VICTORY CHURCH

AUDITORIUM ADDITION

602 GUN CLUB ROAD

SAGLE, IDAHO

Stormwater Management & Erosion Control Plan

February 5, 2024

Table of Content

Introduction:

The purpose of this report is to document that the proposed Grading/Stormwater Management Plan complies with Bonner County Code 12-723.2, Grading, Stormwater Management and Erosion Control. The property will be modified and regraded to direct runoff away from the proposed building, maintain natural site direction & treatment, and prevent erosion and sediment transport.

The conclusions and recommendations contained within this report are based on site inspection, topographical survey, Natural Resources Conservation Service (NRCS) Soil Survey data, aquatic resources delineation report, and best management practices.

Existing Conditions:

The subject lot is located in a 2.88 acres property in the City of Sagle in Bonner County, Idaho. The property is bounded by Gun Club Road to the south, and large single-family acreage lots to the east, west, and north. Most of the site is relatively flat with a moderately 5-10% slope towards the north. The site is primarily covered with a building, a 900 lineal feet gravel driveway approach, miscellaneous hardscape areas, and two existing parking gravel areas, with grass and scattered trees.

Proposed Improvements:

The scope of this project consists of two different phases. Phase 1 includes the expansion of the existing south portion of building of approximate 5,000 square feet. The site improvement involves the expansion of existing parking area to the south. Phase 2 includes the expansion of proposed south portion of building of approximate 800 square feet. Site improvements for phase 2, includes the expansion of parking layout towards the north and south portion of lot. Development of the property includes minimal site grading, erosion control and storm water management improvements. The stormwater management improvements are created to mitigate, store, and treat stormwater runoff generated from the development with nonerosive means.

Soils:

The NCRS lists this site in Bonner County as Mission silt loam, 0 to 4 percent slopes with a hydrologic soils group rating of "B". See attached Soils Survey from the NRCS website in Appendix B.

Rainfall:

The project is in Idaho Storm Designation Area C per the Idaho Transportation Department. Rainfall intensities were calculated from the 25-year, Zone C, Intensity- Duration-Frequency Curve. The ITD Area Classification Map and associated rainfall intensity curve can be found in the Appendix E.

Stormwater management:

The stormwater system was sized to accommodate stormwater runoff for a 25-year event and provide treatment for the first one-half inch (1/2") of runoff in accordance with Bonner County Standards (12-726 and 12-723.2.B).

Passing the runoff through a grass lined ditch is a common method of treating the runoff and is proposed for this project. These grass lined ditches are more commonly called grassed infiltration areas (GIAs). This project proposes four (4) GIA located throughout the site. The GIA is designed such that it retains the required volume and spill once exceeded. The proposed GIA are a combined total of 1919 cubic feet. Design takes into consideration future expansion (phase 2) of building and parking areas. The primary means of detention is by retaining a sufficient volume of stormwater to not allow the exiting flow rate to exceed the 25 year storm event. See calculations further in this report for a detailed breakdown of impervious areas, GIA storage volumes and flow rates. See attached Stormwater Management Plan in

Appendix C & D. The plan shows the relationship of the proposed impervious surfaces to the proposed stormwater features.

Temporary Erosion Control System:

The Temporary Erosion Control System is comprised of the following BMPs. All references to BMPs are to the Idaho Catalog of Storm Water Best Management Practices. The referenced BMPs are included as Appendix F.

- BMP 36 – Construction Timing
- BMP 37 – Staging Areas
- BMP 38 – Preserve Topsoil and Vegetation
- BMP 40 – Vehicle Sediment Control
- BMP 43 – Dust Control
- BMP 46 – Spill Prevention and Control
- BMP 47 – Construction Equipment Washing and Maintenance
- BMP 63 – Biofilter Bags
- BMP 65 – Silt Fence
- BMP 74 – Inlet Protection

The following requirements must also be met:

- The Temporary Erosion Control System shall be installed prior to any ground disturbing activities and shall primarily consist of silt fence (BMP 65).
- The contractor shall also adhere to the Temporary Erosion Control System BMPs listed above and ensure proper planning is made for construction timing (BMP 36), staging areas (BMP 37), vehicle sediment control (BMP 40), dust control (BMP 43), spill prevention and control (BMP 46), construction equipment washing and maintenance (BMP 47).
- The contractor shall conduct daily inspection of the Temporary Erosion Control System and perform timely repair of any deficiencies found. Accumulation of

silt, thereby impairing the function of the Temporary Erosion Control System, shall be properly disposed of.

- Temporary erosion controls shall remain in place until the permanent Stormwater Management System is installed and is functioning properly. The contractor shall remove and properly dispose of temporary erosion controls after construction equipment is removed, the project is complete, and vegetation has been re-established.

The maintenance and repair of the Temporary Erosion Control System is the responsibility of the contractor. When construction is complete, if temporary erosion controls remain, the property owner will assume maintenance and repair responsibilities. Should this condition occur, the property owner and contractor shall discuss and come to an agreement, written or verbal, ahead of construction completion.

Construction Schedule:

Installation of the Temporary Erosion Control System shall occur prior to ground disturbing activities. Installation and/or construction of the Storm Water Control System shall be concurrent with site development. Groundbreaking activities are anticipated for the spring of 2023, with construction completed just before winter of 2023. See timeline below for a more detailed schedule.

Construction Activity	**Tentative Schedule**	
	Start	**Finish**
Rough Grade	05/1/2024	12/01/2024
Utilities	05/1/2024	12/01/2024
Stormwater Treatment Basins	05/1/2024	12/01/2024
Buildings	05/15/2024	05/15/2026
Parking Lot	05/1/2024	12/01/2024
Landscaping	04/1/2024	11/01/2024

Permanent Erosion Control System:

The Permanent Erosion Control System is comprised of the proposed project improvements and the following BMPs. All references to BMPs are to the Idaho Catalog of Storm Water Best Management Practices. The referenced BMPs are included as Appendix F.

- BMP 18 – Bioretention Basin

Operation & Maintenance (O&M) Plan:

Operation and Management consists of inspection of both the Temporary Erosion Control System and the Permanent Erosion Control System. The following table outlines the inspection frequency and maintenance activities for the BMPs.

The O&M of the storm water management system is the responsibility of the contractor during construction. When construction is complete, the property owner will assume O&M responsibilities.

BMP	Name	Inspection Frequency	Maintenance Activities
18	Bioretention Basin	monthly at first to seasonally to semianually based on performance	remove litter and debris; remulch every 2-3 years; prune and weed; spot mulch at bare spots
25	Presettling/Sedimentation Basin	annually at a minimum	remove litter and debris; remulch every 2-3 years; prune and weed; spot mulch at bare spots
37	Staging Areas	within 24 hours prior to storm event; daily during prolonged storm events	repairing the stabilized surface and perimeter controls; following good housekeeping practices
40	Vehicle Sediment Control	after storm events; daily at adjacent surfaces	sweeping of adjacent surfaces, periodic top dressing of stone or cleaning of rumble strips
43	Dust Control	constant attention	water sprinkling
44	Stockpile Management	weekly before forecasted rain events; daily during extended rain or wind events; after the rain or wind event ends	repairing and/or replacing perimeter controls and covers
46	Spill Prevention and Control	daily	repair containment dikes; clean clogged debris from curbing; emptying drip pans
63	Biofilter Bags	after every storm and periodically	remove sediment when reaches one third of barrier height, replace if exposed to sunlight

			every 2-3 months, repair damaged barriers, undercutting, or end runs
66	Sediment Basins and Traps	after each rainfall event	remove sediment deposits; repair leaks
65	Silt Fence	periodically and after rain events	remove sediment deposits; remove and replace silt fence after 5-8 months or after damage

Stormwater Control System Calculations:

The site is less than 10 acres, therefore the Rational Method was used for calculations of flow rates in conjunction with the Idaho Transportation Department Intensity-Duration-Frequency curves. The NRCS National Engineering Handbook, Chapter 15 was used for calculations of times of concentration. The Modified Rational Method was used to calculate the required volume retention. See attached calculations in Appendix D. The following is a summary of the calculations.

Breakdown of existing and proposed quantities:

Existing Site		
Area Type	**Area (SF)**	**Area (Ac.)**
Pervious	86,453	1.98
Impervious	39,132	0.90
Total	125,585	2.88

Proposed Site		
Area Type	**Area (SF)**	**Area (Ac.)**
Pervious	49,810	1.14
Impervious	75,775	1.74
Total	125,585	2.88

From Proposed Site section:

"no measurable increase in the peak rate of runoff from the site after development when compared with the runoff rate in the undeveloped state for a 25-year storm. Sufficient retention capacity shall be constructed within project boundaries to detain the on site surface flow"

Peak Flows

Area A

Pre-Development C=0.70; I=2.1 in/hr (t_c=10 min); A=1.03 ac

Peak flow $Q_{(25)}$ CIA = 1.51 cfs

Post-Development C=0.80; I=2.1 in/hr (t_c=10 min); A=1.03 ac

Peak Flow $Q_{(25)}$ CIA = 1.73 cfs

Total 556 CF of storage is required to mitigate the difference in peak flows.

<u>Area B</u>

Pre-Development C=0.82; I=2.1 in/hr (t_c=10 min); A=0.30 ac

Peak flow $Q_{(25)}$ CIA = 0.52 cfs

Post-Development C=0.85; I=2.1 in/hr (t_c=10 min); A=0.30 ac

Peak Flow $Q_{(25)}$ CIA = 0.54 cfs

Total 147 CF of storage is required to mitigate the difference in peak flows.

<u>Area C</u>

Pre-Development C=0.69; I=2.1 in/hr (t_c=10 min); A=0.53 ac

Peak flow $Q_{(25)}$ CIA = 0.77 cfs

Post-Development C=0.71; I=2.1 in/hr (t_c=10 min); A=0.53 ac

Peak Flow $Q_{(25)}$ CIA = 0.79 cfs

Total 215 CF of storage is required to mitigate the difference in peak flows.

<u>Area D</u>

Pre-Development C=0.71; I=2.1 in/hr (t_c=10 min); A=1.02 ac

Peak flow $Q_{(25)}$ CIA = 1.52 cfs

Post-Development C=0.78; I=2.1 in/hr (t_c=10 min); A=1.02 ac

Peak Flow $Q_{(25)}$ CIA = 1.67 cfs

Total 507 CF of storage is required to mitigate the difference in peak flows.

<u>From Proposed Site section:</u>

"all vegetated swales shall be designed to retain, at a minimum, a volume equal to the first one-half inch (1/2") of runoff over the tributary impervious area"

<u>Retention Requirement</u>

Area A

Proposed New Impervious Areas A=20,965 sf

Required Treatment V=874 cf

The required treatment volume is 874 cf.

The required treatment volume is more than the required detention volume.

GIA Sizing Calculations

Area:	Width: 9’	Length: 100’
Depth	(ft)	Volume (ft^3)
Ponding:	0.5	450
Soil Mix:	0	0
Rock:	1	360
3:1 Slope		82
Total Prop. Volume:		**892**
Total Req. Volume:		874

Area B

Proposed Impervious areas A=-543 sf

Required Treatment N/A

The required detention volume is 147 cf.

The required treatment volume is less than the required detention volume.

GIA Sizing Calculations

Area:	Width: 10’	Length: 15’
Depth	(ft)	Volume (ft^3)
Ponding:	0.5	75
Soil Mix:	0	0
Rock:	1	60
3:1 Slope		19
Total Prop. Volume:		**154**
Total Req. Volume:		147

Area C

Proposed Impervious areas A=1,714 sf

Required Treatment V=71 cf

The required detention volume is 215 cf.

The required treatment volume is less than the required detention volume.

GIA Sizing Calculations

Area:	Width: 12’	Length: 20’
Depth	(ft)	Volume (ft^3)
Ponding:	0.5	120
Soil Mix:	0	0
Rock:	1	96
3:1 Slope		24
Total Prop. Volume:		**240**
Total Req. Volume:		215

Area D

Proposed Impervious areas A=14,507 sf

Required Treatment V=604 cf

The required treatment volume is 604 cf.

The required treatment volume is more than the required detention volume.

GIA Sizing Calculations

Area:	Width: 30’	Length: 22’
Depth	(ft)	Volume (ft^3)
Ponding:	0.5	330
Soil Mix:	0	0
Rock:	1	264
3:1 Slope		39
Total Prop. Volume:		**633**
Total Req. Volume:		604

Conclusions:

The proposed site has four (4) GIA. The proposed storage volume is a total of 1919 cubic feet. If constructed properly, final construction will achieve more of volume than what is required. The design is conservatively excluding infiltration assumptions. The stormwater requirements will be met on-site.

In conclusion, the proposed stormwater BMPs will treat and detain the additional runoff generated by the proposed improvements if properly constructed and maintained as described herein and shown on the plans.

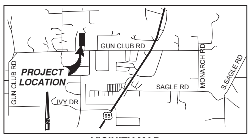
The attached plans and this document were prepared under the direction of the undersigned, whose seal as a licensed professional engineer, is affixed below.

Michael Allshouse, P.E.
Principal Engineer
ID License 16945

PROFESSIONAL ENGINEER
LICENSED
16945
STATE OF IDAHO
MICHAEL D. ALLSHOUSE

Appendix A

Plans



VICINITY MAP
NOT TO SCALE

ABBREVIATION

A.B.	AGGREGATE BASE	MIN.	MINIMUM
AC	ASPHALT CONCRETE	N.T.S.	NOT TO SCALE
ACP	ASBESTOS CEMENT PIPE	O.D.	OUTSIDE DIAMETER
BOTT.	BOTTOM	OH	OVERHEAD WIRES
BW	BACK OF WALL (GRADE AT BW)	PA	PLANTER AREA
C&G	CURB AND GUTTER	PCC	PORTLAND CEMENT CONCRETE
CL	CENTERLINE	P/L	PROPERTY LINE
CLF	CHAIN LINK FENCE	PROP	PROPOSED
CLR.	CLEAR	POC	POINT OF CONNECTION
CONC	CONCRETE	PP	POWER POLE
COTG	CLEAN OUT TO GRADE	PVC	POLYVINYL CHLORIDE
DIP	DUCTILE IRON PIPE	R	RIDGE LINE
DWY	DRIVEWAY	RCP	REINFORCED CONCRETE PIPE
EP	EDGE OF PAVEMENT	R/W	RIGHT OF WAY
ESMT	EASEMENT	RW	RETAINING WALL
E.W.	EACH WAY	SCO	SEWER CLEAN OUT
EX	EXISTING	SF	SQUARE FEET
EJ	EXPANSION JOINT	SD	STORM DRAIN
FG	FINISHED GRADE ELEVATION	STA	STATION
FH	FIRE HYDRANT	SS	SANITARY SEWER
FL	FLOW LINE	SWK	SIDEWALK
FF	FINISHED FLOOR ELEVATION	TC	TOP OF CURB ELEVATION
FS	FINISHED SURFACE ELEVATION	TF	TOP OF FOOTING ELEVATION
FW	FIRE WATER	TG	TOPO OF GRATE ELEVATION
GB	GRADE BREAK	THK.	THICK
HDPE	HIGH DENSITY POLYETHYLENE	TW	TOP OF WALL ELEVATION
HP	HIGH POINT	TYP.	TYPICAL
ICV	IRRIGATION CONTROL VALVE	V.I.F.	VERIFY IN FIELD
INV	PIPE/DRAIN INVERT ELEVATION	W	WATER LINE
LF	LINEAR FEET	WM	WATER METER
LP	LOW POINT	WV	WATER VALVE
MB	MAIL BOX	(XXX)	EXISTING ELEVATION
MJ	MECHANICAL JOINT		
MH	MANHOLE		

EXISTING CONDITIONS

ALL EXISTING INFORMATION SHOWN ON THESE PLANS HAS BEEN BASED ON THE SEARCH OF AVAILABLE RECORDS. THE ENGINEER DOES NOT GUARANTEE THE ACCURACY OR COMPLETENESS OF EXISTING INFORMATION SHOWN. IF THE CONTRACTOR NOTICES ANY DISCREPANCIES BETWEEN EXISTING INFORMATION SHOWN ON THESE PLANS AND THE ACTUAL CONDITIONS, HE SHALL GIVE NOTICE OF SUCH FACT TO THE ENGINEER WITHOUT DELAY.

OWNER

VICTORY BAPTIST CHURCH, INC.

LEGAL DESCRIPTION

THE SOUTH 900 FEET OF THE E1/2 E1/2 SW1/4 SE1/4 OF SECTION 9, TOWNSHIP 56 NORTH, RANGE 2 WEST, BOISE MERIDIAN, BONNER COUTY, IDAHO;

EXCEPT THE EAST 183 FEET THEREOF.

PROJECT INFORMATION:

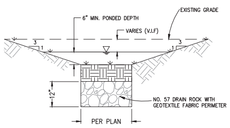
CUT:	381 C.Y.
FILL:	456 C.Y.
IMPORT	75 C.Y
EXPORT	– C.Y

EARTHWORK QUANTITIES ARE ESTIMATES ONLY AND ARE NOT ADJUSTED FOR SHRINKAGE, SWELL, OR SUBSIDENCE. THESE QUANTITIES ARE FOR PERMITTING PURPOSES ONLY. THE CONTRACTOR IS RESPONSIBLE FOR DEVELOPING HIS/HER OWN QUANTITY TAKE-OFFS AND BIDDING ACCORDINGLY.

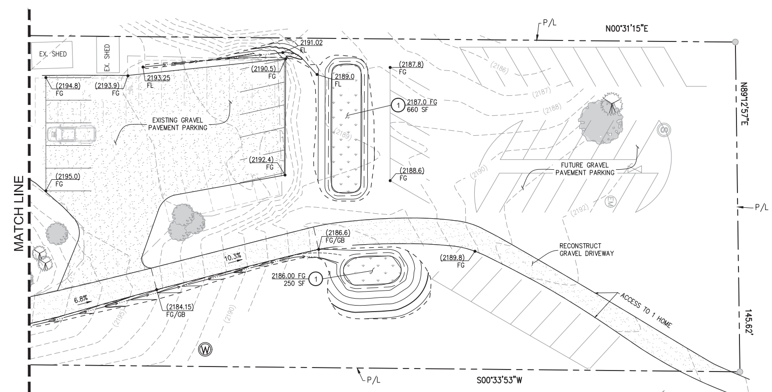
AREA OF DISTURBANCE: (LIMITS OF GRADING)	51,200 SQUARE FEET
MAXIMUM CUT:	4.0 FEET
MAXIMUM FILL:	2.0 FEET
PARCEL AREA:	2.88 ACRES
EX. IMPERVIOUS AREA:	39,132 SF
PROP. IMPERVIOUS AREA:	75,775 SF

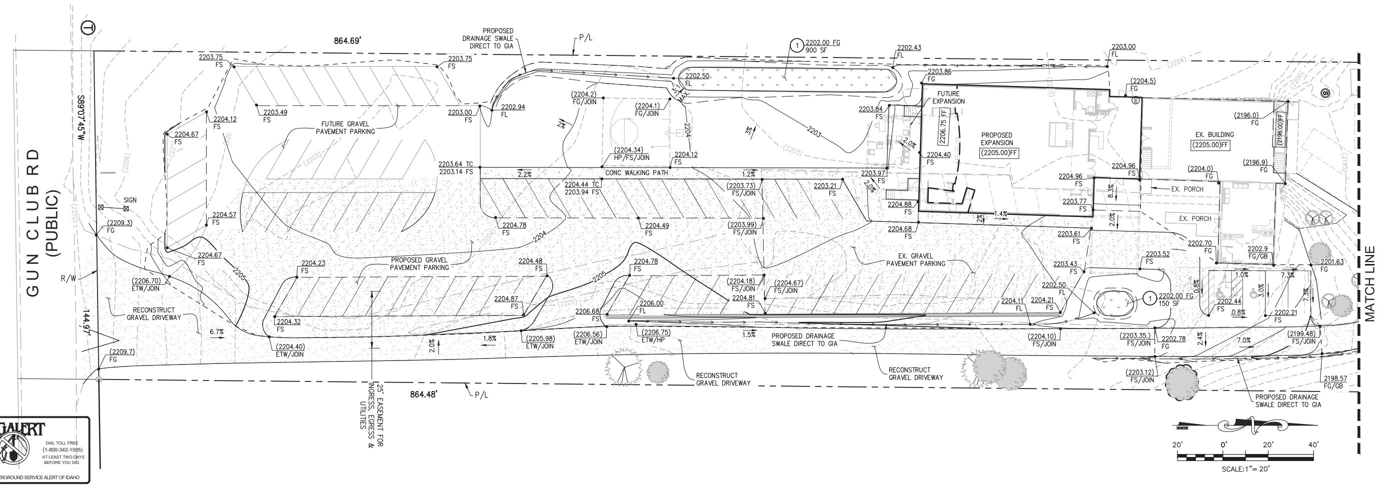
CONSTRUCTION NOTES

(1) CONSTRUCT STORMWATER RETENTION/GIA 3:1 SIDE SLOPES, 1' DEEP STONE, 6" PONDED DEPTH, SQUARE FEET PER PLAN AND DETAIL "A" HEREON.



(A) GRASSY INFILTRATION AREA (GIA) N.T.S.





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VICTORY CHURCH AUDITORIUM ADDITION

602 GUN CLUB RD
SAGLE, ID 83860

Client

No.	Date	Issuance or Revisions
	08/23/23	1ST SUBMITTAL
	01/29/24	2ND SUBMITTAL

Project No.	Checked	Date
23028	YR	07/24/23
Drawn	Approved	Scale
JT	MDA	AS SHOWN

STORMWATER MANAGEMENT PLAN

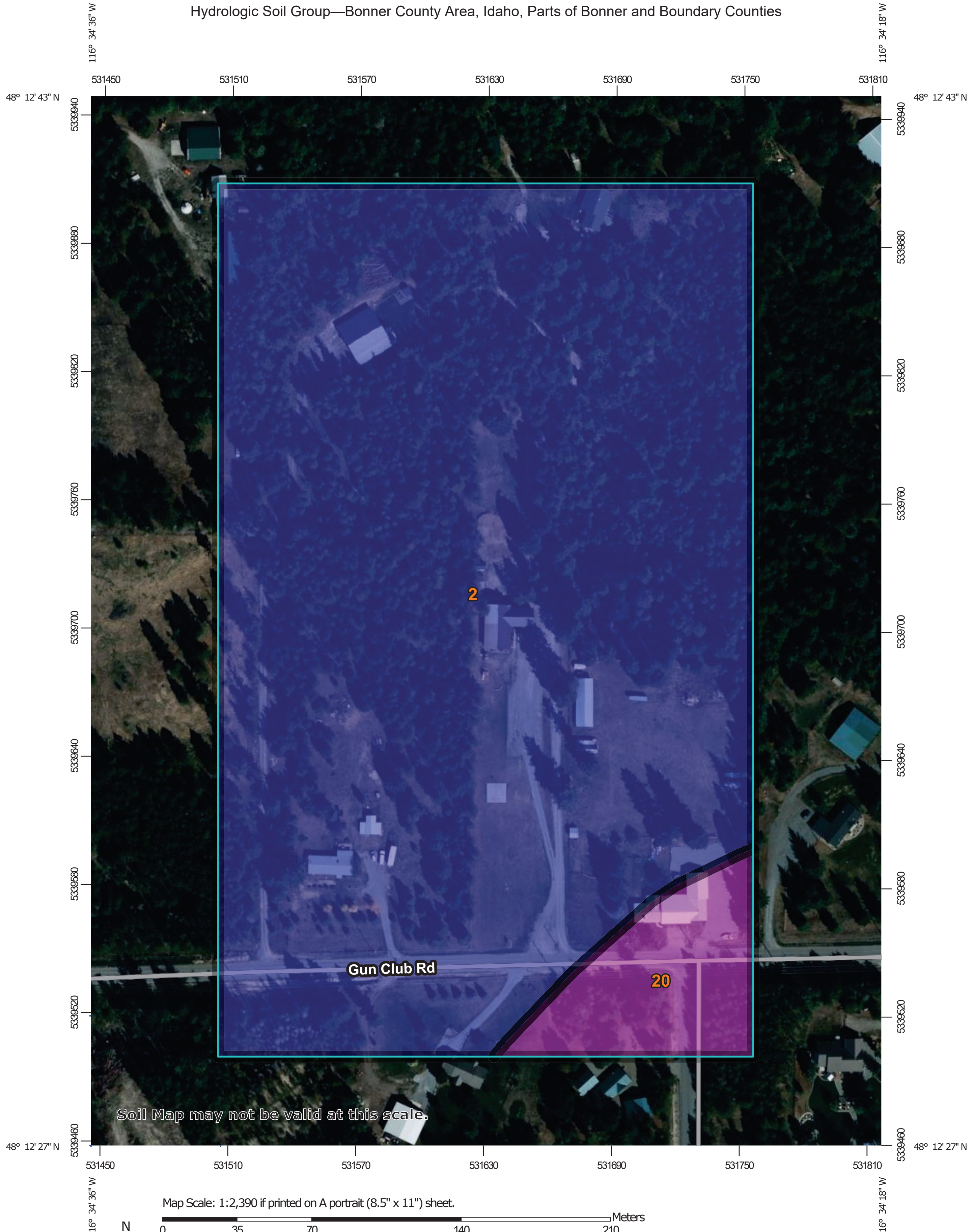
Drawing Title

C-1

Sheet Of

Appendix B

Soil Survey



Map Scale: 1:2,390 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 35, 70, 140, 210

Feet: 0, 100, 200, 400, 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bonner County Area, Idaho, Parts of Bonner and Boundary Counties
Survey Area Data: Version 18, Sep 2, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 16, 2021—Oct 18, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Bonner gravelly ashy silt loam, 0 to 4 percent slopes	B	23.7	93.3%
20	Kaniksu sandy loam, 0 to 4 percent slopes	A	1.7	6.7%
Totals for Area of Interest			**25.5**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

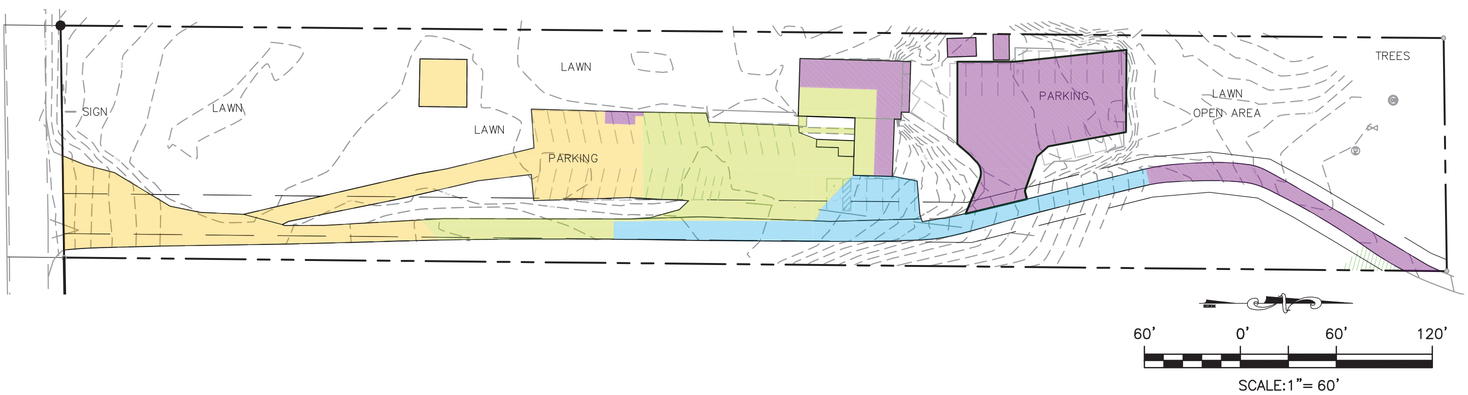
Tie-break Rule: Higher

Appendix C

Exhibit

IMPERVIOUS AREAS

- TRIBUTARY AREA A: 11,969 SQ. FT.
- TRIBUTARY AREA B: 10,450 SQ. FT.
- TRIBUTARY AREA C: 5,317 SQ. FT.
- TRIBUTARY AREA D: 11,396 SQ. FT.



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Seal

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Project No.	23028
Drawn	JT
Checked	YR
Approved	MDA
Date	2023-06-23
Scale	AS SHOWN

No.	Date	Issuance or Revisions

VICTORY CHURCH
AUDITORIUM ADDITION
602 GUN CLUB ROAD
SAGLE, ID

Client

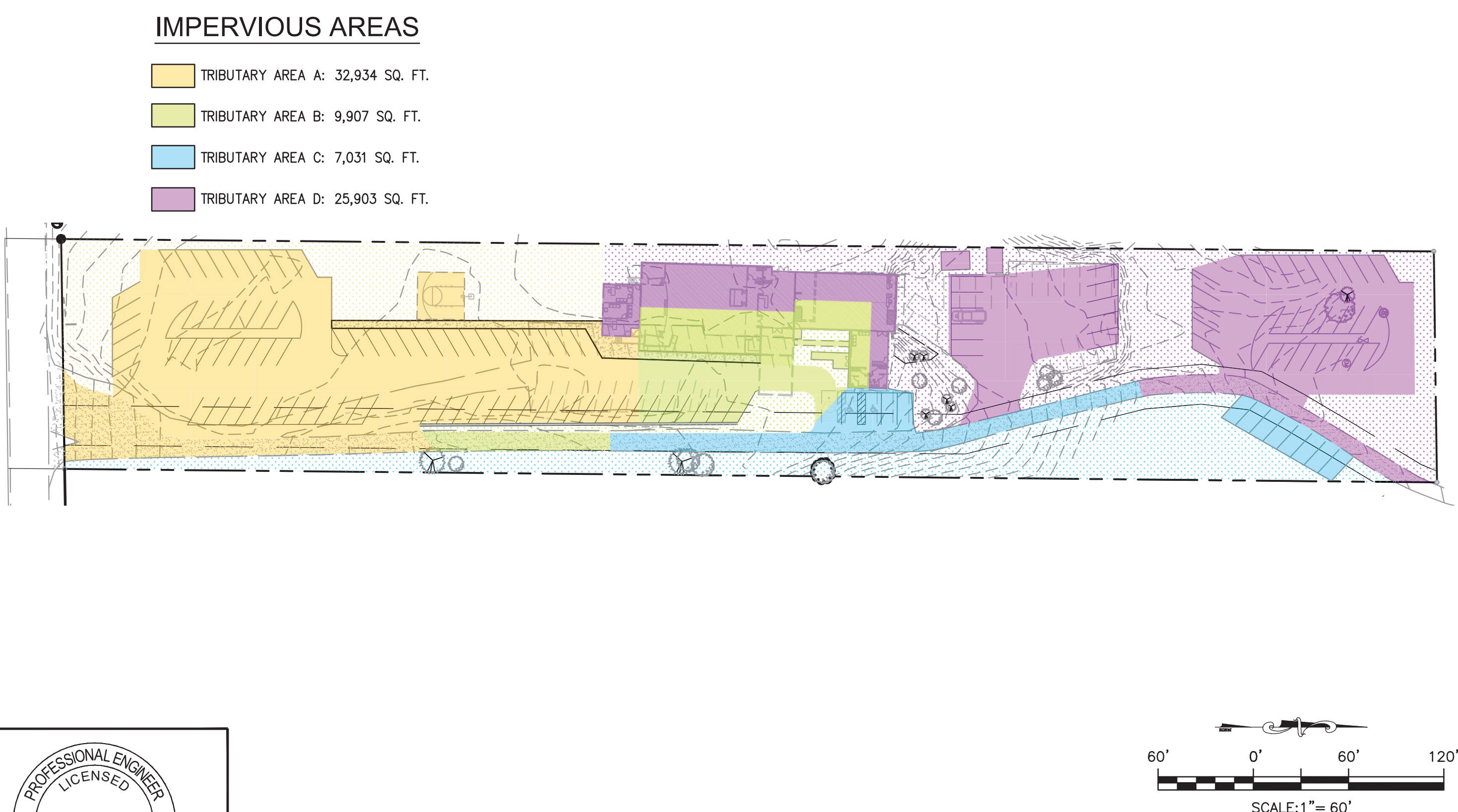
PRE-DEVELOPMENT

Drawing Title

EXHIBIT 1

Sheet Of

X:\02-Projects\08-2023 Projects\23028 - Victory Church (Lakeside Arch) S-ID\02-Civil\04-Drawings\Exhibits\DMA\2023-07-21\23028_PRE.dwg 2/01/24 02:54 PM YosimarRamos



PROFESSIONAL ENGINEER LICENSED 16945 STATE OF IDAHO MICHAEL D. ALLSHOUSE

Seal

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Project No.	23028
Drawn	JT
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Date	2023-06-23
Scale	AS SHOWN

No.	Date	Issuance or Revisions

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602 GUN CLUB ROAD
SAGLE, ID
Client

POST-DEVELOPMENT
Drawing Title

EXHIBIT 2
Sheet Of

X:\02-Projects\08-2023 Projects\23028 - Victory Church (Lakeside Arch) S-ID\02-Civil\04-Drawings\Exhibits\DMA\2023-07-21\23028_POST.dwg 2/01/24 02:55 PM YosimarRamos

Appendix D

Calculation

Lot Size: 125585 SQ FT

POST-DEVELOPMENT COMPOSITE RUNOFF COEFFICIENT

	AREA A (SF)	AREA B (SF)	AREA C (SF)	AREA D (SF)	TOTALS (SF)	
Conc/AC	2,179	696	0	0	2,875	
Roof	0	4,195	0	5,682	9,877	
Gravel	30,755	5,016	7,031	20,221	63,023	
Grass	11,978	3,118	15,960	18,754	49,810	
Total	44,912	13,025	22,991	44,657	**125,585**	TOTAL (SF)
					2.88	TOTAL ACRE

$C_{AVERAGE =}$ $(C_1 X A_1 + C_2 X A_{2+...})$ / TOTAL (SF)

	AREA A		AREA B		AREA C		AREA D	
	AREA (SF)	$C_0 X A_0$	AREA (SF)	$C_0 X A_0$	AREA (SF)	$C_0 X A_0$	AREA (SF)	$C_0 X A_0$
Conc/AC	2,179	2157	696	689	0	0	0	0
Roof	0	0	4,195	4153	0	0	5,682	5625
Gravel	30,755	25834	5,016	4213	7,031	5906	20,221	16986
Grass	11,978	7786	3,118	2027	15,960	10374	18,754	12190
		35777		11082		16280		34801
		0.80		**0.85**		**0.71**		**0.78**

	A		B		C		D	
Pervious	11,978	Pervious	3,118	Pervious	15,960	Pervious	18,754	49,810
Impervious	32,934	Impervious	9,907	Impervious	7,031	Impervious	25,903	75,775
								125,585

	RUNOFF COEFFICIENT	AREA (SF)	$C_0 X A_0$
CONC/AC	0.99	2,875	2846
Roof	0.99	9,877	9778
GRAVEL	0.84	63,023	52939
GRASS	0.65	49,810	32377
SUM		125,585	97940
$C_{COMPOSITE}$			**0.78**

PRE-DEVELOPMENT COMPOSITE RUNOFF COEFFICIENT

	AREA A (SF)	AREA B (SF)	AREA C (SF)	Area D (SF)	TOTALS (SF)	
CONC/AC	882	314	0	0	1,196	
ROOF	0	1,343	0	2,376	3,719	
GRAVEL	11,087	8,793	5,317	9,020	34,217	
GRASS	32,943	2,575	17,674	33,261	86,453	
Total	44,912	13,025	22,991	44,657	**125,585**	TOTAL (SF)
					2.88	TOTAL ACRE

$C_{AVERAGE =}$ $(C_1 X A_1 + C_2 X A_{2+...})$ / TOTAL (SF)

	AREA A		AREA B		AREA C		AREA D	
	AREA (SF)	$C_0 X A_0$	AREA (SF)	$C_0 X A_0$	AREA (SF)	$C_0 X A_0$	AREA (SF)	$C_0 X A_0$
Conc/AC	882	873	314	311	0	0.0	0	0.0
Roof	0	0	1,343	1330	0	0.0	2,376	2352.2
Gravel	11,087	9313	8,793	7386	5,317	4466.3	9,020	7576.8
Grass	32,943	21413	2,575	1674	17,674	11488.1	33,261	21619.7
		31599		10700		15954		31549
		0.70		**0.82**		**0.69**		**0.71**

	A		B		C		D	
Pervious	32,943	Pervious	2,575	Pervious	17,674	Pervious	33,261	86,453
Impervious	11,969	Impervious	10,450	Impervious	5,317	Impervious	11,396	39,132
								125,585

	RUNOFF COEFFICIENT	AREA (SF)	$C_0 X A_0$
CONC/AC	0.99	1,196	1184
ROOF	0.99	3,719	3682
GRAVEL	0.84	34,217	28742
GRASS	0.65	86,453	56194
SUM		125,585	89803
$C_{COMPOSITE}$			**0.72**

Pre-Development Flow Rates **Area A**

Q = CIA

C =	0.70		composite C	
I =	*Per table below*	*25 year storm*		
A =	1.03	*Acres*		

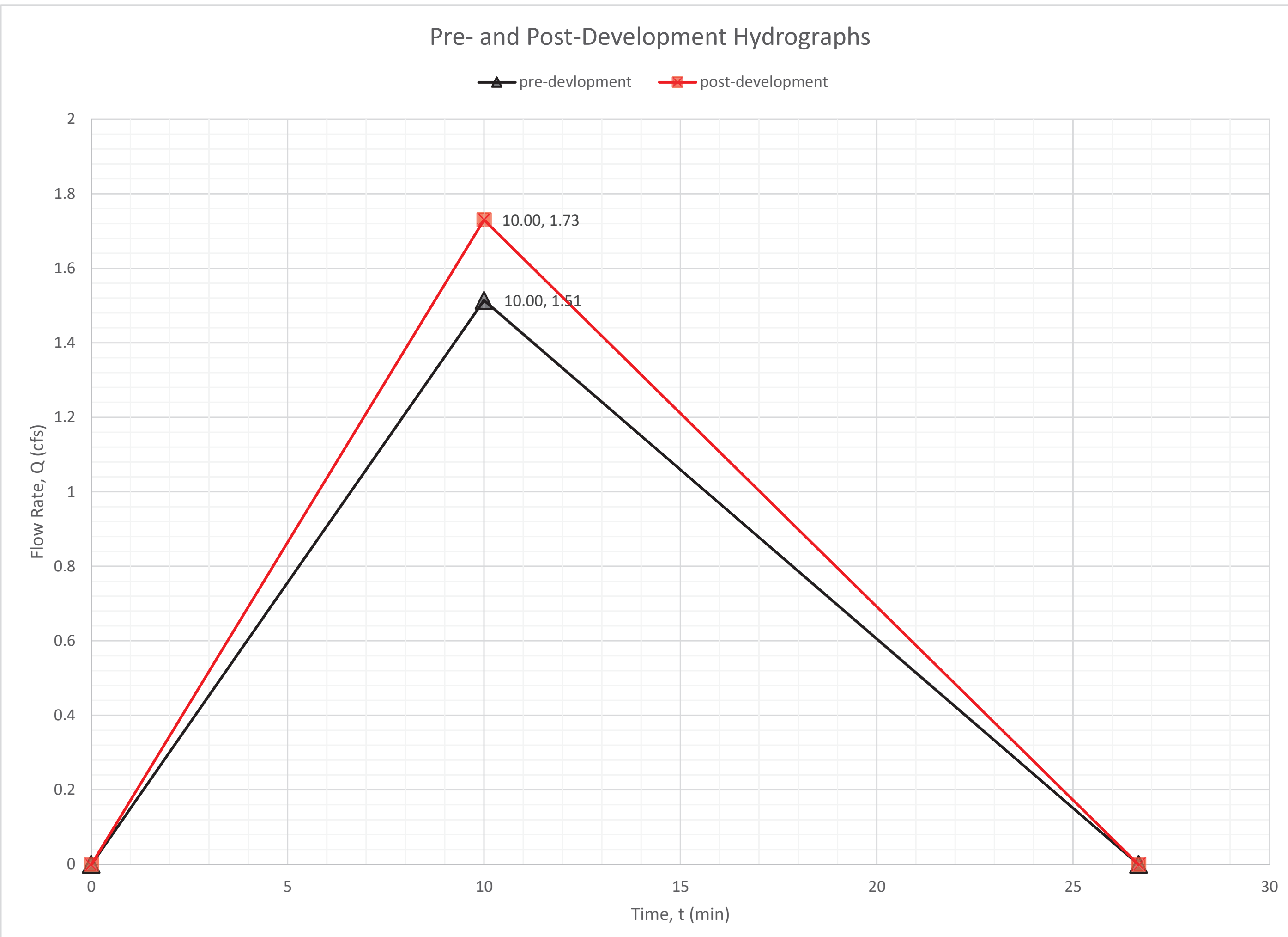
Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)
0.08	5	300	2.80	2.02
0.10	6	360	2.55	1.84
0.12	7	420	2.45	1.77
0.13	8	480	2.30	1.66
0.15	9	540	2.20	1.59
0.17	**10**	**600**	**2.10**	**1.51**
0.25	15	900	1.80	1.30
0.33	20	1200	1.50	1.08
0.50	30	1800	1.20	0.87
0.67	40	2400	0.96	0.69
0.83	50	3000	0.85	0.61
1.00	60	3600	0.78	0.56
2	120	7200	0.51	0.37
3	180	10800	0.40	0.29
4	240	14400	0.35	0.25
5	300	18000	0.29	0.21
6	360	21600	0.26	0.19
8	480	28800	0.23	0.17
10	600	36000	0.18	0.13
12	720	43200	0.17	0.12
18	1080	64800	0.13	0.09
24	1440	86400	0.11	0.08

Post-Development Flow Rates **Area A**

Q = CIA

C =	0.80		composite C
I =	*Per table below*	*25 year storm*	
A =	1.03	*Acres*	

Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)	Vin (CF)	Vout (CF)	Vstorage (CF)
0.08	5	300	2.80	2.31	692	260	433
0.10	6	360	2.55	2.10	756	311	445
0.12	7	420	2.45	2.02	848	363	485
0.13	8	480	2.30	1.90	910	415	494
0.15	9	540	2.20	1.81	979	467	512
0.17	**10**	**600**	**2.10**	**1.73**	1038	519	519
0.25	15	900	1.80	1.48	1335	779	**556**
0.33	20	1200	1.50	1.24	1483	1038	445
0.50	30	1800	1.20	0.99	1780	1557	222
0.67	40	2400	0.96	0.79	1898	2076	0
0.83	50	3000	0.85	0.70	2101	2596	0
1	60	3600	0.78	0.64	2314	3115	0
2	120	7200	0.51	0.42	3026	6229	0
3	180	10800	0.40	0.33	3560	9344	0
4	240	14400	0.35	0.29	4153	12459	0
5	300	18000	0.29	0.24	4301	15574	0
6	360	21600	0.26	0.21	4628	18688	0
8	480	28800	0.23	0.19	5458	24918	0
10	600	36000	0.18	0.15	5340	31147	0
12	720	43200	0.17	0.14	6051	37377	0
18	1080	64800	0.13	0.11	6941	56065	0
24	1440	86400	0.11	0.09	7831	74753	0



Pre- and Post-Development Hydrographs
pre-devlopment
post-development
10.00, 1.73
10.00, 1.51
Flow Rate, Q (cfs)
Time, t (min)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
5
10
15
20
25
30

Pre-Development Flow Rates **Area B**

Q = CIA

C =	0.82		composite C
I =	*Per table below*	*25 year storm*	
A =	0.30	*Acres*	

Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)
0.08	5	300	2.80	0.69
0.10	6	360	2.55	0.63
0.12	7	420	2.45	0.60
0.13	8	480	2.30	0.57
0.15	9	540	2.20	0.54
0.17	**10**	**600**	**2.10**	**0.52**
0.25	15	900	1.80	0.44
0.33	20	1200	1.50	0.37
0.50	30	1800	1.20	0.30
0.67	40	2400	0.96	0.24
0.83	50	3000	0.85	0.21
1.00	60	3600	0.78	0.19
2	120	7200	0.51	0.13
3	180	10800	0.40	0.10
4	240	14400	0.35	0.09
5	300	18000	0.29	0.07
6	360	21600	0.26	0.06
8	480	28800	0.23	0.06
10	600	36000	0.18	0.04
12	720	43200	0.17	0.04
18	1080	64800	0.13	0.03
24	1440	86400	0.11	0.03

Post-Development Flow Rates **Area B**

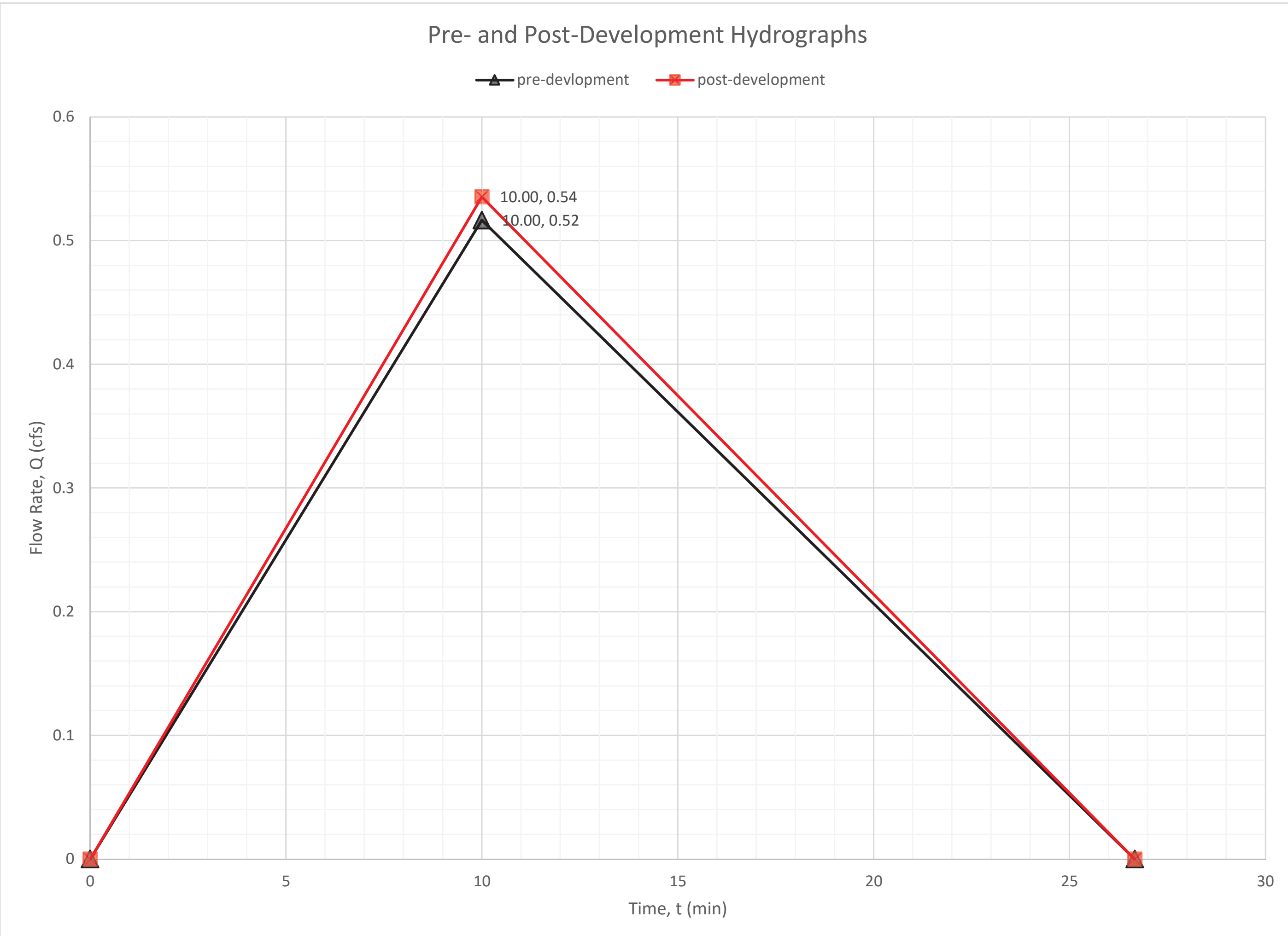
Q = CIA

C = 0.85 composite C

I = *Per table below* *25 year storm*

A = 0.30 *Acres*

Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)	Vin (CF)	Vout (CF)	Vstorage (CF)
0.08	5	300	2.80	0.71	214	89	126
0.10	6	360	2.55	0.65	234	106	128
0.12	7	420	2.45	0.62	262	124	138
0.13	8	480	2.30	0.59	282	142	140
0.15	9	540	2.20	0.56	303	159	144
0.17	**10**	**600**	**2.10**	**0.54**	321	177	144
0.25	15	900	1.80	0.46	413	266	**147**
0.33	20	1200	1.50	0.38	459	354	105
0.50	30	1800	1.20	0.31	551	531	19
0.67	40	2400	0.96	0.24	588	708	0
0.83	50	3000	0.85	0.22	650	886	0
1	60	3600	0.78	0.20	716	1063	0
2	120	7200	0.51	0.13	936	2125	0
3	180	10800	0.40	0.10	1102	3188	0
4	240	14400	0.35	0.09	1285	4251	0
5	300	18000	0.29	0.07	1331	5314	0
6	360	21600	0.26	0.07	1432	6376	0
8	480	28800	0.23	0.06	1689	8502	0
10	600	36000	0.18	0.05	1652	10627	0
12	720	43200	0.17	0.04	1873	12753	0
18	1080	64800	0.13	0.03	2148	19129	0
24	1440	86400	0.11	0.03	2424	25505	0



Pre- and Post-Development Hydrographs
pre-devlopment
post-development
10.00, 0.54
10.00, 0.52
Flow Rate, Q (cfs)
Time, t (min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0
5
10
15
20
25
30

Pre-Development Flow Rates **Area C**

Q = CIA

C =	0.69		composite C	
I =	*Per table below*	*25 year storm*		
A =	0.53	*Acres*		

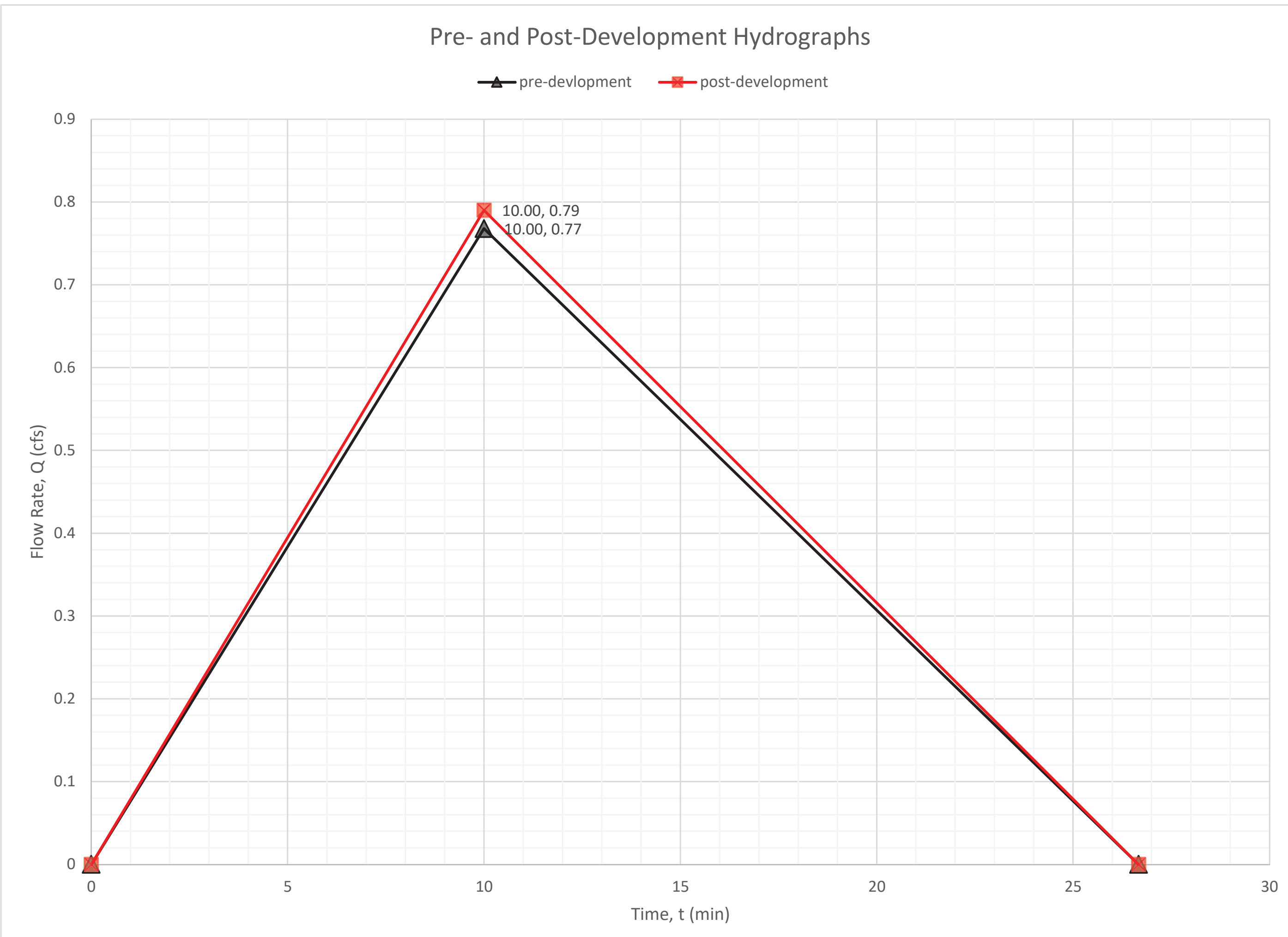
Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)
0.08	5	300	2.80	1.02
0.10	6	360	2.55	0.93
0.12	7	420	2.45	0.90
0.13	8	480	2.30	0.84
0.15	9	540	2.20	0.80
0.17	**10**	**600**	**2.10**	**0.77**
0.25	15	900	1.80	0.66
0.33	20	1200	1.50	0.55
0.50	30	1800	1.20	0.44
0.67	40	2400	0.96	0.35
0.83	50	3000	0.85	0.31
1.00	60	3600	0.78	0.29
2	120	7200	0.51	0.19
3	180	10800	0.40	0.15
4	240	14400	0.35	0.13
5	300	18000	0.29	0.11
6	360	21600	0.26	0.10
8	480	28800	0.23	0.08
10	600	36000	0.18	0.07
12	720	43200	0.17	0.06
18	1080	64800	0.13	0.05
24	1440	86400	0.11	0.04

Post-Development Flow Rates

Q = CIA

C =	0.71	composite C
I =	*Per table below*	*25 year storm*
A =	0.53	*Acres*

Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)	Vin (CF)	Vout (CF)	Vstorage (CF)
0.08	5	300	2.80	1.05	316	132	184
0.10	6	360	2.55	0.96	345	158	187
0.12	7	420	2.45	0.92	387	184	203
0.13	8	480	2.30	0.87	415	211	205
0.15	9	540	2.20	0.83	447	237	210
0.17	**10**	**600**	**2.10**	**0.79**	474	263	211
0.25	15	900	1.80	0.68	610	395	**215**
0.33	20	1200	1.50	0.56	677	527	151
0.50	30	1800	1.20	0.45	813	790	23
0.67	40	2400	0.96	0.36	867	1053	0
0.83	50	3000	0.85	0.32	960	1317	0
1	60	3600	0.78	0.29	1057	1580	0
2	120	7200	0.51	0.19	1382	3160	0
3	180	10800	0.40	0.15	1626	4739	0
4	240	14400	0.35	0.13	1897	6319	0
5	300	18000	0.29	0.11	1964	7899	0
6	360	21600	0.26	0.10	2113	9479	0
8	480	28800	0.23	0.09	2493	12639	0
10	600	36000	0.18	0.07	2438	15798	0
12	720	43200	0.17	0.06	2764	18958	0
18	1080	64800	0.13	0.05	3170	28437	0
24	1440	86400	0.11	0.04	3576	37916	0



Pre- and Post-Development Hydrographs
pre-devlopment
post-development
10.00, 0.79
10.00, 0.77
Flow Rate, Q (cfs)
Time, t (min)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
5
10
15
20
25
30

Pre-Development Flow Rates   Area D

Q = CIA

C =	0.71		composite C
I =	*Per table below*	*25 year storm*	
A =	1.02	*Acres*	

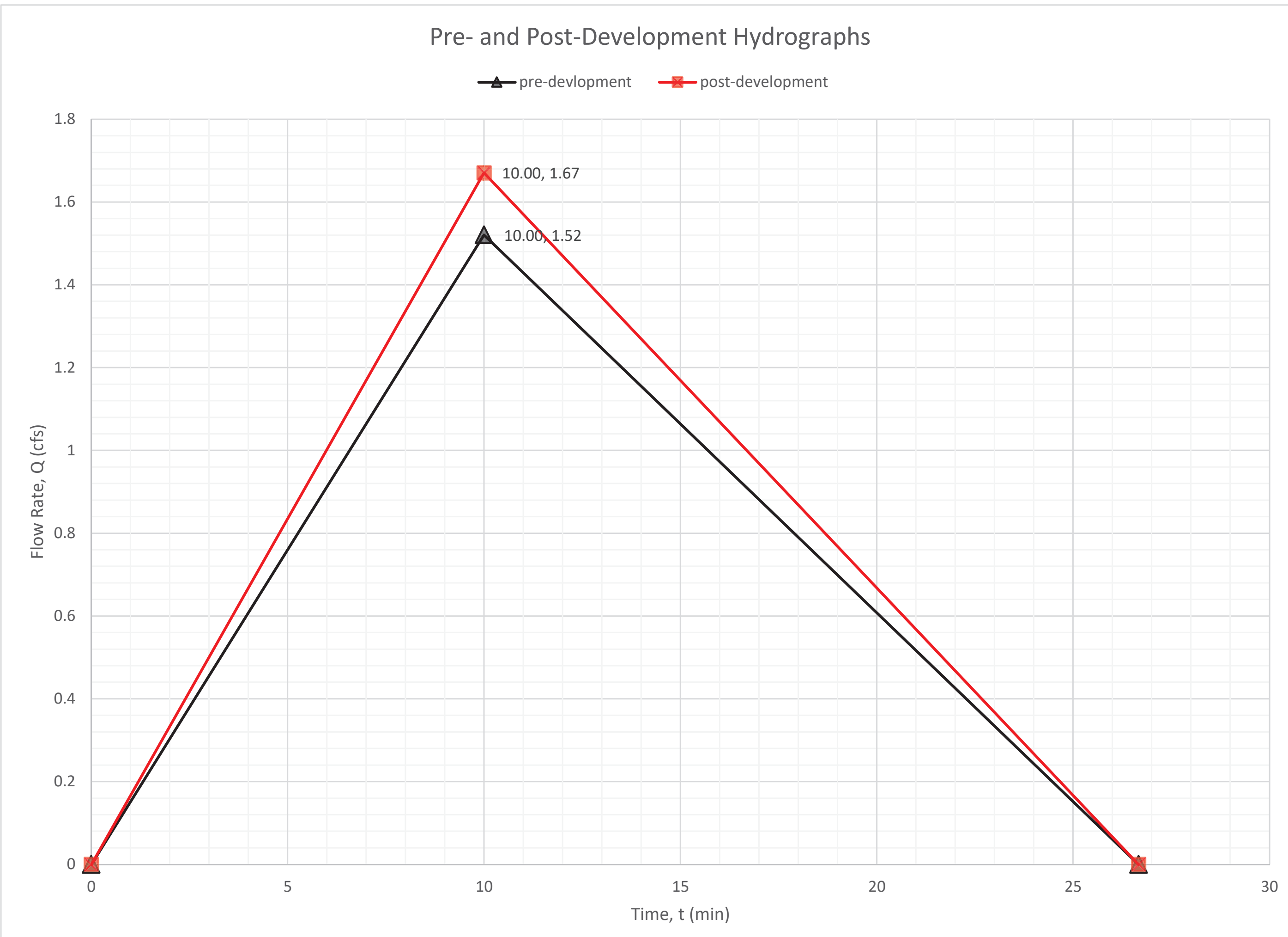
Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)
0.08	5	300	2.80	2.03
0.10	6	360	2.55	1.85
0.12	7	420	2.45	1.77
0.13	8	480	2.30	1.67
0.15	9	540	2.20	1.59
0.17	**10**	**600**	**2.10**	**1.52**
0.25	15	900	1.80	1.30
0.33	20	1200	1.50	1.09
0.50	30	1800	1.20	0.87
0.67	40	2400	0.96	0.70
0.83	50	3000	0.85	0.62
1.00	60	3600	0.78	0.56
2	120	7200	0.51	0.37
3	180	10800	0.40	0.29
4	240	14400	0.35	0.25
5	300	18000	0.29	0.21
6	360	21600	0.26	0.19
8	480	28800	0.23	0.17
10	600	36000	0.18	0.13
12	720	43200	0.17	0.12
18	1080	64800	0.13	0.09
24	1440	86400	0.11	0.08

Post-Development Flow Rates **Area D**

Q = CIA

C =	0.78		composite C
I =	*Per table below*	*25 year storm*	
A =	1.02	*Acres*	

Time (hr)	Time (min)	Time (sec)	Intensity (in/hr)	Q (cfs)	Vin (CF)	Vout (CF)	Vstorage (CF)
0.08	5	300	2.80	2.23	668	261	408
0.10	6	360	2.55	2.03	730	313	418
0.12	7	420	2.45	1.95	819	365	454
0.13	8	480	2.30	1.83	878	417	461
0.15	9	540	2.20	1.75	945	469	476
0.17	**10**	**600**	**2.10**	**1.67**	1002	521	481
0.25	15	900	1.80	1.43	1289	782	**507**
0.33	20	1200	1.50	1.19	1432	1043	389
0.50	30	1800	1.20	0.95	1718	1564	154
0.67	40	2400	0.96	0.76	1833	2086	0
0.83	50	3000	0.85	0.68	2029	2607	0
1	60	3600	0.78	0.62	2234	3129	0
2	120	7200	0.51	0.41	2921	6257	0
3	180	10800	0.40	0.32	3437	9386	0
4	240	14400	0.35	0.28	4010	12514	0
5	300	18000	0.29	0.23	4153	15643	0
6	360	21600	0.26	0.21	4468	18771	0
8	480	28800	0.23	0.18	5270	25028	0
10	600	36000	0.18	0.14	5155	31285	0
12	720	43200	0.17	0.14	5843	37543	0
18	1080	64800	0.13	0.10	6702	56314	0
24	1440	86400	0.11	0.09	7561	75085	0



Pre- and Post-Development Hydrographs
pre-devlopment
post-development
10.00, 1.67
10.00, 1.52
Flow Rate, Q (cfs)
Time, t (min)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
5
10
15
20
25
30

Appendix E

Reference Documents

Thick mulches in forests are associated with low retardance factors and reflect high degrees of retardance, as well as high infiltration rates. Hay meadows have relatively low retardance factors. Like thick mulches in forests, stem densities in meadows provide a high degree of retardance to overland flow in small watersheds. Conversely, bare surfaces with little retardance to overland flows are represented by high retardance factors.

The retardance factor is approximately the same as the curve number (CN) as defined in NEH630.09, Hydrologic Soil-Cover Complexes. In practical usage, CN is used as a surrogate for cn´, and the CN tables in NEH 630.09 may be used to approximate cn´ in equations 15–4a and 15–4b. A CN of less than 50, or greater than 95 should not be used in the solution of equations 15–4a and 15–4b (Mockus 1961).

Applications and limitations—The watershed lag equation was developed using data from 24 watersheds ranging in size from 1.3 acres to 9.2 square miles, with the majority of the watersheds being less than 2,000 acres in size (Mockus 1961). Folmar and Miller (2000) revisited the development of this equation using additional watershed data and found that a reasonable upper limit may be as much as 19 square miles.

(b) Velocity method

Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:
T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

Sheet flow—Sheet flow is defined as flow over plane surfaces. Sheet flow usually occurs in the headwaters of a stream near the ridgeline that defines the watershed boundary. Typically, sheet flow occurs for no more than 100 feet before transitioning to shallow concentrated flow (Merkel 2001).

A simplified version of the Manning's kinematic solution may be used to compute travel time for sheet flow. This simplified form of the kinematic equation was developed by Welle and Woodward (1986) after studying the impact of various parameters on the estimates.

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5} S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:
T_t = travel time, h
n = Manning's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

Table 15–1 Manning's roughness coefficients for sheet flow (flow depth generally ≤ 0.1 ft)

Surface description	*n* [1]
Smooth surface (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short-grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The Manning's *n* values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting *n*, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

This simplification is based on the following assumptions:

- shallow steady uniform flow
- constant rainfall excess intensity (that part of a rain available for runoff) both temporally and spatially
- 2-year, 24-hour rainfall assuming standard NRCS rainfall intensity-duration relations apply (Types I, II, and III)
- minor effect of infiltration on travel time

For sheet flow, the roughness coefficient includes the effects of roughness and the effects of raindrop impact including drag over the surface; obstacles such as litter, crop ridges, and rocks; and erosion and transport of sediment. These *n* values are only applicable for flow depths of approximately 0.1 foot or less, where sheet flow occurs. Table 15–1 gives roughness coefficient values for sheet flow for various surface conditions.

Kibler and Aron (1982) and others indicated the maximum sheet flow length is less than 100 feet. To support the sheet flow limit of 100 feet, Merkel (2001) reviewed a number of technical papers on sheet flow. McCuen and Spiess (1995) indicated that use of flow length as the limiting variable in the equation 15–8 could lead to less accurate designs, and proposed that the limitation should instead be based on:

$$\ell = \frac{100\sqrt{S}}{n} \qquad \text{(eq. 15–9)}$$

Table 15–2 Maximum sheet flow lengths using the McCuen-Spiess limitation criterion

Cover type	*n* values	Slope (ft/ft)	Length (ft)
Range	0.13	0.01	77
Grass	0.41	0.01	24
Woods	0.80	0.01	12.5
Range	0.13	0.05	172
Grass	0.41	0.05	55
Woods	0.80	0.05	28

where:
n = Manning's roughness coefficient
ℓ = limiting length of flow, ft
S = slope, ft/ft

Table 15–2 provides maximum sheet flow lengths based on the McCuen-Spiess limiting criteria for various cover type—*n* value—slope combinations.

Shallow concentrated flow—After approximately 100 feet, sheet flow usually becomes shallow concentrated flow collecting in swales, small rills, and gullies. Shallow concentrated flow is assumed not to have a well-defined channel and has flow depths of 0.1 to 0.5 feet. It is assumed that shallow concentrated flow can be represented by one of seven flow types. The curves in figure 15–4 were used to develop the information in table 15–3.

To estimate shallow concentrated flow travel time, velocities are developed using figure 15–4, in which average velocity is a function of watercourse slope and type of channel (Kent 1964). For slopes less than 0.005 foot per foot, the equations in table 15–3 may be used.

After estimating average velocity using figure 15–4, use equation 15–1 to estimate travel time for the shallow concentrated flow segment.

Open channel flow— Shallow concentrated flow is assumed to occur after sheet flow ends at shallow depths of 0.1 to 0.5 feet. Beyond that channel flow is assumed to occur. Open channels are assumed to begin where surveyed cross-sectional information has been obtained, where channels are visible on aerial photographs, or where bluelines (indicating streams) appear on U.S. Geological Survey (USGS) quadrangle sheets.

Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for the bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

Figure 15–4 Velocity versus slope for shallow concentrated flow

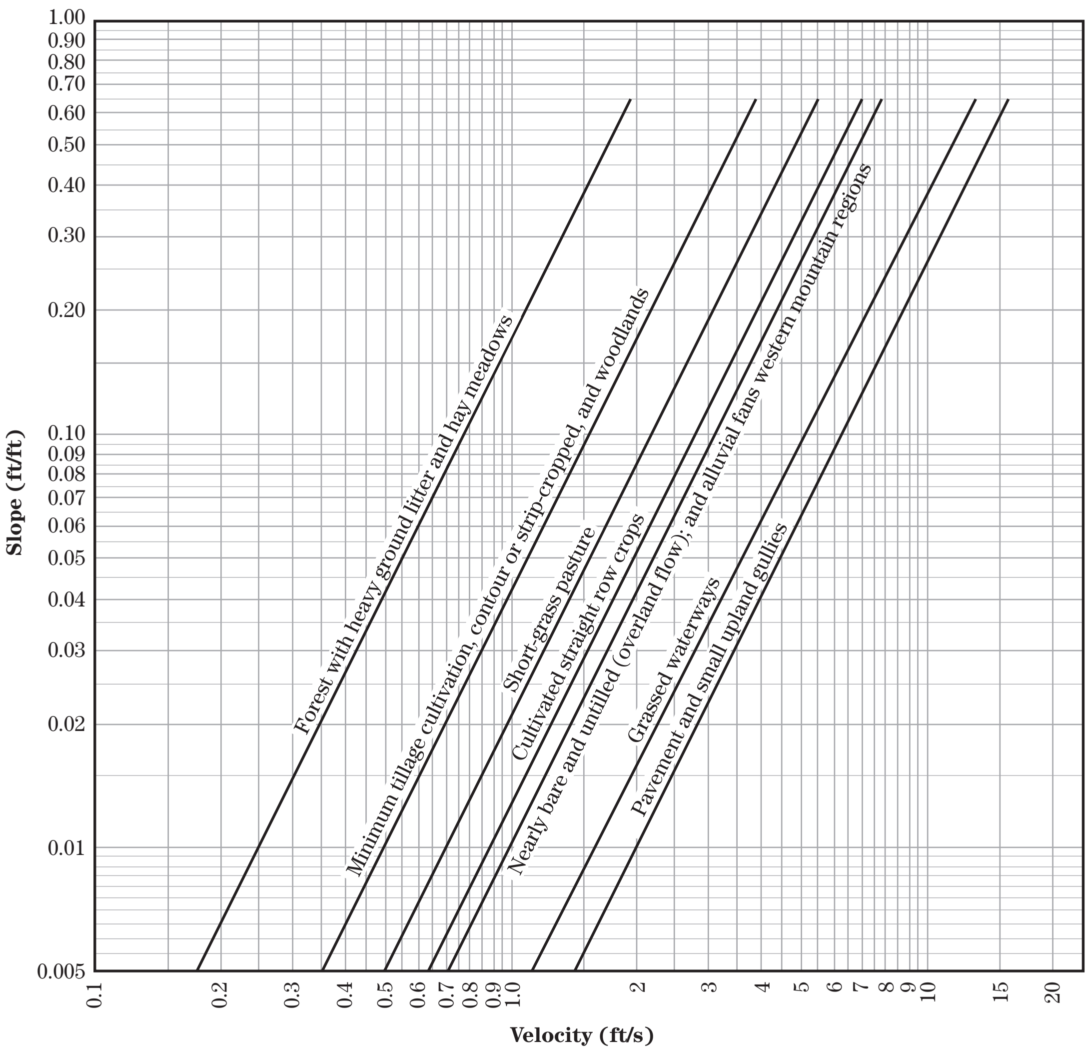


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.516(s)^{0.5}$

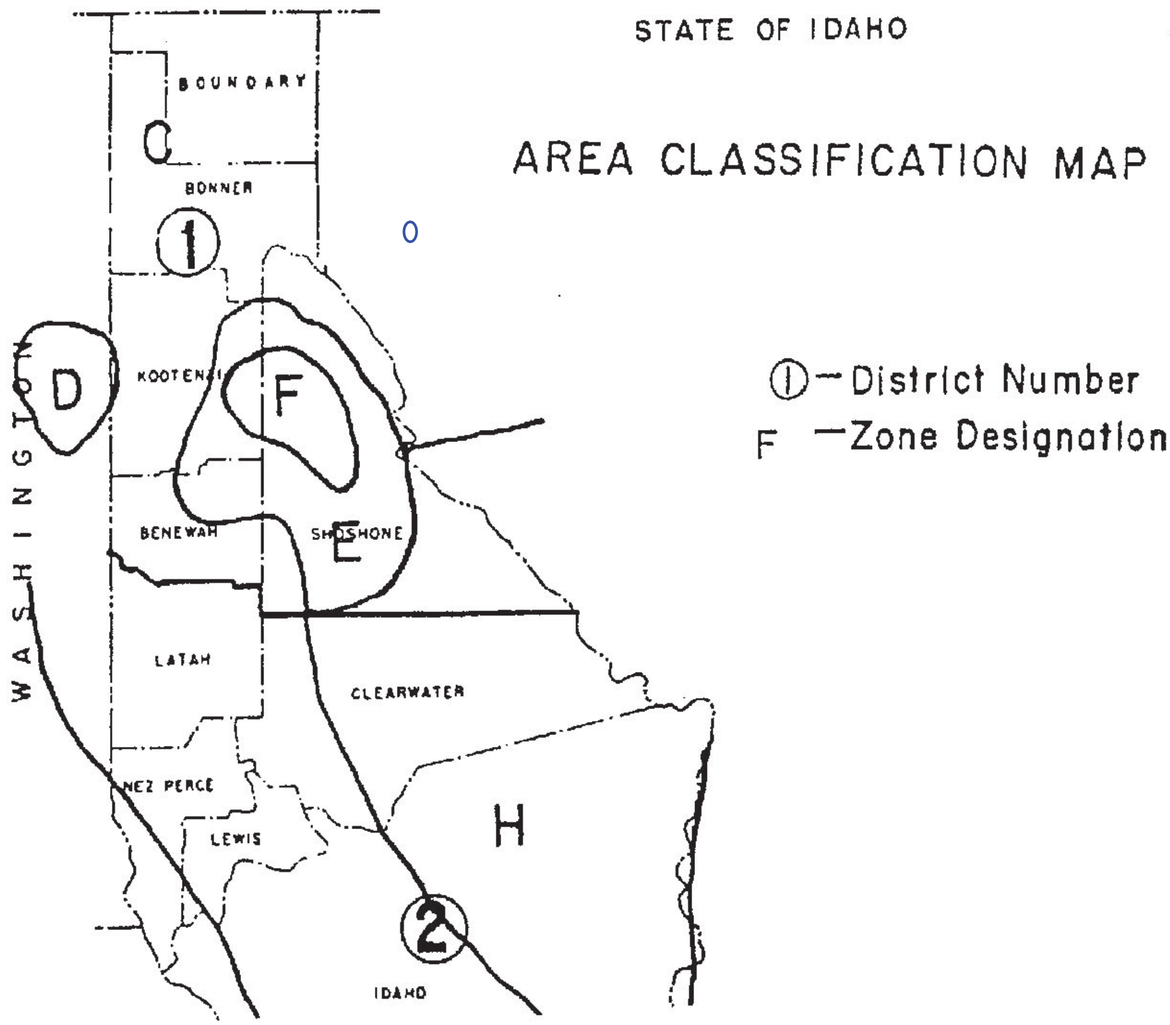


FIGURE 6-3 AREA CLASSIFICATION MAP FOR IDF CURVES - IDAHO
(IDAHO TRANSPORTATION DEPARTMENT)

FIGURE 6-4 ZONE C, INTENSITY-DURATION-FREQUENCY CURVE
(IDAHO TRANSPORTATION DEPARTMENT)

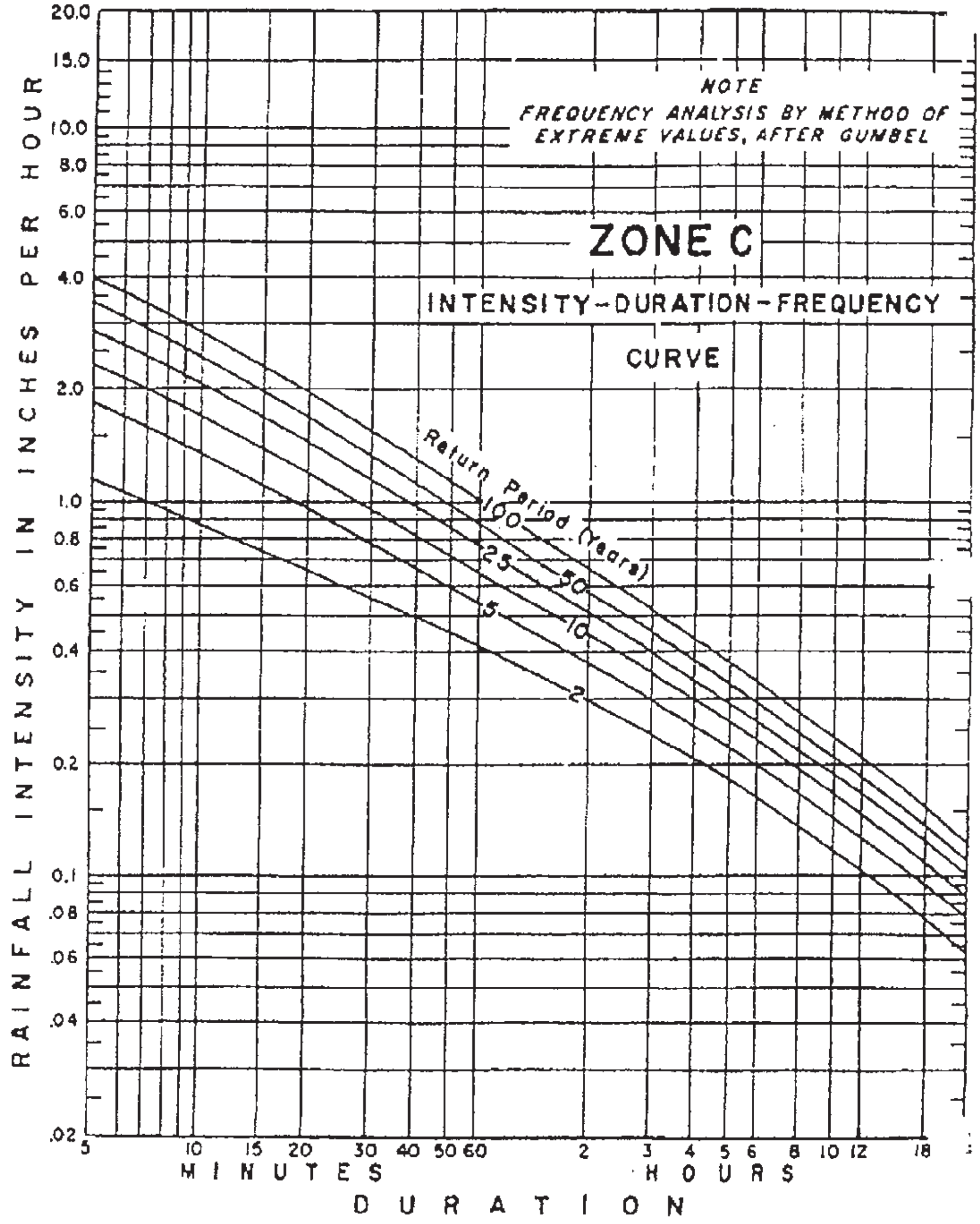


Table 1A.2. Values of Runoff Coefficient (C) for Rational Formula

Land Use	Description	Hydrologic Soils Group			
		A	B	C	D
Cultivated Land	Without conservation treatment	0.49	0.67	0.81	0.88
	With conservation treatment	0.27	0.43	0.67	0.67
Pasture or Range Land	Poor condition	0.38	0.63	0.78	0.84
	Good condition	---	0.25	0.51	0.65
Meadow	Good condition	---	---	0.41	0.61
Wood or Forest Land	Thin stand, poor cover, no mulch	---	0.34	0.59	0.70
	Good cover	---	---	0.45	0.59
Open Space, Lawn, Park, Golf Course, or Cemetery	Good condition (grass cover on 75% or more)	---	0.25	0.51	0.65
	Fair condition (grass cover on 50% to 75%)	---	0.45	0.63	0.74
Commercial and Business Area	85% impervious	0.84	0.90	0.93	0.96
Industrial District	72% impervious	0.67	0.81	0.88	0.92
Residential Lot Average lot size (acres):	Average % of lot impervious:				
1/8	65	0.59	0.76	0.86	0.90
1/4	38	0.29	0.55	0.70	0.80
1/3	30	---	0.49	0.67	0.78
1/2	25	---	0.45	0.65	0.76
1.0	20	---	0.41	0.63	0.74
Paved Area	Parking lots, roofs, driveways, etc.	0.99	0.99	0.99	0.99
Street or Road	Paved with curbs and storm sewers	0.99 0.57	0.99 0.76	0.99 0.84	0.99 0.88
	Gravel	0.49	0.69	0.80	0.84

Note: The designer must use judgment to select the appropriate C value within the range. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have the lowest C values. Smaller areas with dense soils, moderate to steep slopes, and sparse vegetation should assigned the highest C values.

Appendix F

BMPs

BMP 18: Bioretention Basin

Description

A bioretention basin is a storm water management landscaping feature designed to mimic natural hydrologic processes that occur in vegetated areas through infiltration and evapotranspiration. A bioretention basin, or *rain garden,* consists of a shallow depression of porous soil covered with a thin layer of mulch planted with grasses, shrubs, and small trees that promote evapotranspiration, maintain soil porosity, encourage biological activity, and promote uptake of some pollutants (Figure 47).

Figure 47. Bioretention basin (Virginia DCR 2011).

The system can include a pretreatment filter strip of grass channel inlet area, a shallow surface water ponding area, a bioretention planting area, a soil zone, an underdrain system, and an overflow outlet structure, depending on the site conditions and land use. Bioretention basins are designed so that water infiltrates and does not pond for long periods of time.

Primary BMP Functions and Controls

☐ Construction	☒ Permanent
☐ Erosion Control	☒ Sediment Control
☐ Source Control	☒ Flood Control
☐ Filtration	☒ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
●	Phosphorus
◖	Metals
◖	Bacteria
◖	Hydrocarbons
○	Litter

Other BMP Considerations

Overall Cost	$$
Maintenance Requirements	Medium
Ease of Installation	Medium
Freeze/Thaw Resistance	Fair
Max. Tributary Drainage Area	5 acre
Max. Upstream Slope	25%
NRCS Soil Group	ABCD
Min. Ground Water Separation	3 feet
Min. Bedrock Separation	6 feet

Applicability

Bioretention basins typically serve a tributary area of one impervious acre or less and can be used in small landscaped areas such as parking lot islands, street medians, landscape areas between the road and a detached walk, and depressed landscaping beds in lawns. Bioretention basins can be used in highly urbanized landscapes such as commercial or office developments and in residential developments within open space areas or on individual lots.

For larger project sites, bioretention practices can be integrated throughout the project and strategically placed to intercept runoff near the source, preferably lot by lot. Originally designed to provide an element of water quality control, studies have shown that quantity control can be achieved as well. Bioretention systems function similar to infiltration/filtration practices with the added advantage of providing aesthetically pleasing landscaping.

Limitations

The surface of the bioretention basin should be flat, so the basin's use may be limited on steep slopes unless there is room for terracing multiple basins. Bioretention basins should not be located within 10 feet of a building or other structure that may be impacted by oversaturated subgrade soil, especially in areas of expansive soils unless protective measures are taken with consultation of a geotechnical engineer.

Bioretention facilities should not be used in areas with shallow aquifers unless they include an underdrain designed to divert water to an appropriate discharge location and are lined with a geomembrane liner to restrict seepage. An underdrain may also be needed where the native subgrade soils do not allow sufficient infiltration.

In many areas, large bioretention basins that treat more than 1 acre have lower pollutant removal rates than smaller ones. This lower rate is due to higher velocities and often failure of the infiltration system to keep the basin from performing optimally.

Design Basis

Most bioretention devices are off-line basins designed to infiltrate all flow up to the water quality design storm. General design parameters for bioretention facilities include the following:

Pretreatment

If the bioretention basin is located in a watershed with high expected sediment loads, pretreatment will help reduce the likelihood that the planting soil will clog over time. Pretreatment of a basin within a vegetated area could be accomplished by placing a minimum 5-foot wide grassed buffer strip around the facility. The grass buffer strip reduces the velocity of the incoming runoff and filters some of the coarser particulates.

For bioretention basins located adjacent to parking areas, the inflow gutter can be designed at a minimal slope of 0.5% to facilitate sediment and debris deposition before entering the BMP. This design will reduce maintenance of the basin but may increase the amount of sweeping and cleaning required of the gutter.

If the inlet to the basin is through a curb cut with concentrated flow, include energy dissipation at the inlet such as small rock riprap or a level spreader.

Basin Geometry

The facility should be sized to hold the volume of runoff from the water quality design storm. The Low Impact Development Center (2007) offers excel spreadsheets to assist with *bioretention basin design*. Generally, the area of the basin will be equal to 5% to 7% of the tributary drainage area depending on the amount of impervious surface in the watershed.

Ensure a minimum depth of 3 feet from the bottom of the facility to the ground water table. If this is not possible, see design guidelines for underdrains.

The recommended ponding depth is 6 to 9 inches with a maximum of 12 inches. This depth provides some temporary storage while preventing water from standing for long periods of time. If the bioretention basin is located adjacent to a parking lot or other impervious surface, provide a 2 to 3-inch drop from the edge of the pavement to the surface of the basin. This drop will prevent accumulation of debris and plant growth at the entrance to the basin and can prevent water from entering the basin (Figure 48).

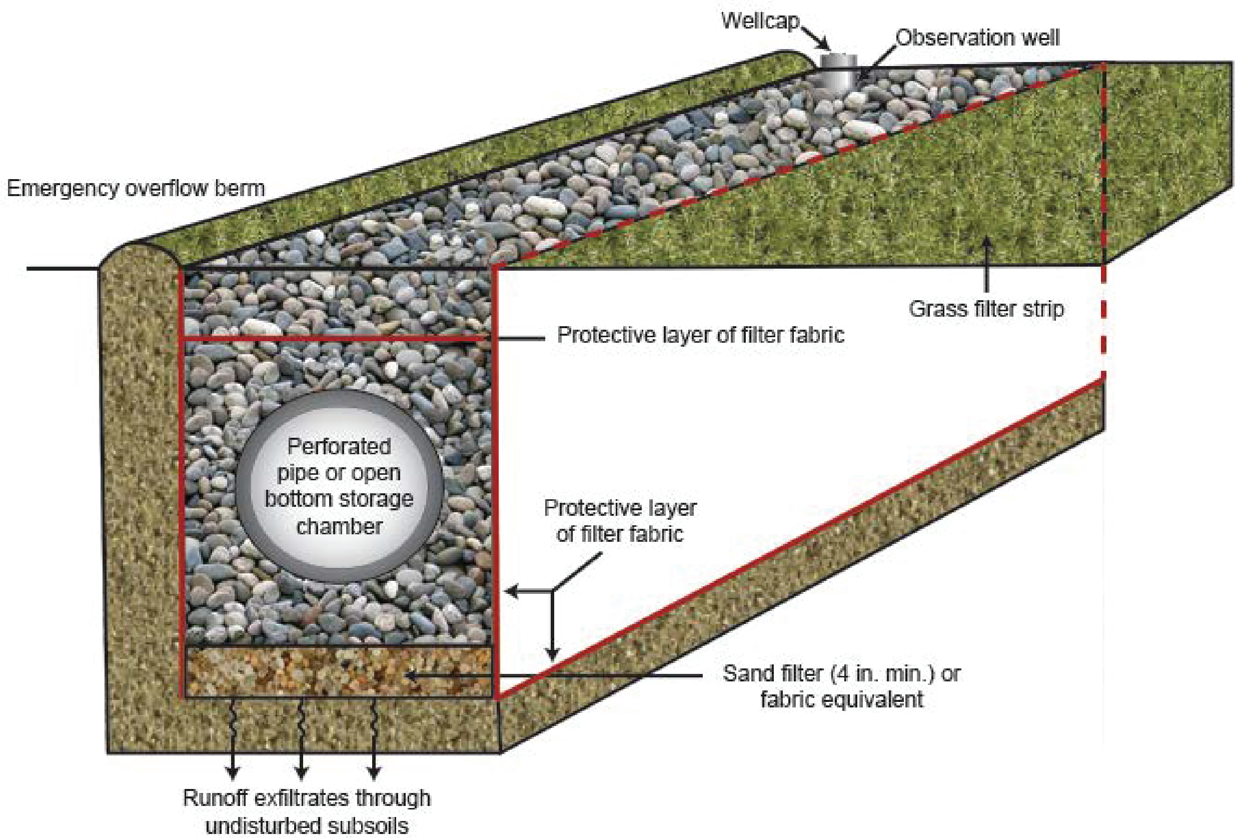


Figure 48. Bioretention detail (Virginia DCR 2011).

Mulch

If ground cover or grass is not immediately established after trees and shrubs are planted, place 2 to 3 inches of aged, fine shredded hardwood over the basin to filter pollutants and protect the planting soil from drying out and eroding. A mulch layer deeper than 3 inches interferes with the cycling of oxygen and carbon dioxide in the soil. Other types of mulch, such as Beauty Bark, tend to float and may clog overflow outlets.

Planting Soil

Planting soil filters pollutants and provides temporary storage for runoff. Planting soil should be a sand/soil mixture at a minimum depth of 4 inches deeper than the bottom of the largest plant root ball. While adequate nutrient removal requires a minimum depth of 2 feet, a depth of 4 feet is desirable.

Depending on its infiltrative capacity, the natural soil can be amended to create the planting soil (BMP 7: Soil Restoration and Enhancement). Soil infiltration capacity should be a minimum of 0.5 inches per hour for the life of the facility. The maximum desirable infiltration rate is 3 inches per hour. A higher maximum infiltration rate may be acceptable if an adequate vegetative cover can be maintained without excessive irrigation. The design infiltration rate should be considered equal to one-half the infiltration rate found from the soil textural analysis or in-situ infiltration tests due to decreases in infiltration rate as the planting mix ages. Thus, the measured infiltration rate should be 1 to 6 inches per hour.

If the natural soil does not meet the minimum measured infiltration rate of 1 inch per hour, the planting soil can be entirely imported and an underdrain may be required to avoid water ponding.

Sand Bed

If an underdrain surrounded by gravel is not used, a sand bed underlying the planting soil provides aeration and ensures infiltration across the entire bottom of the facility. A depth of 1.5 feet of sand is recommended. If the sand bed is extended to the sides of the planting soil, it acts as a sand filter and filters particulates.

Underdrain System

An underdrain system may be needed if the underlying soil does not provide adequate infiltrative capacity, infiltrated water must be diverted from a structure, or if sensitive high ground water is present. The underdrain should be located within a minimum 6-inch deep washed gravel layer under the planting soil. Perforated PVC pipe, commonly 4, 6, or 8 inches in diameter, can be used as an underdrain; select the pipe size based on the capacity needed to remove water substantially faster (10 times) than water enters from the planting soil above. Cleanouts should be provided to facilitate inspection and maintenance of the underdrain (Figure 49).

Overflow System

Overflow of the bioretention basin during large storms should be evaluated. Overflow could be provided via a spillway to another drainage basin that has capacity to handle larger flows. For urban settings, a grated inlet and outlet pipe can be installed in the bioretention basin with the top of the inlet set to the desired maximum water depth in the basin. The outlet pipe can convey larger storm events to another storm drainage facility.

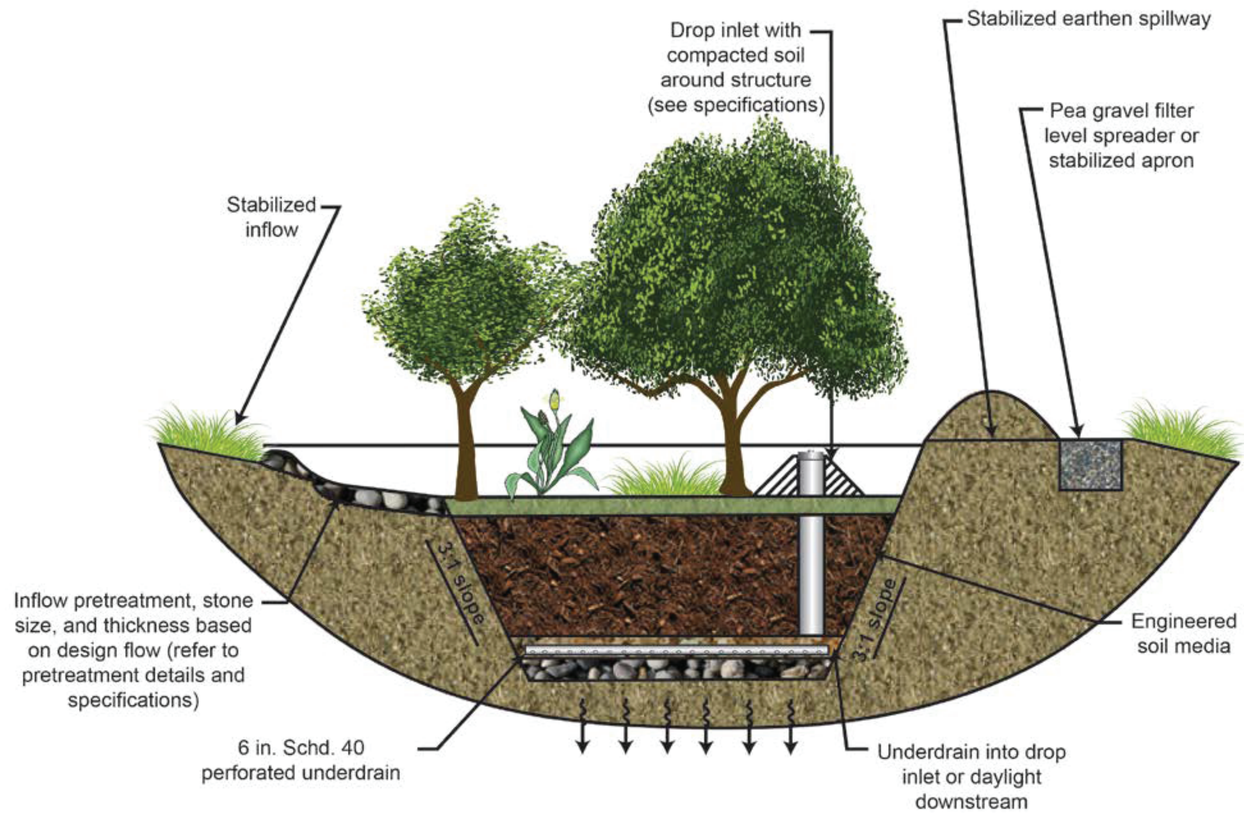


Figure 49. Bioretention inflow and outflow section (Virginia DCR 2011).

Vegetation

Vegetation reduces the potential for erosion and provides evapotranspiration. Select native plant species that are tolerant to pollutant loads and varying soil moisture (referred to as facultative). A mixture of small trees, shrubs, flowers, and grasses should be used. A variety of trees and shrubs should be selected to enhance the aesthetic appeal of the facility. If an underdrain is used, select trees and shrubs that do not have overly aggressive roots that search out water and clog the underdrain pipe.

Plant placement is important to the success of the bioretention basin and should resemble a natural, random pattern. To avoid damage to the plant and possible channelization of flow, woody plants should not be placed where flows enter the bioretention facility. The microclimate of the facility should be considered in vegetation placement. For example, evergreen trees or other wind-tolerant species may be placed on the northern end of the area to block cold winter winds. Plants that tolerate dryer conditions could be placed at the edges and plants that tolerate both wet and dry conditions could be placed in the bottom.

If sod is chosen to vegetate the basin, select sod that has been grown in permeable soils. Sod grown in clay soils will not be effective because the clay soil can restrict water infiltration reducing the expected infiltration rate of the system. If sod grown in clay soils is the only sod available, ask the grower to wash off the soil from the sod to remove all clay material.

Avoid sprinkler irrigation of bioretention areas, although temporary irrigation may be needed for plant establishment.

Construction Guidelines

Schedule

The sequence of various phases of basin construction should be coordinated with the overall project construction schedule. The project should schedule rough excavation of the basin with the rough grading phase to permit use of the material as fill in earthwork areas. The partially excavated basin may serve as a temporary sediment trap or pond to assist in erosion and sediment control during construction. However, basins near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed basin with a heavy concentration of fine sediment. This sediment could seriously impair the natural infiltration characteristics of the basin floor. Final grade of an infiltration basin should not be attained until after its use as a sediment control basin is completed.

Specifications for basin construction should state the earliest point in construction progress when storm drainage may be directed to the basins, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each project should be separately evaluated to postpone use as long as is reasonably possible. Drainage areas should be stabilized before beginning to use the facility to minimize sediment load to the treatment area.

Excavation

Initial excavation should be carried to within 1 foot of the final elevation of the basin’s floor. Final excavation to the finished grade should be deferred until all disturbed areas on the site have been stabilized or protected. The final phase of excavation should remove all accumulated sediment. Relatively light-tracked equipment is recommended for this operation to avoid compacting the basin floor. After the final grading is completed, the basin floor should be deeply tilled with rotary tillers or disk harrows to provide a well-aerated, highly porous surface texture. Fill the bioretention area with planting soil, sand, gravel, and underdrains per the basin design. Placement of the planting soil should be in lifts of 1.5 feet or less and lightly compacted. Expect the soil to settle by up to 20% during the first storm event.

Infiltration Test

An in-situ infiltration test should be conducted after final grading and may be required by the local jurisdiction. Infiltration rates used to design the facility should be verified during construction and if the rates vary, the design should be modified.

Maintenance

Bioretention basins require seasonal landscaping maintenance. In many cases, bioretention areas require intense maintenance initially to establish the plants, but less maintenance is required in the long term. When bioretention basins are first placed into use, they should be inspected on a monthly basis, and after large storms to ensure adequate drainage is being provided. Water standing longer than 4 days will severely limit the growth of most plants, and mosquitoes and other insects may start to breed. Additionally, the microbial processes of the planting soil that remove nutrients will not work as well if the facility becomes waterlogged and anaerobic.

Once it is determined that the basin is functioning in a satisfactory manner and no potential sediment problems exist, inspection can be reduced to a semiannual basis with additional inspections following the occurrence of a large storm. Litter and debris should be removed as needed.

Trees and shrubs should be inspected twice per year. Any dead or severely diseased vegetation should be removed. Prune and weed to maintain the bioretention area's appearance. Spot mulch when bare spots appear. Every 2 to 3 years, the entire area should be remulched.

Soil should be tested annually to detect toxic concentrations of pollutants. As toxins accumulate, they may impair plant growth and bioretention effectiveness, and soil replacement may be required.

Additional Resources

Bitter S. and J.K. Bowers. 1994. "Bioretention as a Water Quality Best Management Practice." *Watershed Protection Techniques*. 1(3).

EPA (US Environmental Protection Agency). 1999. *Storm Water Technology Fact Sheet*: *Bioretention*. Washington, DC: EPA Office of Water. EPA-832-F-99-012.

ETA (Engineering Technologies Associates, Inc.). 1993. *Design Manual for Use of Bioretention in Stormwater Management*. Prepared for Prince George's County, Maryland, Department of Environmental Resources. Troy, MI.

Hunt, W.F. and N. White. 2001. *Designing Rain Gardens (Bio-Retention Areas).* North Carolina State University Cooperative Extension.

Low Impact Design Center. 2008. *Rain Garden Design Templates*. Beltsville, MD.

Virginia DCR (Virginia Department of Conservation and Recreation). 2011. *Bioretention*. Best Management Practice Fact Sheet 9.

BMP 31: Topsoiling

Description

Topsoiling places material suitable for vegetative growth over disturbed lands. Often topsoiling includes native seeds and propagules in the plant growth mix. Topsoiling may involve transporting soils from off site or reusing the existing topsoil that has been stripped and stockpiled during earlier site development activities (Figure 83).

Sites improved with topsoiling are benefitted by additional biofiltration capacity, increased storm water retention and, through a more established root zone, less watering, fertilizing, and pesticide application requirements.

Figure 83. Placing new topsoil on Pioneer Mountain scenic byway, Orofino, Idaho (*Debco Construction*).

Applicability

Topsoiling is recommended on slopes no greater than 2:1 where native soils are unsuitable for vegetative growth. Topsoiling is an effective way to improve plant establishment on sites where moisture, nutrients, or pH levels are low, or where the existing soil is incapable of supporting root systems. This BMP should be used with BMP 32: Landscaping.

Limitations

Topsoil should not be applied over a subsoil of contrasting permeability. Placing clay-like topsoil over a sandy soil may cause the topsoil to separate from the existing subsoil as water flows between the two soil layers of different permeability. Topsoil should not be applied when the subsoil is frozen or extremely wet.

Stockpiling topsoil for an extended period of time disrupts soil health, resulting in the partial or total loss of microorganisms. Mixing the top foot of stockpiled topsoil with the remainder of the stockpiled topsoil before final placement ensures a uniform distribution of living organisms (BMP 44: Stockpile Management).

Primary BMP Functions and Controls

☐ Construction	☒ Permanent
☒ Erosion Control	☐ Sediment Control
☐ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

◖	Sediment
○	Nitrogen
○	Phosphorus
○	Metals
○	Bacteria
○	Hydrocarbons
○	Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Low
Ease of Installation	Easy
Freeze/Thaw Resistance	Fair
Max. Tributary Drainage Area	Unlimited
Max. Site Slope	50%
NRCS Soil Group	ABCD
Min. Ground Water Separation	3 feet
Min. Bedrock Separation	2 feet

Design Basis

To the maximum extent practicable, the moisture-holding capacity of the soil should be maintained or increased by reusing native topsoil or adding soil amendments. The topsoil should be uniformly distributed at a minimum compacted depth of 4 inches on slopes 3:1 or steeper, and 8 inches deep or greater on flatter slopes. The soil should be approved by an agronomist and may consist of loam, sandy loam, clay loam, silt loam, sandy clay loam, or other mixtures. It should be free of subsoil debris such as sticks, invasive species, stones larger than 1.5 inch diameter, and other extraneous materials.

Topsoil can be obtained commercially or stripped, stockpiled, and replaced following construction. Stockpiled topsoil should undergo a laboratory analysis to determine organic content, pH, and soluble salts. A pH of 6.0 to 7.5 and organic content of not less than 1.5% by weight is recommended. Where soil pH is less than 6.0, lime may be applied to adjust pH to 6.5 or higher. Any soils having soluble salt content greater than 500 parts per million should not be reused.

The topsoil should be tailored to the type of permanent native vegetation desired on site. Traditional topsoil will favor grasses, while the addition of acidic high-carbon amendments may encourage more woody species.

Construction Guidelines

The following guidelines apply to the placement of topsoil:

- The existing or established grade of subsoil should be maintained.
- Lime may be uniformly applied over designated areas where the subsoil is highly acidic or high in clay content.
- Before spreading topsoil, scarify the subgrade to 4 inches deep to permit bonding of subsoil to topsoil. Ripping or restructuring (BMP 45: Minimize Soil Compaction) the subgrade may be necessary in areas that have been overly compacted to restore the infiltrative capacity of the subgrade. Tracking a bulldozer vertically over the slope will pack the soil and create horizontal erosion check slots to prevent topsoil from sliding down the slope.
- Where quantities of stockpiled topsoil on site are limited, it is more desirable to cover all areas of exposed subsoil to a lesser depth than to cover partial areas to the suggested minimum depth.
- Topsoil should not be placed when the subgrade is frozen, excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or vegetation establishment.
- Immediately after topsoil placement, stabilize the soil using landscaping (BMP 32), mulching (BMP 52), matting (BMP 54), or soil binders (BMP 55) before proceeding to the next construction phase.
- Stockpiled topsoil should be protected from erosion (BMP 44: Stockpile Management).

Maintenance

Before a site is fully established, inspect topsoil periodically and after major storm events for signs of erosion such as rills and gullies. Damaged areas should be repaired with additional topsoil and reseeded as necessary to minimize erosion and loss of topsoil.

Additional Resources

ITD (Idaho Transportation Department). 2014. *Best Management Practices.* Boise, ID: ITD.

Washington State Department of Ecology. 2012. *Stormwater Management Manual for Western Washington*. Lacey, WA. Publ. 12-10-030. *http://www.ecy.wa.gov/programs/wq/stormwater/manual.html*

BMP 36: Construction Timing

Description

Figure 97. Construction phasing reduces the amount of time soil is exposed (EPA 2003).

Proper timing and sequencing of construction activities minimizes erosion and sediment transport by coordinating land-disturbing activities and erosion and sediment control measures installation and by completing construction during periods of low erosion potential (Figure 97). In construction phasing, only a portion of a site is disturbed at one time, and final stabilization is completed before moving on to another part of the site, which limits potential erosion (BMP 1: Minimize Land Disturbance, BMP 39: Clearing Limits, BMP 38: Preserve Topsoil and Vegetation, and BMP 45: Minimize Soil Compaction).

Applicability

All construction projects can benefit from upfront planning to phase and sequence construction activities to minimize the extent and duration of disturbance.

Large construction projects and areas where work activities can be timed to coincide with periods of low erosion potential, such as during dry weather, especially benefit from good construction timing. Small projects that are less than 5 acres in size and occur during a short time period during the dry season may qualify for waived NPDES permitting requirements. See EPA's *rainfall erosivity waivers*.

Limitations

Timing construction based on seasonal limitations may not always be possible due to bidding, letting, timing, and contract administration. Additional restrictions may exist on scheduling or sequencing of certain work activities and the maximum allowable exposure of surface area based on environmental permits and requirements.

Primary BMP Functions and Controls

☒ Construction	☐ Permanent
☒ Erosion Control	☒ Sediment Control
☐ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
●	Phosphorus
◖	Metals
○	Bacteria
○	Hydrocarbons
○	Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Low
Ease of Installation	Easy
Freeze/Thaw Resistance	N/A
Max. Tributary Drainage Area	N/A
Max. Upstream Slope	N/A
NRCS Soil Group	ABCD
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Design Basis

The locations and dimensions of BMPs appropriate to the major phases of development should be clearly identified on the SWPPP map and included in the construction drawings (Table 21). In some cases, several drawings may be needed to show construction-phase BMPs placed according to phases of construction (e.g., clearing and grading, utility installation, active construction, and final stabilization) as erosion and sediment controls needed at a site will change as construction progresses.

Consider site characteristics and permit conditions when deciding what kind of erosion control devices to incorporate into a construction project. Select measures that can be installed without disrupting critical timing or sequencing of other construction or erosion control activities.

Construction Guidelines

Phasing

Typical phasing best practices include the following:

- Conduct work in phases so that some portions of the project site are final-graded and stabilized before the next phase of the project is started.
- Limit the amount of disturbed area at any given time on a site to the extent practical. For example, a 100-acre subdivision might be constructed in five phases of 20 acres each.
- If stockpiled material is carried over from one phase to the next, position carryover material in a location easily accessible for the pending phase so the stabilized area is not disturbed.

Timing and Sequencing

Typical timing and construction sequencing best practices include the following:

- Schedule construction during seasonal low-runoff periods under favorable soil moisture conditions, whenever possible.
- Allow time to install sediment collection systems, drainage systems, and runoff diversion devices before beginning ground-disturbing work in an area.
- Install and maintain effective soil stabilization measures as work progresses, not just when construction is completed.
- Initiate slope stabilization measures within 14 calendar days after construction activities in the portion of the site where earthmoving activities have temporarily or permanently ceased.
- Develop a scheduling/sequencing plan addressing the construction sequencing to reduce erosion potential. If using a Critical Path Method (CPM) for scheduling, incorporate the erosion control and storm water management practices into the method.

Table 21. Recommended BMPs for construction phases (Colorado UDFCD 2010).

Project Phase	Best Management Practice
Predisturbance site access	• Install sediment controls downgradient of access point (on paved streets this may consist of inlet protection) (BMP 66, BMP 74). • Establish vehicle tracking control at entrances to paved street. Fence as needed (BMP 40, BMP 65). • Use construction fencing to define the project's boundaries and limit access to areas of the site not to be disturbed (BMP 41). **Note**: it may be necessary to protect inlets in the general vicinity of the site, even if not downgradient, if there is a possibility that sediment tracked from the site could contribute to the inlets.
Site clearing and grubbing	• Install perimeter controls (e.g., silt fence and wattles) as needed on downgradient perimeter of site (BMP 64, BMP 65). • Limit disturbance to areas planned for disturbance and protect undisturbed areas within the site (e.g., construction fence and flagging) (BMP 1, BMP 2, BMP 3, BMP 39). • Preserve vegetative buffer at site perimeter (BMP 2, BMP 38). • Create stabilized staging area (BMP 37). • Locate portable toilets on flat surface away from drainage paths. Stake in areas susceptible to high winds (BMP 50). • Construct concrete washout area and provide signage (BMP 47). • Establish waste disposal areas (BMP 51). • Install sediment basins (BMP 66). • Create dirt perimeter berms and or brush barriers during grubbing and clearing (BMP 70). • Separate and stockpile topsoil; leave roughened and/or cover (BMP 31). • Protect stockpiles with perimeter control BMPs. Locate stockpiles away from drainage paths and access from the upgradient side so perimeter controls can remain in place on the downgradient side. Use erosion control blankets, temporary seeding, and/or mulch for stockpiles that will be inactive for an extended period (BMP 44). • Leave disturbed area of site in a roughened condition to limit erosion. Consider temporary revegetation for areas of the site that have been disturbed but will be inactive for an extended period (BMP 8, BMP 32, BMP 58). • Water to minimize dust but not to the point that watering creates runoff (BMP 43).
Utility and infrastructure installation	**In addition to the BMPs above**: • Close trench as soon as possible (generally at the end of the day). • Use rough-cut street control or apply road base for streets that will not be promptly paved (BMP 40, BMP 41). • Provide inlet protection as streets are paved and inlets are constructed (BMP 74). • Protect and repair BMPs as necessary. • Perform street sweeping as needed (BMP 75).
Building construction	**In addition to the BMPs above**: • Implement materials management and good housekeeping practices for home building activities (BMP 80, BMP 90). • Use perimeter controls for temporary stockpiles from foundation excavations (BMP 44). • For lots adjacent to streets, lot-line perimeter controls may be needed at the back of curb (BMP 41).
Final grading	**In addition to the BMPs above**: • Remove excess or waste materials (BMP 48, BMP 49, BMP 50, BMP 51). • Remove stored materials (BMP 32).

Project Phase	Best Management Practice
Final stabilization	**In addition to the BMPs above**: • Seed and mulch/ tackify (BMP 32, BMP 52). • Seed and install blankets on steep slopes (BMP 32, BMP 53, BMP 54) • Remove all temporary BMPs when site reaches final stabilization (BMP 62, BMP 68, BMP 70).

Maintenance

Continually monitor site conditions and work progress. Update the project work schedule to maintain appropriate timing and sequencing of construction and control applications. When the construction schedule is altered, erosion and sediment control measures in the SWPPP and construction drawings should be adjusted to reflect exiting conditions. Maintain appropriate erosion and sediment control measures that align with construction phasing and sequencing.

Additional Resources

Colorado UDFCD (Colorado Urban Drainage and Flood Control District). 2010. *Urban Storm Drainage Criteria Manual, Volume 3 Best Management Practices*. Denver, CO. *http://udfcd.org/wp-content/uploads/2014/07/Title-Page.pdf*

ITD (Idaho Transportation Department). 2014. *Best Management Practices.* Boise, ID: ITD.

Washington State Department of Ecology. 2012. *Stormwater Management Manual for Western Washington*. Lacey, WA. Publ. 12-10-030. *http://www.ecy.wa.gov/programs/wq/stormwater/manual.html*

BMP 37: Staging Areas

Description

Staging areas are clearly designated locations where construction equipment, vehicles, stockpiles, waste bins, office trailers, and other construction-related materials may be stored on site. Staging areas should be located, constructed, and maintained to prevent the discharge of sediment, solid waste, dust, trash, debris, or other pollutants from the site (Figure 98).

Figure 98. Construction staging area (Colorado UDFCD 2010).

Applicability

Most construction sites require a staging area. The size of the staging area depends on the size and type of the project and duration of construction.

Primary BMP Functions and Controls

☒ Construction	☐ Permanent
☐ Erosion Control	☒ Sediment Control
☒ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
◖	Phosphorus
◖	Metals
◖	Bacteria
◖	Hydrocarbons
◖	Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Medium
Ease of Installation	Medium
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	N/A
Max. Upstream Slope	N/A
NRCS Soil Group	ABCD
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Limitations

Some sites have limited space available, and it may be desirable to place the staging area off site or within an adjacent roadway. Staging areas in roadways require special measures to prevent materials from washing into existing storm inlets.

Measures to prevent storm water from entering the staging area tend to concentrate flow and can result in excessive erosion downstream if additional BMPs are not installed.

Design Basis

Size and Location

Size the staging area so that it provides appropriate space to accommodate storage and parking needs, as well as loading and unloading operations. When designing the stabilized staging area, minimize the area of disturbance to the maximum extent practical as oversizing the staging area may disturb existing vegetation in excess of the project requirements (BMP 1: Minimize Land Disturbance and BMP 39: Clearing Limits). Oversizing increases costs and requires long-term stabilization after the construction period. Consider using off-site parking areas and restrict vehicle access to the site if possible to minimize the size needed for staging.

Place staging areas where site impacts will be minimized and at least 50 feet away from streams, surface waters, or wetlands. If possible, locate the staging area in a place that will be disturbed, such as the planned location for a road or parking area, and move it as construction progresses to limit the amount of unnecessary site disturbance.

Features

The staging area should have a stabilized surface, either paved or covered with 2- to 4-inch diameter aggregate at 3 to 6 inches deep, and accessed by a stabilized construction entrance. If the staging area is located in an area that would not be otherwise disturbed, consider using construction mats in lieu of rock to minimize long-term stabilization needs. BMP 41: Stabilized Construction Roads and Staging Areas provides more information on surface treatment requirements.

The grading in and around the staging area should control uncontaminated flow by diverting it around areas that may have pollutants and also contain potentially contaminated flows or divert them to treatment facilities.

Surround the staging area by construction fencing to prevent unauthorized access to construction materials. Perimeter sediment controls such as silt fence (BMP 65), sediment fiber rolls (BMP 64), or other measures should also be installed around the area as appropriate.

Materials storage should follow guidelines from BMP 77: Outdoor Storage, BMP 46: Spill Prevention and Control, and BMP 87: Outdoor Loading and Unloading of Materials. To comply with the Construction General Permit (EPA 2012b), storage areas for building products must provide either cover (e.g., plastic sheeting or temporary roofs) to prevent these products from coming into contact with rainwater, or a similarly effective means designed to prevent the discharge of pollutants from these areas.

Materials should be stored separately as appropriate using guidelines from BMP 48: Hazardous Materials Management. Hazardous or toxic wastes should be stored separate from construction and domestic waste. Flammable and combustible material should be segregated and stored in appropriately sized secondary containment.

Flow Diversion

Limiting the flow across staging areas reduces the volume of storm water that may carry pollutants from the area and require treatment. If the staging area cannot be located away from areas expected to receive significant volumes of storm water runoff, flow diversion BMPs, such as storm water conveyances, dikes, or berms, are needed.

Storm Water Conveyances

Storm water conveyances include either temporary or permanent channels, gutters, drains, or sewers. The conveyances are constructed or lined with many different materials, including concrete, clay tiles, asphalt, plastics, metals, riprap, compacted soils, and vegetation. By their nature, storm water conveyances concentrate flow, and storm water should be routed through stabilized structures to discharge to a receiving water or other storm water BMP.

In planning for storm water conveyances, consider the amount and speed of typical storm water runoff. Also, consider the storm water drainage patterns, so that channels may be located to collect the most flow and built to handle the appropriate runoff volume. When deciding on the type of material for the conveyance, consider the material's resistance, durability, and compatibility with any pollutants it may carry.

Conveyance systems are most easily installed when a facility is initially constructed. Where possible, use existing grades to decrease costs. Grades should be positive to allow for the continued movement of the runoff through the conveyance system; however, grades should not increase velocity, causing excess erosion. When assessing erosion potential, consider the materials used for lining the conveyance and types of outlet controls provided. Reference the following BMPs for additional design parameters.

- BMP 28: Conveyance Furrows for Roof Runoff
- BMP 56: Riprap Slope Protection
- BMP 57: Pipe Slope Drain
- BMP 68: Temporary Swale

Dikes and Berms

Diversion dikes or berms are ridges built to block runoff from passing beyond a certain point. In planning for dike installation, consider the slope of the drainage area, height of the dike, amount of runoff it will need to divert, and type of conveyance that will be used with the dike. Steeper slopes result in higher volumes of runoff and higher velocities, which the dike should be capable of handling. Dikes are limited in their ability to manage large volumes of runoff. Temporary dikes (usually made of dirt) generally only last for 18 months or less but can become permanent structures by stabilizing them with vegetation. Slope protection such as vegetation is crucial for preventing the erosion of the dike. For additional design parameters, see BMP 69: Diversion Dike and BMP 70: Temporary Berms.

Construction Guidelines

Staging areas should be planned and designed before starting construction; however, certain BMPs, such as dikes and berms, may be constructed at any time. Implementing staging areas and associated drainage needs should also be incorporated into BMP 36: Construction Timing.

Specific construction methods apply to the type of conveyance, dikes, berms, graded areas, and pavements being used. Refer to applicable BMPs for construction guidelines.

Maintenance

Maintenance of staging areas includes inspecting and repairing the stabilized surface, repairing perimeter controls, and following good housekeeping practices.

Storm water diversions, such as conveyances and dikes, should be inspected regularly and within 24 hours of a storm event. Daily inspections may be required during periods of prolonged rainfall as heavy storms may clog or damage the conveyances or wash away parts of temporary dikes. Any necessary repairs should be made immediately to ensure the structure continues to function effectively.

Inspect unpaved, graded areas to check for gullies and other signs of erosion. Inspect paving regularly for cracks that may allow contaminants to seep into the ground. Ensure drains receiving the discharge from the paved area remain free of clogged sediment or other debris so that the water does not back up into areas where pollutants may be.

When construction is complete, debris, unused stockpiles, and materials should be recycled or disposed of properly (Section 3.10.7, "Construction Disposal Alternatives"). Permanently stabilize staging areas with vegetation or other surface cover planned for the development.

Additional Resources

Colorado UDFCD (Colorado Urban Drainage and Flood Control District). 2010. *Urban Storm Drainage Criteria Manual, Volume 3 Best Management Practices*. Denver, CO. *http://udfcd.org/wp-content/uploads/2014/07/Title-Page.pdf*

ITD (Idaho Transportation Department). 2014. *Best Management Practices.* Boise, ID: ITD.

BMP 38: Preserve Topsoil and Vegetation

Description

Protect topsoil and vegetation (e.g., trees, grasses, and other plants) by preventing disturbance or damage to specified areas of the construction site. Preserving natural vegetation and native topsoil prevents soil erosion by minimizing the amount of bare soil exposed to erosive forces (Figure 99). Vegetation also provides storm water detention, biofiltration, and aesthetic value.

Even if existing vegetation will not remain permanently after construction is completed, existing vegetation and topsoil can still be preserved with proper phasing during construction to provide a stable surface cover.

Figure 99. Preserve vegetation (Elkhart County SWCD 2007).

Applicability

This BMP applies to all construction sites with existing vegetation. Areas where preserving vegetation and topsoil can be particularly beneficial are floodplains, wetlands, streambanks, steep slopes, and other areas where structural erosion controls would be difficult to establish, install, or maintain.

Compared to newly planted or seeded areas, preserving natural vegetation has many advantages:

- Handles higher quantities of storm water runoff than newly seeded areas.
- Does not require time to establish.
- Greater filtering capacity because the vegetation and root structure are denser in preserved natural vegetation than in newly seeded areas.
- Requires less maintenance, watering, and chemical application (e.g., fertilizer and pesticides) than new vegetation.
- Enhances aesthetics.
- Provides areas for infiltration, reducing the quantity and velocity of storm water runoff.
- Allows areas where wildlife can remain undisturbed.
- Provides noise buffers and visual screens for construction operations.

Primary BMP Functions and Controls

☒ Construction	☐ Permanent
☒ Erosion Control	☐ Sediment Control
☐ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
○	Phosphorus
○	Metals
○	Bacteria
○	Hydrocarbons
○	Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Low
Ease of Installation	Easy
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	N/A
Max. Upstream Slope	N/A
NRCS Soil Group	ABCD
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Limitations

Preserving natural vegetation may be impractical in some situations because it may constrict the area available for construction activities, or it may not be cost-effective in areas with high land values. In areas with high land values, projects may need to be designed with little or no vegetation intended to remain to maximize development density. For sites with diverse topography, it may be difficult and expensive to save existing vegetation while grading the site for the development.

Design Basis

Successfully preserving vegetation requires good planning and site management. Preserving natural vegetation may affect some aspects of staging, work sequencing, and construction cost. Erosion control measures may be needed around the perimeter of the preserved area to maintain adequate water flow and drainage and prevent damage from excessive erosion or sedimentation.

Identify areas to be protected on the construction plans. Preserve individual natural vegetation, such as trees, shrubs, or vines, although preserving vegetation in clumps may be more practical. Protection areas should extend to the dripline of any trees to be preserved. The dripline marks the edge of the tree's foliage where drips from rainfall would drop. When selecting trees to be preserved, consider the location, vigor, age, species, and wildlife benefits of the tree. Healthy, older trees that are well-suited to the site conditions and are beneficial to wildlife are most important to preserve.

Vegetation protection areas should be marked in the field before any site disturbance begins. Clearly mark the areas to be preserved with construction fencing and/or a perimeter control, such as silt fencing (BMP 65) or fiber rolls (BMP 64) if the protected area is located downgradient of areas to be disturbed. Use appropriate fence posts and adequate post spacing and depth to completely support the fence in an upright position. No construction activity, including stockpiling, materials storage, or equipment parking, should be allowed within the protected area.

Plants must be protected from three types of injuries possible during construction: impacts, grade changes, and excavations. By instructing employees and subcontractors to honor the limits of protection areas, the vegetation should be protected from these injuries.

Construction Guidelines

Check the project plans for areas designated for preserving natural vegetation. Keep all construction equipment, materials, and waste out of the designated areas. Root pruning and fertilizing before construction is recommended where trees are near the edge of protected areas. These practices should be supervised by a licensed arborist for the maximum survival rate.

Do not modify existing drainage patterns through or into any preservation area unless specifically directed by the plans or approved by the local permitting authority.

Retain protective fencing until all construction activity is complete to avoid damage during site cleanup and final stabilization.

Maintenance

Inspect fencing at regular intervals to ensure it is in place, and the preserved vegetated areas remain undisturbed and are not overwhelmed by sediment. Implement maintenance or restorative actions as needed. Proper maintenance is important to ensure healthy vegetation that can control erosion.

Different species, soil groups, and climatic conditions will require different maintenance activities such as mowing. Perform maintenance regularly, especially during construction.

If damage occurs to a tree, consult an arborist for guidance on how to care for the tree. If a tree in a designated preservation area is damaged beyond repair, remove and replace with a 2-inch diameter tree of the same or similar species. If damage occurs to vegetation, reseed the area with the same or similar species.

Additional Resources

CASQA (California Stormwater Quality Association). 2015. *California Stormwater Best Management Practices Handbook: Construction.* Menlo Park, CA. *https://www.casqa.org*

Colorado UDFCD (Colorado Urban Drainage and Flood Control District). 2010. *Urban Storm Drainage Criteria Manual, Volume 3 Best Management Practices*. Denver, CO. *http://udfcd.org/wp-content/uploads/2014/07/Title-Page.pdf*

Elkhart County SWCD (Elkhart County Soil and Water Conservation District). 2007. *BMP Hall of Fame*. Goshen, IN.

EPA (US Environmental Protection Agency). 2014. *Preserving Natural Vegetation*. Water: Best Management Practices. *https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu*

King County (King County, Washington). 2009. *King County, Washington Surface Water Design Manual.* Seattle, WA: King County, Department of Natural Resources.

BMP 40: Vehicle Sediment Control

Description

This BMP describes measures to minimize track out of sediment from construction vehicles exiting the construction site onto off-site streets, other paved areas, and sidewalks. Sediment transported off site onto paved streets is a significant problem because it is difficult to effectively remove, and any sediment not removed ends up in the drainage system.

Temporary devices, such as a pad of coarse aggregate or a construction mat, should be installed at all exits from the construction site to a public roadway to stabilize the road and remove sediment (Figure 102). Additional controls to remove sediment from tires, such as wheel washing, rumble strips, and rattle plates, can also be used where necessary.

Figure 102. Stabilized gravel construction entrance examples (EPA 2003).

Primary BMP Functions and Controls

☒ Construction	☐ Permanent
☐ Erosion Control	☒ Sediment Control
☐ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
○	Phosphorus
○	Metals
○	Bacteria
○	Hydrocarbons
○	Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Medium
Ease of Installation	Medium
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	N/A
Max. Slope	15%
NRCS Soil Group	ABCD
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Applicability

Vehicle sediment control is appropriate for all construction sites in the following locations:

- Wherever vehicles are entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.
- At any unpaved entrance/exit location where risk exists of transporting mud or sediment onto paved roads.

Vehicle sediment control is particularly important during wet weather periods when mud is easily tracked off site, during dry weather where dust is a concern, and when poorly drained, clayey soils are present on site.

Limitations

Vehicle sediment control using stabilized construction entrances are most effective when installed on level ground. If wheel washing is needed due to high sediment loads, washwater will need to be available and an additional sediment trap (BMP 66) may need to be installed.

Design Basis

Vehicle sediment controls include aggregate pad construction entrances and turf mat construction entrances. Additional controls may be needed if the stabilized construction entrance does not remove sufficient amounts of sediment from vehicle and equipment tires. The following sections provide design information for these practices.

Access and exits should be limited to one route if possible or two for linear projects such as roadways where more than one access/exit is necessary. Construction entrances should avoid crossing existing sidewalks if possible. If they must cross a sidewalk, the full length of the sidewalk should be covered and protected from sediment leaving the site.

Construct entrances on a level surface, and if feasible, grade to drain towards the construction site to reduce off-site runoff. Runoff from a stabilized construction entrance should drain to a sediment trap or a sediment basin, and a culvert should be installed under the entrance to convey water along the ditch of the public road if necessary.

Aggregate Pad Construction Entrance

A coarse aggregate pad underlain with a geotextile fabric is a common technique for stabilizing construction entrances (Figure 103). The width should be at least 15 feet but not less than the full width of points where ingress or egress occurs. At sites where traffic volume is high, the entrance should be wide enough for two vehicles to pass safely. Flare the entrance where it meets the existing road to provide a sufficient turning radius.

The recommended minimum length should be 50 feet, although 100 feet is preferred. The aggregate should include 3- to 6-inch diameter rock. The placement depth should be 9 inches minimum or as recommended by a soils engineer based on the maximum expected vehicle loads. For entrances that will become permanent or for long-term installations during construction, two layers may be needed with a base layer of 2- to 8-inch diameter crushed stone and a top layer of 2 inch diameter or smaller stone.

Place geotextile filter fabric under the aggregate to prevent fine sediment from pumping up into the rock pad and to reduce maintenance and loss of aggregate. The geotextile should be a nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The geotextile should be inert to commonly encountered chemicals, hydrocarbons, and mildew and rot resistant.

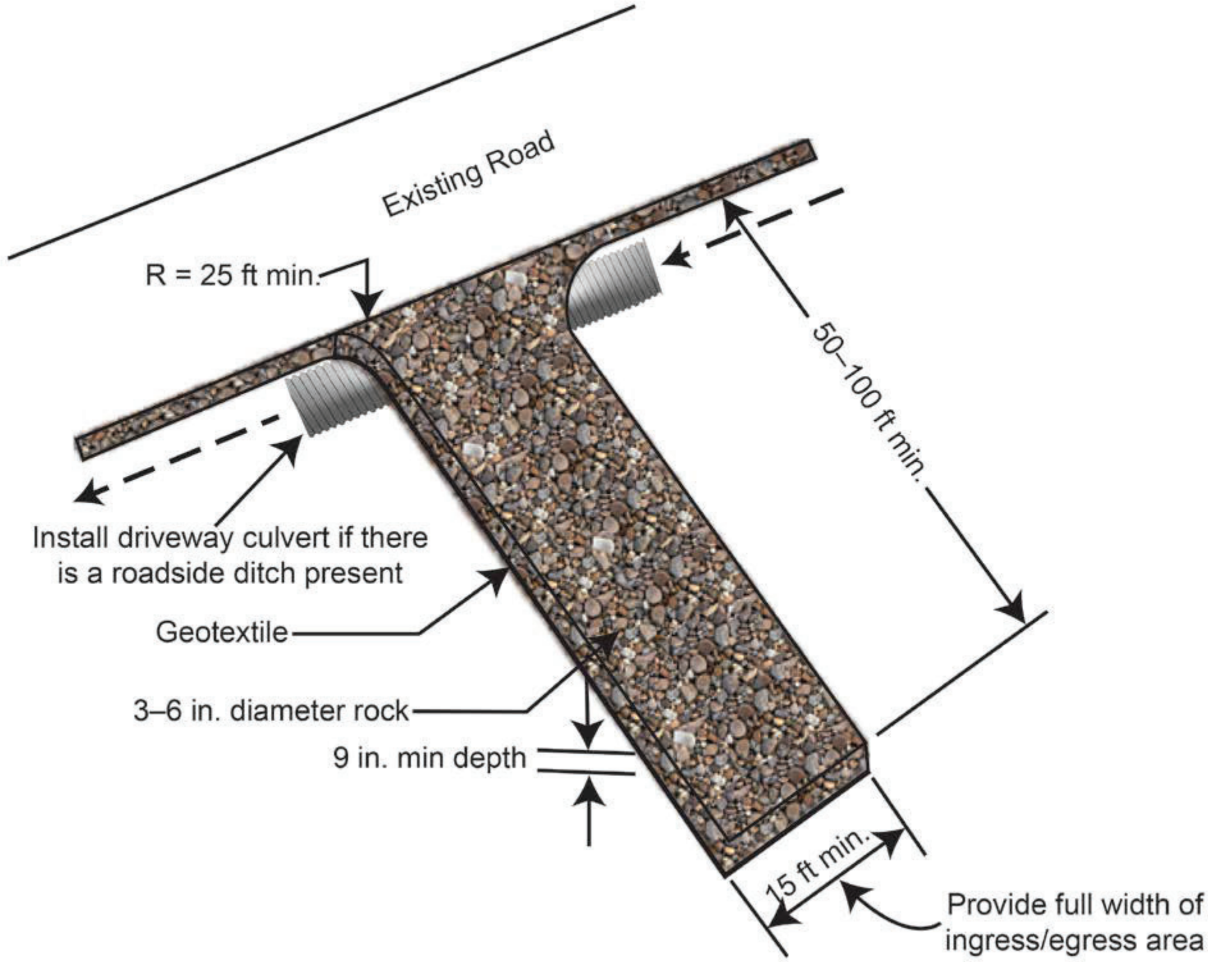


Figure 103. Aggregate pad construction entrance (adapted from King County 2009).

Construction Mat or Turf Reinforcement Mat

For small construction sites with low traffic volume, use a construction mat or turf reinforcement mat to stabilize the entrance (Figure 104 and Figure 105). The mats are made of steel, high-density polyethylene, timber, or a woven geotextile. Turf mats do not remove a significant amount of sediment from vehicles but do stabilize the entrance and prevent vehicles from causing rutting. These mats are especially suited for sites containing saturated soils, wetlands, or soft/poor subgrade as they provide immediate stabilization and some protection to existing vegetation. Some mats can be removed and reused on multiple sites.

Figure 104. Construction mat (*Matrax*).

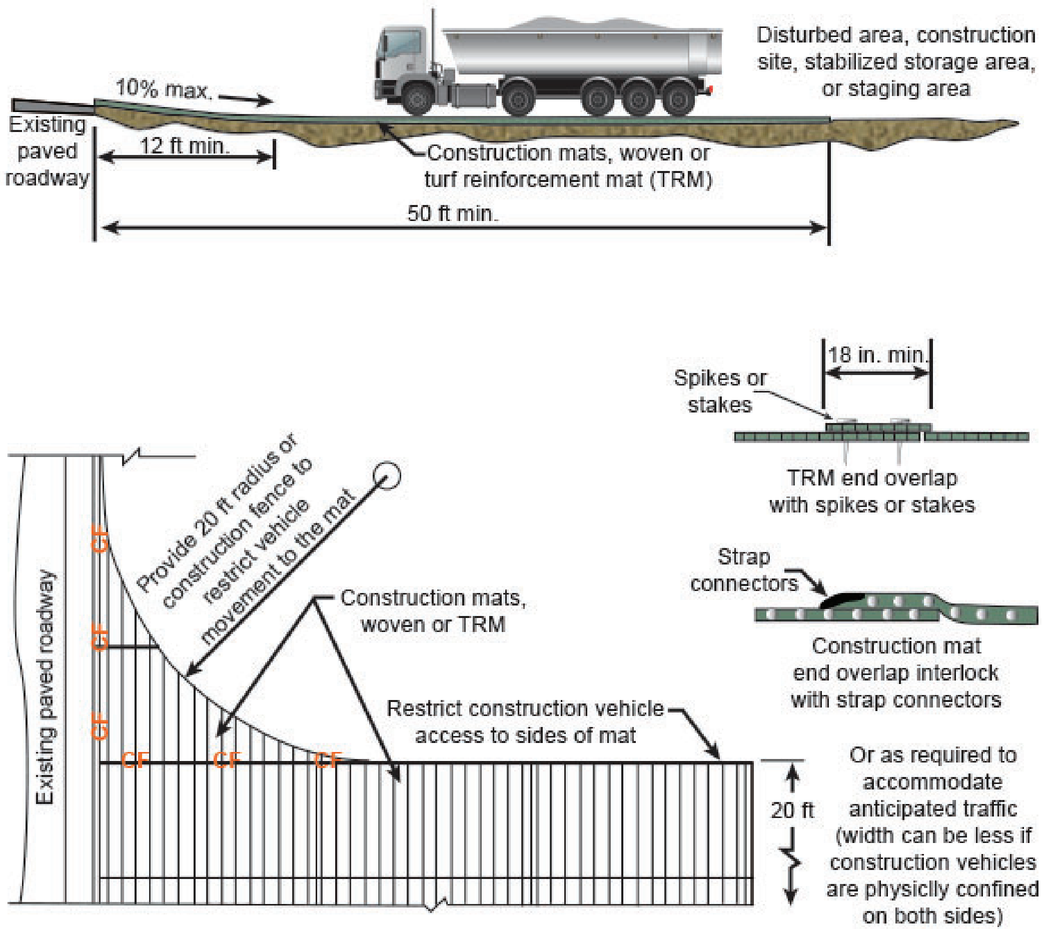


Figure 105. Vehicle-tracking control with construction mat or turf reinforcement mat (Colorado UDFCD 2010).

Additional Controls

If the stabilized construction entrance does not remove sufficient amounts of sediment from vehicle and equipment tires due to site conditions, additional controls may be required. Examples of additional controls include, but are not limited to, wheel washing, mountable berms, rumble strips, and rattle plates.

Wheel-washing facilities can be included within the stabilized construction entrance (Figure 106). It can be as simple as handheld power washing equipment to more advance systems. When washing is required, perform on an area stabilized with aggregate that drains into an approved sediment trap.

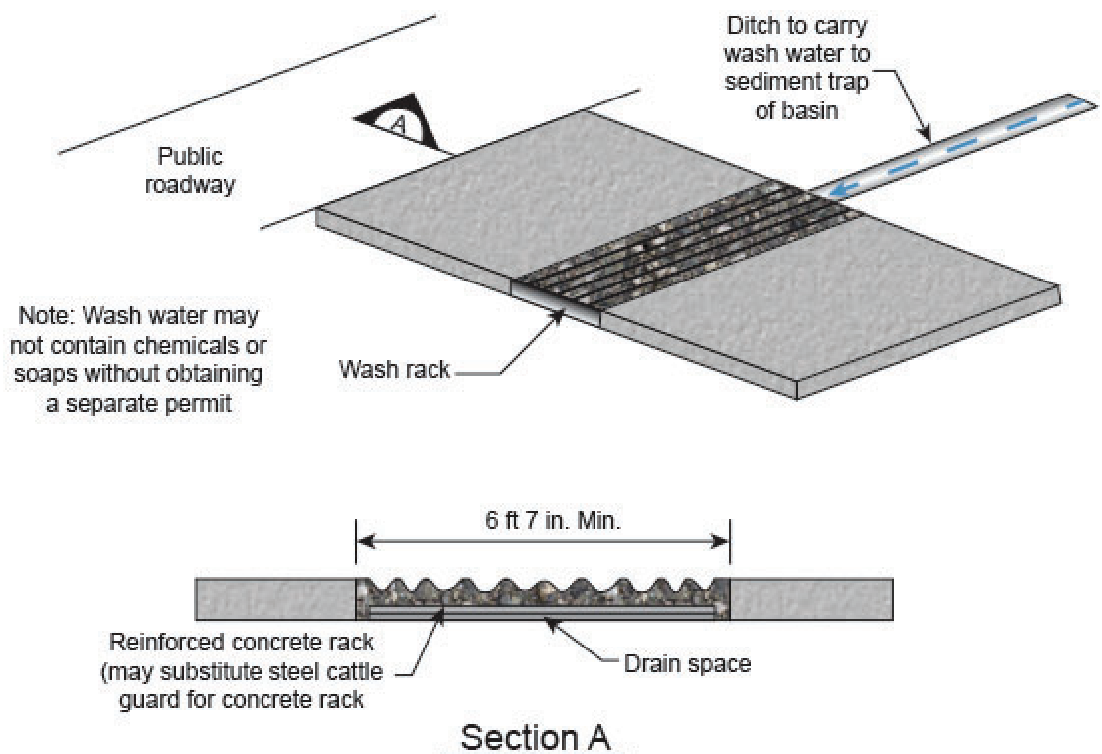


Figure 106. Aggregate vehicle-tracking control with wash rack (Colorado UDFCD 2010).

Mountable berms can be used in construction entrances to *bump* soil off of tires. These berms should be used when the entrance cannot be graded to flow away from the road. A mountable berm traps the pad water and keeps it from entering the adjacent road.

Rumble strips and rattle plates are constructed of steel panels with ridges or corrugations or pipes welded to a steel frame and can be installed within the construction entrance to remove additional sediment from vehicles. Rumble strips loosen and remove dirt and mud from vehicle tires as they pass over the construction entrance. Construct barriers around the sides of the rumble strips to ensure all construction vehicle and equipment tires travel over the rumble strips.

Rumble strip dimensions vary but typically are 8 feet long x 10 feet wide. Place rumble strip panels on a stable base and in the center of an aggregate entrance (Figure 107).

Figure 107. Rattle plates in construction entrance (*The Bag Lady*).

If sediment is tracked out of the construction site and onto off-site streets, sidewalks, or other paved areas, remove the sediment by sweeping, shoveling, or vacuuming. Complete cleanup by the end of the same work day when the track out occurs or by the end of the next work day if track out occurs on a nonwork day. Sediment should not be hosed or swept into an off-site storm water conveyance, storm drain inlet, or surface water.

Construction Guidelines

Stabilized construction entrances and any additional vehicle sediment controls should be installed as the first step in clearing and grading. Clear all vegetation, roots, and all other obstructions to prepare for grading, and ensure the entrance is properly graded and compacted before placing the geotextile fabric in the aggregate construction entrances.

All employees, subcontractors, and suppliers should be required to use the stabilized construction entrance. Place signage to direct construction traffic to the designated stabilized entrance, and use fencing where practical to restrict traffic to the stabilized construction entrance. Vehicle speeds should be limited to control dust (BMP 43: Dust Control). The stabilized construction entrance may be removed after final site stabilization is achieved or after the temporary BMPs are no longer needed. If stabilized entrances are located in a permanent site entrance, a geotechnical engineer should approve the subgrade after removal and before building the permanent entrance.

Maintenance

Inspect construction entrances and additional controls regularly and after storm events. Inspect local roads, sidewalks, and other paved surfaces adjacent to the site daily and sweep or vacuum accumulated sediment. Keep all temporary roadway ditches clear.

Construction entrances should be maintained in a condition that will prevent tracking or flow of mud onto public rights-of-way. Aggregate entrances may require periodic top dressing with additional 2 inches of stone (as conditions demand). If the aggregate pad is clogged with sediment, remove the aggregate and separate and dispose of the sediment. Rumble strips and rattle plates must be kept clean to function properly. Sweep or scrape panels, and if water is used, discharge the washwater into a sediment trap adjacent to the rumble strips.

Additional Resources

Colorado UDFCD (Colorado Urban Drainage and Flood Control District). 2010. *Urban Storm Drainage Criteria Manual, Volume 3 Best Management Practices*. Denver, CO. *http://udfcd.org/wp-content/uploads/2014/07/Title-Page.pdf*

EPA (US Environmental Protection Agency). 2014. *Construction Entrances*. Water: Best Management Practices. *https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#constr*

King County (King County, Washington). 2009. *King County, Washington Surface Water Design Manual.* Seattle, WA: King County, Department of Natural Resources.

BMP 43: Dust Control

Description

Dust control and wind erosion prevention BMPs keep soil particles from entering the air as a result of land-disturbing construction activities by protecting the soil surface, roughening the surface, and/or reducing the surface wind velocity (Figure 113).

Figure 113. Sprinkling water for dust control on a pathway construction project, Driggs, Idaho.

Dust control practices apply to either disturbed graded areas or construction roadways. For disturbed graded areas, practices such as seeding or sodding (BMP 32), mulching (BMP 52), using soil binders (BMP 55), sprinkling, surface roughing (BMP 58) or practices that provide prompt surface cover can be used. For construction roadways, practices such as using a stabilized surface (BMP 41), sprinkling, or using chemical dust tackifiers are options. Wind barriers can control wind currents and minimize the amount of dust transported into air and water.

Primary BMP Functions and Controls

☒ Construction ☐ Permanent
☒ Erosion Control ☐ Sediment Control
☐ Source Control ☐ Flood Control
☐ Filtration ☐ Infiltration

Typical Effectiveness for Targeted Pollutants

● Sediment
○ Phosphorus
◖ Metals
○ Bacteria
◖ Hydrocarbons
○ Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Medium
Ease of Installation	Easy
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	N/A
Max. Upstream Slope	N/A
NRCS Soil Group	ABCD
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Applicability

Use control measures on any construction site where the potential exists for air or water pollution from dust, especially when open, dry areas of soil are anticipated on site and where heavy construction activity such as clearing, grading, excavation, demolition, or excessive vehicle traffic takes place. Dust control is especially important in regions experiencing long periods without rain and during the summer when soil can become dry and vulnerable to transport by wind. In many cases, water erosion control measures incorporated into the project will indirectly prevent wind erosion.

Limitations

Vegetative dust control measures may not be practical during dry periods without a reliable supply of establishment water. Other methods should be stipulated in the project contract to ensure that dust control is not overlooked.

Wind barriers (such as walls or fences) can be part of the long-term dust control strategy in arid and semiarid areas, but they are not a substitute for permanent stabilization.

Chemically treated subgrades may make the soil water repellent, interfering with long-term infiltration and vegetation/revegetation of the site. Some chemical dust suppressants may be subject to freezing and may contain solvents that must be handled properly.

Overwatering may cause erosion and wash sediment or other constituents into the drainage system.

Design Basis

Develop a dust control plan before construction. The plan should evaluate the site with potential dust emission sources identified, provide a selection of dust control methods for each area of the site, determine the maintenance needed, and monitor the effectiveness of the selected dust control measures. The site evaluation should consider the soil type, prevailing wind direction, and effects of other prescribed erosion control measures.

Dust Prevention

The best method of controlling dust is to prevent dust production:

- **Minimize the surface area disturbed—**By limiting the amount of bare soil exposed at one time, less ground is disturbed, less dust is raised while working, and less cleanup is required when work is done. During project design, identify areas where ground disturbance will not be allowed and fence or provide signage during construction. Design and locate haul roads, detours, and staging areas to avoid unnecessary exposure of bare ground.
- **Limit dusty work on windy days—**Minimize amount of ground disturbance occurring when potential for wind erosion is highest. Apply dust suppression measures when needed. Monitor dust suppression efforts to ensure dust emissions are adequately controlled. Depending on weather conditions, adjust to fewer or more frequent application intervals.
- **Clean up dusty spills immediately—**Do not wait for the next scheduled housekeeping; the mess will just get bigger and cleanup will take longer.
- **Plan ahead to limit dust—**Avoid using areas most susceptible to wind erosion. In the storm water site plan, specify staging or work-sequencing techniques that minimize the risk of wind erosion from bare soil. In most cases, a change will be required from traditional construction techniques that allow large areas to be disturbed at the outset of construction and remain exposed for long periods of time.

Graded Areas

Clearing and grading activities create the opportunity for large amounts of dust to become airborne. Stabilize graded areas as soon as practicable after disturbance and do not leave open areas uncovered. The following practices can help with dust control in graded areas:

- **Grow vegetative ground cover**—Exposed areas that are not being paved should be stabilized using vegetation and landscaping (BMP 32) to prevent wind and water erosion. When rainfall is insufficient to establish vegetative cover, mulching (BMP 52) conserves moisture, prevents surface crusting, reduces run-off erosion, and helps to establish vegetation. It is a critical treatment on sites with erosive slopes.

- **Use wind barriers**—Barriers prevent erosion by obstructing the wind near the ground and preventing the soil from blowing off site. Wind, snow, or silt fences or similar barriers are temporary measures that can reduce wind velocity. Perennial grass, bushes, stands of trees, rock walls, wooden board fences, or earthen banks are more permanent measures that can serve as wind barriers. A wind barrier generally protects soil downwind for a distance of 10 times the height of the barrier. If additional protection is needed, use other methods with the barrier.
- **Surface roughening**—Deep tillage in large open areas brings soil clods to the surface where they rest on top of dust, preventing it from becoming airborne. Tilling or disking should leave 6-inch (minimum) furrows, preferably perpendicular to the prevailing wind direction, to gain the greatest reduction in wind erosion. If the surface cannot be furrowed perpendicular to the prevailing wind direction, roughening the surface by using a ripper/scarifier (grader) or a ripper (cat) will produce the desired result of a 6-inch irregular surface. BMP 58: Slope Roughening provides more information.

Construction Roadways and Storage Areas

Temporary construction roads and storage areas should be stabilized using recommendations in BMP 42: Erosion Prevention on Construction Roads to minimize the amount of dust generated by construction vehicles. Other recommendations for dust control on construction roadways and storage areas include the following:

- **Water and/or sweep often**—Sprinkle the site with water until the surface is wet. Apply at a rate of 3 gallons per acre so that the soil is wet but not saturated or muddy and so that no dust is being generated. To ensure vehicle traffic is not picking up dust from wind action and carryout, water and sweep roadways often. Fewer treatments are necessary in cool, wet weather.
- **Spray-on chemical soil treatments (palliatives)**—Spray-on soil binders form a bond between soil particles keeping them grounded. Chemicals include mineral salts, petroleum resins, asphalt emulsion, acrylics, and adhesives. These treatments must be reapplied periodically to ensure continued effectiveness. Chemical tackifiers should only be used on mineral soils, and the chemicals should not create any adverse effects on storm water, plant life, surface water, or ground water. Check with DEQ to ensure the material to be applied is not harmful and may be used for this purpose.
- **Reduce speed limits**—Reduce speed limits on unpaved surfaces to 10 to 15 miles per hour for well-traveled areas and heavy vehicles. Never exceed 25 miles per hour for any vehicle on any unpaved surface.
- **Prevent transport of dusty material off site**—Minimize transport of dusty material off site by rinsing vehicles before they leave the property, tightly cover loaded trucks, and provide stabilized construction roads and staging areas (BMP 41).
- **Enclose storage and handling areas**—If dusty materials are frequently loaded and unloaded in storage and handling areas, enclose the areas to reduce dust production. Use storage silos, three-sided bunkers, or open-ended buildings. If handling is less frequent, try wind fencing. Conveyor loading may require enclosure or the use of water or foam spray bars both above and below the belt surface to reduce emissions.

- **Keep storage piles covered**—When storage piles are not in use, apply a physical cover or a dust suppressant spray to reduce dust emissions. Limit the working face of the pile to the downwind side. Most emissions come from loading the pile, loadout from the pile, and truck and loader traffic in the immediate area if the pile is batch loaded. Keep the drop height low to reduce dust and the ground at the base of the pile clear of spills.

Construction Guidelines

Dust control measures should be considered and selected before clearing and grading activities. During construction, monitor dust control activities on a regular basis to ensure the measures taken are adequately preventing airborne dust from leaving the site.

Maintenance

Dust control requires constant attention: it is not a one-time or once-in-awhile activity. Dust control sprinkling may have to be done several times a day during hot, dry weather.

Areas protected by mulch, adhesive emulsions, or barriers need to be checked at regular intervals according to the inspection schedule in the storm water plan.

Apply spray-on chemical treatments using the manufacturer's specified rates and according to all federal, state, and local regulations. Chemical products should be stored, handled, and disposed of according to all applicable local and state regulations and policies.

Additional Resources

DEQ (Idaho Department of Environmental Quality). 2013. *Controlling Fugitive Dust at Construction Sites.* Boise, ID: DEQ.

EPA (US Environmental Protection Agency). 2014. *Dust Control*. Water: Best Management Practices. *https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#constr*

BMP 46: Spill Prevention and Control

Description

A spill prevention and control plan includes procedures for preventing spills of hazardous waste and methods for handling and cleaning up spills (Figure 116). Numerous spill containment methods range from large structural barriers to simple, small drip pans. The benefits vary based on cost, maintenance requirements, and the size of spill control.

Figure 116. Collapsible wall containment berm (*The Spill Source*).

Applicability

Develop a spill prevention and control plan for any construction site where hazardous wastes are stored or used. Hazardous wastes include pesticides, paints, cleaners, petroleum products, fertilizers, deicing materials, and solvents.

Primary BMP Functions and Controls

☒ Construction ☐ Permanent
☐ Erosion Control ☐ Sediment Control
☒ Source Control ☐ Flood Control
☐ Filtration ☐ Infiltration

Typical Effectiveness for Targeted Pollutants

○ Sediment
○ Phosphorus
● Metals
○ Bacteria
● Hydrocarbons
○ Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Medium
Ease of Installation	Easy
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	N/A
Max. Upstream Slope	N/A
NRCS Soil Group	N/A
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Limitations

Some sites may also be subject to the oil pollution regulations specified in 40 CFR 112 and CWA §331, and required to develop a Spill Prevention Control and Countermeasure (SPCC) plan. Check with federal, state, and local agencies that may also have applicable regulations that must be adhered to.

Design Basis

Address the following elements in a spill control and response plan.

Spill Prevention

Prevention is the first line of defense in protecting storm water runoff from contamination due to spills and leaks:

- Use recycled, reclaimed, or reused materials where possible to reduce the amount of new material needed. Substitute less or nontoxic materials for toxic materials.

- Routinely maintain and check the condition of containers holding hazardous waste, and replace containers that are leaky, corroded, or otherwise deteriorating.
- Label all containers according to their contents. Educate all employees on how to prevent spills and how to clean up if a spill occurs. All employees should be able to recognize and report illegal dumping incidents.

Spill Control and Containment

Identify potential spill source locations such as loading and unloading areas, materials storage areas, processing areas, and waste disposal areas. Containment methods include diking, curbing, and drip pans. If a spill occurs, adequately control and contain the spill to prevent contaminating surface water or ground water.

Containment diking consists of temporary or permanent berms or retaining walls designed to hold spills. Diking is one of the best protective measures against storm water pollution because it surrounds the area of concern and keeps spill materials separated from the storm water outside of the diked area (BMP 69: Diversion Dike and BMP 70: Temporary Berms).

Diking is commonly used for controlling large spills or releases from liquid storage and transfer areas because it is an effective containment method around tank truck loading and unloading areas. The size of a containment dike system for tank truck loading and unloading operations should be capable of holding a volume equal to any single tank truck compartment plus some amount of freeboard to ensure that discharge from the secondary containment area will not occur.

Materials used to construct the dike should be strong enough to safely hold spilled materials. The materials used usually depend on what is available on site and the substance to be contained. Dikes may be made of earth (i.e., soil or clay), concrete, synthetic materials (liners), metal, or other impervious materials. Containment dikes may need to be designed with impervious materials to prevent leaking or pollution of storm water, surface water, and ground water supplies.

In general, strong acids and bases may react with metal containers, concrete, and some plastics. Where spills may consist of these substances, consider other alternatives. More reactive organic chemicals may also need to be contained with special liners. If uncertain about the suitability of certain dike construction materials, refer to the Material Safety Data Sheet (MSDS) for the chemical being contained.

Curbing, like containment diking, is a barrier that surrounds an area of concern and prevents spills or leaks from being released to the environment by routing runoff to treatment or control areas. The terms *curbing* and *diking* are sometimes used interchangeably, but curbing is usually small scale and cannot contain large spills like diking. Common materials used for curbing include earth, concrete, synthetic materials, metal, or other impenetrable materials. Asphalt is also a common material used in curbing. Curbing is inexpensive, easy to install, and provides excellent control of run-on. As with diking, materials spilled within a curbed area can be collected for proper disposal and/or recycling.

When using curbing for runoff control, protect the curb by limiting traffic and installing reinforced curbs in areas of concern. Materials spilled within a curbed area can be tracked outside of that area when personnel and equipment leave the area. This tracking can be minimized by grading within the curbing to direct the spilled materials to a downslope side of the curbed area, keeping the materials away from personnel and equipment that pass through the area. It will also allow the materials to accumulate in one area and make cleanup much easier. Manual or mechanical methods, such as those provided by sump systems, can be used to remove accumulated material from a curbed area.

Drip pans are used to contain very small volumes of leaks, drips, and spills. Drip pans can be depressions in concrete, asphalt, or other impenetrable materials or they can be made of metals, plastic, or any material that does not react with the dripped chemicals. Empty or discarded containers may be used as drip pans. Drip pans catch material or chemical drips that can be cleaned up easily or recycled before contacting storm water. Drip pans can be a temporary or permanent measure.

Use drip pans at any site where valves and piping are present and the potential exists for small-volume leakage and dripping. Although leaks and drips should be repaired and eliminated as part of preventive maintenance programs, drip pans provide a temporary solution where repair or replacement is delayed. In addition, drip pans provide a safeguard when positioned beneath areas where leaks and drips may occur. Drip pans are inexpensive, easy to install, and simple to operate. They allow for reuse or recycling of the collected material.

When using drip pans, consider local weather conditions, the location of the drip pans, materials used for the drip pans, and how the pans will be cleaned. Drip pans should be inspected and cleaned frequently, so place them in areas that are easy to reach. Avoid placing drip pans in precarious positions such as next to walkways or on uneven surfaces. Drip pans in these locations are easily overturned and may present a safety or environmental hazard.

Weather is also an important factor. Heavy winds and rainfall can move or damage drip pans because the pans are small and lightweight. Secure the pans by installing or anchoring them to platforms, place behind wind blocks, or tie the pans down.

Cleanup and Disposal

Clean up spills or contaminated surfaces immediately using dry cleanup measures where possible and eliminating the source of the spill to prevent discharge or further discharge. Adequate supplies should be available at all times to handle spills, leaks, and disposal of used liquids from fueling and maintenance of equipment or vehicles. When cleaning up spills, follow MSDS guidelines to prevent unintentional chemical reactions.

If spilled materials are hazardous, the cleanup materials are also hazardous and must be disposed of properly. If the spill is large, a Hazmat team or private spill cleanup company may be necessary depending on permit requirements.

Reporting

Keep a record of any spills, including the date and time of the incident, causes, duration, response procedures, and persons notified. If a spill occurs, and it is not contained by the on-site containment methods, report it to the proper authorities. Federal regulations require that oil spills into a navigable water or adjoining shoreline above a certain threshold must be reported to the National Response Center at (800) 424-8802. Oil spills must be reported in the following cases:

- Violate applicable water quality standards.
- Cause a film or *sheen* upon, or discolor, the surface of the water or adjoining shorelines.
- Cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.

Spills should also be reported to local agencies, such as the fire department, if necessary to assist with cleanup.

Construction Guidelines

Spill prevention and containment measures should be employed as long as hazardous materials are stored on site. Key spill response personnel should be identified before the project starts, and all employees and subcontractors should be trained on spill prevention, response, and cleanup procedures.

Maintenance

Update the spill prevention and control plan when changes occur in staffing, to the site, or where the materials are stored. Regular inspections should be conducted to ensure proper procedures are posted and cleanup equipment is available. Guidelines for maintaining spill containment measures are provided below:

Containment dikes should be inspected during or after significant storms or spills to check for washouts or overflows. Regular testing is recommended to ensure that the dikes can hold spills. Soil dikes may need to be inspected on a more frequent basis.

Changes in vegetation, inability of the structure to retain storm water, dike erosion, or soggy areas indicate problems with the dike's structure. Damaged areas should be patched and stabilized immediately, where necessary. Earthen dikes may require special maintenance of vegetation, such as mowing and irrigation.

When evaluating the performance of the containment system, pay attention to the overflow system because it is often the source of uncontrolled leaks. If overflow systems do not exist, accumulated storm water should be released periodically. Polluted storm water should be treated before release. Mechanical parts (e.g., pumps) or manual systems (e.g., slide gates and stopcock valves) may require regular cleaning and maintenance.

Curbing is sized to contain small spill volumes, and frequent maintenance is needed to prevent overflow of any spilled materials. Inspect all curbed areas regularly and clean clogging debris. Repair the curb by patching or replacing it as needed to ensure effective functioning. Conduct inspections before forecasted rainfall events and immediately after storm events. If spilled or leaked materials are observed, start cleanup immediately to allow space for future spills. Prompt cleanup of spilled materials will prevent dilution by rainwater, which can adversely affect recycling opportunities.

Drip pan effectiveness depends on site operators paying attention and emptying the pans when they are nearly full. Because of their small holding capacities, drip pans easily overflow if not emptied. Recycling efforts can be affected if storm water accumulates in drip pans and dilutes the spilled material. Ensure clearly specified and easy to follow practices for reuse, recycle, and/or disposal of pans, especially the disposal of hazardous materials. Consider dumping the drip pan contents into a nearby larger-volume storage container and periodically recycling the contents of the storage container.

Frequent inspection of the drip pans is necessary due to the possibility of leaks in the pan itself. Check for random leaking of piping or valves and for irregular, slow drips that may increase in volume. Conduct inspections before forecasted rainfall events to remove accumulated materials. Empty accumulations immediately after each storm event.

Additional Resources

CASQA (California Stormwater Quality Association). 2004. *California Stormwater Best Management Practices Handbook: New Development and Redevelopment*. Menlo Park, CA. *https://www.casqa.org.*

EPA (US Environmental Protection Agency). 2014. *Spill Prevention and Control Plan*. Water: Best Management Practices. *https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu*.

BMP 47: Construction Equipment Washing and Maintenance

Description

A good construction vehicle and equipment washing and maintenance facility prevents the discharge of pollutants from these operations to surface water or ground water. A typical vehicle/equipment washing and maintenance system is a lined or paved, depressed area that collects the water used in washing trucks, cars, or other construction vehicles/equipment and drains the wastewater into a collection or treatment system (Figure 117).

Ideally, vehicle maintenance should not occur on active construction sites. However, if it must occur, the following practices should be used to minimize or eliminate pollutant discharge.

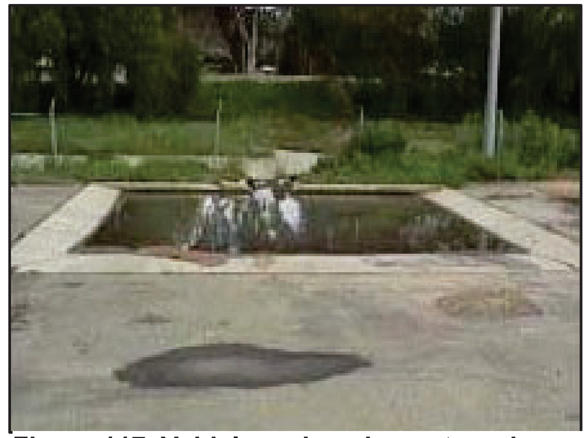


Figure 117. Vehicle and equipment wash area (CALTRANS 2003).

Primary BMP Functions and Controls

☒ Construction	☐ Permanent
☐ Erosion Control	☒ Sediment Control
☐ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
●	Phosphorus
◖	Metals
○	Bacteria
◖	Hydrocarbons
○	Litter

Other BMP Considerations

Relative Cost	$$
Maintenance Requirements	Low
Ease of Installation	Easy
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	N/A
Max. Slope	5%
NRCS Soil Group	ABCD
Min. Ground Water Separation	N/A
Min. Bedrock Separation	N/A

Applicability

Use vehicle washing and maintenance BMPs on all sites where vehicle and equipment cleaning and maintenance are performed. BMPs are particularly important on projects where the soil is silty or a heavy clay, and it is likely that dirt and mud will be transported off site. It is also important for projects taking place during the rainy season and in areas where water is expected to be encountered (high ground water table) during project construction.

Limitations

Limitations depend on the method chosen for disposing of vehicle washwater. If washwater is discharged to a sediment pond on site, sufficient acreage is required. If washwater is discharged to off-site sanitary sewer systems or hazardous waste disposal facilities, the cost of connection or disposal could be a limitation. Discharge of treated washwater to waters of the state (including canals, rivers, ponds, streams, lakes, and ground water) may require pretreatment to remove turbidity or separate oils, as well as federal, state, or local permits.

Design Basis

Washing vehicles generates liquid, semisolid, and solid wastes. These wastes should be contained on site and treated before discharged off site. A stabilized construction entrance (BMP 41) should be installed at the vehicle wash/maintenance area to reduce off-site tracking of mud, dirt, and rocks.

Wash Location and Design

Vehicle washing on site should be located within a structure or building equipped with appropriate disposal facilities. If this is not available, locate outside vehicle wash stations away from storm drain inlets, drainage facilities, and watercourses, and divert site drainage away from the wash area. Vehicle washing and maintenance should be conducted in disturbed areas (staging areas) but should not be conducted in a cut or fill area until grading has been performed or where a high volume of construction traffic exists. Avoid highly erodible soils or frequently wet areas.

Outdoor vehicle wash areas should be lined or paved with concrete or asphalt and have a berm to contain runoff and prevent run-on. It should also be equipped with a sump for collecting and disposing of washwater.

Clearly mark the wash areas with signage and educate employees and subcontractors on proper washing procedures. Include the location of the washing facilities in the SWPPP.

Wash Practices

Use the smallest amount of water and no, or a minimal amount of, detergents if possible. Use a positive shut-off valve and a high-pressure spray to conserve water. Water alone can remove most dirt adequately, but if detergents must be used, they should not contain phosphates. Use biodegradable products that are free of halogenated solvents.

Washwater Discharge

On-site washwater can be contained for evaporative drying with any residual waste disposed of properly. Washwater can also be discharged to surface water if it is permitted and pretreated. Treatment is required for all discharges to waters of the state because they can be contaminated with degreasers, hydrofluoric acid, hydrochloric acid, nitric acid, phosphoric acid, oil, hydraulic fluids, lubrication, and engine cleaning solvents. Contact the local permitting authority to determine proper treatment and disposal methods.

Other discharge options for vehicle washwater include the following:

- Lagoon—A pond-like structure that uses physical, chemical, and biological processes to treat wastewater. They are easy to install and require low maintenance. Safety is a concern, so the area must be fenced from the public.
- Land application system—A method of reusing wastewater by applying it to land for irrigation and to assimilate it into the soil structure. Land application systems require large land area and may need to be permitted.
- Filtering and recycling washwater—A good conservation measure that includes using a sediment basin with a turbidity curtain. Monitoring of the operation could be intensive.

- Municipal wastewater treatment plant—Available only in areas where a municipal wastewater treatment plant exists and the operation is capable of handling the load. This is the best option for limiting liability on larger construction projects. Vehicle and equipment washing activities should be reviewed to determine if oil and sediment controls are needed to comply with any applicable sanitary sewer discharge limits.

Vehicle Maintenance

Vehicle maintenance or repairs should not be conducted in the wash area. Designate a special paved area for vehicle repair.

Properly maintaining and inspecting vehicles and equipment can prevent hazardous chemical leaks. A spill prevention and cleanup plan (BMP 46) should be in place if a hazardous spill or leak occurs.

Properly dispose of any hazardous waste from vehicle maintenance activities, including used oil, antifreeze, solvents, and other automotive-related chemicals (BMP 48).

Construction Guidelines

Vehicle sediment controls including vehicle and equipment washing areas should be installed as the first step in clearing and grading. The location and design should follow the design guidelines listed above.

Maintenance

Ensure the system controls are working as designed and make any repairs as necessary (e.g., repairs to berms or conveyance to any off-site disposal facility). Inspect local roads, sidewalks, and other paved surfaces adjacent to the site daily and sweep up or vacuum accumulated sediment.

Additional Resources

CALTRANS (California Department of Transportation, Division of Construction). 2003. *Construction Site Best Management Practice Manual*. Sacramento, CA.

EPA (US Environmental Protection Agency). 2014. *Vehicle Maintenance and Washing Areas at Construction Sites*. WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities. *https://www.epa.gov/sites/production/files/2017-02/documents/watersense-at-work_final_508c3.pdf*.

BMP 65: Silt Fence

Description

A silt fence is a temporary sediment barrier created with a porous fabric stretched and attached to supporting posts. Woven wire fence backing is necessary with several types of filter fabric commonly used. The silt fence ponds sediment-laden storm water runoff, and the sediment is retained by settling (Figure 157).

Figure 157. Silt fence (York County Conservation District 2009).

Applicability

Silt fences can be used around the perimeter of a disturbed area to intercept sediment while allowing water to percolate through. The fences should remain in place until the disturbed area is permanently stabilized.

Silt fences can also be used along the toe of fills, on the downhill side of large through-cut areas, along streams, at grade breaks on cut/fill slopes, and above interceptor dikes.

Limitations

Silt fence is a popular BMP choice on construction sites, but to work effectively, it must be properly designed, installed, and maintained.

Do not use silt fences where water concentrates in a ditch, channel, or drainageway or where soil conditions prevent the minimum fabric toe-in depth or minimum depth for installation of support posts. If concentrated flow occurs after installation, place rock berms or other corrective measures in the areas of concentrated flow.

Silt fences should not be used in places where vehicle or equipment crossing is expected.

Primary BMP Functions and Controls

☒ Construction	☐ Permanent
☒ Erosion Control	☒ Sediment Control
☐ Source Control	☐ Flood Control
☐ Filtration	☐ Infiltration

Typical Effectiveness for Targeted Pollutants

●	Sediment
○	Phosphorus
◖	Metals
○	Bacteria
○	Hydrocarbons
◖	Litter

Other BMP Considerations

Relative Cost	$
Maintenance Requirements	Medium
Ease of Installation	Easy
Freeze/Thaw Resistance	Good
Max. Tributary Drainage Area	0.25 acres/ 100 lineal feet
Max. Upstream Slope	33%
NRCS Soil Group	ABCD
Min. Ground Water Separation	2 feet
Min. Bedrock Separation	2 feet

Design Basis

Location

Proper placement and design of silt fence is critical to its effectiveness. Silt fence installed along a contour should have a maximum disturbed tributary drainage area of 10,000 ft^2 per 100 feet of fence with a maximum tributary slope length of 150 feet and a tributary slope gradient of 3:1. Longer and steeper slopes require additional measures, such as multiple rows of silt fence or other sediment control. Placement and length should also consider the maximum allowable slope lengths contributing runoff to a silt fence as listed in Table 35.

Table 35. Maximum allowable slope lengths.

Slope Steepness	Maximum Slope Length (feet)
2:1	50
3:1	75
4:1	125
5:1	175
Flatter than 5:1	200

Place the silt fence as close to the contour as possible, with the area below the fence undisturbed or stabilized. Long runs of silt fence should be avoided to limit opportunities for large areas of concentrated water. Extend each end of the silt fence upslope to prevent runoff from going around the end. Multiple J-hooks can be used to break up long runs and provide ministorage areas to pond small amounts of water.

The location and details for silt fence should be shown on the SWPPP map and contain the following minimum requirements:

- Type, size, and spacing of fence posts
- Size of woven wire fences
- Type of filter fabric used
- Method of anchoring the filter fabric
- Method of fastening the filter fabric to the fencing support

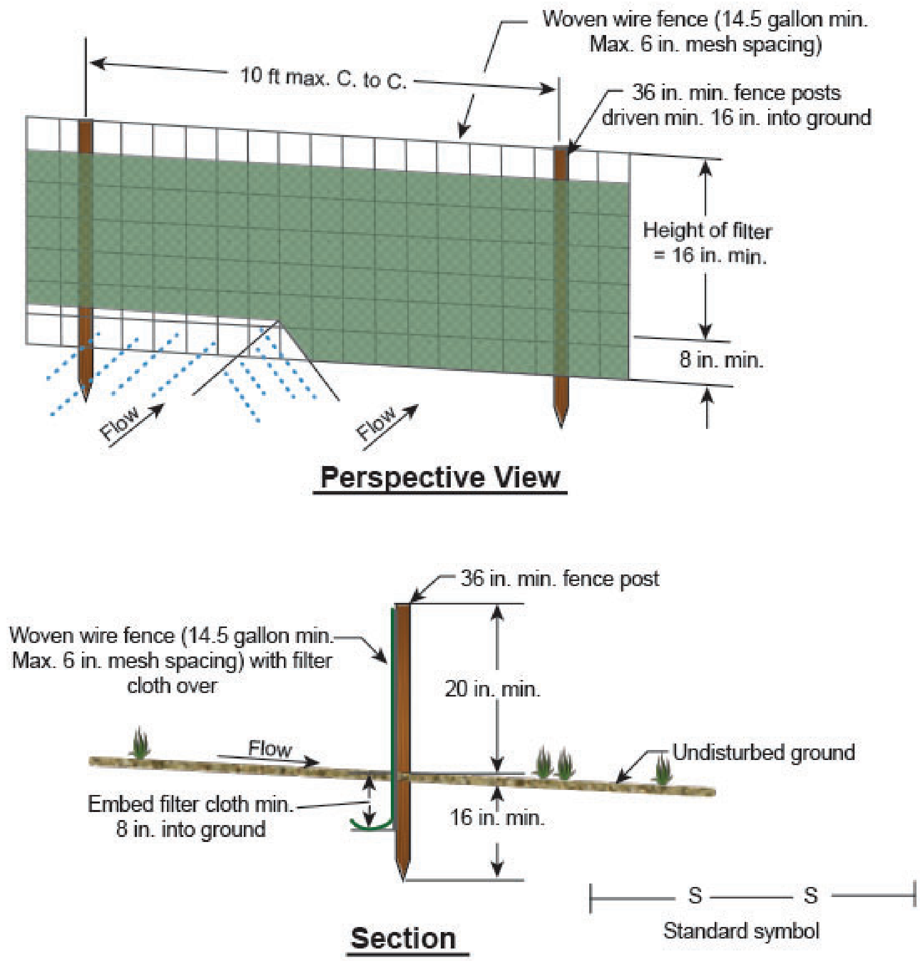
Materials

The filter fabric should meet specifications for silt fence materials included in ASTM D6461, unless otherwise approved by the appropriate erosion and sediment control plan approval authority. The fabric can be woven, nonwoven, or monofilament with a minimum width of 36 inches (Figure 158 and Figure 159).

Support posts should be 36 to 48 inches long and can be either wood or steel. Wood posts should be sound quality wood with a minimum cross-sectional area of 3 square inches, typically 2 x 2 inches nominal dimensions. Steel posts can be standard “T” or “U” sections weighing not less than 1 pound per linear foot. Steel posts can be easier to drive into compacted ground to a depth sufficient enough to hold the fabric up and support the horizontal load of retained water and sediment.

Woven wire fence can be used to help the silt fence withstand heavy rain or high wind events. Wire fencing should be a minimum 14.5 gage with a maximum 6-inch mesh opening, or as approved.

In lieu of constructing silt fence on site using the above recommended materials, prefabricated units can be used if installed per the manufacturer's instructions. Prefabricated fences do not allow for variable post spacing or posting after the ground is compacted.



Construction Notes for Fabricated Silt Fence

1. Woven wire fence to be fastened securely to fence posts with wire ties or staples.
2. Filter cloth to be fastened securely to woven wire fence with ties spaced every 24 in. at top and mid-section.
3. When two sections of filter cloth adjoin each other, they shall be overlapped by 6 in. and folded.
4. Maintenance shall be performed as needed and material removed when bulges develop in the silt fence.

Figure 158. Silt fence diagram.

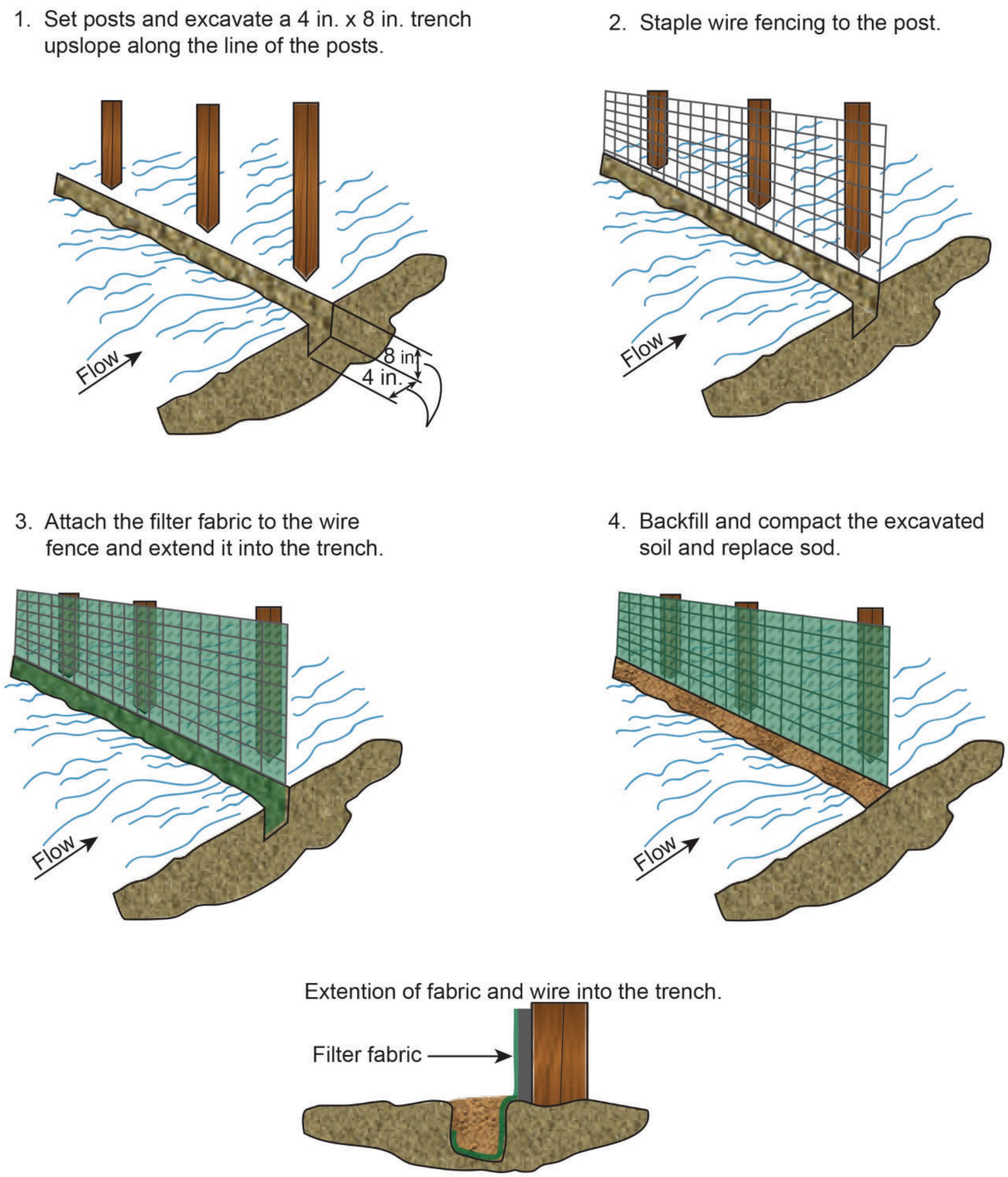


Figure 159. Silt fence construction diagram.

Construction Guidelines

Install the silt fence after cutting and slashing trees and before excavating haul roads, fill benches, or any soil-disturbing construction activity within the contributing drainage areas.

Silt fence can be installed using either the traditional trenching method or the static slicing method. The trenching method places the fence along a 6-inch wide x 8-inch deep trench; the fabric is keyed into the trench; and the trench is backfilled and compacted. To reduce sediment load, replace the vegetation or sod removed to create the trench.

The static slicing method uses a narrow blade pulled behind a tractor to create a 12-inch deep slit where the silt fence fabric is placed. Once the fabric is installed, the soil is compacted on both sides of the slit using tractor tires. The static slicing method achieves better performance with less time and effort than the trenching method (EPA 2012b).

Other guidelines for constructing and installing a silt fence include the following:

- Space posts 10 feet apart when a woven wire fence is used and no more than 6 feet apart when using extra-strength filter fabric (without a wire fence). Extend the posts a minimum of 18 inches into the ground, 24 inches if heavy sediment load is expected, and 30 inches if heavy wire-backed fencing is used. For prefabricated fencing, use the manufacturer's recommendations for post embedment depth.
- If standard strength filter fabric is used, fasten the optional wire mesh support fence to the upslope side of the posts using heavy duty wire staples, tie wires, or hog rings. Extend the wire mesh support to the bottom of the trench. Staple or wire the filter fabric to the fence.
- Extra strength filter fabric does not require a wire mesh support fence. Staple or wire the filter fabric directly to the posts.
- Do not attach filter fabric to trees.
- Where ends of filter fabric come together, overlap, fold, and staple the ends to prevent sediment bypass.
- Where joints in the fabric are required, splice it together only at a support post, with a minimum 6 inch overlap, and securely seal the joint.
- Extend the embedded filter fabric in a flap anchored by backfill to prevent the fabric from pulling out of ground.

Maintenance

Silt fences should be inspected periodically and after runoff events for damage (such as layover or tearing by wind, animals, or equipment) and for the amount of accumulated sediment. Remove the sediment when it reaches one-half the height of the silt fence. Where access is available, machinery can be used; otherwise, the sediment should be removed manually.

- Remove sediment deposits before heavy rain or when high water is anticipated.
- Place sediment deposits in an area protected by sediment and erosion control measures and where little danger of erosion exists.
- The life span of silt fence is generally 5 to 8 months. Remove and replace damaged silt fencing.
- If the silt fence has become clogged and no longer drains, replace it or install a second silt fence either above or below the original fence to collect additional sediment.
- Do not remove the silt fence until land-disturbing activities are completed and contributing drainage areas have been stabilized. Ensure the fabric is cut at ground level; remove the wire and posts and remaining sediment; and rake, seed, and mulch the area immediately.

Additional Resources

EPA (US Environmental Protection Agency). 2012. *Silt Fences*. Stormwater Best Management Practice. *http://www.epa.gov/npdes/pubs/siltfences.pdf*