Halfmoon Creek Watershed Sediment TMDL
(Upper Juniata River Basin)
Centre County

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

March 2018

TABLE OF CONTENTS

Halfmoon Creek Sediment TMDL
(Little Juniata River)
Centre County, Pennsylvania

Executive Summary

A Total Maximum Daily Load (TMDL) was developed to address aquatic life use impairments in Halfmoon Creek as noted in ***2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report*** (Integrated List-Table 2.), initially listed in 1998. Halfmoon Creek is a tributary of Spruce Creek and the greater Little Juniata River basin, Centre County (Figure 1.). The watershed lies near Halfmoon and Ferguson Townships, Centre County. Biological impairments were originally noted during bioassessments in the watershed (NCRO, 2007-Bioassessment Summaries, Figures 2a.-d., page 6.). The source of degradation is related to agricultural activities, which effect the High Quality (HQ) attributes of Halfmoon Creek, most significantly in benthic inundation. PA does not currently have water quality criteria for excess siltation, so a sediment TMDL endpoint was identified using a reference watershed approach. Based on a comparison to a similar watershed in land use, yet biologically non-impaired HQ watershed, the maximum sediment loading should still allow water quality objectives to be met. Adjacent to the east, Beaver Branch, chosen for comparison and is also a tributary of Spruce Creek and the greater Little Juniata River, Centre County.

This proposed TMDL sets allowable sediment loadings within the specifically impaired stream segments of the Halfmoon Creek watershed. The loading was allocated among the land uses of cropland, hay/pasture land, and associated stream banks present in the watershed. Data used in these TMDLs was generated using a watershed analysis model (MAPSHED) designed by the Penn State University. The following table shows the estimated current loadings for the watershed.

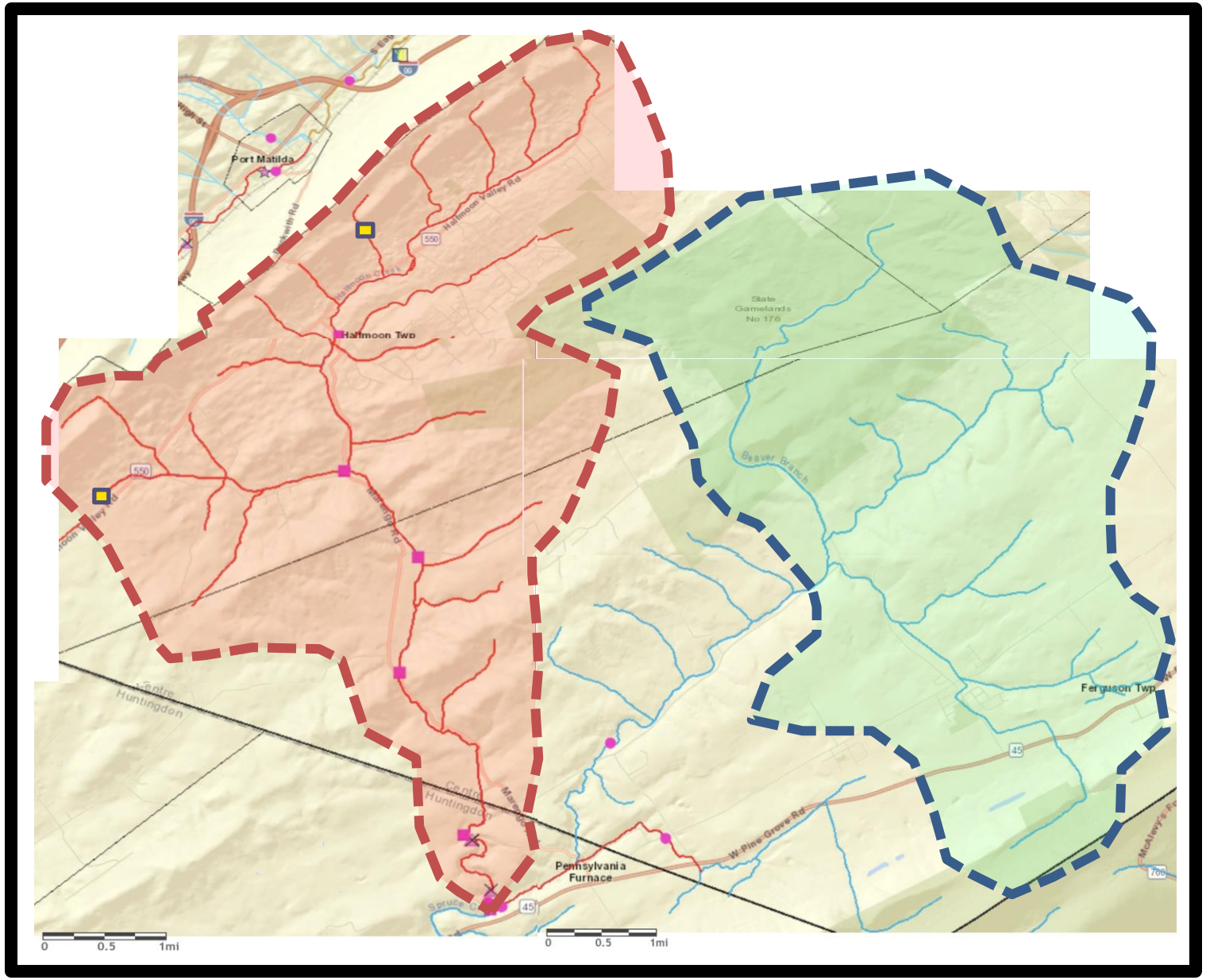
Table 1. Summary of TMDL based load reductions in Halfmoon Creek (lbs./yr. & lbs./d.)

Source	TMDL	WLA	MOS	LA	LNR	ALA
Sediment	2,399,098.4	24,173.7	239,909.8	2,135,014.8	36,600.0	2,098,414.8
Sediment	6,572.9	66.2	657.3	5,849.4	100.3	5,749.1

TMDL – Total Maximum Daily Load, WLA – Waste Load Allocation, MOS – Margin of Safety
LA – Load Allocation, LNR – Loads Not Reduced, ALA – Adjusted Load Allocation

Load allocations were distributed to nonpoint sources, specifically all land use sources other than National Pollutant Discharge Elimination System (NPDES) permitted point source discharges with 10% of the TMDL reserved explicitly as a margin of safety (MOS). A search of the Pennsylvania Department of Environmental Protection's (Department) online, GIS database, EMAP, identified **two, point source discharges** within the Halfmoon Creek watershed. 1% of the TMDL was incorporated into the WLA as a bulk reserve to take in account future permit activity. Loads not reduced (LNR) are the portion of the LA associated with nonpoint sources other than agricultural (croplands, hay/pasture), and associated stream banks. It is equal to the sum of modeled loading on forested land use, wetlands, open space, and development. The adjusted load allocation (ALA) represents the remaining portion of the LA distributed among agricultural land and associated stream banks. The TMDL developed for the impaired stream segments within the Halfmoon Creek watershed to establish a reduction in the overall, sediment loading to **51.9%**

Figure 1. Overview maps of the Halfmoon Creek, Centre County (red-impaired HQ waters) and Beaver Branch, (blue-non-impaired, reference HQ waters)
(Red Points-Bioassessment Sites; Yellow Boxes-Water Pollution Control Facility)

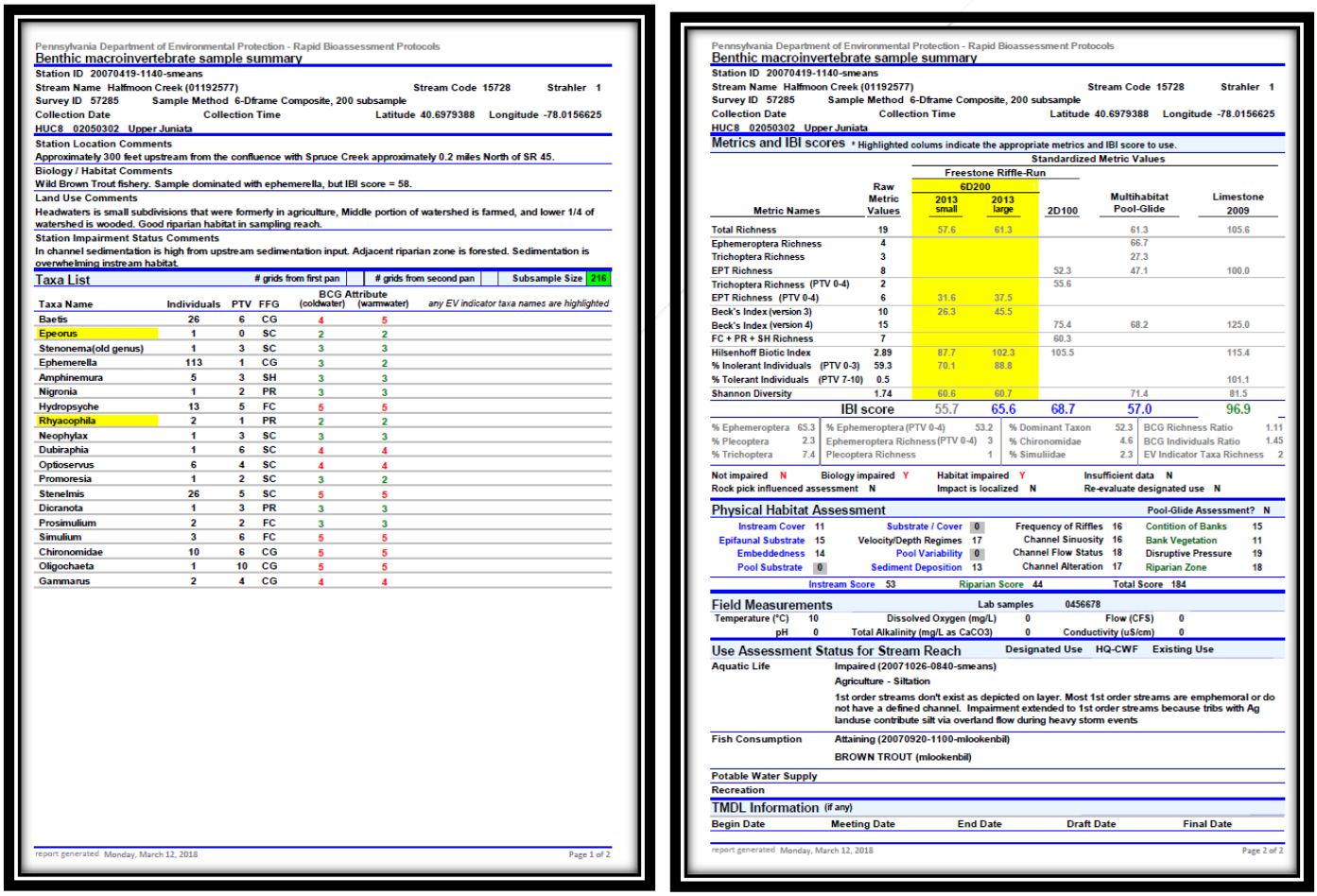


Introduction

The Halfmoon Creek Watershed is currently designated as a High Quality, Cold Water Fishery (HQ-CWF), (PA Code 25 § 93.9o), which are surface waters of a quality which exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water by satisfying § 93.4b(a). CWF – Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold-water habitat.

This Total Maximum Daily Load (TMDL) calculation has been prepared for all sediment-impaired segments in the Halfmoon Creek Watershed. The headwaters are located in Halfmoon and Ferguson Townships, Centre County. Halfmoon Creek, including all its tributaries, encompasses approximately 32.3 stream miles downstream to the confluence of Spruce Creek (Map, Figure 1.; Locations, characteristics, and bioassessment summaries, see Figures 4a.- 4d.)

Figure 2a. 2007 Water Quality Bioassessment-Halfmoon Creek-headwaters (impaired)



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1140-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57285 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.6979388 Longitude -78.0156625
HUC8 02050302 Upper Juniata

Station Location Comments
Approximately 300 feet upstream from the confluence with Spruce Creek approximately 0.2 miles North of SR 45.

Biology / Habitat Comments
Wild Brown Trout fishery. Sample dominated with ephemerella, but IBI score = 58.

Land Use Comments
Headwaters is small subdivisions that were formerly in agriculture, Middle portion of watershed is farmed, and lower 1/4 of watershed is wooded. Good riparian habitat in sampling reach.

Station Impairment Status Comments
In channel sedimentation is high from upstream sedimentation input. Adjacent riparian zone is forested. Sedimentation is overwhelming instream habitat.

Taxa List — # grids from first pan | # grids from second pan | Subsample Size 210

Taxa Name	Individuals	PTV	FFG	BCG Attribute (coldwater)	BCG Attribute (warmwater)
Baetis	26	6	CG	4	5
Epeorus	1	0	SC	2	2
Stenonema(old genus)	1	3	SC	3	3
Ephemerella	113	1	CG	3	2
Amphinemura	5	3	SH	3	3
Nigronia	1	2	PR	3	3
Hydropsyche	13	5	FC	5	5
Rhyacophila	2	1	PR	2	2
Neophylax	1	3	SC	3	3
Dubiraphia	1	6	SC	4	4
Optioservus	6	4	SC	4	4
Promoresia	1	2	SC	3	2
Stenelmis	26	5	SC	5	5
Dicranota	1	3	PR	3	3
Prosimulium	2	2	FC	3	3
Simulium	3	6	FC	5	5
Chironomidae	10	6	CG	5	5
Oligochaeta	1	10	CG	5	5
Gammarus	2	4	CG	4	4

any EV indicator taxa names are highlighted

report generated Monday, March 12, 2018 Page 1 of 2

Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1140-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57285 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.6979388 Longitude -78.0156625
HUC8 02050302 Upper Juniata

Metrics and IBI scores * Highlighted colums indicate the appropriate metrics and IBI score to use.

Standardized Metric Values — Freestone Riffle-Run — 6D200

Metric Names	Raw Metric Values	2013 small	2013 large	2D100	Multihabitat Pool-Glide	Limestone 2009
Total Richness	19	57.6	61.3		61.3	105.6
Ephemeroptera Richness	4				66.7	
Trichoptera Richness	3				27.3	
EPT Richness	8			52.3	47.1	100.0
Trichoptera Richness (PTV 0-4)	2			55.6		
EPT Richness (PTV 0-4)	6	31.6	37.5			
Beck's Index (version 3)	10	26.3	45.5			
Beck's Index (version 4)	15			75.4	68.2	125.0
FC + PR + SH Richness	7			60.3		
Hilsenhoff Biotic Index	2.89	87.7	102.3	105.5		115.4
% Inolerant Individuals (PTV 0-3)	59.3	70.1	88.8			
% Tolerant Individuals (PTV 7-10)	0.5					101.1
Shannon Diversity	1.74	60.6	60.7		71.4	81.5
IBI score		55.7	65.6	68.7	57.0	96.9

% Ephemeroptera	65.3	% Ephemeroptera (PTV 0-4)	53.2	% Dominant Taxon	52.3	BCG Richness Ratio	1.11
% Plecoptera	2.3	Ephemeroptera Richness (PTV 0-4)	3	% Chironomidae	4.6	BCG Individuals Ratio	1.45
% Trichoptera	7.4	Plecoptera Richness	1	% Simuliidae	2.3	EV Indicator Taxa Richness	2

Not impaired N Biology impaired Y Habitat impaired Y Insufficient data N
Rock pick influenced assessment N Impact is localized N Re-evaluate designated use N

Physical Habitat Assessment — Pool-Glide Assessment? N

Instream Cover	11	Substrate / Cover	0	Frequency of Riffles	16	Contition of Banks	15
Epifaunal Substrate	15	Velocity/Depth Regimes	17	Channel Sinuosity	16	Bank Vegetation	11
Embeddedness	14	Pool Variability	0	Channel Flow Status	18	Disruptive Pressure	19
Pool Substrate	0	Sediment Deposition	13	Channel Alteration	17	Riparian Zone	18

Instream Score 53 Riparian Score 44 Total Score 184

Field Measurements — Lab samples 0456678

Temperature (°C)	10	Dissolved Oxygen (mg/L)	0	Flow (CFS)	0
pH	0	Total Alkalinity (mg/L as CaCO3)	0	Conductivity (uS/cm)	0

Use Assessment Status for Stream Reach — Designated Use HQ-CWF Existing Use

Aquatic Life: Impaired (20071026-0840-smeans)
Agriculture - Siltation
1st order streams don't exist as depicted on layer. Most 1st order streams are emphemoral or do not have a defined channel. Impairment extended to 1st order streams because tribs with Ag landuse contribute silt via overland flow during heavy storm events

Fish Consumption: Attaining (20070920-1100-mlookenbil)
BROWN TROUT (mlookenbil)

Potable Water Supply

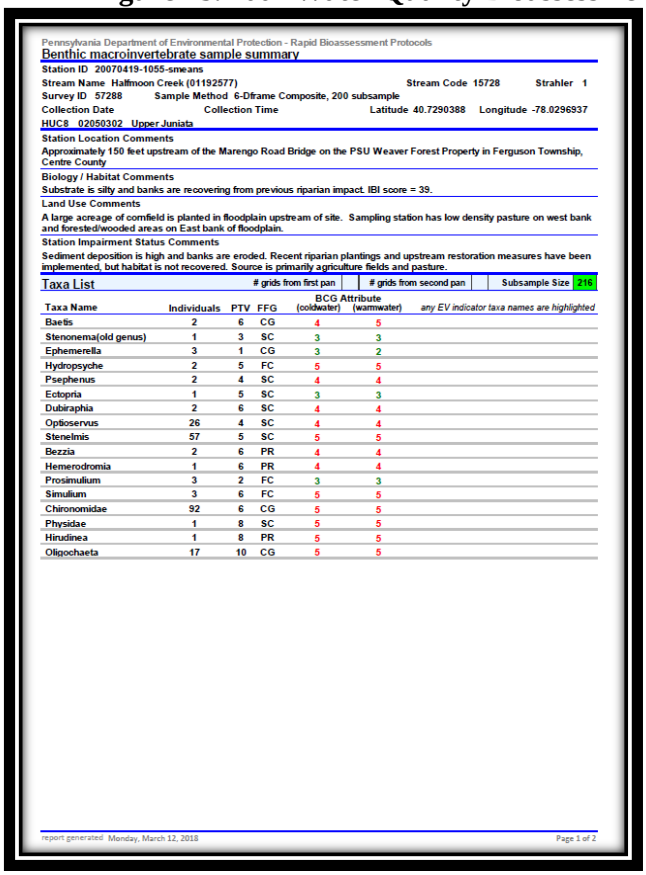
Recreation

TMDL Information (if any)

Begin Date	Meeting Date	End Date	Draft Date	Final Date

report generated Monday, March 12, 2018 Page 2 of 2

Figure 2b. 2007 Water Quality Bioassessment-Halfmoon Creek-upper middle (impaired)



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1055-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57288 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7290388 Longitude -78.0296937
HUC8 02050302 Upper Juniata

Station Location Comments
Approximately 150 feet upstream of the Marengo Road Bridge on the PSU Weaver Forest Property in Ferguson Township, Centre County

Biology / Habitat Comments
Substrate is silty and banks are recovering from previous riparian impact. IBI score = 39.

Land Use Comments
A large acreage of cornfield is planted in floodplain upstream of site. Sampling station has low density pasture on west bank and forested/wooded areas on East bank of floodplain.

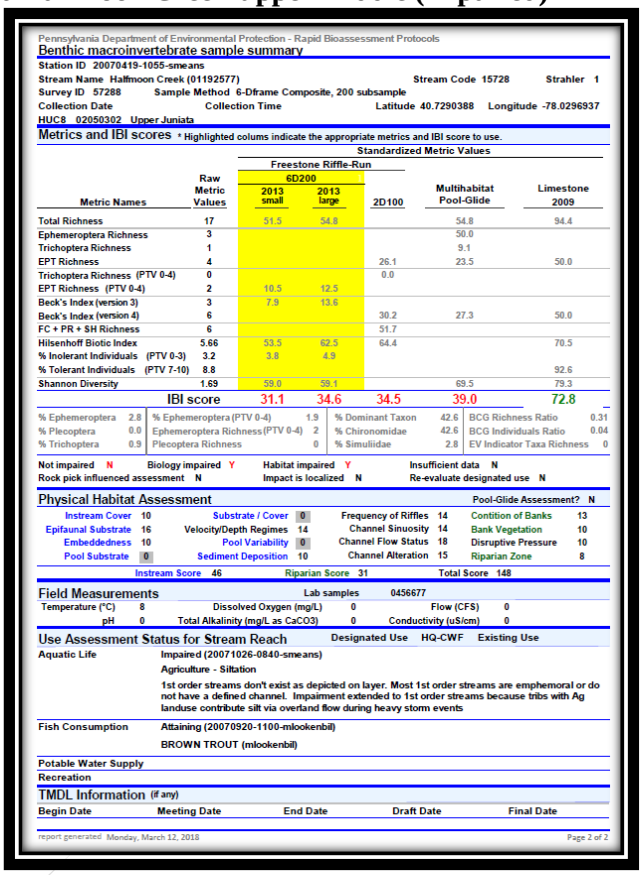
Station Impairment Status Comments
Sediment deposition is high and banks are eroded. Recent riparian plantings and upstream restoration measures have been implemented, but habitat is not recovered. Source is primarily agriculture fields and pasture.

Taxa List — # grids from first pan | # grids from second pan | Subsample Size 216

Taxa Name	Individuals	PTV	FFG	BCG Attribute (coldwater)	BCG Attribute (warmwater)
Baetis	2	6	CG	4	5
Stenonema(old genus)	1	3	SC	3	3
Ephemerella	3	1	CG	3	2
Hydropsyche	2	5	FC	5	5
Psephenus	2	4	SC	4	4
Ectopria	1	5	SC	3	3
Dubiraphia	2	6	SC	4	4
Optioservus	26	4	SC	4	4
Stenelmis	57	5	SC	5	5
Bezzia	2	6	PR	4	4
Hemerodromia	1	6	PR	4	4
Prosimulium	3	2	FC	3	3
Simulium	3	6	FC	5	5
Chironomidae	92	6	CG	5	5
Physidae	1	8	SC	5	5
Hirudinea	1	8	PR	5	5
Oligochaeta	17	10	CG	5	5

any EV indicator taxa names are highlighted

report generated Monday, March 12, 2018 Page 1 of 2



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1055-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57288 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7290388 Longitude -78.0296937
HUC8 02050302 Upper Juniata

Metrics and IBI scores * Highlighted colums indicate the appropriate metrics and IBI score to use.

Metric Names	Raw Metric Values	Standardized Metric Values: Freestone Riffle-Run 6D200 2013 small	2013 large	2D100	Multihabitat Pool-Glide	Limestone 2009
Total Richness	17	51.5	54.8		54.8	94.4
Ephemeroptera Richness	3				50.0	
Trichoptera Richness	1				9.1	
EPT Richness	4			26.1	23.5	50.0
Trichoptera Richness (PTV 0-4)	0			0.0		
EPT Richness (PTV 0-4)	2	10.5	12.5			
Beck's Index (version 3)	3	7.9	13.6			
Beck's Index (version 4)	6			30.2	27.3	50.0
FC + PR + SH Richness	6			51.7		
Hilsenhoff Biotic Index	5.66	53.5	62.5	64.4		70.5
% Inolerant Individuals (PTV 0-3)	3.2	3.8	4.9			
% Tolerant Individuals (PTV 7-10)	8.8					92.6
Shannon Diversity	1.69	59.0	59.1		69.5	79.3
IBI score		31.1	34.6	34.5	39.0	72.8

% Ephemeroptera	2.8	% Ephemeroptera (PTV 0-4)	1.9	% Dominant Taxon	42.6	BCG Richness Ratio	0.31
% Plecoptera	0.0	Ephemeroptera Richness (PTV 0-4)	2	% Chironomidae	42.6	BCG Individuals Ratio	0.04
% Trichoptera	0.9	Plecoptera Richness	0	% Simuliidae	2.8	EV Indicator Taxa Richness	0

Not impaired N Biology impaired Y Habitat impaired Y Insufficient data N
Rock pick influenced assessment N Impact is localized N Re-evaluate designated use N

Physical Habitat Assessment — Pool-Glide Assessment? N

Instream Cover	10	Substrate / Cover	0	Frequency of Riffles	14	Contition of Banks	13
Epifaunal Substrate	16	Velocity/Depth Regimes	14	Channel Sinuosity	14	Bank Vegetation	10
Embeddedness	10	Pool Variability	0	Channel Flow Status	18	Disruptive Pressure	10
Pool Substrate	0	Sediment Deposition	10	Channel Alteration	15	Riparian Zone	8

Instream Score 46 Riparian Score 31 Total Score 148

Field Measurements — Lab samples 0456677

Temperature (°C)	8	Dissolved Oxygen (mg/L)	0	Flow (CFS)	0
pH	0	Total Alkalinity (mg/L as CaCO3)	0	Conductivity (uS/cm)	0

Use Assessment Status for Stream Reach — Designated Use HQ-CWF Existing Use

Aquatic Life: Impaired (20071026-0840-smeans)
Agriculture - Siltation
1st order streams don't exist as depicted on layer. Most 1st order streams are emphemoral or do not have a defined channel. Impairment extended to 1st order streams because tribs with Ag landuse contribute silt via overland flow during heavy storm events

Fish Consumption: Attaining (20070920-1100-mlookenbil)
BROWN TROUT (mlookenbil)

Potable Water Supply

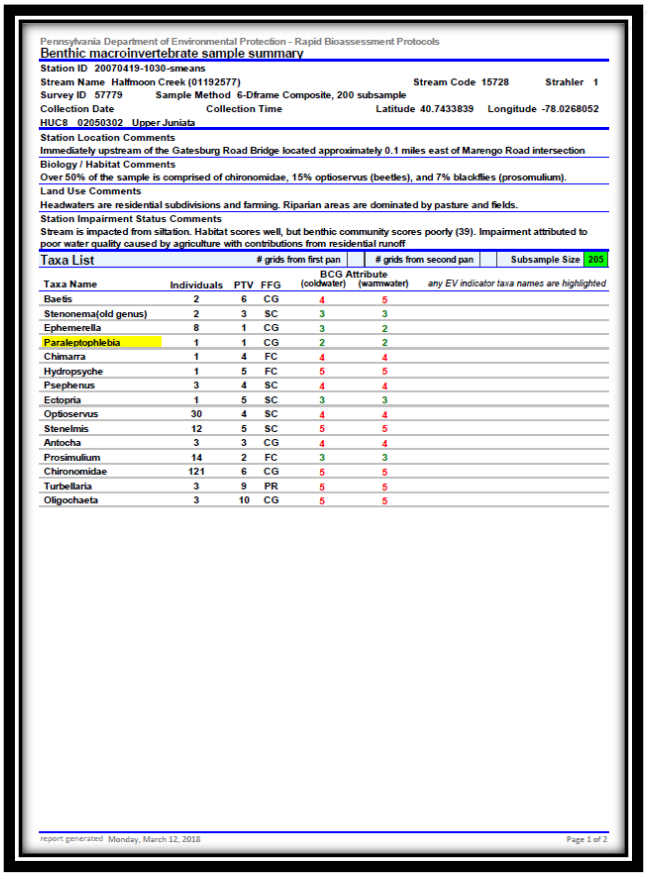
Recreation

TMDL Information (if any)

Begin Date	Meeting Date	End Date	Draft Date	Final Date

report generated Monday, March 12, 2018 Page 2 of 2

Figure 2b. 2007 Water Quality Bioassessment-Halfmoon Creek-lower middle (impaired)



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1030-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57779 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7433839 Longitude -78.0268052
HUC8 02050302 Upper Juniata

Station Location Comments
Immediately upstream of the Gatesburg Road Bridge located approximately 0.1 miles east of Marengo Road intersection

Biology / Habitat Comments
Over 50% of the sample is comprised of chironomidae, 15% optioservus (beetles), and 7% blackflies (prosomulium).

Land Use Comments
Headwaters are residential subdivisions and farming. Riparian areas are dominated by pasture and fields.

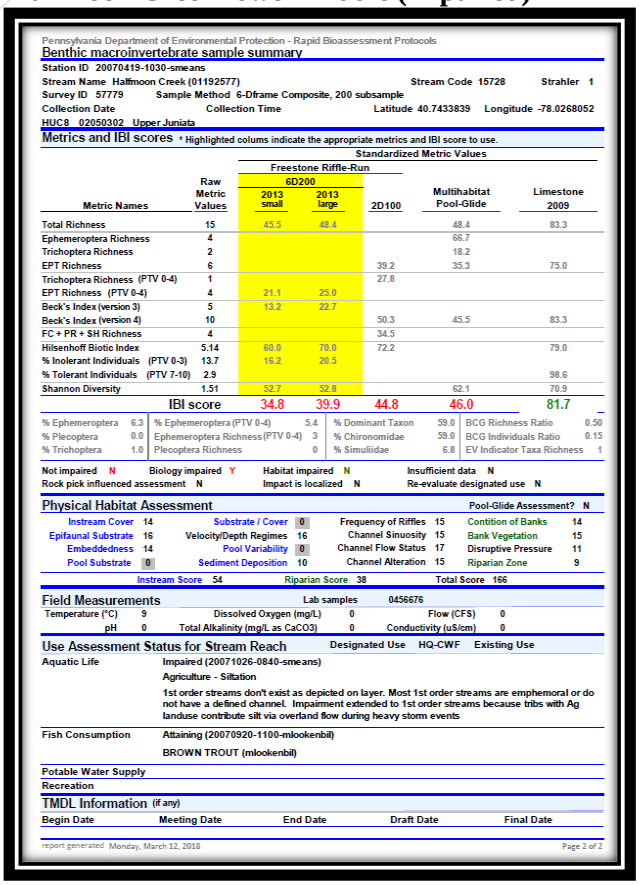
Station Impairment Status Comments
Stream is impacted from siltation. Habitat scores well, but benthic community scores poorly (39). Impairment attributed to poor water quality caused by agriculture with contributions from residential runoff

Taxa List — # grids from first pan | # grids from second pan | Subsample Size 205

Taxa Name	Individuals	PTV	FFG	BCG Attribute (coldwater)	BCG Attribute (warmwater)
Baetis	2	6	CG	4	5
Stenonema(old genus)	2	3	SC	3	3
Ephemerella	8	1	CG	3	2
Paraleptophlebia	1	1	CG	2	2
Chimarra	1	4	FC	4	4
Hydropsyche	1	5	FC	5	5
Psephenus	3	4	SC	4	4
Ectopria	1	5	SC	3	3
Optioservus	30	4	SC	4	4
Stenelmis	12	5	SC	5	5
Antocha	3	3	CG	4	4
Prosimulium	14	2	FC	3	3
Chironomidae	121	6	CG	5	5
Turbellaria	3	9	PR	5	5
Oligochaeta	3	10	CG	5	5

any EV indicator taxa names are highlighted

report generated Monday, March 12, 2018 Page 1 of 2



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1030-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57779 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7433839 Longitude -78.0268052
HUC8 02050302 Upper Juniata

Metrics and IBI scores * Highlighted colums indicate the appropriate metrics and IBI score to use.

Metric Names	Raw Metric Values	Standardized Metric Values: Freestone Riffle-Run 6D200 2013 small	2013 large	2D100	Multihabitat Pool-Glide	Limestone 2009
Total Richness	15	45.5	48.4		48.4	83.3
Ephemeroptera Richness	4				66.7	
Trichoptera Richness	2				18.2	
EPT Richness	6			39.2	35.3	75.0
Trichoptera Richness (PTV 0-4)	1			27.8		
EPT Richness (PTV 0-4)	4	21.1	25.0			
Beck's Index (version 3)	5	13.2	22.7			
Beck's Index (version 4)	10			50.3	45.5	83.3
FC + PR + SH Richness	4			34.5		
Hilsenhoff Biotic Index	5.14	60.0	70.0	72.2		79.0
% Inolerant Individuals (PTV 0-3)	13.7	16.2	20.5			
% Tolerant Individuals (PTV 7-10)	2.9					98.6
Shannon Diversity	1.51	52.7	52.8		62.1	70.9
IBI score		34.8	39.9	44.8	46.0	81.7

% Ephemeroptera	6.3	% Ephemeroptera (PTV 0-4)	5.4	% Dominant Taxon	59.0	BCG Richness Ratio	0.50
% Plecoptera	0.0	Ephemeroptera Richness (PTV 0-4)	3	% Chironomidae	59.0	BCG Individuals Ratio	0.15
% Trichoptera	1.0	Plecoptera Richness	0	% Simuliidae	6.8	EV Indicator Taxa Richness	1

Not impaired N Biology impaired Y Habitat impaired N Insufficient data N
Rock pick influenced assessment N Impact is localized N Re-evaluate designated use N

Physical Habitat Assessment — Pool-Glide Assessment? N

Instream Cover	14	Substrate / Cover	0	Frequency of Riffles	15	Contition of Banks	14
Epifaunal Substrate	16	Velocity/Depth Regimes	16	Channel Sinuosity	15	Bank Vegetation	15
Embeddedness	14	Pool Variability	0	Channel Flow Status	17	Disruptive Pressure	11
Pool Substrate	0	Sediment Deposition	10	Channel Alteration	15	Riparian Zone	9

Instream Score 54 Riparian Score 38 Total Score 166

Field Measurements — Lab samples 0456676

Temperature (°C)	9	Dissolved Oxygen (mg/L)	0	Flow (CFS)	0
pH	0	Total Alkalinity (mg/L as CaCO3)	0	Conductivity (uS/cm)	0

Use Assessment Status for Stream Reach — Designated Use HQ-CWF Existing Use

Aquatic Life: Impaired (20071026-0840-smeans)
Agriculture - Siltation
1st order streams don't exist as depicted on layer. Most 1st order streams are emphemoral or do not have a defined channel. Impairment extended to 1st order streams because tribs with Ag landuse contribute silt via overland flow during heavy storm events

Fish Consumption: Attaining (20070920-1100-mlookenbil)
BROWN TROUT (mlookenbil)

Potable Water Supply

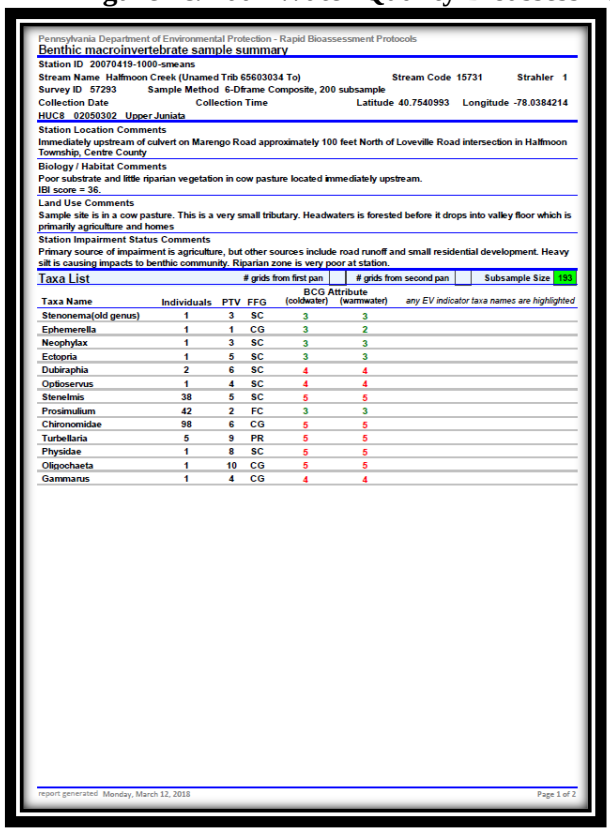
Recreation

TMDL Information (if any)

Begin Date	Meeting Date	End Date	Draft Date	Final Date

report generated Monday, March 12, 2018 Page 2 of 2

Figure 2c. 2007 Water Quality Bioassessment-Halfmoon Creek-Tributary (impaired)



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1000-smeans
Stream Name Halfmoon Creek (Unamed Trib 65603034 To) Stream Code 15731 Strahler 1
Survey ID 57293 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7540993 Longitude -78.0384214
HUC8 02050302 Upper Juniata

Station Location Comments
Immediately upstream of culvert on Marengo Road approximately 100 feet North of Loveville Road intersection in Halfmoon Township, Centre County

Biology / Habitat Comments
Poor substrate and little riparian vegetation in cow pasture located immediately upstream.
IBI score = 36.

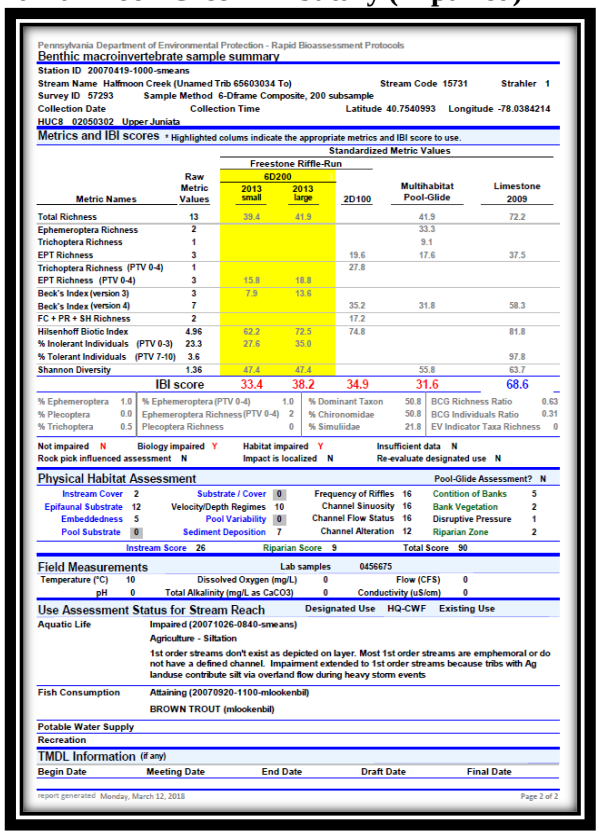
Land Use Comments
Sample site is in a cow pasture. This is a very small tributary. Headwaters is forested before it drops into valley floor which is primarily agriculture and homes

Station Impairment Status Comments
Primary source of impairment is agriculture, but other sources include road runoff and small residential development. Heavy silt is causing impacts to benthic community. Riparian zone is very poor at station.

Taxa List # grids from first pan | # grids from second pan | Subsample Size 193

Taxa Name	Individuals	PTV	FFG	BCG Attribute (coldwater)	BCG Attribute (warmwater)	any EV indicator taxa names are highlighted
Stenonema(old genus)	1	3	SC	3	3	
Ephemerella	1	1	CG	3	2	
Neophylax	1	3	SC	3	3	
Ectopria	1	5	SC	3	3	
Dubiraphia	2	6	SC	4	4	
Optioservus	1	4	SC	4	4	
Stenelmis	38	5	SC	5	5	
Prosimulium	42	2	FC	3	3	
Chironomidae	98	6	CG	5	5	
Turbellaria	5	9	PR	5	5	
Physidae	1	8	SC	5	5	
Oligochaeta	1	10	CG	5	5	
Gammarus	1	4	CG	4	4	

report generated Monday, March 12, 2018 Page 1 of 2



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-1000-smeans
Stream Name Halfmoon Creek (Unamed Trib 65603034 To) Stream Code 15731 Strahler 1
Survey ID 57293 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7540993 Longitude -78.0384214
HUC8 02050302 Upper Juniata

Metrics and IBI scores * Highlighted colums indicate the appropriate metrics and IBI score to use.

Standardized Metric Values

Metric Names	Raw Metric Values	Freestone Riffle-Run 6D200 2013 small	Freestone Riffle-Run 6D200 2013 large	2D100	Multihabitat Pool-Glide	Limestone 2009
Total Richness	13	39.4	41.9		41.9	72.2
Ephemeroptera Richness	2				33.3	
Trichoptera Richness	1				9.1	
EPT Richness	3			19.6	17.6	37.5
Trichoptera Richness (PTV 0-4)	1			27.8		
EPT Richness (PTV 0-4)	3	15.8	18.8			
Beck's Index (version 3)	3	7.9	13.6			
Beck's Index (version 4)	7			35.2	31.8	58.3
FC + PR + SH Richness	2			17.2		
Hilsenhoff Biotic Index	4.96	62.2	72.5	74.8		81.8
% Inolerant Individuals (PTV 0-3)	23.3	27.6	35.0			
% Tolerant Individuals (PTV 7-10)	3.6					97.8
Shannon Diversity	1.36	47.4	47.4		55.8	63.7
IBI score		33.4	38.2	34.9	31.6	68.6

% Ephemeroptera	1.0	% Ephemeroptera (PTV 0-4)	1.0	% Dominant Taxon	50.8
% Plecoptera	0.0	Ephemeroptera Richness (PTV 0-4)	2	% Chironomidae	50.8
% Trichoptera	0.5	Plecoptera Richness	0	% Simuliidae	21.8

BCG Richness Ratio	0.63		
BCG Individuals Ratio	0.31		
EV Indicator Taxa Richness	0		

Not impaired N Biology impaired Y Habitat impaired Y Insufficient data N
Rock pick influenced assessment N Impact is localized N Re-evaluate designated use N

Physical Habitat Assessment Pool-Glide Assessment? N

Instream Cover	2	Substrate / Cover	0	Frequency of Riffles	16	Contition of Banks	5
Epifaunal Substrate	12	Velocity/Depth Regimes	10	Channel Sinuosity	16	Bank Vegetation	2
Embeddedness	5	Pool Variability	0	Channel Flow Status	16	Disruptive Pressure	1
Pool Substrate	0	Sediment Deposition	7	Channel Alteration	12	Riparian Zone	2

Instream Score 26 Riparian Score 9 Total Score 90

Field Measurements Lab samples 0456675

Temperature (C)	10	Dissolved Oxygen (mg/L)	0	Flow (CFS)	0
pH	0	Total Alkalinity (mg/L as CaCO3)	0	Conductivity (uS/cm)	0

Use Assessment Status for Stream Reach Designated Use HQ-CWF Existing Use

Aquatic Life: Impaired (20071026-0840-smeans)
Agriculture - Siltation
1st order streams don't exist as depicted on layer. Most 1st order streams are emphemoral or do not have a defined channel. Impairment extended to 1st order streams because tribs with Ag landuse contribute silt via overland flow during heavy storm events

Fish Consumption: Attaining (20070920-1100-mlookenbil)
BROWN TROUT (mlookenbil)

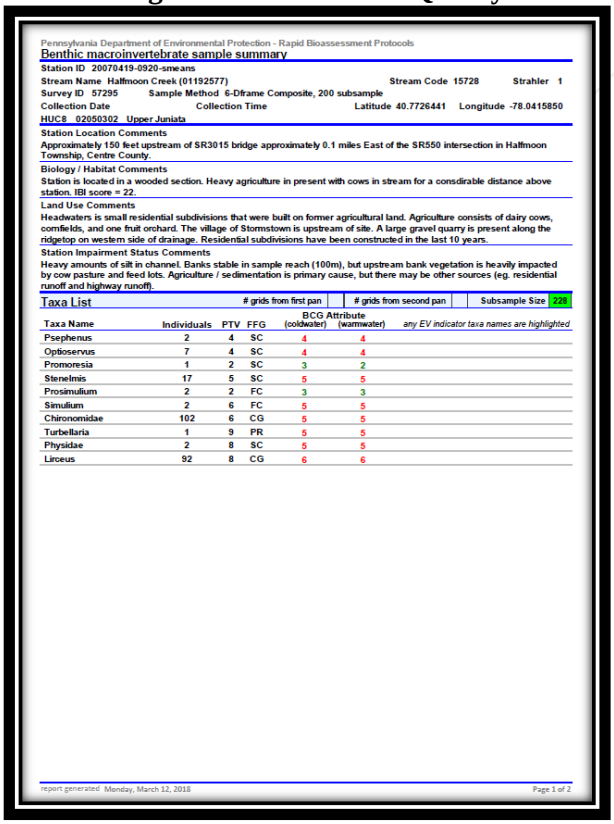
Potable Water Supply
Recreation

TMDL Information (if any)

Begin Date	Meeting Date	End Date	Draft Date	Final Date

report generated Monday, March 12, 2018 Page 2 of 2

Figure 2d. 2007 Water Quality Bioassessment-Halfmoon Creek-mouth (impaired)



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-0920-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57295 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7726441 Longitude -78.0415850
HUC8 02050302 Upper Juniata

Station Location Comments
Approximately 150 feet upstream of SR3015 bridge approximately 0.1 miles East of the SR550 intersection in Halfmoon Township, Centre County.

Biology / Habitat Comments
Station is located in a wooded section. Heavy agriculture in present with cows in stream for a consdirable distance above station. IBI score = 22.

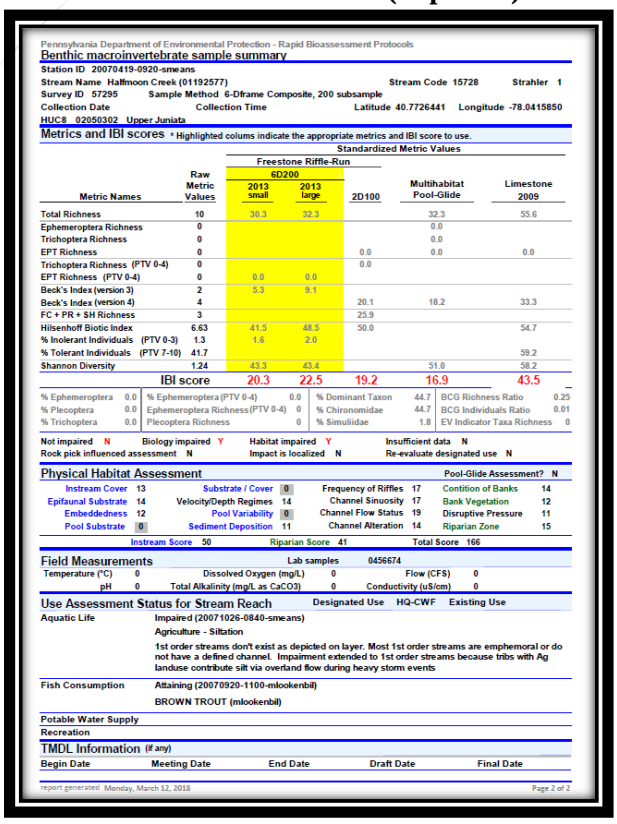
Land Use Comments
Headwaters is small residential subdivisions that were built on former agricultural land. Agriculture consists of dairy cows, cornfields, and one fruit orchard. The village of Stormstown is upstream of site. A large gravel quarry is present along the ridgetop on westem side of drainage. Residential subdivisions have been constructed in the last 10 years.

Station Impairment Status Comments
Heavy amounts of silt in channel. Banks stable in sample reach (100m), but upstream bank vegetation is heavily impacted by cow pasture and feed lots. Agriculture / sedimentation is primary cause, but there may be other sources (eg. residential runoff and highway runoff).

Taxa List # grids from first pan | # grids from second pan | Subsample Size 228

Taxa Name	Individuals	PTV	FFG	BCG Attribute (coldwater)	BCG Attribute (warmwater)	any EV indicator taxa names are highlighted
Psephenus	2	4	SC	4	4	
Optioservus	7	4	SC	4	4	
Promoresia	1	2	SC	3	2	
Stenelmis	17	5	SC	5	5	
Prosimulium	2	2	FC	3	3	
Simulium	2	6	FC	5	5	
Chironomidae	102	6	CG	5	5	
Turbellaria	1	9	PR	5	5	
Physidae	2	8	SC	5	5	
Lirceus	92	8	CG	6	6	

report generated Monday, March 12, 2018 Page 1 of 2



Pennsylvania Department of Environmental Protection - Rapid Bioassessment Protocols

Benthic macroinvertebrate sample summary

Station ID 20070419-0920-smeans
Stream Name Halfmoon Creek (01192577) Stream Code 15728 Strahler 1
Survey ID 57295 Sample Method 6-Dframe Composite, 200 subsample
Collection Date Collection Time Latitude 40.7726441 Longitude -78.0415850
HUC8 02050302 Upper Juniata

Metrics and IBI scores * Highlighted colums indicate the appropriate metrics and IBI score to use.

Standardized Metric Values

Metric Names	Raw Metric Values	Freestone Riffle-Run 6D200 2013 small	Freestone Riffle-Run 6D200 2013 large	2D100	Multihabitat Pool-Glide	Limestone 2009
Total Richness	10	30.3	32.3		32.3	55.6
Ephemeroptera Richness	0				0.0	
Trichoptera Richness	0				0.0	
EPT Richness	0			0.0	0.0	0.0
Trichoptera Richness (PTV 0-4)	0			0.0		
EPT Richness (PTV 0-4)	0	0.0	0.0			
Beck's Index (version 3)	2	5.3	9.1			
Beck's Index (version 4)	4			20.1	18.2	33.3
FC + PR + SH Richness	3			25.9		
Hilsenhoff Biotic Index	6.63	41.5	48.5	50.0		54.7
% Inolerant Individuals (PTV 0-3)	1.3	1.6	2.0			
% Tolerant Individuals (PTV 7-10)	41.7					59.2
Shannon Diversity	1.24	43.3	43.4		51.0	58.2
IBI score		20.3	22.5	19.2	16.9	43.5

% Ephemeroptera	0.0	% Ephemeroptera (PTV 0-4)	0.0	% Dominant Taxon	44.7
% Plecoptera	0.0	Ephemeroptera Richness (PTV 0-4)	0	% Chironomidae	44.7
% Trichoptera	0.0	Plecoptera Richness	0	% Simuliidae	1.8

BCG Richness Ratio	0.25		
BCG Individuals Ratio	0.01		
EV Indicator Taxa Richness	0		

Not impaired N Biology impaired Y Habitat impaired Y Insufficient data N
Rock pick influenced assessment N Impact is localized N Re-evaluate designated use N

Physical Habitat Assessment Pool-Glide Assessment? N

Instream Cover	13	Substrate / Cover	0	Frequency of Riffles	17	Contition of Banks	14
Epifaunal Substrate	14	Velocity/Depth Regimes	14	Channel Sinuosity	17	Bank Vegetation	12
Embeddedness	12	Pool Variability	0	Channel Flow Status	19	Disruptive Pressure	11
Pool Substrate	0	Sediment Deposition	11	Channel Alteration	14	Riparian Zone	15

Instream Score 50 Riparian Score 41 Total Score 166

Field Measurements Lab samples 0456674

Temperature (C)	0	Dissolved Oxygen (mg/L)	0	Flow (CFS)	0
pH	0	Total Alkalinity (mg/L as CaCO3)	0	Conductivity (uS/cm)	0

Use Assessment Status for Stream Reach Designated Use HQ-CWF Existing Use

Aquatic Life: Impaired (20071026-0840-smeans)
Agriculture - Siltation
1st order streams don't exist as depicted on layer. Most 1st order streams are emphemoral or do not have a defined channel. Impairment extended to 1st order streams because tribs with Ag landuse contribute silt via overland flow during heavy storm events

Fish Consumption: Attaining (20070920-1100-mlookenbil)
BROWN TROUT (mlookenbil)

Potable Water Supply
Recreation

TMDL Information (if any)

Begin Date	Meeting Date	End Date	Draft Date	Final Date

report generated Monday, March 12, 2018 Page 2 of 2

Geography of Halfmoon Creek

Halfmoon Creek generally flows southwest, then south, for over four and half miles and is approximately 15,252.0 acres. The watershed starts from draining Eagle Mountain flowing southwest (adjacent SR 550, east of Port Mathilda). As it opens to valley, the stream travels southeast (adjacent Morengo Road). Where it meets Beaver Branch is slightly in Huntingdon County. Land use in this watershed is composed of agriculture (33.8%) including croplands and hay/pasture, forestland (57.8%), and in development (8.4%), (Figure 3a.). Beaver Branch (Figure 3b.) will be discussed later.

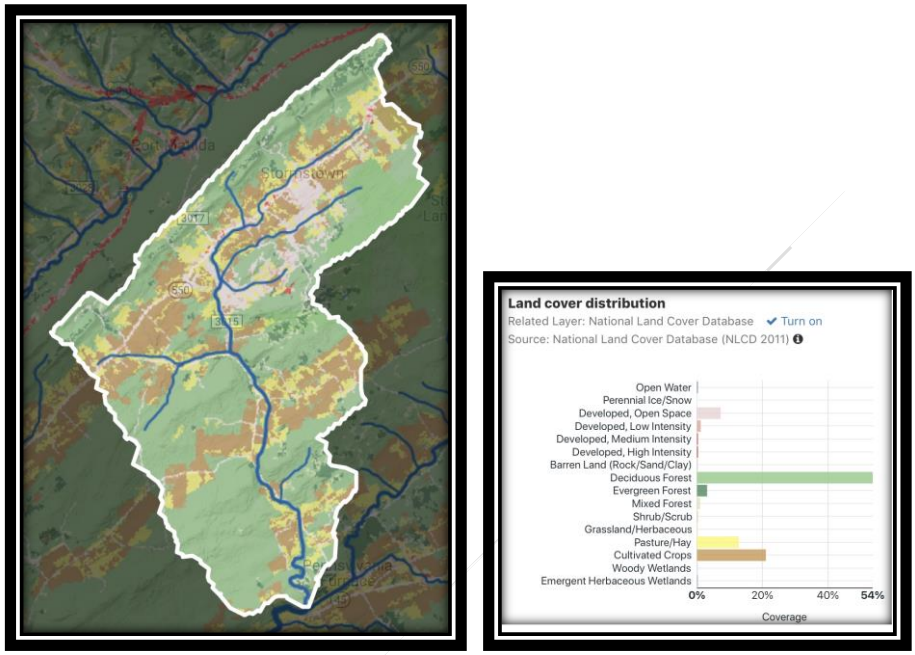
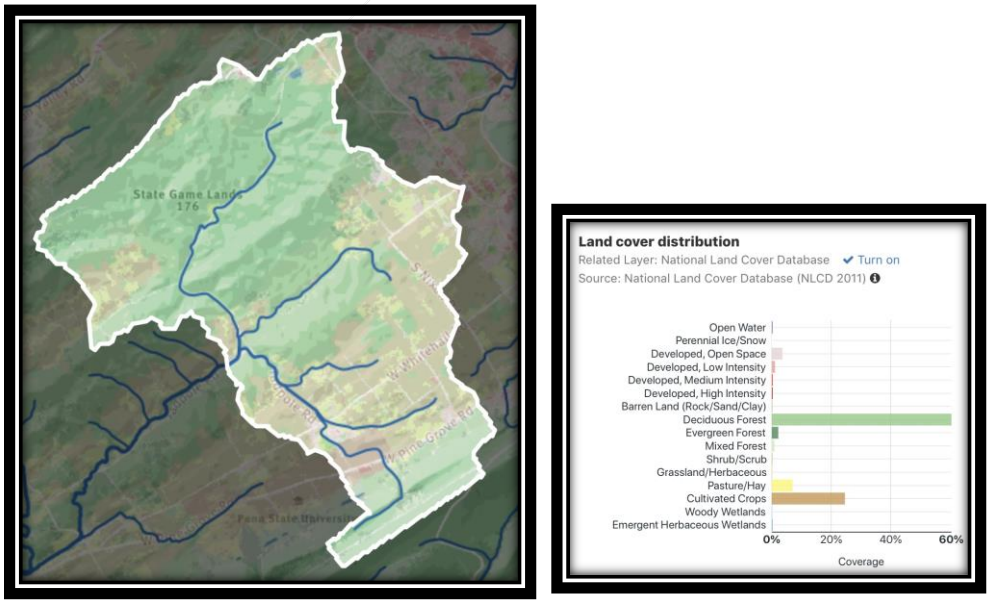


Figure 3a. and 3b., Comparison of land use distribution in Halfmoon Creek and Beaver Branch

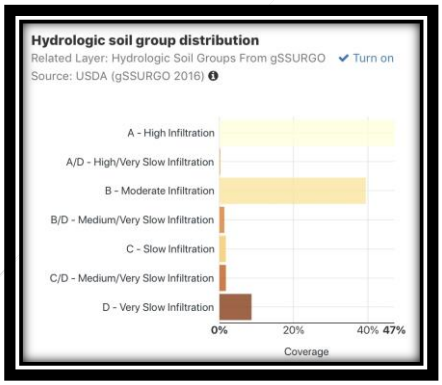


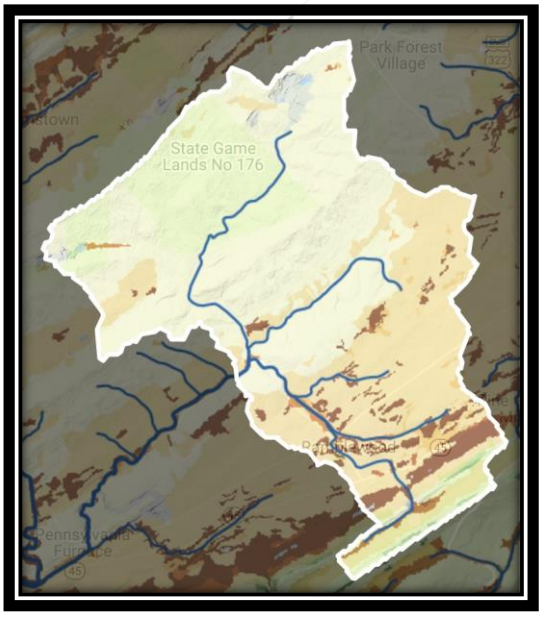
(pink/red-development, green-forest, yellow-pasture/hay, brown-cropland)

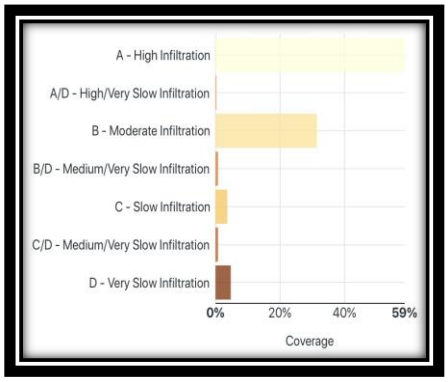
Hydric Soils of Halfmoon Creek

The soils of Halfmoon Creek (Figure 4a.), as well as, Beaver Branch (Figure 4b.) have a dominance of Hydrologic Soils Group (HSG), with them being A and B. These specific types are characterized as having high infiltration rates when thoroughly wetted and consist chiefly of soils of moderately fine to fine structure. At higher elevations, C and D, being of slow infiltration of soils, will have a high runoff potential and must be managed as such to minimize impairments to receiving waters. A and B will be found amongst the wetland region called the Barrens.

Figure 4a. and 4b., Comparison of soil distribution in Halfmoon Creek and Beaver Branch (tan-A-slow infiltration, yellow-B-moderate, orange-C-slow, red-D-very slow infiltration)







Topography and Geology of Halfmoon Creek

Both Halfmoon Creek (Figure 5.-red) and Beaver Branch (Figure 5.-blue) watersheds lie within the Ridge and Valley Province (Appalachian Mountain Section). This section consists of long, narrow ridges made of remnant anticlines and synclines pushed up from early Appalachian orogeny with broad to narrow valleys, some including karst.

Rocks within the watershed are generally interbedded sedimentary, and generally, seven underlying bedrock groups. The higher elevations are made up of thin cross sections of the following: the Juniata Formation (light brown) consists of brownish-red, fine to coarse grained quartzitic sandstone with well-developed crossbedding; it also has interbedded red siltstone and shale. The Reedsville Formation (dark brown) has dark-gray shale containing thin sandy to silty shale and siltstone interbeds, and it has an upper fossiliferous sandstone. The Coburn Formation (green) is medium gray to very dark gray, fossiliferous limestone and shaly limestone. Bellefonte Formation (dark blue) consists of light to medium gray, tan weathering, very fine-grained dolomite (the Tea Creek Member) at its top. The Axemann Formation (light pink) is composed of light-gray, fossiliferous, coarsely crystalline limestone interbedded with silty, fine-grained dolomitic limestone. The Nittany Formation (light green) has medium to dark gray, finely to coarsely crystalline dolomite. The lower valley is made up of the Lower members of the Gatesburg Formation, which consists of mainly sandstone. The sequence than goes up in reverse order near Pennsylvania Furnace.

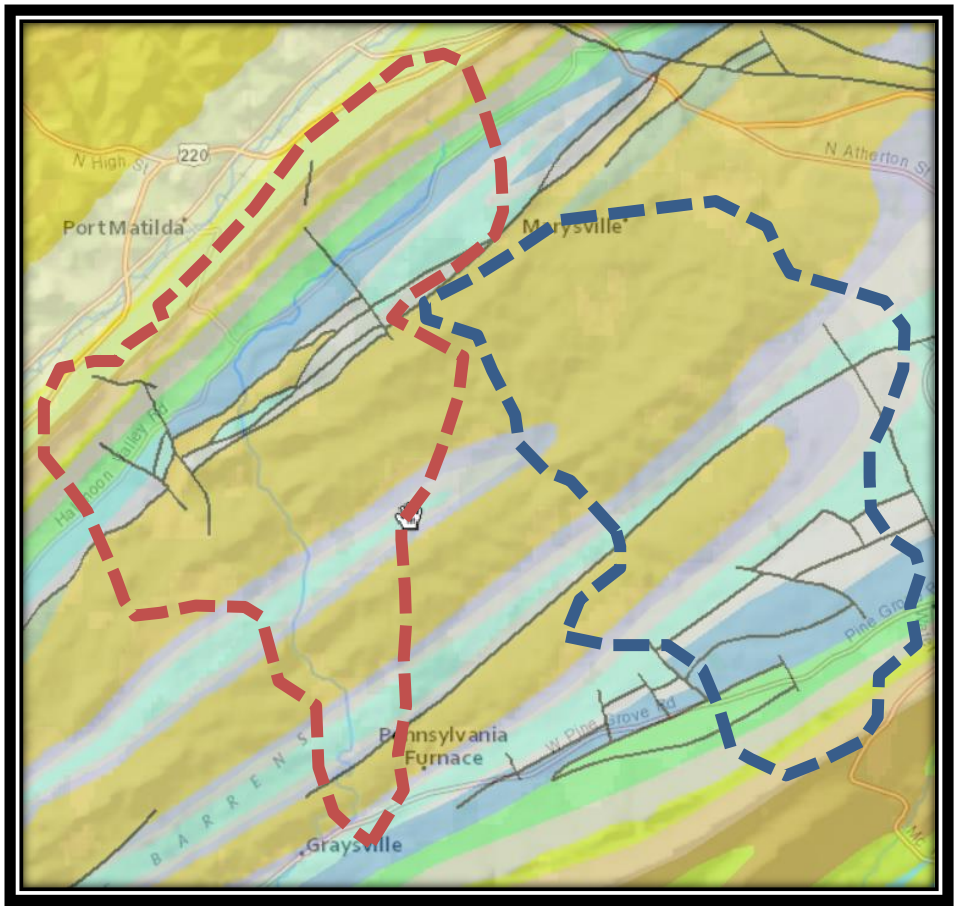


Figure 5a. General geology of Halfmoon Creek and Beaver Branch

The TMDL was completed to address the impairments noted on the ***2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report, Streams, Category 5, Waterbodies, Pollutants Requiring a TMDL*** as required under the Clean Water Act (Table 2.)

Table 2. 2016 Integrated WQ Monitoring & Assessment Report - Impaired Streams List

2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Streams, Category 4a and 5 Waterbodies, Pollutants Requiring a TMDL

Stream Name HUC / Use Assessed (Assessment ID) - Miles / Source	Cause	Date Listed	TMDL Date
Hydrologic Unit Code: 02050302-Upper Juniata			
Halfmoon Creek HUC: 02050302			
Aquatic Life (14113) - 14.12 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 14.12 miles			
Halfmoon Creek Unnamed Of (ID:65602962) HUC: 02050302			
Aquatic Life (14113) - 1.16 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 1.16 miles			
Halfmoon Creek Unnamed Of (ID:65603032) HUC: 02050302			
Aquatic Life (14113) - 0.65 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 0.65 miles			
Halfmoon Creek Unnamed Of (ID:65603072) HUC: 02050302			
Aquatic Life (14113) - 0.5 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 0.5 miles			
Halfmoon Creek Unnamed Of (ID:65603104) HUC: 02050302			
Aquatic Life (14113) - 0.59 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 0.59 miles			
Halfmoon Creek Unnamed Of (ID:65603120) HUC: 02050302			
Aquatic Life (14113) - 1.23 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 1.23 miles			
Halfmoon Creek Unnamed To (ID:65602882) HUC: 02050302			
Aquatic Life (14113) - 0.99 miles			
Agriculture	Siltation	1998	2011
Fish Consumption (15156) - 0.99 miles			

Page 1 of 3

2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Streams, Category 4a and 5 Waterbodies, Pollutants Requiring a TMDL

Stream Name
HUC
Use Assessed (Assessment ID) - Miles
Source | Cause | Date Listed | TMDL Date

Halfmoon Creek Unnamed To (ID:65602886)
HUC: 02050302

Aquatic Life (14113) - 1.06 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 1.06 miles

Halfmoon Creek Unnamed To (ID:65602894)
HUC: 02050302

Aquatic Life (14113) - 1.21 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 1.21 miles

Halfmoon Creek Unnamed To (ID:65602908)
HUC: 02050302

Aquatic Life (14113) - 0.99 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 0.99 miles

Halfmoon Creek Unnamed To (ID:65602920)
HUC: 02050302

Aquatic Life (14113) - 0.58 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 0.58 miles

Halfmoon Creek Unnamed To (ID:65602948)
HUC: 02050302

Aquatic Life (14113) - 1 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 1 miles

Halfmoon Creek Unnamed To (ID:65602956)
HUC: 02050302

Aquatic Life (14113) - 2.8 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 2.8 miles

Halfmoon Creek Unnamed To (ID:65602976)
HUC: 02050302

Aquatic Life (14113) - 0.92 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 0.92 miles

2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Streams, Category 4a and 5 Waterbodies, Pollutants Requiring a TMDL

Stream Name
HUC
Use Assessed (Assessment ID) - Miles
Source | Cause | Date Listed | TMDL Date

Halfmoon Creek Unnamed To (ID:65602996)
HUC: 02050302

Aquatic Life (14113) - 1.18 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 1.18 miles

Halfmoon Creek Unnamed To (ID:65603034)
HUC: 02050302

Aquatic Life (14113) - 2.91 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 2.91 miles

Halfmoon Creek Unnamed To (ID:65603116)
HUC: 02050302

Aquatic Life (14113) - 1.24 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 1.24 miles

Halfmoon Creek Unnamed To (ID:65603144)
HUC: 02050302

Aquatic Life (14113) - 0.89 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 0.89 miles

Halfmoon Creek Unnamed To (ID:65603224)
HUC: 02050302

Aquatic Life (14113) - 1.01 miles
Agriculture | Siltation | 1998 | 2011
Fish Consumption (15156) - 1.01 miles

Clean Water Act Requirements

Section 303(d) of the 1972 Clean Water Act requires states, territories, and authorized tribes to establish water quality standards. The water quality standards identify the uses for each waterbody and the scientific criteria needed to support that use. Uses can include designations for drinking water supply, contact recreation (swimming), and aquatic life support. Minimum goals set by the Clean Water Act require that all waters be "fishable" and "swimmable."

Additionally, the federal Clean Water Act and the United States Environmental Protection Agency's (EPA) implementing regulations (40 CFR 130) require:

- States to develop lists of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);
- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;
- States to submit the list of waters to EPA every two years (April 1 of the even numbered years);
- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and
- EPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

Despite these requirements, states, territories, authorized tribes, and EPA have not developed many TMDLs since 1972. Beginning in 1986, organizations in many states filed lawsuits against EPA for failing to meet the TMDL requirements contained in the federal Clean Water Act and its implementing regulations. While EPA has entered into consent agreements with the plaintiffs in several states, many lawsuits still are pending across the country.

In the cases that have been settled to date, the consent agreements require EPA to backstop TMDL development, track TMDL development, review state monitoring programs, and fund studies on issues of concern (e.g., Abandoned Mine Drainage (AMD), implementation of nonpoint source Best Management Practices (BMPs), etc.).

Pennsylvania Clean Streams Law Requirements and Agricultural Operations

All Pennsylvania farmers are subject to the water quality regulations authorized under the Pennsylvania Clean Streams Law, Title 25 Environmental Protection, and found within Chapters 91-93, 96, 102 and 105. These regulations include topics such as manure management, Concentrated Animal Operations (CAOs), Concentrated Animal Feeding Operations (CAFOs), Pollution Control and Prevention at Agricultural Operations, Water Quality Standards, Water Quality Standards Implementation, Erosion and Sediment Control Requirements, and Dam Safety and Waterway Management. To review these regulations, please refer to http://pacode.com/ or the Pennsylvania Water Quality Action Packet for Agriculture which is supplied by the County Conservation Districts. To find your County Conservation

District's contact information, please refer to http://pacd.org/ or call any DEP office or the Pennsylvania Conservation Districts Headquarters at 717-238-7223.

Integrated WQ Monitoring and Assessment Report, List 5, 303(d), Listing Process

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be listed in the Integrated Water Quality Monitoring and Assessment Report. Prior to 2004 the impaired waters were found on the 303(d) List; from 2004 to present, the 303(d) List was incorporated into the Integrated Water Quality Monitoring and Assessment Report and found on Table 2. Please see Table 3 below for a breakdown of the changes to listing documents and assessment methods through time. Actual Bioassessment Summaries on Halfmoon Creek and McKinley Run start on page 6.

With guidance from EPA, the states have developed methods for assessing the waters within their respective jurisdictions. From 1996-2006, the primary method adopted by the Pennsylvania Department of Environmental Protection for evaluating waters found on the 303(d) lists (1998-2002) or in the Integrated Water Quality Monitoring and Assessment Report (2004-2006) was the Statewide Surface Waters Assessment Protocol (SSWAP). SSWAP was a modification of the EPA Rapid Bioassessment Protocol II (RPB-II) and provided a more consistent approach to assessing Pennsylvania's streams.

The assessment method required selecting representative stream segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selected as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. All the biological surveys included kick-screen sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Benthic macroinvertebrates were identified to the family level in the field.

The listings found in the Integrated Water Quality Monitoring and Assessment Reports from 2008 to present were derived based on the Instream Comprehensive Evaluation protocol (ICE). Like the SSWAP protocol that preceded the ICE protocol, the method requires selecting representative segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the stream segment could vary between sites. All the biological surveys include D-frame kick-net sampling of benthic macroinvertebrates, habitat surveys, and measurements of pH, temperature, conductivity, dissolved oxygen, and alkalinity. Collected samples are returned to the laboratory where the samples are then subsampled to obtain a benthic macroinvertebrate sample of 200 + or – 20% (160 to 240). The benthic macroinvertebrates in this subsample were then identified to the generic level. The ICE protocol is a modification of the EPA Rapid Bioassessment Protocol III (RPB-III) and provides a more rigorous and consistent approach to assessing Pennsylvania's streams than the SSWAP.

After these surveys (SSWAP, 1998-2006 lists or ICE, 2008-present lists) were completed, the biologist determined the status of the stream segment. The decision was based on the performance of the segment using a series of biological metrics. If the stream segment was classified as impaired, it was then listed on the state's 303(d) List or presently the Integrated Water Quality Monitoring and Assessment Repor.t

Once a stream segment is listed as impaired, a TMDL must be developed for it. A TMDL addresses only one pollutant. If a stream segment is impaired by multiple pollutants, all those pollutants receive separate and specific TMDLs within that stream segment. For the TMDL process to be most effective, adjoining stream segments with the same source and impairment causes listing are addressed

Table 3. Impairment Documentation and Assessment Chronology		
Listing Date	Listing Document	Assessment Method
1998	303(d) List	SSWAP
2002	303(d) List	SSWAP
2004	Integrated List	SSWAP
2006	Integrated List	SSWAP
2008-Present	Integrated List	ICE

Integrated List= Integrated Water Quality Monitoring and Assessment Report
SSWAP= Statewide Surface Waters Assessment Protocol ICE= Instream Comprehensive Evaluation Protocol

Basic Steps for Determining a TMDL

Although all watersheds must be handled on a case-by-case basis when developing TMDLs, there are basic processes or steps that apply to all cases. They include:

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculate TMDL for the waterbody using EPA approved methods and computer models;
3. Allocate pollutant loads to various sources;
4. Determine critical and seasonal conditions;
5. Submit draft report for public review and comments; and
6. EPA approval of the TMDL.

TMDL Elements (WLA, LA, MOS)

A TMDL equation consists of a waste load allocation, load allocation and a margin of safety. The waste load allocation (WLA) is the portion of the load assigned to point sources (National Pollutant Discharge Elimination System (NPDES) permitted discharges). The load allocation (LA) is the portion of the load assigned to nonpoint sources (non-permitted). The margin of safety (MOS) is applied to account for uncertainties in the computational process. The MOS may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Future TMDL Modifications

In the future, the Department may adjust the load and/or waste load allocations in this TMDL to account for new information or circumstances that are developed or discovered during the implementation of the TMDL when a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment between the load and waste load allocation will only be made following an opportunity for public participation. A waste load allocation adjustment will be made consistent and

simultaneous with associated permit(s) revision(s)/reissuances (i.e., permits for revision/reissuance in association with a TMDL revision will be made available for public comment concurrent with the related TMDLs availability for public comment). New information generated during TMDL implementation may include among other things, monitoring data, BMP effectiveness information, and land use information. All changes in the TMDL will be tallied and once the total changes exceed 1% of the total original TMDL allowable load, the TMDL will be revised. The adjusted TMDL, including its LAs and WLAs, will be set at a level necessary to implement the applicable water quality standards (WQS) and any adjustment increasing a WLA will be supported by reasonable assurance demonstration that load allocations will be met. The Department will notify EPA of any adjustments to the TMDL within 30 days of its adoption and will maintain current tracking mechanisms that contain accurate loading information for TMDL waters.

Changes in TMDLs That May Require EPA Approval

- Increase in total load capacity.
- Transfer of load between point (WLA) and nonpoint (LA) sources.
- Modification of the margin of safety (MOS).
- Change in water quality standards (WQS).
- Non-attainment of WQS with implementation of the TMDL.
- Allocation transfers in trading programs.

Changes in TMDLs That May Not Require EPA Approval

- Changes among individual WLAs but not the total sum of the WLA with no other changes in the TMDL; TMDL public notice concurrent with permit public notice.
- Removal of a pollutant source that will not be reallocated.
- Reallocation between LAs.
- Changes in land use.

TMDL Endpoints

PA does not currently have water quality criteria for excess siltation, a sediment TMDL endpoint was identified using a reference watershed approach. Therefore, so as, to meet the designated uses of the Halfmoon Creek watershed for attainment and maintenance, for all waterbodies, Pennsylvania utilizes its narrative water quality criteria, which state that:

> *Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life. (25 PA Code Chapter 93.6 (a)); and,*
>
> *In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, odors, turbidity or settle to form deposits. (25 PA Code, Chapter 93.6 (b)).*

Based on a reference watershed approach, a total load capacity (or endpoint) of **2,399,098.4** lbs./yr. of sediment loading in the Halfmoon Creek watershed was determined sufficient in order to be protective of all High Quality water attributes as it is maintained in the reference watershed, Beaver Branch.

Defining Sedimentation

Sedimentation is an essential component of aquatic ecosystems, as it often contains minerals used by many aquatic organisms, and provides habitat. Sedimentation is a natural process that is caused by the weathering of landscape, whereby wind and water erode the surfaces of rocks and soils creating small particles. When these particles enter streams, they may flow with the current (suspended solids), or be deposited on the streambed. Typically, natural inputs of sediment to streams do not cause problems; however, when landscape is modified, excessive amounts of sediment can enter streams or erode from streams and cause undesirable effects (Bryan and Rutherford 1995).

Agricultural practices such as row cropping involve the tilling of landscapes to make the soil porous and fertile, which consequently loosens soil directly, as well as indirectly by removing plants whose roots once held soil in place. During rain events, loosened soil is directed toward nearby streams via overland runoff, and depending upon the density of vegetation along the shoreline, sediment enters into the water. The soil of pasture land is often more stable than that of cropland, yet in-stream sedimentation issues arise from the surface runoff associated with this land use. If the pasture land is grazed, the soil becomes compacted from the constant trampling by livestock, and therefore precipitation leaves the area via surface runoff and enters streams instead of infiltrating into the soil. In addition, because vegetation within pasture land typically has shallow roots and little water retention ability, precipitation that does infiltrate the soil saturates the soil quickly, which consequently reduces absorbance and increases surface runoff. The sudden increase in water volume in a stream raises the velocity of the flow to a point where soil from the stream banks begins to erode into the channel. Runoff volume from this land use is further increased in areas with steep topography, and areas in which cattle have overgrazed the vegetation. In addition to facilitating hydrology-related sedimentation issues, the overgrazing and trampling of vegetation in riparian zones leads to loosened soil that directly enters streams.

Eroded sediment can cause numerous problems for aquatic organisms. Suspended sediment causes turbidity, which can interfere with predation efficiency; cause respiration problems by clogging gills of aquatic organisms (Horne and Goldman 1994); and also reduces sunlight penetration, which affects plant photosynthesis (Waters 1995). Causing a higher magnitude of problems, deposited sediment can 1) suffocate eggs of fish and other organisms, 2) suffocate small organisms, 3) severely reduce habitat and habitat diversity, and 4) alter flow patterns (USEPA 1999).

Selection of the Reference Watershed

The reference watershed approach was used to estimate the appropriate sediment loading reduction necessary to restore healthy aquatic communities to the Halfmoon Creek. This approach is based on selecting a non-impaired, or reference, watershed and estimating its current loading rates for the pollutants of interest. The objective of the process is to reduce loading rates of those pollutants identified as causing impairment to a level equivalent to or lower than the loading rates in the reference watershed.

Achieving the appropriate load reductions should allow the return of a healthy biological community to affected stream segments.

First, there are three factors that should be considered when selecting a suitable reference watershed: impairment status, similarity of physical properties, and size of the watershed. A watershed that the Department has assessed and determined to be attaining water quality standards should be used as the reference. Second, a watershed that closely resembles the impaired watershed in physical properties such as land use/land cover, physiographic province, elevation, slope and geology should be chosen.

Finally, the size of the reference watershed should be within 20-30% of the impaired. The search for a reference watershed that would satisfy the above characteristics was done by means of a desktop screening using several GIS shapefiles, including a watershed layer, geologic formations layer, physiographic province layer, soils layer, Landsat-derived land cover/use grid, and the stream assessment information found on the Department's Instream Comprehensive Evaluation Protocol (ICE) GIS-based website. The suitability of the chosen watershed was confirmed through discussions with Department staff as well as through field verification of conditions.

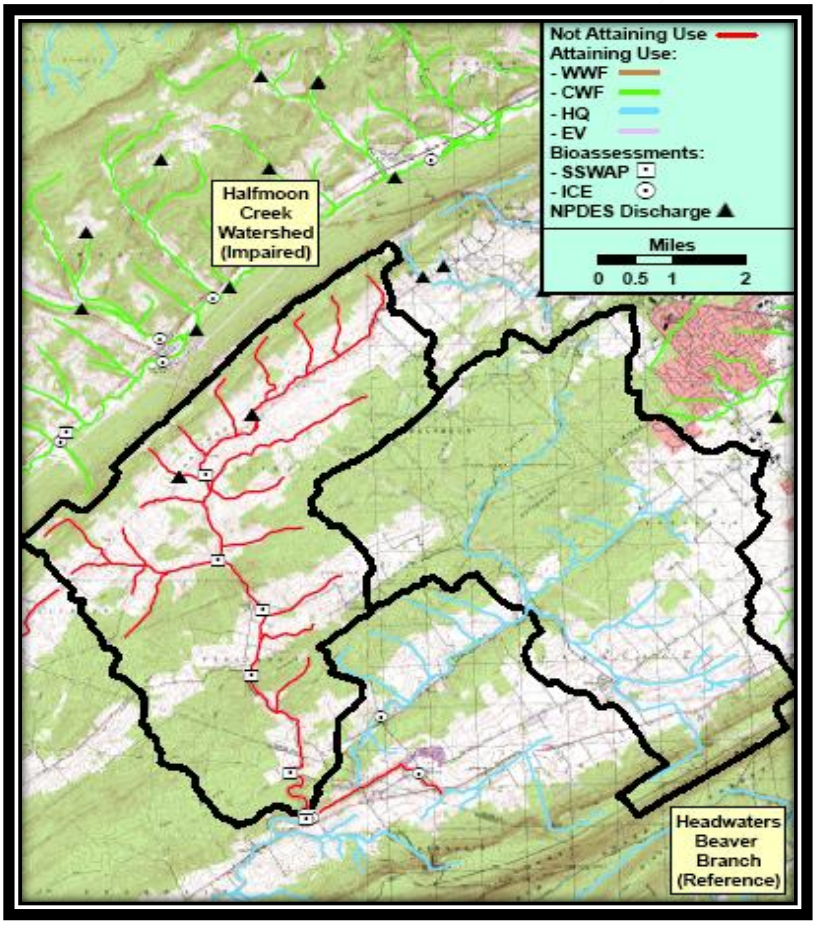
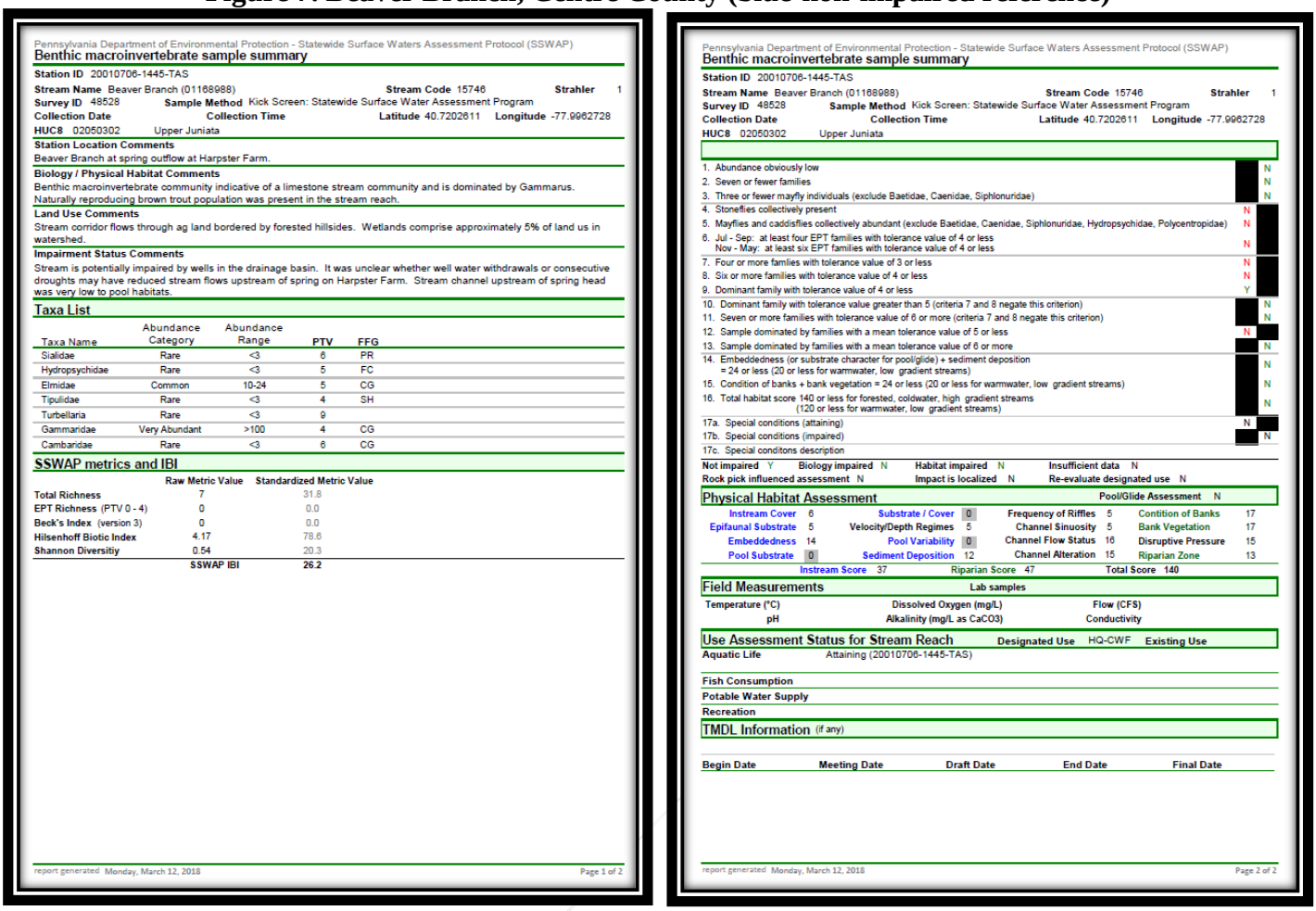


Figure 6. Halfmoon Creek, (red-impaired), and Beaver Branch topographic map

Figure 7. Beaver Branch, Centre County (blue-non-impaired reference)



Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

Station ID 20010706-1445-TAS

Stream Name Beaver Branch (01168988) **Stream Code** 15746 **Strahler** 1
Survey ID 48528 **Sample Method** Kick Screen: Statewide Surface Water Assessment Program
Collection Date **Collection Time** **Latitude** 40.7202611 **Longitude** -77.9962728
HUC8 02050302 Upper Juniata

Station Location Comments
Beaver Branch at spring outflow at Harpster Farm.

Biology / Physical Habitat Comments
Benthic macroinvertebrate community indicative of a limestone stream community and is dominated by Gammarus. Naturally reproducing brown trout population was present in the stream reach.

Land Use Comments
Stream corridor flows through ag land bordered by forested hillsides. Wetlands comprise approximately 5% of land us in watershed.

Impairment Status Comments
Stream is potentially impaired by wells in the drainage basin. It was unclear whether well water withdrawals or consecutive droughts may have reduced stream flows upstream of spring on Harpster Farm. Stream channel upstream of spring head was very low to pool habitats.

Taxa List

Taxa Name	Abundance Category	Abundance Range	PTV	FFG
Sialidae	Rare	<3	6	PR
Hydropsychidae	Rare	<3	5	FC
Elmidae	Common	10-24	5	CG
Tipulidae	Rare	<3	4	SH
Turbellaria	Rare	<3	9	
Gammaridae	Very Abundant	>100	4	CG
Cambaridae	Rare	<3	6	CG

SSWAP metrics and IBI

	Raw Metric Value	Standardized Metric Value
Total Richness	7	31.8
EPT Richness (PTV 0 - 4)	0	0.0
Beck's Index (version 3)	0	0.0
Hilsenhoff Biotic Index	4.17	78.6
Shannon Diversitiy	0.54	20.3
	SSWAP IBI	26.2

report generated Monday, March 12, 2018 Page 1 of 2

Pennsylvania Department of Environmental Protection - Statewide Surface Waters Assessment Protocol (SSWAP)

Benthic macroinvertebrate sample summary

Station ID 20010706-1445-TAS

Stream Name Beaver Branch (01168988) **Stream Code** 15746 **Strahler** 1
Survey ID 48528 **Sample Method** Kick Screen: Statewide Surface Water Assessment Program
Collection Date **Collection Time** **Latitude** 40.7202611 **Longitude** -77.9962728
HUC8 02050302 Upper Juniata

1. Abundance obviously low		N
2. Seven or fewer families		N
3. Three or fewer mayfly individuals (exclude Baetidae, Caenidae, Siphlonuridae)		N
4. Stoneflies collectively present	N	
5. Mayflies and caddisflies collectively abundant (exclude Baetidae, Caenidae, Siphlonuridae, Hydropsychidae, Polycentropidae)	N	
6. Jul - Sep: at least four EPT families with tolerance value of 4 or less Nov - May: at least six EPT families with tolerance value of 4 or less	N	
7. Four or more families with tolerance value of 3 or less	N	
8. Six or more families with tolerance value of 4 or less	N	
9. Dominant family with tolerance value of 4 or less	Y	
10. Dominant family with tolerance value greater than 5 (criteria 7 and 8 negate this criterion)		N
11. Seven or more families with tolerance value of 6 or more (criteria 7 and 8 negate this criterion)		N
12. Sample dominated by families with a mean tolerance value of 5 or less	N	
13. Sample dominated by families with a mean tolerance value of 6 or more		N
14. Embeddedness (or substrate character for pool/glide) + sediment deposition = 24 or less (20 or less for warmwater, low gradient streams)		N
15. Condition of banks + bank vegetation = 24 or less (20 or less for warmwater, low gradient streams)		N
16. Total habitat score 140 or less for forested, coldwater, high gradient streams (120 or less for warmwater, low gradient streams)		N
17a. Special conditions (attaining)	N	
17b. Special conditions (impaired)		N
17c. Special conditons description		

Not impaired Y **Biology impaired** N **Habitat impaired** N **Insufficient data** N
Rock pick influenced assessment N **Impact is localized** N **Re-evaluate designated use** N

Physical Habitat Assessment **Pool/Glide Assessment** N

Instream Cover	6	Substrate / Cover	0	Frequency of Riffles	5	Contition of Banks	17
Epifaunal Substrate	5	Velocity/Depth Regimes	5	Channel Sinuosity	5	Bank Vegetation	17
Embeddedness	14	Pool Variability	0	Channel Flow Status	16	Disruptive Pressure	15
Pool Substrate	0	Sediment Deposition	12	Channel Alteration	15	Riparian Zone	13

Instream Score 37 **Riparian Score** 47 **Total Score** 140

Field Measurements **Lab samples**

Temperature (°C) **Dissolved Oxygen (mg/L)** **Flow (CFS)**
pH **Alkalinity (mg/L as CaCO3)** **Conductivity**

Use Assessment Status for Stream Reach **Designated Use** HQ-CWF **Existing Use**
Aquatic Life Attaining (20010706-1445-TAS)

Fish Consumption
Potable Water Supply
Recreation

TMDL Information (if any)

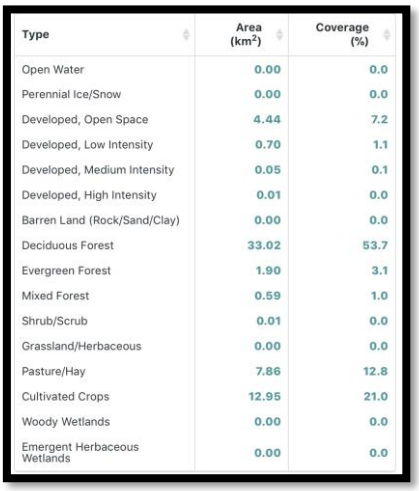
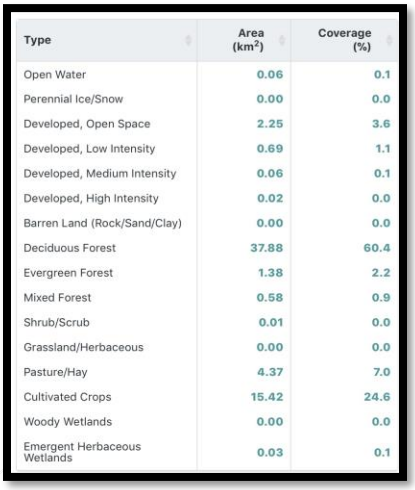
Begin Date	Meeting Date	Draft Date	End Date	Final Date

report generated Monday, March 12, 2018 Page 2 of 2

Beaver Branch were selected as the reference for developing the Halfmoon Creek TMDL. It has a total drainage area of 15,539.0. This watershed is also a HQ-CWF and also part of Spruce Creek and the larger Little Juniata River basin, Centre County. Land use in this watershed is composed of agriculture (31.6%) including croplands and hay/pasture, forestland (62.6%), and development and wetland (5.8%) (Figure 7.). Beaver Branch is also designated as a High Quality, Cold Water Fishery like the Halfmoon Creek, but is attaining its designated aquatic life uses based on biological sampling done by the Department in 2007 (Figure 7. And Table 4.).

Table 4. compares of impaired and reference streams in terms of size, location, and other characteristics.

Table 4. Comparison of Halfmoon Creek(impaired) and Beaver Branch (reference)

	Halfmoon Creek	**Beaver Branch**
Physiographic Province	Ridge and Valley Province (Appalachian Mountain Section)	Ridge and Valley Province (Appalachian Mountain Section)
Area (acres)	15,252.0	15,539.0
Land Use Distribution		
Surface Geology: **Hydric Soils:**	**100% Interbedded Sedimentary** 	**100% Interbedded Sedimentary** 
Average Rainfall (in.) **Average Runoff (in.)**		

Hydrologic / Water Quality Modeling

Part 1. Model Overview & Data Compilation

The core watershed simulation model for the MAPSHED software application is the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker. The original DOS version of the model was re-written in Visual Basic by Evans et al. (2002) to facilitate integration with ArcView, and tested extensively in the U.S. and elsewhere.

The GWLF model provides the ability to simulate runoff and corresponding sediment and total phosphorus (nutrient) loading from a watershed given variable-size source areas (i.e., agricultural, forested, and developed land). It is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment/total phosphorus (nutrient) loads based on the daily water balance accumulated to monthly values.
GWLF is considered to be a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios, but each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but simply aggregates the loads from each source area into a watershed total; in other words, there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

With respect to the major processes simulated, GWLF models surface runoff using the Soil Conservation Service Curve Number, or SCS-CN, approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (i.e., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss erosion (K), the length slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and transport capacity, which is based on average daily runoff, is then applied to the calculated erosion to determine sediment yield for each source area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and

evapotranspiration values. For execution, the model requires two separate input files containing transport and weather-related data. The transport (transport.dat) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The weather (weather.dat) file contains daily average temperature and total precipitation values for each year simulated.

Since its initial incorporation into MAPSHED, the GWLF model has been revised to include a number of routines and functions not found in the original model. For example, a significant revision in one of the earlier versions of MAPSHED was the inclusion of a streambank erosion routine. This routine is based on an approach often used in the field of geomorphology in which monthly streambank erosion is estimated by first calculating a watershed-specific lateral erosion rate (LER). After a value for LER has been computed, the total sediment load generated via streambank erosion is then calculated by multiplying the above erosion rate by the total length of streams in the watershed (in meters), the average streambank height (in meters), and the average soil bulk density (in kg/m3).

The inclusion of the various model enhancements mentioned above has necessitated the need for several more input files than required by the original GWLF model, including a "scenario" (*.scn) file, an animal data (animal.dat) file. Also, given all of the new and recent revisions to the model, it has been renamed "GWLF-E" to differentiate it from the original model.

In utilizing this interface, the user is prompted to load required GIS files and to provide other information related to various "non-spatial" model parameters (e.g., beginning and end of the growing season; the months during which manure is spread on agricultural land, etc.). This information is subsequently used to automatically derive values for required model input parameters which are then written to the appropriate input files needed to execute the GWLF-E model.

Also accessed through the interface are Excel-formatted weather files containing daily temperature and precipitation information. (In the version of MAPSHED used in Pennsylvania, a statewide weather database was developed that contains about twenty-five (25) years of temperature and precipitation data for seventy-eight (78) weather stations around the state). This information is used to create the necessary weather.dat input file for a given watershed simulation.

Part 2. GIS Based Derivation of Input Data

The primary sources of data for this analysis were geographic information system (GIS) formatted databases and shapefiles. In using the MAPSHED interface, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g. beginning and end of growing

season, manure spreading period, etc.). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT and WEATHER.DAT input files needed to execute the GWLF model.

For use in Pennsylvania, MAPSHED has been linked with statewide GIS data layers such as land use/cover, soils, topography and physiography; and includes location-specific default information such as cropping practices. Complete GWLF-formatted weather files are also included for the seventy-eight weather stations around the state. Table 5. lists GIS datasets and shapefiles used for the Halfmoon Creek TMDL calculations via MAPSHED and provides explanations of how they were used for development of the input files for the GWLF model.

Table 5. GIS Datasets

DATASET	DESCRIPTION
county.shp	The county boundaries coverage lists data on conservation practices which provides C and P values in the Universal Soil Loss Equation (USLE).
padem	100-meter digital elevation model; this is used to calculate land slope and slope length.
palumrlc	A satellite image derived land cover grid which is classified into 15 different landcover categories. This dataset provides landcover loading rates for the different categories in the model.
physprov.shp	A shapefile of physiographic provinces. This is used in rainfall erosivity calculations.
smallsheds.shp	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
streams.shp	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
PAgeo	A shapefile of the surface geology used to compare watersheds of similar qualities.
weathersta.shp	Historical weather files for stations around Pennsylvania to simulate flow.
soils.shp	A shapefile providing soil characteristics data. This is used in multiple calculations.
zipcodes.shp	This shapefile provides animal density numbers used in the LER calculation.

In the GWLF model, the nonpoint source load calculated is affected by terrain conditions such as amount of agricultural land, land slope, and inherent soil erodibility. It is also affected by farming practices utilized in the area. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized below:

Areal extent of different land use/cover categories*:* This is calculated directly from a GIS layer of land use/cover.

Curve number: This determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type, and is calculated directly using digital land use/cover and soils layers.

K factor: This factor relates to inherent soil erodibility, and affects the amount of soil erosion taking place on a given unit of land.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, the crops grown and the cultivation practices utilized largely control this factor. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

P factor: This factor is directly related to the conservation practices utilized in agricultural areas. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment that is delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This relates to the amount of water that can be stored in the soil and affects runoff and infiltration. It is calculated using a digital soils layer.

The MAPSHED model was used to establish existing loading conditions for the sediment watersheds of Halfmoon Creek and Beaver Branch. All MAPSHED data and outputs have been attached to this TMDL as Attachment A. Department staff visited the listed watersheds to get a better understanding of existing conditions that might influence the MAPSHED model (2005, 2008, and 2017). The following are general observations (as detailed with photos and descriptions (starting on Figure 8.) of Halfmoon Creek and its non-impaired, HQ reference, Beaver Branch. Special attention was given to what BMPs were implemented in Beaver Branch in comparison with the Halfmoon Creek being that many land uses were relatively similar.

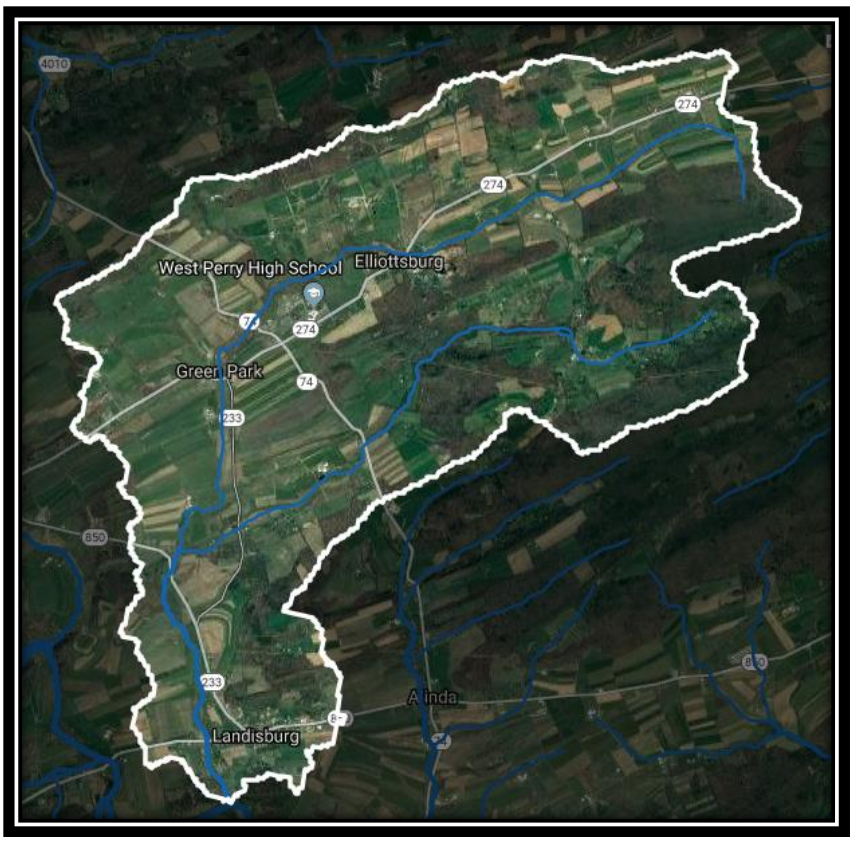


Figure 8. Aerial map, and Figure 9., Map of land use distribution in Halfmoon Creek

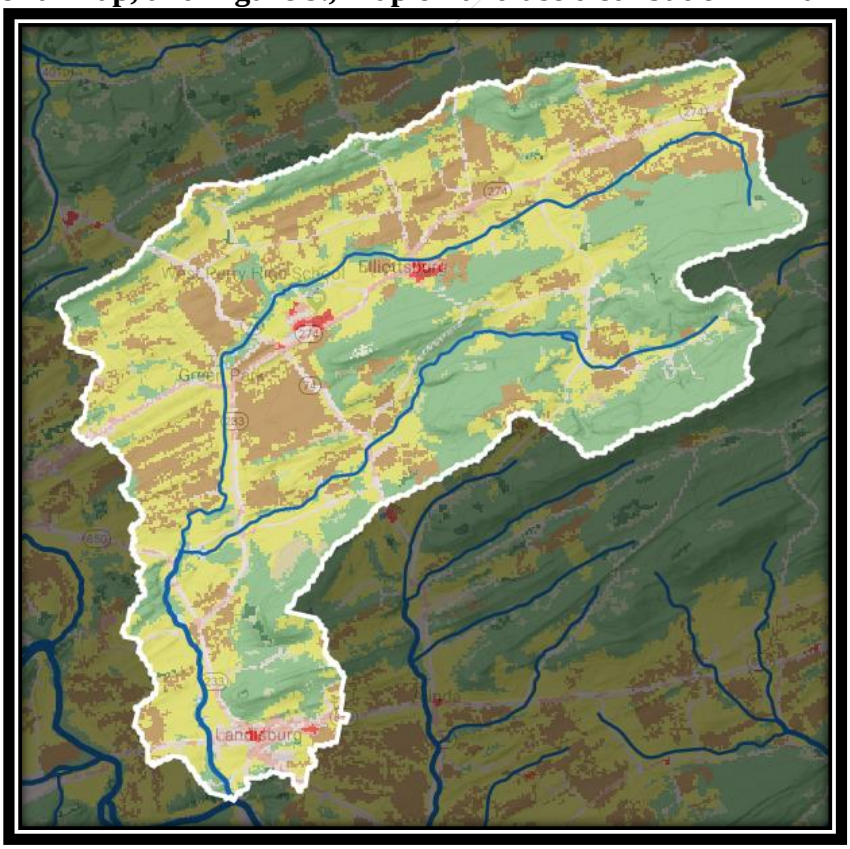
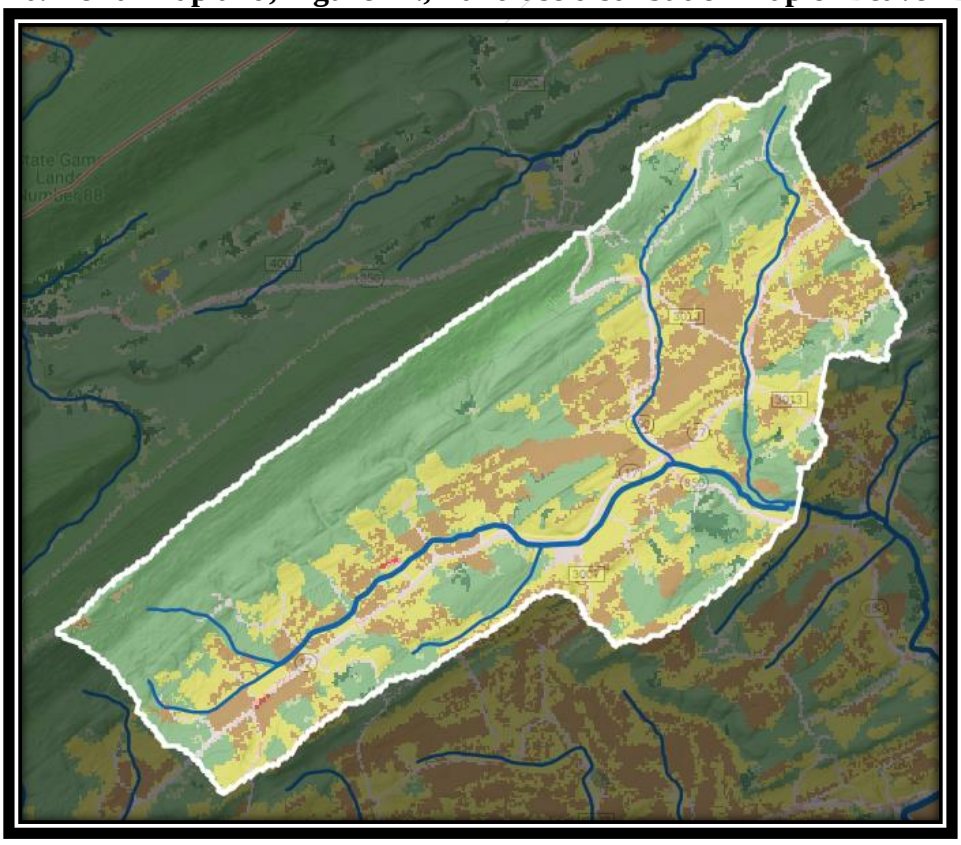


Figure 10. Aerial map and, Figure 11., Land use distribution map of Beaver Branch



To summarize some of the visual comparisons, both the impaired and reference watersheds are similar; however, differences were found that likely explain why streams within the Beaver Branch watershed are not impaired, whereas Halfmoon Creek and its tributaries are. It should be noted that some areas in the Beaver Branch watershed could be improved; however, there are more areas in this watershed that are protective of the streams relative to the Beaver Branch watershed. Because most of the sediment impairments within the Halfmoon Creek watershed arise from within agricultural land, attention was given to such areas that exist within the reference watershed. The two major sedimentation issues in the Halfmoon Creek watershed are 1) direct sediment runoff and stream bank decay resulting from overgrazed and trampled riparian areas, and 2) in-stream erosion caused by accelerated flow resulting from large volumes of overland runoff during rain events.

Table 6. Sediment loads in Halfmoon Creek and Beaver Branch

Pollutant Source	Area (Acres)	Sediment (lbs./yr.)	Area (Acres)	Sediment (lbs./yr.)
Hay/Past	1,948.0	135,200.0	1,084.0	113,400.0
Cropland	3,209.0	2,697,600.0	3,822.0	1,710,200.0
Forest	8,806.0	18,800.0	9,875.0	10,400.0
Wetland	0.0	0.0	8.0	0.0
Low Development	1,275.0	16,800.0	731.0	6,000.0
Medium Develop.	12.0	800.0	15.0	1,000.0
High Develop.	2.0	200.0	5.0	400.0
Stream Bank	-	1,528,400.0	-	603,000.0
Point Sources	-	182.8	-	0.0
TOTAL	**15,252.0**	**4,397,982.8**	**15,540.0**	**2,444,400.0**

For Table 6 the "stream bank" sediment loads are calculated by MAPSHED's stream bank routine. This routine uses stream bank (linear) miles rather than area.

Development of a Sediment TMDL

The target TMDL value for the biologically impaired Halfmoon Creek was established based on current loading rates for sediment in the reference, the Beaver Branch watershed. Reducing the loading rates in Halfmoon Creek to levels equal to, or less than, the reference watershed should allow for the reversal of current use impairments and maintain its HQ aquatic life use value. As described in the previous section, sediment loading rates were computed for the reference stream using the MAPSHED model. The target TMDL value was determined by multiplying the unit area loading rates for the reference stream by the total area of the biologically impaired one (Table 7.).

Table 7. Target TMDL = Reference Loading Rate by Area of Impairment

Pollutant	Loading Rate in Reference (lb./ac-yr.)	Total Area Impaired Watershed (ac)	Target TMDL Value (lb./yr.)
Sediment	**157.3**	**15,252.0**	**2,399,098.4**

The target TMDL value was then used as the basis for load allocations and reductions in Halfmoon Creek, using the following two equations:

1. TMDL = WLA + LA + MOS

2. LA = ALA + LNR. where: TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation (Point Sources),
LA = Load Allocation (Nonpoint Sources)
MOS = Margin of Safety
ALA = Adjusted Load Allocation
LNR = Loads Not Reduced

WASTE LOAD ALLOCATION

A search of the Pennsylvania Department of Environmental Protection's (Department), online, GIS database, EMAP, identified 2 known point source discharges within the Halfmoon Creek (Table 8.). None were in the reference stream, Beaver Branch.

Table 8. NPDES point sources in Halfmoon Creek

		HALFMOON CREEK		TSS	DESIGN	DAILY	YEARLY
				LIMIT	FLOW	LOADING	LOADING
PERMIT TYPE	NPDES PERMITS	PRIMARY FACILITY	OUTFALL	(mg/L)	(MGD)	(lbs./d.)	(lbs./yr.)
SEWAGE-NONPUBLIC	PA0228796	MATTHEW BARR APT	OUTFALL 001	10	0.002	0.2	60.9
SEWAGE-NONPUBLIC	PA0209431	SHROUT THOMAS R RES	OUTFALL 001	20	0.002	0.3	121.8
					TOTAL	0.5	182.8

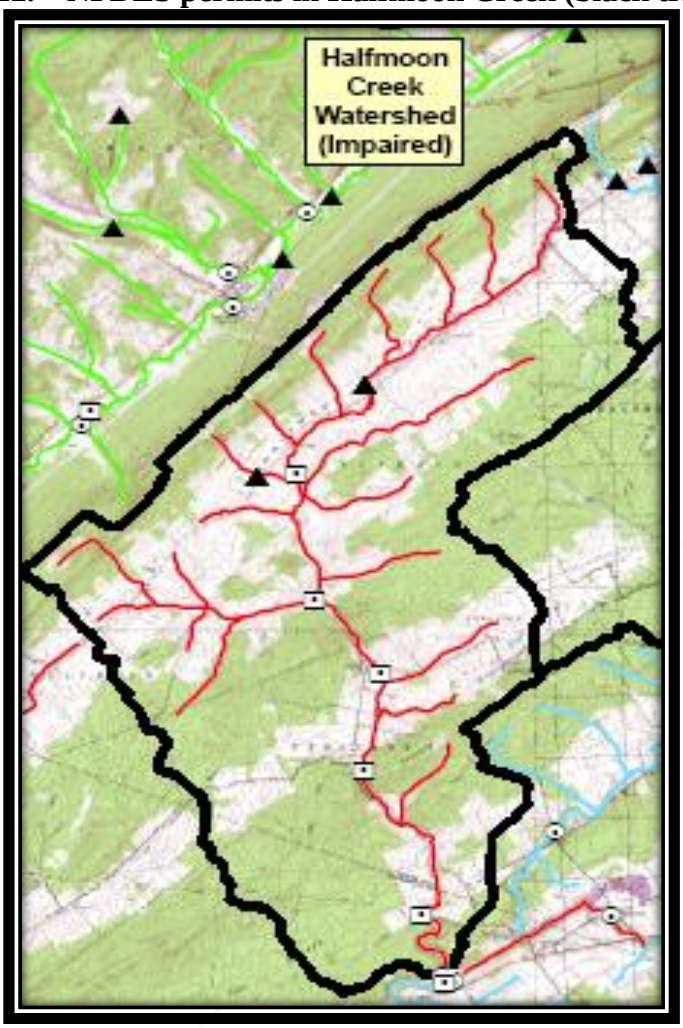
In addition to a waste load allocation (WLA) of the total point source load, 1% of the Sediment TMDL (**2,399,098.4** lbs./yr.) was incorporated as a bulk reserve (**23,991.0** lbs./yr.) for the dynamic nature of future permit activity.

WLA = 2,399,098.4 lbs./yr. (TMDL) x 0.01 (1% Bulk Reserve)

WLA = 23,991.0 lbs./yr. (1% Bulk Reserve) + 182.8 lbs./yr. (Point Sources)

Halfmoon Creek Sediment TMDL
WLA = 24,173.7 lbs./yr. lbs./yr. or 66.2 lbs./day

Figure 12. – NPDES permits in Halfmoon Creek (black triangles)



Margin of Safety

The margin of safety (MOS) is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDL for sediment was reserved as the MOS. Using 10% of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of Halfmoon Creek. The MOS used for the Sediment TMDL was set at 239,909.8 lbs./yr.

Halfmoon Creek Sediment TMDL:
MOS = 2,399,098.4 lbs./yr. (TMDL) * 0.1 = **239,909.8 lbs./yr. or 657.3 lbs./d.**

Load Allocation

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. The LA for the Sediment TMDL was computed by subtracting the MOS value and the WLA from the TMDL value. The LA for Sediment TMDL was set at 2,135,014.8 lbs./yr.

Halfmoon Creek Sediment TMDL:
LA = **2,399,098.4 lbs./yr. (TMDL) – 239,909.8 lbs./yr. (MOS) – 24,173.7 lbs./yr. (WLA)**
= 2,135,014.8 lbs./yr. or 5,849.4 lbs./d.

Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those nonpoint source loads that are not being considered for reductions (loads not reduced (LNR)) from the LA. The Halfmoon Creek TMDLs was developed to address impairments caused by agricultural activities, including hay/pastureland and cropland. Associated stream banks are also considered a contributor to the sediment loading in the watershed. Land uses/source loads not reduced (LNR) were carried through at their existing loading values (Table 9.).

Table 9. Load Allocations, Loads Not Reduced, Adjusted Load Allocations

	Sediment (lbs./yr.)
Load Allocation	**2,135,014.8**
Loads Not Reduced:	**36,600.0**
Forest	18,800.0
Low Development	16,800.0
Med. Development	800.0
High Development	200.0
Adjusted Load Allocation	**2,098,414.8 (5,749.1 lbs./d.)**

TMDL Summary

The sediment TMDLs established for the Halfmoon Creek consists of a Load Allocation (LA) and a Margin of Safety (MOS). The individual components of the Halfmoon Creek TMDLs are summarized in Table 10. Daily expressions of the TMDLs are based on dividing the annual load by 365 days.

Table 10. Components for the Halfmoon Creek TMDL

	Sediment (lbs./yr.)	Sediment (lbs./d.)
TMDL (Total Maximum Daily Load)	**2,399,098.4**	**6,572.9**
WLA (Waste Load Allocation)	**24,173.7**	**66.2**
MOS (Margin of Safety)	**239,909.8**	**657.3**
LA (Load Allocation)	**2,135,014.8**	**5,849.4**
LNR Loads Not Reduced)	**36,600.0**	**100.3**
ALA (Adjusted Load Allocation)	**2,098,414.8**	**5,749.1**

Calculation of Sediment Load Reductions

The adjusted load allocation established in the previous section represents the sediment loads that is available for allocation between agricultural activities (cropland and hay/pastureland) and associated stream banks in Halfmoon Creek. Data needed for load reduction analyses, including land use distribution, were obtained by GIS analysis. The Equal Marginal Percent Reduction (EMPR) allocation method, Attachment B, was used to distribute the ALA between the two land use types and stream banks. The process is summarized below:

1.
2. Each land use/source load is compared with the total allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load to the receiving waterbody. If the contributor exceeds the allocable load, that contributor would be reduced to the allocable load. This is the baseline portion of EMPR. For this evaluation Cropland was in excess of the adjusted load allocation (ALA).

3. After any necessary reductions, have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the total allocable load. If the allocable load is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed. For this evaluation, the allocable load was exceeded. The equal percent reduction, i.e., the **ALA divided by the summation of the baselines, worked out to a reduction in the overall**, sediment loading to **51.9%**.

Table 11. (Annual Values) and Table 12. (Daily Values) contain the results of the EMPR in sediment loading for the respective land use in the Halfmoon Creek. The load allocation for each land use is shown along with the percent reduction of current loads necessary to reach the targeted LA.

Table 11. Sediment Load Allocations/Reductions for Land Uses and Stream Banks In the Halfmoon Creek (Annual Values)

Pollutant Source	Current Loading Rate (lbs./yr./acre)	Allowable Loading Rate (lbs. /yr./acre)	Current Load (lbs./yr.)	Allowable Load (lbs. /yr.)	Percent Load Reduction
Cropland	840.6	364.8	2,697,600.0	1,170,475.1	**56.6%**
Hay/Pasture	69.4	38.7	135,200.0	75,413.2	**44.2%**
Stream bank	-	-	1,528,400.0	852,526.5	**44.2%**

Table 12. Sediment Load Allocations/Reductions for Land Uses and Stream Banks In the Halfmoon Creek (Daily Values)

Pollutant Source	Current Loading Rate (lbs./d./acre)	Allowable Loading Rate (lbs. /d./acre)	Current Load (lbs./d.)	Allowable Load (lbs. /d.)	Percent Load Reduction
Cropland	2.3	1.0	7,390.7	3,206.8	**56.6%**
Hay/Pasture	0.2	0.1	370.4	206.6	**44.2%**
Stream bank	-	-	4,187.4	2,335.7	**44.2%**

Consideration of Critical Conditions

The MAPSHED model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance accumulated in monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the waterbody.

Consideration of Seasonal Variations

The continuous simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions by the model accounts for seasonal variability.

Consideration of Background Contributions

The MAPSHED model accounts for all land uses within the watershed and their respective contributions to the sediment load. The only background sources of sediment loading within the watershed would be from forested areas. There are no additional "upstream" these non-point sources to this watershed. The remaining land uses are anthropogenic sources of sediment loading to the watershed, thus will not be considered background.

Recommendations

Sediment reductions in the TMDL are allocated to nonpoint sources in the watershed including: agricultural activities, transitional lands and stream banks. Implementation of best management practices (BMPs) in these affected areas are called for according to this TMDL document. The proper implementation of these BMPs should achieve the loading reduction goals established in the TMDL.

From an agricultural perspective, reductions in the amount of sediment reaching the streams in the watershed can be made through the right combination of BMPs including, but not limited to: establishment of cover crops, strip cropping, residue management, no till, crop rotation, contour farming, terracing, stabilizing heavy use areas and proper management of storm water. Vegetated or forested buffers are acceptable BMPs to intercept any runoff from farm fields. For the pasturing of farm animals and animal heavy use areas, acceptable BMPs may include: manure storage, rotational grazing, livestock exclusion fencing and forested riparian buffers. Some of these BMPs were observed in the biologically impaired Halfmoon Creek; however, they were more extensively used in the unimpaired, reference Beaver Branch watershed, with forested riparian buffers being the predominant BMP in use. Since both watersheds have a considerable amount of agricultural activities, it is apparent that the greater use of BMPs, especially forested riparian buffers, in the reference watershed has contributed to its ability to maintain its attainment status as a HQ stream.

Stream banks contribute to the sediment load and phosphorus loading (nutrient) in Halfmoon Creek. Stream bank stabilization projects would be acceptable BMPs for the eroded stream banks in the area. However, the establishment of forested riparian buffers is the most economical and effective BMP at providing stream bank stabilization and protection of the banks from freeze/thaw erosion and scouring flows. Forested riparian buffers are also essential to maintaining the biologically rich yet sensitive HQ habitat. Forested riparian buffers also provide important natural and durable connectivity of land and water. This connectivity is necessary to provide cover, nesting and nursery sites, shade and stable temperatures, and viable substrate for aquatic organisms of all layers of the food web protected under the HQ use designation.

Important to TMDLs, established forested riparian buffers act as sediment loading sinks. This is because the highly active and concentrated biological communities they maintain will assimilate and remove sediment loading from the water column instead of allowing them to pass downstream, thus forested riparian buffers work directly toward attaining the goals of the TMDL by reducing pollutant loads. These forested riparian buffers also provide the essential conditions necessary to meet the HQ designated use of the waterway. Forested riparian buffers also provide critical habitat to rare and sensitive amphibious and terrestrial organisms as well as migratory species. While forested riparian buffers are considered the most effective BMP, other possibilities for attaining the desired reductions may exist for the agricultural usages, as well as for the stream banks.

Funding Sources

The Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act) is one funding source for nonpoint source pollution reduction BMPs, such as those described above. This grant program provides funding to assist in implementing Pennsylvania's Nonpoint Source Management Program. This includes funding for abandoned mine drainage, agricultural and urban run-off, and natural channel design/stream bank stabilization projects. Information on Pennsylvania's Nonpoint Source Management Program can be found at: http://www.portal.state.pa.us/portal/server.pt/community/nonpoint_source_management/10615

As mentioned before, a second funding source is Pennsylvania's Growing Greener Watershed Grants, which provides nearly $547 million in funding to clean up non-point sources of pollution throughout Pennsylvania. The grants were established by the Environmental Stewardship and Watershed Protection Act.
Information on Pennsylvania's Growing Greener Watershed Grants can be found at:
http://www.depweb.state.pa.us/portal/server.pt/community/growing_greener/13958
Information on these and other programs and additional funding sources can be found at:
http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Grants/GrantLoans

Public Participation

Public notice of the TMDL will be published in the Pennsylvania Bulletin on May 26, 2018 to foster public comment on the allowable loads calculated. A 30-day period will be provided for the submittal of comments and notice. Any public contribution will be placed in the Comments and Response, Section B, Pg. 43.

References

USDA (United States Department of Agriculture). 1981. Soil Survey of Allegheny County, Pennsylvania. National Cooperative Soil Survey. 93 pp.

USEPA (United States Environmental Protection Agency). 1992. TMDL case study: Sycamore Creek, Michigan. EPA841-F-92-012. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, DC

USEPA (United States Environmental Protection Agency). 1999a. Protocol for developing nutrient TMDLS. EPA841-B-99-007. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, DC.

USEPA (United States Environmental Protection Agency). 1999b. Protocol for developing sediment TMDLS. EPA841-B-99-004. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, DC.

Byran, C.F. and D.A. Rutherford. 1995. Impacts of warm water streams: Guidelines for evaluation (2nd Edition). Southern Division, American Fisheries Society, Little Rock, Arkansas. 285 pp.

Evans, B.M and K.J. Corradini. 2001 (In Review). BMP pollution reduction guidance document. Environmental Resources Research Institute, Pennsylvania State University, PA. 15 pp.

Horne, A.J. and C.R. Goldman. 1994. Limnology (2nd Edition). McGraw-Hill Inc, New York, New York. 576 pp.

Novotny, Vladimir. 2003. Water quality, diffuse pollution and watershed management. Second Edition. John Wiley & Sons, Inc, New York, New York. 424 p.

Attachment A.

Equal Marginal Percent Reduction Method

Equal Marginal Percent Reduction (EMPR) (An Allocation Strategy)

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) among the appropriate contributing non-point sources. The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix E. The 5 major steps identified in the spreadsheet are summarized below:

Step 1: Calculation of the TMDL based on impaired watershed size and unit area loading rate of reference watershed.

Step 2: Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

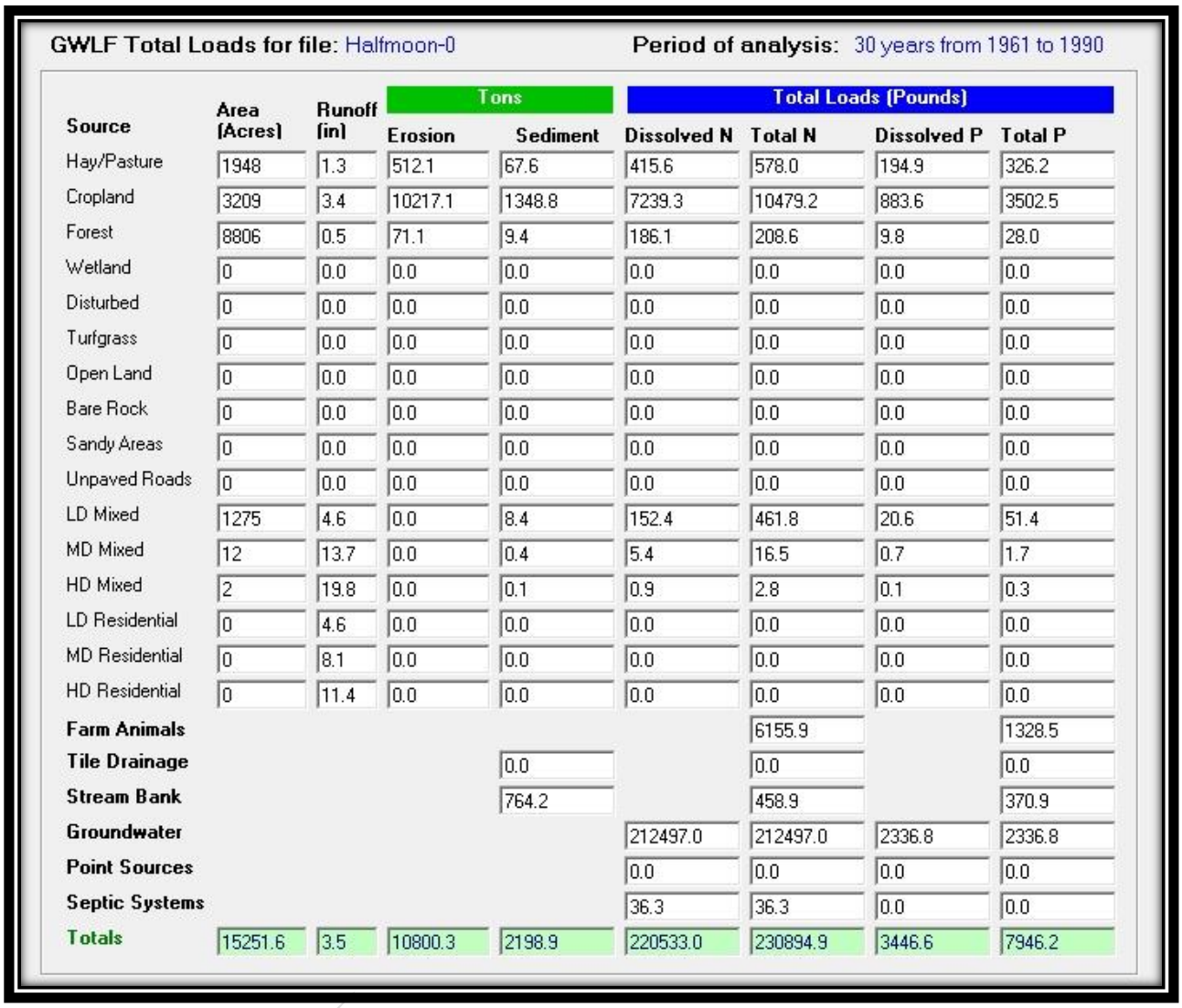
Step 3: Actual EMPR Process.

1. a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving water-body. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of EMPR.
2. b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

Step 4: Calculation of total loading rate of all sources receiving reductions.

Step 5: Summary of existing loads, final load allocations, and % reduction for each pollutant source.

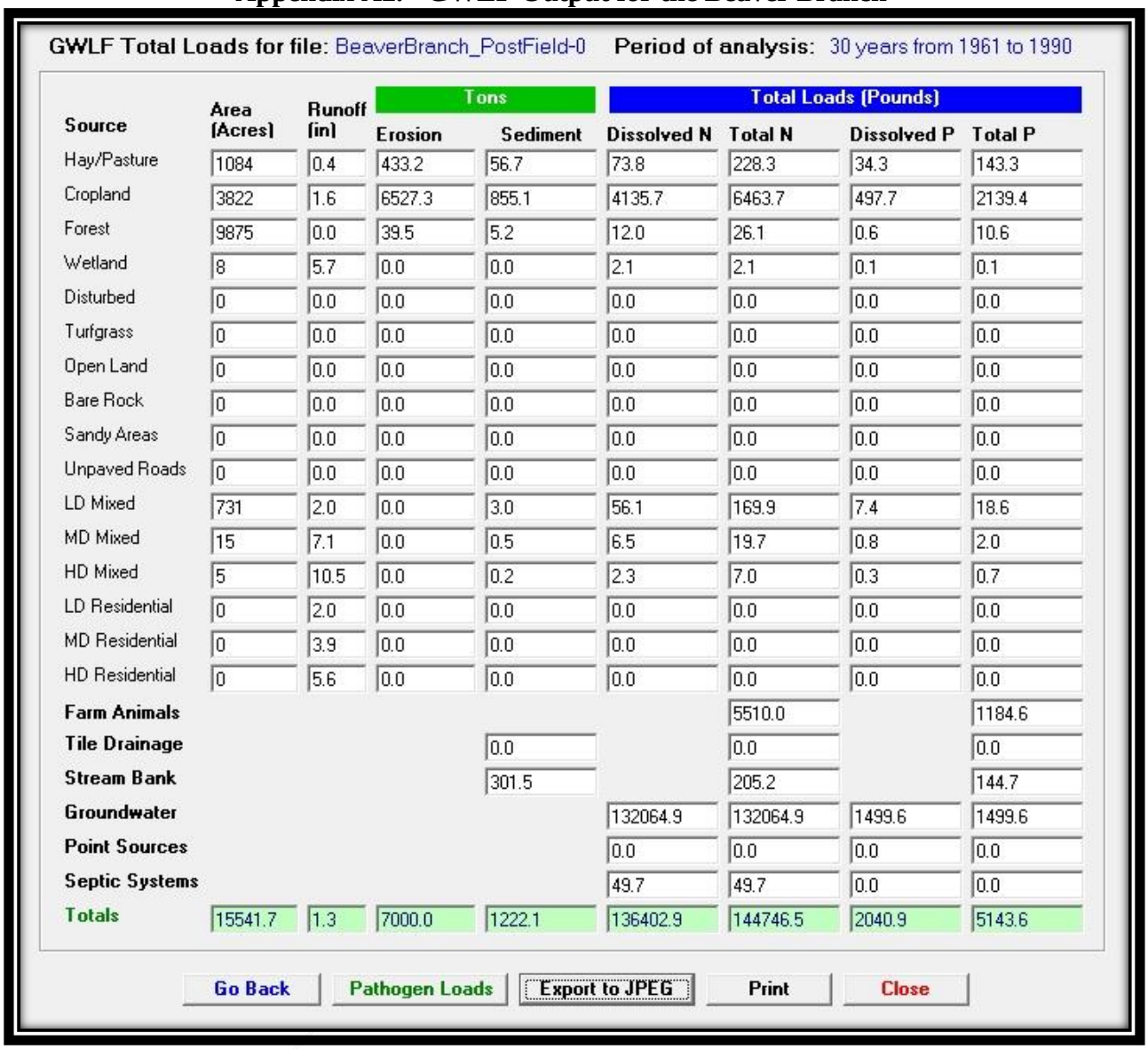
Appendix A1. - GWLF Output for the Halfmoon Creek



GWLF Total Loads for file: Halfmoon-0 **Period of analysis:** 30 years from 1961 to 1990

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	1948	1.3	512.1	67.6	415.6	578.0	194.9	326.2
Cropland	3209	3.4	10217.1	1348.8	7239.3	10479.2	883.6	3502.5
Forest	8806	0.5	71.1	9.4	186.1	208.6	9.8	28.0
Wetland	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disturbed	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turfgrass	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Land	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LD Mixed	1275	4.6	0.0	8.4	152.4	461.8	20.6	51.4
MD Mixed	12	13.7	0.0	0.4	5.4	16.5	0.7	1.7
HD Mixed	2	19.8	0.0	0.1	0.9	2.8	0.1	0.3
LD Residential	0	4.6	0.0	0.0	0.0	0.0	0.0	0.0
MD Residential	0	8.1	0.0	0.0	0.0	0.0	0.0	0.0
HD Residential	0	11.4	0.0	0.0	0.0	0.0	0.0	0.0
Farm Animals						6155.9		1328.5
Tile Drainage				0.0		0.0		0.0
Stream Bank				764.2		458.9		370.9
Groundwater					212497.0	212497.0	2336.8	2336.8
Point Sources					0.0	0.0	0.0	0.0
Septic Systems					36.3	36.3	0.0	0.0
Totals	15251.6	3.5	10800.3	2198.9	220533.0	230894.9	3446.6	7946.2

Appendix A2. - GWLF Output for the Beaver Branch



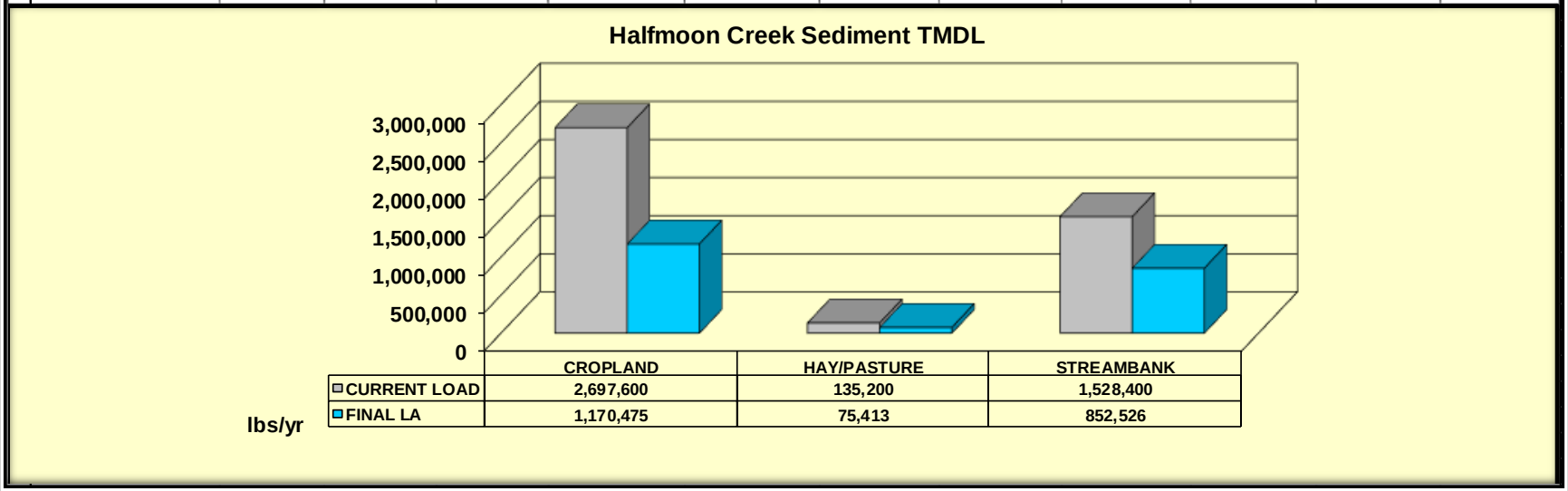
GWLF Total Loads for file: BeaverBranch_PostField-0 Period of analysis: 30 years from 1961 to 1990

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	1084	0.4	433.2	56.7	73.8	228.3	34.3	143.3
Cropland	3822	1.6	6527.3	855.1	4135.7	6463.7	497.7	2139.4
Forest	9875	0.0	39.5	5.2	12.0	26.1	0.6	10.6
Wetland	8	5.7	0.0	0.0	2.1	2.1	0.1	0.1
Disturbed	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turfgrass	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Land	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LD Mixed	731	2.0	0.0	3.0	56.1	169.9	7.4	18.6
MD Mixed	15	7.1	0.0	0.5	6.5	19.7	0.8	2.0
HD Mixed	5	10.5	0.0	0.2	2.3	7.0	0.3	0.7
LD Residential	0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
MD Residential	0	3.9	0.0	0.0	0.0	0.0	0.0	0.0
HD Residential	0	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Farm Animals						5510.0		1184.6
Tile Drainage				0.0		0.0		0.0
Stream Bank				301.5		205.2		144.7
Groundwater					132064.9	132064.9	1499.6	1499.6
Point Sources					0.0	0.0	0.0	0.0
Septic Systems					49.7	49.7	0.0	0.0
Totals	15541.7	1.3	7000.0	1222.1	136402.9	144746.5	2040.9	5143.6

Go Back | Pathogen Loads | Export to JPEG | Print | Close

Appendix A3 - Equal Marginal Percent Reduction Calculations for Halfmoon Creek for Sediment Loading

1	TMDL				2	Adjusted LA = TMDL total load - ((MOS) - loads not reduced)						
	TMDL = Sediment loading rate in ref. * Impaired Acres					2098414.8	2098414.8					
	2399098.4											
		Annual				Recheck	% reduction	Load			Allowable	%
3		Avg. Load	Load Sum	Check	Initial Adjust	Adjust	allocation	Reduction	Initial LA	Acres	Loading Rate	Reduction
	CROPLAND	2697600.0	4361200.0	bad	2098414.8		0.6	927939.7	1170475.1	3209.0	364.7	56.6%
	HAY/PASTURE	135200.0		good	135200.0	1663600.0	0.0	59786.8	75413.2	1948.0	38.7	44.2%
	STREAMBANK	1528400.0		good	1528400.0		0.4	675873.5	852526.5			44.2%
					3762014.8		1.0		2098414.8			
4	All Ag. Loading Rate	241.59										
			Allowable		Current	Current						
		Acres	loading rate	Final LA	Loading Rate	Load	% Red.		CURRENT LOAD		FINAL LA	
5	CROPLAND	3209.0	364.7	1170475.1	840.6	2697600.0	56.6%		CROPLAND	2,697,600	1,170,475	
	HAY/PASTURE	1948.0	38.7	75413.2	69.4	135200.0	44.2%		HAY/PASTURE	135,200	75,413	
	STREAMBANK			852526.5		1528400.0	44.2%		STREAMBANK	1,528,400	852,526	
				2098414.8		4361200.0	51.9%					



Attachment B.

Comment and Response

Any public notice contribution for the Halfmoon Creek Sediment TMDL will be placed in this section upon completion of the 30-day comment period after May 26, 2018.