Volume I Figures

SB1
(2 acres)

SB4
(94 acres)

SB5
(73 acres)

SB3
(14 acres)

SB2
(3 acres)

280

260

240

220

300

320

300

320

340

280

LEGEND

—280— Topographic Contour

Stream

Wetland

Bioretention

Permeable Sidewalk

Roadway

SB3   Subbasin Boundary

Watershed Boundary

Existing Tree
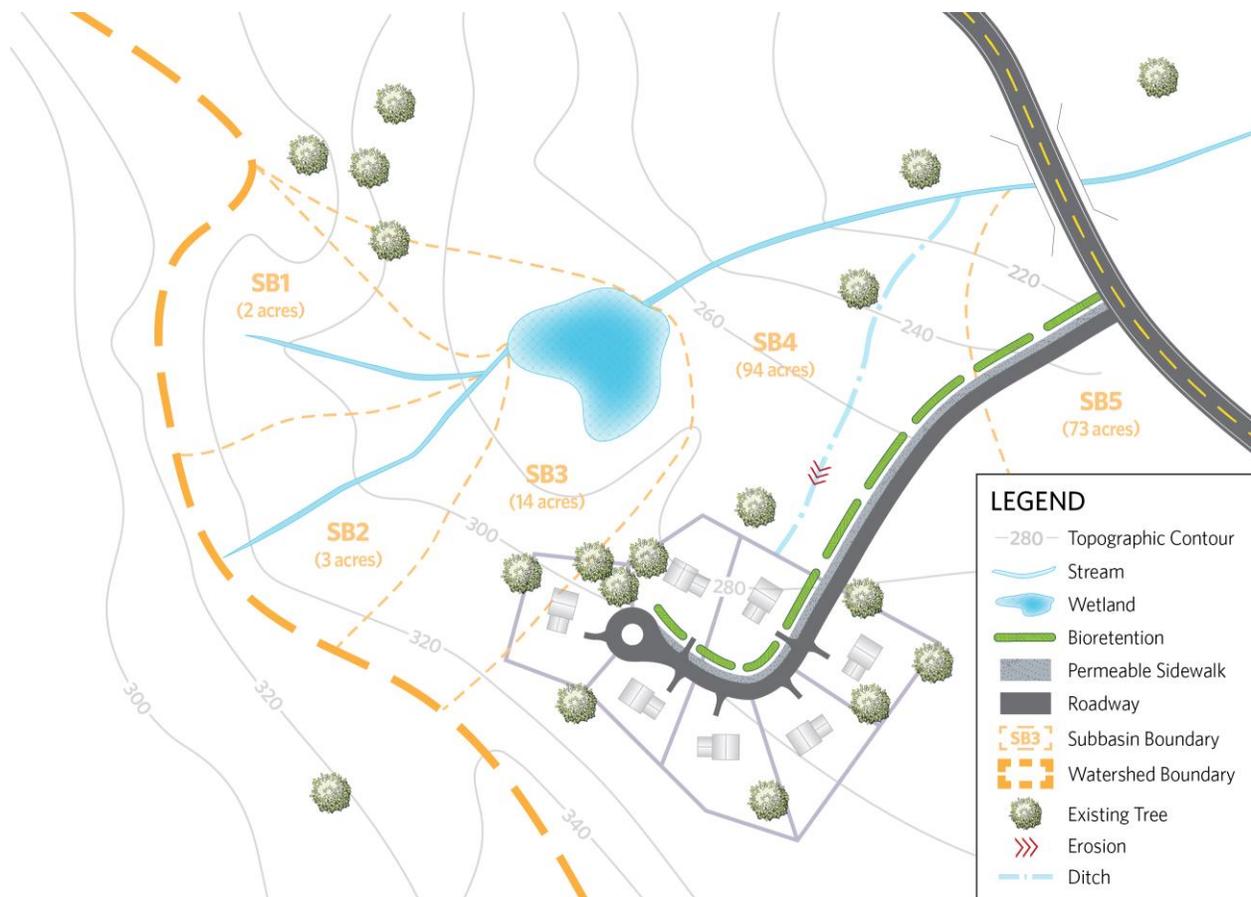
Erosion

Ditch

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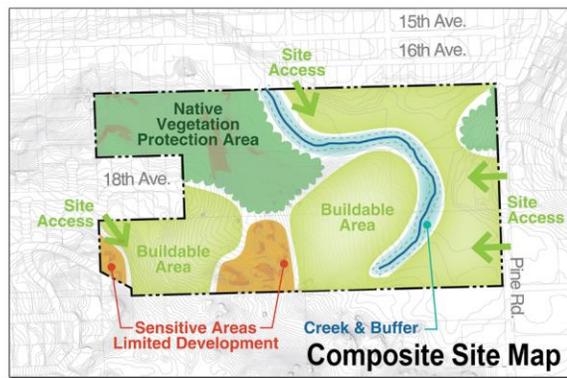Figure 2.1
Example Map Documenting
Existing Hydrologic Features

March 2020

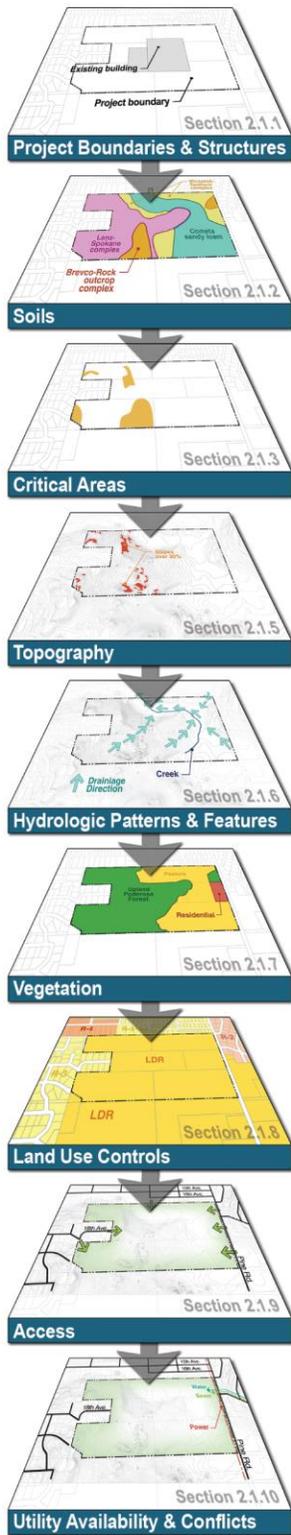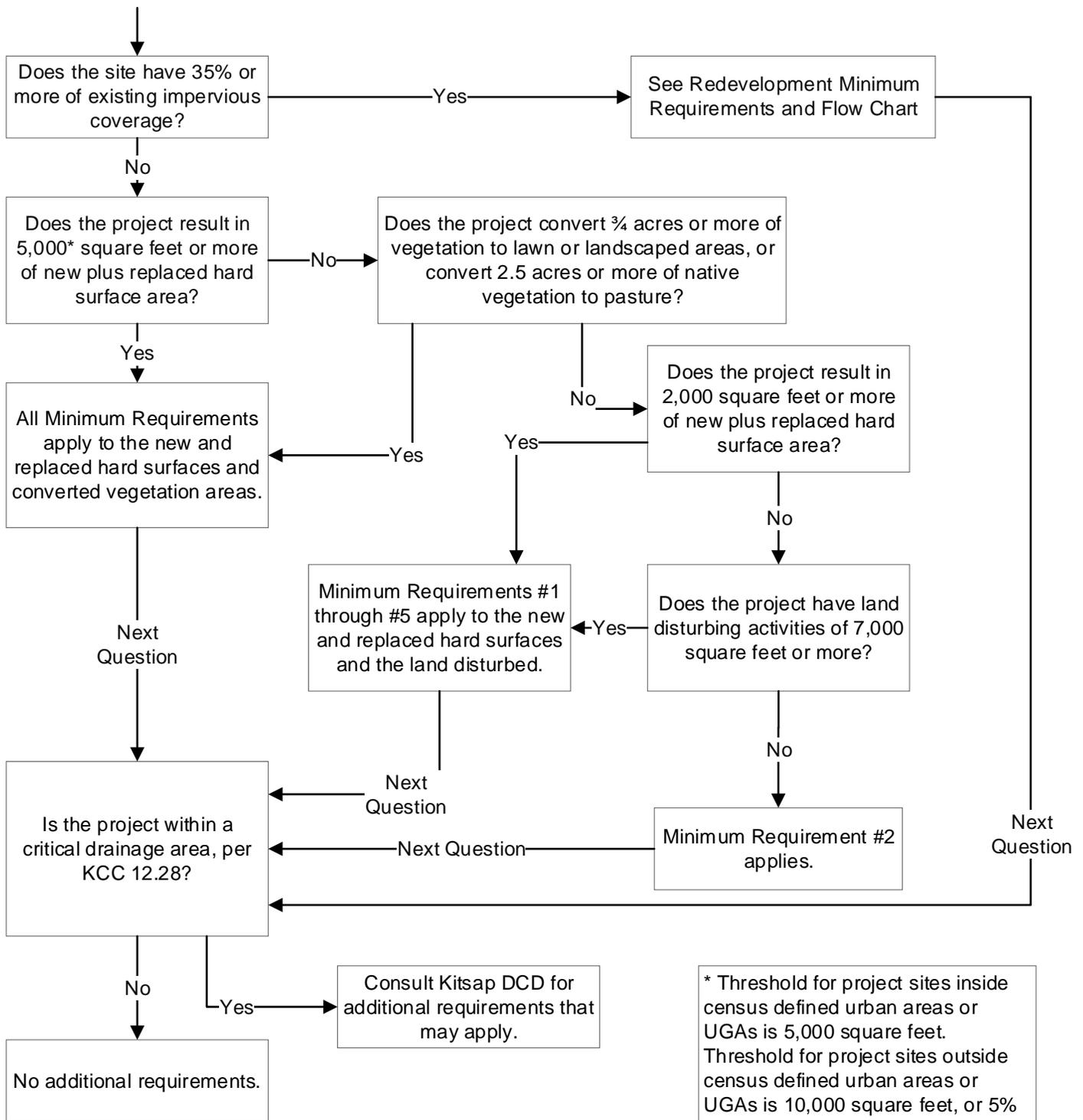Figure 2.2
Example Composite Site Map

March 2020

120'

70'

50'

20'

Property Line

Rain Barrel

Existing Patio and Walkway to be Replaced *(120 square feet)*

60'

New house footprint

8' x 12' Existing Shed

10'

Existing house footprint

20'

Existing Driveway

30'

40'

10' x 12' New Patio *(Permeable Pavement)*

Existing Walkway to Remain *(180 square feet)*

Extension of Existing Walkway *(125 square feet Permeable Pavement Extension)*

Existing Walkway to be Removed *(30 square feet)*

LEGEND

— · — Property Line

Existing Hard Surface *(476 square feet)*

New Hard Surface *(1,425 square feet)*

Replaced Hard Surface *(1,620 square feet)*

Removed Hard Surface *(30 square feet)*

Maple Tree

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Figure 3.1
Example Determination of New and Replaced Hard Surfaces

March 2020

Start Here

Does the site have 35% or more of existing impervious coverage? —Yes→ See Redevelopment Minimum Requirements and Flow Chart

No ↓

Does the project result in 5,000* square feet or more of new plus replaced hard surface area? —No→ Does the project convert ¾ acres or more of vegetation to lawn or landscaped areas, or convert 2.5 acres or more of native vegetation to pasture?

Yes ↓

All Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas.

Does the project convert... —No→ Does the project result in 2,000 square feet or more of new plus replaced hard surface area?

(vegetation box) Yes →

Yes→ Minimum Requirements #1 through #5 apply to the new and replaced hard surfaces and the land disturbed.

Does the project result in 2,000 square feet... No ↓

Does the project have land disturbing activities of 7,000 square feet or more? —Yes→ Minimum Requirements #1 through #5 apply to the new and replaced hard surfaces and the land disturbed.

No ↓ (from 7,000 box)

Minimum Requirement #2 applies.

Next Question ↓ (from All Minimum Requirements)

Next Question (from Minimum Requirements #1 through #5) →

Next Question (from Minimum Requirement #2 applies) →

Next Question ↓ (right side)

Is the project within a critical drainage area, per KCC 12.28?

No ↓ — Yes→ Consult Kitsap DCD for additional requirements that may apply.

No additional requirements.

* Threshold for project sites inside census defined urban areas or UGAs is 5,000 square feet. Threshold for project sites outside census defined urban areas or UGAs is 10,000 square feet, or 5% of the lot area (whichever is greater).

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Figure 4.1
Flow Chart for Determining Minimum Requirements for New Development Projects
March 2020

Does the Project result in 2,000 square feet, or more, of new plus replaced hard surface area? OR Does the land disturbing activity total 7,000 square feet or greater?

Yes → Minimum Requirement #1 through #5 apply to the new and replaced hard surfaces and the land disturbed.

No → Minimum Requirements #2 applies.

Next Question

Does the Project add 5,000* square feet or more of new hard surfaces? OR Convert ¾ acres or more of vegetation to lawn or landscaped areas? OR Convert 2.5 acres or more of native vegetation to pasture?

Yes → All Minimum Requirements apply to the new hard surfaces and the converted vegetation areas.

No →

Next Question

Next Question → Is this a road related project?

Yes / No

Does the Project add 5,000* square feet or more of new hard surfaces?

Yes → Do new hard surfaces add 50% or more to the existing hard surfaces within the Site?

Yes → All Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas.

No →

No →

Is the total of new plus replaced hard surfaces 5,000* square feet or more, AND does the value of the proposed improvements – including interior improvements – exceed 50% of the assessed value (or replacement value) of the:

- existing Project Site improvements (for commercial or industrial projects) OR
- existing Site improvements (for all other projects)

Yes → All Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas.

No →

Next Question →

Is the project within a critical drainage area per KCC 12.28?

No → No additional requirements

Yes → Consult Kitsap DCD for additional requirements that may apply

* Threshold for project sites inside census defined urban areas or UGAs is 5,000 square feet. Threshold for project sites outside census defined urban areas or UGAs is 10,000 square feet, or 5% of the lot area (whichever is greater).

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Figure 4.2
Flow Chart for Determining
Minimum Requirements for
Redevelopment Projects

June 2020

Does the entire project qualify as Flow Control exempt (per MR #7)?

— Yes →

Did the project developer choose to meet the LID Performance Standard?

— No → **REQUIRED:** For each surface, consider the BMPs in the order listed in **List #3** for that type of surface. Use the first BMP that is considered feasible.

NOT REQUIRED: Achievement of the LID Performance Standard.

— Yes → **REQUIRED:**
- Meet the **LID Performance Standard** through the use of any Flow Control BMP(s) in this manual.
- Apply BMP T5.13 **Post Construction Soil Quality and Depth**.

NOT REQUIRED: Applying the BMPs in Lists #1 or #2.

No ↓

Does the project trigger only MRs #1 - #5 (Per the Project Thresholds in Volume I, Chapter 4)

— Yes → **Did the project developer choose to meet the LID Performance Standard?**

— No → **REQUIRED:** For each surface, consider the BMPs in the order listed in **List #1** for that type of surface. Use the first BMP that is considered feasible.

NOT REQUIRED: Achievement of the LID Performance Standard.

No ↓

Is the project outside or inside the UGA?

— Outside UGA → **Is the project outside or inside the UA?**

Inside UA ↓

What is the project size?

— **Less than 5 acres** → **Did the project developer choose to meet the LID Performance Standard?**

— **Greater than or equal to 5 acres** → **REQUIRED:**
- Meet the **LID Performance Standard** through the use of any Flow Control BMP(s) in this manual.
- Apply BMP T5.13 **Post Construction Soil Quality and Depth**.

NOT REQUIRED: Applying the BMPs in Lists #1 or #2.

Outside UA → **Did the project developer choose to meet the LID Performance Standard?**

— No → **REQUIRED:** For each surface, consider the BMPs in the order listed in List #2 for that type of surface. Use the first BMP that is considered feasible.

OR (if feasible) Full Dispersion.

NOT REQUIRED: Achievement of the LID Performance Standard.

Yes →

Inside UGA ↓

Did the project developer choose to meet the LID Performance Standard?

No ↓

REQUIRED: For each surface, consider the BMPs in the order listed in List #2 for that type of surface. Use the first BMP that is considered feasible.

NOT REQUIRED: Achievement of the LID Performance Standard.

Yes →

KITSAP COUNTY WASHINGTON 18 57

Figure 4.3
Flow Chart for Determining MR #5 Requirements

March 2021

Volume I Photos

Volume I, Section 2.3 Photo

Bioretention BMP in a cul-de-sac of a LID residential neighborhood in construction in western WA. The bioretention manages stormwater runoff from the roadway and contributing roof and driveway areas. Numerous large existing trees were retained, adding valuable stormwater and community benefits.

Volume I, Section 4.2.2, Element 6 Photo

Example of shallow gradient slope with berm installed at downgradient edge to minimize silt-laden runoff onto the sidewalk.

Volume I, Section 4.2.2, Element 9 Photo

Temporary sand bags divert construction site stormwater runoff to inlet protected with a catch basin filter sock.

Volume I, Section 4.2.2, Element 13 Photo

Sand bags prevent silt-laden flow from entering the bioretention BMP. Green construction fencing prevents compaction due to foot traffic.

Volume II Figures

Is the project a small (KCC 12.08) single family residential (SFR) development that does not implement a TDA approach AND is the project located outside of critical areas and their ~~critical area~~ buffers?

— Yes → **Simplified Drainage Review**

No ↓

Is the project a small (KCC 12.08) SFR ~~single family residential~~ development located inside ~~within a~~ critical area~~s~~ or their ~~critical area~~ buffers OR is the project a small (KCC 12.08) project that is implementing a TDA approach?

— Yes → **Simplified Drainage Review - Engineered**

No ↓

Is the project a small (KCC 12.08) non-SFR project OR a grading only project involving the movement of 150 to 5,000 cubic yards of material AND is the project located outside of critical areas and their ~~or critical area~~ buffers?

— Yes → **Abbreviated Drainage Review**

No ↓

Is the project a small (KCC 12.08) non-SFR project OR a grading only project involving the movement of 150 to 5,000 cubic yards of material that:

- Connects into a drainage system in the right of way; OR
- Constructs improvements in the right of way; OR
- Constructs in a critical area or critical area buffer?

— Yes → **Abbreviated Drainage Review - Engineered**

— No → **Full Drainage Review**

Flow Chart for Determining Type of Drainage Review

KITSAP COUNTY
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USED GREASE
CONTAINER (FOG)

6 CY RECYCLING

6 CY DUMPSTER

GATE OPENING

DRAIN

PEDESTRIAN
DOOR
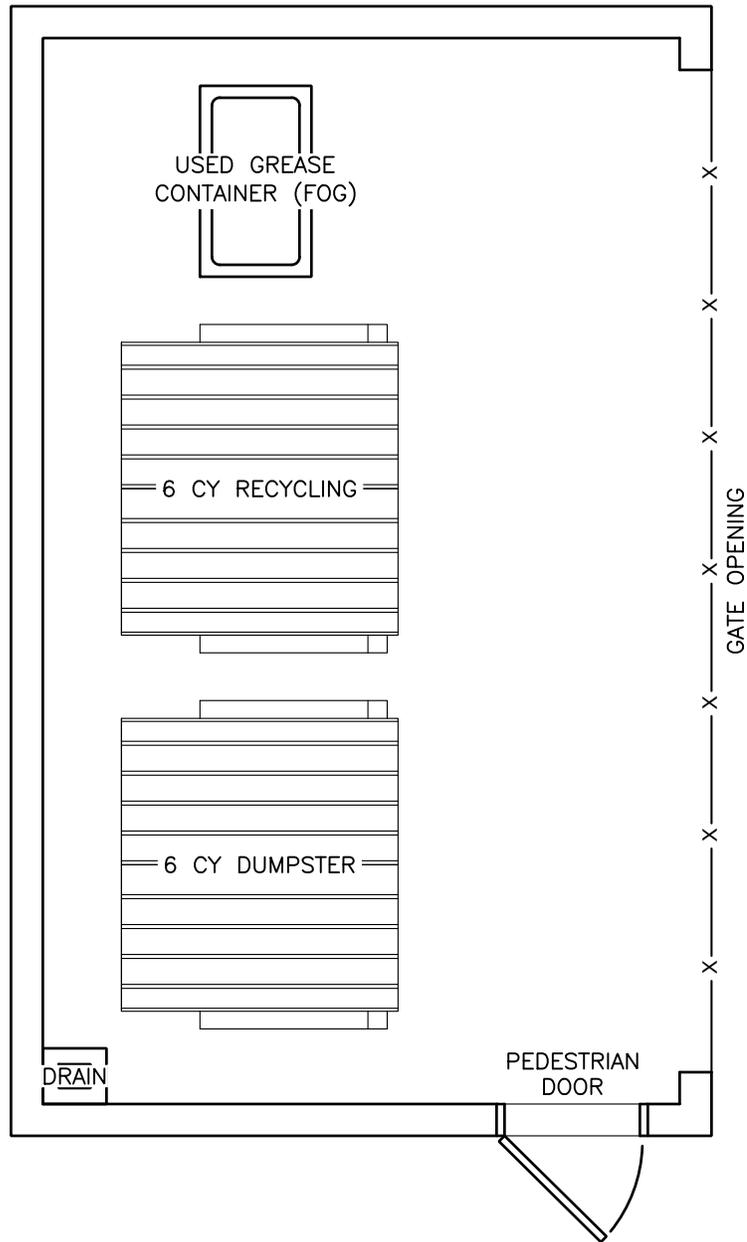
Figure 3.1
Example of a covered, bermed
and plumbed area - plan view

KITSAP COUNTY
18 57
WASHINGTON

March 2020

\\herrera.local\hecnet\seattle\proj\Y2019\19-07028-000\CADIDwg\FIG 3.dwg

DRAIN TO SEWER

GATE OPENING

CONNECTION TO SEWER

OR DEAD—END SUMP
IN ABSENCE OF SEWER

GREASE
REMOVAL
DEVICE

Figure 3.2
Example of a covered, bermed
and plumbed area - side view

KITSAP COUNTY
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WASHINGTON

March 2020

pipe O.D.

1' min.   1' min.

end cap or plug

clean out wye from pipe

4" or 6" perforated pipe
laid flat/level

50'   A   A

notched grade
board 2" x 2"
notches 18" O.C.

influent pipe (max design
flow ≤0.5 cfs per trench)

See Note 5

Locate structure where
flow enters trench (see
Note 6)

clean out wye from pipe

Flow to second
dispersal trench
if necessary

See Note 5

Flow to other
branching CB's
as necessary

Plan

pipe O.D.

galvanized bolts

1' min.   1' min.

*20% max

*20% max

12" min.
36" max

4" or 6"
perforated pipe
laid flat

2" x 12"
pressure treated
grade board

6' min.

filter fabric

4" x 4"
support post

clean (≤5% fines)
1 ½" - ¾" washed
rock

Section A-A

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

18" O.C.

2"

2" grade
board notches

2"

Notes:
1. This trench shall be constructed so as 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.
5. For roof area less than or equal to 700 square
   feet, structure shall be a small catch basin, yard
   drain, or Type 1 CB with with solid cover or
   equivalent as approved by the County.
6. Structure shall be set back a minimum of 5 feet
   from building foundation.

NOT TO SCALE

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Figure 4.1
Flow Dispersion Trench

March 2020

galvanized bolts

1'-6" min.

*20% max

*20% max

2" x 12"
pressure treated
grade board

2"x2" notches
18" O.C.

12" min.
36" max

4" x 4"
support post

clean (≤5% fines)
1 ½" - ¾" washed
rock

filter fabric
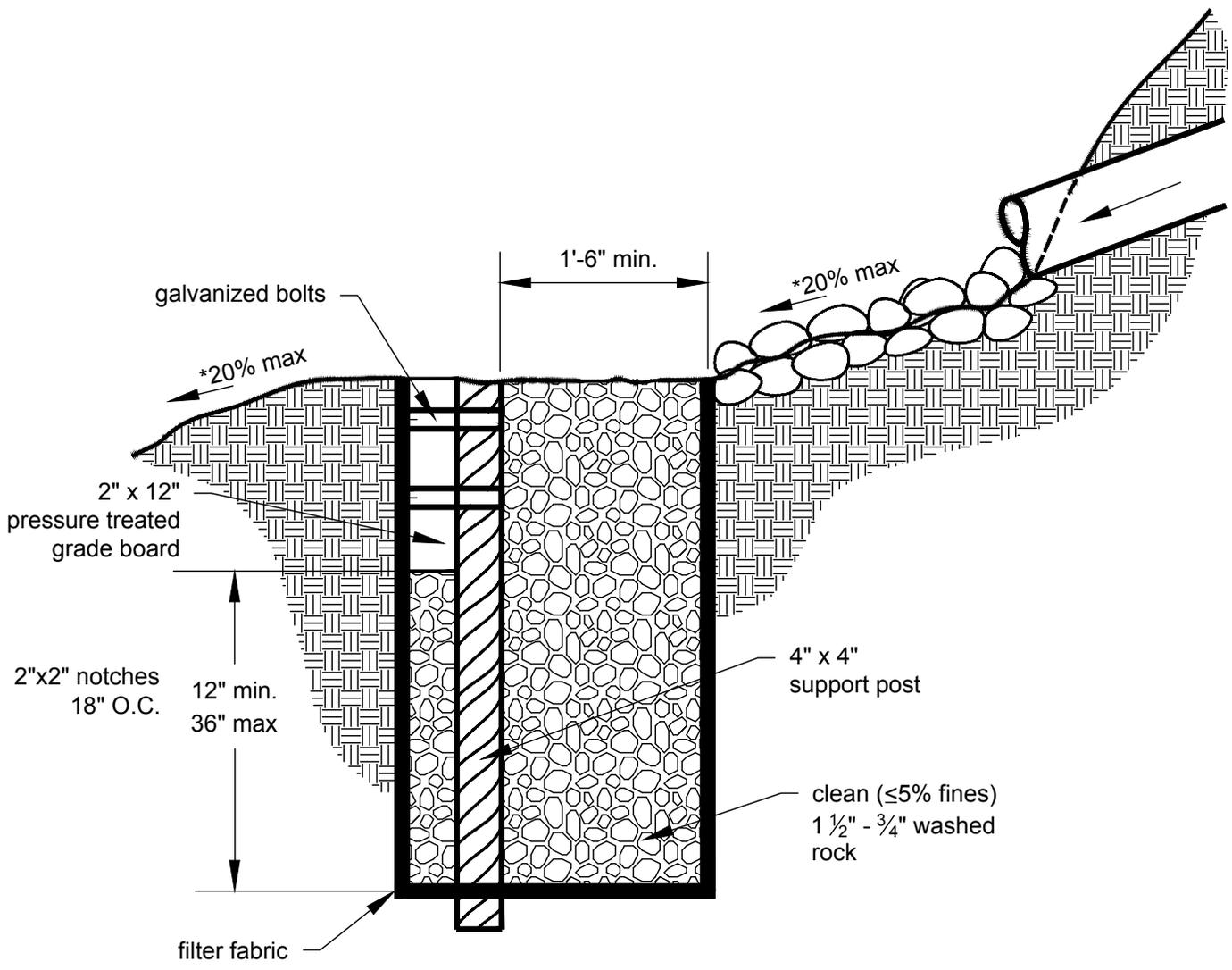
*15% max for flow control/runoff
treatment in rural areas.

Section A-A

Notes:
1. This trench shall be constructed so as 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.

NOT TO SCALE

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Figure 4.2
Alternative Flow Dispersion Trench

March 2020

TOP OF CURB

GUTTER

PLANTING STRIP OR SIDEWALK

PROPERTY OF KING COUNTY

DUMP NO. POLLUTANTS CAPITAL TO STREAM FOUNDRY NAME

FLOW

FLOW

CONC CURB AND GUTTER

ROADWAY SURFACE

DUMMY JOINTS

PLAN

FACE OF CURB

GUTTER

DUMMY JOINTS

FLOW

CATCH BASIN

SECTION A

GUTTER

CATCH BASIN
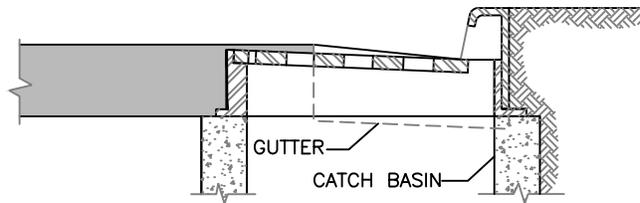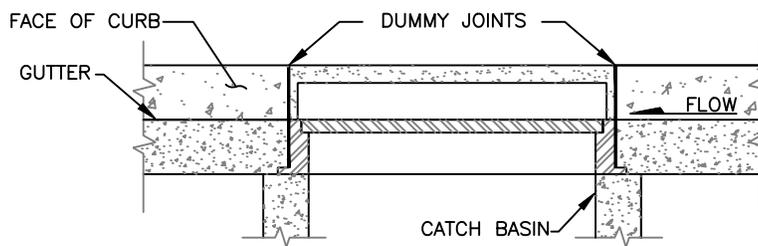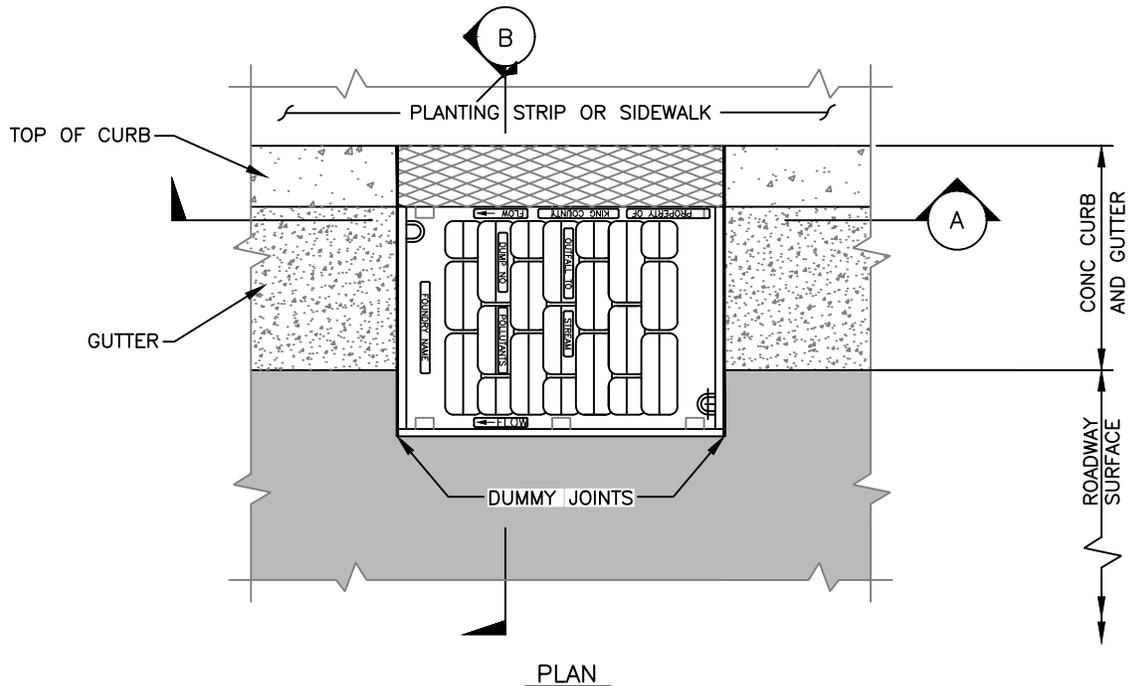
SECTION B

NOTES:

1. SET TO GRADE AND CONSTRUCT ROAD AND GUTTER TO BE FLUSH WITH FRAME.

2. SEE SEC. 3.04 FOR JOINT REQUIREMENTS.

3. SEE WSDOT/APWA STANDARD SPECIFICATIONS SECTION 9-05.15 FOR METAL GRATINGS REQUIREMENTS.

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Figure 4.3
Through-Curb Inlet

March 2020

6" MIN

PIPE JOINT (TYP)

2' MIN

6" MIN

3' MIN

PIPE TRENCH

PIPE BEDDING
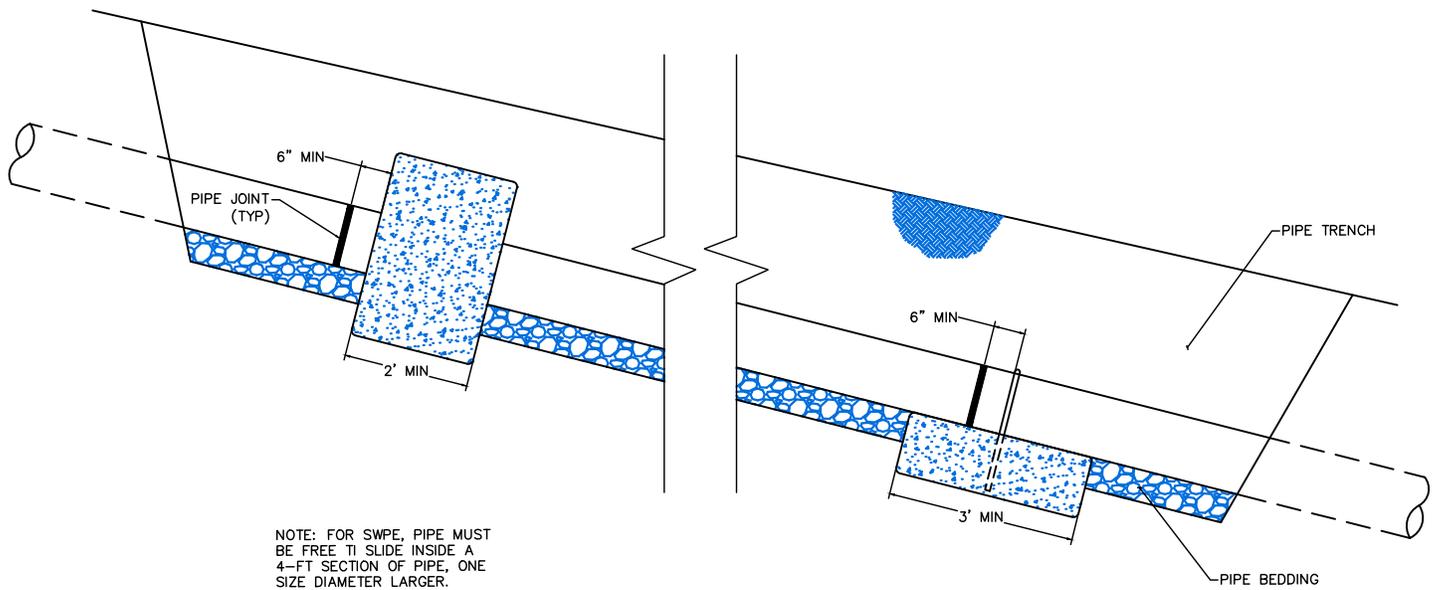
NOTE: FOR SWPE, PIPE MUST BE FREE TI SLIDE INSIDE A 4-FT SECTION OF PIPE, ONE SIZE DIAMETER LARGER.

SWPE PIPE ANCHOR DETAIL
NTS

PIPE TRENCH

6" MIN

1' MIN

6" MIN

6" MIN

KEY CONCRETE BLOCK INTO UNDISTURBED SOIL

SECTION A-A
NTS

PIPE TRENCH

1" MIN DIAMETER STEEL ROD CLAMPED SECURELY TO PIPE

KEY CONCRETE BLOCK INTO UNDISTURBED SOIL

PIPE BEDDING

6" MIN

1' MIN

2 X PIPE DIAMETER MIN
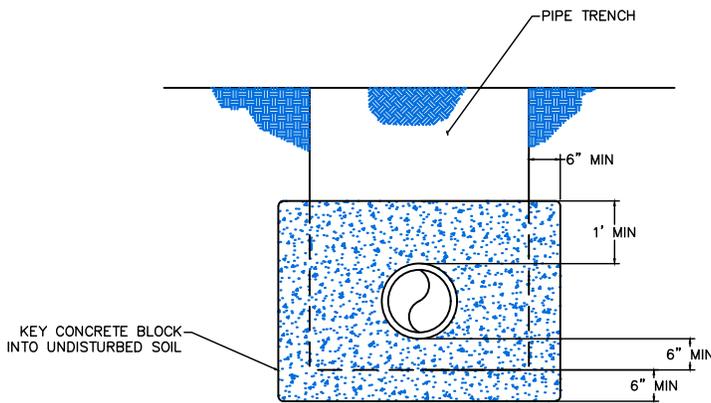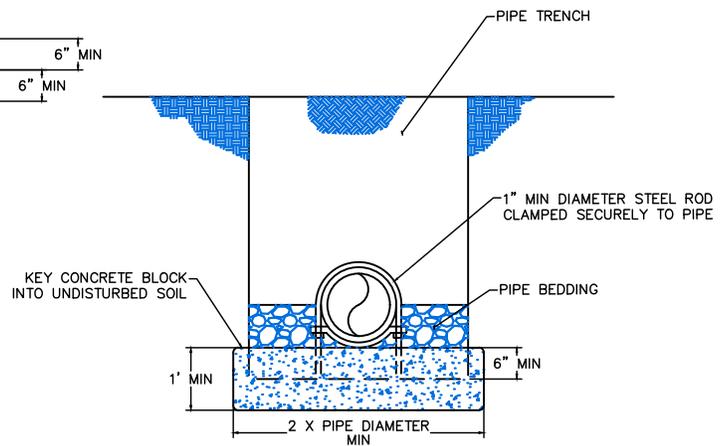
SECTION B-B
NTS

Figure 4.4
Pipe Anchor Detail

KITSAP COUNTY
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March 2020

12"
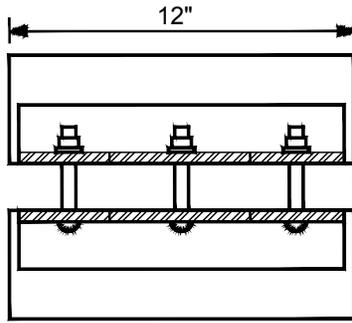
Smooth Coupling Band
for Smooth Pipe

pipe
stakes

3"

1"R

2"

$6\frac{5}{8}$"

$4\frac{1}{8}$"

all holes
$\frac{3}{4}$" diam.

slots to be
$1\frac{19}{32}$ x $\frac{3}{4}$"

$\frac{7}{8}$"

$\frac{3}{4}$"

$1\frac{7}{8}$" $1\frac{7}{8}$"

$4\frac{1}{2}$"

7" coupling band

$4\frac{1}{2}$"

12" or 24" coupling band

12"

Plate Detail

$7\frac{1}{2}$"

$1\frac{3}{4}$" X $\frac{3}{4}$" (TYP)

$\frac{15}{16}$" X $\frac{3}{4}$" (TYP)

6"

2" X 3"

COUPLING BAND

COLLAR – 2" PIPE
(TYP)

WELD
(TYP)

PLATE (SEE DETAIL)

$1\frac{1}{2}$" X 6' PIPE STAKES
EACH SIDE OF CULVERT

FLATTEN
TO
POINT

CMP Pipe Anchor
Detail
NTS
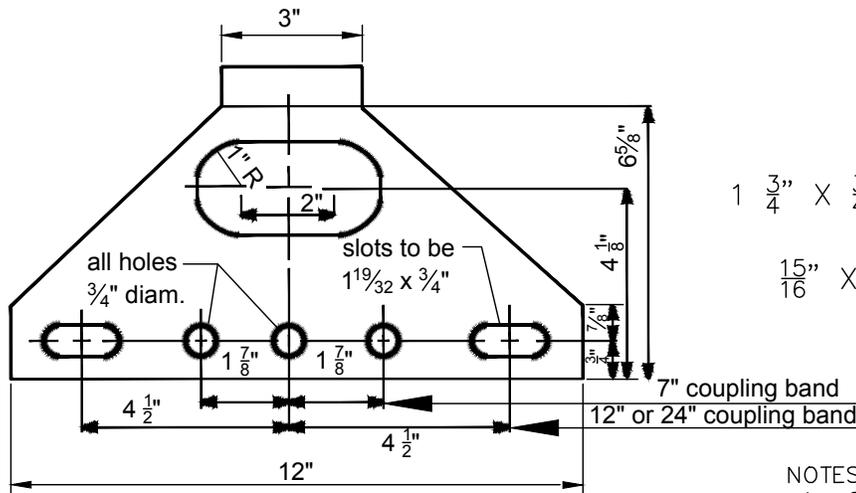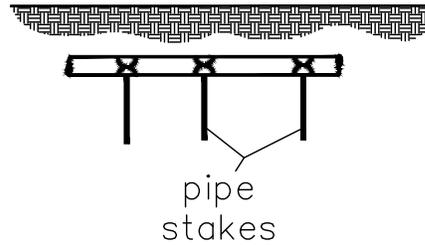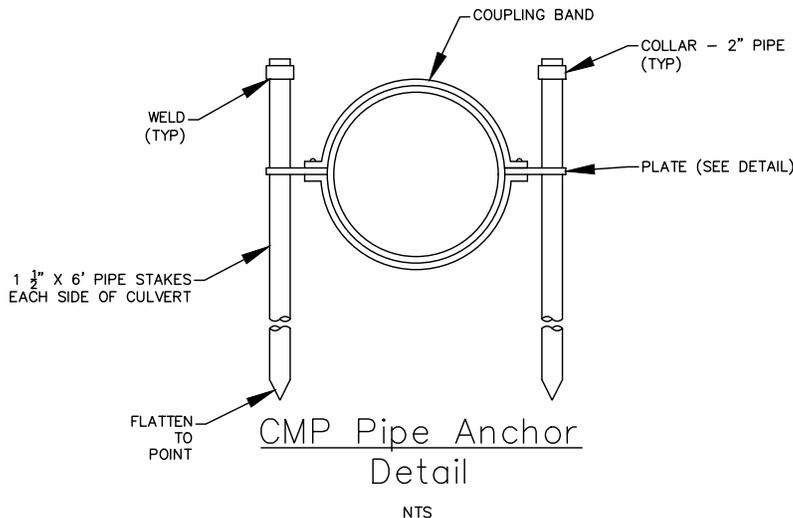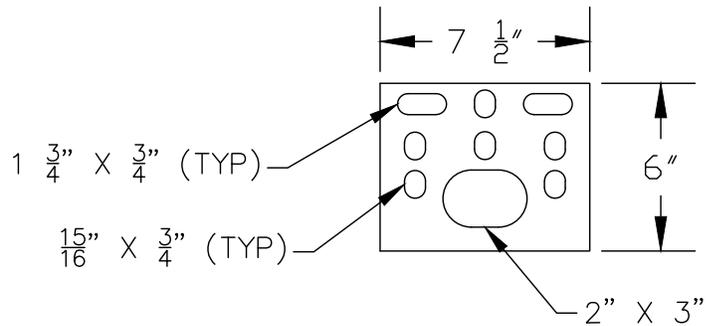
NOTES:
1. STAKES AND PLATES SHALL BE GALVANIZED PER ASTM A 36 AND A 153.
2. THE SMOOTH COUPLING BAND SHALL BE PER WSDOT STD PLANS B–60.20–01 AND B–60.20–01 AND USED IN COMBINATION WITH CONCRETE PIPE.
3. CONCRETE PIPE WITHOUT A BELL AND SPIGOT CONNECTION SHALL NOT BE INSTALLED ON GRADES IN EXCESS OF 20%.
4. THE FIRST ANCHOR SHALL BE INSTALLED ON TEH FIRST SECTION OF THE LOWER END OF THE PIPE; THE REMAINING ANCHORS SHALL BE EVENLY SPACED THROUGHOUT THE INSTALLATION.
5. 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.
6. 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.
7. ALL PIPE ANCHORS SHALL BE SECURELY INSTALLED BEFORE BACKFILLING AROUND THE PIPE.

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Figure 4.5
Corrugated Metal Pipe Coupling Anchor Assembly

March 2020

may be removed

3/4" dia. smooth bars
w/ends welded to
bar-frame

1' min.

6" O.C. max.
bar spacing

3
1

3/4" diameter
bar frame

beveled pipe end section

3" - 5" for 18" dia.
5" - 8" for 24" dia.
7" - 9" for 30" dia. & greater

pipe coupling

2" x 5" anchor strips welded to
3/4" dia. bar-frame 4 places spaced
uniformly. Fasten w/ 1/2" galv. or
non-corrosive bolts & nuts.
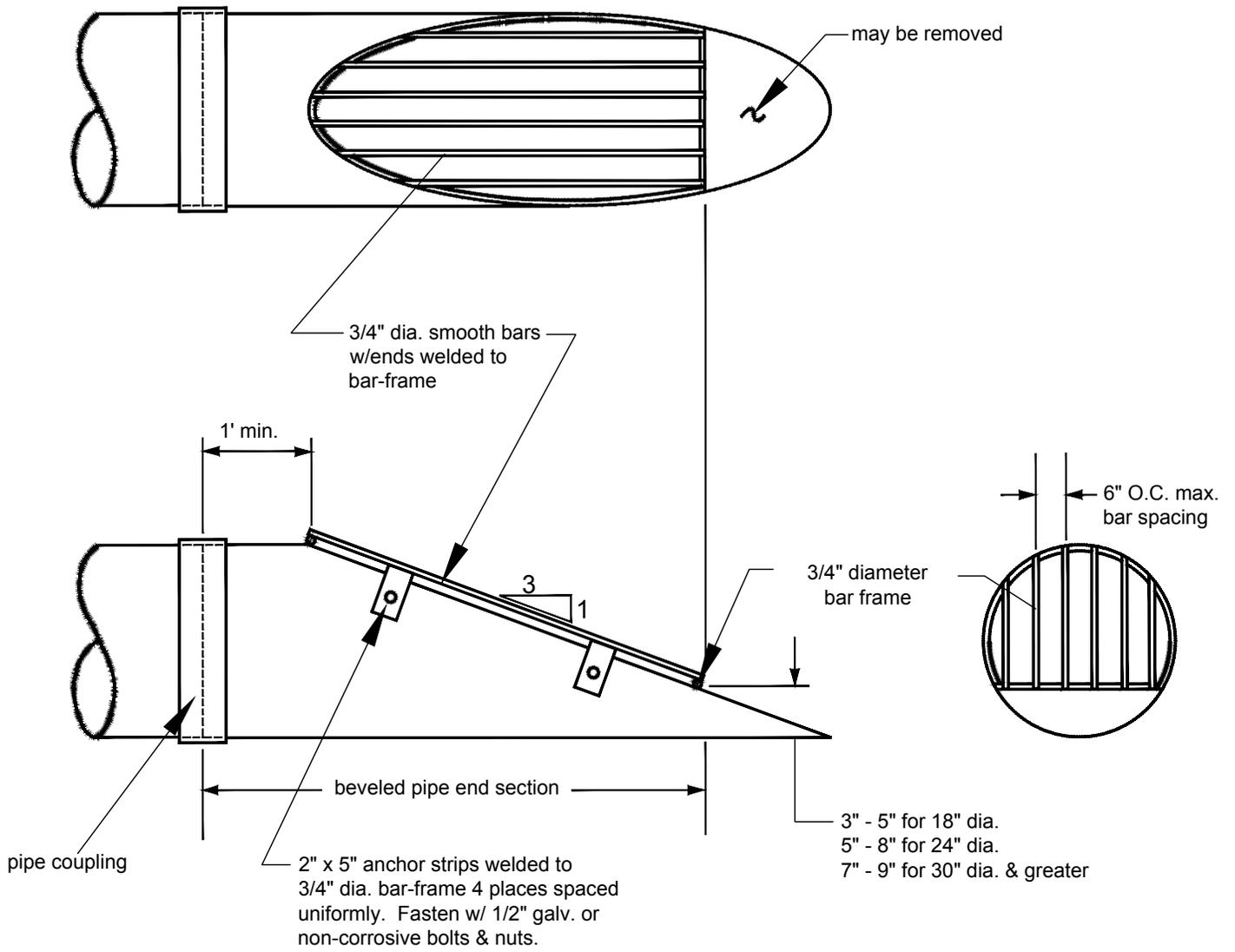
NOTES:
1. CMP or LCPE pipe end-section shown; for concrete pipe beveled
   end section, see KCRS drawing No. 2-001.
2. All steel parts must be galvanized and asphalt coated (treatment 1 or better).

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Figure 4.6
Debris Barrier (In Road Right-of-Way)

March 2020

B

gabion mattress

B

SWPE pipe

C

C

B

gabions (typical)
(size as required)

45° preferred

A
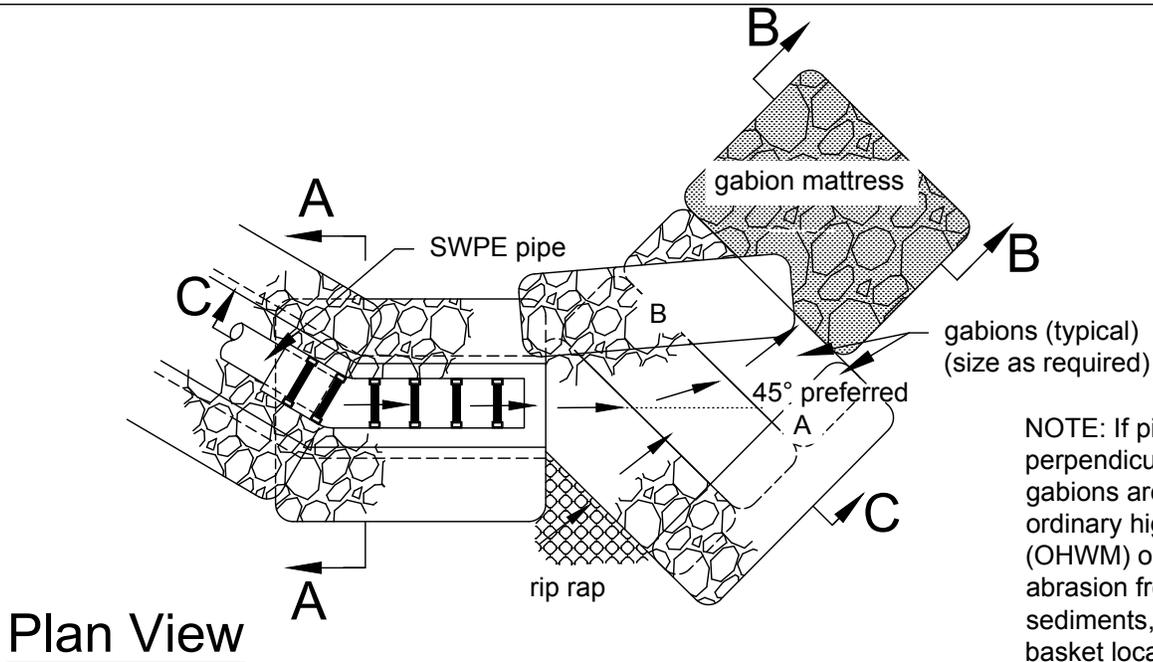
NOTE: If pipe discharges
perpendicular to stream, or
gabions are located within the
ordinary high water mark
(OHWM) or will be subject to
abrasion from upstream
sediments, a four-sided gabion
basket located outside the
OHWM should be considered.

A

C

rip rap

A

Plan View

pipe anchor

gabion mattress

Section B-B

Section A-A

existing
groundline

sleeve of next larger size
diameter pipe for thermal
expansion and concentration

D

B

A

3xD

2xD

place filter fabric
between gabions
at soil bedding

Section C-C

NOT TO SCALE

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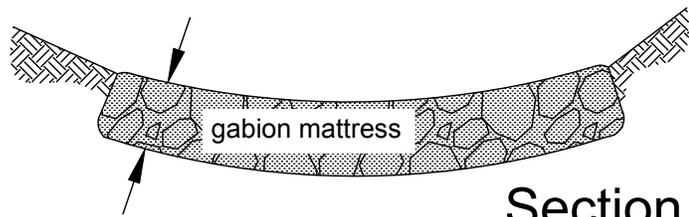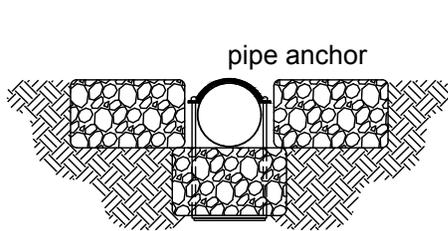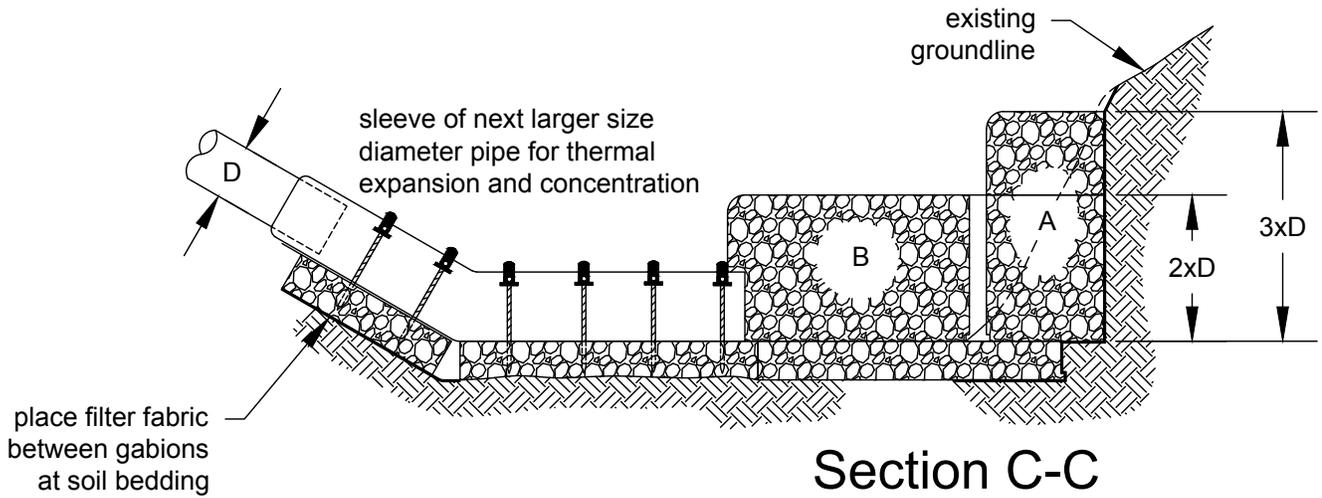
Figure 4.7
Gabion Outfall Detail

March 2020

pipe from bluff

fused or flanged connection
specified in profile/plan

HDPE moulded or fabricated tee same
diameter and dimension ratio as pipe

flow

2.0 x tee diam.

1.5 x hole
diam. min.

spacing =
1.5 x hole diameter

no holes
opposite pipe
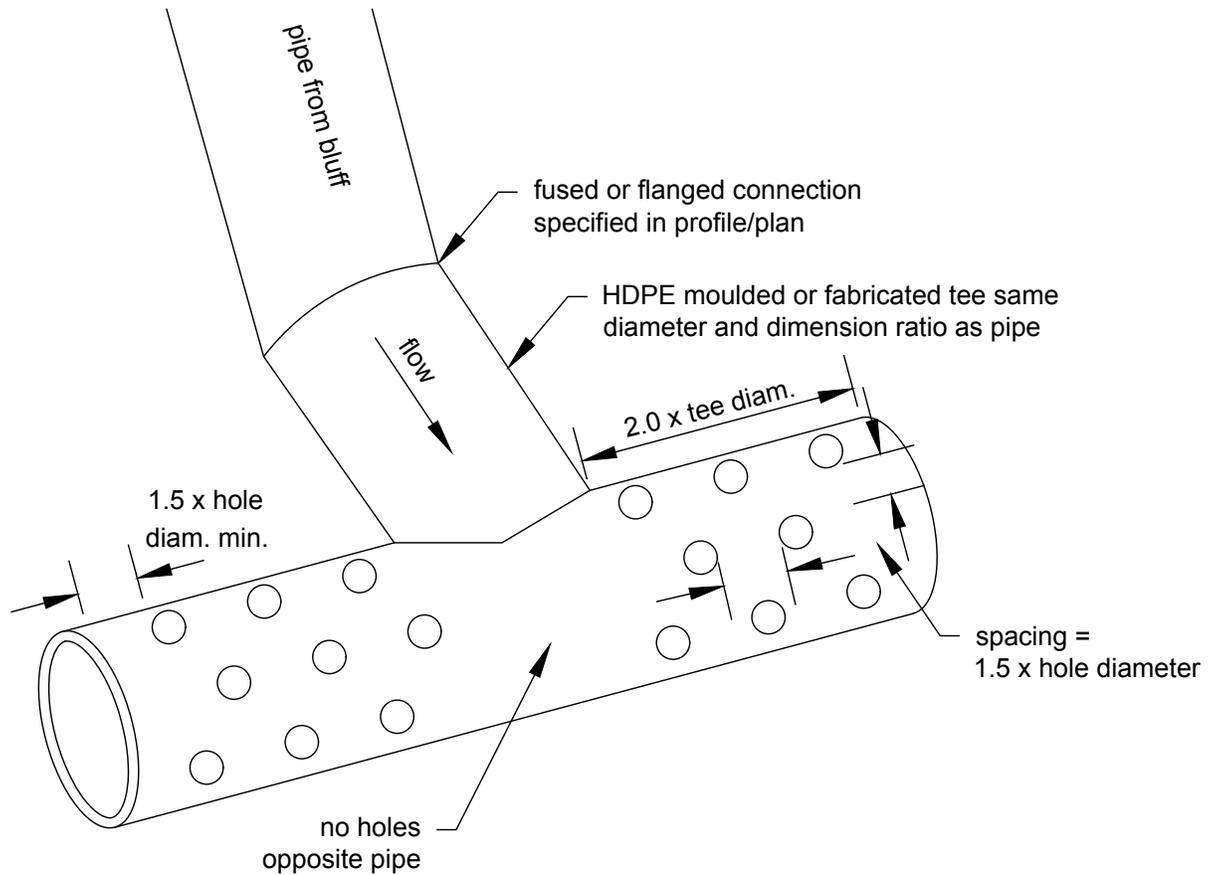
Drill holes in front half of tee only.
Hole diameter (inches) = tee diameter (inches) divided by 6
  (ex. 6 inch tee = 1 inch holes
       18 inch tee = 3 inch holes)

NOT TO SCALE

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Figure 4.8
Diffuser TEE
(an example of energy dissipating end feature)

March 2020

℄ channel

flow

A

"B"
4' min.

"A"

30°
min.

2' min.

top of bank

top of bank

toe of bank

toe of bank

top of bank

A
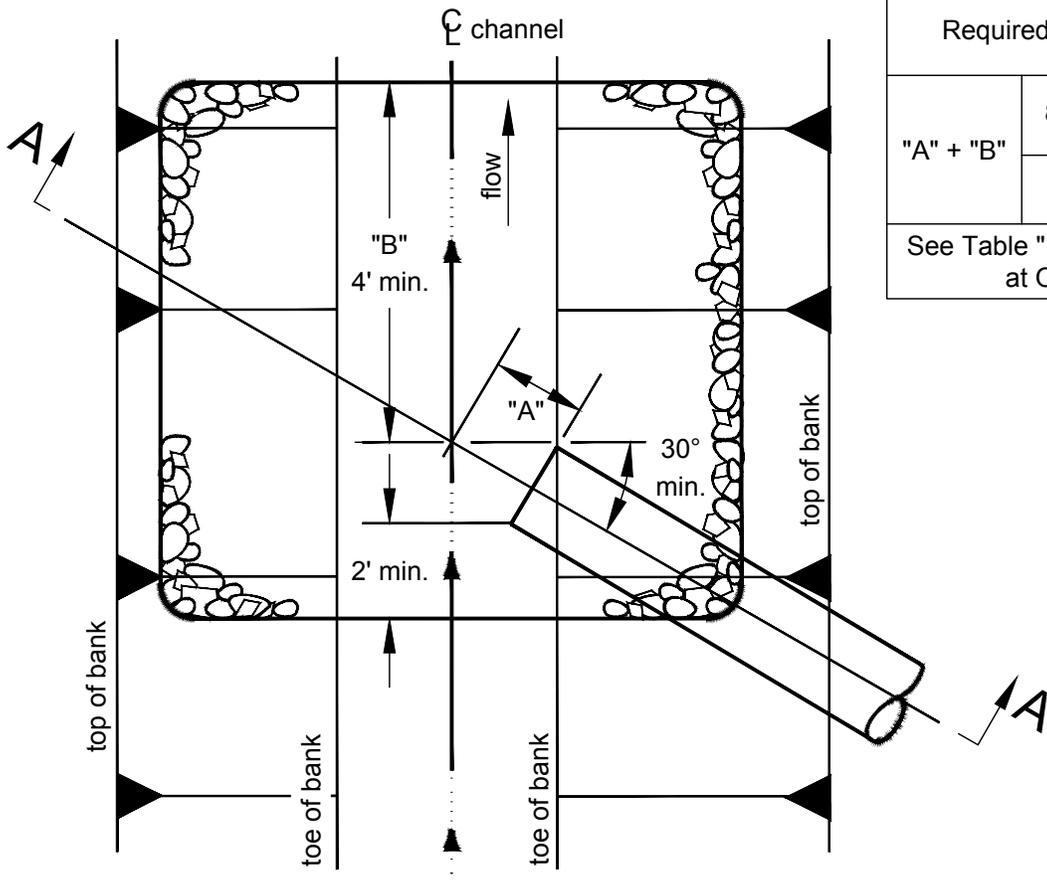
Required Dimensions	
"A" + "B"	8' for rock lining
	12' for rip rap
See Table "Rock Protection at Outfalls"	

Plan

place rock 1' above crown
both sides of chanel for "A" < 8'
one side of channel for "A" ≥ 8'

1' min.

discharge pipe

filter fabric liner
under rock

1' or 2' rock thickness
see Table 4.5

Section A-A

NOT TO SCALE

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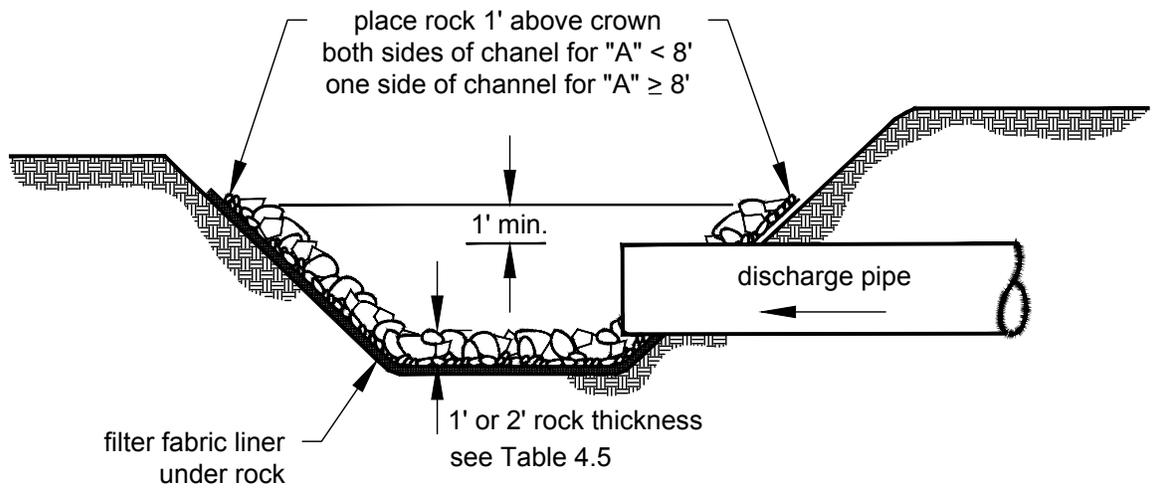
Figure 4.9
Pipe/Culvert Outfall Discharge Protection

March 2020

SLOPE FRONT FACE TO
COINCIDE WITH EMBANKMENT
OR DITCH SLOPE

D/4 (6" min.)

6"

D/4 (6" min.)

1 #4 BAR,
CONTINUOUS
(SPLICE OK)

D
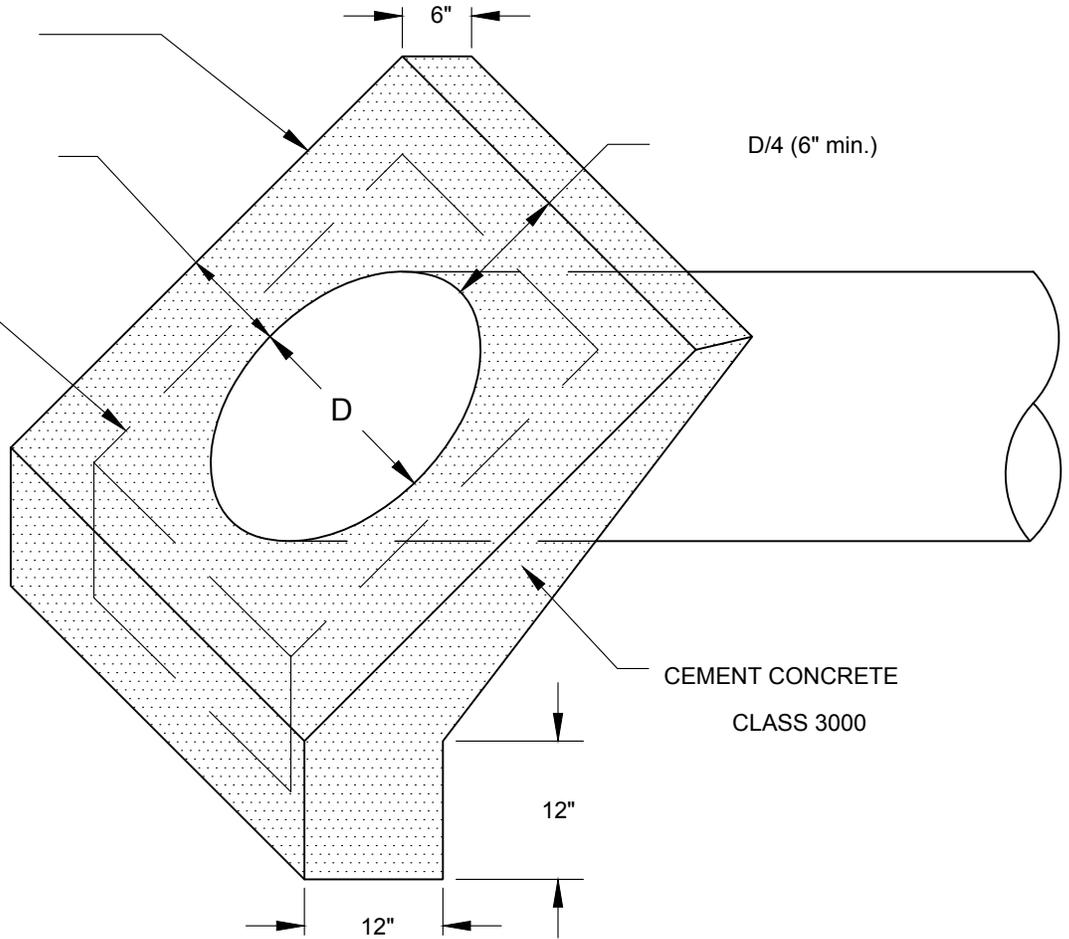
CEMENT CONCRETE
CLASS 3000

12"

12"

NOTE:

REINFORCING STEEL SHALL HAVE 1 1/2 INCH CLEAR
COVER TO ALL CONCRETE SURFACES AND SHALL BE
GRADE 40 OR GRADE 60.

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Figure 4.10
Concrete End Protection

March 2020

	DIMENSIONS				HYDRAULICS			
NO.	Side Slopes	B	H	W	A	WP	R	$R^{(2/3)}$
D-1	--	--	6.5"	5'-0"	1.84	5.16	0.356	0.502
D-1C	--	--	6"	25'-0"	6.25	25.5	0.245	0.392
D-2A	1.5:1	2'-0"	1'-0"	5'-0"	3.5	5.61	0.624	0.731
B	2:01	2'-0"	1'-0"	6'-0"	4	6.47	0.618	0.726
C	3:01	2'-0"	1'-0"	8'-0"	5	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	2:01	3'-0"	1'-6"	9'-0"	9	9.71	0.927	0.951
C	3:01	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	10.21	1.175	1.114
B	2:01	3'-0"	2'-0"	11'-0"	14	11.94	1.172	1.112
C	3:01	3'-0"	2'-0"	15'-0"	18	15.65	1.15	1.098
D-5A	1.5:1	4'-0"	3'-0"	13'-0"	25.5	13.82	1.846	1.505
B	2:01	4'-0"	3'-0"	16'-0"	30	16.42	1.827	1.495
C	3:01	4'-0"	3'-0"	22'-0"	39	21.97	1.775	1.466
D-6A	2:01	--	1'-0"	4'-0"	2	4.47	0.447	0.585
B	3:01	--	1'-0"	6'-0"	3	6.32	0.474	0.608
D-7A	2:01	--	2'-0"	8'-0"	8	8.94	0.894	0.928
B	3:01	--	2'-0"	12'-0"	12	12.65	0.949	0.965
D-8A	2:01	--	3'-0"	12'-0"	18	13.42	1.342	1.216
B	3:01	--	3'-0"	18'-0"	27	18.97	1.423	1.265
D-9	7:01	--	1'-0"	14'-0"	7	14.14	0.495	0.626
D-10	7:01	--	2'-0"	28'-0"	28	28.28	0.99	0.993
D-11	7:01	--	3'-0"	42'-0"	63	42.43	1.485	1.302

D-1 Segmental (parabolic)

D-1c Curbed crowned street

D-2, D-3, D-4, D-5 Trapezoidal

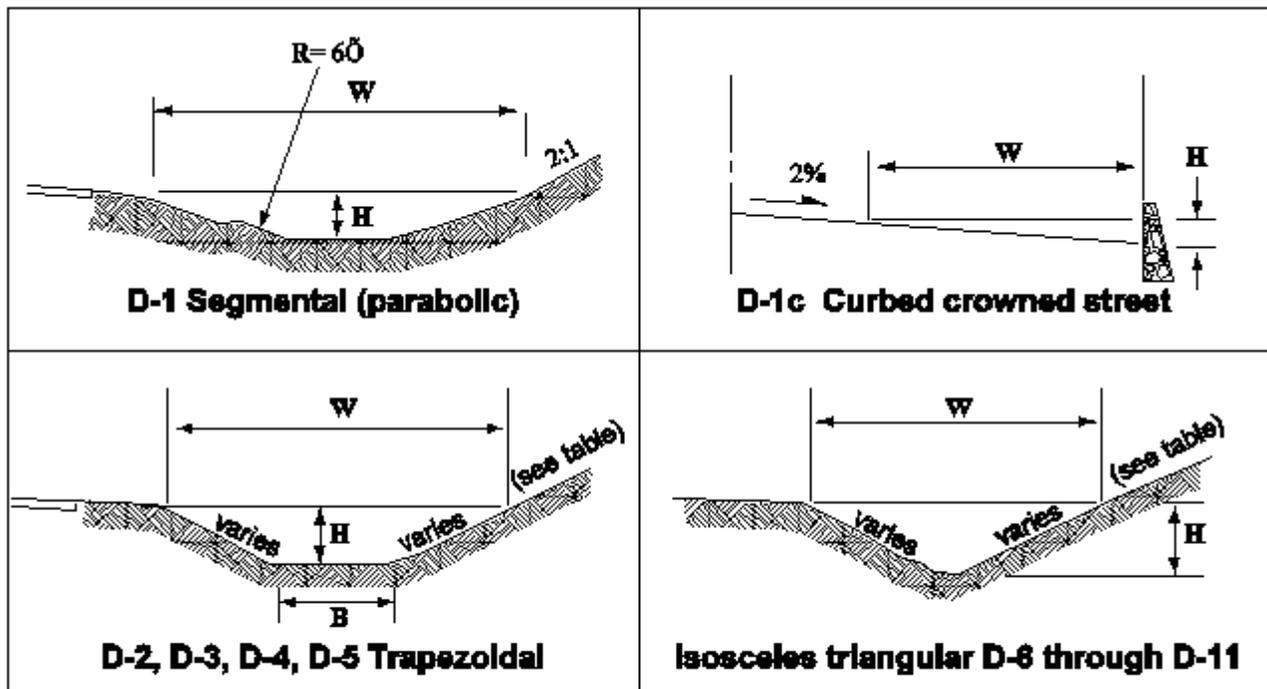Isosceles triangular D-6 through D-11

Figure 4.11
Ditches – Common Sections

March 2020

NOTE: A) Chart based on Manning formula Q=1.49/n*A*R2/3*S1/2 with n=0.030, except D-1C which is based on n=0.015. For other values of n, multiply discharge by 0.030/n.

B) 1 indicates a velocity of 1 ft. per sec.

Example: Given- Slope=3.3' per 1000', discharge=6.3 c.f.s., n=0.025. Required- Size of ditch and velocity. Solution- To use chart, multiply discharge, 6.3 by (.03/.025) = 7.56 c.f.s. Point satisfying given conditions lies between lines for D-2A and D-2B. Select larger of the two ditches, in this case D-2B. Velocity approx. 2.1 ft. per sec.
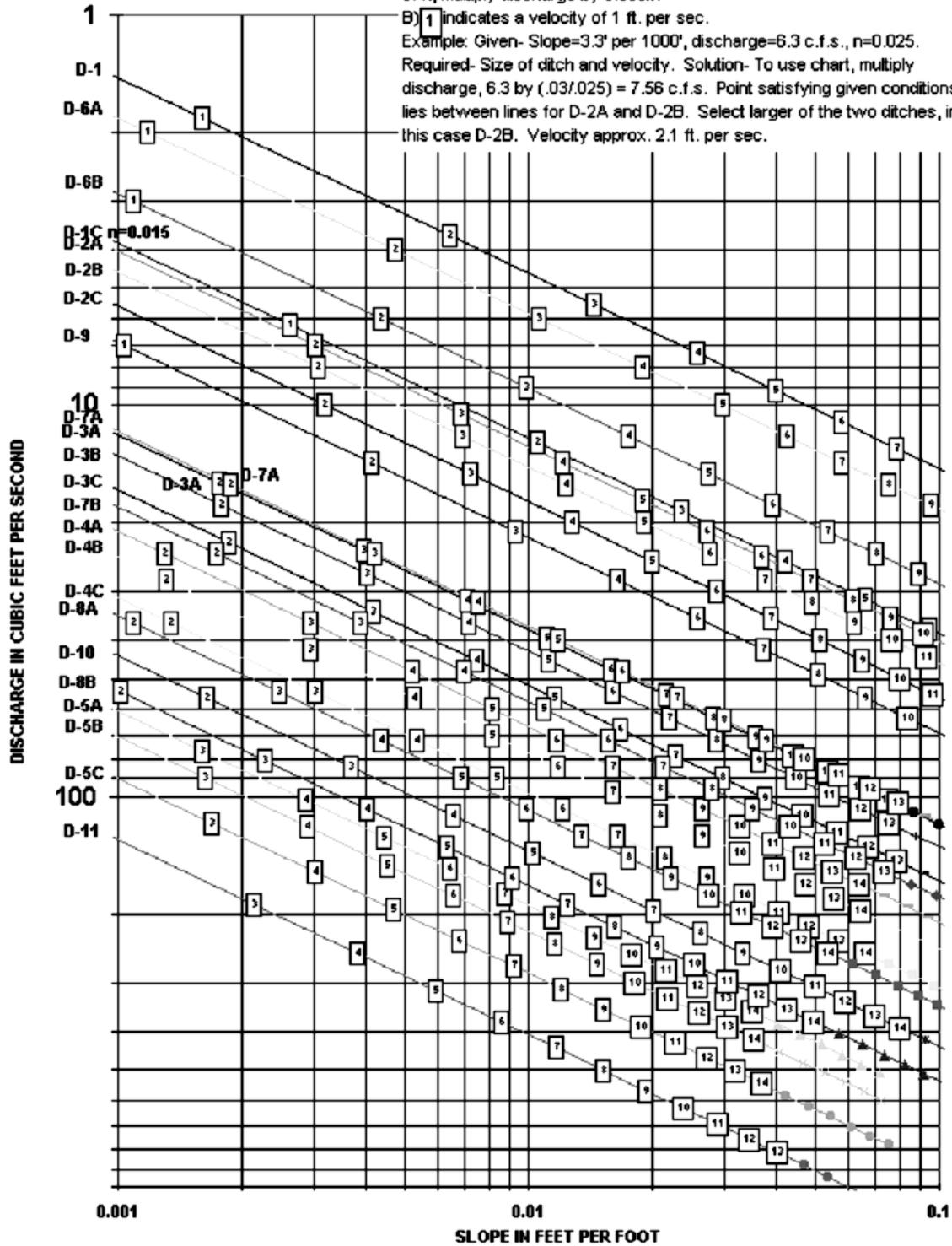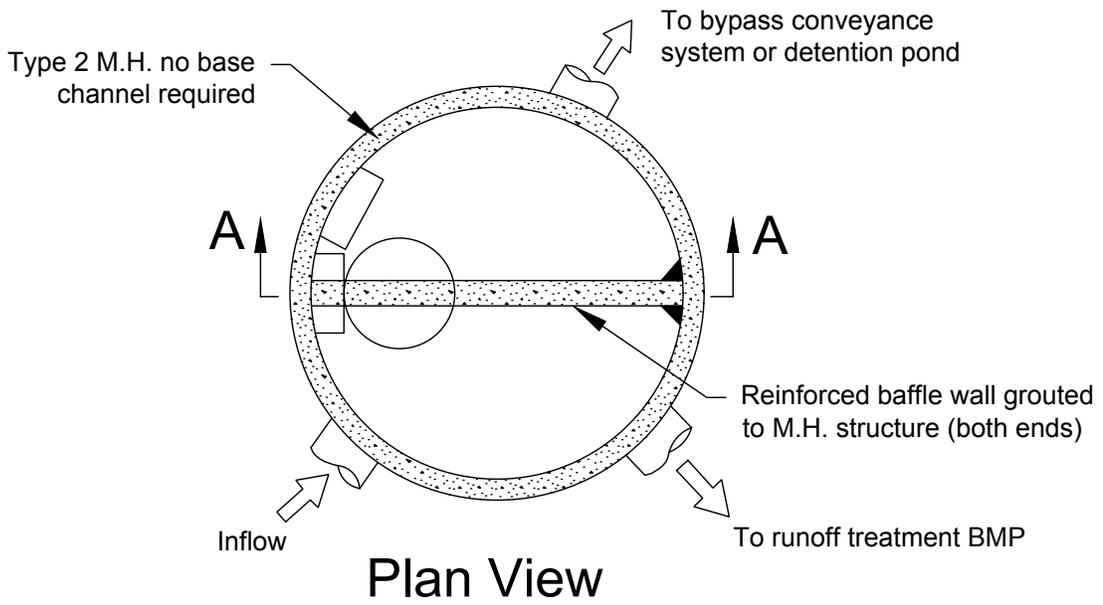
Figure 4.12
Drainage Ditches –
Common Sections

Section	Area A	Wetted perimeter P	Hydraulic radius R	Top width W	Hydraulic depth D	Section factor Z
Rectangle	by	$b + 2y$	$\dfrac{by}{b+2y}$	b	y	$by^{1.5}$
Trapezoid	$(b+zy)y$	$b + 2y\sqrt{1+z^2}$	$\dfrac{(b+zy)y}{b+2y\sqrt{1+z^2}}$	$b + 2zy$	$\dfrac{(b+zy)y}{b+2zy}$	$\dfrac{[(b+zy)y]^{1.5}}{\sqrt{b+2zy}}$
Triangle	zy^2	$2y\sqrt{1+z^2}$	$\dfrac{zy}{2\sqrt{1+z^2}}$	$2zy$	$\tfrac{1}{2}y$	$\dfrac{\sqrt{2}}{2}zy^{2.5}$
Circle	$\tfrac{1}{8}(\theta - \sin\theta)d_0^2$	$\tfrac{1}{2}\theta d_0$	$\tfrac{1}{4}\left(1 - \dfrac{\sin\theta}{\theta}\right)d_0$	$\left(\sin\tfrac{1}{2}\theta\right)d_0$ or $2\sqrt{(d_0 - y)y}$	$\tfrac{1}{8}\left(\dfrac{\theta - \sin\theta}{\sin\tfrac{1}{2}\theta}\right)d_0$	$\dfrac{\sqrt{2}}{32}\dfrac{(\theta - \sin\theta)^{1.5}}{(\sin\tfrac{1}{2}\theta)^{0.5}}d_0^{2.5}$
Parabola	$\tfrac{2}{3}Ty$	$T + \dfrac{8y^2}{3T}$	$\dfrac{2T^2y}{3T^2 + 8y^2}$	$\dfrac{3A}{2y}$	$\tfrac{2}{3}y$	$\tfrac{2}{9}\sqrt{6}Ty^{1.5}$
Round-cornered Rectangle	$\left(\tfrac{\pi}{2} - 2\right)r^2 + (b + 2r)y$	$(\pi - 2)r + b + 2y$	$\dfrac{\left(\tfrac{\pi}{2}-2\right)r^2 + (b+2r)y}{(\pi-2)r + b + 2y}$	$b + 2r$	$\dfrac{\left(\tfrac{\pi}{2}-2\right)r^2}{(b+2r)} + y$	$\dfrac{\left[\left(\tfrac{\pi}{2}-2\right)r^2 + (b+2r)y\right]^{1.5}}{\sqrt{b+2r}}$
Round-bottomed Triangle	$\dfrac{T^2}{4z} - \dfrac{r^2}{z}(1 - z\cot^{-1}z)$	$\dfrac{T}{z}\sqrt{1+z^2} - \dfrac{2r}{z}(1 - z\cot^{-1}z)$	$\dfrac{A}{P}$	$2[z(y - r) + r\sqrt{1+z^2}]$	$\dfrac{A}{T}$	$A\sqrt{\dfrac{A}{T}}$

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

Figure 4.13
Geometric Elements of Common Sections

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Type 2 M.H. no base
channel required

To bypass conveyance
system or detention pond

A ↑ ↑ A

Reinforced baffle wall grouted
to M.H. structure (both ends)

Inflow

To runoff treatment BMP

Plan View

Handhold and steps or ladder
access (provide ladders to both
sides of wall if weir > 36" high)

4' min. or provide
separate access to
either side of baffle wall

Water quality design flow
rate water surface
elevation

7' min.

Inflow

To runoff treatment BMP

6" min.

4" min, thickness reinforced concrete
baffle wall or other suitable material
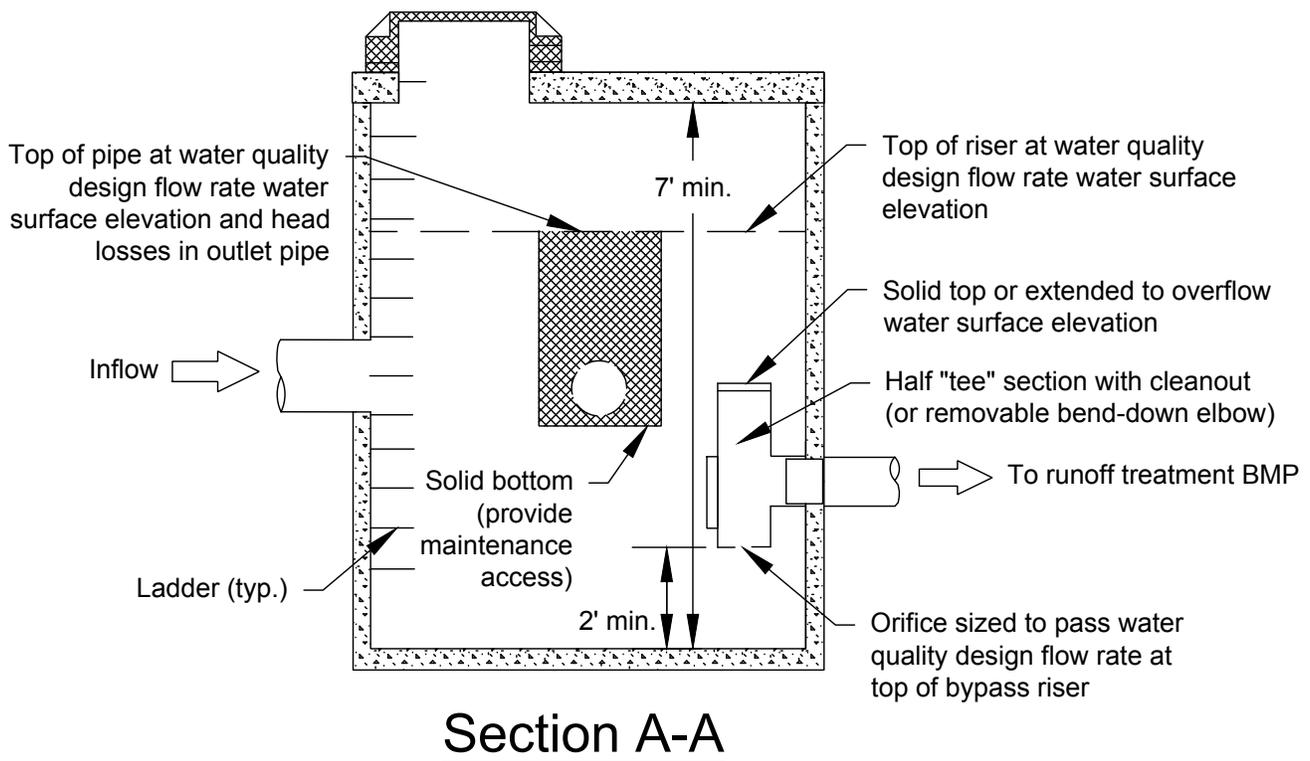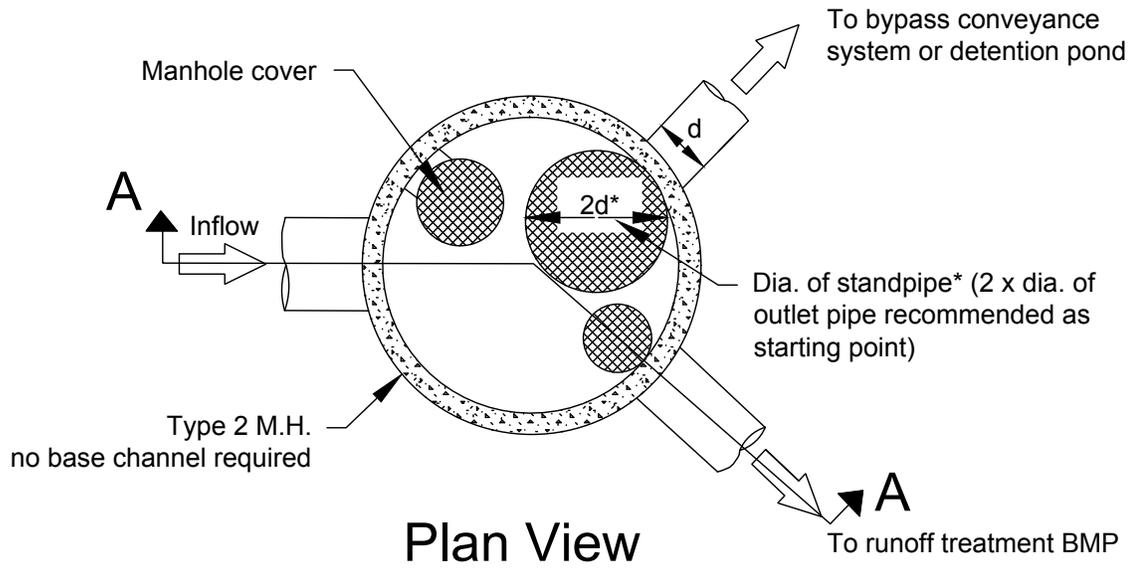
Bypass pipe

Section A-A

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

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Figure 4.14
Flow Splitter, Option A

March 2020

Manhole cover

To bypass conveyance system or detention pond

d

2d*

A

Inflow

Dia. of standpipe* (2 x dia. of outlet pipe recommended as starting point)

Type 2 M.H. no base channel required

A

To runoff treatment BMP

Plan View

Top of pipe at water quality design flow rate water surface elevation and head losses in outlet pipe

7' min.

Top of riser at water quality design flow rate water surface elevation

Solid top or extended to overflow water surface elevation

Inflow

Half "tee" section with cleanout (or removable bend-down elbow)

To runoff treatment BMP

Solid bottom (provide maintenance access)

Ladder (typ.)

2' min.

Orifice sized to pass water quality design flow rate at top of bypass riser

Section A-A

*Note: Diameter of standpipe (2d) 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.
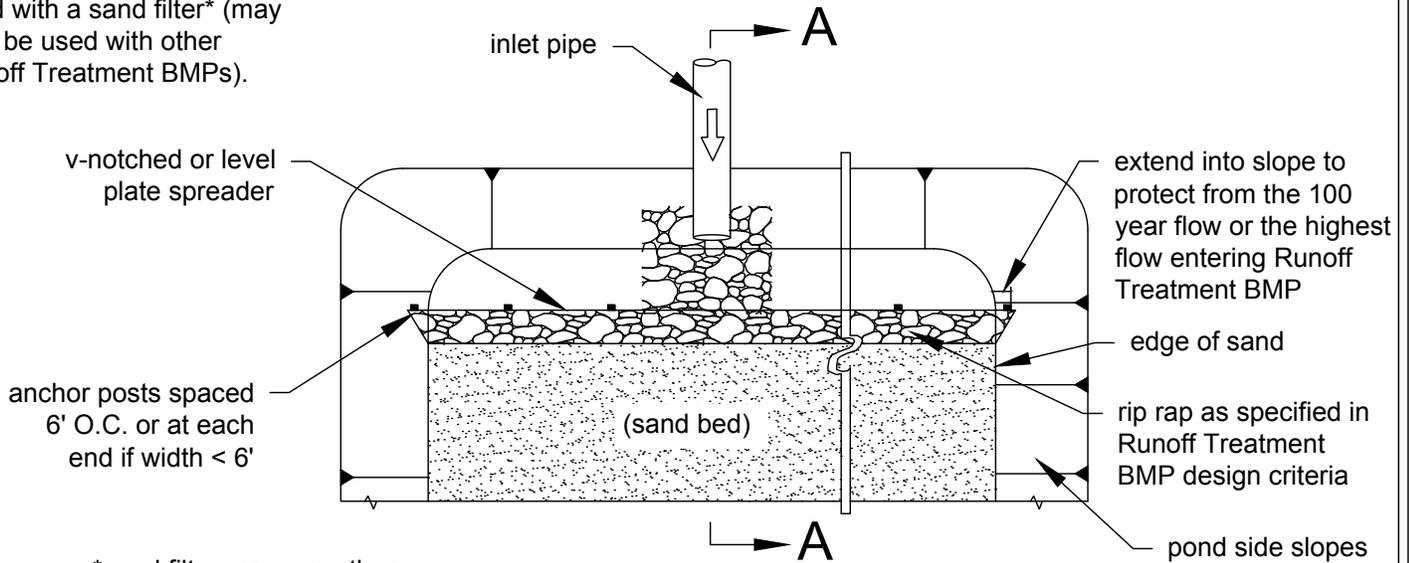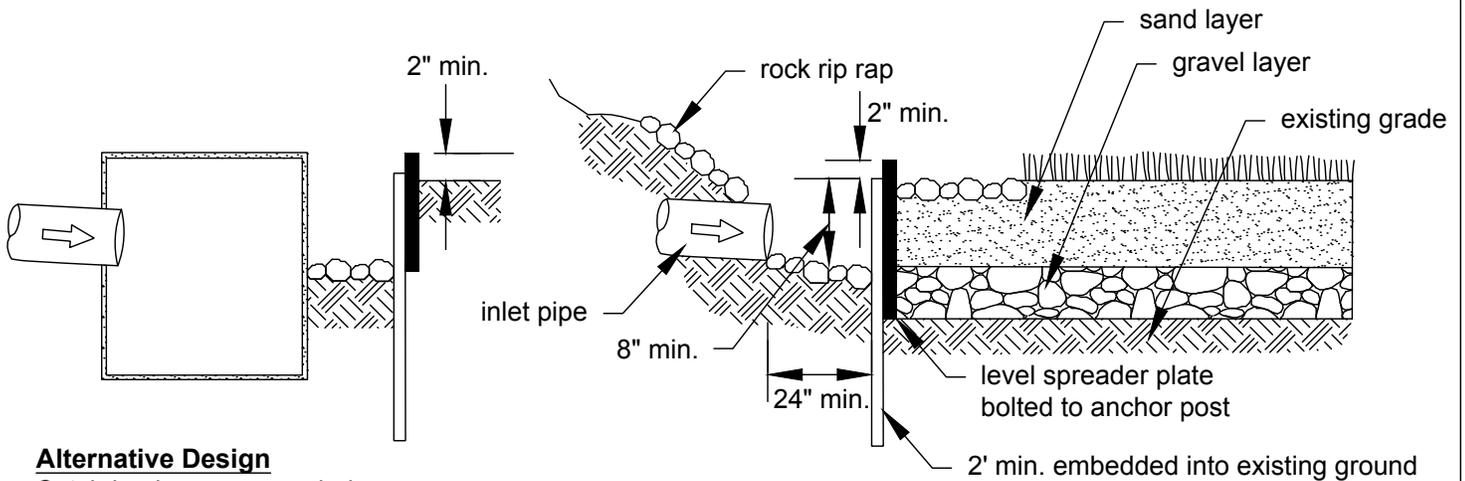
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Figure 4.15
Flow Splitter, Option B

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Example of anchored plate used with a sand filter* (may also be used with other Runoff Treatment BMPs).

v-notched or level plate spreader

inlet pipe

A

extend into slope to protect from the 100 year flow or the highest flow entering Runoff Treatment BMP

edge of sand

anchor posts spaced 6' O.C. or at each end if width < 6'

(sand bed)

rip rap as specified in Runoff Treatment BMP design criteria

A

*sand filter may use other spreading options

pond side slopes

Plan View

2" min.

rock rip rap

sand layer

gravel layer

2" min.

existing grade

inlet pipe

8" min.

24" min.

level spreader plate bolted to anchor post

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

2' min. embedded into existing ground

Section A-A

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Figure 4.16
Flow Spreader Option A: Anchored Plate

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Side with wing walls
see note

Concrete sump

Swale bottom

Outfall rip rap pad

Inlet pipe

B

A

A

A

Example of a
concrete sump flow
spreader used with a
biofiltration swale
(may be used with
other Runoff
Treatment BMPs).

B

Wing wall

Plan View

Inlet pipe

Wing wall outline
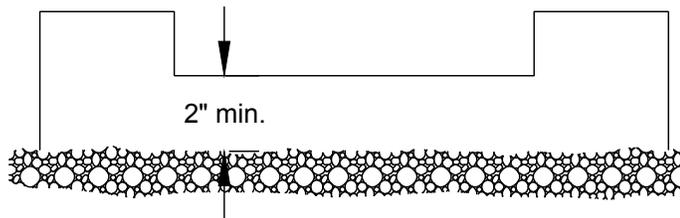
2" min. clearance

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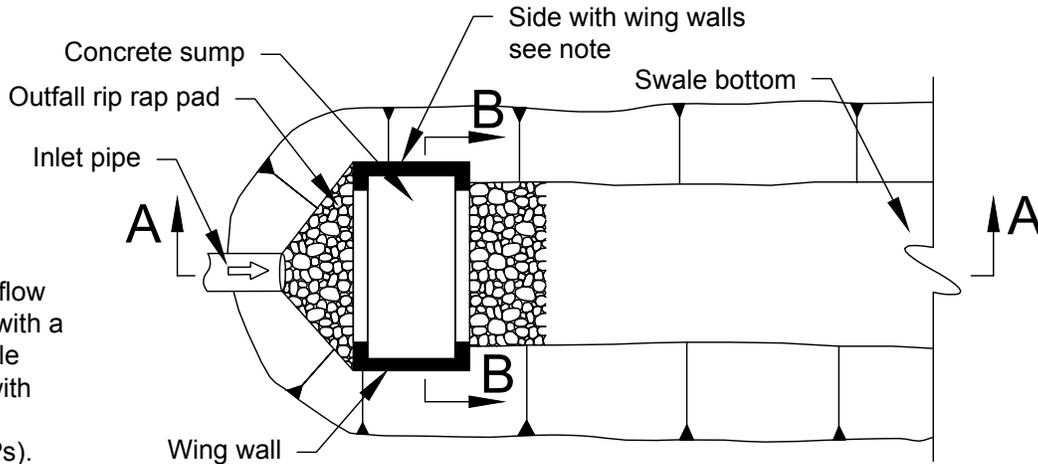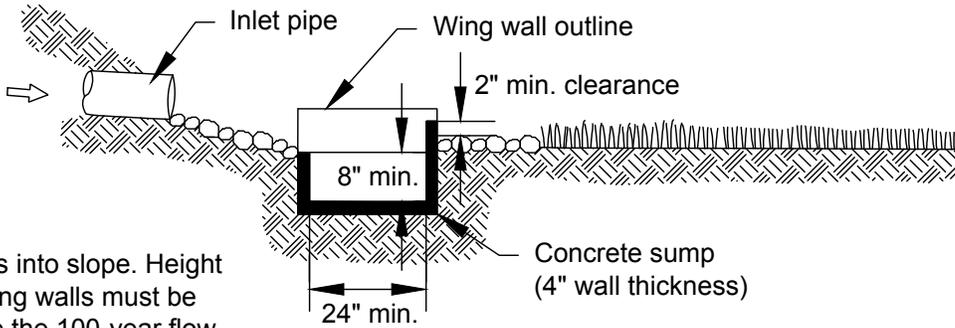
Note: Extend sides into slope. Height
of side wall and wing walls must be
sufficient to handle the 100-year flow
or the highest flow entering the BMP.

Concrete sump
(4" wall thickness)

24" min.

Section A-A

2" min.

Section B-B

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Figure 4.17
Flow Spreader Option B: Concrete Sump Box

March 2020

48"/section (typ.)

B

12"

A

Plan View

A

B

60°

6"

12"

8"

top of inlet
channel

Front View A-A

Inflow

8"

30°

Sand

Section B-B

2 - #5 rebar or reinforce
as necessary

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Figure 4.18
Flow Spreader Option C: Notched Curb Spreader

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max 6' O.C.

Reinforced
concrete curb

Opening
11" min.

Grass filter strip

Curb Port

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Figure 4.19
Flow Spreader Option D: Through-Curb Port

March 2020

Figure 5.1
Infiltration Feasibility Flow Chart

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Step 1 – Evaluate horizontal setbacks & site constraints.

Is the project site in a landslide-prone area?

— No →

Is the project site within a setback above a steep slope area (1)?

— No →

Can horizontal setback requirements be met (2)?

Yes ↓ (from first diamond)

Yes ↓ (from second diamond)

No →

No further infiltration investigation required to meet On-site, Flow Control, or Runoff Treatment requirements.

← No (from third diamond)

Yes (from third diamond) ↑

1. Setback is 10 times the height of the steep slope area to a maximum of 500 feet above a steep slope area.
2. Horizontal Setbacks include:
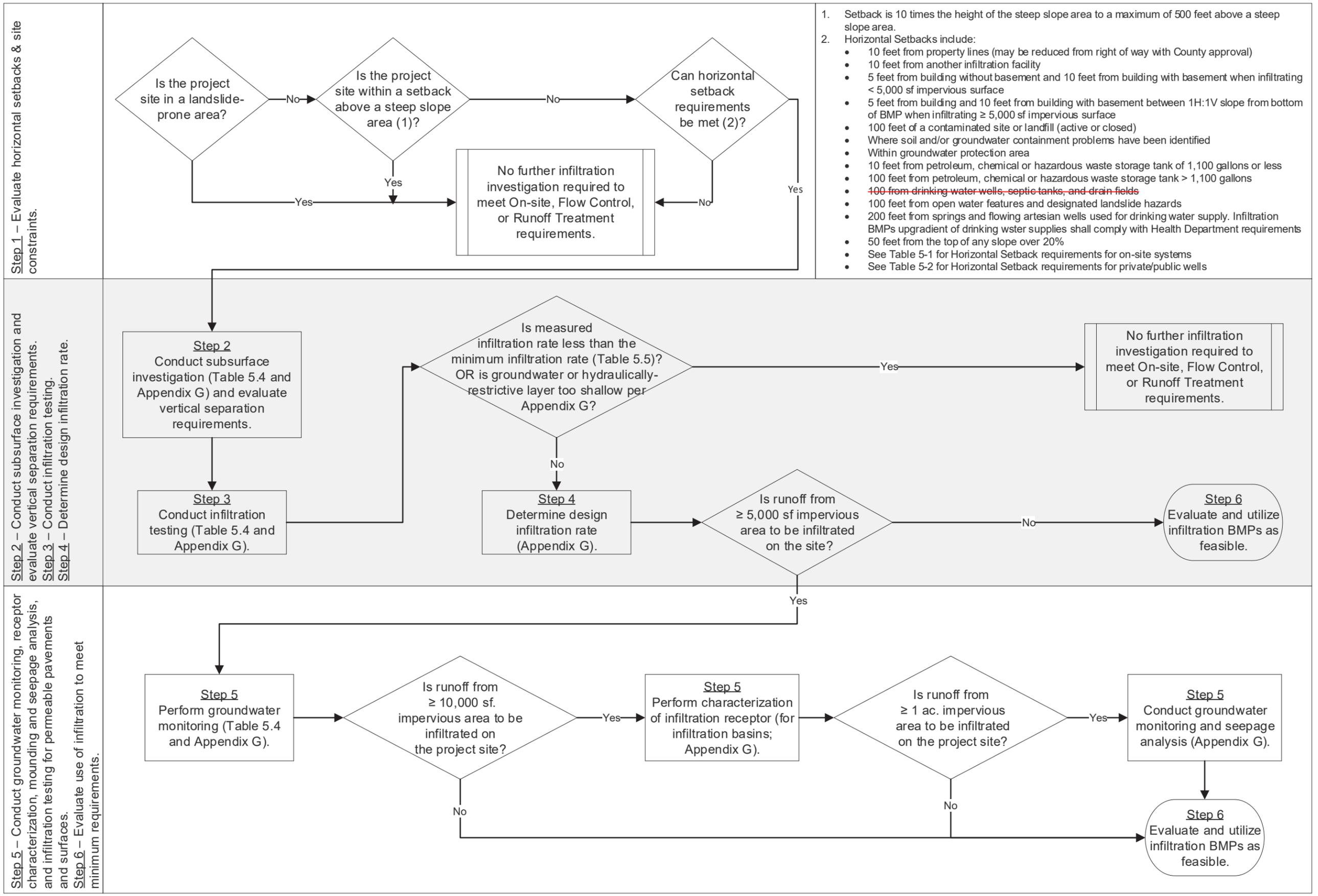   - 10 feet from property lines (may be reduced from right of way with County approval)
   - 10 feet from another infiltration facility
   - 5 feet from building without basement and 10 feet from building with basement when infiltrating < 5,000 sf impervious surface
   - 5 feet from building and 10 feet from building with basement between 1H:1V slope from bottom of BMP when infiltrating ≥ 5,000 sf impervious surface
   - 100 feet of a contaminated site or landfill (active or closed)
   - Where soil and/or groundwater containment problems have been identified
   - Within groundwater protection area
   - 10 feet from petroleum, chemical or hazardous waste storage tank of 1,100 gallons or less
   - 100 feet from petroleum, chemical or hazardous waste storage tank > 1,100 gallons
   - ~~100 from drinking water wells, septic tanks, and drain fields~~
   - 100 feet from open water features and designated landslide hazards
   - 200 feet from springs and flowing artesian wells used for drinking water supply. Infiltration BMPs upgradient of drinking water supplies shall comply with Health Department requirements
   - 50 feet from the top of any slope over 20%
   - See Table 5-1 for Horizontal Setback requirements for on-site systems
   - See Table 5-2 for Horizontal Setback requirements for private/public wells

Step 2 – Conduct subsurface investigation and evaluate vertical separation requirements.
Step 3 – Conduct infiltration testing.
Step 4 – Determine design infiltration rate.

Step 2
Conduct subsurface investigation (Table 5.4 and Appendix G) and evaluate vertical separation requirements.

Step 3
Conduct infiltration testing (Table 5.4 and Appendix G).

Is measured infiltration rate less than the minimum infiltration rate (Table 5.5)? OR is groundwater or hydraulically-restrictive layer too shallow per Appendix G?

— Yes →

No further infiltration investigation required to meet On-site, Flow Control, or Runoff Treatment requirements.

↓ No

Step 4
Determine design infiltration rate (Appendix G).

Is runoff from ≥ 5,000 sf impervious area to be infiltrated on the site?

— No →

Step 6
Evaluate and utilize infiltration BMPs as feasible.

Yes ↓

Step 5 – Conduct groundwater monitoring, receptor characterization, mounding and seepage analysis, and infiltration testing for permeable pavements and surfaces.
Step 6 – Evaluate use of infiltration to meet minimum requirements.

Step 5
Perform groundwater monitoring (Table 5.4 and Appendix G).

Is runoff from ≥ 10,000 sf. impervious area to be infiltrated on the project site?

— Yes →

Step 5
Perform characterization of infiltration receptor (for infiltration basins; Appendix G).

Is runoff from ≥ 1 ac. impervious area to be infiltrated on the project site?

— Yes →

Step 5
Conduct groundwater monitoring and seepage analysis (Appendix G).

↓ No (from 10,000 sf diamond)

↓ No (from 1 ac diamond)

Step 6
Evaluate and utilize infiltration BMPs as feasible.

Note: This flow chart does not include all Runoff Treatment BMP options. Review the text in Volume II, Section 5.3.4 for all options for each Runoff Treatment Performance Goal.
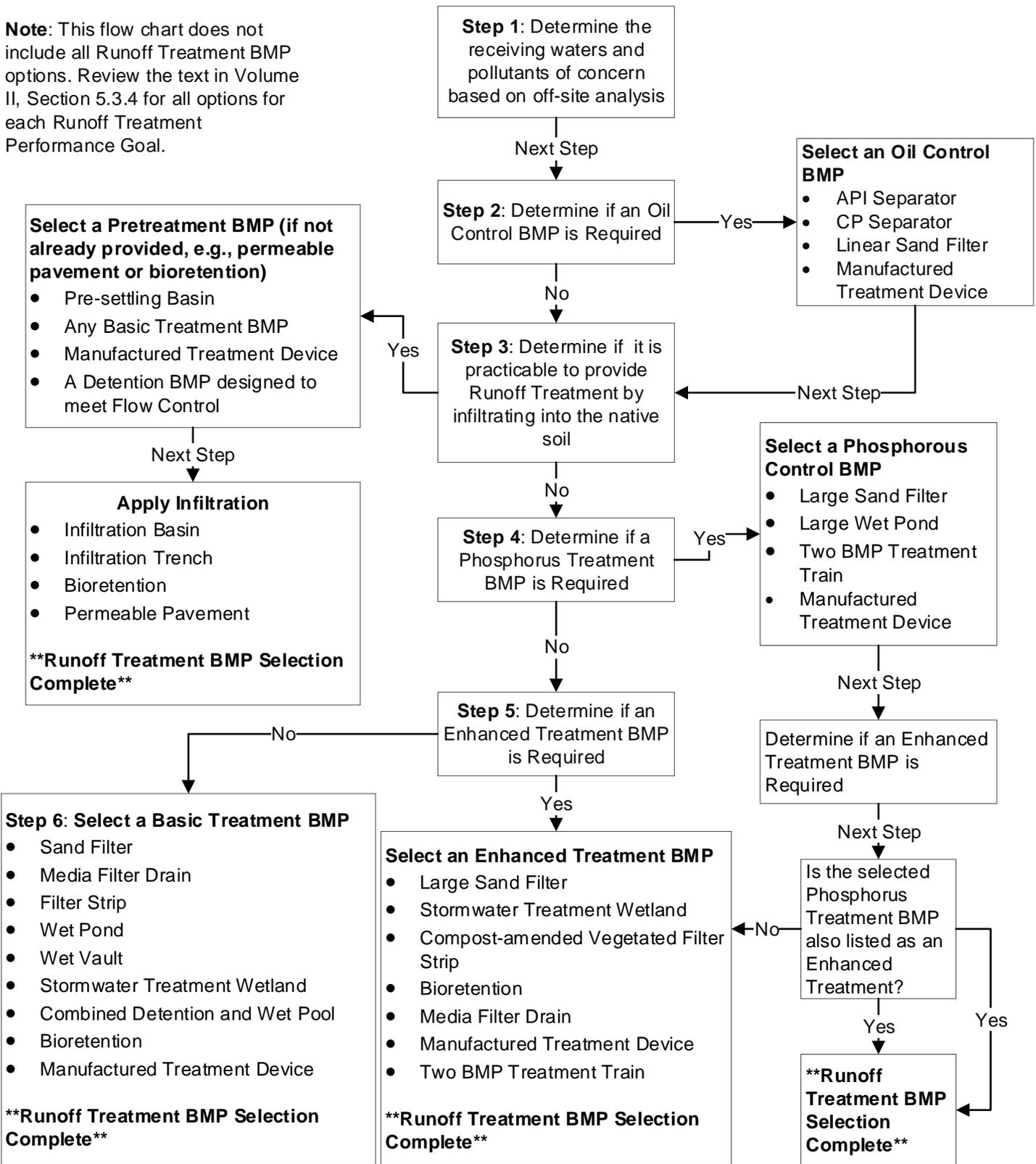
Step 1: Determine the receiving waters and pollutants of concern based on off-site analysis

↓ Next Step

Step 2: Determine if an Oil Control BMP is Required

→ Yes →

Select an Oil Control BMP
- API Separator
- CP Separator
- Linear Sand Filter
- Manufactured Treatment Device

No ↓

Step 3: Determine if it is practicable to provide Runoff Treatment by infiltrating into the native soil

← Next Step ←

← Yes

Select a Pretreatment BMP (if not already provided, e.g., permeable pavement or bioretention)
- Pre-settling Basin
- Any Basic Treatment BMP
- Manufactured Treatment Device
- A Detention BMP designed to meet Flow Control

↓ Next Step

Apply Infiltration
- Infiltration Basin
- Infiltration Trench
- Bioretention
- Permeable Pavement

Runoff Treatment BMP Selection Complete

No ↓

Step 4: Determine if a Phosphorus Treatment BMP is Required

→ Yes →

Select a Phosphorous Control BMP
- Large Sand Filter
- Large Wet Pond
- Two BMP Treatment Train
- Manufactured Treatment Device

↓ Next Step

Determine if an Enhanced Treatment BMP is Required

↓ Next Step

No ↓

Step 5: Determine if an Enhanced Treatment BMP is Required

←No←

Yes ↓

Is the selected Phosphorus Treatment BMP also listed as an Enhanced Treatment?

←No←

Yes ↓ | Yes →

Step 6: Select a Basic Treatment BMP
- Sand Filter
- Media Filter Drain
- Filter Strip
- Wet Pond
- Wet Vault
- Stormwater Treatment Wetland
- Combined Detention and Wet Pool
- Bioretention
- Manufactured Treatment Device

Runoff Treatment BMP Selection Complete

Select an Enhanced Treatment BMP
- Large Sand Filter
- Stormwater Treatment Wetland
- Compost-amended Vegetated Filter Strip
- Bioretention
- Media Filter Drain
- Manufactured Treatment Device
- Two BMP Treatment Train

Runoff Treatment BMP Selection Complete

Runoff Treatment BMP Selection Complete

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Figure 5.2
Runoff Treatment BMP
Selection Flow Chart

March 2020

Figure 8.2
Critical Drainage Areas
Commissioner District 2

June 2020

HOOD

Poulsbo

JEFFERSON

COUNTY

Keyport

Silverdale

Brownsville

Seabeck

Gilberton

HOOD CANAL

Chico

Tracyton

Illahe

Camp Union

Enetai

Holly

Bremerton

Manette

Retsil

Annapolis

MASON COUNTY

Port Orchard

Sunnyslope

MASON COUNTY

Glenwood

KITSAP COUNTY

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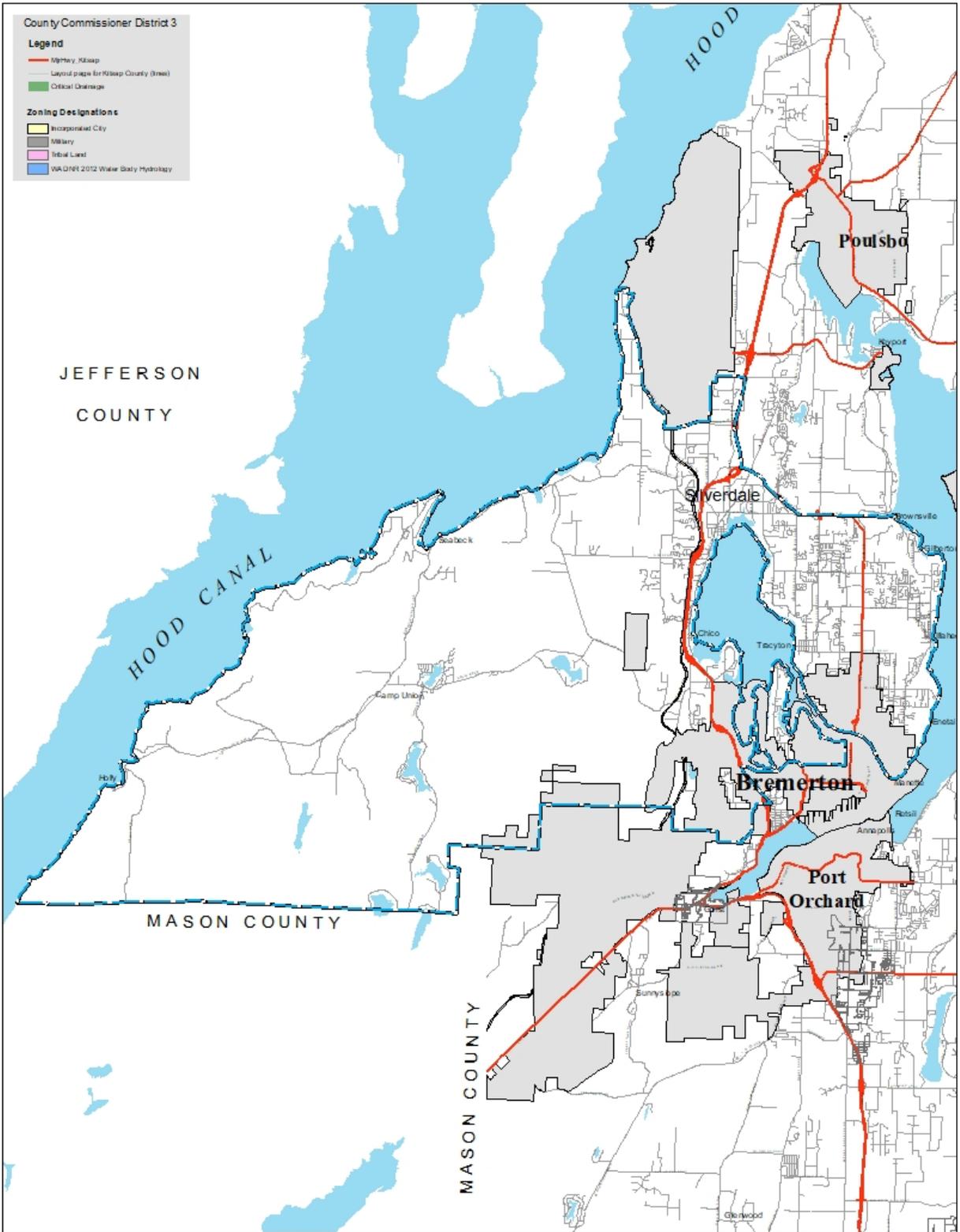
Figure 8.3
Critical Drainage Areas
Commissioner District 3

June 2020

Appendix A Figures

Example of a Project Site with a single natural discharge and a single TDA

Single TDA

Natural discharge location
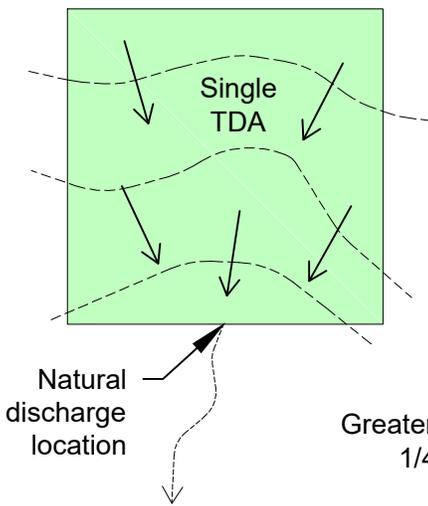
Example of a Project Site with multiple natural discharges and a single TDA

Single TDA

ridgeline

Naural discharge locations

Greater than 1/4 mile

1/4 mile
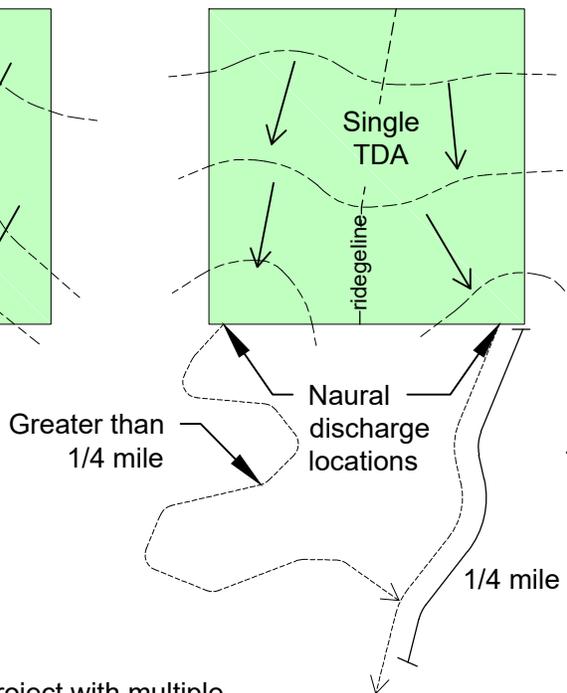
Example of a Project Site with multiple natural discharges and multiple TDAs

TDA 1   TDA 2

ridgeline

Natural discharge locations
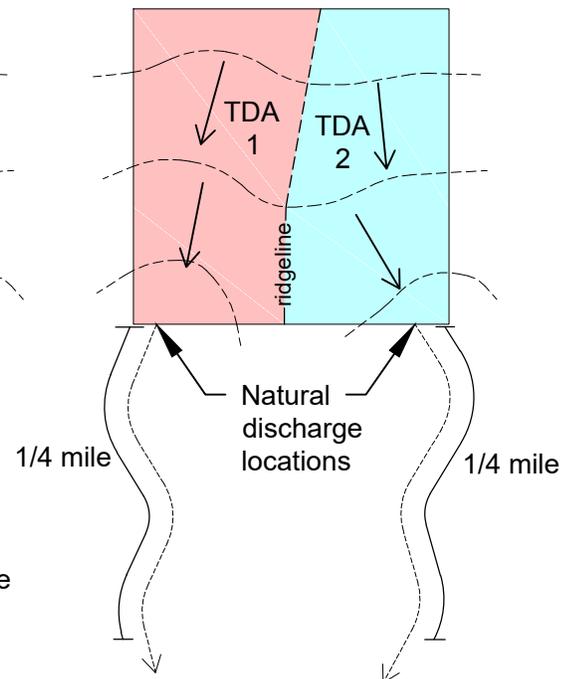
1/4 mile   1/4 mile

Example of a road project with multiple discharge points and a single TDA

culvert   high point-   high point-   roadway crown

Discharge location

1/4 mile
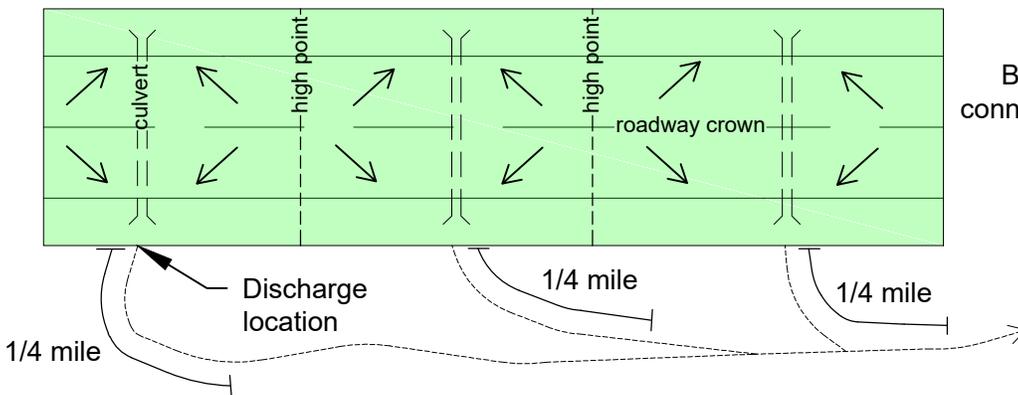
1/4 mile   1/4 mile

Because the right-most discharge connects to the other two discharge flow paths within 1/4 mile, all areas are connected as one TDA.

culvert   high point

Discharge location

1/4 mile

1/4 mile
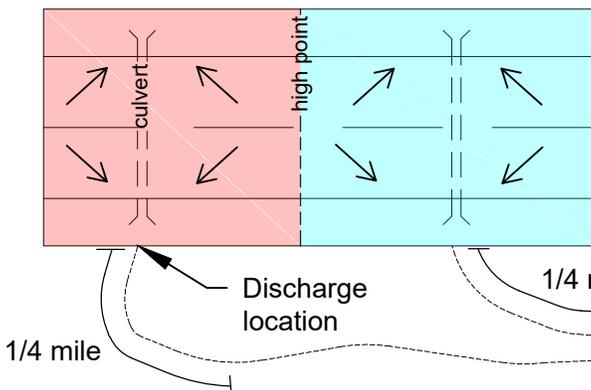
Example of a road project with multiple discharge points and multiple TDAs

Note: Shaded areas represent the limites of the project site.

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Figure A-1
Example TDA Delineations

March 2021

Appendix F Figures

Bremerton IDF Curves
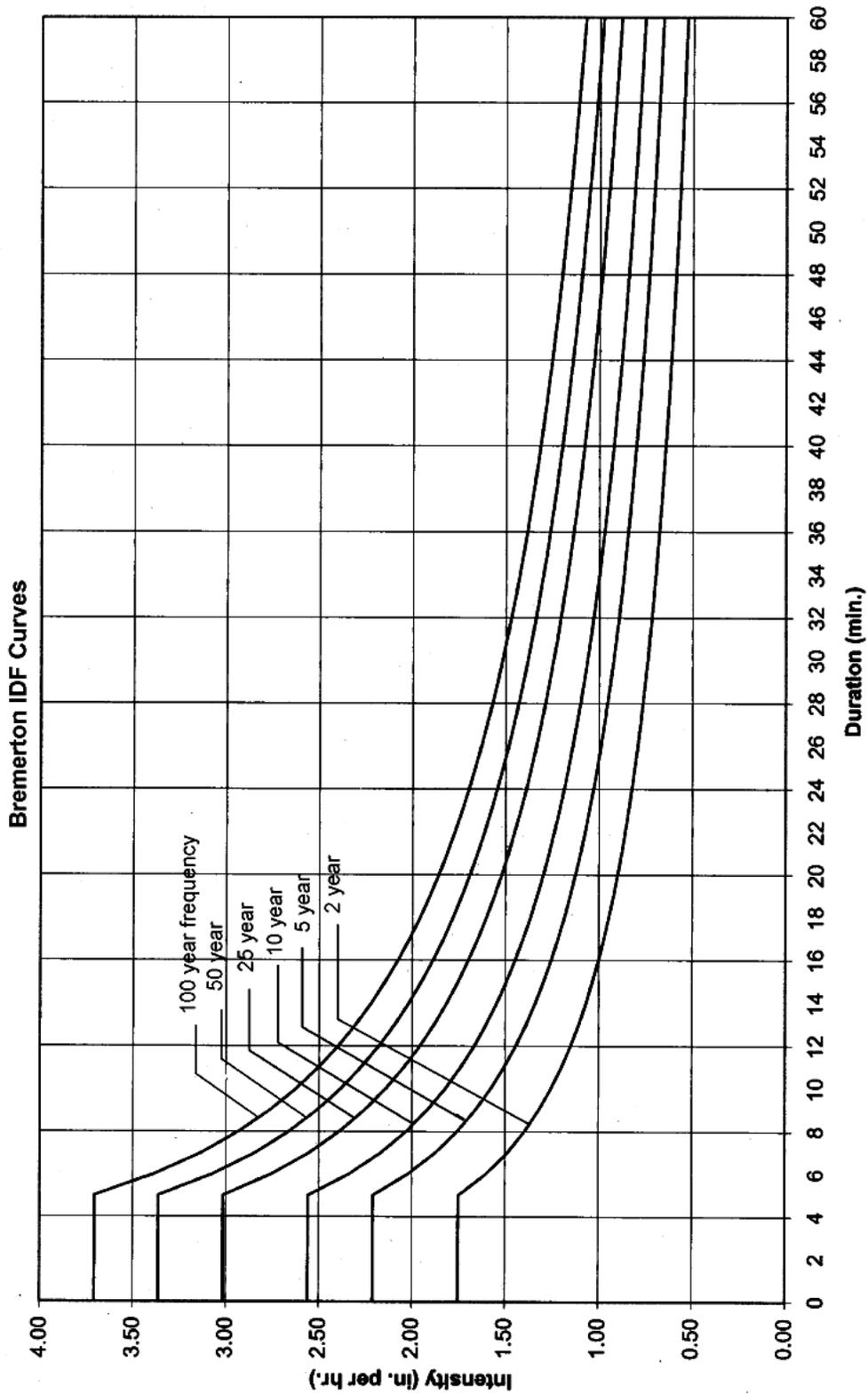
Figure F.1
Rainfall Intensity-Duration
Curves

DISCHARGE IN C.F.S.

1,000
900
800
700
600
500
400

300

200

100
90
80
70
60
50
40

30

20

10
9
8
7
6
5
4
3
2
1

DIAMETER OF PIPE IN INCHES

120
108
96
90
84
78
72
66
60
54
48
42
36
33
30
27
24
21
18
15
12
10
8
6

.0001
.0002
.0003
.0004
.0005
.0006
.0008
.001
.002
.003
.004
.005
.006
.008
.01
.02
.03
.04
.05
.06
.08
.10

SLOPE FOR n = 0.024

.0001
.0002
.0003
.0004
.0005
.0006
.0008
.001
.002
.003
.004
.005
.006
.008
.010
.020
.030
.040
.050
.060
.080
.100

SLOPE FOR n=0.012

VELOCITY IN FEET PER SECOND

2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
20.0
30.0
40.0

Minimum Allowable Velocity (Flowing Full)

SAMPLE USE

24" dia. CMP @ 2% slope yields 17cfs @ 5.4 fps velocity (n=0.024)

Values per Manning's equation

$$Q = \left(\frac{1.49}{n} \right) AR^{2/3} S_o^{1/2}$$

This table can be converted to other "n" values by applying formula:

$$\frac{Q1}{Q2} = \frac{n2}{n1}$$

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Figure F.2
Nomograph for Sizing Circular
Drains Flowing Full
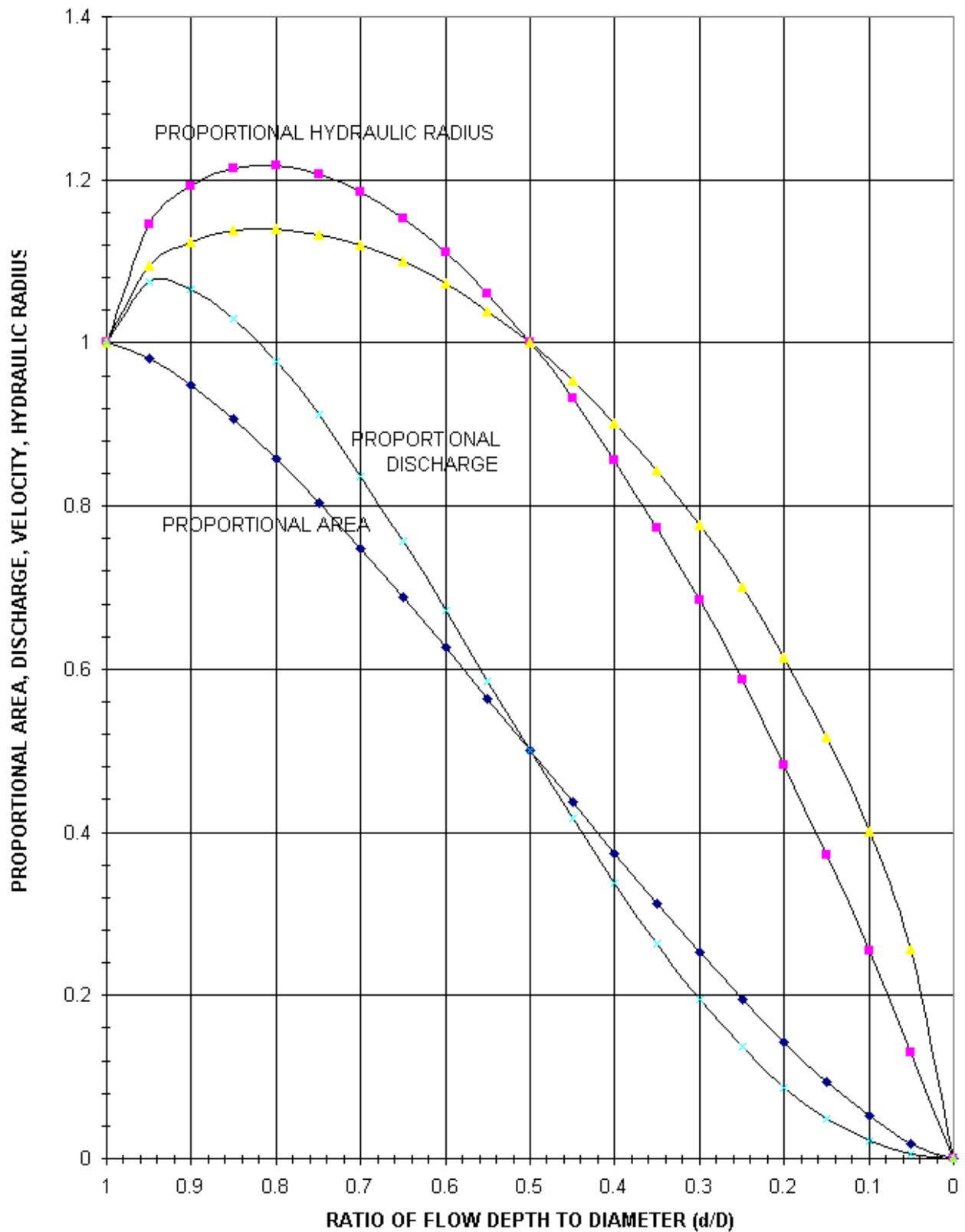
Figure F.3
Circular Channel Ratios

Pipe Segment CB to CB	(1) Q (cfs)	(2) Lngth (ft)	(3) Pipe Size	(4) OmO Value	(5) Outlet Elev (ft)	(6) Inlet Elev (ft)	(7) Barrel Area (sq. ft)	(8) Barrel Vel (fps)	(9) Barrel Vel Head (ft)	(10) TW Elev (ft)	(11) Friction Loss (ft)	(12) Entr HGL Elev (ft)	(13) Entr Head Loss (ft)	(14) Exit Head Loss (ft)	(15) Outlt Cntrl Elev (ft)	(16) Inlet Cntrl Elev (ft)	(17) Appr Vel Head (ft)	(18) Bend Head Loss (ft)	(19) Junc Head Loss (ft)	(20) HW Elev (ft)

Figure F.4
Backwater Calculation Sheet

Column (1) - Design flow to be conveyed by pipe segment.

Column (2) - Length of pipe segment.

Column (3) - Pipe Size; indicate pipe diameter or span x rise.

Column (4) - Manning's "n" value.

Column (5) - Outlet Elevation of pipe segment.

Column (6) - Inlet Elevation of pipe segment.

Column (7) - Barrel Area; this is the full cross-sectional area of the pipe.

Column (8) - Barrel Velocity; this is the full velocity in the pipe as determined by:

$$V = Q/A \quad \text{or} \quad \text{Col.(8)} = \text{Col.(1)} / \text{Col.(7)}$$

Column (9) - Barrel Velocity Head $= V^2/2g \quad$ or $\quad (\text{Col.(8)})^2/2g$

where $g = 32.2$ ft/sec^2 (acceleration due to gravity)

Column (10) - Tailwater (*TW*) Elevation; this is the water surface elevation at the outlet of the pipe segment. If the pipe's outlet is not submerged by the *TW* and the *TW* depth is less than $(D+d_c)/2$, set TW equal to $(D+d_c)/2$ to keep the analysis simple and still obtain reasonable results (D = pipe barrel height and d_c = critical depth, both in feet. See Figure F.14 for determination of d_c).

Column (11) - Friction Loss $= S_f$ x $L \quad$ [or $\quad S_f$ x Col.(2)]
where S_f is the friction slope or head loss per linear foot of pipe as determined by Manning's equation expressed in the form:

$$S_f = (nV)^2/2.22\ R^{1.33}$$

Column (12) - Hydraulic Grade Line (HGL) Elevation just inside the entrance of the pipe barrel; this is determined by adding the friction loss to the *TW* elevation:

$$\text{Col.(12)} = \text{Col.(11)} + \text{Col.(10)}$$

If this elevation falls below the pipe's inlet crown, it no longer represents the true HGL when computed in this manner. The true HGL will fall somewhere between the pipe's crown and either normal flow depth or critical flow depth, whichever is greater. To keep the analysis simple and still obtain reasonable results (i.e., erring on the conservative side), set the HGL elevation equal to the crown elevation.

Column (13) - Entrance Head Loss $= K_e$ x $V^2/2g \quad$ [or $\quad K_e$ x Col.(9)]
where K_e = Entrance Loss Coefficient (from Table F.4). This is the head lost due to flow contractions at the pipe entrance.

Column (14) - Exit Head Loss $= 1.0$ x $V^2/2g \quad$ or $\quad 1.0$ x Col.(9)

This is the velocity head lost or transferred downstream.

Column (15) - Outlet Control Elevation $= \text{Col.(12)} + \text{Col.(13)} + \text{Col.(14)}$

This is the maximum headwater elevation assuming the pipe's barrel and inlet/outlet characteristics are controlling capacity. It does not include structure losses or approach velocity considerations.

Column (16) - Inlet Control Elevation (see Appendix F for computation of inlet control on culverts); this is the maximum headwater elevation assuming the pipe's inlet is controlling capacity. It does not include structure losses or approach velocity considerations.

Column (17) - Approach Velocity Head; this is the amount of head/energy being supplied by the discharge from an upstream pipe or channel section, which serves to reduce the headwater elevation. If the discharge is from a pipe, the approach velocity head is equal to the barrel velocity head computed for the upstream pipe. If the upstream pipe outlet is significantly higher in elevation (as in a drop manhole) or lower in elevation such that its discharge energy would be dissipated, an approach velocity head of zero should be assumed.

Column (18) - Bend Head Loss $= K_b$ x $V^2/2g \quad$ [or $\quad K_b$ x Col.(17)]
where K_b = Bend Loss Coefficient (from Figure F.7). This is the loss of head/energy required to change direction of flow in an access structure.

Column (19) - Junction Head Loss. This is the loss in head/energy that results from the turbulence created when two or more streams are merged into one within the access structure. Figure F.8 may be used to determine this loss, or it may be computed using the following equations derived from Figure F.8:

Junction Head Loss $= K_j$ x $V^2/2g \quad$ [or $\quad K_j$ x Col.(17)]

where K_j is the Junction Loss Coefficient determined by:

$$K_j = (Q_3/Q_1)/(1.18 + 0.63(Q_3/Q_1))$$

Column (20) - Headwater (HW) Elevation; this is determined by combining the energy heads in Columns 17, 18, and 19 with the highest control elevation in either Column 15 or 16, as follows:

$$\text{Col.(20)} = \text{Col.(15 or 16)} - \text{Col.(17)} + \text{Col.(18)} + \text{Col.(19)}$$

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Figure F.5
Backwater Calculation Sheet Notes

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Figure F.6
Backwater Pipe Calculation Example

Diagram labels:

- WS=105.84
- PROJ. INLET
- IE=104.0
- 90ɸ~18ɸ CMP @ 2.78%
- HGL
- Q=6 cfs
- 90° BEND
- CB#2 WS=103.90
- IE=101.5
- 110ɸ~18ɸ CP @ 0.91%
- HGL
- Q=8 cfs
- IE=100.5
- FLOW JUNCTION — Q₁=6 cfs, Q₃=4 cfs
- CB#1 WS=103.26
- 80ɸ~18ɸ CP @ 0.63%
- HGL Q=10 cfs
- IE=100.0
- TW=102.0
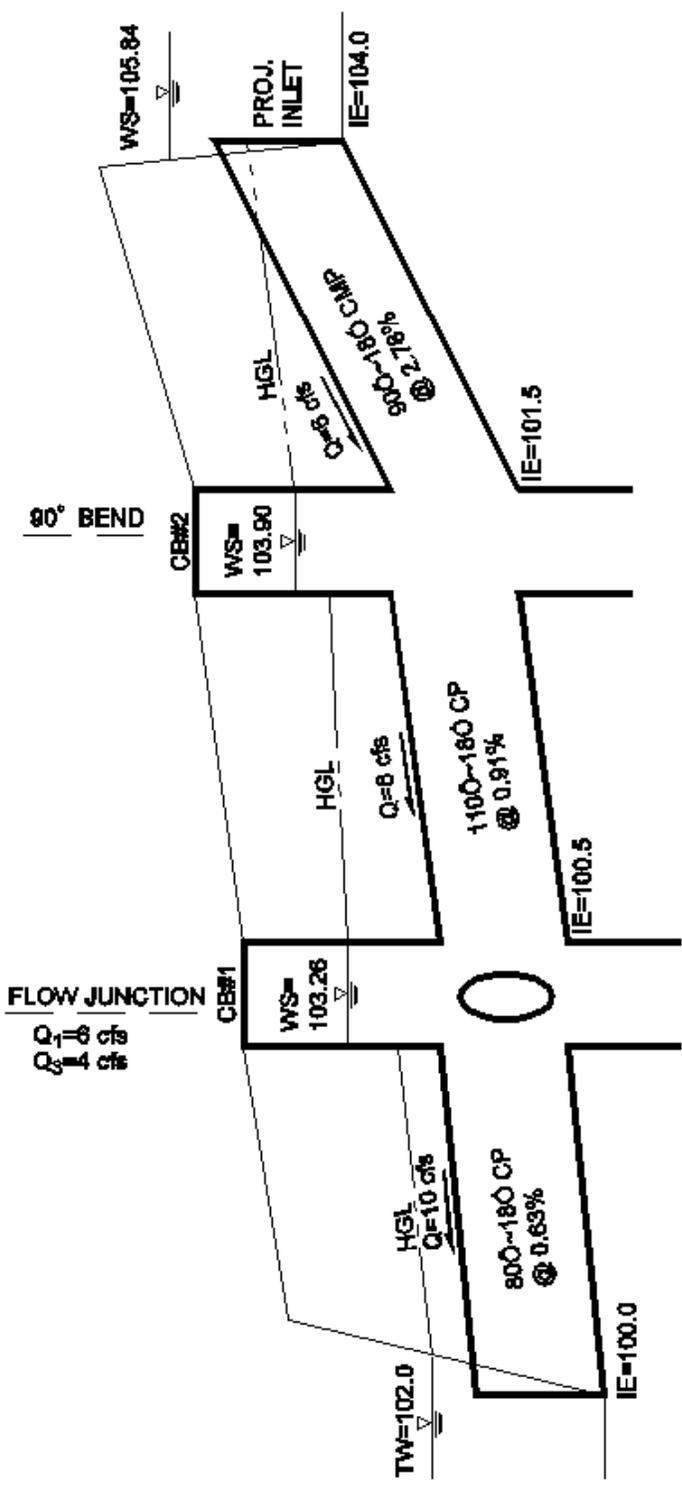
BACKWATER CALCULATION SHEET

Pipe Segment CB to CB	(1) Q (cfs)	(2) Length (ft)	(3) Pipe Size	(4) OnO Value	(5) Outlet Elev (ft)	(6) Inlet Elev (ft)	(7) Barrel Area (sqft)	(8) Barrel Vel (fps)	(9) Barrel Vel Head (ft)	(10) TW Elev (ft)	(11) Friction Loss (ft)	(12) Entr HGL Elev (ft)	(13) Entr Head Loss (ft)	(14) Exit Head Loss (ft)	(15) Outlt Contr Elev (ft)	(16) Inlet Contr Elev (ft)	(17) Appr Vel Head (ft)	(18) Bend Head Loss (ft)	(19) Junc Head Loss (ft)	(20) HW Elev (ft)
Out fall	10	80	18ɸ	0.012	100.00	100.50	1.77	5.65	0.50	102.00	0.62	102.62	0.25	0.50	103.37	102.75	-0.18	0.002	0.07	103.26
1	6	110	18ɸ	0.012	100.50	101.50	1.77	3.39	0.18	103.26	0.31	103.57	0.09	0.18	103.84	102.95	-0.18	0.24	0.0	103.90
2 / Inlet	6	90	18ɸ	0.024	101.50	104.00	1.77	3.39	0.18	103.90	1.00	(104.9) 105.5	0.18	0.18	105.84	105.60	-0.0	0.0	0.0	105.84

Select the greater elevation (columns 15 & 16 → column 20)

Figure F.7
Bend Head Losses in Structure
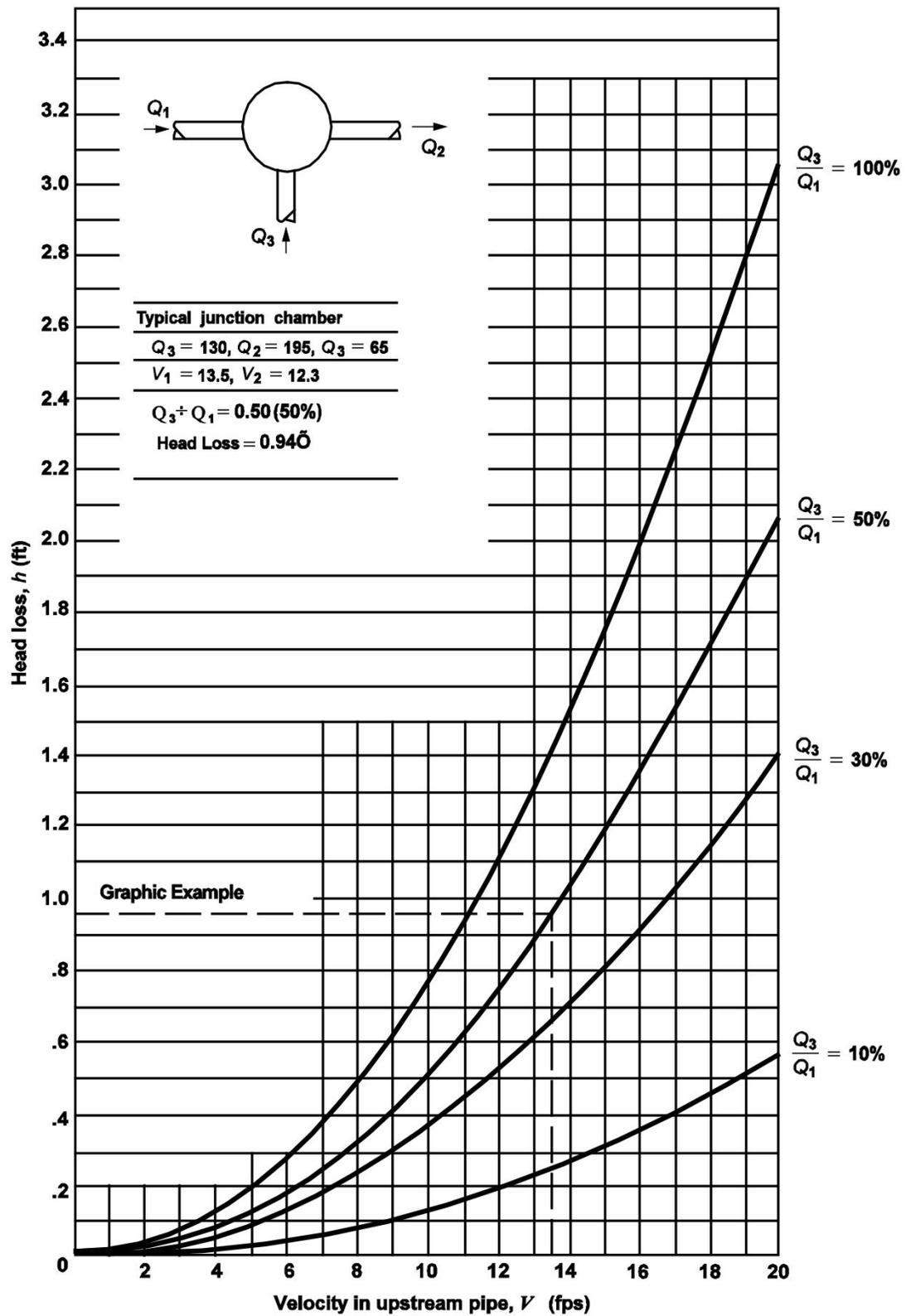
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Figure F.8
Junction Head Loss in Structure

Chart details:
- Y-axis: Head loss, h (ft), ranging from 0 to 3.4
- X-axis: Velocity in upstream pipe, V (fps), ranging from 0 to 20

Curves labeled:
- $\dfrac{Q_3}{Q_1} = 100\%$
- $\dfrac{Q_3}{Q_1} = 50\%$
- $\dfrac{Q_3}{Q_1} = 30\%$
- $\dfrac{Q_3}{Q_1} = 10\%$

Inset text:
Typical junction chamber
$Q_3 = 130$, $Q_2 = 195$, $Q_3 = 65$
$V_1 = 13.5$, $V_2 = 12.3$
$Q_3 \div Q_1 = 0.50 \,(50\%)$
Head Loss = 0.94Õ

Graphic Example
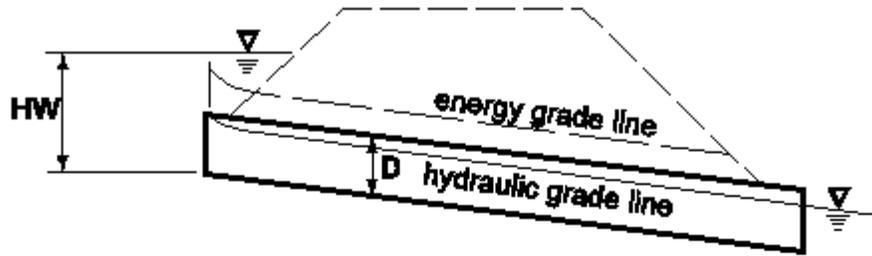
Inlet Control - Submerged Inlet
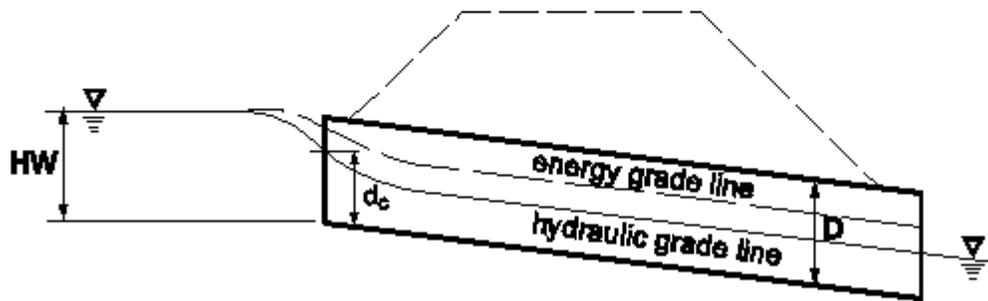
Inlet Control - Unsubmerged Inlet
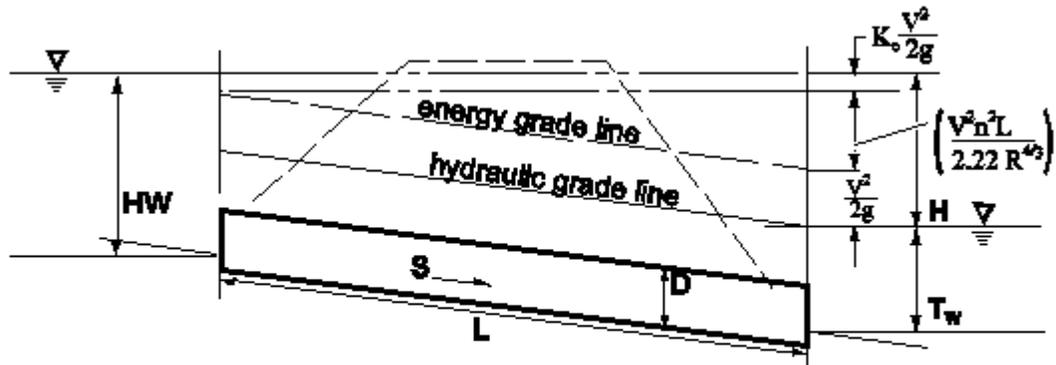
Outlet Control - Submerged Inlet and Outlet

NOTE: See FHWA no. 5 for other possible conditions

Figure F.9
Inlet/Outlet Control Conditions
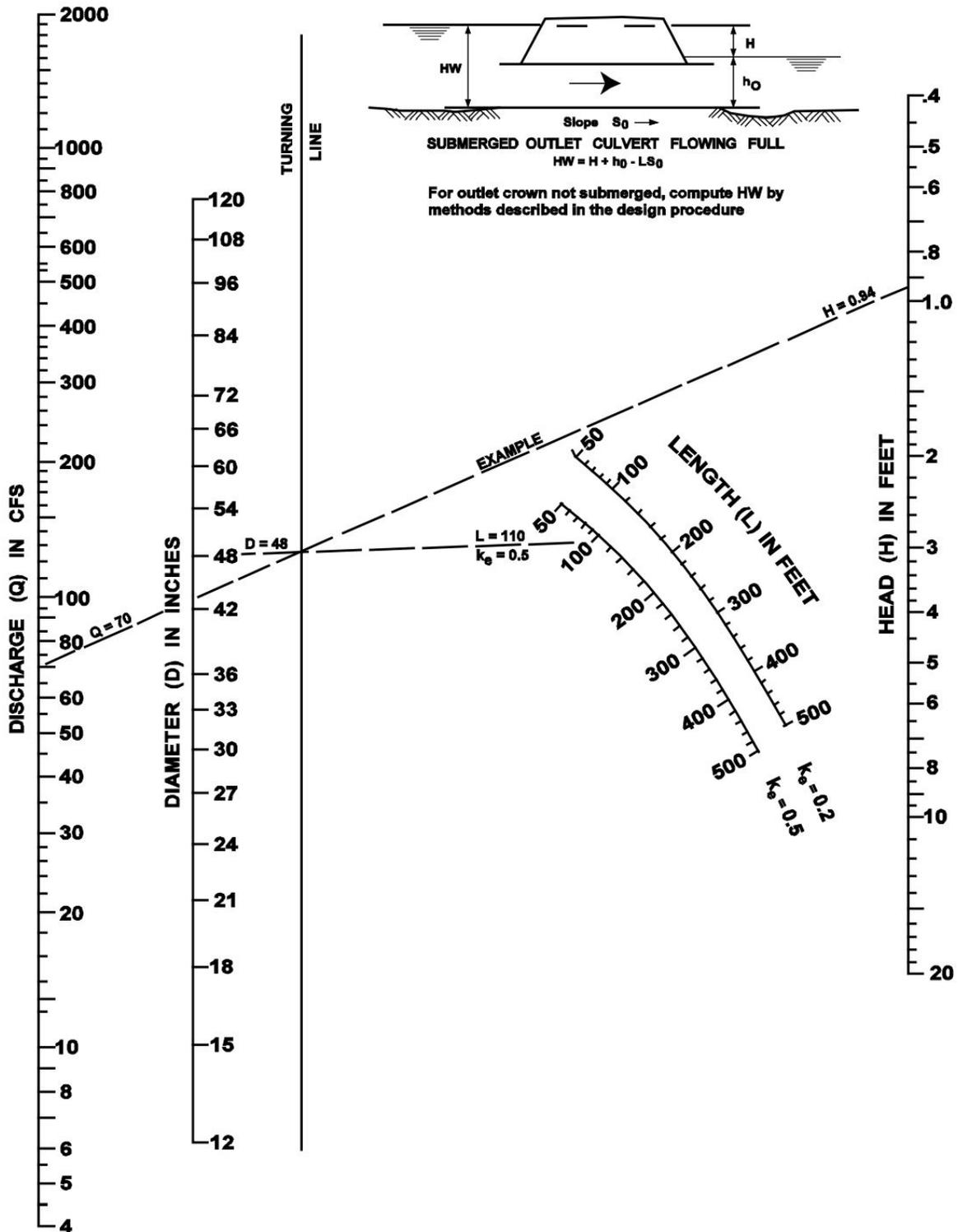
Figure F.10
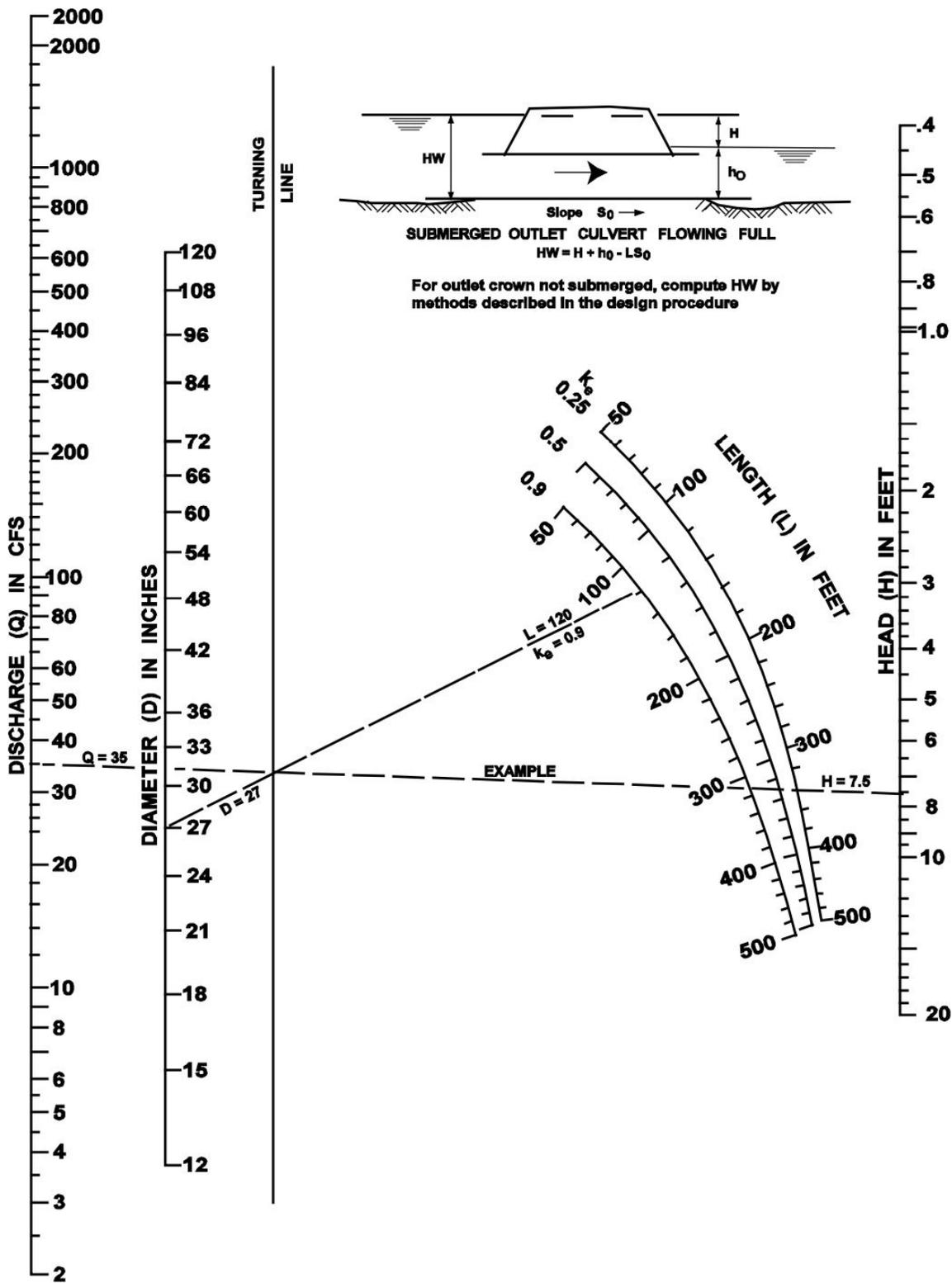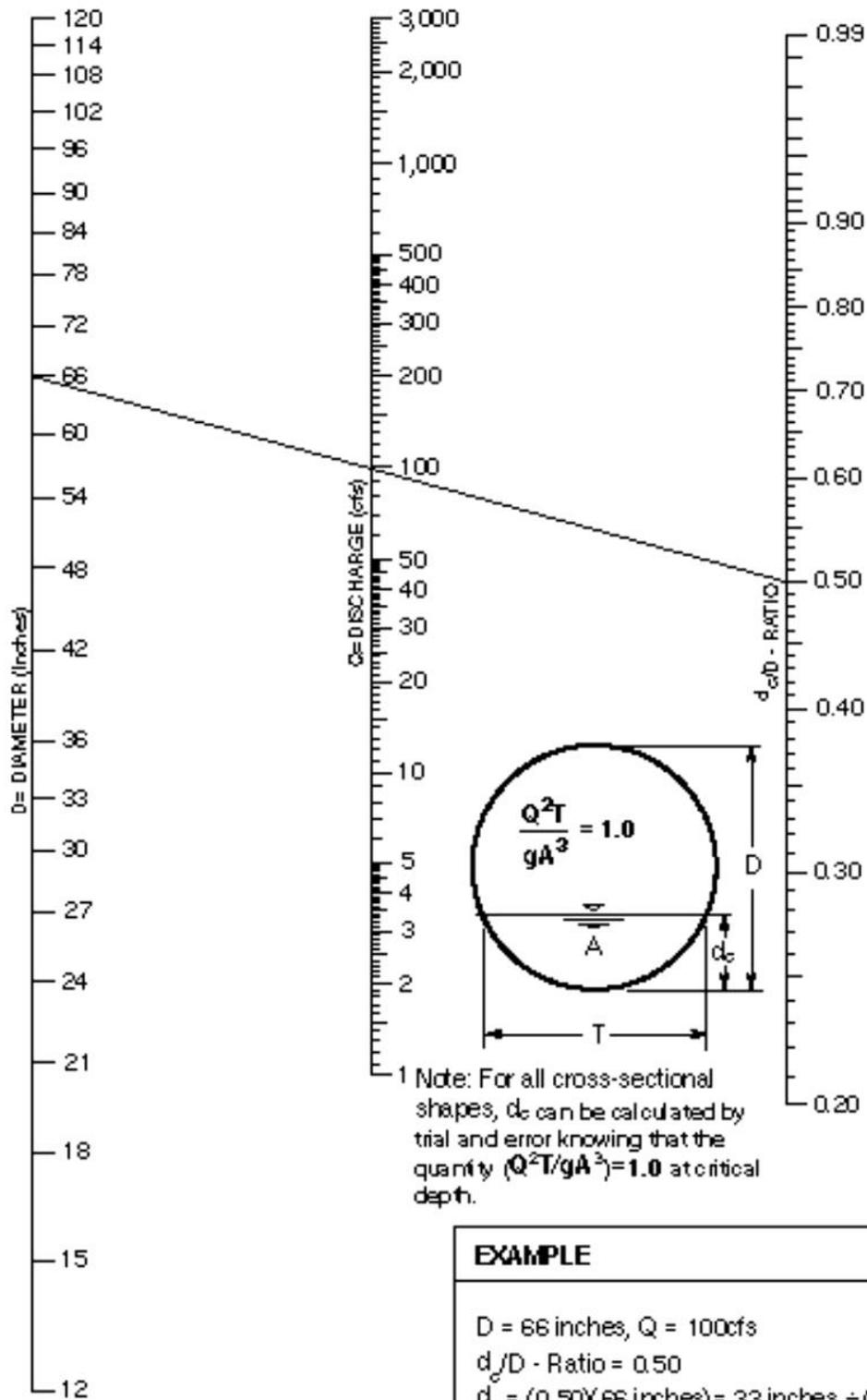Head for Culverts (Pipe with n=0.012) Flowing Full with Outlet Control

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Figure F.11
Head for Culverts (Pipe with n=0.024) Flowing Full with Outlet Control

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D = DIAMETER (inches)

120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
33
30
27
24
21
18
15
12

Q = DISCHARGE (cfs)

3,000
2,000
1,000
500
400
300
200
100
50
40
30
20
10
5
4
3
2
1

d_c/D - RATIO

0.99
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20

$$\frac{Q^2T}{gA^3} = 1.0$$

Note: For all cross-sectional shapes, d_c can be calculated by trial and error knowing that the quantity $(Q^2T/gA^3) = 1.0$ at critical depth.

EXAMPLE

D = 66 inches, Q = 100cfs

d_c/D - Ratio = 0.50

d_c = (0.50)(66 inches) = 33 inches ÷ (12 inches/ft)

d_c = 2.75 feet

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Figure F.12
Critical Depth of Flow for Circular Culverts

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$Q =$ _____ $n =$ _____ $S_o =$ _____ $\alpha =$ _____ $Y_n =$ _____

y	A	R	$R^{4/3}$	V	$\alpha V^2/2g$	E	ΔE	S_f	$\overline{S_f}$	$\overline{S_o} - S_f$	Δx	x
-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13

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Figure F.13
Open Channel Flow
Profile Computation

y	A	R	$R^{4/3}$	V	$\alpha V^2/2g$	E	ΔE	S_f	$\overline{S_f}$	$S_o - S_f$	Δx	x
-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13
6	72	2.68	3.72	0.42	0.0031	6.0031	-	0.00002	-	-	-	-
5.5	60.5	2.46	3.31	0.5	0.004	5.504	0.499	0.00003	0.000025	0.00698	71.5	71.5
5	50	2.24	2.92	0.6	0.0064	5.0064	0.4976	0.00005	0.00004	0.00696	71.49	142.99
4.5	40.5	2.01	2.54	0.74	0.0098	4.5098	0.4966	0.00009	0.00007	0.00693	71.64	214.63
4	32	1.79	2.17	0.94	0.0157	4.0157	0.4941	0.00016	0.000127	0.00687	71.89	286.52
3.5	24.5	1.57	1.82	1.22	0.0268	3.5268	0.4889	0.00033	0.000246	0.00675	72.38	358.9
3	18	1.34	1.48	1.67	0.0496	3.0496	0.4772	0.00076	0.000547	0.00645	73.95	432.85
2.5	12.5	1.12	1.16	2.4	0.1029	2.6029	0.4467	0.00201	0.001387	0.00561	79.58	512.43
2	8	0.89	0.86	3.75	0.2511	2.2511	0.3518	0.00663	0.00432	0.00268	131.27	643.7

The step computations are carried out as shown in the above table. The values in each column of the table are explained as follows:

Col. 1. Depth of flow (ft) assigned from 6 to 2 feet

Col. 2. Water area (ft^2) corresponding to depth y in Col. 1

Col. 3 Hydraulic radius (ft) corresponding to y in Col. 1

Col. 4. Four-thirds power of the hydraulic radius

Col. 5. Mean velocity (fps) obtained by dividing Q (30 cfs) by the water area in Col. 2

Col. 6. Velocity head (ft)

Col. 7. Specific energy (ft) obtained by adding the velocity head in Col. 6 to depth of flow in Col. 1

Col. 8. Change of specific energy (ft) equal to the difference between the E value in Col. 7 and that of the previous step.

Col. 9. Friction slope S_f, computed from V as given in Col. 5 and $R^{4/3}$ in Col. 4

Col. 10. Average friction slope between the steps, equal to the arithmetic mean of the friction slope just computed in Col. 9 and that of the previous step

Col. 11. Difference between the bottom slope, S_o, and the average friction slope, S_f

Col. 12. Length of the reach (ft) between the consecutive steps;
Computed by $x = E/(S_o - S_f)$ or by dividing the value in Col. 8 by the value in Col. 11

Col. 13. Distance from the beginning point to the section under consideration. This is equal to the cumulative sum of the values in Col. 12 computed for previous steps.

Figure F.14
Open Channel Flow
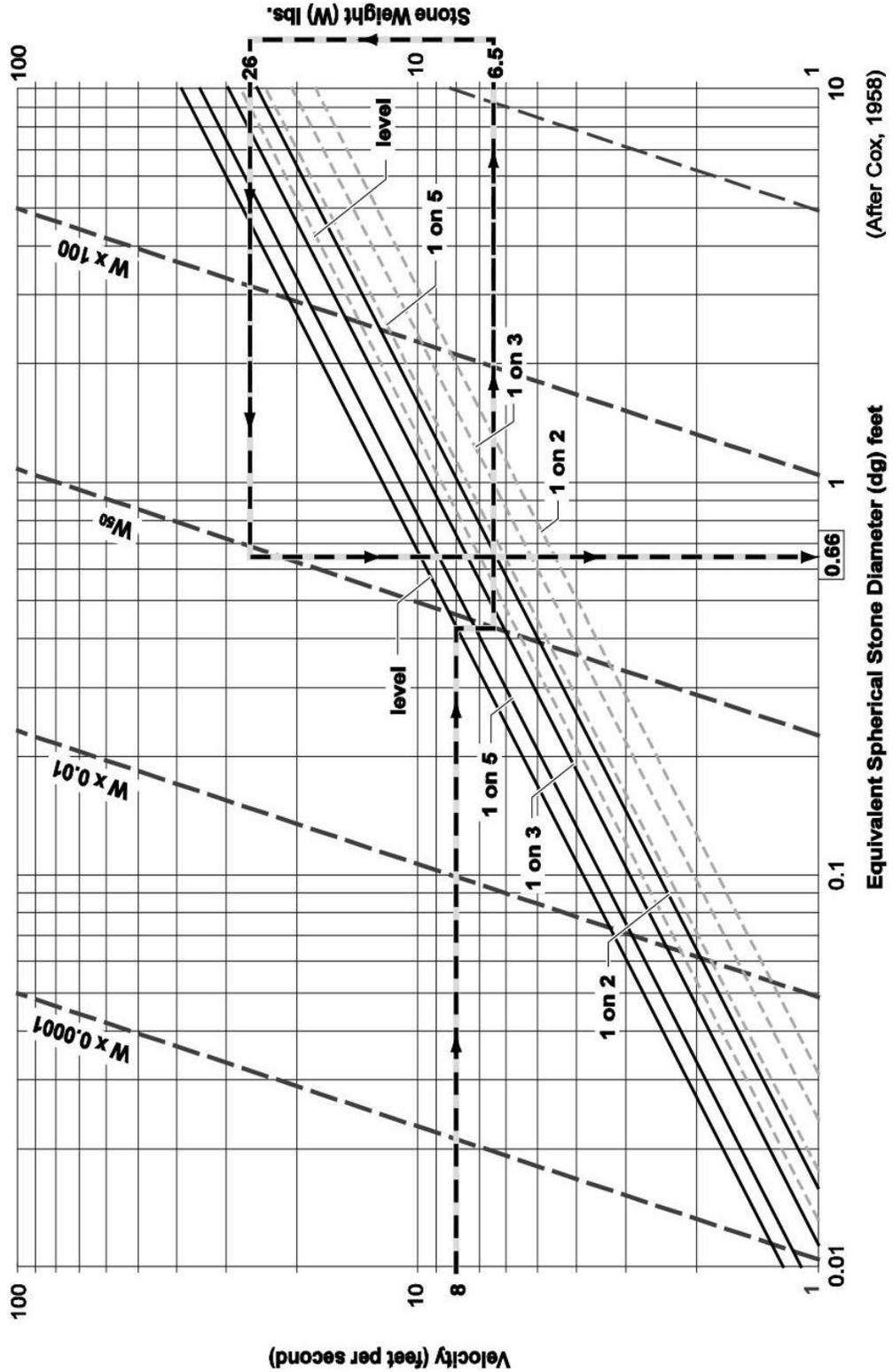Profile Computation
(Example)

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Figure F.15
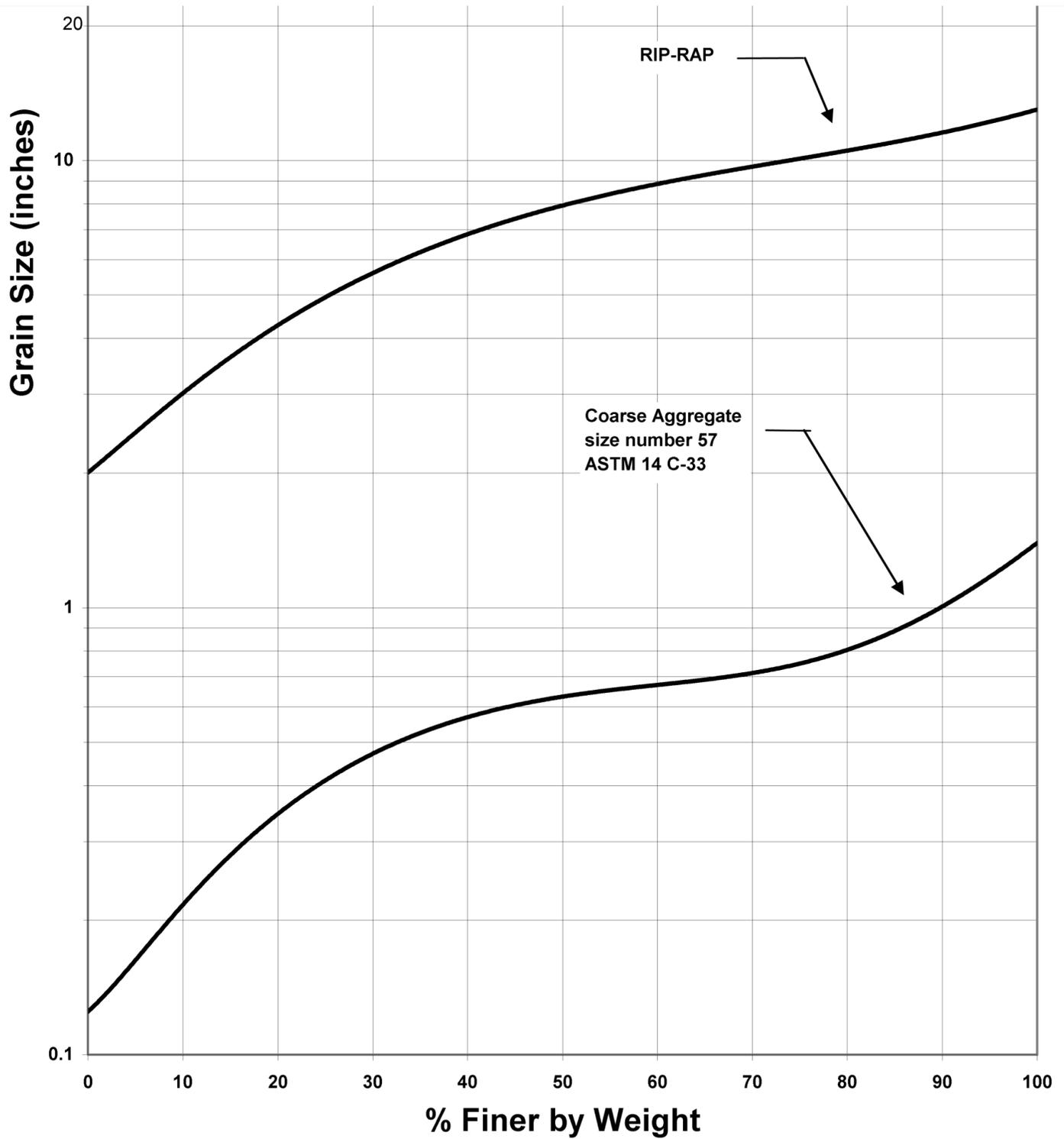Mean Channel Velocity vs
Medium Stone Weight and
Equivalent Stone Diameter

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Figure F.16
Riprap/Filter Example Gradation Curve

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