LBM Engineering, LLC
11 Hally Lane, Colchester, CT 06415-2133 Phone 860-416-9809 Email John@LBMEngineering.com

CIVIL ENGINEERING - LAND DEVELOPMENT - SITE PLANS - STORMWATER MANAGEMENT

Exhibit #55

Stormwater Management Report
For Land Use Commissions Submittals
Avery Brook Homes Subdivision,
Stoddards Warf Road, Ledyard, Connecticut

November 13, 2022
Rev. 02/20/2023

EXISTING CONDITIONS: Reference is made to the following Plan Set: "Plan Showing Resubdivision Property of Avery Brook Homes LLC 94, 96, 98 and 100 Stoddards Wharf Road, A.K.A. Connecticut Route 214 Ledyard, Connecticut" Scales as Shown July 2022, Revised February 13, 2023, By Dieter & Gardner, Gales Ferry, CT. The property is located on the north side of Stoddards Wharf Road approximately one quarter mile east of the intersection of Whalehead Road and Stoddards Wharf Road. The property is wooded. The property drains primarily to the east and north.

STORMWATER MANAGEMENT: Detention of peak flow rates is not proposed for this development. The Town of Ledyard's Ordinance Regulating the Management of Stormwater Runoff, Part I. Section 3. Paragraph C. states: "A zero percent increase in discharge characteristics is specifically not applicable in cases where the applicant can demonstrate that the runoff will discharge to the Thames River or Groton Reservoir system without increasing the potential of downstream flooding."

This proposal will not increase the potential for downstream flooding. The subdivision is located at the bottom of the Billings Avery Brook, 770-acre watershed. Runoff from the development will precede the peak flow in Billings Avery Brook, thereby having no effect on downstream flooding.

WATER QUALITY: The Connecticut D.E.E.P. 2004 Stormwater Quality Manual (SWQM) defines the Water Quality Volume (WQV) as the volume of runoff from a one-inch rainfall event. SWQM Paragraph 7.4.1 states: "In the northeastern U.S., the 90 percent rainfall event is equal to approximately one inch, which is consistent with the recommended WQV sizing criteria for Connecticut." Therefore, by treating the WQV, the proposal effectively meets the requirements of the SWQM.

The proposed drainage system (catch basins and culverts) captures runoff from 950 feet of paved road and 15 building lots and carries the flow to a water quality basin. The water quality basin is designed to hold the WQV for 12 hours to settle out the suspended solids. The water quality basin's outlet is an extended detention underdrain which further filters the outflow and meters the flow through the outlet structure. The basin has a riprap spillway for storms larger than one inch. The wide spillway and the underdrain outlet have flow velocities below two feet per second (2 FPS) which is sub-erosive on grass surfaces.

The subsoil throughout the property consists of sand and gravel with no evidence of seasonally high ground water. The soil conditions are excellent for infiltrating storm water. Therefore, roof runoff from each of the proposed homes will have an infiltration area, sized to hold and infiltrate the WQV thereby providing groundwater recharge per the SWQM guidelines. Surface water runoff is measurably reduced by infiltrating clean water back into the groundwater.

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Vegetated filter strips are proposed along the portions of the road that are not curbed. Runoff from the pavement will sheet-flow into the adjacent lawn and landscaping thereby providing filtration and infiltration. Proposed gentile slopes and small drainage areas make the vegetated filter strips a suitable application.

AREA	TREATMENT
4.7 Acres	To Stormwater Quality Basin
0.15 Acres of Road to 0.15 Acres of Lawn	Sheet Flow to Vegetated Filter Strips
1.5 Acres Lawns and Driveways	Sheet Flow to Undisturbed Vegetation
2.7 Acres Undisturbed Vegetation	Treatment Not Required
9.2 Acres Total	

CONCLUSION: The proposed development meets the requirements of the Connecticut D.E.E.P. 2004 Stormwater Quality Manual and will not have adverse effects on down-gradient properties, nor will it increase the potential for downstream flooding and is in keeping with the policies and goals of the Ledyard Planning and Zoning Commission.

Submitted by:
LBM Engineering, LLC

John R. Martucci, P.E.

PREPARED BY	DATE PREPARED	LBM Engineering, LLC	JOB NUMBER	PAGE NUMBER
JRM	10/2022	11 HALLY LANE COLCHESTER, CONNECTICUT 06415 TEL: (860)-416-9809 EMAIL: JOHN@LBMENGINEERING.COM		
CHECKED BY	DATE CHECKED REV. 2/2023		CLIENT NAME	TOTAL PAGES

AVERY BROOK HOMES

DRAINAGE AREA BREAKDOWN TO DETERMINE WQV TO STORMWATER QUALITY BASIN

4.7 ACRES TOTAL TO ROADWAY STORMDRAINS

ROOF RUNOFF FROM HOUSES ARE PIPED TO STORMTECH CHAMBERS SIZED TO HOLD & INFILTRATE 1" (ONE INCH) OF VOLUME

15 LOTS DRAIN TO STORM DRAIN, DEDUCT ROOF AREA:
$15 \times (26' \times 36') = 14{,}040$ SF = 0.32 ACRES

950' OF 22' WIDE ROAD = 20,900 SF = 0.48 AC

15 DRIVEWAYS - ASSUME PAVED TO BE CONSERVATIVE
15×700 SF = 10,500 = 0.24 AC

4.7 AC TOTAL MINUS (0.32 AC. ROOFS + 0.48 AC ROAD + 0.24 AC DRIVE)
= 3.66 AC OVERLAND

0.48 AC ROAD + 0.24 AC DRIVES = 0.72 AC IMPERVIOUS

SEE "WATER QUALITY FLOW / WATER QUALITY VOLUME" SPREAD SHEET

COMPUTATIONS FOR:	Project
WATER QUALITY FLOW / WATER QUALITY VOLUME	Made By: JRM
AVERY BROOK HOMES SUBDIVIDION	Date: 8/3/2022
LEDYARD	Rev:
	Date: 2/19/2023

IN SYSTEM TO BASIN

ConnDOT Drainage Manual Ch. 10 and Ch. 11, Appendix C

Contributing Basins	Wooded Area (acres)	Grass Area (acres)	Paved (acres)	Total Area (acres)
TO BASIN	0	3.66	0.48	4.14
			0.24	0.24
Total	0	3.66	0.72	4.38

Equation 10.31: WQV = (1")(R)(A)/12 = 0.072 acre-feet or 3,147 cubic-feet WQV (3,900 CF PROVIDED)

I = % of Impervious Cover = 16%

R = volumetric runoff coeff. 0.05 + 0.009(I) = 0.1979

A = site area (acres) = 4.38 acres = 0.0068 miles^2

Q = runoff depth (in watershed inches) = [WQV(acrefeet)]*[12(inches/foot)]/drainage area (acres)

Q = 0.1979452

$CN = 1000 / [10 + 5P + 10Q - 10(Q^2 + 1.25QP)^{0.5}]$ = 86.0

P = design precipitation (1" for water quality storm) = 1 inch

Q = runoff depth (in watershed inches)

t_c 10 min

t_c = 10 minutes = 0.167 hours

From Table 4-1, Ia = 0.326 Ia/P = 0.326

From Exhibit 4-III, q_u = 500

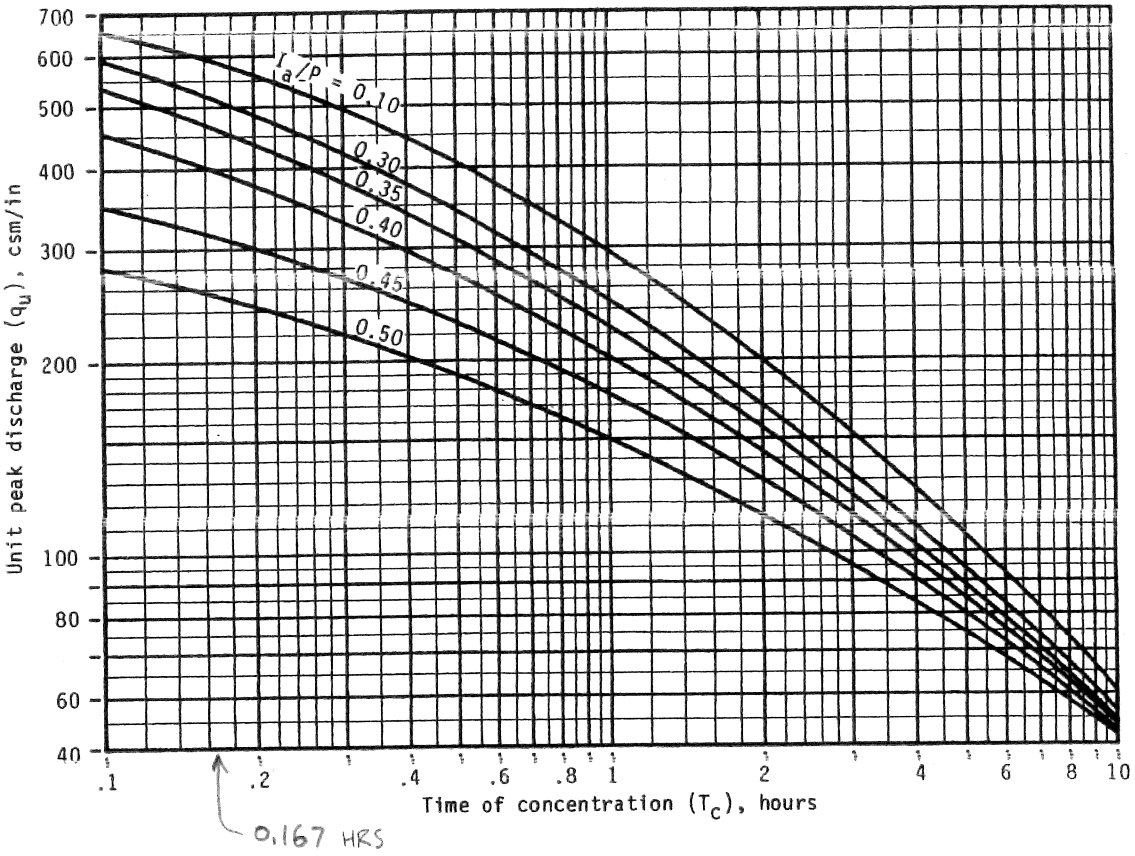
WQF = (qu)(A)(Q) = 0.68 cfs

I_a values for runoff curve numbers (Table 4-1 TR55)

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

- Read the unit peak discharge (q_u) from Exhibit 4-III in Chapter 4 of TR-55 (reproduced below) for appropriate t_c

Unit peak discharge (q_u) for SCS type III rainfall distribution (Exhibit 4-III TR55)



- Substituting the water quality volume (WQV), converted to watershed inches, for runoff depth (Q), compute the water quality flow (WQF) from the following equation:

$$WQF = (q_u)(A)(Q)$$

where: WQF = water quality flow (cfs) (English units only)
qu = unit peak discharge (cfs/mi^2/inch)
A = drainage area (mi^2)
Q = runoff depth (in watershed inches)

$$Q = \frac{[WQV(acre feet)]X[12(inches/foot)]}{DrainageArea(acres)}$$

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JRM	11/2022	11 HALLY LANE COLCHESTER, CONNECTICUT 06415 TEL: (860)-416-9809 EMAIL: JOHN@LBMENGINEERING.COM		
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DRAINAGE SYSTEM DESIGN

CB 1 STA 12+30 RT
CB 2 STA 23+13 RT
CB 3 STA 23+13 LT

CB 1

STA 10+0 – 16+20 RIGHT SIDE OF ROAD

ROAD 620' x 11' = 6820 SF = 0.16 ACRES 'C' = 0.9

CB 2

ROAD 630' x 11' = 6930 SF = 0.16 AC
ROOF & DRIVES 1500 SF x 2 LOTS = 3000 SF = 0.07 AC
OVERLAND 16,200 SF = 0.37 AC
TOTAL AREA 0.60 AC

WEIGHTED 'C' $[(0.23 \times 0.9) + (0.37 \times 0.3)] \div 0.60\ AC = 0.53$

CB 3

ROAD 750' x 11' = 8250 SF = 0.19 AC
ROOF & DRIVES 1500 x 6 LOTS = 9,000 SF = 0.21 AC
OVERLAND 50,095 SF = 1.15 AC (1.55 TOTAL)

WEIGHTED 'C' $[(0.40 \times 0.9) + (1.15 \times 0.3)] \div 1.55 = 0.45$

PROJECT: AVERY BROOK SUBDIVISION
PROJECT NO.:
TOWN: Ledyard
ROUTE:
LOCATION: N/A

DESIGNED BY: JRM DATE: 11/12/22
REV:
CHECKED BY: DATE:

GUTTER FLOW ANALYSIS - 25 YR STORM

Inlet ID	Inlet Station and Offset	Area in Acres (A)	Runoff Coeff. (C)	Time to Inlet (min.)	Rainfall Intensity (in/hr)	AC	Total AC	Q to Inlet (cfs)	Grade of Gutter ft/ft (SL)	Cross Slope Of Shoulder ft/ft (Sx)	Depth of Flow of Gutter (ft)	Gutter Flow Width (ft)	Q Bypassing Inlet (cfs)	AC Bypassing Inlet	AC Entering Catch Basin	Inlet Type
PROPOSED ROAD RIGHT GUTTER																
CB 1	12+30, RT	0.160	0.9	10	6.20	0.144	0.144	0.982	LOW PT	0.043	SEE LOW POINT ANALYSIS				0.144	"C"
CB 2	23+13, RT	0.600	0.53	10	6.20	0.318	0.318	2.169	LOW PT	0.043	SEE LOW POINT ANALYSIS				0.318	"C"
PROPOSED ROAD LEFT GUTTER																
CB 3	23+13, LT	1.550	0.45	10	6.20	0.698	0.698	4.757	LOW PT	0.043	SEE LOW POINT ANALYSIS				0.698	"C"
											NOTES:					

LOW POINT ANALYSIS

INLET	Q TO INLET	PERIM.	C WEIR	d WEIR	WIDTH OF FLOW	d ORIFICE										
CB 1	0.982	5.020	3	0.162	3.24	0.014	<0.4' DEEP - OK									
CB 2	2.169	5.020	3	0.275	5.49	0.066	<0.4' DEEP - OK									
CB 3	4.757	7.330	3	0.360	7.20	0.320	<0.3' DEEP - OK									

Notes:

1.) Manning's n = 0.016 (asphalt)
2.) Tc = 5 minutes minimum for areas with all pavement.
3.) Tc = 10 minutes minimum for small areas with pavement and grass.
4.) All low points operate as a wier. Depth (d) over grate is less than 0.4 feet.

GRATES	PERIM	AREA
C	5.02	3.13
C DOUB	7.33	6.26
CL	7.33	3.13
CL DOUB	11.96	6.26

STORM SEWER SYSTEM DESIGN

Client:
Project: AVERY BROOK SUBDIVISION
Proj. No.:
Return Period for Design: 25-YR

Prepared By: JRM Date: 11/12/22 Revised: 12/12/22

Line Segment		Time to Inlet	Time in Pipe	Accumul. Time	A x C Entering System	Sum of A x C in System	Rainfall Intensity, R (in./hr.)	**Q in System (c.f.s.)**	Pipe Data						
From	To	(min.)	(min.)	(min.)					Size (in.)	Length (ft.)	Slope (ft./ft.)	Avg. Vel. (f.p.s.)	**Full Cap. (c.f.s.)**	Headwater (ft.)	Manning "n"
CB 3 23+13,LT	CB 2 23+13,RT	10	0.11	10.0	0.698	0.698	6.2	4.33	15	32	0.013	5.0	7.82	0.50	0.012
CB 2 23+13,RT	CB 1 12+30,RT	10	0.08	10.1	0.318	1.016	6.2	6.30	15	24	0.013	5.0	7.82	0.50	0.012
CB 1 12+30,RT	BASIN	10	0.09	10.2	0.144	1.16	6.2	7.19	15	42	0.048	8.0	15.32	0.80	0.012

Manning's "n" for, HDPE and RC pipe = 0.012

NOTE: ALL PIPES ARE BELOW FULL CAPACITY.

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AVERY BROOK HOMES

CROSS CULVERT 11+12, LEFT TO 11+25, RIGHT - 25 YR STORM

82,580 SF TOTAL = 1.90 AC

ROOF & DRIVES 1500 SF × 7 LOTS = 10,500 SF = 0.24 AC

OVERLAND 1.90 − 0.24 = 1.66 AC

WEIGHTED 'C' = [(0.24 × 0.9) + (1.66 × 0.3)] ÷ 1.90 = 0.38

R = 6.2"/hr Q_{25} = 1.9 AC × 6.2 × 0.38 = 4.5 CFS

USE 15" HDPE @ 1.1% SLOPE

FULL CAPACITY 7.3 CFS

COMPUTATIONS FOR:

ORIFICE SIZING WORKSHEET
AVERY BROOK HOMES
LEDYARD, CT

Project	
Made By:	JRM
Date:	11/13/2022
Rev:	12/3/2022

ORIFICE SIZING FOR EXTENDED DETENTION UNDERDRAIN

BASIN VOLUME AT SPILLWAY = 4,300 CUBIC FT
TARGET VOLUME (HALF EMPTY)

ConnDOT Drainage Manual Equation 10.32

Qav = VOL./T

VOLUME (FT^3)	4300	
T (SEC.)= 12 Hrs =	43,200	
Qav (CFS) =	0.0995	Target Q at Half Volome

ConnDOT Drainage Manual Equation 10.18

$Q = Kor\ D^2\ Ho^{0.50}$ Kor = 3.78

Q = Flow in CFS
Kor= Oriface Coefficient = 3.78
D= Oriface
H= Head in Feet

HEAD AT FULL = 2.5'

D (inch)	D (FT.)	H	Q (CFS)	
1.75	0.146	1.50	0.0985	
2.00	0.167	1.50	0.1286	USE 2" ORIFICE
2.50	*0.208*	*1.50*	*0.2009*	
3.00	0.250	1.50	0.2893	

HEAD AT HALF EMPTY = 0.75'

D (inch)	D (FT.)	H	Q (CFS)	
1.75	0.146	0.75	0.0696	
2.00	0.167	0.75	0.0909	USE 2" ORIFICE
2.50	0.208	0.75	0.1421	
3.00	0.250	0.75	0.2046	

HEAD AT 0.5'

D (inch)	D	H	Q (CFS)	
1.75	0.146	0.50	0.0568	
2.00	0.167	0.50	0.0742	USE 2" ORIFICE
2.50	0.208	0.50	0.1160	
3.00	0.250	0.50	0.1671	

OUTLET RATE OF STORMWATER QUALITY BASIN = 0.1 CFS

CHANNEL DESIGN WORK SHEET

Client: AVERY BROOK HOMES
Location: WATER QUAL BASIN
Town: LEDYARD
Return Period for Design: 1 INCH STORM

Prepared By: JRM Date: 02/19/23
Checked By: Revised:

Manning's equation - $Q = (1.49/n)\ A\ R^{0.67}\ S^{0.5}$

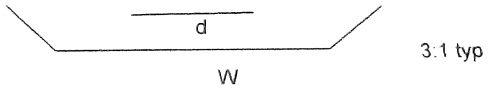
CHECKED IN BOX
THE CHANNEL WORKSHEET IS USED TO DETERMINE THE DEPTH OF FLOW "D" (d) AND THE VELOCITY OF FLOW "V".

GRASS SWALE

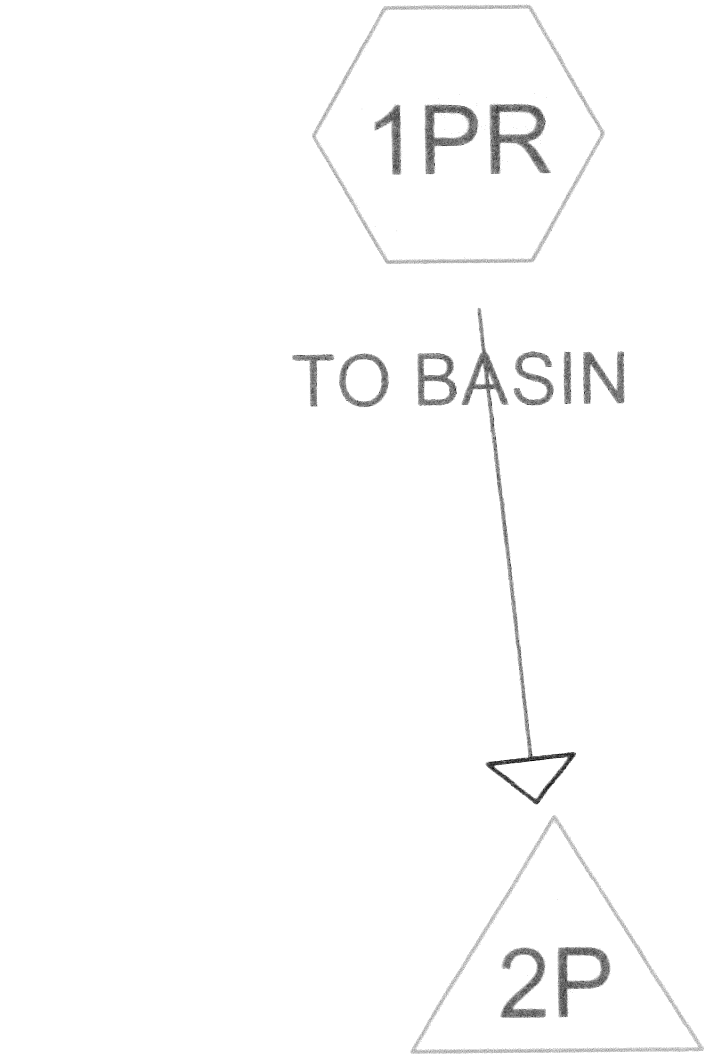
YEAR	2	10	25	1-INCH	
S (FT/FT)				0.01	
d (FT)				0.08	← *
W (FT)				2	
A (SF)				0.1792	
SS:1				3	
R (A/WP)				0.0715	
n				0.030	
Q_{CALC} (CFS)				0.152	
V = Q/A (FPS)				0.8	← *

2002 GUIDELINES P. 5-6-25

n	RIPRAP
0.034	MODIFIED
0.037	INTERMEDIATE
0.041	STANDARD



* AFTER A 1" STORM, OUTLET OF STORMWATER QUALITY BASIN IS LESS THAN 1" DEEP AND FLOWING AT LESS 1 FT/SEC WHICH IS NON EROSIVE IN A GRASS SWALE.



Subcat Reach Pond Link

Routing Diagram for BASIN WORKING
Prepared by LBM Engineering LLC. Printed 2/19/2023
HydroCAD® 10.20-2g s/n 09192 © 2022 HydroCAD Software Solutions LLC

Summary for Subcatchment 1PR: TO BASIN

Runoff = 8.78 cfs @ 0.25 hrs, Volume= 13,804 cf, Depth= 0.87"
Routed to Pond 2P : WQ BASIN

Runoff by Rational method, Rise/Fall=1.0/2.5 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
CT-Ledyard 25-yr Duration=15 min, Inten=4.84 in/hr

Area (ac)	C	Description	Land Use
3.660	0.30	overland	
0.720	0.95	pavement and driveways	
4.380	0.41	Weighted Average	
3.660		83.56% Pervious Area	
0.720		16.44% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.0					**Direct Entry, TO BASIN**

Summary for Pond 2P: WQ BASIN

Inflow Area = 190,793 sf, 16.44% Impervious, Inflow Depth = 0.87" for 25-yr event
Inflow = 8.78 cfs @ 0.25 hrs, Volume= 13,804 cf
Outflow = 6.97 cfs @ 0.38 hrs, Volume= 9,868 cf, Atten= 21%, Lag= 7.6 min
Primary = 6.97 cfs @ 0.38 hrs, Volume= 9,868 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Peak Elev= 146.42' @ 0.38 hrs Surf.Area= 3,704 sf Storage= 5,384 cf

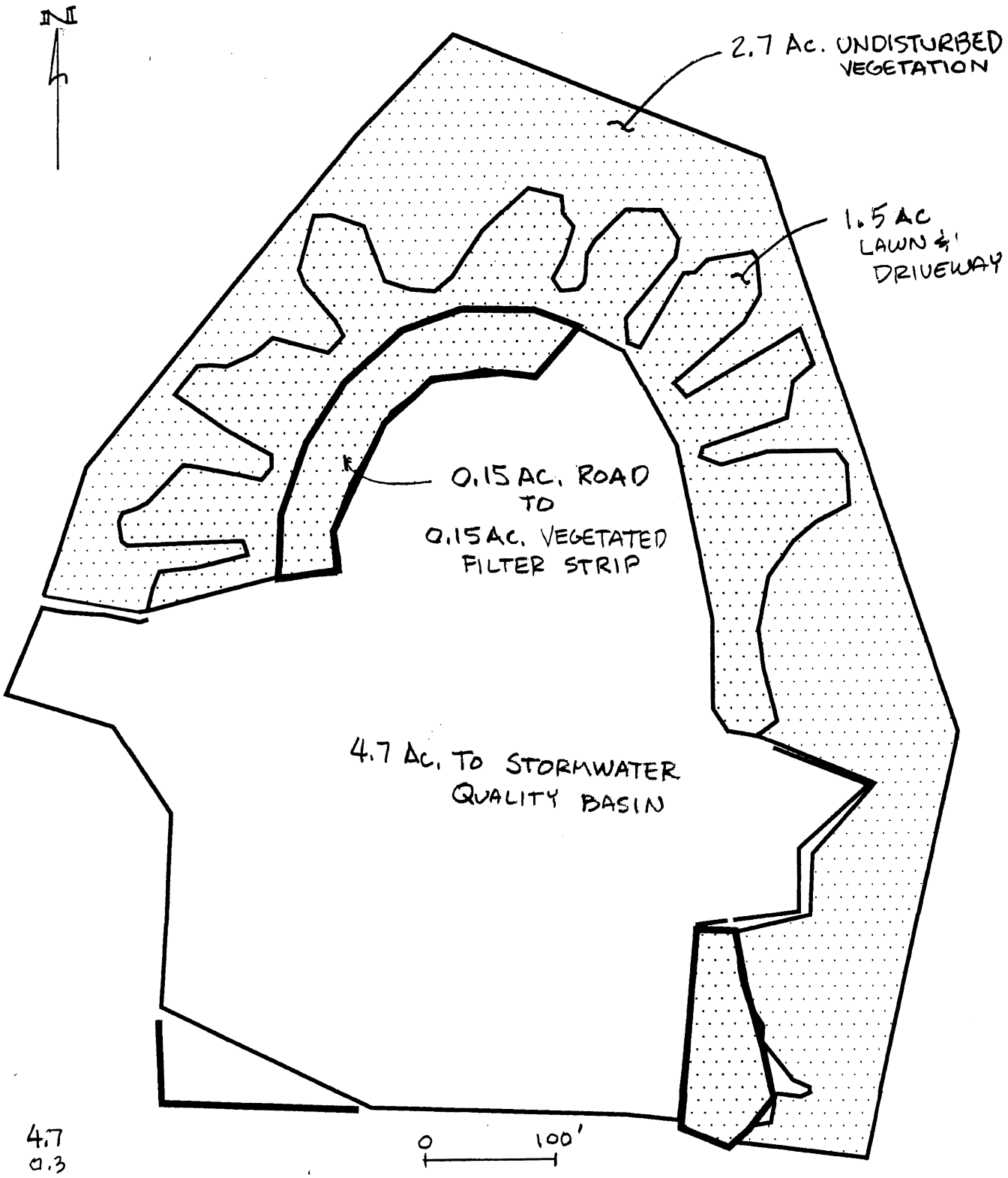
Plug-Flow detention time= 14.9 min calculated for 9,868 cf (71% of inflow)
Center-of-Mass det. time= 9.2 min (31.7 - 22.5)

Volume	Invert	Avail.Storage	Storage Description
#1	144.50'	5,683 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
144.50	2,044	0	0
146.00	3,200	3,933	3,933
146.50	3,800	1,750	5,683

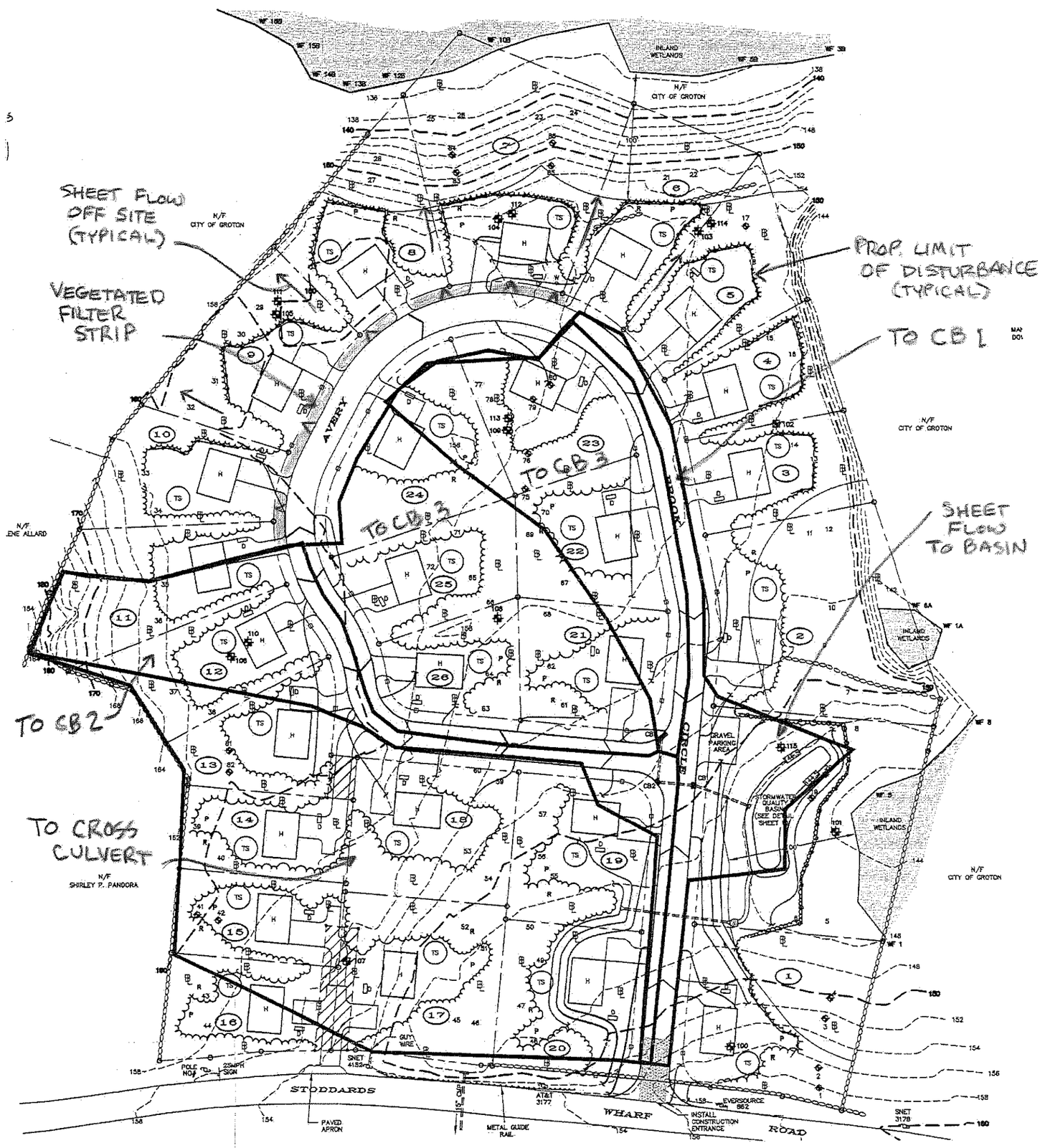
Device	Routing	Invert	Outlet Devices
#1	Primary	146.00'	**10.0' long x 8.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74

Primary OutFlow Max=6.97 cfs @ 0.38 hrs HW=146.42' (Free Discharge)
↑**1=Broad-Crested Rectangular Weir** (Weir Controls 6.97 cfs @ 1.66 fps) ← MODIFIED RIPRAP SPILLWAY LESS THAN 2 FPS - NON EROSIVE ON GRASS SURFACE



4.7
0.3
1.5
2.7
9.2 AC TOTAL

AVERY BROOK HOMES
RUNOFF TREATMENT
MAP



AVERY BROOK HOMES

DRAINAGE AREA MAP