.951
C	3:1	3’-0”	1’-6”	12'-0"	11.25	12.49	0.901	0.933
D-4A	1.5:1	3’-0”	2’-0”	9'-0"	12.00	10.21	1.175	1.114
B	2:1	3’-0”	2’-0”	11'-0"	14.00	11.94	1.172	1.112
C	3:1	3’-0”	2’-0”	15'-0"	18.00	15.65	1.150	1.098
D-5A	1.5:1	4’-0”	3’-0”	13'-0"	25.50	13.82	1.846	1.505
B	2:1	4’-0”	3’-0”	16'-0"	30.00	16.42	1.827	1.495
C	3:1	4’-0”	3’-0”	22'-0"	39.00	21.97	1.775	1.466
D-6A	2:1	--	1’-0”	4'-0"	2.00	4.47	0.447	0.585
B	3:1	--	1’-0”	6'-0"	3.00	6.32	0.474	0.608
D-7A	2:1	--	2’-0”	8'-0"	8.00	8.94	0.894	0.928
B	3:1	--	2’-0”	12'-0"	12.00	12.65	0.949	0.965
D-8A	2:1	--	3’-0”	12'-0"	18.00	13.42	1.342	1.216
B	3:1	--	3’-0”	18'-0"	27.00	18.97	1.423	1.265
D-9	7:1	--	1’-0”	14'-0"	7.00	14.14	0.495	0.626
D-10	7:1	--	2’-0”	28'-0"	28.00	28.28	0.990	0.993
D-11	7:1	--	3’-0”	42'-0"	63.00	42.43	1.485	1.302

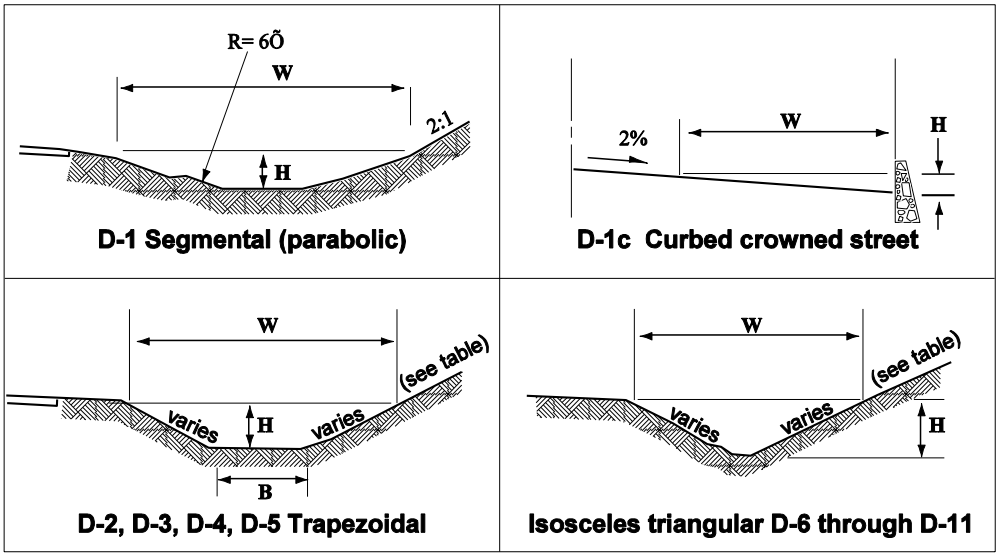
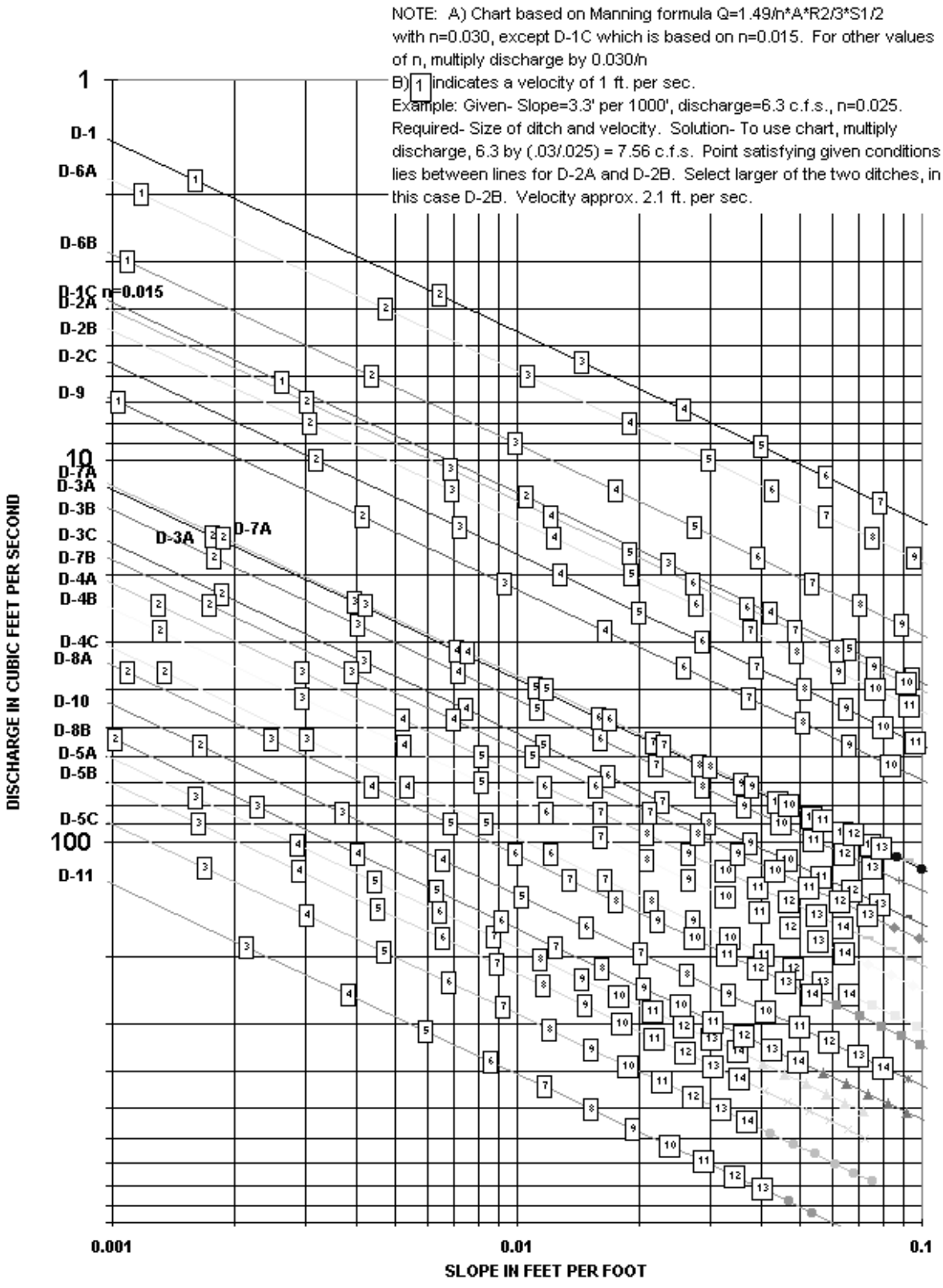
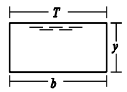
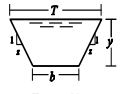
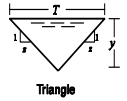
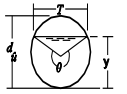
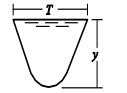
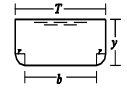
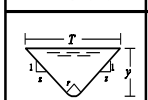


Figure 4.13 – Drainage Ditches – Common Sections

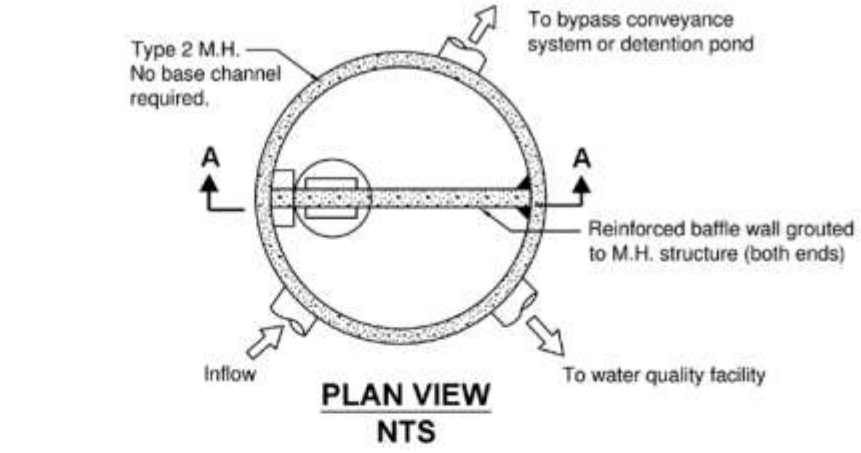


Section	Area A	Wetted perimeter P	Hydraulic radius R	Top width W	Hydraulic depth D	Section factor Z
 Rectangle	by	$b + 2y$	$\frac{by}{b + 2y}$	b	y	$by^{1.5}$
 Trapezoid	$(b + zy)y$	$b + 2y\sqrt{1 + z^2}$	$\frac{(b + zy)y}{b + 2y\sqrt{1 + z^2}}$	$b + 2zy$	$\frac{(b + zy)y}{b + 2zy}$	$\frac{[(b + zy)y]^{1.5}}{\sqrt{b + 2zy}}$
 Triangle	zy^2	$2y\sqrt{1 + z^2}$	$\frac{zy}{2\sqrt{1 + z^2}}$	$2zy$	$\frac{1}{2}y$	$\frac{\sqrt{2}}{2}zy^{2.5}$
 Circle	$\frac{1}{8}(\theta - \sin\theta)d^2$	$\frac{1}{2}\theta d$	$\frac{1}{4}\left(1 - \frac{\sin\theta}{\theta}\right)d$	$\left(\sin\left(\frac{1}{2}\theta\right)d\right)$ or $2\sqrt{y(d - y)}$	$\frac{1}{8}\left(\frac{\theta - \sin\theta}{\sin\frac{1}{2}\theta}\right)d$	$\frac{\sqrt{2}}{32}\frac{(\theta - \sin\theta)^{1.5}}{(\sin\frac{1}{2}\theta)^{0.5}}d^{2.5}$
 Parabola	$\frac{2}{3}Ty$	$T + \frac{8y^2}{3T}$ *	$\frac{2T^2y}{3T^2 + 8y^2}$ *	$\frac{3A}{2y}$	$\frac{2}{3}y$	$\frac{2}{9}\sqrt{6}Ty^{1.5}$
 Round-cornered Rectangle (y>r)	$(\frac{\pi}{2} - 2)r^2 + (b + 2r)y$	$(\pi - 2)r + b + 2y$	$\frac{(\frac{\pi}{2} - 2)r^2 + (b + 2r)y}{(\pi - 2)r + b + 2y}$	$b + 2r$	$\frac{(\frac{\pi}{2} - 2)r^2}{(b + 2r)} + y$	$\frac{[(\frac{\pi}{2} - 2)r^2 + (b + 2r)y]^{1.5}}{\sqrt{b + 2y}}$
 Round-bottomed Triangle	$\frac{T^2}{4z} - \frac{r^2}{z}(1 - z\cot^{-1}z)$	$\frac{T}{z}\sqrt{1 + z^2} - \frac{2r}{z}(1 - z\cot^{-1}z)$	$\frac{A}{P}$	$2[z(y - r) + r\sqrt{1 + z^2}]$	$\frac{A}{T}$	$A\sqrt{\frac{A}{T}}$

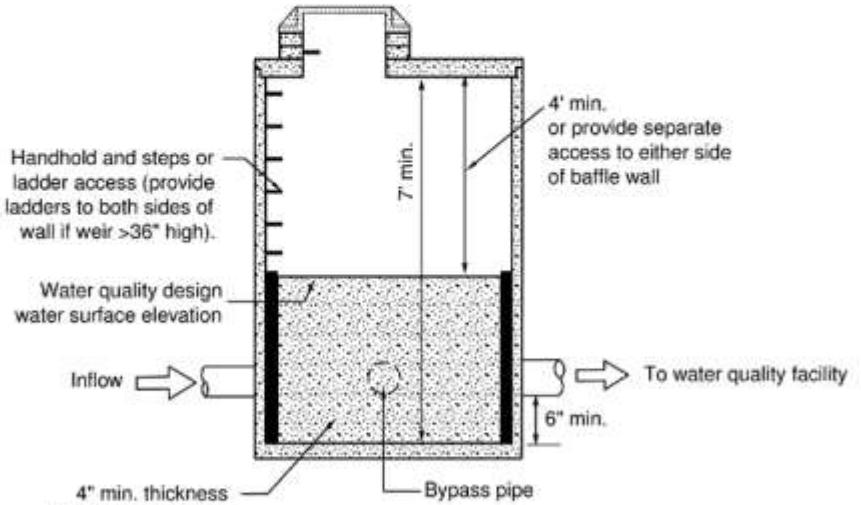
*Satisfactory approximation for the interval $0 < x \leq 1$, where $x = 4y/T$. When $x > 1$, use the exact expression $P = \left(\frac{T}{2}\right)\left[\sqrt{1 + x^2} + \frac{1}{x}\ln\left(x + \sqrt{1 + x^2}\right)\right]$

Figure 4.14 – Geometric Elements of Common Sections

Figure 4.15 – Flow Splitter, Option A



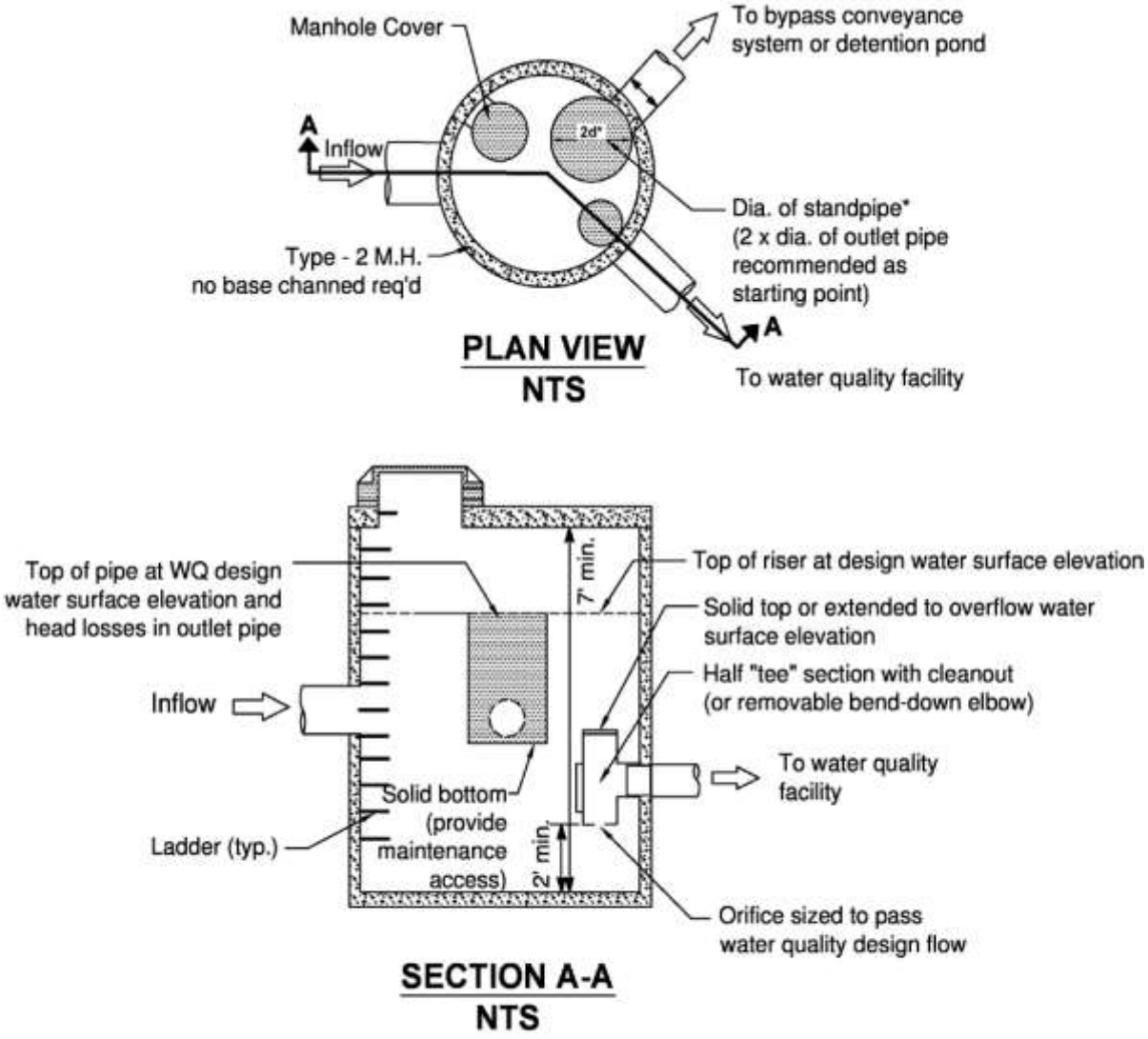
PLAN VIEW
NTS



SECTION A-A
NTS

Note: The water quality discharge pipe may require an orifice plate to be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimum headwater/diameter ratio of 2.0 on the outlet pipe.

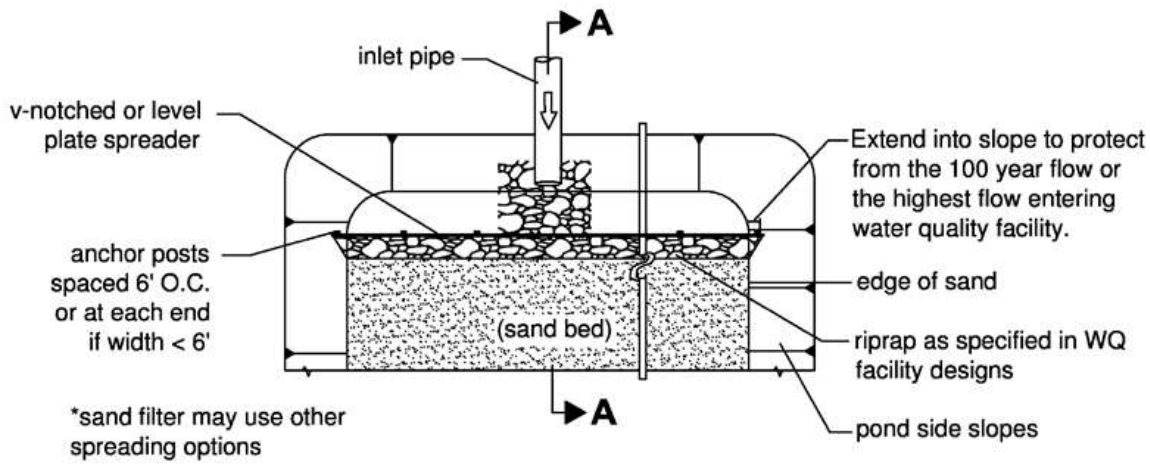
Figure 4.16 – Flow Splitter, Option B



***NOTE:** Diameter (d) of standpipe should be large enough to minimize head above water quality design water surface and to keep water quality design flows from increasing more than 10% during 100-year flows.

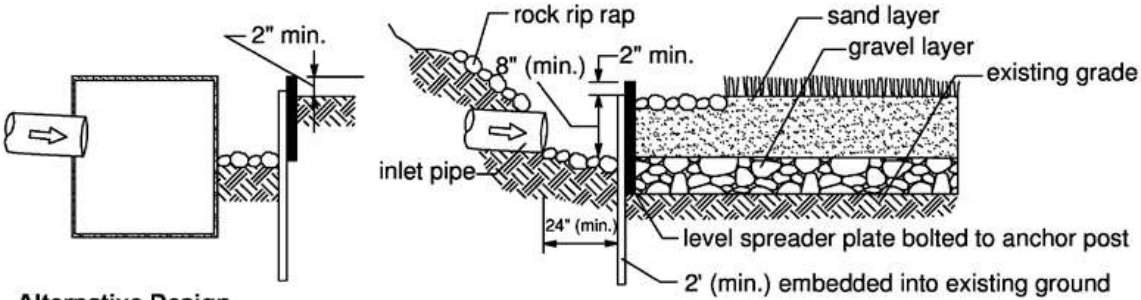
Figure 4.17 – Flow Spreader Option A: Anchored Plate

Example of anchored plate used with a sand filter* (may also be used with other water quality facilities).



*sand filter may use other spreading options

PLAN VIEW
NTS

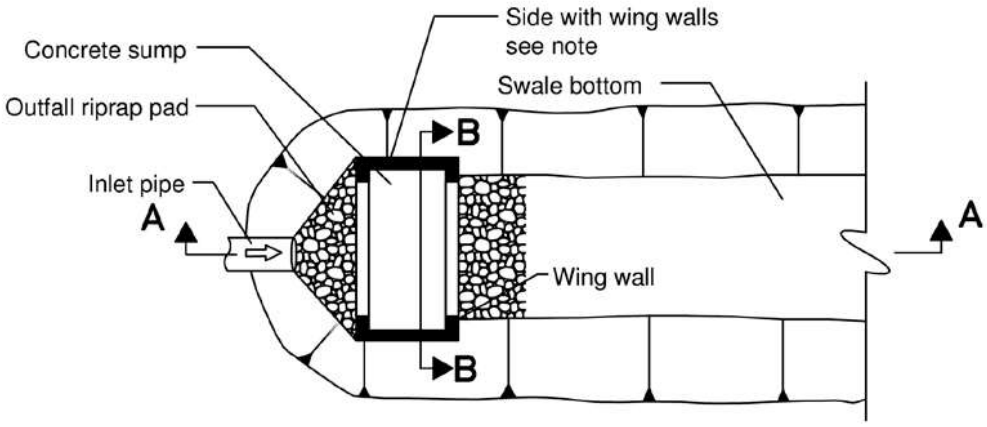


Alternative Design
Catch basin recommended for higher flow situations (generally for inflow velocities of 5 fps or greater for 100 year storm).

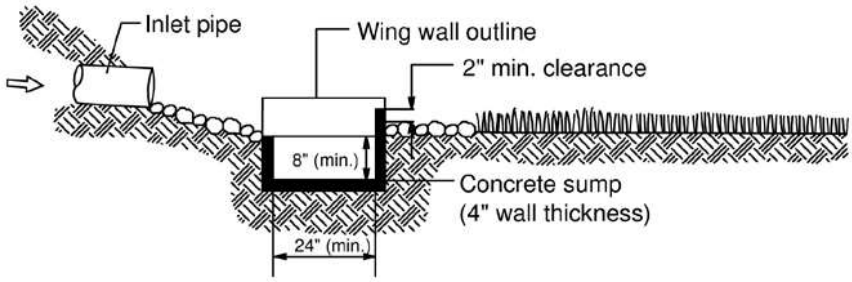
SECTION A-A
NTS

Figure 4.18 – Flow Spreader Option B: Concrete Sump Box

Example of a concrete sump flow spreader used with a biofiltration swale (may be used with other WQ facilities).

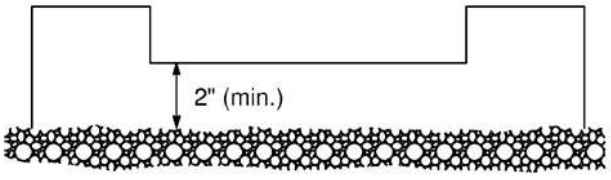


PLAN VIEW
NTS



Note: Extend sides into slope. Height of side wall and wing walls must be sufficient to handle the 100-year flow or the highest flow entering the facility.

SECTION A-A
NTS



SECTION B-B
NTS

Figure 4.19 – Flow Spreader Option C: Notched Curb Spreader

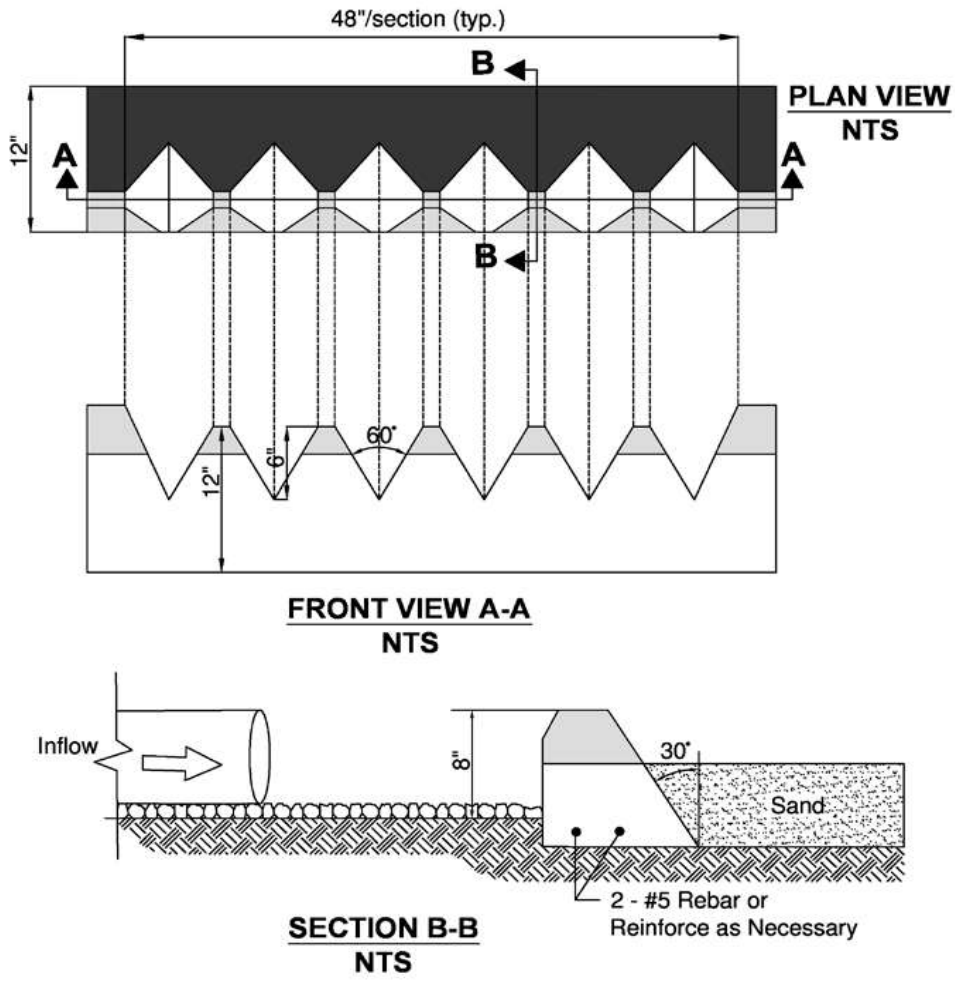
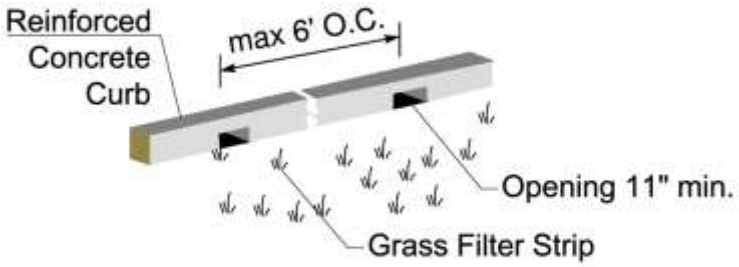


Figure 4.20 – Flow Spreader Option D: Through-Curb Port



CURB PORT
NTS