DEQ Certification Class Presentations

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August 2024

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Exercise 5

Bringing It All Together

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Exercise 5: Bringing It All Together

Given:

- Existing and proposed site plans
- Booklet containing narrative and design details
- Details for each proposed P-BMP

Hint!

Use your previous exercises to help find the answers

Exercise materials: Plan sheets

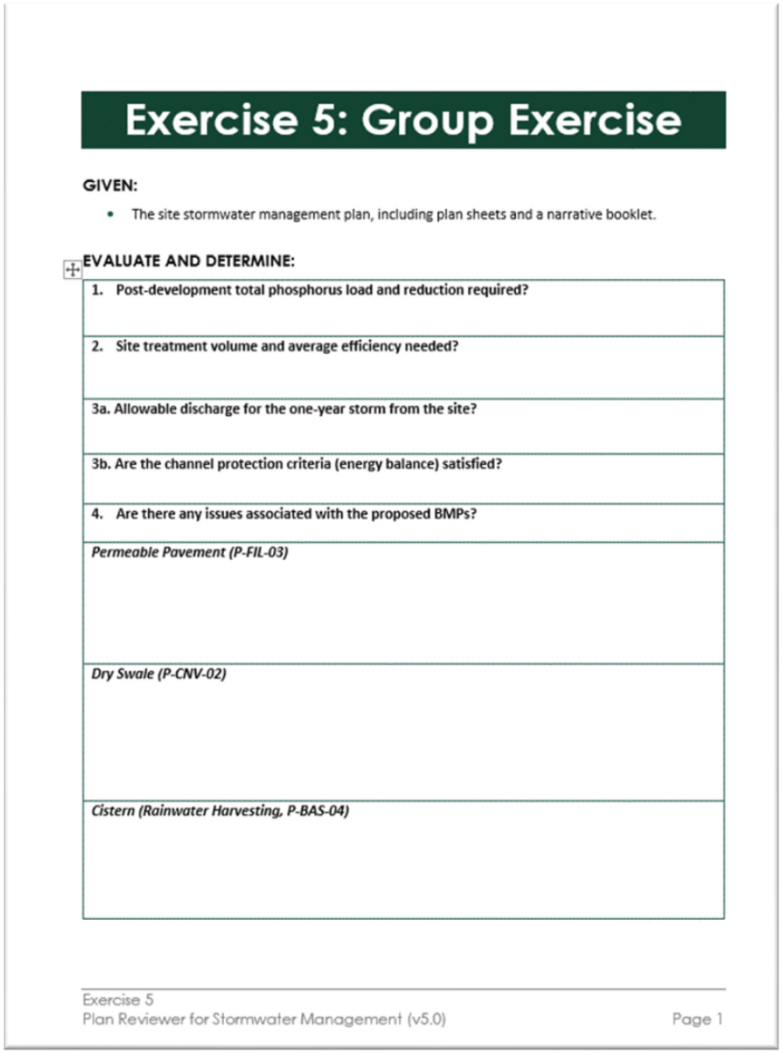
Industrial Park Narrative Booklet

P-BMP specifications

Exercise 5 Materials

In your participant guide

- Exercise 5 instructions
  - Use this sheet to jot down your observations and notes



Exercise 5: Group Exercise

GIVEN:

- The site stormwater management plan, including plan sheets and a narrative booklet.

EVALUATE AND DETERMINE:

1. Post-development total phosphorus load and reduction required?
2. Site treatment volume and average efficiency needed?
3a. Allowable discharge for the one-year storm from the site?
3b. Are the channel protection criteria (energy balance) satisfied?
4. Are there any issues associated with the proposed BMPs?
Permeable Pavement (P-FIL-03)
Dry Swale (P-CNV-02)
Cistern (Rainwater Harvesting, P-BAS-04)

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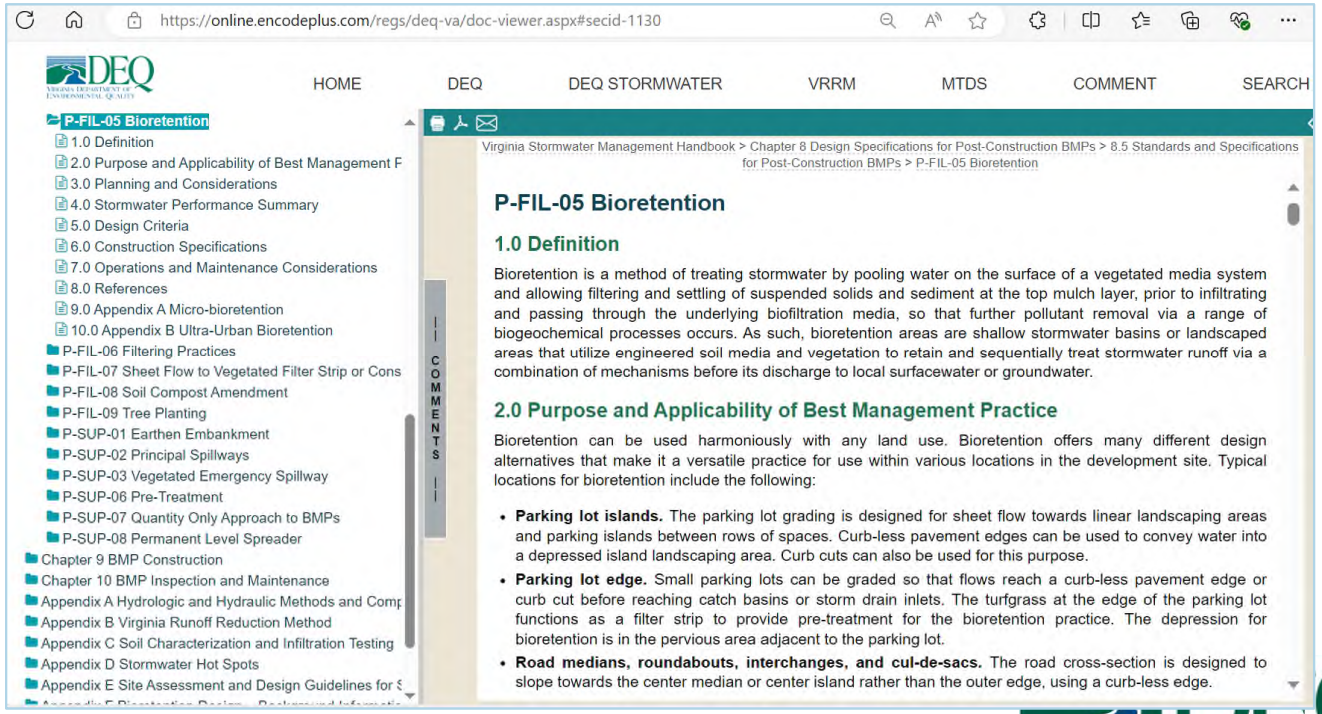
Exercise 5 Materials

BMP specifications for:

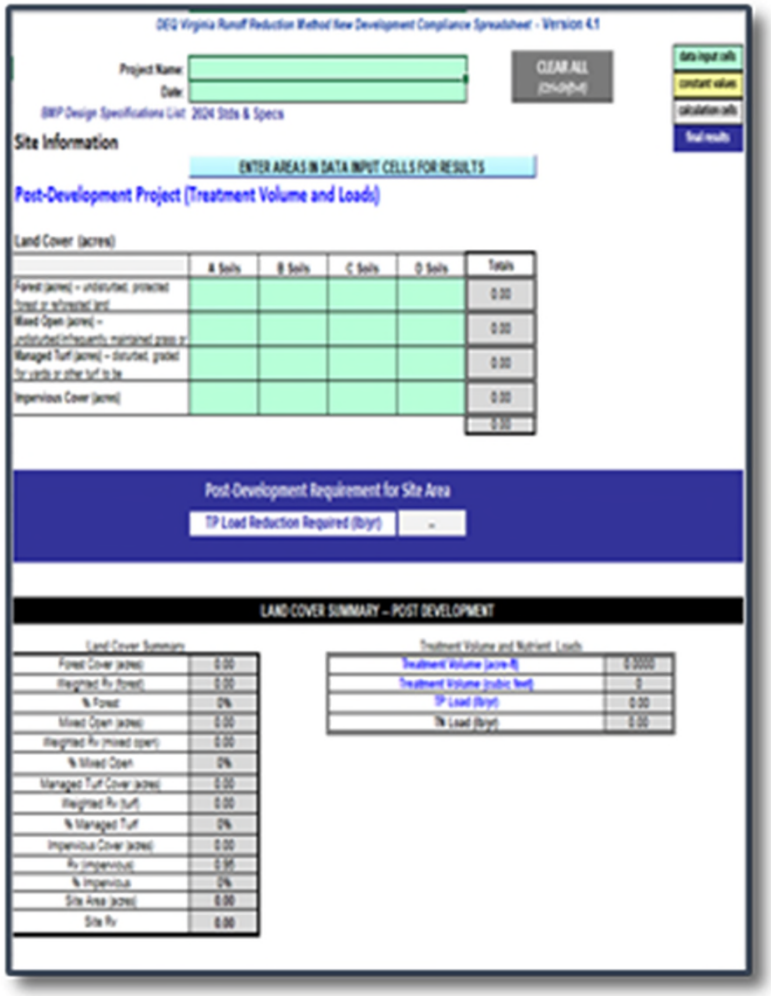
- Permeable pavement (P-FIL-03)
- Dry swale (P-CNV-02)
- Cistern (P-BAS-04)
- Extended detention (P-BAS-04)



VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Exercise 5 Materials

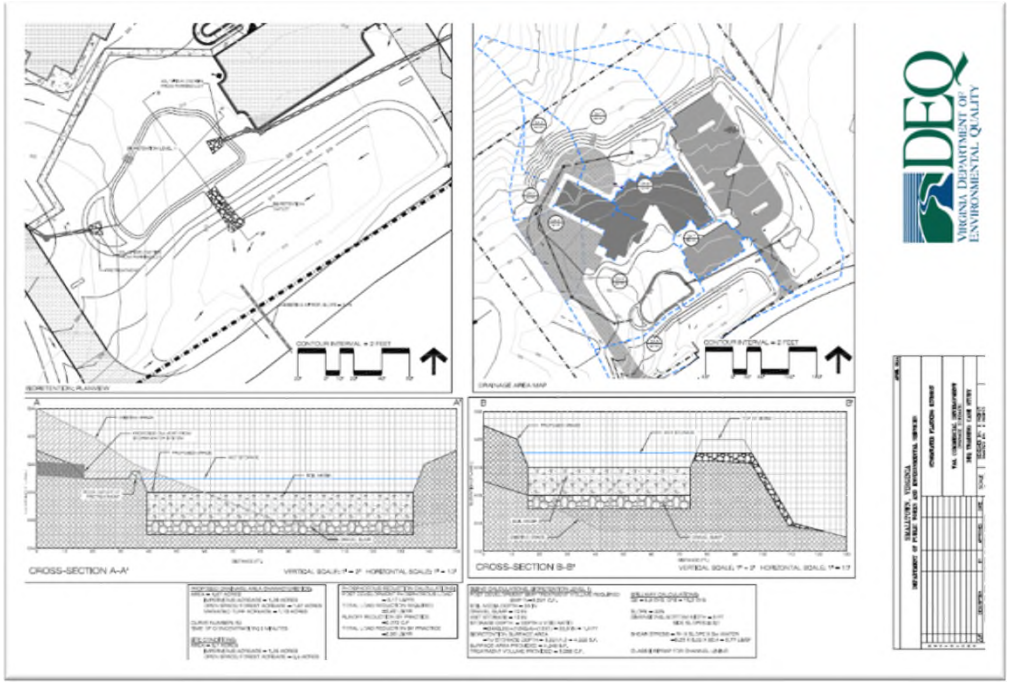
Virginia Runoff Reduction Method (VRRM) 4.1 New Development Spreadsheet



Exercise 5 Materials

- **Narrative booklet**
- **Plan sheets (PDF):**
  - Existing and proposed site
  - BMP detail sheets (4)

    (permeable pavement, dry swale, cistern, extended detention)



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Narrative Booklet

August 2024 Revisions

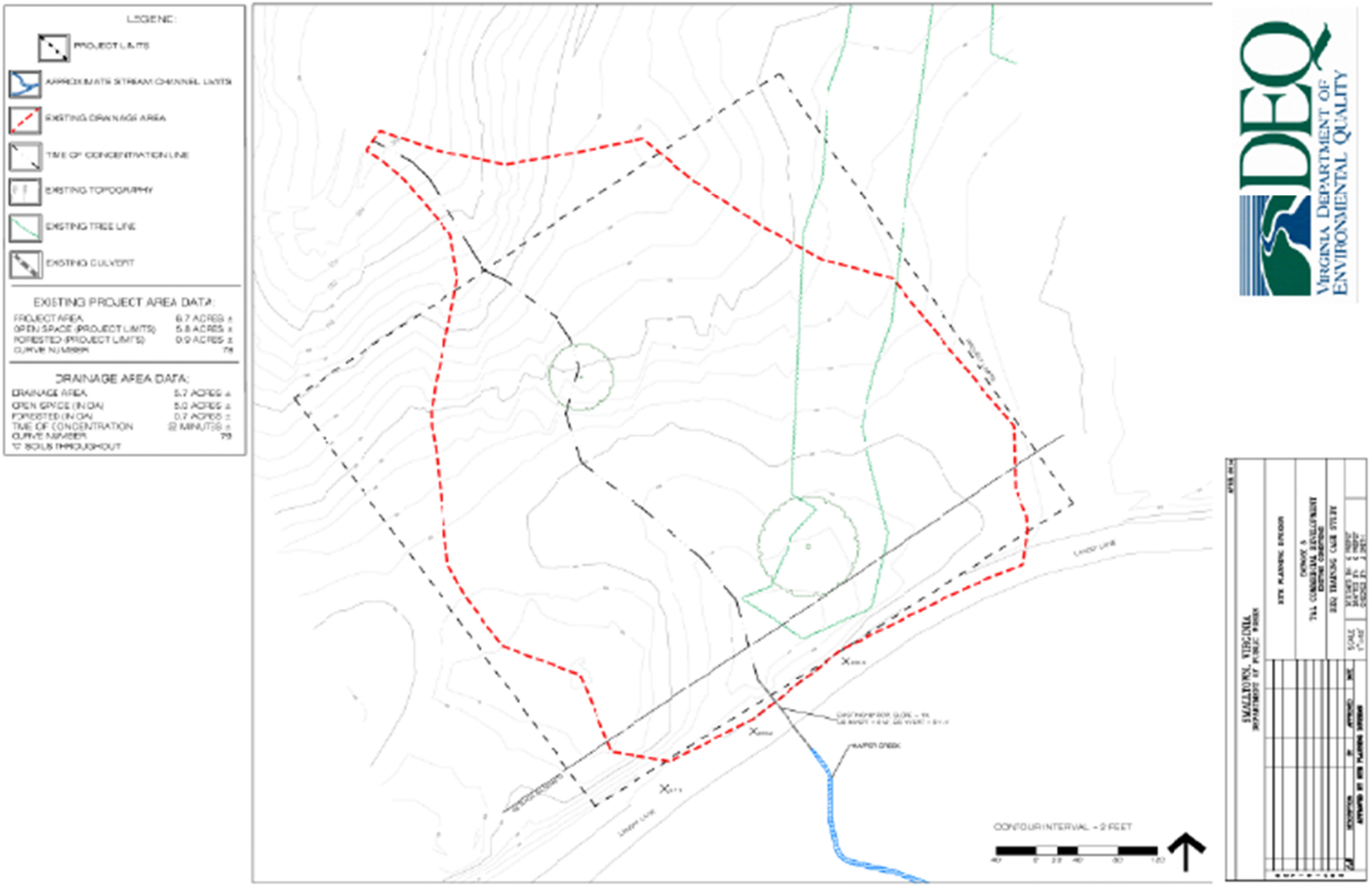
Industrial Park Design

Narrative and Details

T&L COMMERCIAL DEVLOPMENT

DEQ DESIGN & ASSOCIATES

Existing


LEGEND:
PROJECT LIMITS
APPROXIMATE STREAM CHANNEL LIMITS
EXISTING DRAINAGE AREA
TIME OF CONCENTRATION LINE
EXISTING TOPOGRAPHY
EXISTING TREE LINE
EXISTING CULVERT
EXISTING PROJECT AREA DATA:
PROJECT AREA 6.7 ACRES ±
OPEN SPACE (PROJECT LIMITS) 5.8 ACRES ±
FORESTED (PROJECT LIMITS) 0.9 ACRES ±
CURVE NUMBER 78
DRAINAGE AREA DATA:
DRAINAGE AREA 5.7 ACRES ±
OPEN SPACE (IN DA) 5.0 ACRES ±
FORESTED (IN DA) 0.7 ACRES ±
TIME OF CONCENTRATION 22 MINUTES ±
CURVE NUMBER 78
'C' SOILS THROUGHOUT
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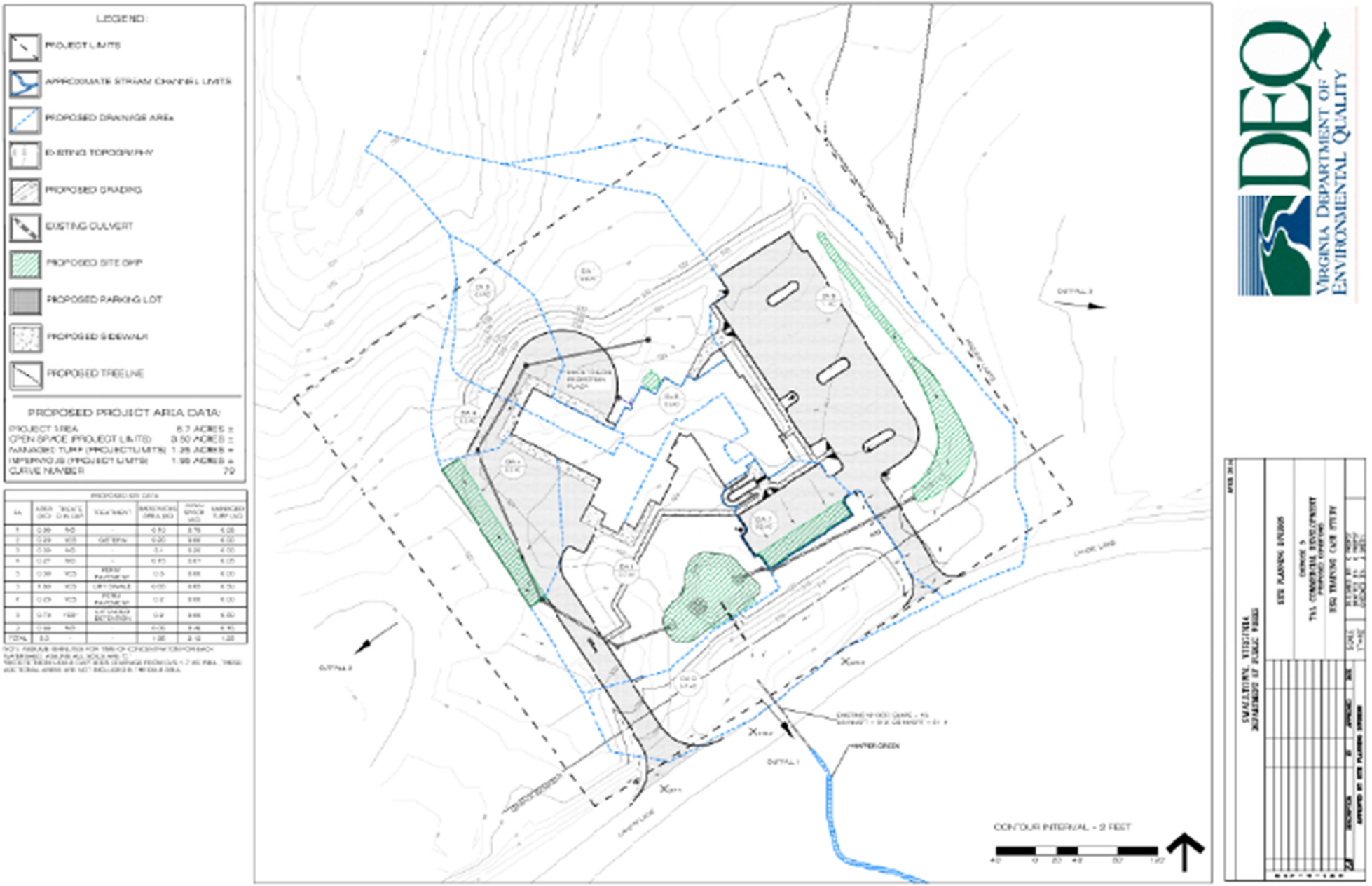
CONTOUR INTERVAL = 2 FEET

Proposed


LEGEND:
PROJECT LIMITS
APPROXIMATE STREAM CHANNEL LIMITS
PROPOSED DRAINAGE AREA
EXISTING TOPOGRAPHY
PROPOSED GRADING
EXISTING CULVERT
PROPOSED SITE OPP
PROPOSED PARKING LOT
PROPOSED SIDEWALK
PROPOSED TREELINE
PROPOSED PROJECT AREA DATA:
PROJECT AREA 6.7 ACRES ±
OPEN SPACE (PROJECT LIMITS) 3.50 ACRES ±
IMPERVIOUS (PROJECT LIMITS) 1.99 ACRES ±
CURVE NUMBER 79
OUTFALL 2
OUTFALL 3
OUTFALL 1
CONTOUR INTERVAL - 2 FEET
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Exercise 5: Bringing It All Together

Review a set of plans and determine:

1. Post-development total phosphorus load and reduction required
2. Site treatment volume and average efficiency needed
3. Allowable discharge for the one-year storm from the site and whether energy balance criteria are satisfied *(channel protection criteria)*
4. Any issues associated with proposed BMPs

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Question 1

- Narrative booklet, p. 8
- Appendix A, p. 11
- Proposed plan sheet (area summary)

Post-development total phosphorus load and reduction required:

Question 1

- Narrative booklet, p. 8
- Appendix A, p. 11
- Proposed plan sheet (area summary)

Post-development total phosphorus load and reduction required:

- ❑ Did they include a water quality compliance summary?
- ❑ Verify project areas listed on plan sheets correspond with spreadsheet summary
- ❑ Verify total phosphorus load and reduction requirement

Question 1

- Narrative booklet, p. 8
- Appendix A, p. 11
- Proposed plan sheet (area summary)

Post-development total phosphorus load and reduction required:

- ☑ Did they include a water quality compliance summary?
- ❑ Verify project areas listed on plan sheets correspond with spreadsheet summary
- ❑ Verify total phosphorus load and reduction requirement

Narrative Booklet, Page 12

DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 4.1

BMP Design Specifications List: **2024 Stds & Specs**

Site Summary

Project Title: NA

Date: NA

Site Land Cover Summary

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest (acres)	0.00	0.00	3.25	0.00	3.25	49
Mixed Open (acres)	0.00	0.00	0.25	0.00	0.25	4
Managed Turf (acres)	0.00	0.00	1.25	0.00	1.25	19
Impervious Cover (acres)	0.00	0.00	1.95	0.00	1.95	29
					6.70	100

Site Tv and Land Cover Nutrient Loads

Site Rv	0.34
Treatment Volume (ft^3)	0
TP Load (lb/yr)	2.97
TN Load (lb/yr)	38.97

Total TP Load Reduction Required (lb/yr)	0.00

Site Compliance Summary

Total Runoff Volume Reduction (ft^3)	2,981
Total TP Load Reduction Achieved (lb/yr)	1.31
Total TN Load Reduction Achieved (lb/yr)	16.45
Remaining Post Development TP Load (lb/yr)	1.66
Remaining TP Load Reduction (lb/yr) Required	0.00

** TARGET TP REDUCTION EXCEEDED BY 0.09 LB/YEAR **

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Narrative Booklet, Page 8

7 Compliance Summary

Several measures were taken to reduce the impact of the proposed development on the downstream areas. A summary is provided below.

Table 7-1: Water Quality Compliance Summary

Post-development Load (lbs/yr)	Required Load Reduction (lbs/yr)	Provided Load Reduction (lbs/yr)	Post-development Adjusted Load (lbs/yr)
2.97	1.23	1.31	1.66

The BMPs collectively reduce TP by **1.31 lb/yr** which exceeds the reduction requirement of **1.23 lb/yr.** The Water quantity compliance is assessed at the single outlet point from the site, the existing culvert that is located along Landry Lane. The channel protection summary is provided in the table below:

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Proposed Plan Sheet

PROPOSED PROJECT AREA DATA:

PROJECT AREA	6.7 ACRES ±
CPEN SPACE (PROJECT LIMITS)	3.50 ACRES ±
MANAGED TURF (PROJECT LIMITS)	1.25 ACRES ±
IMPERVIOJS (PROJECT LIMITS)	1.95 ACRES ±
CURVE NUMBER	79

PROPOSED SITE DATA

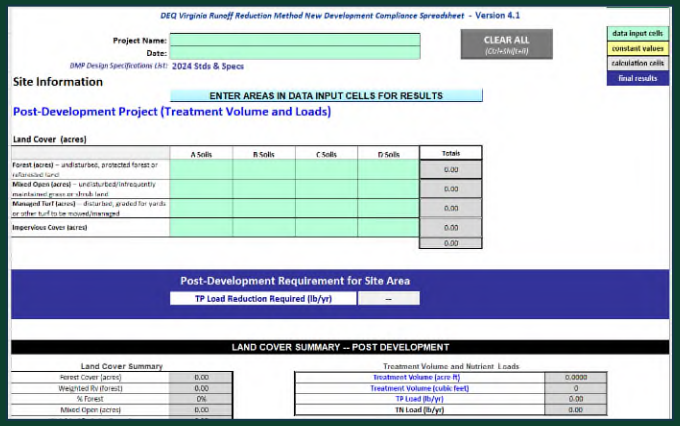
DA	AREA (AC)	TREATED IN DA?	TREATMENT	IMPERVIOUS AREA (AC)	OPEN SPACE (AC)	MANAGED TURF (AC)
1	0.90	NO	-	0.10	0.75	0.05
2	0.20	YES	CISTERN	0.20	0.00	0.00
3	0.30	NO	-	0.1	0.20	0.00
4	0.27	NO	-	0.15	0.07	0.05
5	0.30	YES	PERM. PAVEMENT	0.3	0.00	0.00
6	1.80	YES	DRY SWALE	0.65	0.65	0.50
7	0.20	YES	PERM. PAVEMENT	0.2	0.00	0.00
8	0.70	YES*	EXTENDED DETENTION	0.2	0.00	0.50
9	0.66	NO	-	0.05	0.46	0.15
TOTAL	5.3	-	-	1.95	2.13	1.25

NOTE: ASSUME 5 MINUTES FOR TIME OF CONCENTRATION FOR EACH WATERSHED. ASSUME ALL SOILS ARE 'C.'
*BICRETETNION IN DA 8 CAPTURES DRAINAGE FROM DAS 1-7 AS WELL, THESE ADDITIONAL AREAS ARE NOT INCLUDED IN THE DA 8 AREA.

Question 1

Post-development total phosphorus load and reduction required:

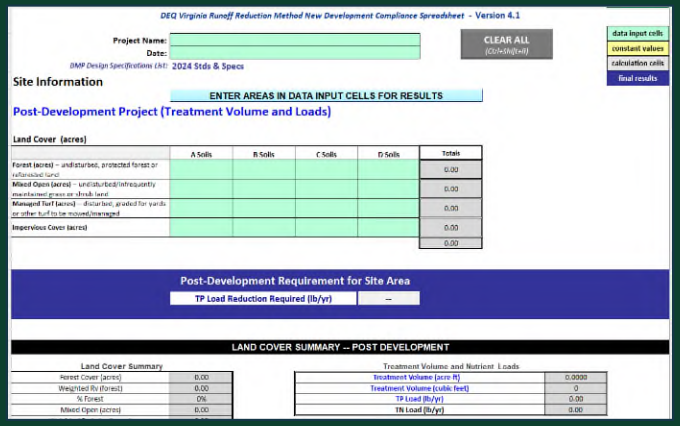
- [x] Did they include a water quality compliance summary?
- [ ] Do the project areas listed on plan sheets correspond with spreadsheet summary
- [ ] Verify total phosphorus load and reduction requirement



Question 1

Post-development total phosphorus load and reduction required:

- ☑ Did they include a water quality compliance summary?
- ☒ Do the project areas listed on plan sheets correspond with spreadsheet summary
- ☐ Verify total phosphorus load and reduction requirement



Verify Phosphorous Load and Required Reduction

Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			3.25		3.25 *
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land			0.25		0.25
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			1.25		1.25
Impervious Cover (acres)			1.95		1.95
					6.70

** Forest and Mixed Open areas must be protected in accordance with the Virginia Runoff Reduction Method*

Post-Development Requirement for Site Area	
TP Load Reduction Required (lb/yr)	1.23

Phosphorus reduction requirement = 1.23

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summar	
Forest Cover (acres)	
Weighted Rv (forest)	
% Forest	
Mixed Open (acres)	
Weighted Rv (mixed open)	
% Mixed Open	4%
Managed Turf Cover (acres)	1.25
Weighted Rv (turf)	0.22
% Managed Turf	19%
Impervious Cover (acres)	1.95

Phosphorous load discharged from site = 2.97 lbs/yr

Treatment Volume and Nutrient Loads	
Treatment Volume (acre-ft)	0.1908
Treatment Volume (cubic feet)	8,313
TP Load (lb/yr)	2.97
TN Load (lb/yr)	38.97

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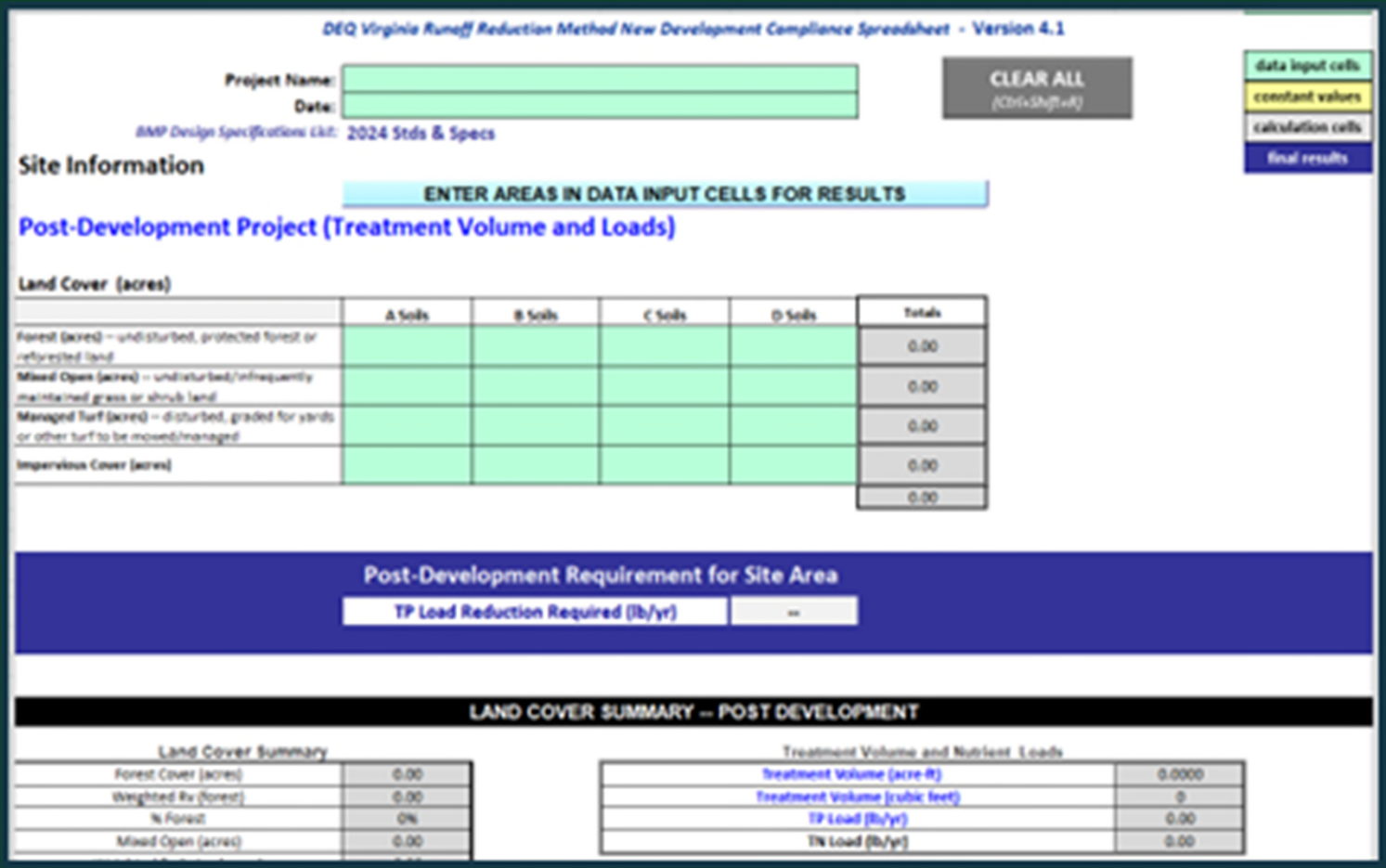
Question 2

Target (or Site) treatment volume and average efficiency needed?



DEQ Virginia Runoff Reduction Method New Development Compliance Spreadsheet - Version 4.1

Project Name:
Date:
BMP Design Specifications List: 2024 Stds & Specs

CLEAR ALL (Ctrl+Shift+R)

data input cells
constant values
calculation cells
final results

Site Information

ENTER AREAS IN DATA INPUT CELLS FOR RESULTS

Post-Development Project (Treatment Volume and Loads)

Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed					0.00
Impervious Cover (acres)					0.00
					0.00

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	--

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary

Forest Cover (acres)	0.00
Weighted Rv (forest)	0.00
% Forest	0%
Mixed Open (acres)	0.00

Treatment Volume and Nutrient Loads

Treatment Volume (acre-ft)	0.0000
Treatment Volume (cubic feet)	0
TP Load (lb/yr)	0.00
TN Load (lb/yr)	0.00

Proposed Total Phosphorous Load and Required Reduction

Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			3.25		3.25 *
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land			0.25		0.25
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			1.25		
Impervious Cover (acres)			1.95		

** Forest and Mixed Open areas must be protected in accordance with the Virginia Runoff Reduction Method*

Average efficiency
= Reduction required
÷ phosphorous load

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	1.23

= 1.23/2.97
= 41%

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary

Forest Cover (acres)	3.25
Weighted Rv (forest)	0.04
% Forest	49%
Mixed Open (acres)	0.25
Weighted Rv (mixed open)	0.13
% Mixed Open	4%
Managed Turf Cover (acres)	1.25
Weighted Rv (turf)	0.22
% Managed Turf	19%
Impervious Cover (acres)	1.95

Treatment Volume and Nutrient Loads

Treatment Volume (acre-ft)	0.1908
Treatment Volume (cubic feet)	8,313
TP Load (lb/yr)	2.97
TN Load (lb/yr)	38.97

Site treatment volume
= 8,231 cubic feet

Question 3 *(Channel Protection)*

- Narrative booklet p.4, 9
- Appendix B, p. 16

a. Allowable discharge from site for a one-year storm?

b. Is energy balance criteria satisfied?

Evaluate the energy balance calculation shown in the narrative booklet.

Is the allowable release rate calculated correctly?

Question 3 *(Channel Protection)*

- Narrative booklet p.4, 9
- Appendix B, p. 16

a. Allowable discharge from site for a one-year storm?

Question 3 *(Channel Protection)*

a. Allowable discharge from site for a one-year storm?

Allowable discharge is 4.1 cubic feet per second (cfs)

Table 7-2: Water Quantity, Channel Protection Compliance Summary

Q_{Pre}, 1year (cfs)	V_{Pre}, 1 year (Ac-ft)	$Q_{Allowable}$, 1 year (cfs)	Q_{Post}, 1 year (cfs)	V_{Post}, 1 year (Ac-ft)
3.62	0.43	4.1	3.56	0.38

The channel protection criteria are met as 3.56 cfs is less than the allowable 1-year peak discharge of 4.1 cfs. The flood protection criteria is summarized below:

Narrative Booklet, p. 9 *(Compliance Summary)*

Question 3 *(Channel Protection)*

- Narrative booklet p.4, 9
- Appendix B, p. 16

a. Allowable discharge from site for a one-year storm? **4.1 cfs**

b. Is energy balance criteria satisfied?

Evaluate the energy balance calculation shown in the narrative booklet.

Is the allowable release rate calculated correctly?

Question 3 *(Channel Protection)*

Existing discharge is 3.62 cfs

Allowable discharge is 4.1 cfs

Proposed design discharge is 3.56 cfs

Table 7-2: Water Quantity, Channel Protection Compliance Summary

Q_{Pre}, 1year (cfs)	V_{Pre}, 1 year (Ac-ft)	$Q_{Allowable}$, 1 year (cfs)	Q_{Post}, 1 year (cfs)	V_{Post}, 1 year (Ac-ft)
3.62	0.43	4.1	3.56	0.38

The channel protection criteria are met as 3.56 cfs is less than the allowable 1-year peak discharge of 4.1 cfs. The flood protection criteria is summarized below:

Narrative Booklet, p. 9 *(Compliance summary)*

Question 3 *(Channel Protection)*

- Narrative booklet p.4, 9
- Appendix B, p. 16

4.2.3 Water Quantity Requirements

A. Channel Protection Requirement - The site drains concentrated stormwater flow into a natural stormwater conveyance system. Therefore, the energy balance equation must be satisfied for the 1-year storm. The energy balance equation is:

$$Q_{1,post} x\ Vpost \leq Q_{1,pre} x\ Vpre$$

Where **Qpre = 3.6 cfs** and **Vpre = 0.43 Acre-ft**. The Vpost and Qpost shall be less than the product of Qpre and Vpre. $Q_{allowable}$ is 4.1 cfs. See Appendix B for detailed calculations.

Narrative Booklet, p. 4 *(Site Drainage and Hydrology)*

Question 3 *(Channel Protection)*

Energy Balance:

$$Q_{post} \leq Q_{pre}\left(\frac{V_{pre}}{V_{post}}\right)$$

$$= 3.6\left(\frac{0.43}{0.33}\right)$$

$$= 4.7\ cfs$$

Allowable Q_1 > Proposed Q_1

Problems?

Appendix B, p. 16

Question 3 *(Channel Protection)*

Energy Balance:

$$Q_{post} \leq Q_{pre}\left(\frac{V_{pre}}{V_{post}}\right)$$

$$= 3.6\left(\frac{0.43}{0.33}\right)$$

$$= 4.7\ cfs$$

Allowable Q_1 > Proposed Q_1

Used energy balance to show compliance

but did not include improvement factor (IF)

☒

Allowable release rate not calculated correctly

Appendix B, p. 16

Question 3 *(Channel Protection)*

Energy Balance:

$$Q_{post} \leq Q_{pre}\left(\frac{V_{pre}}{V_{post}}\right)$$

$$= 3.6\left(\frac{0.43}{0.33}\right)$$

$$= 4.7\ cfs$$

Allowable Q_1 > Proposed Q_1

What else should we check?

Hint:
What are the inputs for flow and volume?

Appendix B, p. 16

Question 3 *(Channel Protection)*

Energy Balance:

$$Q_{post} \leq Q_{pre}\left(\frac{V_{pre}}{V_{post}}\right)$$

$$= 3.6\left(\frac{0.43}{0.33}\right)$$

$$= 4.7\ cfs$$

Allowable Q_1 > Proposed Q_1

What else should we check?

Hint:
What are the inputs for flow and volume?

Precipitation (P)
Time of Concentration (Tc)
Curve Number (CN)

Appendix B, p. 16

Question 3 *(Channel Protection)*

Table 4-1: Precipitation, 24 hour storm events for select storm events

	1-year	2-year	10-year	100-year
24-hour total	2.6 in	3.6 in	5.6 in	9.3 in

Precipitation (P) given

Narrative, p. 3

Question 3 *(Channel Protection)*

Pre-development Tc = 22 minutes

Post-development Tc = 5 minutes

Narrative, p. 2–3

Question 3 *(Channel Protection)*

Curve numbers:

What are the pre- and post-development CNs?

Are they reasonable?

Inputs:

- [x] **P**
- [x] **Tc**
- [ ] **CN**

Narrative, p. 2–3

Question 3 *(Channel Protection)*

Curve numbers:

What are the pre- and post-development CNs?

pre CN = 79 post CN=78

Are they reasonable?

Inputs:

- [x] **P**
- [x] **Tc**
- [ ] **CN**

Narrative, p. 2–3

Channel Protection Compliance

Appendix B: Water Quantity Calculations

Existing Conditions:

Pre: $S = \frac{1000}{CN} - 10 = \frac{1000}{79} - 10 = 2.7in$

$$q_{pre} = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{(2.6 - (0.2 \times 2.7))^2}{2.6 + (0.8 \times 2.7)} = 0.90\ in$$

$V_{pre} = q\ x\ A\ x\ \frac{1}{12} = 0.90\ in\ x\ 5.7\ Ac\ x\ \frac{1\ ft}{12\ in} =$ **$0.43\ Acre - ft$**

Appendix B, p. 16

Channel Protection Compliance

4 Site Drainage and Hydrology

4.1 Existing Site Hydrology and Drainage

Currently there is one primary drainage area of approximately 5.8 acres draining the site. It begins just north of the northern edge of the property and flows overland to the existing culvert along the southern edge of the property that drains under Landry Lane, which serves as the outlet from the site. The culvert then outfalls to Harper Creek on the other side of the road. The existing culvert is an 18" concrete pipe that is undersized for the site currently. Large storms every few years flood the road. Flows also exit the pipe at high velocities and have caused severe erosion downstream. The time of concentration (Tc) was estimated as 22 minutes and the curve number (CN) equal to 79 based on fair existing site conditions.

Narrative Booklet, p. 2 *(Site Drainage and Hydrology)*

Curve Number

A pre-development curve number of 79 was given

Runoff Volume and CN Calculations

	1-year storm	2-year storm	10-year storm
Target Rainfall Event (in)	2.60	0.00	0.00

Drainage Areas	RV & CN	Drainage Area A	Drainage Area B	Drainage Area C	Drainage Area D	Drainage Area E
CN		79	0	0	0	0
RR (ft^3)		2,981	0	0	0	0
1-year return period	RV wo RR (ws-in)	0.91	0.00	0.00	0.00	0.00
	RV w RR (ws-in)	0.78	0.00	0.00	0.00	0.00
	CN adjusted	76	0	0	0	0
2-year return period	RV wo RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	RV w RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	CN adjusted	100	0	0	0	0
10-year return period	RV wo RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	RV w RR (ws-in)	0.00	0.00	0.00	0.00	0.00
	CN adjusted	100	0	0	0	0

Using curve numbers in channel and flood protection (now the Runoff Volume and CN tab): composite post-development curve number is 76

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Question 3 *(Channel Protection)*

Existing CN: 79

- Based on fair existing site conditions

TR-55 User's Manual
Table 2-2A
curve number for good existing site conditions
at most **74**

Narrative, p. 2–3

Inputs:

- ☑ **P**
- ☑ **Tc**
- ☒ **CN**

For existing conditions

- Assume good

Question 3 *(Channel Protection)*

Appendix B: Water Quantity Calculations

Existing Conditions:

Pre: $S = \frac{1000}{CN} - 10 = \frac{1000}{79} - 10 = 2.7\ in$

$$q_{pre} = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{(2.6 - (0.2 \times 2.7))^2}{2.6 + (0.8 \times 2.7)} = 0.90\ in$$

$$V_{pre} = q \times A \times \frac{1}{12} = 0.90\ in \times 5.7\ Ac \times \frac{1ft}{12in} = \mathbf{0.43\ Acre - ft}$$

Proposed Conditions:

Post: $S = \frac{1000}{CN} - 10 = \frac{1000}{76} - 10 = 3.16\ in$

$$q_{post} = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{(2.6 - (0.2 \times 3.16))^2}{2.6 + (0.8 \times 3.16)} = 0.76\ in$$

$$V_{post} = q \times A \times \frac{1}{12} = 0.76\ in \times 5.3\ Ac \times \frac{1ft}{12in} = \mathbf{0.33\ Acre - ft}$$

Appendix B, p. 16

Note:
Pre-development drainage area (DA) = 5.7 acres

Post-development DA = 5.3 acres

Question 3 *(Channel Protection)*

$$Pre\ S = \left(\frac{1000}{74}\right) - 10 = \left(\frac{1000}{74}\right) - 10 = 3.5\ in$$

$$Q_{1pre} = \left(\frac{(P - 0.2S)^2}{P + 0.8S}\right) = \left(\frac{(2.6 - 0.2 \times 3.5)^2}{2.6 + 0.8 \times 3.5}\right) = 0.67\ in$$

$$Vr_{1pre} = Q \times A \times \frac{1\ ft}{12\ in}$$

$$= 0.67\ in \times 5.7 ac \times \frac{1\ ft}{12\ in}$$

$$= 0.32\ ac\ ft$$

Question 3 *(Channel Protection)*

Energy Balance:

$$Q_{post} \leq Q_{pre}\left(\frac{V_{pre}}{V_{post}}\right)$$

$$= 3.6\left(\frac{0.43}{0.33}\right)$$

$$= 4.7\ cfs$$

Allowable Q_1 > Proposed Q_1

Pre-development volume
= 0.32 acre feet

Appendix B, p. 16

Question 3 *(Channel Protection)*

$$q_{1post}$$

$$\leq q_{1pre}\left(\frac{Vr_{1pre}}{Vr_{1post}}\right)(IF)$$

$$= 3.6\left(\frac{0.32}{0.33}\right)(0.8)$$

$$= 2.8\ cfs$$

☒

Allowable release rate of 4.1 cubic feet per second is incorrect

Question 3 *(Channel Protection)*

Proposed design discharge is 3.56 cfs

Table 7-2: Water Quantity, Channel Protection Compliance Summary

Q_{Pre}, 1year (cfs)	V_{Pre}, 1 year (Ac-ft)	$Q_{Allowable}$, 1 year (cfs)	Q_{Post}, 1 year (cfs)	V_{Post}, 1 year (Ac-ft)
3.62	0.43	4.1	3.56	0.33

The channel protection criteria are met as 3.56 cfs is less than the allowable 1-year peak discharge of 4.1 cfs. The flood protection criteria is summarized below:

Narrative Booklet, p. 9 *(Compliance summary)*

Question 3 *(Channel Protection)*

$$q_{1post}$$

$$\leq q_{1pre}\left(\frac{Vr_{1pre}}{Vr_{1post}}\right)(IF)$$

$$= 3.6\left(\frac{0.32}{0.33}\right)(0.8)$$

$$= 2.8\ cfs$$

Used energy balance to show compliance

- Proposed design discharge is 3.56 cfs
- Less than existing site discharge of 3.6 cfs

☒ **BUT** not low enough to meet energy balance requirements

☒ Allowable release rate incorrect

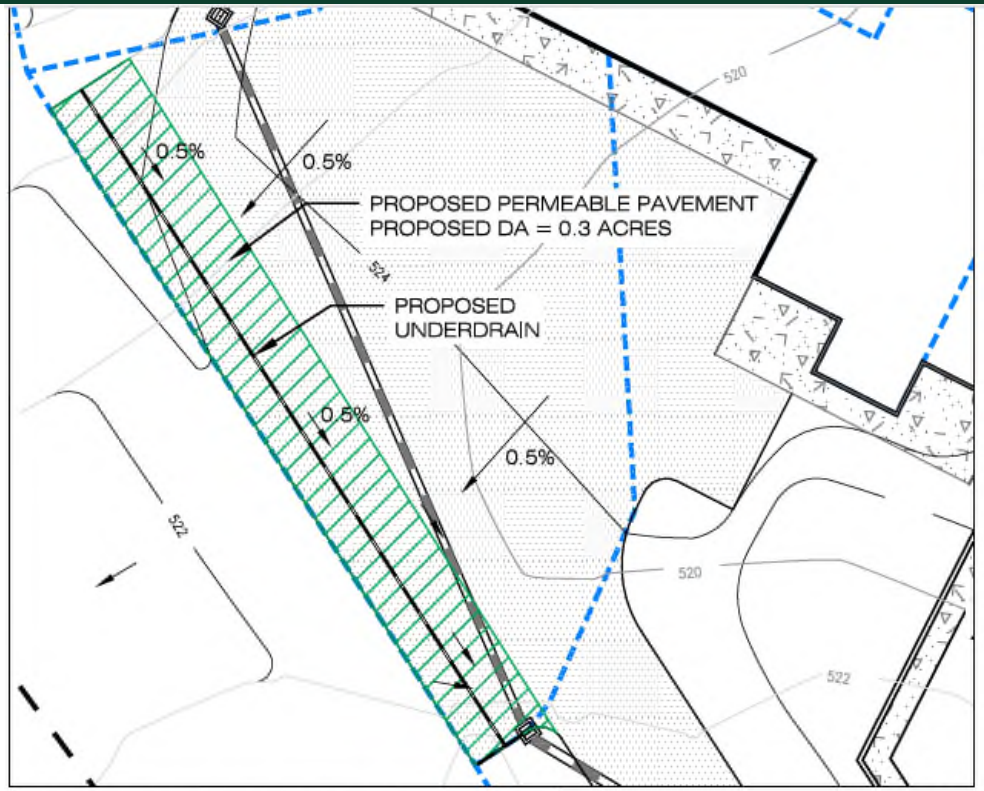
****Does not meet compliance requirements**

P-BMPs:

Permeable pavement
Cistern
Dry swale
Extended detention pond

Permeable Pavement

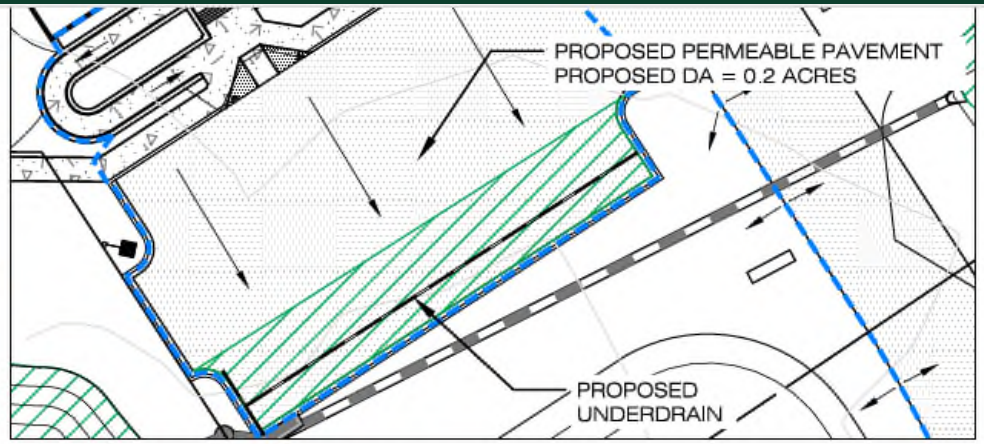
Permeable Pavement (P-FIL-03)



PROPOSED DA 4 CHARACTERISTICS:
AREA = 0.3 ACRES
IMPERVIOUS ACREAGE = 0.3 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.42 CFS
10 YR DISCHARGE = 1.57 CFS

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 0.65 LBS
EFFICIENCY OF BMP = 25%
VOLUME TO BMP = 1035 C.F.
RUNOFF REDUCTION BY PRACTICE
=466 C.F
TOTAL PHOSPHOROUSLOAD REDUCTION
=0.38 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.27 LBS

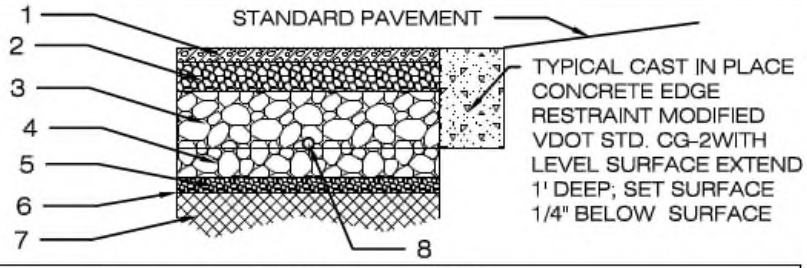
PERMEABLE PAVEMENT SIZING
DESIGNED IN ACCORDANCE WITH LEVEL 1
DESIGN GUIDELINES
CONTRIBUTING TOTAL AREA = 0.3 ACRES
SURFACE AREA PROVIDED = 3,030 S.F.
Tv PROVIDED = 196 C.F.



PROPOSED DA 7 CHARACTERISTICS:
AREA = 0.2 ACRES
IMPERVIOUS ACREAGE = 0.2 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.60 CFS
10 YR DISCHARGE = 1.41 CFS

PHOSPHOROUS REDUCTION CALCULATIONS (DA7):
LOAD TO BMP = 0.43
MASS LOAD EFFICIENCY = 59%
VOLUME TO BMP = 689 C.F.
RUNOFF REDUCTION BY PRACTICE
=310 C.F
TOTAL PHOSPHOROUSLOAD REDUCTION
=0.25 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.18 LBS

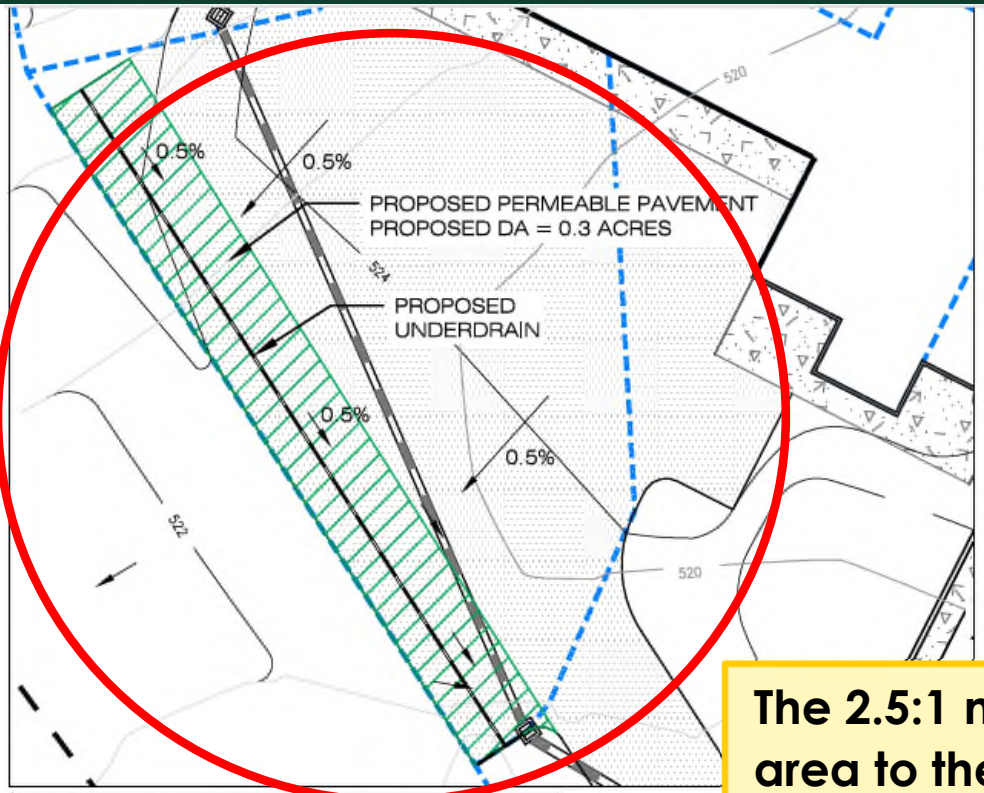
PERMEABLE PAVEMENT SIZING (DA7):
DESIGNED IN ACCORDANCE WITH LEVEL 1
DESIGN GUIDELINES
CONTRIBUTING TOTAL AREA = 0.2 ACRES
SURFACE AREA PROVIDED = 1,706 S.F.
Tv PROVIDED = 111 C.F.

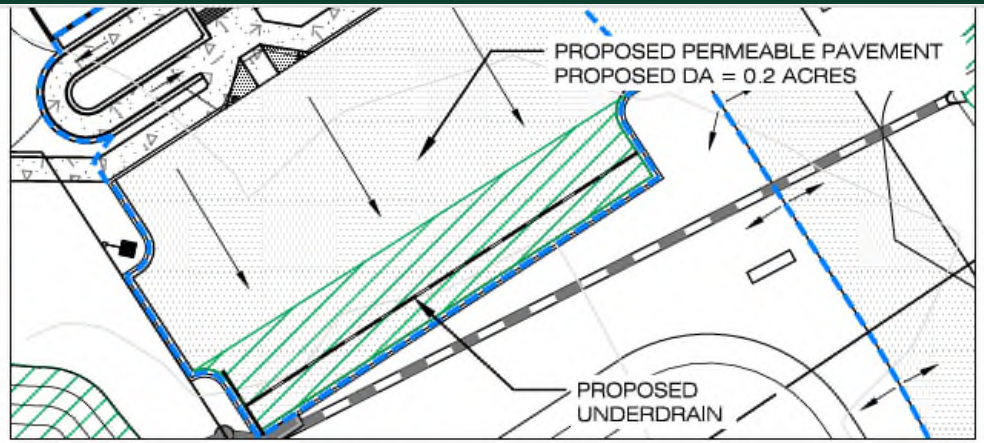


PAVEMENT LAYERS		
1	SURFACE LAYER	POROUS ASPHALT
2	BEDDING	4" NO. 57 STONE
3	RESERVOIR	12" NO. 2 STONE
4	INFILTRATION SUMP	SAME AS RESERVOIR LAYER
5	BOTTOM FILTER	4' NO. 8 STONE
6	IMPERMEABLE LINER	NECESSARY DUE TO PLACEMENT ON FILL
7	UNCOMPACTED SYBGRADE	4' TO BE SCARIFIED PRIOR TO INSTALLATION
8	UNDERDRAIN	6" PVC, SCHEDULE 40

PERMEABLE PAVEMENT TYPICAL CROSS-SECTION

Permeable Pavement (P-FIL-03)





PROPOSED DA 7 CHARACTERISTICS:
AREA = 0.2 ACRES
IMPERVIOUS ACREAGE = 0.2 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.60 CFS
10 YR DISCHARGE = 1.41 CFS

The 2.5:1 maximum flow area to the permeable pavement is not satisfied

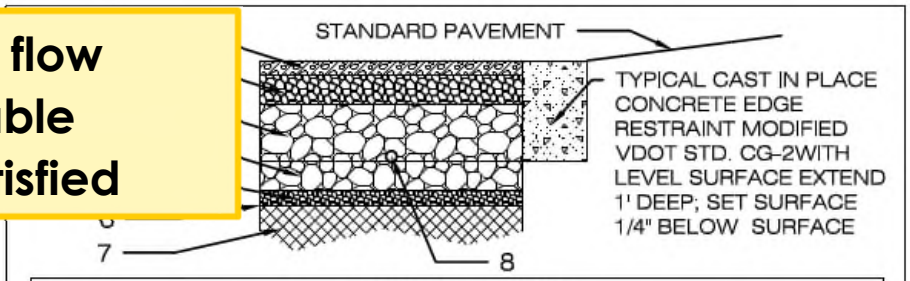
PROPOSED DA 4 CHARACTERISTICS:
AREA = 0.3 ACRES
IMPERVIOUS ACREAGE = 0.3 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.42 CFS
10 YR DISCHARGE = 1.57 CFS

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 0.65 LBS
EFFICIENCY OF BMP = 25%
VOLUME TO BMP = 1035 C.F.
RUNOFF REDUCTION BY PRACTICE
=466 C.F
TOTAL PHOSPHOROUSLOAD REDUCTION
=0.38 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.27 LBS

PERMEABLE PAVEMENT SIZING
DESIGNED IN ACCORDANCE WITH LEVEL 1 DESIGN GUIDELINES
CONTRIBUTING TOTAL AREA = 0.3 ACRES
SURFACE AREA PROVIDED = 3,030 S.F.
Tv PROVIDED = 196 C.F.

PHOSPHOROUS REDUCTION CALCULATIONS (DA7):
LOAD TO BMP = 0.43
MASS LOAD EFFICIENCY = 59%
VOLUME TO BMP = 689 C.F.
RUNOFF REDUCTION BY PRACTICE
=310 C.F
TOTAL PHOSPHOROUSLOAD REDUCTION
=0.25 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.18 LBS

PERMEABLE PAVEMENT SIZING (DA7):
DESIGNED IN ACCORDANCE WITH LEVEL 1 DESIGN GUIDELINES
CONTRIBUTING TOTAL AREA = 0.2 ACRES
SURFACE AREA PROVIDED = 1,706 S.F.
Tv PROVIDED = 111 C.F.



PAVEMENT LAYERS		
1	SURFACE LAYER	POROUS ASPHALT
2	BEDDING	4" NO. 57 STONE
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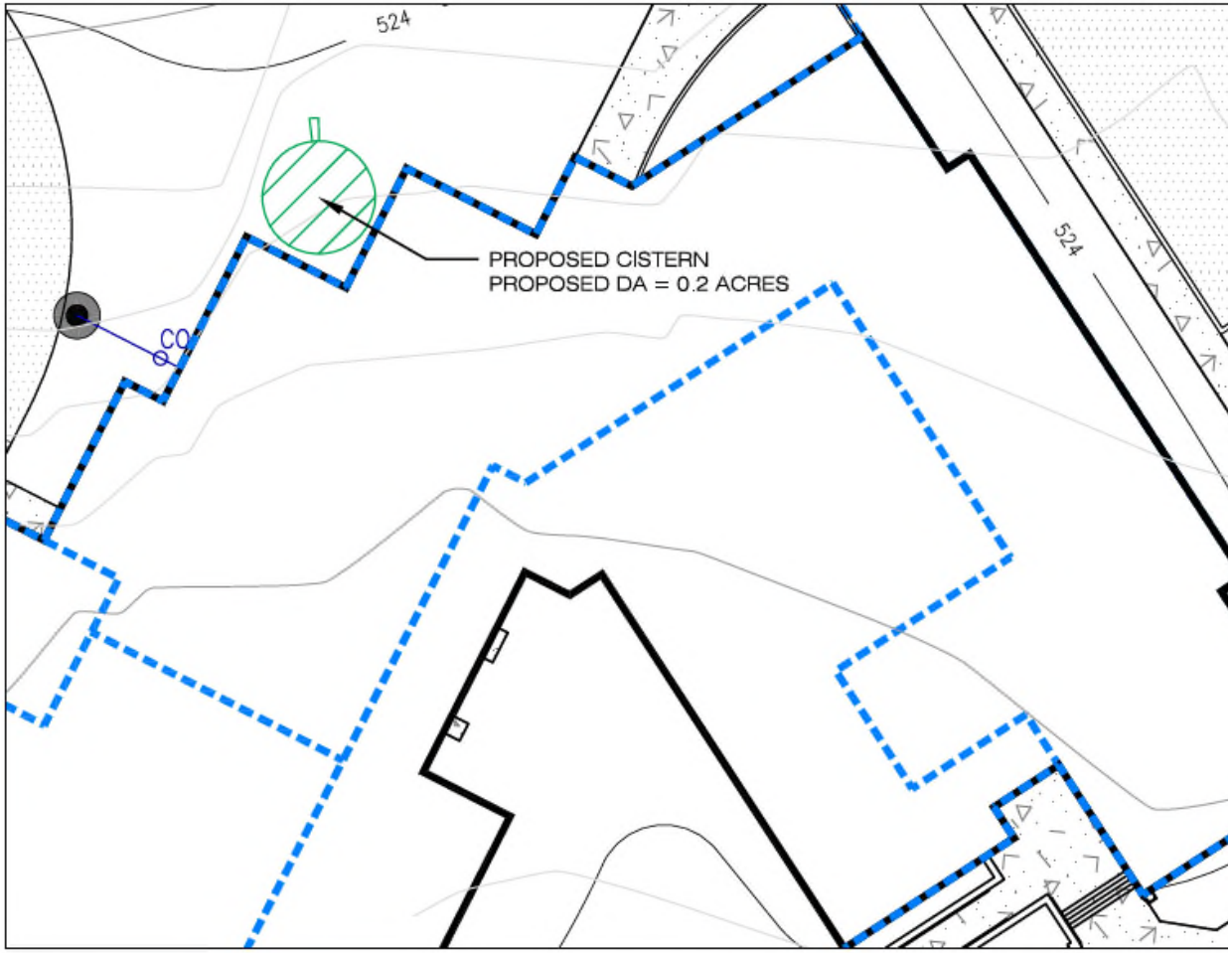
4	INFILTRATION SUMP	SAME AS RESERVOIR LAYER
5	BOTTOM FILTER	4' NO. 8 STONE
6	IMPERMEABLE LINER	NECESSARY DUE TO PLACEMENT ON FILL
7	UNCOMPACTED SYBGRADE	4' TO BE SCARIFIED PRIOR TO INSTALLATION
8	UNDERDRAIN	6" PVC, SCHEDULE 40

PERMEABLE PAVEMENT TYPICAL CROSS-SECTION

Cistern

Cistern (P-BAS-04)



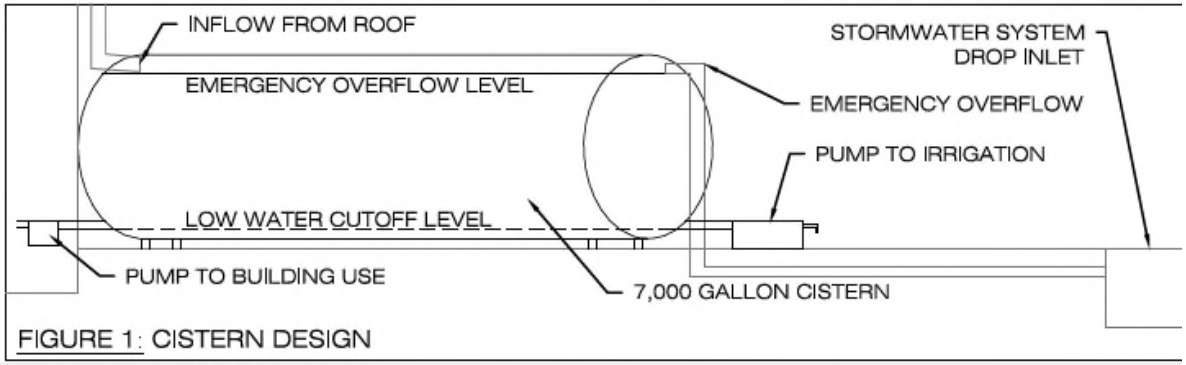


FIGURE 1: CISTERN DESIGN

PROPOSED DRAINAGE AREA CHARACTERISTICS:

AREA = 0.2 ACRES

IMPERVIOUS ACREAGE = 0.2 ACRES

CURVE NUMBER: 98

TIME OF CONCENTRATION: 5 MINUTES

1 YR DISCHARGE = 0.51 CFS

2 YR DISCHARGE = 0.78 CFS

10 YR DISCHARGE = 1.33 CFS

CISTERN:

DESIGNED USING VA DEQ CISTERN DESIGN SPREADSHEET

ASSUMED:

- 0.2 ACRES OF ROOF DRAINAGE TO CONTRIBUTE TO CISTERN RUNOFF
- ASSUMED THAT MANAGED TURF AREA IN PROJECT SITE WOULD BE IRRIGATED DURING GROWING SEASON
- ASSUMED 70 PEOPLE WORK IN BUILDING

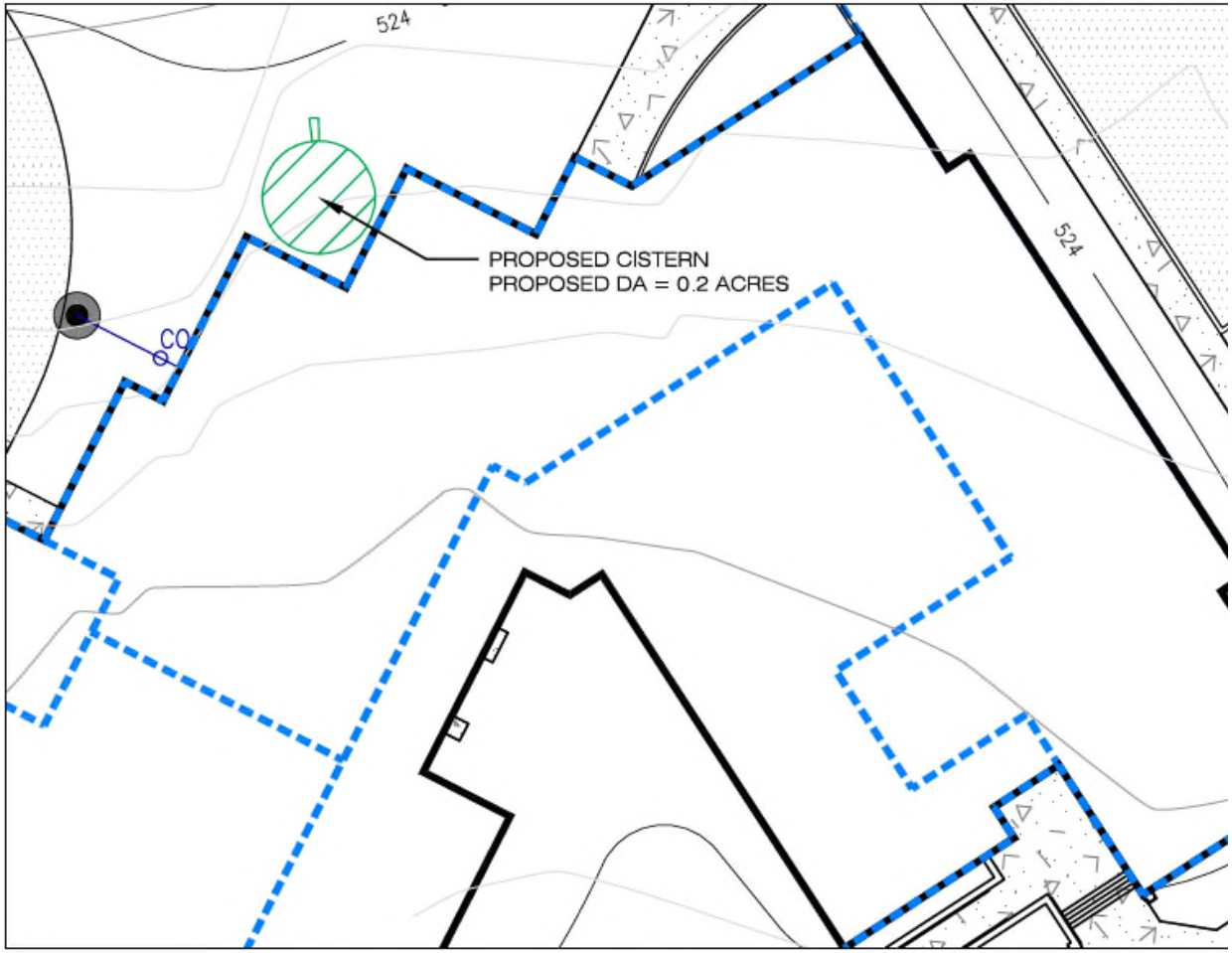
CISTERN REQUIRED TO HAVE 90% EFFICENCY

Cistern Storage Associated with Design Volume (gallons)	Average Annual Overflow days for storms <=1" (days/year)*	Average Annual Overflow Volume for storms <= 1" (1000's gal/year)*	Runoff Reduction Volume Credit
1,000	39	54	50%
2,000	28	35	67%
3,000	21	24	78%
5,000	12	14	87%
7,000	9	11	90%
10,000	7	8	92%
13,000	5	7	94%
18,000	4	5	95%

ACCORDING TO SPREADSHEET, THE TANK MUST BE 7,000 GALLONS IN ORDER TO BE 90% EFFICIENT

SEE FIGURE 1 ON THIS SHEET TO REVIEW SPREADSHEET TANK ASSUMPTIONS

Cistern (P-BAS-04)



PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 0.2 ACRES
IMPERVIOUS ACREAGE = 0.2 ACRES
CURVE NUMBER: 98
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 0.51 CFS
2 YR DISCHARGE = 0.78 CFS
10 YR DISCHARGE = 1.33 CFS

CISTERN:
DESIGNED USING VA DEQ CISTERN DESIGN SPREADSHEET
ASSUMED:
- 0.2 ACRES OF ROOF DRAINAGE TO CONTRIBUTE TO CISTERN RUNOFF
- ASSUMED THAT MANAGED TURF AREA IN PROJECT SITE WOULD BE IRRIGATED DURING GROWING SEASON
-ASSUMED 70 PEOPLE WORK IN BUILDING
CISTERN REQUIRED TO HAVE 90% EFFICENCY

Cistern Storage Associated with Design Volume (gallons)	Average Annual Overflow days for storms <=1" (days/year)*	Average Annual Overflow Volume for storms <= 1" (1000's gal/year)*	Runoff Reduction Volume Credit

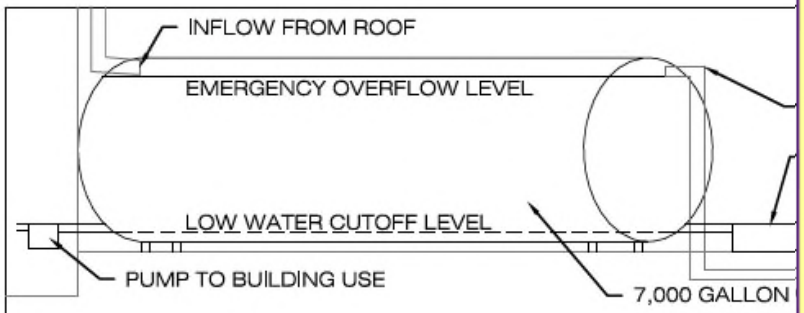
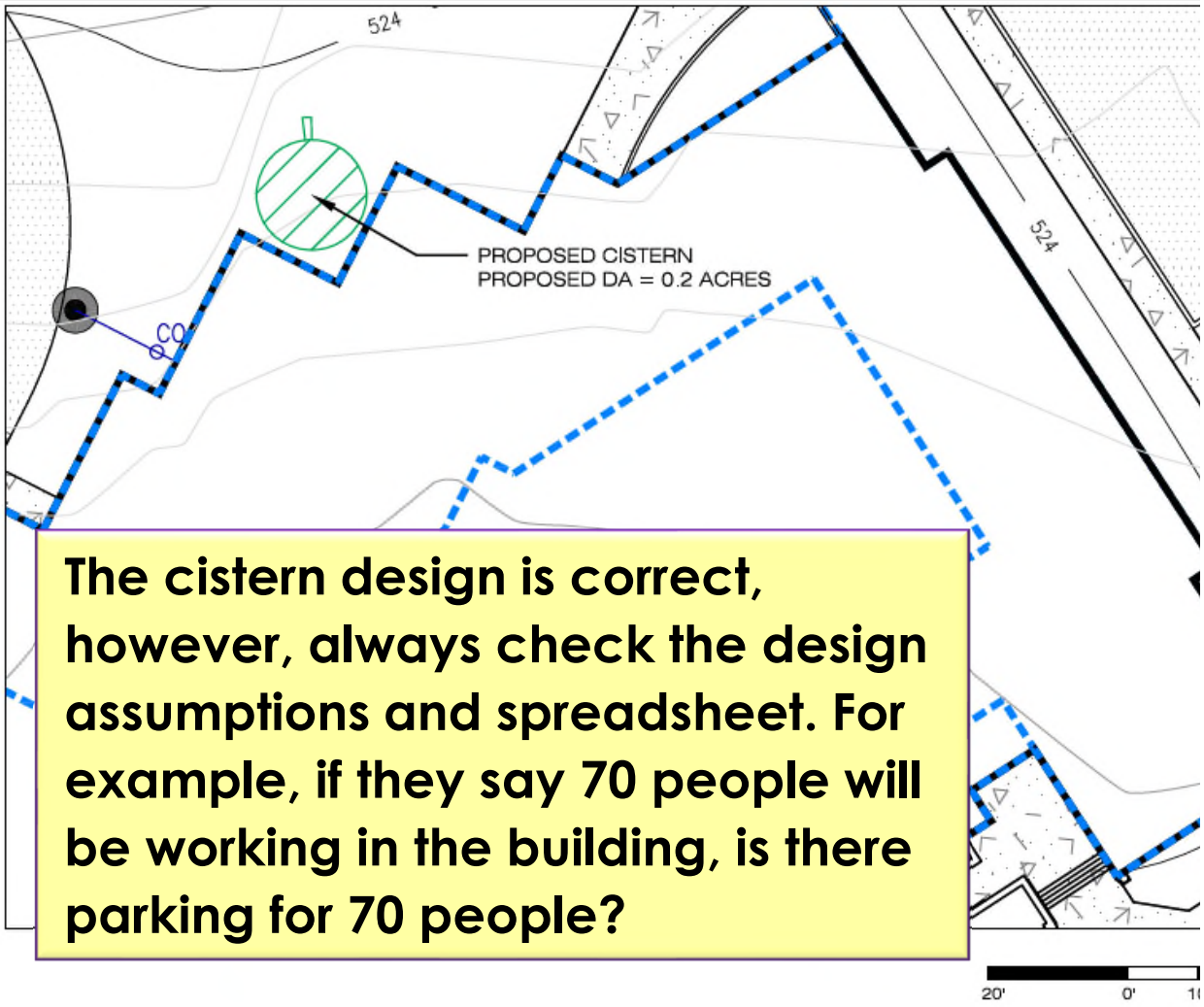


FIGURE 1: CISTERN DESIGN

Note: Specification recommends a soak away pit to meet seasonal demands (such as irrigation). Keep up with the changing regulations to ensure that designers also use the correct requirements for site design. Using old requirements for review may cause the design to be inadequate.

Cistern



The cistern design is correct, however, always check the design assumptions and spreadsheet. For example, if they say 70 people will be working in the building, is there parking for 70 people?

PROPOSED DRAINAGE AREA CHARACTERISTICS:

AREA = 0.2 ACRES

IMPERVIOUS ACREAGE = 0.2 ACRES

CURVE NUMBER: 98

TIME OF CONCENTRATION: 5 MINUTES

1 YR DISCHARGE = 0.51 CFS

2 YR DISCHARGE = 0.78 CFS

10 YR DISCHARGE = 1.33 CFS

CISTERN:

DESIGNED USING VA DEQ CISTERN DESIGN SPREADSHEET

ASSUMED:

- 0.2 ACRES OF ROOF DRAINAGE TO CONTRIBUTE TO CISTERN RUNOFF
- ASSUMED THAT MANAGED TURF AREA IN PROJECT SITE WOULD BE IRRIGATED DURING GROWING SEASON
- ASSUMED 70 PEOPLE WORK IN BUILDING

CISTERN REQUIRED TO HAVE 90% EFFICENCY

Cistern Storage Associated with Design Volume (gallons)	Average Annual Overflow days for storms <=1" (days/year)*	Average Annual Overflow Volume for storms <= 1" (1000's gal/year)*	Runoff Reduction Volume Credit
1,000	39	54	50%
2,000	28	35	67%
3,000	21	24	78%
5,000	12	14	87%
7,000	9	11	90%
10,000	7	8	92%
13,000	5	7	94%
18,000	4	5	95%

ACCORDING TO SPREADSHEET, THE TANK MUST BE 7,000 GALLONS IN ORDER TO BE 90% EFFICIENT

SEE FIGURE 1 ON THIS SHEET TO REVIEW SPREADSHEET TANK ASSUMPTIONS

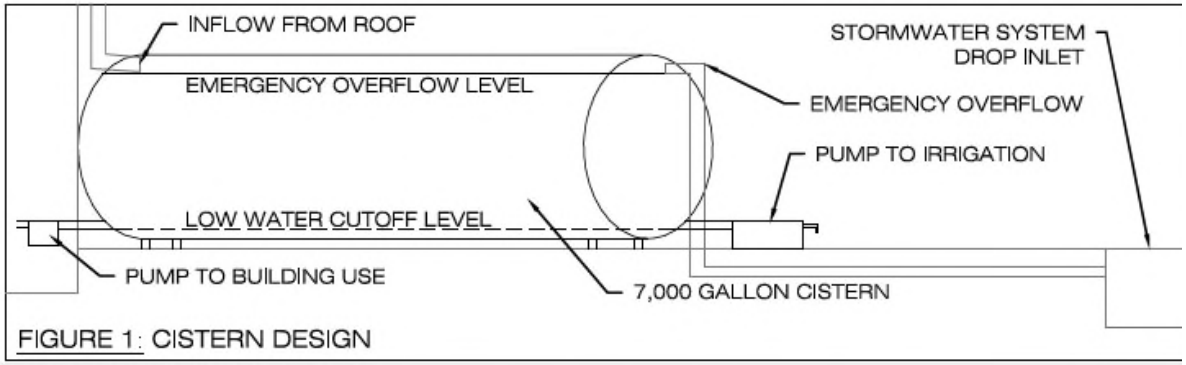
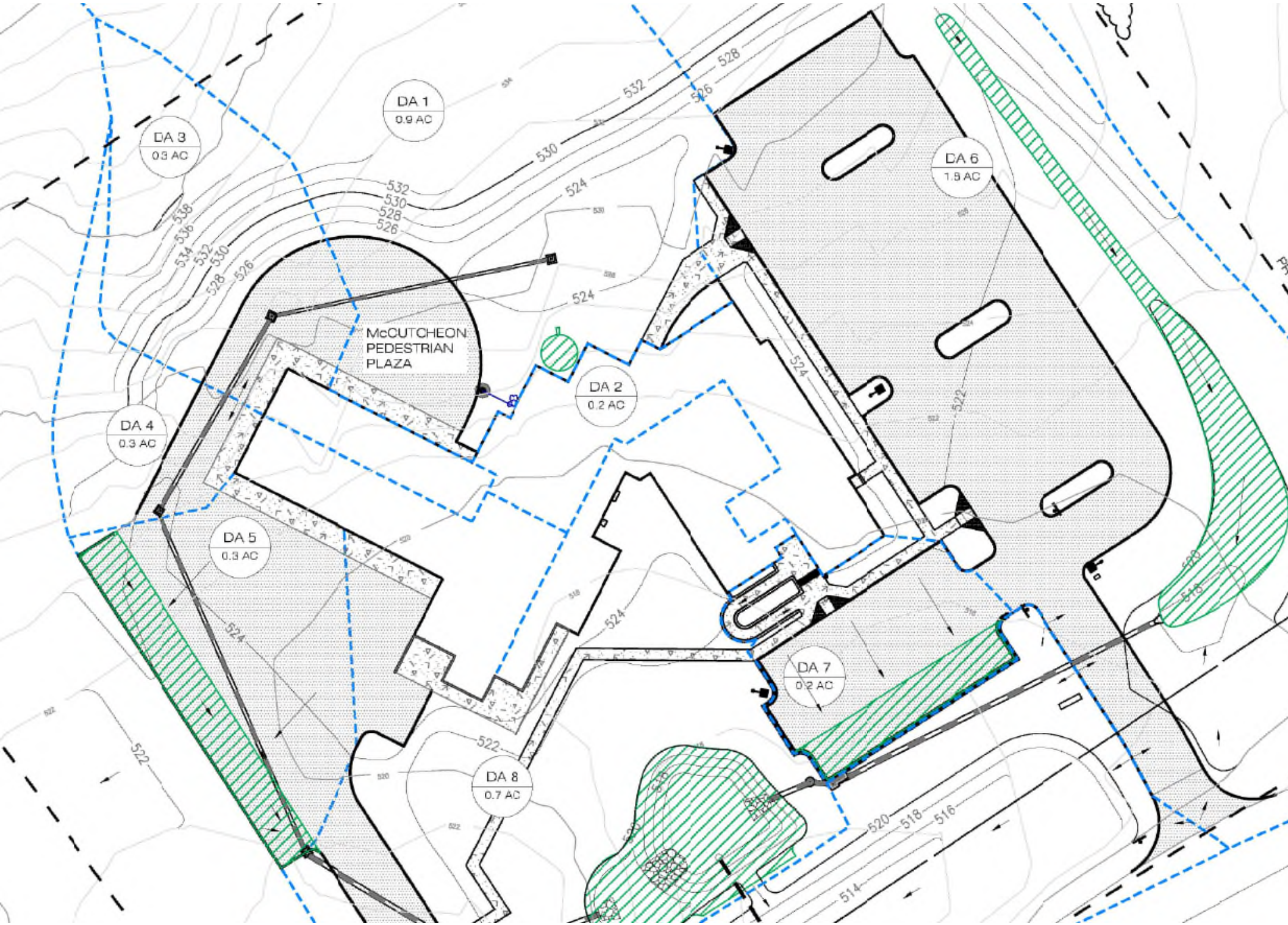
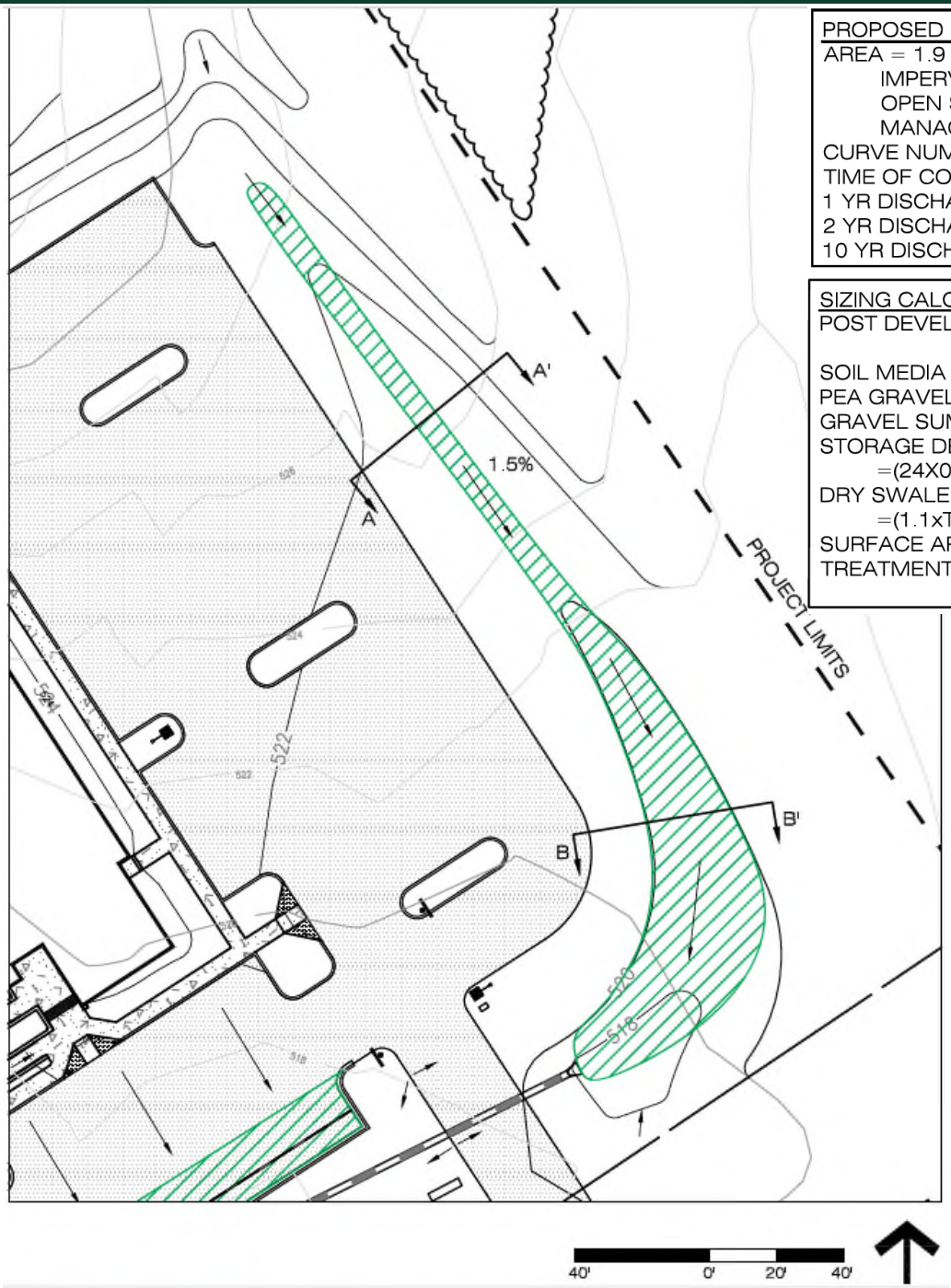


FIGURE 1: CISTERN DESIGN


DA 1
0.9 AC
DA 3
0.3 AC
DA 6
1.9 AC
McCUTCHEON
PEDESTRIAN
PLAZA
DA 2
0.2 AC
DA 4
0.3 AC
DA 5
0.3 AC
DA 7
0.2 AC
DA 8
0.7 AC
532
530
528
526
524
522
520
518
516
514

Dry Swale

Dry Swale (P-CNV-02)



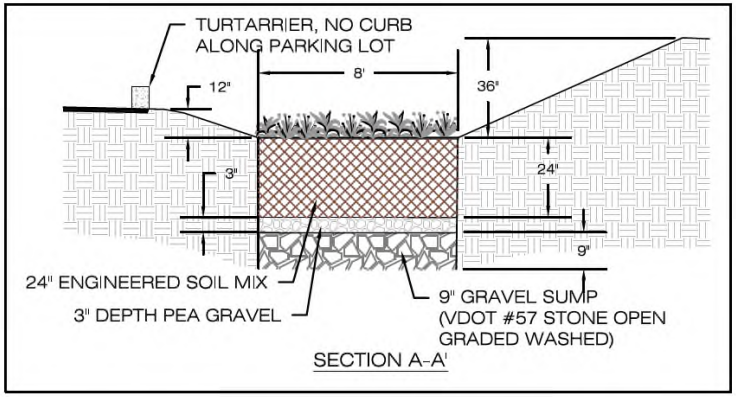
PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 1.9 ACRES
IMPERVIOUS ACREAGE = 0.65 ACRES
OPEN SPACE/ FOREST ACREAGE = 0.65 ACRES
MANAGED TURF ACREAGE = 0.50 ACRES
CURVE NUMBER: 81
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 2.33 CFS
2 YR DISCHARGE = 4.43 CFS
10 YR DISCHARGE = 9.13 CFS

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 1.66 LBS
MASS LOADING EFFICIENCY = 76%
VOLUME TO BMP = 2642 C.F.
RUNOFF REDUCTION BY PRACTICE
=1,585 C.F
TOTAL LOAD REDUCTION BY PRACTICE
=1.26 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.40 LBS

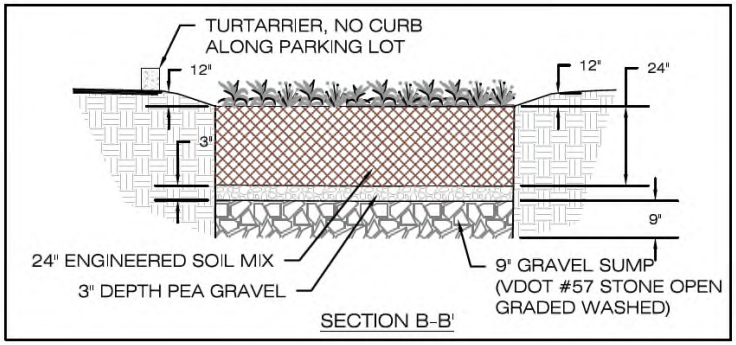
SIZING CALCULATIONS, DRY SWALE LEVEL 2:
POST DEVELOPMENT TREATMENT VOLUME REQUIRED
Tv=2,735 C.F.
SOIL MEDIA DEPTH = 24 IN
PEA GRAVEL = 3 IN
GRAVEL SUMP = 9 IN
STORAGE DEPTH = DEPTH x VOID RATIO
=(24X0.25)+(12X0.4) = 10.8 IN = 0.9 FT
DRY SWALE LEVEL 2 SURFACE AREA REQUIRED
=(1.1xTv)/ STORAGE DEPTH = 2,735/0.9 = 3,342 S.F.
SURFACE AREA PROVIDED = 4,782 S.F.
TREATMENT VOLUME PROVIDED = 4,303 C.F.

VELOCITY COMPUTATIONS:
CROSS-SECTION A-A' MODELED
SLOPE = 1.5%
DIMENSIONS:
SIDE SLOPES = 3:1, BOTTOM WIDTH = = 8'
DEPTH 10 YR = 0.42 FT
RH 10 YR = 0.37
SHEAR STRESS 10 YR = 0.35 LB/S.F.
VELOCITY 10 YR = 2.33 FT/S

VELOCITY AND SHEAR STRESSES MEET TURF AND VEGETATION ALLOWABLE VALUES



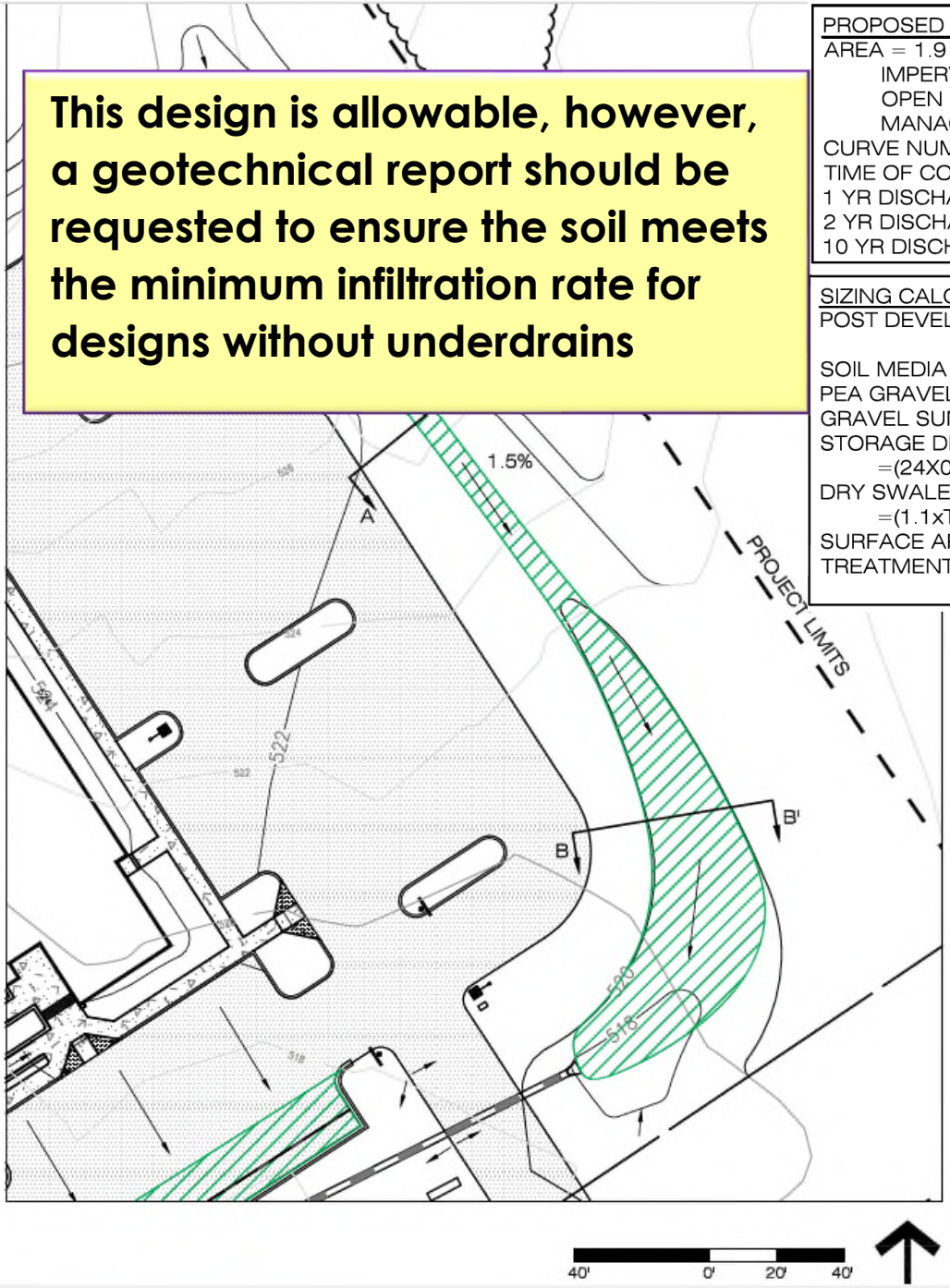
SECTION A-A'



SECTION B-B'

Dry Swale (P-CNV-02)

This design is allowable, however, a geotechnical report should be requested to ensure the soil meets the minimum infiltration rate for designs without underdrains



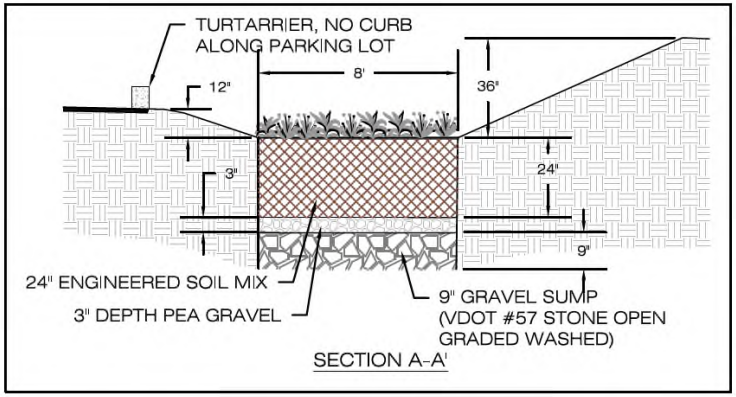
PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 1.9 ACRES
IMPERVIOUS ACREAGE = 0.65 ACRES
OPEN SPACE/ FOREST ACREAGE = 0.65 ACRES
MANAGED TURF ACREAGE = 0.50 ACRES
CURVE NUMBER: 81
TIME OF CONCENTRATION: 5 MINUTES
1 YR DISCHARGE = 2.33 CFS
2 YR DISCHARGE = 4.43 CFS
10 YR DISCHARGE = 9.13 CFS

PHOSPHOROUS REDUCTION CALCULATIONS:
LOAD TO BMP = 1.66 LBS
MASS LOADING EFFICIENCY = 76%
VOLUME TO BMP = 2642 C.F.
RUNOFF REDUCTION BY PRACTICE
=1,585 C.F
TOTAL LOAD REDUCTION BY PRACTICE
=1.26 LB/YR
TOTAL PHOSPHOROUS LOAD REMAINING
=0.40 LBS

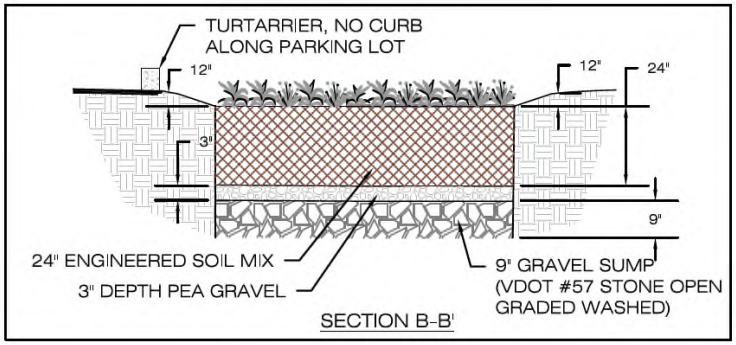
SIZING CALCULATIONS, DRY SWALE LEVEL 2:
POST DEVELOPMENT TREATMENT VOLUME REQUIRED
Tv=2,735 C.F.
SOIL MEDIA DEPTH = 24 IN
PEA GRAVEL = 3 IN
GRAVEL SUMP = 9 IN
STORAGE DEPTH = DEPTH x VOID RATIO
=(24X0.25)+(12X0.4) = 10.8 IN = 0.9 FT
DRY SWALE LEVEL 2 SURFACE AREA REQUIRED
=(1.1xTv)/ STORAGE DEPTH = 2,735/0.9 = 3,342 S.F.
SURFACE AREA PROVIDED = 4,782 S.F.
TREATMENT VOLUME PROVIDED = 4,303 C.F.

VELOCITY COMPUTATIONS:
CROSS-SECTION A-A' MODELED
SLOPE = 1.5%
DIMENSIONS:
SIDE SLOPES = 3:1, BOTTOM WIDTH = = 8'
DEPTH 10 YR = 0.42 FT
RH 10 YR = 0.37
SHEAR STRESS 10 YR = 0.35 LB/S.F.
VELOCITY 10 YR = 2.33 FT/S

VELOCITY AND SHEAR STRESSES MEET TURF AND VEGETATION ALLOWABLE VALUES



SECTION A-A'



SECTION B-B'

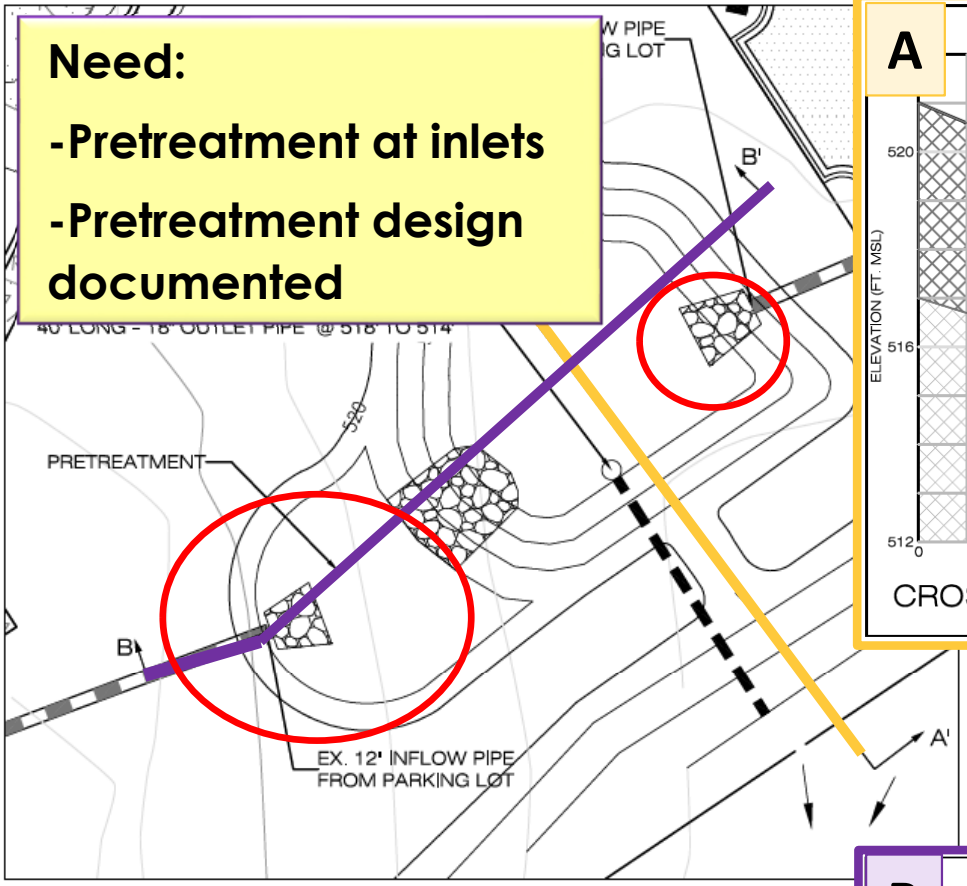
Extended Detention Pond

Extended Detention (P-BAS-03)

Need:

-Pretreatment at inlets

-Pretreatment design documented

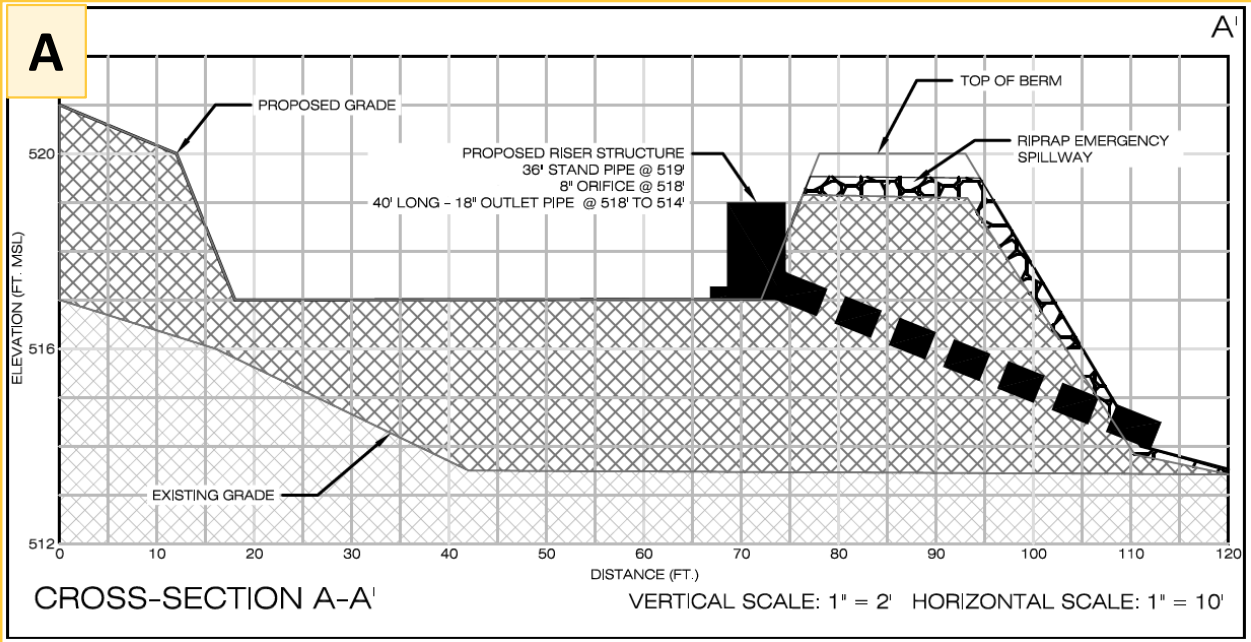


20' 0' 10' 20'

PROPOSED DRAINAGE AREA CHARACTERISTICS:
AREA = 4.67 ACRES
IMPERVIOUS ACREAGE = 0.6 ACRES
OPEN SPACE/ FOREST ACREAGE = 0.65 ACRES
MANAGED TURF ACREAGE = 0.50 ACRES
CURVE NUMBER: 81
TIME OF CONCENTRATION: 5 MINUTES

BMP DESIGN DISCHARGES			
	IN	OUT	ELEVATION (FT)
Q1	5.99	3.17	518.7
Q2	9.57	7.08	519.2
Q10	11.93	12.02	519.8

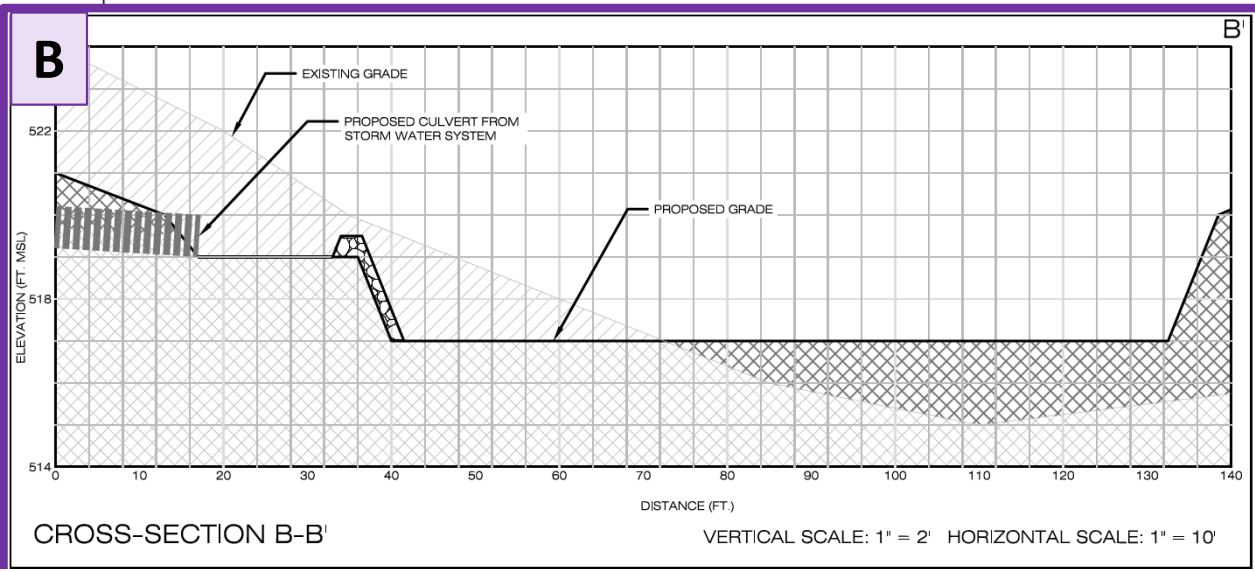
A



CROSS-SECTION A-A'

VERTICAL SCALE: 1" = 2' HORIZONTAL SCALE: 1" = 10'

B



CROSS-SECTION B-B'

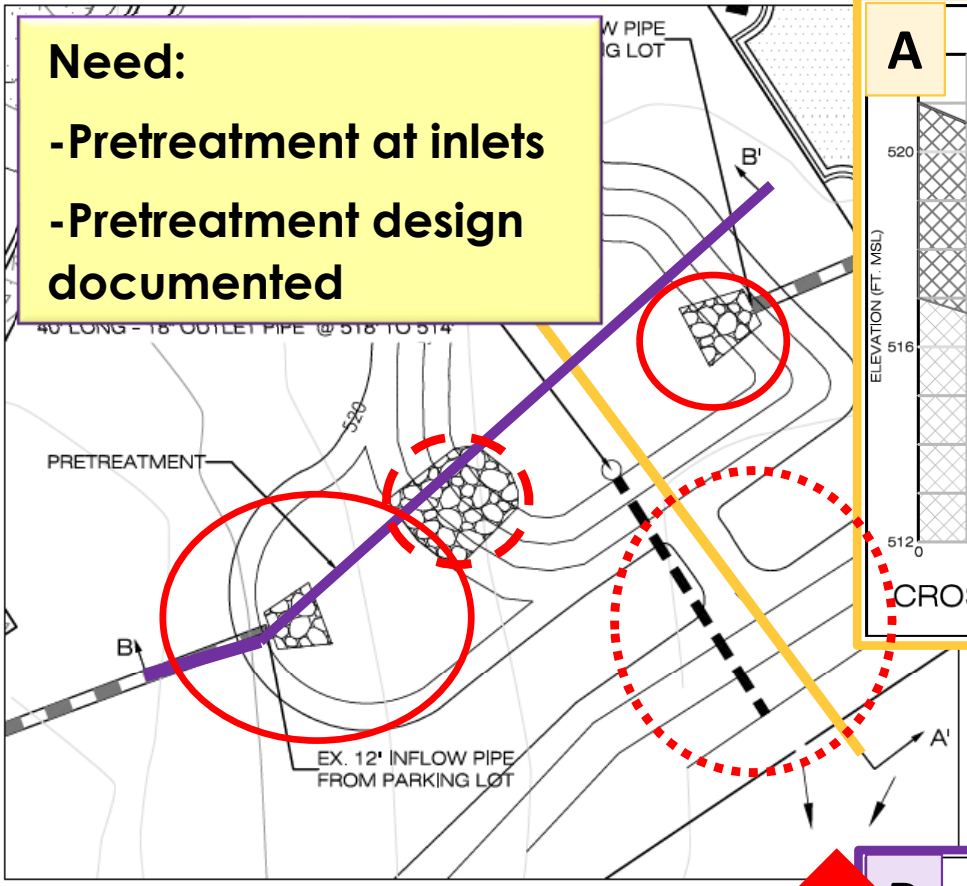
VERTICAL SCALE: 1" = 2' HORIZONTAL SCALE: 1" = 10'

Extended Detention (P-BAS-03)

Need:

-Pretreatment at inlets

-Pretreatment design documented



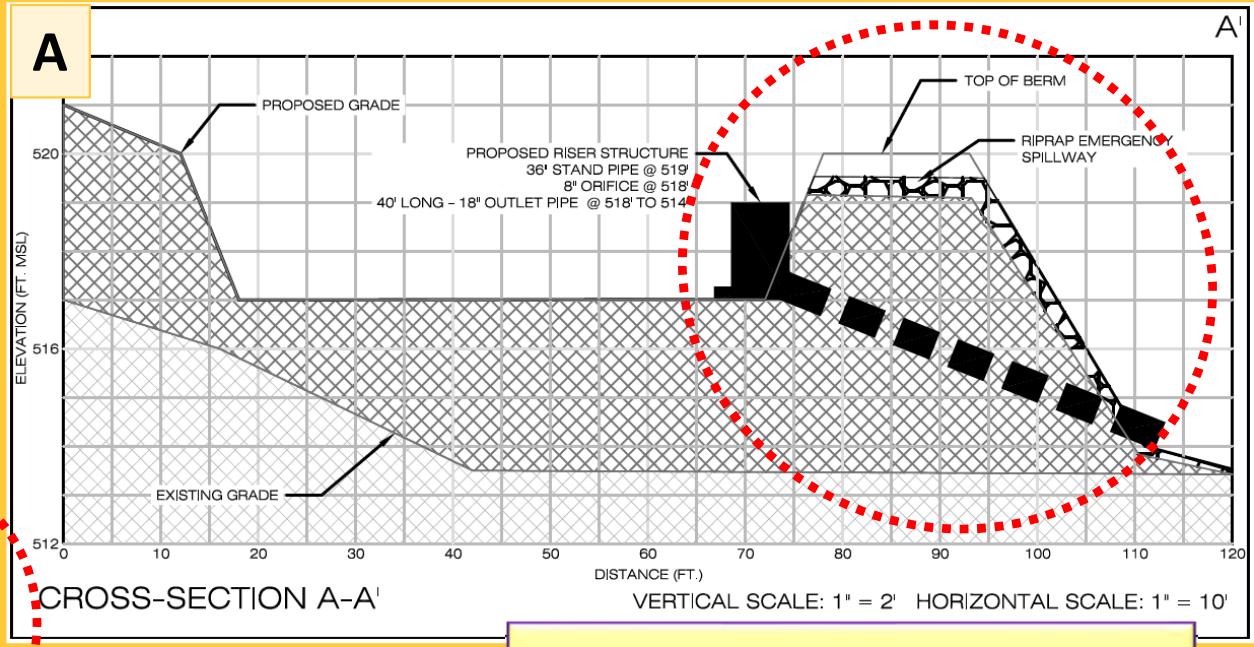
PROPOSED DRAINAGE AREA C
AREA = 4.67 ACRES
IMPERVIOUS ACREAGE =
OPEN SPACE/ FOREST AC
MANAGED TURF ACREAG
CURVE NUMBER: 81
TIME OF CONCENTRATION: 5 M

BMP DESIGN DISC

	IN	OUT	ELEVATION (FT)
Q1	5.99	3.17	518.7
Q2	9.57	7.08	519.2
Q10	11.93	12.02	519.8

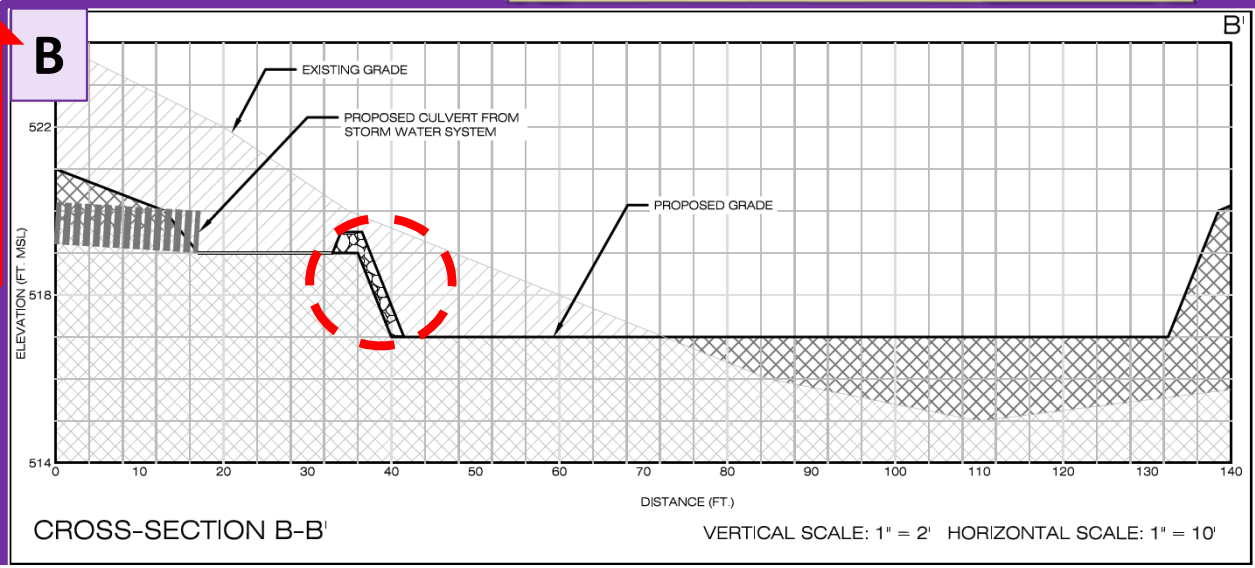
Need channel from outlet of basin to exit of site

A



Need computations for riprap sizing and spillway computations

B



Bonus *(Flood Protection?)*

- Narrative (p. 5) implies flooding is occurring at road culvert
- Decrease 10-year discharge to 15.9 cubic feet per second (cfs), which is less than the existing discharge (17.5 cfs)
- Reduce headwater elevation at the culvert from 517.6 feet to 516.7 feet

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Question 6 *(Volume in ED enough?)*

What volume will be needed to meet criteria?

$q_{allowable}$ = 2.4 cfs **Required storage = 0.14 acre feet**

Narrative, p. 20

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Extended Detention (IN)	1-Year	1	0.404	11.930	5.99	(N/A)	(N/A)
Extended Detention (OUT)	1-Year	1	0.441	12.080	3.17	518.70	0.080
Extended							

The one-year storage volume provided will not be sufficient

Question 7 *(Any info missing?)*

Where did the other 0.4 acres go?

It's important to evaluate all outfalls from a site, even if they are not the primary outfall.

Other outfalls could be negatively affected if more drainage is being forced to flow to other areas.

DEQ
Virginia Department of Environmental Quality

Answer Summary

Post-development total phosphorous load	2.97 lb/yr
Total phosphorus load reduction required	1.23 lb/yr
Target treatment volume	8,231 cubic feet (cf)
Average efficiency needed	41%
Allowable discharge from site	2.8 cfs
Storage volume required to comply with water quantity requirements	0.14 acre feet (6,290 cf)

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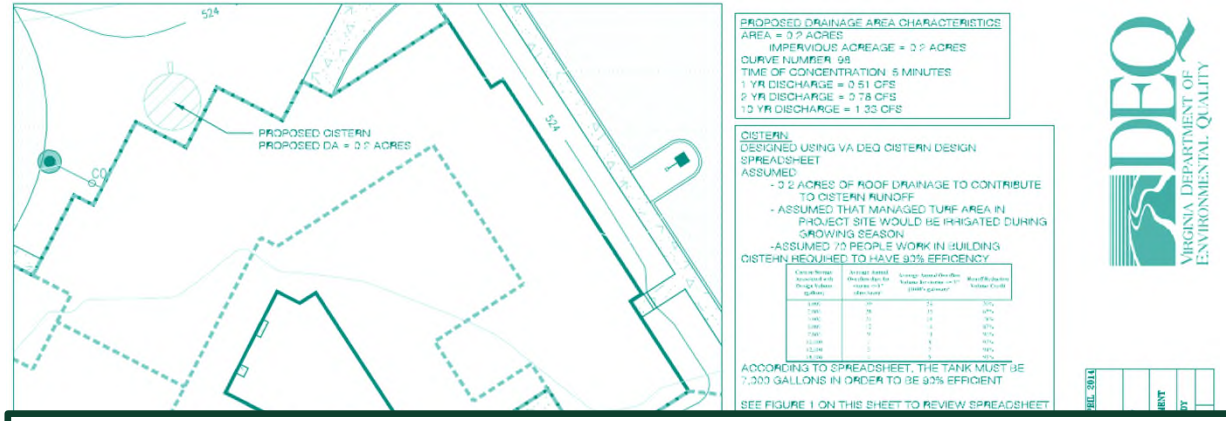
Questions?
Comments?



Exercise Solution PowerPoints available on ELMS

Password: SecretSauce2000