

CLARKSBURG TOWN CENTER
PHASE 1A
Computations for Water Quality Control
Facilities
Sand filter #1 ,Recharge facility #6 &
Bioretention Facility #2

Project Number: 29-100

Revised by: RH
June, 2003

Prepared by : RH
April, 2003

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Project Summery

The proposed project area under this plan is located in part of Block EE, Block FF and block GG. The purpose of this project is to develop the lots and private roads in block EE and block FF. install utilities (water and Sewer lines) and to provide the water quality control facilities to the entire area.

Under this plan Sand Filter #1, Recharge Facility #6, Bioretention Facility #2 and Bioretention Facility #3 will be installed.

The Splitter Structure # 57 has been designed to divert first ½ inch storm run off per impervious area to the Sand Filter #1. A 12-inch non-perforated PVC Sch 40 pipe has been provided to convey the filtered water from Sand Filter #1 to the top surface of the Recharge Facility #6.

A standard inlet structure will be installed in each Bioretention Facility and 12" RCP will be installed to convey the 10-yr storm overflow water and filtered water to the Structure # 179.

A standard WR inlet 'A' will be installed on the drive way and a 12" RCP will be installed to convey first flush water from the WR inlet to Bioretention #2.

Bioretention Facility # 2 has been designed for the total drainage area of 0.99 Ac and Bioretention Facility # 2 has been designed for the total drainage area of 0.23 Ac.

Clarksburg Town Center

Drainage Area st STR # 151:

Total Drainage Area to Str # 151 = 10.18 Ac
 $A \cdot R = 6.31$
 $R = 0.62$

Value of R for imp area = 0.90
 value of R for lawns = 0.25

propotion of imp land 0.57
 total imp area 5.79 Ac
 total grass area 4.39 Ac
 total area 10.18 Ac

Sand Filter #1

Imp Area = 5.79 Ac
 Total DA = 10.18 Ac

Required Water Quality storage Volume:

$WQv = Q_i \cdot A_{imp}$
 $Q_i = \text{first flush run off} = 0.50 \text{ in}$
 $A_{imp} = \text{imp area sf} = 5.79 \text{ Ac}$

$WQv = (0.5/12) \cdot 5.79 \cdot 43560$

$WQv = 10513.04 \text{ cf} = \text{Required Volume}$
 Provided storage volume = 12696.75 cf at WSEL = 631.0 ft

Required filter bed Surface Area:

filter bed area required = 0.1% of WQv sf

filter bed area required = 1051 sf
 Provided Filter bed Area = 1080 sf

Underdrain Pipe:

Provided surface area = 1080 sf
 required length of pipe = 0.05 times filter bed area
 required length of pipe = 54 LF
 provided length of pipe = 57 LF

JOB: clarksburg town center - sand filter#1
 COMPUTED BY RH

DATE 02 03 03

STAGE - STORAGE TABULATION

STUDY POINT sand filter #1

WSEL FT	AREA sf	AVG AREA sf	DELTA H FT	DELTA VOL CF	TOTAL VOL CF	TOTAL VOL Ac.FT	remarks
627.00	1620.00						bottom EL
		1962.00	1.00	1962.00			
628.00	2304.00				1962.00	0.0450	
		3141.00	2.00	6282.00			
630.00	3978.00				8244.00	0.1893	
		4452.75	1.00	4452.75			
631.00	4927.50				12696.75	0.2915	
		5402.25	1.00	5402.25			
632.00	5877.00				18099.00	0.4155	top of emb EL

Recharge Facility # 6

Total Impervious Area = 5.79 Ac
Total Area = 10.18 Ac

Recharge volume required :

$Re_v = \frac{(s)(R_v)(A)}{12}$ --percent volume method
Rv = $0.05 + 0.009(I)$ where I = % impervious cover = 56.90
0.56
A = total area Ac 10.18 Ac

s = 0.26 for 'B' soil

$Re_v = \frac{(s)(R_v)(A)}{12}$
Rv = 0.12 Ac.ft
Re_v = 5400.50 cf

Water quality storage requirement:

WQv = $Q_i \cdot A_{imp}$
 Q_i = first flush run off = 0.50 in from page 8-21 Montgomery county-
 A_{imp} = imp area sf = 5.79 Ac -SWM design manual

WQv = $(0.5/12) \cdot 5.79 \cdot 43560$

WQv = 10513.04 cf

Assumed void ratio = 0.40

Storage required = $10513.04 / 0.4$ cf

Storage required = 26282.60 cf

recharge facility#6:

recharge area of provided = 7047.00 sf

thickness provided 4.00 ft

storage provided = 7047×4 cf

storage provided = 28188.00 cf

Recharge facility provided under the Sand filter #1:

provided area = 1620.00 sf

provided thickness = 3.00 ft

storage provided = 1620×3 cf

storage provided = 4860.00 cf

total storage provided = 33048.00 cf

Provided media: ASTM D448 Stone size#1 Dmax = 3"

Splitter structure Design: (Str#151)

flow rate required for sand filter = (Impervious DA in Sq.Miles)*Run off* 1010 cfs From montgomery County
SWM design manual pg8-21
= (5.79 /640)*(0.5)*1010
4.57 cfs

15" PVC from Str #151
to Sand Filter

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE
June 29, 2003

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet).....	1.25
FWHA Chart Number (1,2 or 3).....	1
Scale Number on Chart (Type of Culvert Entrance).....	1
Manning's Roughness Coefficient (n-value).....	0.0130
Entrance Loss Coefficient of Culvert Opening.....	1.00
Culvert Length (feet).....	53.0
Culvert Slope (feet per foot).....	0.0123

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater Inlet Control (ft)	Normal Outlet Control Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.6	1.25	1.40	1.29	0.73	0.87	0.73

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name:

Comment:

Solve For Full flow Slope

Given Input Data:

Diameter.....	1.25 ft
Manning's n.....	0.013
Discharge.....	4.60 cfs

Computed Results:

Full Flow Channel Slope	0.0051 ft/ft
Full Flow Depth.....	1.25 ft
Velocity.....	3.75 fps
Flow Area.....	1.23 sf
Critical Depth....	0.87 ft
Critical Slope....	0.0074 ft/ft
Percent Full.....	100.00 %
Full Capacity.....	4.60 cfs
QMAX @.94D.....	4.95 cfs
Froude Number.....	FULL

Clarksburg Town Center**Bioretention facility # 2****BIORETENTION FILTER BED AREA:****DRAINAGE AREA for Bioretention facility #2**

Development	Area ac	run off	coef'C'	A*C
impervious	0.47	0.90		0.42
grass	0.51	0.25		0.13
total	0.99	0.56		0.55

Required Surface Area=5% of Drainage area multiplied by "C"

Required Surface Area= 0.05*A*C Ac

Required Surface Area= 1204.11 sf

Surface area provided = 1503.00 sf

from Montgomery county SWM design -
manual pg 8-55

Required storage size for bioretention facility:

Required Bioretention Volume: 1" of run off per impervious area

= (1/12)x0.47x43560 cf

= 1711.50 cf

Bioretention facility must be size to store water quality volume

Water quality volume= WQv= $\frac{(1.0)(R_v)(A)}{12.00}$

eastern rainfall zone

P=1 in of rainfall

WQv= water quality volume Ac-ft

Rv= Volumetric runoff coefficient=0.005+0.009(I)

I=percent impervious cover= 47.84

Rv= 0.48

A= area Ac = 0.99 Ac

WQv= $\frac{(1.0)(R_v)(A)}{12.00}$

WQv= 1719.23 cf

Required water Quality Volume= 1719.23 cf

STORAGE PROVIDED= 1991.25 ft at EL=657.00 ft

Underdrain Pipe:

Provided surface area = 1503 sf

required length of pipe = 0.05 times filter bed area

required length of pipe = 75 LF

provided length of pipe= 75 LF

Check for over flow (10-YR peak flow)

TYPE OF WIER:

Amercast VB-EI INLLET WITH 3 SLOTS

SLOT ELEVATION 657.00 FT

$$Q = C * L * H^{1.5}$$

C 3.10

L 7.50 ft

10-YR FLOW= 4.00 CFS **FROM TR55**

$$4.00 = 3.10 * 7.50 * (H^{1.5})$$

$$H = 0.31 \text{ FT}$$

$$10\text{yr WSEL} = 657.0 + 0.31 = 657.31 \text{ ft}$$

JOB: clarksburg town center - bioretention facility # 2
COMPUTED BY RH DATE 04--29--04

STAGE - STORAGE TABULATION

STUDY POINT bioretention facility#2

WSEL FT	AREA sf	AVG AREA sf	DELTA H FT	DELTA VOL CF	TOTAL VOL CF	TOTAL VOL Ac.FT	remarks
656.00	1503.00						bottom EL
		1991.25	1.00	1991.25			
657.00	2479.50				1991.25	0.0457	
		2967.75	1.00	2967.75			
658.00	3456.00				4959.00	0.1138	TOP OF EMB

RUNOFF CURVE NUMBER COMPUTATION

Version 2.00

Project : clrkdburg town center User: rh Date:
 County : montgomery State: md Checked: Date:
 Subtitle: study point at bioretention facility 2

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Acres (CN)			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Residential districts	Avg % imperv			
(by average lot size)				
1/8 acre (town houses)	65	- 0.61(85)	-	-
1/4 acre	38	- 0.38(75)	-	-
Total Area (by Hydrologic Soil Group)	.99			
	====			

TOTAL DRAINAGE AREA: .99 Acres WEIGHTED CURVE NUMBER: 81*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME

Version 2.00

Project : clrkdburg town center

User: rh

Date:

County : montgomery

State: md

Checked: _____

Date: _____

Subtitle: study point at bioretention facility 2

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	86	0.021	f					0.207
Shallow Concent'd		130	0.092	u					0.007

Time of Concentration = 0.21*

=====

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Fallow (No Res.)	G Grass, Bermuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short	J Range, Natural	

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD

Version 2.00

Project : clrkdburg town center User: rh Date: _____
 County : montgomery State: md Checked: _____ Date: _____
 Subtitle: study point at bioretention facility 2

Data: Drainage Area : .99 * Acres
 Runoff Curve Number : 81 *
 Time of Concentration: 0.21 * Hours
 Rainfall Type : II
 Pond and Swamp Area : NONE

=====	
Storm Number	1

Frequency (yrs)	10
24-Hr Rainfall (in)	5.1
Ia/P Ratio	0.09
Used	0.10
Runoff (in)	3.07
Unit Peak Discharge (cfs/acre/in)	1.226
Pond and Swamp Factor	1.00
0.0% Ponds Used	

Peak Discharge (cfs)	4
=====	

* - Value(s) provided from TR-55 system routines

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE
June 16, 2003

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet).....	1.00
FHWA Chart Number (1,2 or 3).....	2
Scale Number on Chart (Type of Culvert Entrance).....	1
Manning's Roughness Coefficient (n-value).....	0.0130
Entrance Loss Coefficient of Culvert Opening.....	1.00
Culvert Length (feet).....	53.0
Culvert Slope (feet per foot).....	0.0160

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater Inlet Control Depth (ft)	Normal Outlet Control Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.0	1.00	1.67	1.62	0.73	0.85	0.73

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Clarksburg Town Center

Bioretention facility #3

BIORETENTION FILTER BED AREA

DRAINAGE AREA for Bioretention facility #2

Development	Area ac	run off	coef"C'	A*C
impervious	0.04	0.90		0.04
grass	0.19	0.25		0.05
total	0.23	0.37		0.09

Required Surface Area=5% of Drainage area multiplied by "C"

from Montgomery county SWM design -
manual pg 8-55

Required Surface Area=	$0.05 \times A \times C$	Ac
Required Surface Area=	185.13	sf
provided Surface area=	288.00	sf

Required storage size for bioretention facility:

Required Bioretention Volume: 1' of run off per impervious area

$$= (1/12) \times 0.04 \times 43560 \text{ cf}$$

$$= 154.50 \text{ cf}$$

Bioretention facility must be size to store water quality volume

$$\begin{aligned} \text{Water quality volume} &= WQv = \frac{(1.0)(Rv)(A)}{12.00} \end{aligned}$$

eastern rainfall zone
P=1 in of rainfall

WQv= water quality volume Ac-ft

Rv= Volumetric runoff coefficient=0.005+0.009(I)

I=percent impervious cover= 18.56

Rv= 0.22

A= area Ac = 0.23 Ac

$$WQv = \frac{(1.0)(Rv)(A)}{12.00}$$

$$WQv = 180.68 \text{ cf}$$

$$\text{Required water Quality Volume} = 180.68 \text{ cf}$$

$$\text{STORAGE PROVIDED} = 492.00 \text{ ft at EL}=657.50 \text{ ft}$$

Underdrain Pipe:

Provided surface area =	288 sf
required length of pipe =	0.05 times filter bed area
required length of pipe =	14 LF
provided length of pipe =	14 LF

17

Check for over flow (10-YR peak flow)

TYPE OF WIER:

Amercast VB-EI INLET WITH 3 SLOTS

SLOT ELEVATION 657.50 FT

$$Q = C * L * H^{1.5}$$

C 3.10

L 7.50 ft

10-YR FLOW= 1.00 CFS FROM TR55

$$1.00 = 3.10 * 7.50 * (H^{1.5})$$

$$H = 0.12 \text{ FT}$$

$$10\text{yr WSEL} = 657.5 + 0.26 = 657.76 \text{ ft}$$

RUNOFF CURVE NUMBER COMPUTATION

Version 2.00

Project : clarksburg town center User: rh Date:
County : montgomery State: md Checked: Date:
Subtitle: bioretention facility #3

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Acres (CN)			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Residential districts	Avg % imperv			
(by average lot size)				
1/4 acre	38	-	0.23(75)	-

Total Area (by Hydrologic Soil Group) .23
=====

TOTAL DRAINAGE AREA: .23 Acres WEIGHTED CURVE NUMBER: 75*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME

Version 2.00

Project : clarksburg town center User: rh Date:
County : montgomery State: md Checked: _____ Date: _____
Subtitle: bioretention facility #3

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	61	0.016	f					0.175
Shallow Concent'd		1330.	0.075	u					0.084

Time of Concentration = 0.26*

=====

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Fallow (No Res.)	G Grass, Burmuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short	J Range, Natural	

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME

Version 2.00

Project : clarksburg town center

User: rh

Date:

County : montgomery

State: md

Checked: _____

Date: _____

Subtitle: bioretention facility #3

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	61	0.016	f					0.175
Shallow Concent'd		1330.	0.075	u					0.084

Time of Concentration = 0.26*

=====

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Fallow (No Res.)	G Grass, Burmuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short	J Range, Natural	

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD

Version 2.00

Project : clarksburg town center

User: rh

Date:

County : montgomery

State: md

Checked: _____

Date: _____

Subtitle: bioretention facility #3

Data: Drainage Area : .23 * Acres
 Runoff Curve Number : 75 *
 Time of Concentration: 0.26 * Hours
 Rainfall Type : II
 Pond and Swamp Area : NONE

Storm Number	1
Frequency (yrs)	10
24-Hr Rainfall (in)	5.1
Ia/P Ratio	0.13
Runoff (in)	2.53
Unit Peak Discharge (cfs/acre/in)	1.099
Pond and Swamp Factor 0.0% Ponds Used	1.00
Peak Discharge (cfs)	1

* - Value(s) provided from TR-55 system routines

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name:

Comment: 2

Solve For Full Flow Slope

Given Input Data:

Diameter.....	1.00 ft
Manning's n.....	0.013
Discharge.....	1.00 cfs

Computed Results:

Full Flow Channel Slope	0.0008 ft/ft
Full Flow Depth.....	1.00 ft
Velocity.....	1.27 fps
Flow Area.....	0.79 sf
Critical Depth....	0.42 ft
Critical Slope....	0.0058 ft/ft
Percent Full.....	100.00 %
Full Capacity.....	1.00 cfs
QMAX @.94D.....	1.08 cfs
Froude Number.....	FULL

Bio Retention #3

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE
June 16, 2003

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet).....	1.00
FHWA Chart Number (1,2 or 3).....	2
Scale Number on Chart (Type of Culvert Entrance).....	1
Manning's Roughness Coefficient (n-value).....	0.0130
Entrance Loss Coefficient of Culvert Opening.....	1.00
Culvert Length (feet).....	52.0
Culvert Slope (feet per foot).....	0.0260

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Normal Depth Outlet Control	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.0	1.00	0.59	-0.26	0.28	0.42	0.28
						5.48

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WR INLET 'A' SH#190
FROM TR 55

Q10= 10 yr peak flow from drainage area of WR INLET 'A' =

1.00 CFS

A= 2.5X2.5X0.5 SF

3.13 SF

Ca=0.6

Q10= $Ca \cdot A \cdot (2gh)^{0.5}$ 1= 15.05 $h^{0.5}$

h= 0.004 ft

WR INLET 'A' TOP EL = 660.60 FT

10 YR WSEL = 660.60 FT

RUNOFF CURVE NUMBER COMPUTATION

Version 2.00

WR Inlet to Sh #190

Project : clrkdburg town center User: rh Date: _____
 County : montgomery State: md Checked: _____ Date: _____
 Subtitle: study point at WRL inlet A

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Acres (CN)			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Residential districts	Avg % imperv			
(by average lot size)				
1/8 acre (town houses)	65	- 0.14(85)	-	-
1/4 acre	38	- 0.07(75)	-	-
Total Area (by Hydrologic Soil Group)	.21			
	====			

 TOTAL DRAINAGE AREA: .21 Acres WEIGHTED CURVE NUMBER: 82*

* - Generated for use by GRAPHIC method

Project : clrkdburg town center

User: rh

Date:

County : montgomry

State: md

Checked: _____

Date: _____

Subtitle: study point at WRL inlet A

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.2	60	0.143	f					0.072
Shallow Concent'd		600	0.090	u					0.034

Time of Concentration = 0.11*

=====

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Fallow (No Res.)	G Grass, Burmuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short	J Range, Natural	

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD

Version 2.00

Project : clrkdburg town center

User: rh

Date:

County : montgomery

State: md

Checked: _____

Date: _____

Subtitle: study point at WRL inlet A

Data: Drainage Area : .21 * Acres
 Runoff Curve Number : 82 *
 Time of Concentration: 0.11 * Hours
 Rainfall Type : II
 Pond and Swamp Area : NONE

Storm Number	1
Frequency (yrs)	10
24-Hr Rainfall (in)	5.1
Ia/P Ratio	0.09
Used	0.10
Runoff (in)	3.17
Unit Peak Discharge (cfs/acre/in)	1.535
Pond and Swamp Factor 0.0% Ponds Used	1.00
Peak Discharge (cfs)	1

* - Value(s) provided from TR-55 system routines

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

12" RCP from
w/ Inlet 'SM#170' >
B-C 1.1.1

Worksheet Name:

Comment:

Solve For Full Flow Slope

Given Input Data:

Diameter.....	1.00 ft
Manning's n.....	0.013
Discharge.....	1.00 cfs

Computed Results:

Full Flow Channel Slope	0.0008 ft/ft
Full Flow Depth.....	1.00 ft
Velocity.....	1.27 fps
Flow Area.....	0.79 sf
Critical Depth....	0.42 ft
Critical Slope....	0.0058 ft/ft
Percent Full.....	100.00 %
Full Capacity.....	1.00 cfs
QMAX @.94D.....	1.08 cfs
Froude Number.....	FULL

30
15" CMP from str 128
to Ex Trap #1

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE
June 29, 2003

=====

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet).....	1.50
FHWA Chart Number (1,2 or 3).....	2
Scale Number on Chart (Type of Culvert Entrance).....	1
Manning's Roughness Coefficient (n-value).....	0.0240
Entrance Loss Coefficient of Culvert Opening.....	1.00
Culvert Length (feet).....	38.0
Culvert Slope (feet per foot).....	0.0426

=====

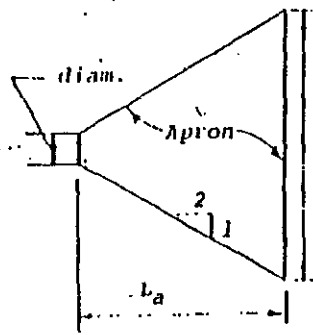
PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater Inlet Control (ft)	Normal Depth Outlet Control (ft)	Critical Depth (ft)	Depth at (ft)	Outlet Velocity (fps)
10.0	1.50	2.25	2.04	1.06	1.27	1.06 7.45

=====

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DESIGN OF OUTLET PROTECTION MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)



$$W = \text{diam.} + L_a$$

15' + 10' = 25'

11.5'

Median stone diameter, d_{50} , is the stone size which 50% of the riprap mixture, by weight, is larger than.

Velocities shown are for pipes flowing full.

Minimum Length of Apron, L_a , feet

60
50
40
30
20

SECTION

Slope = 0
Flow

Median Stone Diameter, d_{50} , in feet

Class I

Discharge, cfs

Table 19

1511 CMP from Stry #1381
to EX Trap #1

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name:

Comment:

Solve For Full Flow Slope

Given Input Data:

Diameter.....	1.50 ft
Manning's n.....	0.024
Discharge.....	10.00 cfs

Computed Results:

Full Flow Channel Slope	0.0309 ft/ft
Full Flow Depth.....	1.50 ft
Velocity.....	5.66 fps
Flow Area.....	1.77 sf
Critical Depth....	1.22 ft
Critical Slope....	0.0314 ft/ft
Percent Full.....	100.00 %
Full Capacity.....	10.00 cfs
QMAX @.94D.....	10.76 cfs
Froude Number.....	FULL