Appendix A – Watershed Modeling Technical Data

An overview of the process that was used to complete the hydrologic modeling in preparation of this Plan is presented in *Section 6 – Technical Analysis* of this report. The following technical data is included here to supplement the general information provided in that section.

DATA COLLECTION

The GIS data for the hydrologic models was compiled from a variety of sources by county, state, and federal agencies. The data was collected in and processed using GIS software. A description of GIS data collected, the source and its use is provided in *Table A.1*.

Data	Source	Use
10-m Digital Elevation Model (DEMs)	USGS (2008a)	Watershed delineation, length, basin slope, stream slope, average elevation
High Resolution Streamlines	USGS (2008b)	Watershed delineation, cartography, spatial orientation
National Land Cover Dataset – Land Use 2001	USGS (2008c)	Curve number generation for watershed subareas outside of County
2010 Land Use for Butler County	Southwestern Planning Commission	Curve number generation for watershed subareas inside of County for year 2010
2010 Land Use for Butler County (digitized by HRG from redlines)	Butler County Planning Department	Curve number generation for watershed subareas inside of County for year 2020
SURRGO Soils Data	NRCS (2008)	Curve number generation; analysis of infiltration limitations
Storage (percent of lakes, ponds, and wetlands)	USGS (2008d)	Calculation of parameters for USGS Regression Equations
Roadway Data	PennDOT (2009)	Cartography, spatial orientation

Table A.1. GIS Data Used in Act 167 Technical Analysis

HYDROLOGIC MODEL PARAMETER DATA

SOILS, LAND USE, AND CURVE NUMBERS

The determination of curve numbers is a function of soil type and land use. The hydrologic soil groups were defined by NRCS (2008). The 2001 NLCD was simplified to provide an estimate of curve numbers using the scheme shown in *Table A.2*.

GIS Value	NLCD (2001) Description	NRCS (1986) Description	A	B	C	D
11	Open Water	Water	98	98	98	98
21	Developed, Open Space	Open space	39	61	74	80
22	Developed, Low Intensity	Residential - 1 acre	51	68	79	84
23	Developed, Medium Intensity	Residential - 1/2 acre	54	70	80	85
24	Developed, High Intensity	Commercial and Business	89	92	94	95
31	Barren Land (Rock/Sand/Clay)	Newly graded areas	77	86	91	94
41	Deciduous Forest	Woods	30	55	70	77
42	Evergreen Forest	Woods	30	55	70	77
43	Mixed Forest	Woods	30	55	70	77
52	Shrub/Scrub	Brush	30	48	65	73
71	Grassland/Herbaceous	Meadow	30	58	71	78
81	Pasture/Hay	Pasture	39	61	74	80
82	Cultivated Crops	Contoured Row Crops	65	75	82	86
90	Woody Wetlands	Woods	30	55	70	77
95	Emergent Herbaceous Wetlands	Water	98	98	98	98
111	Residential-High Density	Residential - 1/8 acre or less	77	85	90	92
112	Residential-Med Density	Residential - 1/2 acre	54	70	80	85
113	Residential-Med Low Density	Residential - 1/2 acre	54	70	80	85
114	Residential-Low Density Rural	Residential - 1 acre	51	68	79	84
115	Residential-Large Yard	Residential - 1 acre	51	68	79	84
121	Commercial-CBD	Commercial and Business	89	92	94	95
122	Commercial-Strip	Commercial and Business	89	92	94	95
123	Commercial-Commercial and Services	Commercial and Business	89	92	94	95
131	Industrial-Manufacturing	Industrial	81	88	91	93
132	Industrial-Chemical	Industrial	81	88	91	93
133	Industrial-Industrial	Industrial	81	88	91	93
141	Transportation-Major Highways	Industrial	81	88	91	93
142	Transportation-Railroads	Industrial	81	88	91	93
143	Transportation-Airports	Industrial	81	88	91	93
144	Transportation-Docking Ports	Industrial	81	88	91	93
145	Transportation-Dams	Industrial	81	88	91	93
146	Transportation-Substation	Industrial	81	88	91	93
147	Transportation-Powerline Pipeline right of Ways	Industrial	81	88	91	93
148	Transportation-Water Sewage Treatment	Industrial	81	88	91	93
149	Transportation-Water Communication Tower	Industrial	81	88	91	93
151	Industrial and Commercial Complexes-Industrial Complex	Industrial	81	88	91	93
152	Industrial and Commercial Complexes-Mall	Industrial	81	88	91	93
153	Industrial and Commercial Complexes-Business Complex	Industrial	81	88	91	93

Notes: All TR-55 land use designations assumed good condition (e.g., woods in conditions)

Table A.2. Curve Number Determination for each Hydrologic Soil Group for Butler County

GIS Value	NLCD (2001) Description	NRCS (1986) Description	A	B	C	D
161	Mixed Urban or Built-Up-Mixed Urban	Mixed Urban (assumed 65% impervious)	77	85	90	92
171	Other Urban Built-Up-Open Spaces	Open space	39	61	74	80
172	Other Urban Built-Up-Parks Recreation	Open space	39	61	74	80
173	Other Urban Built-Up-Golf Courses	Open space	39	61	74	80
174	Other Urban Built-Up-Ski Areas	Open space	39	61	74	80
175	Other Urban Built-Up-Institutional	Institutional (assumed 50% impervious)	69	80	86	89
176	Other Urban Built-Up-Historic Sites Regions	Open space	39	61	74	80
177	Other Urban Built-Up-Cemeteries	Open space	39	61	74	80
178	Other Urban Built-Up-Vegetated Buffer	Open space	39	61	74	80
179	Other Urban Built-Up-Non Vegetated Buffer	Open space	39	61	74	80
211	Crop Pasture Orchards Groves-Row Crops	Contoured Row Crops	65	75	82	86
212	Crop Pasture Orchards Groves-Fallow Fields	Pasture	39	61	74	80
213	Crop Pasture Orchards Groves-Orchards Groves	Contoured Row Crops	65	75	82	86
214	Crop Pasture Orchards Groves-Pasture	Pasture	39	61	74	80
215	Crop Pasture Orchards Groves-Vineyards	Contoured Row Crops	65	75	82	86
216	Crop Pasture Orchards Groves-Nurseries	Contoured Row Crops	65	75	82	86
217	Crop Pasture Orchards Groves-Farmstead	Pasture	39	61	74	80
311	Mixed Rangeland-Sparse Tree Crown	Meadow	30	58	71	78
312	Mixed Rangeland-Shrub Brush	Meadow	30	58	71	78
313	Mixed Rangeland-Mixed Rangeland	Meadow	30	58	71	78
431	Mixed Forest-Deciduous	Woods	30	55	70	77
432	Mixed Forest-Coniferous Evergreen	Woods	30	55	70	77
433	Mixed Forest-Mixed Forest	Woods	30	55	70	77
511	Rivers Streams Canals-Rivers	Water	98	98	98	98
512	Rivers Streams Canals-Streams	Water	98	98	98	98
513	Rivers Streams Canals-Canals	Water	98	98	98	98
531	Reservoirs Ponds-Reservoirs	Water	98	98	98	98
532	Reservoirs Ponds-Ponds	Water	98	98	98	98
533	Reservoirs Ponds-Lake	Water	98	98	98	98
751	Extraction-Strip Mines	Newly graded areas	77	86	91	94
752	Extraction-Slag Piles	Newly graded areas	77	86	91	94
753	Extraction-Quarries	Newly graded areas	77	86	91	94
754	Extraction-Gravel Pitts	Newly graded areas	77	86	91	94
761	Transitional-Construction	Newly graded areas	77	86	91	94
762	Transitional-Transitional Cleared	Newly graded areas	77	86	91	94
771	Mixed Barren-Mixed Barren	Newly graded areas	77	86	91	94

Notes: All TR-55 land use designations assumed good condition (e.g., woods in conditions)

Table A.2 (continued). Curve Number Determination for each Hydrologic Soil Group for Butler County

The curve numbers presented in the above tables represent "average" antecedent runoff condition (i.e. ARC = 2). In a significant hydrologic event, runoff is often influenced by external factors such as extremely dry antecedent runoff conditions (ARC=1) or wet antecedent runoff conditions (ARC=3). The antecedent runoff conditions of the above curve numbers were altered during the calibration process so that model results are within a reasonable range of other hydrologic estimates.

INFILTRATION AND HYDROLOGIC LOSS ESTIMATES

Infiltration and all other hydrologic loss estimates (e.g., evapotranspiration, percolation, depression storage, etc.) taken into account within the HEC-HMS model was consistent with the recharge volume criteria contained in Control Guidance 1 and 2 (CG-1 and CG-2). These losses were modeled in existing conditions as the standard initial abstraction in the NRCS Curve Number Runoff method (i.e., $I_a = 0.2S$). CG1 was simulated by modifying the standard initial abstraction using the following procedure.

The runoff volume is computed by HEC-HMS using the following equation:

$$Q_{volume} = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where P = rainfall for a specific storm event (in),
I_a = initial abstraction (in), and
S = maximum retention (in).

S is defined by the following equation which relates runoff volume to curve number:

$$S = \frac{1000}{CN} - 10$$

The standard initial abstraction I_a used in Pennsylvania is typically $0.2S$. HEC-HMS calculates this automatically if no value is entered by the user. This was the approach used for the existing and future conditions modeling scenarios.

In future conditions with implementation of CG-1, the following equation is applicable. The goal of CG-1 is to ensure there is no discharge volume increase for the 2-year storm event, so

$$Q_{CG1} = Q_{Existing} = \frac{(P - I_a)^2}{(P - I_a) + S_{Proposed}}$$

Where P = rainfall for a specific storm event(in),
I_a = initial abstraction (in), and
$S_{Proposed}$ = maximum retention in proposed conditions as a function of the proposed conditions curve number (in).

Assuming $I_a = 0.2S$ as the Initial abstraction is no longer applicable with CG-1 since BMPs are to be installed to control or remove the increase in runoff volume for the 2-year storm. Using the

HEC-HMS modeling output for $Q_{Existing}$, the initial abstraction for CG-1 may be calculated using the following equation:

$$I_a = P_{2-year} - \frac{1}{2}(Q_{Existing} \pm \sqrt{Q^2_{Existing} + 4Q_{Existing}S_{Proposed}}) \text{ for the 2-year event}$$

Thus, the volume control required by CG-1 is implicitly modeled by overriding the HEC-HMS default for initial abstraction with the above value. The qualitative effect of this will be to eliminate the increase in runoff volume for the 2-year storm and to reduce the increase in runoff volume of the more extreme events. Increases in the peak flow values are reduced for all storms, but not eliminated, since the time of concentrations for proposed condition are decreased. Figure C.1 shows the effects of implementing a CG-1 policy on an example watershed. In the first figure representing a 2-year storm event, the hydrograph volumes are exactly the same and the peaks are similar. In the second figure representing a 100-year storm event, the hydrograph volumes are not the same since only the 2-year volume is abstracted; consequently there is still a substantial increase in peak flows, although the CG-1 implementation does reduce the peak flow.

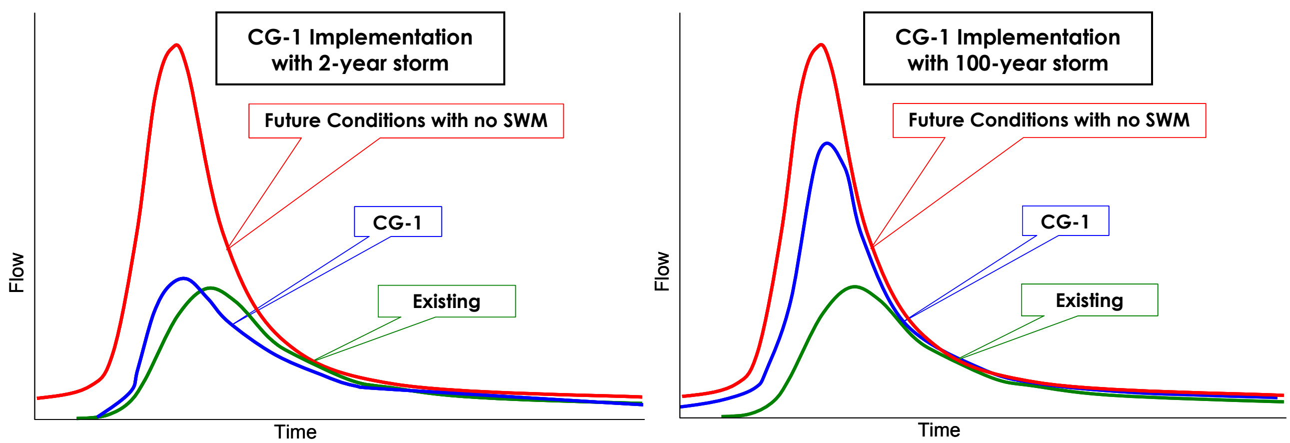

Figure A.1. Typical On-Site Runoff Control Strategy

In the case of this particular sample, release rates might be necessary to prevent increases in peak flow. In situations where there is only a small increase in impervious coverage, however, CG-1 may reduce the proposed conditions peak flow to existing conditions levels without the use of release rates.

For the 2-year event, modeling CG-1 with the above equations results in an increased approximation in initial abstraction represented by D:

$$D = I_a^{CG-1} - 0.2S$$

For the every event of greater magnitude (e.g., 10, 25, 50, and 100-year events), the initial abstraction is calculated using the sum of the traditional method and the increase in initial abstraction for the 2-year event.

$I_a = 0.2S + D$ for all events greater than the 2-year event.

MODEL CALIBRATION

Three parameters were modified to develop a calibrated hydrologic model: the curve number, the time of concentration, and the Manning's coefficient used in the Muskingum-Cunge routing method.

The antecedent runoff condition was altered for each storm event so that each subbasin and calibration point was within an acceptable range of a target flow. The equation used to modify antecedent runoff condition (Maryland Hydrology Panel, 2006):

For ARC≤2:

$$CN_x = \frac{[10 + 5.8(x - 2)]CN_2}{10 + 0.058(x - 2)CN_2}$$

For ARC>2:

$$CN_x = \frac{[10 + 13(x - 2)]CN_2}{10 + 0.013(x - 2)CN_2}$$

Thus a unique ARC and resulting curve number was calculated for each subbasin for each storm event. The same ARC was applied in both existing and proposed conditions. The calibrated and future condition curve numbers for the two watersheds are presented in the Tables at the end of this appendix.

Additionally, lag times were calculated using both TR-55 and the NRCS lag equation. The initial model runs used the results from the NRCS lag equation. A factor between 0 and 2 was applied to the initial value to obtain a calibrated time of concentration value. The same time of concentration was applied to all existing condition storms. The future land use time of concentration was calculated using the NRCS lag equation with future land curve numbers and it was subsequently adjusted by the same factor used in existing conditions.

Finally the Manning's n value for channels and overbank areas was modified to obtain realistic flow values. The respective ranges for the channel and overbank areas were 0.02-0.07 and 0.03-0.2.

MODELING RESULTS

A summary of the hydrologic modeling results has been provided in Section 5 of this Plan. The full modeling results are as presented in the tables at the end of this appendix.

STORMWATER MANAGEMENT DISTRICTS

The regional philosophy used in Act 167 planning introduces a different stormwater management approach than is found in the traditional on-site approach. The difference between the on-site stormwater control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts throughout an individual watershed. The objective of typical on-site design is to control post-development peak flow rates from the site itself; however, a watershed-level design is focused on maintaining existing peak flow rates in the entire drainage basin. The watershed approach requires knowledge of how the site relates to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations, and the impact of the additional runoff volume generated by the development of the site. The proposed watershed-level stormwater runoff control philosophy is based on the assumption that runoff volumes will increase with development and the philosophy seeks to manage the increase in volumes such that peak rates of flow throughout the watershed are not increased. The controls implemented in this Plan are aimed at minimizing the increase in runoff volumes and their impacts, especially for the 2-year storm event.

The basic goal of both on-site and watershed-level philosophies is the same, i.e. no increase in the peak rate of stream flow. The end products, however, can be very different as illustrated in the following simplified example.

Presented in *Figure A.2* is a typical on-site runoff control strategy for dealing with the increase in the peak rate of runoff with development. The Existing Condition curve represents the pre-development runoff hydrograph. The Developed Condition hydrograph illustrates three important changes in the site runoff response with development:

1. A higher peak rate,
2. A faster occurring peak (shorter time for the peak rate to occur), and
3. An increase in total runoff volume

The "Controlled" Developed Condition hydrograph is based on limiting the post-development runoff peak rate to the pre-development level through use of detention facilities; but the volume is still increased. The impact of "squashing" the post-development runoff to the pre-development peak without reducing the volume is that the peak rate occurs over a much longer period of time. The instantaneous pre-development peak has become an extended peak (approximately two (2) hours long in this example) under the "Controlled" Developed Condition.

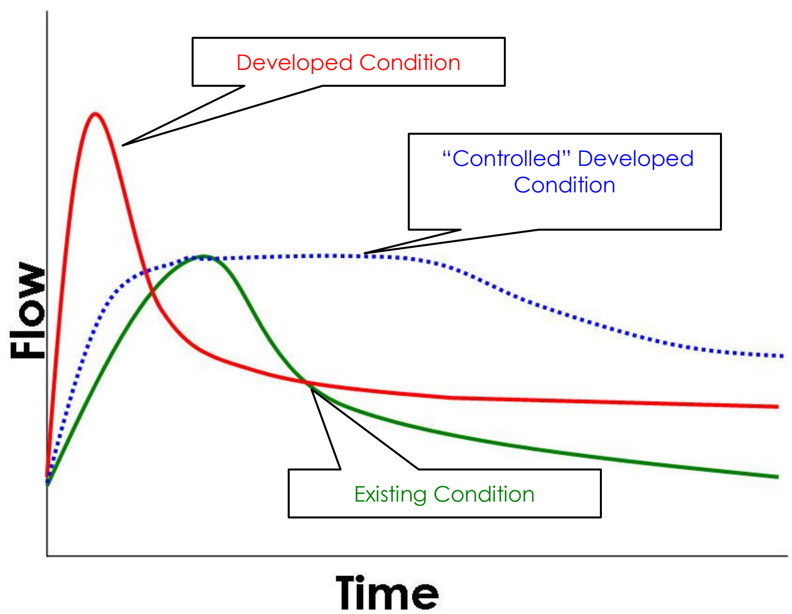

Figure A.2. Typical On-Site Runoff Control Strategy

Considering the outflow from the site only, the maintenance of the pre-development peak rate of runoff is an effective management approach. However, *Figures A.3* and *A.4* illustrate the potential detrimental impact of this approach. *Figure A.3* represents the existing hydrograph at the point of confluence of Watershed A and Watershed B. The timing relationship of the watersheds is that Watershed A peaks more quickly (at time T_{pA}) than the Total Hydrograph, while Watershed B peaks later (at time T_{pB}), than the Total Hydrograph, resulting in a combined time to peak approximately in the middle (at time T_p). Watershed A is an area of significant development pressure, and all new development proposals are met with the on-site runoff control philosophy as depicted in *Figure A.2*. The eventual end product of the Watershed A development under the "Controlled" Development Condition is an extended peak rate of runoff as shown in *Figure A.4*. The extended Watershed A peak occurs long enough so that it coincides with the peak of Watershed B. Since the Total Hydrograph at the confluence is the summation of Watershed A and Watershed B, the Total Hydrograph peak is increased under these conditions to the "Controlled" Total Hydrograph. The conclusion from the example is that simply controlling peak rates of runoff on-site does not guarantee an effective watershed level of control because of the increase in total runoff volume. The net result is that downstream peaks can increase and extend for longer durations.

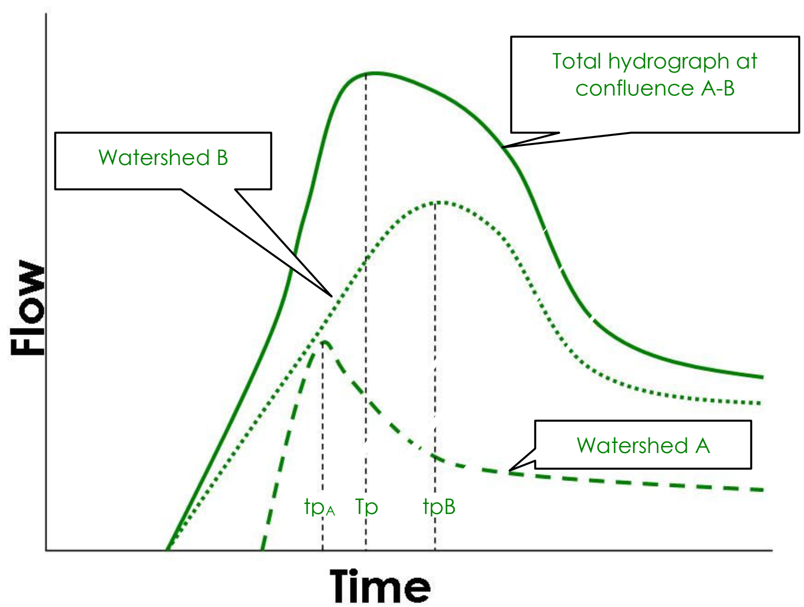

Figure A.3. Existing Hydrograph (Pre-Development)

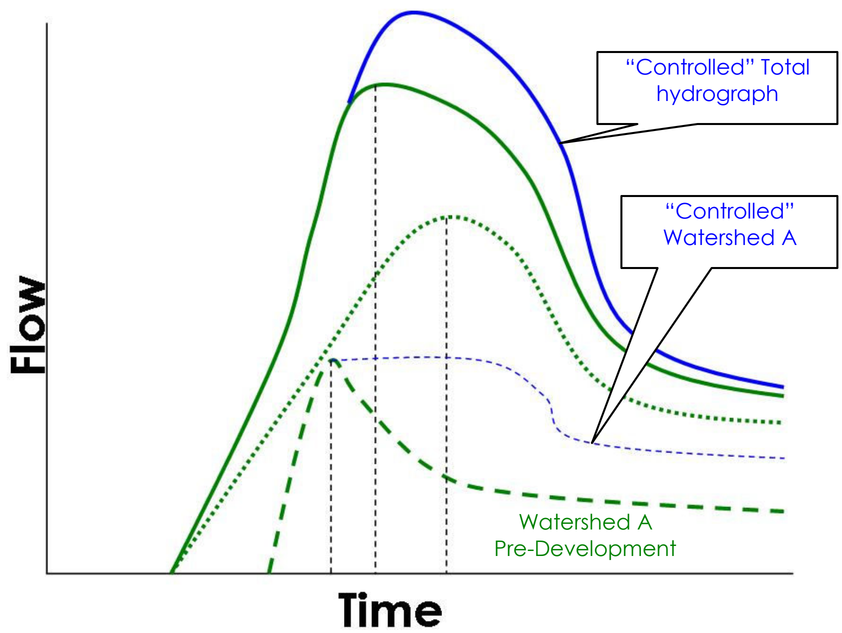

Figure A.4. Controlled Runoff Condition (Post-Development)

RELEASE RATE CONCEPT

The previous example indicated that, in certain circumstances, it is not enough to control post-development runoff peaks to pre-development levels if the overall goal is no increase in peak runoff at any point in the watershed. The reasons for this potential increase are how the various parts of the watershed interact, in time, with one another and the increased rate and volume of runoff associated with development and increases in impervious surfaces. The critical runoff criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest.

To account for increases of volume and peak flow resulting from the combination of these post-development hydrographs, stormwater management districts have been assigned to various areas within the county boundary that have more restrictive release rates than the conventional 100% release rate. As shown in Plate 10, some areas within specific watersheds have reduced release rates where CG-1 may be difficult to completely implement.

The specification of a 100% release rate as a performance standard would represent the conventional approach to runoff control philosophy, namely controlling the post-development peak runoff to pre-development levels. This is a well-established and technically feasible control that is effective at-site and, where appropriate, would be an effective watershed-level control.

It is important to acknowledge that there are several problems with the release rate concept. One of the problems is that some areas can reach unreasonably low release rates. This can be seen in the release rate equation, which dictates that sub-watersheds that peak farther away from the entire watershed will have a lower release rate. Indeed, sub-watersheds whose runoff drains almost completely before or after the watershed peak will approach a release rate of zero (because the numerator approaches zero).

Another problem is that release rates are highly dependent on, and sensitive to, the timing of hydrographs. Since natural storms follow a different timing than design storms, it is still possible that watershed wide controls designed with release rates only, will encounter increased runoff problems. This is because the runoff rates are still much higher in the developed condition, and increased volumes over an extended time can combine to increase peak flow rates. Similar to the traditional on-site detention pond, release rates are purely a peak "rate" type of control.

Patterns of development may also determine how effective designs are that use only release rates, or any control based on timing. This is because rates based on timing assume a certain development and rainfall patterns, and the model uses uniform parameters across a sub-watershed. In reality, the actual development and rainfall patterns can be highly variable across a sub-watershed and can be quite different than the "Future Full Build Out" land use scenario used in the planning study. This uncertainty can affect any type of control, but controls based on timing alone are especially sensitive to these parameters. Some controls, such as volume controls, are less sensitive since they remove a certain amount of runoff from the storm event wherever development occurs. In a sense, volume controls tend to more closely simulate what occurs in a natural system.

Combining volume controls with peak rate controls, as proposed in this plan, will be more effective than having only peak rate controls. Volume controls have several advantages such as:

1. Increased runoff volume may infiltrate and provide recharge to existing groundwater supplies. This may not happen with rate controls since all of the runoff excess is discharged in a relatively short time frame.

2. Volume controls tend to mimic natural systems (i.e., excess runoff volume is infiltrated) and thus are more effective in controlling natural storms since they are not highly sensitive to timing issues.

3. Volume controls often have enhanced water quality benefits.

The Design Storm Method and The Simplified Method as implemented in this Plan, provide the benefits described above.

SUMMARY MODEL OUTPUT

For data management purposes, the HEC-HMS models for Butler County were broken into seven different models. The modeling input and output is provided with the following pages. In order that they occur, they include:

BUFFALO CREEK HEC-HMS MODELS:

Hydrologic Parameters for Buffalo Creek HEC-HMS Model
Hydrologic Results for Buffalo Creek HEC-HMS Model

CONNEQUENESSING CREEK HEC-HMS MODELS:

Hydrologic Parameters for Wolf Creek HEC-HMS Model
Hydrologic Results for Wolf Creek HEC-HMS Model

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model
Hydrologic Results for Upper Slippery Rock Creek HEC-HMS Model

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model
Hydrologic Results for Lower Slippery Rock Creek HEC-HMS Model

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model
Hydrologic Results for Upper Connoquenessing Creek HEC-HMS Model

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model
Hydrologic Results for Lower Connoquenessing Creek HEC-HMS Model

Hydrologic Parameters for Breakneck Creek HEC-HMS Model
Hydrologic Results for Breakneck Creek HEC-HMS Model

Calibration Results for Detailed HEC-HMS Models with 2010 Land Use

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Buffalo Creek	W008	3.34	71.3	67.0	71.3	67.0
	W010	3.87	64.6	94.6	64.6	94.6
	W012	3.13	62.0	105.7	62.0	105.7
	W014	1.14	64.2	57.4	64.2	57.4
	W042	4.43	65.0	102.0	65.0	102.0
	W044	0.86	68.8	48.4	68.8	48.4
	W046	3.43	66.1	71.7	66.1	71.7
	W048	1.59	66.7	52.4	67.1	51.9
	W050	2.03	59.0	80.2	59.0	80.2
	W052	0.09	66.1	20.9	66.1	20.9
	W054	0.54	62.7	50.3	62.7	50.3
	W056	1.10	58.7	62.9	58.7	62.9
	W058	0.84	66.1	44.7	66.1	44.7
	W060	0.09	70.7	14.5	70.7	14.5
	W062	3.04	70.9	77.1	70.9	77.1
	W064	3.94	76.3	70.5	76.3	70.5
	W066	2.78	72.0	53.9	72.0	67.4
	W068	1.90	76.8	45.8	76.8	50.8
	W072	1.00	71.2	48.8	71.2	48.8
	W074	2.48	67.8	73.9	67.8	73.9
	W076	0.98	59.5	42.8	59.5	42.8
	W078	0.77	64.3	40.4	64.3	40.4
	W120	3.60	75.3	57.5	75.3	71.8
	W122	2.04	74.1	62.0	74.0	69.0
	W170	1.47	71.8	69.5	71.8	69.5
	W172	0.52	73.3	27.5	73.3	27.5
	W174	1.30	72.5	42.1	72.5	42.1
	W176	1.49	74.5	53.5	74.5	53.5
	W178	3.44	70.7	83.4	70.7	83.4
	W180	0.35	59.5	28.2	59.5	28.2
	W182	0.96	65.2	43.3	65.2	43.3
	W184	0.65	73.4	33.1	73.4	33.1
	W186	1.29	70.6	51.7	70.6	51.7
	W188	1.10	68.9	45.1	68.9	45.1
	W190	0.65	64.5	50.3	64.5	50.3
	W192	0.00	52.9	3.4	52.9	3.4
	W194	0.20	59.4	25.1	59.4	25.1
	W196	3.10	69.8	68.8	69.9	68.6
	W198	1.25	70.6	43.7	71.9	42.1
Buffalo Run	W016	2.67	65.4	64.1	65.4	64.1
	W018	2.66	63.3	83.0	63.3	83.0
	W020	1.00	66.3	52.9	66.3	52.9
Cornplanter Run	W106	1.01	70.0	55.5	70.0	55.5
	W108	2.44	71.7	79.0	71.7	79.0

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Cornplanter Run	W110	1.23	73.8	35.1	73.8	43.9
Little Buffalo Creek	W124	0.78	80.5	47.4	80.5	47.4
	W126	2.42	79.2	141.0	79.2	94.0
	W138	1.16	78.8	85.9	78.7	57.4
	W140	1.81	75.0	80.7	75.3	53.2
	W142	1.72	75.8	66.8	77.0	43.0
	W144	2.97	78.4	106.3	78.6	70.6
	W146	1.01	78.2	75.1	78.2	50.1
	W148	2.38	74.3	141.4	74.4	94.0
	W150	0.76	76.3	60.9	76.4	40.5
	W152	0.23	67.5	50.8	67.5	33.8
	W154	0.01	59.7	12.6	59.7	8.4
	W156	1.82	70.8	95.6	71.2	63.0
	W158	0.20	55.2	41.5	55.6	27.4
Little Buffalo Run	W022	1.22	60.2	63.1	60.2	63.1
	W024	3.54	77.1	73.7	77.4	73.2
	W026	2.44	69.4	64.0	69.4	64.0
	W028	1.06	69.3	32.4	69.3	32.4
	W030	3.19	60.1	112.4	60.1	112.4
	W032	0.39	63.2	42.3	63.2	42.3
	W034	0.85	59.6	56.2	59.6	56.2
	W036	0.59	63.0	40.0	63.0	40.0
	W038	1.16	66.0	53.9	66.0	53.9
	W040	0.16	61.3	23.2	61.3	23.2
Long Run	W004	1.98	68.0	54.9	68.0	54.9
	W006	3.16	71.1	73.0	71.1	73.0
Marrowbone Run	W070	3.14	71.9	51.7	71.9	51.7
North Branch Rough Run	W082	2.09	72.2	47.3	72.2	59.1
	W084	1.21	62.4	42.8	62.4	53.5
	W086	0.22	61.5	28.7	61.5	28.7
Patterson Creek	W002	3.33	62.8	98.7	62.8	98.7
	W160	3.46	73.4	67.7	73.4	67.7
	W162	3.61	70.9	74.9	70.9	74.9
	W164	2.87	70.5	70.0	70.5	70.0
	W166	2.75	68.7	70.8	68.7	70.8
	W168	0.71	69.7	37.1	69.7	37.1
Pine Run	W112	1.55	71.9	46.1	71.9	46.1
	W114	2.62	72.5	64.9	72.5	81.1
	W116	1.84	71.9	58.4	71.9	58.4
	W118	1.20	71.0	34.8	71.0	43.5
Rough Run	W088	1.53	68.0	60.1	68.0	60.1
	W090	2.74	76.1	56.3	76.1	56.3
	W092	2.23	76.2	50.4	76.2	50.4
	W094	1.44	71.5	43.0	71.5	53.8

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

			Existing Conditions (2010)		Future Conditions (2020)	
Subwatershed Name	**Subbasin**	**Drainage Area (mi^2)**	**CN**	**Lag (min)**	**CN**	**Lag (min)**
Rough Run	W096	1.71	67.6	70.9	67.6	70.9
	W098	0.59	70.5	43.3	70.5	43.3
	W100	2.66	60.1	71.0	60.1	71.0
	W102	0.40	50.1	33.2	50.1	33.2
Sarver Run near Dennys Mills	W080	1.24	67.5	75.6	67.5	75.6
Sarver Run near Sarverville	W128	2.27	79.5	115.9	79.4	77.4
	W130	0.88	78.3	77.9	79.2	50.5
	W132	1.24	78.7	106.8	79.0	70.5
	W134	2.05	76.1	103.4	76.0	69.1
	W136	2.31	79.7	138.5	80.1	91.4
Sipes Run	W104	1.95	71.6	32.6	71.6	40.7

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Buffalo Creek	W008	71.3	71.3	68.5	66.5	64.2	63.4
	W010	64.6	74.0	71.9	69.8	67.3	66.5
	W012	62.0	74.0	72.8	71.0	69.0	68.4
	W014	64.2	72.1	70.8	68.5	65.9	64.2
	W042	65.0	74.2	72.3	70.2	67.7	66.9
	W044	68.8	68.6	66.9	65.1	63.0	62.3
	W046	66.1	73.4	70.4	66.4	64.0	63.1
	W048	66.7	72.0	68.6	65.6	63.4	62.5
	W050	59.0	72.4	71.0	69.1	66.9	66.3
	W052	66.1	65.8	64.1	62.2	60.1	59.4
	W054	62.7	62.4	60.6	58.7	56.5	55.7
	W056	58.7	71.8	70.5	68.6	66.4	65.6
	W058	66.1	65.8	64.1	62.2	60.0	59.3
	W060	70.7	70.4	68.8	67.0	65.0	64.3
	W062	70.9	72.9	69.6	67.8	65.8	65.0
	W064	76.3	71.7	69.7	67.1	64.1	63.1
	W066	72.0	70.2	69.2	66.8	64.0	63.2
	W068	76.8	70.5	69.4	66.7	63.4	62.6
	W072	71.2	70.6	68.9	66.6	64.0	63.3
	W074	67.8	72.2	70.9	67.2	64.8	64.0
	W076	59.5	59.2	57.4	55.4	53.2	52.4
	W078	64.3	64.0	62.2	60.3	58.1	57.4
	W120	75.3	70.8	69.7	67.3	64.4	63.5
	W122	74.1	71.8	70.7	68.3	65.5	64.9
	W170	71.8	71.7	70.6	68.6	66.4	65.9
	W172	73.3	73.0	71.5	69.8	67.9	67.2
	W174	72.5	69.9	67.9	65.2	62.1	61.2
	W176	74.5	71.1	69.5	67.0	64.1	63.4
	W178	70.7	72.4	69.9	67.8	65.3	64.6
	W180	59.5	59.2	57.4	55.3	53.1	52.4
	W182	65.2	64.9	63.2	61.3	59.1	58.4
	W184	73.4	73.1	71.6	69.9	68.0	67.4
	W186	70.6	70.3	68.6	66.4	63.7	63.0
	W188	68.9	70.8	67.8	65.4	62.6	61.9
	W190	64.5	64.2	62.4	60.5	58.3	57.6
	W192	52.9	52.6	50.7	48.7	46.5	45.7
	W194	59.4	59.0	57.2	55.2	53.0	52.2
	W196	69.8	71.6	68.9	66.5	63.6	62.7
	W198	70.6	69.8	67.9	65.4	62.4	61.4
Buffalo Run	W016	65.4	72.9	70.2	66.4	63.7	62.7
	W018	63.3	73.4	71.5	69.4	66.9	66.1
	W020	66.3	72.4	71.0	67.5	64.9	64.2
Cornplanter Run	W106	70.0	71.8	69.4	67.4	65.0	64.4
	W108	71.7	71.7	70.5	68.4	66.1	65.4

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Cornplanter Run	W110	73.8	69.8	68.5	66.0	63.0	62.1
Little Buffalo Creek	W124	80.5	80.3	79.1	77.7	76.2	75.6
	W126	79.2	72.3	70.1	69.6	69.1	68.9
	W138	78.8	70.8	68.0	67.3	66.6	66.1
	W140	75.0	69.5	65.9	64.9	63.8	62.8
	W142	75.8	69.0	65.0	63.8	62.4	61.6
	W144	78.4	70.7	64.8	63.5	62.0	61.1
	W146	78.2	70.4	64.5	63.1	61.6	60.7
	W148	74.3	71.8	69.7	69.1	68.5	68.1
	W150	76.3	76.1	74.7	73.1	71.3	70.7
	W152	67.5	67.2	65.5	63.7	61.6	60.9
	W154	59.7	59.4	57.5	55.5	53.3	52.6
	W156	70.8	69.6	66.8	65.8	64.7	63.8
	W158	55.2	54.8	53.0	50.9	48.7	48.0
Little Buffalo Run	W022	60.2	72.3	70.6	68.6	66.3	65.3
	W024	77.1	72.1	70.5	68.4	66.0	65.3
	W026	69.4	71.7	68.6	66.7	64.5	63.7
	W028	69.3	68.7	66.2	63.9	61.4	60.4
	W030	60.1	73.8	72.9	71.3	69.6	69.1
	W032	63.2	62.9	61.1	59.2	57.0	56.3
	W034	59.6	59.3	57.5	55.4	53.2	52.5
	W036	63.0	62.7	60.9	58.9	56.8	56.0
	W038	66.0	72.2	70.6	67.0	64.5	63.7
	W040	61.3	61.0	59.2	57.2	55.0	54.3
Long Run	W004	68.0	71.7	67.7	65.7	63.3	62.5
	W006	71.1	72.1	69.2	67.3	65.2	64.3
Marrowbone Run	W070	71.9	69.8	67.3	64.5	61.2	60.3
North Branch Rough Run	W082	72.2	70.1	68.9	66.5	63.7	62.9
	W084	62.4	70.5	69.8	66.8	63.3	62.4
	W086	61.5	61.2	59.4	57.4	55.2	54.5
Patterson Creek	W002	62.8	73.9	72.1	70.2	68.0	67.3
	W160	73.4	71.6	69.1	67.0	64.5	63.7
	W162	70.9	72.2	69.1	67.2	65.0	64.1
	W164	70.5	71.3	69.1	67.1	64.9	64.2
	W166	68.7	72.8	69.2	67.0	64.9	64.1
	W168	69.7	69.4	67.8	66.0	63.9	63.3
Pine Run	W112	71.9	70.0	67.9	65.3	62.3	61.4
	W114	72.5	71.9	70.7	68.6	66.3	65.6
	W116	71.9	70.8	68.9	66.6	63.9	63.1
	W118	71.0	69.2	67.8	65.3	62.5	61.7
Rough Run	W088	68.0	72.0	69.9	66.7	64.2	63.6
	W090	76.1	70.4	69.2	66.4	63.1	62.3
	W092	76.2	70.1	68.9	66.1	62.9	61.8
	W094	71.5	70.0	68.9	66.5	63.8	63.0

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Rough Run	W096	67.6	72.4	72.0	68.0	65.6	65.0
	W098	70.5	70.2	68.6	66.8	64.8	64.1
	W100	60.1	71.2	69.8	67.1	63.8	62.7
	W102	50.1	49.8	47.9	45.9	43.6	42.9
Sarver Run near Dennys Mills	W080	67.5	73.9	73.2	70.6	67.5	67.0
Sarver Run near Sarverville	W128	79.5	71.5	68.9	68.1	67.3	66.8
	W130	78.3	78.1	76.7	75.3	73.6	73.0
	W132	78.7	71.8	69.5	69.0	68.5	68.1
	W134	76.1	70.5	67.7	66.8	65.9	65.2
	W136	79.7	72.5	70.2	69.7	69.2	69.0
Sipes Run	W104	71.6	68.7	66.8	64.0	60.7	59.8

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Buffalo Creek	W008	71.3	71.3	68.6	66.5	64.2	63.4
	W010	64.6	74.0	71.9	69.8	67.3	66.5
	W012	62.0	74.0	72.8	71.0	69.0	68.4
	W014	64.2	72.1	70.8	68.5	65.9	64.2
	W042	65.0	74.2	72.3	70.2	67.7	66.9
	W044	68.8	68.6	66.9	65.1	63.0	62.3
	W046	66.1	73.4	70.4	66.4	64.0	63.1
	W048	67.1	72.4	69.0	66.0	63.8	62.9
	W050	59.0	72.4	71.0	69.1	66.9	66.3
	W052	66.1	65.8	64.1	62.2	60.1	59.4
	W054	62.7	62.4	60.6	58.7	56.5	55.7
	W056	58.7	71.8	70.5	68.6	66.4	65.6
	W058	66.1	65.8	64.1	62.2	60.0	59.3
	W060	70.7	70.4	68.8	67.0	65.0	64.3
	W062	70.9	72.9	69.6	67.8	65.8	65.0
	W064	76.3	71.7	69.7	67.1	64.1	63.1
	W066	72.0	70.2	69.2	66.8	64.0	63.2
	W068	76.8	70.5	69.4	66.7	63.4	62.6
	W072	71.2	70.6	68.9	66.6	64.0	63.3
	W074	67.8	72.2	70.9	67.2	64.8	64.0
	W076	59.5	59.2	57.4	55.4	53.2	52.4
	W078	64.3	64.0	62.2	60.3	58.1	57.4
	W120	75.3	70.8	69.7	67.3	64.4	63.5
	W122	74.0	71.7	70.6	68.2	65.4	64.8
	W170	71.8	71.7	70.6	68.6	66.4	65.9
	W172	73.3	73.0	71.5	69.8	67.9	67.2
	W174	72.5	69.9	67.9	65.2	62.1	61.2
	W176	74.5	71.1	69.5	67.0	64.1	63.4
	W178	70.7	72.4	69.9	67.8	65.3	64.6
	W180	59.5	59.2	57.4	55.3	53.1	52.4
	W182	65.2	64.9	63.2	61.3	59.1	58.4
	W184	73.4	73.1	71.6	69.9	68.0	67.4
	W186	70.6	70.3	68.6	66.4	63.7	63.0
	W188	68.9	70.8	67.8	65.4	62.6	61.9
	W190	64.5	64.2	62.4	60.5	58.3	57.6
	W192	52.9	52.6	50.7	48.7	46.5	45.7
	W194	59.4	59.0	57.2	55.2	53.0	52.2
	W196	69.9	71.7	69.0	66.5	63.7	62.8
	W198	71.9	71.2	69.4	66.9	64.0	63.0
Buffalo Run	W016	65.4	72.9	70.2	66.4	63.7	62.7
	W018	63.3	73.4	71.5	69.4	66.9	66.1
	W020	66.3	72.4	71.0	67.5	64.9	64.2
Cornplanter Run	W106	70.0	71.8	69.4	67.4	65.0	64.4
	W108	71.7	71.7	70.5	68.4	66.1	65.4

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Cornplanter Run	W110	73.8	69.8	68.5	66.0	63.0	62.1
Little Buffalo Creek	W124	80.5	80.3	79.1	77.7	76.2	75.6
	W126	79.2	72.3	70.1	69.6	69.1	68.9
	W138	78.7	70.7	67.9	67.2	66.5	66.0
	W140	75.3	70.0	66.4	65.4	64.3	63.3
	W142	77.0	70.3	66.5	65.2	63.9	63.1
	W144	78.6	70.9	65.0	63.6	62.2	61.3
	W146	78.2	70.4	64.5	63.1	61.6	60.7
	W148	74.4	71.9	69.9	69.2	68.6	68.2
	W150	76.4	76.2	74.8	73.2	71.4	70.8
	W152	67.5	67.2	65.5	63.7	61.6	60.9
	W154	59.7	59.4	57.5	55.5	53.3	52.6
	W156	71.2	70.1	67.3	66.2	65.1	64.3
	W158	55.6	55.3	53.4	51.3	49.1	48.4
Little Buffalo Run	W022	60.2	72.3	70.6	68.6	66.3	65.3
	W024	77.4	72.4	70.8	68.7	66.3	65.6
	W026	69.4	71.7	68.6	66.7	64.5	63.7
	W028	69.3	68.7	66.2	63.9	61.4	60.4
	W030	60.1	73.8	72.9	71.3	69.6	69.1
	W032	63.2	62.9	61.1	59.2	57.0	56.3
	W034	59.6	59.3	57.5	55.4	53.2	52.5
	W036	63.0	62.7	60.9	58.9	56.8	56.0
	W038	66.0	72.2	70.6	67.0	64.5	63.7
	W040	61.3	61.0	59.2	57.2	55.0	54.3
Long Run	W004	68.0	71.7	67.7	65.7	63.3	62.5
	W006	71.1	72.1	69.2	67.3	65.2	64.3
Marrowbone Run	W070	71.9	69.8	67.3	64.5	61.2	60.3
North Branch Rough Run	W082	72.2	70.1	68.9	66.5	63.7	62.9
	W084	62.4	70.5	69.8	66.8	63.3	62.4
	W086	61.5	61.2	59.4	57.4	55.2	54.5
Patterson Creek	W002	62.8	73.9	72.1	70.2	68.0	67.3
	W160	73.4	71.6	69.1	67.0	64.5	63.7
	W162	70.9	72.2	69.1	67.2	65.0	64.1
	W164	70.5	71.3	69.1	67.1	64.9	64.2
	W166	68.7	72.8	69.2	67.0	64.9	64.1
	W168	69.7	69.4	67.8	66.0	63.9	63.3
Pine Run	W112	71.9	70.0	67.9	65.3	62.3	61.4
	W114	72.5	71.9	70.7	68.6	66.3	65.6
	W116	71.9	70.8	68.9	66.6	63.9	63.1
	W118	71.0	69.2	67.8	65.3	62.5	61.7
Rough Run	W088	68.0	72.0	69.9	66.7	64.2	63.6
	W090	76.1	70.4	69.2	66.4	63.1	62.3
	W092	76.2	70.1	68.9	66.1	62.9	61.8
	W094	71.5	70.0	68.9	66.5	63.8	63.0

Hydrologic Parameters for Buffalo Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Rough Run	W096	67.6	72.4	72.0	68.0	65.6	65.0
	W098	70.5	70.2	68.6	66.8	64.8	64.1
	W100	60.1	71.2	69.8	67.1	63.8	62.7
	W102	50.1	49.8	47.9	45.9	43.6	42.9
Sarver Run near Dennys Mills	W080	67.5	73.9	73.2	70.6	67.5	67.0
Sarver Run near Sarverville	W128	79.4	71.4	68.8	68.0	67.2	66.7
	W130	79.2	79.0	77.7	76.3	74.6	74.1
	W132	79.0	72.1	69.9	69.4	68.9	68.5
	W134	76.0	70.4	67.6	66.7	65.8	65.1
	W136	80.1	72.9	70.7	70.1	69.6	69.4
Sipes Run	W104	71.6	68.7	66.8	64.0	60.7	59.8

Hydrologic Results for Buffalo Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1530	1430993.6	587638.0	2.67	268	532	621	704	867	268	532	621	704	867
2	P201	1427453.7	577072.1	5.33	492	993	1,215	1,378	1,696	492	993	1,215	1,378	1,696
3	P292	1412261.2	560961.6	3.54	295	651	849	971	1,203	306	668	871	996	1,231
4	J1490	1415060.4	568805.0	4.41	305	658	870	1,018	1,245	305	658	870	1,018	1,245
5	P287	1417034.7	567616.9	4.80	313	681	901	1,055	1,292	313	681	901	1,055	1,292
6	J1331	1418906.3	565722.1	11.63	778	1,689	2,239	2,599	3,221	789	1,708	2,263	2,626	3,252
7	P288	1422083.5	565184.3	12.22	779	1,684	2,231	2,590	3,227	789	1,702	2,253	2,615	3,257
8	J1303	1427117.2	562975.0	14.44	831	1,770	2,330	2,702	3,374	841	1,787	2,351	2,725	3,405
9	J1500	1456694.4	571033.2	1.98	196	367	493	573	715	196	367	493	573	715
10	J1527	1442745.2	586508.6	3.46	292	611	806	923	1,146	292	611	806	923	1,146
11	J1518	1443691.4	576405.4	10.40	841	1,714	2,259	2,604	3,215	841	1,714	2,259	2,604	3,215
12	J1497	1446408.0	567584.1	13.27	1,022	2,090	2,760	3,188	3,955	1,022	2,090	2,760	3,188	3,955
13	J1487	1446499.6	564440.1	21.16	1,654	3,275	4,340	5,032	6,240	1,654	3,275	4,340	5,032	6,240
14	J1452	1428002.3	549331.0	3.48	286	647	783	897	1,117	286	647	783	897	1,117
15	P136	1430161.7	545034.7	4.46	300	699	862	994	1,251	300	699	862	994	1,251
16	O037	1420385.3	549693.5	2.09	192	477	618	691	863	192	477	618	691	863
17	J1300	1419913.6	544416.7	4.54	407	984	1,250	1,373	1,714	407	984	1,250	1,373	1,714
18	J1447	1405048.7	547682.7	2.74	229	559	705	763	959	229	559	705	763	959
19	J1444	1409901.9	546034.5	4.97	395	960	1,217	1,320	1,653	395	960	1,217	1,320	1,653
20	J1436	1414816.2	542615.8	6.41	483	1,161	1,478	1,614	2,022	483	1,161	1,478	1,614	2,022
21	J1429	1420615.6	542280.1	12.88	1,001	2,365	2,962	3,268	4,083	1,001	2,365	2,962	3,268	4,083
22	J1422	1421958.7	540784.4	15.00	1,115	2,618	3,279	3,663	4,597	1,115	2,618	3,279	3,663	4,597
23	P145	1430345.3	537231.9	17.66	1,292	3,021	3,787	4,220	5,293	1,292	3,021	3,787	4,220	5,293
24	J1392	1429253.8	527720.4	3.45	272	606	796	914	1,136	272	606	796	914	1,136
25	J1395	1439387.6	520150.5	2.62	235	536	702	805	994	235	536	702	805	994
26	J1374	1439021.3	518258.1	6.01	515	1,173	1,531	1,734	2,159	515	1,173	1,531	1,733	2,159
27	J1371	1403797.2	517861.3	4.39	204	422	608	766	949	206	425	612	770	953
28	J1366	1410024.0	513221.7	6.44	312	641	922	1,159	1,436	313	642	924	1,161	1,439
29	J1404	1408528.3	532054.7	3.75	253	441	591	705	858	255	445	597	712	867
30	USGS 03049100	1409874.4	528212.8	4.76	321	551	753	908	1,114	323	555	759	915	1,122
31	J1386	1413595.2	516793.0	9.56	546	1,022	1,447	1,792	2,218	551	1,030	1,458	1,805	2,233
32	J1356	1414907.8	511237.7	19.07	1,022	1,990	2,828	3,521	4,357	1,034	2,010	2,853	3,550	4,390
33	J1353	1417380.2	508948.4	20.46	1,079	2,105	2,988	3,719	4,602	1,091	2,124	3,013	3,748	4,635
34	J1344	1417685.4	508429.5	22.28	1,147	2,238	3,173	3,948	4,883	1,161	2,260	3,202	3,981	4,921

Hydrologic Results for Buffalo Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J1336	1424858.4	506689.7	25.82	1,271	2,480	3,507	4,356	5,384	1,292	2,512	3,545	4,400	5,433
36	J1533	1416708.6	594658.4	6.77	605	1,208	1,491	1,723	2,143	606	1,209	1,493	1,724	2,145
37	J1536	1421378.7	588431.6	12.23	1,026	2,039	2,555	2,939	3,634	1,029	2,044	2,561	2,944	3,640
38	J1511	1423851.1	576039.1	17.39	1,338	2,686	3,403	3,925	4,848	1,341	2,691	3,410	3,932	4,856
39	J1506	1423973.2	574421.3	18.62	1,335	2,671	3,383	3,923	4,854	1,339	2,676	3,390	3,931	4,863
40	J1503	1424858.4	570544.8	25.49	1,718	3,481	4,397	5,080	6,313	1,723	3,488	4,406	5,090	6,325
41	J1472	1428795.9	564165.4	41.19	2,525	5,188	6,635	7,666	9,494	2,538	5,209	6,662	7,696	9,526
42	J1482	1433343.9	566180.0	46.46	2,748	5,617	7,190	8,300	10,307	2,762	5,639	7,218	8,331	10,342
43	J1479	1434198.6	564592.8	47.41	2,643	5,459	7,001	8,089	10,029	2,655	5,480	7,027	8,117	10,061
44	J_UpperBuffalo_PattersonCk	558689.1	: J1467	72.32	3,417	6,914	8,955	10,383	12,917	3,431	6,938	8,985	10,417	12,959
45	J1455	1444668.2	554825.2	77.73	3,541	7,149	9,259	10,727	13,336	3,554	7,173	9,289	10,761	13,379
46	J1458	1441585.3	551009.8	81.03	3,452	7,057	9,155	10,605	13,170	3,463	7,078	9,181	10,635	13,206
47	J1439	1440944.3	545149.3	84.23	3,501	7,149	9,270	10,736	13,329	3,512	7,170	9,296	10,765	13,365
48	J1419	1442012.6	537640.5	88.86	3,470	7,038	9,111	10,526	13,111	3,480	7,056	9,133	10,550	13,142
49	J1318	1433191.3	538098.4	97.53	3,603	7,284	9,421	10,885	13,549	3,613	7,301	9,442	10,909	13,580
50	J1414	1431878.8	534588.2	115.94	3,909	7,870	10,157	11,719	14,575	3,918	7,887	10,179	11,744	14,606
51	J1409	1435999.5	528758.2	118.85	3,940	7,927	10,230	11,801	14,671	3,950	7,945	10,251	11,825	14,702
52	J1389	1436028.1	523497.0	124.18	3,908	7,910	10,218	11,785	14,632	3,917	7,926	10,237	11,807	14,659
53	J1377	1433466.0	515633.1	132.68	4,017	8,108	10,468	12,070	14,970	4,026	8,123	10,487	12,091	14,998
54	J1363	1429009.6	512122.9	137.38	4,075	8,214	10,601	12,220	15,149	4,084	8,230	10,620	12,241	15,176
55	USGS 03049000	1428119.2	509623.8	138.03	4,033	8,159	10,534	12,143	15,049	4,041	8,173	10,552	12,163	15,075
56	J1297	1427941.3	509589.4	140.07	4,060	8,209	10,599	12,215	15,137	4,068	8,224	10,617	12,235	15,163
57	J1339	1427178.2	507086.5	166.29	4,552	9,137	11,903	13,834	17,198	4,564	9,156	11,926	13,860	17,230
58	P212	1430115.8	497782.0	169.39	4,587	9,197	11,979	13,920	17,297	4,599	9,217	12,003	13,946	17,330
59	J_Outlet_BuffaloCk	1429681.2	492769.8	170.64	4,531	9,116	11,888	13,815	17,168	4,544	9,136	11,912	13,841	17,201

Hydrologic Parameters for Wolf Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Black Run	W042	11.08	71.8	207.2	71.8	207.2
East Branch Wolf Creek	W034	7.18	77.1	102.8	77.1	102.8
	W036	15.42	75.7	197.7	75.7	197.7
Wolf Creek	W028	16.28	73.0	283.3	73.0	283.3
	W030	4.15	77.4	109.4	77.2	110.1
	W032	1.09	79.5	57.6	79.9	57.0
	W038	12.86	75.6	196.4	75.6	196.4
	W040	12.45	71.7	266.7	71.7	266.7
	W044	11.77	73.4	243.9	73.4	243.9
	W046	2.09	73.3	79.8	73.3	79.8
	W048	3.63	76.5	82.1	76.5	82.0
	W050	3.93	76.9	93.8	77.0	93.6

Hydrologic Parameters for Wolf Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Black Run	W042	71.8	68.1	63.4	60.6	57.4	54.9
East Branch Wolf Creek	W034	77.1	69.6	67.5	66.0	64.3	63.1
	W036	75.7	69.5	65.9	63.7	61.2	58.9
Wolf Creek	W028	73.0	69.1	64.6	62.0	58.9	56.4
	W030	77.4	71.0	70.0	68.8	67.5	66.4
	W032	79.5	69.9	68.7	67.6	66.6	65.8
	W038	75.6	68.4	63.9	61.4	58.5	56.6
	W040	71.7	70.8	67.5	65.2	62.5	60.3
	W044	73.4	70.8	67.6	65.4	63.0	60.9
	W046	73.3	69.6	67.7	66.2	64.6	63.3
	W048	76.5	68.7	66.1	64.4	62.5	60.8
	W050	76.9	70.6	69.2	67.9	66.6	65.7

Hydrologic Parameters for Wolf Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Black Run	W042	71.8	68.1	63.4	60.6	57.4	54.9
East Branch Wolf Creek	W034	77.1	69.6	67.5	66.0	64.3	63.1
	W036	75.7	69.5	65.9	63.7	61.2	58.9
Wolf Creek	W028	73.0	69.1	64.6	62.0	58.9	56.4
	W030	77.2	70.8	69.7	68.5	67.2	66.1
	W032	79.9	70.4	69.1	68.1	67.0	66.3
	W038	75.6	68.4	63.9	61.4	58.5	56.6
	W040	71.7	70.8	67.5	65.2	62.5	60.4
	W044	73.4	70.8	67.6	65.4	63.0	60.9
	W046	73.3	69.6	67.7	66.2	64.6	63.3
	W048	76.5	68.7	66.1	64.4	62.6	60.9
	W050	77.0	70.7	69.3	68.0	66.7	65.8

Hydrologic Results for Wolf Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J103	1348302.9	694134.5	7.18	364	821	1,142	1,381	1,666	365	821	1,142	1,381	1,667
2	J4707	1333254.8	689494.9	38.88	1,179	2,334	3,113	3,592	4,159	1,180	2,334	3,113	3,592	4,160
3	J102	1328706.8	679666.3	51.74	1,342	2,532	3,334	3,813	4,409	1,342	2,532	3,334	3,814	4,410
4	J4671	1322968.4	661657.5	64.19	1,622	3,036	3,983	4,550	5,259	1,622	3,037	3,983	4,551	5,259
5	J101	1323639.9	661291.2	75.27	1,804	3,349	4,384	4,995	5,765	1,804	3,350	4,384	4,995	5,765
6	USGS 03106140	1327943.7	656895.8	87.04	2,065	3,831	5,014	5,719	6,605	2,066	3,831	5,014	5,720	6,605
7	J4544	1329988.8	648837.6	93.28	2,139	3,963	5,183	5,917	6,835	2,139	3,963	5,183	5,917	6,834
8	J4497	1326539.6	641481.4	98.00	2,184	4,042	5,284	6,034	6,970	2,184	4,042	5,284	6,034	6,970
9	J_WolfCreek_Outlet	1319971.5	630995.8	101.93	2,219	4,101	5,356	6,117	7,066	2,219	4,101	5,356	6,118	7,066

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Big Run near Slippery Rock Park	W254	2.32	67.0	81.0	67.1	80.7
	W256	1.40	71.0	49.0	71.0	49.0
	W258	3.36	72.3	82.8	72.5	82.5
Blacks Creek	W166	3.04	70.7	87.5	70.7	87.5
	W168	4.33	70.1	101.8	70.1	101.8
	W170	1.48	71.1	59.7	71.1	59.7
Christy Run	W200	2.83	70.3	85.7	70.3	85.7
Findlay Run	W210	1.63	64.9	79.1	64.9	79.1
	W212	1.63	69.0	74.7	69.0	74.7
	W214	2.89	68.3	83.9	68.3	83.9
Hogue Run	W260	1.12	73.4	50.1	73.4	50.1
	W262	4.15	69.9	96.7	69.9	96.7
	W264	2.19	73.6	101.9	73.6	101.9
Long Run	W244	3.83	74.8	109.0	74.9	108.7
McDonald Run	W238	3.95	74.1	111.9	74.1	111.9
McMurray Run	W184	3.62	77.3	92.3	77.3	92.3
	W186	1.16	73.2	59.5	73.2	59.5
	W188	2.49	76.8	101.1	76.8	101.1
	W190	2.82	74.3	100.8	74.6	100.0
	W192	1.29	72.5	64.7	72.5	64.7
	W194	1.84	70.8	73.8	70.8	73.8
North Branch Slippery Rock Creek	W172	3.27	69.7	95.7	69.7	95.7
	W174	1.02	64.9	64.6	64.9	64.6
	W176	4.08	74.2	85.5	74.2	85.5
	W178	3.17	69.6	113.7	69.6	113.7
	W180	3.53	67.5	107.6	67.5	107.6
	W182	1.08	70.4	59.5	70.4	59.5
Seaton Creek	W158	4.35	69.9	85.8	69.9	85.8
	W160	3.52	67.4	78.6	67.4	78.6
	W162	0.73	59.1	57.5	59.1	57.5
	W164	1.89	69.2	63.2	69.2	63.2
Slippery Rock Creek	W150	2.25	66.8	71.7	66.8	71.7
	W152	2.94	67.0	60.6	67.0	60.6
	W154	1.00	66.0	49.0	66.0	49.0
	W156	1.74	64.8	63.8	64.8	63.8
	W240	1.88	68.5	81.3	68.5	81.3
	W242	1.15	69.7	54.1	69.7	54.1
	W246	1.56	74.5	86.5	74.6	86.3
	W248	1.31	72.4	64.3	72.4	64.3
	W250	4.05	68.0	114.7	68.0	114.7
	W252	2.25	70.7	79.7	70.7	79.7
	W266	3.45	63.2	86.3	63.2	86.3
	W268	2.01	62.7	86.8	62.7	86.8
	W270	0.82	63.8	46.3	63.8	46.3

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Slippery Rock Creek	W272	2.41	65.6	72.0	65.6	72.0
	W274	1.30	70.4	74.2	70.4	74.2
	W276	1.53	69.2	63.3	69.2	63.3
	W278	2.58	69.1	92.3	69.1	92.3
	W280	1.05	72.9	76.6	72.9	76.6
	W282	0.16	70.7	34.6	70.7	34.6
	W284	0.90	70.1	64.1	70.1	64.1
	W286	0.31	71.8	41.5	71.8	41.5
	W288	0.11	71.0	31.0	71.1	31.0
	W290	1.32	74.8	60.6	74.8	60.6
	W292	3.96	76.8	124.8	77.3	123.2
	W294	2.11	75.6	88.2	75.6	88.2
	W296	2.63	79.1	104.3	79.2	104.0
	W298	2.44	76.7	73.8	76.7	73.8
South Branch Slippery Rock Creek	W196	2.23	72.7	54.0	72.7	54.0
	W198	2.44	74.2	76.3	74.2	76.3
	W202	1.58	64.2	62.2	64.2	62.2
	W204	0.46	75.7	31.8	75.7	31.8
	W206	2.27	67.9	77.8	67.9	77.8
	W208	1.57	71.2	67.7	71.2	67.7
	W216	3.22	73.5	62.1	73.5	62.1
	W218	3.47	74.5	79.2	74.5	79.2
	W220	0.14	76.7	25.0	76.7	25.0
	W222	0.00	68.0	3.5	68.0	3.5
	W224	2.45	73.0	69.9	73.0	69.9
	W226	3.39	70.5	104.7	70.9	103.6
	W228	4.48	71.0	101.4	71.0	101.4
	W230	0.44	68.2	36.7	68.2	36.7
	W232	0.16	70.3	24.3	70.3	24.3
	W234	1.55	66.7	74.0	66.7	74.0
	W236	0.74	67.2	63.1	67.2	63.1

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Big Run near Slippery Rock Park	W254	67.0	74.7	72.7	68.2	64.9	62.0
	W256	71.0	71.5	68.7	65.8	62.3	58.8
	W258	72.3	72.1	69.4	66.3	62.6	58.6
Blacks Creek	W166	70.7	71.8	68.7	66.4	63.9	60.3
	W168	70.1	73.3	69.4	67.3	64.9	61.5
	W170	71.1	67.8	62.7	59.3	55.3	53.2
Christy Run	W200	70.3	74.3	69.8	67.0	63.6	60.3
Findlay Run	W210	64.9	73.4	70.8	65.5	62.1	58.7
	W212	69.0	75.2	72.7	68.4	65.7	62.7
	W214	68.3	73.9	67.9	64.8	61.1	57.1
Hogue Run	W260	73.4	72.1	69.8	67.0	63.7	60.2
	W262	69.9	75.6	71.9	68.3	65.2	62.0
	W264	73.6	75.9	74.1	71.9	69.6	67.0
Long Run	W244	74.8	74.3	72.9	70.5	67.6	64.4
McDonald Run	W238	74.1	74.4	72.7	70.3	67.4	64.1
McMurray Run	W184	77.3	72.7	70.6	68.6	66.3	62.5
	W186	73.2	71.4	69.3	67.4	65.2	61.9
	W188	76.8	73.7	72.2	70.5	68.6	65.7
	W190	74.3	72.9	71.2	69.4	67.2	64.1
	W192	72.5	71.7	69.9	67.9	65.7	62.8
	W194	70.8	71.6	68.9	66.7	64.2	61.0
North Branch Slippery Rock Creek	W172	69.7	73.7	69.9	67.8	65.5	62.5
	W174	64.9	72.5	70.6	68.2	65.5	62.9
	W176	74.2	71.1	68.2	65.7	62.9	58.5
	W178	69.6	74.7	72.8	69.6	67.8	65.1
	W180	67.5	73.1	70.3	66.5	63.9	60.7
	W182	70.4	69.3	65.4	62.7	59.5	54.9
Seaton Creek	W158	69.9	71.9	68.2	66.0	63.4	59.8
	W160	67.4	71.9	66.7	64.2	61.4	57.7
	W162	59.1	60.4	57.1	54.2	51.0	47.4
	W164	69.2	67.4	62.2	58.8	54.7	49.6
Slippery Rock Creek	W150	66.8	72.1	68.9	65.6	63.1	60.0
	W152	67.0	71.3	65.9	63.5	60.6	57.0
	W154	66.0	67.1	64.0	61.3	58.2	54.7
	W156	64.8	71.1	68.0	64.0	61.5	58.0
	W240	68.5	75.3	73.4	68.7	65.9	63.0
	W242	69.7	72.7	68.5	65.6	62.1	58.5
	W246	74.5	74.4	73.2	71.0	68.5	65.8
	W248	72.4	73.1	70.8	68.2	65.2	62.2
	W250	68.0	75.9	74.4	70.8	67.2	64.5
	W252	70.7	75.0	71.7	68.7	65.8	62.9
	W266	63.2	71.0	67.7	63.3	60.9	57.4
	W268	62.7	71.6	68.6	65.8	62.6	59.3
	W270	63.8	65.0	61.8	59.1	55.9	52.3

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Slippery Rock Creek	W272	65.6	68.6	61.8	58.4	54.3	49.5
	W274	70.4	67.5	61.9	58.6	54.7	51.7
	W276	69.2	67.8	62.8	59.6	55.7	50.6
	W278	69.1	68.8	64.1	60.9	57.1	52.0
	W280	72.9	71.9	69.6	67.5	65.1	61.8
	W282	70.7	71.8	68.9	66.4	63.5	60.1
	W284	70.1	71.2	68.3	65.8	62.8	59.4
	W286	71.8	72.8	70.0	67.5	64.6	61.3
	W288	71.0	72.1	69.3	66.8	63.8	60.4
	W290	74.8	73.1	71.4	68.9	65.9	62.6
	W292	76.8	75.2	73.9	71.6	68.7	65.4
	W294	75.6	74.1	72.6	70.1	67.2	64.1
	W296	79.1	72.9	69.4	65.9	61.4	61.4
	W298	76.7	73.1	70.7	67.7	63.9	59.7
South Branch Slippery Rock Creek	W196	72.7	70.9	67.7	64.3	60.1	55.7
	W198	74.2	72.5	70.0	67.0	63.2	59.3
	W202	64.2	72.3	68.2	62.9	59.0	55.2
	W204	75.7	76.6	74.1	71.8	69.1	65.9
	W206	67.9	74.8	72.1	67.4	64.4	61.3
	W208	71.2	73.9	70.5	68.0	65.0	62.0
	W216	73.5	71.8	69.1	66.1	62.4	58.4
	W218	74.5	71.9	68.8	65.3	61.0	56.4
	W220	76.7	77.7	75.2	73.0	70.3	67.2
	W222	68.0	69.1	66.1	63.5	60.5	57.0
	W224	73.0	70.9	67.3	63.4	59.2	54.2
	W226	70.5	71.5	67.1	63.3	59.1	54.2
	W228	71.0	73.9	69.9	67.0	63.5	59.8
	W230	68.2	69.3	66.3	63.7	60.6	57.1
	W232	70.3	71.4	68.5	65.9	63.0	59.5
	W234	66.7	73.9	70.5	65.6	62.2	58.7
	W236	67.2	68.3	65.3	62.6	59.5	56.0

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Big Run near Slippery Rock Park	W254	67.1	74.8	72.8	68.4	65.1	62.1
	W256	71.0	71.5	68.7	65.8	62.3	58.8
	W258	72.5	72.3	69.6	66.5	62.8	58.8
Blacks Creek	W166	70.7	71.8	68.7	66.4	63.9	60.3
	W168	70.1	73.3	69.4	67.3	64.9	61.5
	W170	71.1	67.8	62.7	59.3	55.3	53.2
Christy Run	W200	70.3	74.3	69.8	67.0	63.6	60.3
Findlay Run	W210	64.9	73.4	70.8	65.5	62.1	58.7
	W212	69.0	75.2	72.7	68.4	65.7	62.7
	W214	68.3	73.9	67.9	64.8	61.1	57.1
Hogue Run	W260	73.4	72.1	69.8	67.0	63.7	60.2
	W262	69.9	75.6	71.9	68.3	65.2	62.0
	W264	73.6	75.9	74.1	71.9	69.6	67.0
Long Run	W244	74.9	74.4	73.0	70.6	67.7	64.5
McDonald Run	W238	74.1	74.4	72.7	70.3	67.4	64.1
McMurray Run	W184	77.3	72.7	70.6	68.6	66.3	62.5
	W186	73.2	71.4	69.3	67.4	65.2	61.9
	W188	76.8	73.7	72.3	70.5	68.6	65.7
	W190	74.6	73.2	71.5	69.6	67.5	64.4
	W192	72.5	71.7	69.9	67.9	65.7	62.8
	W194	70.8	71.6	68.9	66.7	64.2	61.0
North Branch Slippery Rock Creek	W172	69.7	73.7	69.9	67.8	65.5	62.5
	W174	64.9	72.5	70.6	68.2	65.5	62.9
	W176	74.2	71.1	68.2	65.7	62.9	58.5
	W178	69.6	74.7	72.8	69.6	67.8	65.1
	W180	67.5	73.1	70.3	66.5	63.9	60.7
	W182	70.4	69.3	65.4	62.7	59.5	54.9
Seaton Creek	W158	69.9	71.9	68.2	66.0	63.4	59.8
	W160	67.4	71.9	66.7	64.2	61.4	57.7
	W162	59.1	60.4	57.1	54.2	51.0	47.4
	W164	69.2	67.4	62.2	58.8	54.7	49.6
Slippery Rock Creek	W150	66.8	72.1	68.9	65.6	63.1	60.0
	W152	67.0	71.3	65.9	63.5	60.6	57.0
	W154	66.0	67.1	64.0	61.3	58.2	54.7
	W156	64.8	71.1	68.0	64.0	61.5	58.0
	W240	68.5	75.3	73.4	68.7	65.9	63.0
	W242	69.7	72.7	68.5	65.6	62.1	58.5
	W246	74.6	74.5	73.3	71.1	68.6	65.9
	W248	72.4	73.1	70.8	68.2	65.2	62.2
	W250	68.0	75.9	74.4	70.8	67.2	64.5
	W252	70.7	75.0	71.7	68.7	65.8	62.9
	W266	63.2	71.0	67.7	63.3	60.9	57.4
	W268	62.7	71.6	68.6	65.8	62.6	59.3
	W270	63.8	65.0	61.8	59.1	55.9	52.3

Hydrologic Parameters for Upper Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Slippery Rock Creek	W272	65.6	68.6	61.8	58.4	54.3	49.5
	W274	70.4	67.5	61.9	58.6	54.7	51.7
	W276	69.2	67.8	62.8	59.6	55.7	50.6
	W278	69.1	68.8	64.1	60.9	57.1	52.0
	W280	72.9	71.9	69.6	67.5	65.1	61.8
	W282	70.7	71.8	68.9	66.4	63.5	60.1
	W284	70.1	71.2	68.3	65.8	62.8	59.4
	W286	71.8	72.8	70.0	67.5	64.6	61.3
	W288	71.1	72.1	69.3	66.8	63.8	60.4
	W290	74.8	73.1	71.4	68.9	65.9	62.6
	W292	77.3	75.6	74.4	72.1	69.3	66.0
	W294	75.6	74.1	72.6	70.1	67.2	64.1
	W296	79.2	73.0	69.6	66.0	61.5	61.5
	W298	76.7	73.1	70.7	67.7	63.9	59.7
South Branch Slippery Rock Creek	W196	72.7	70.9	67.7	64.3	60.1	55.7
	W198	74.2	72.5	70.0	67.0	63.2	59.3
	W202	64.2	72.3	68.2	62.9	59.0	55.2
	W204	75.7	76.6	74.1	71.8	69.1	65.9
	W206	67.9	74.8	72.1	67.4	64.4	61.3
	W208	71.2	73.9	70.5	68.0	65.0	62.0
	W216	73.5	71.8	69.2	66.1	62.5	58.4
	W218	74.5	71.9	68.8	65.3	61.0	56.4
	W220	76.7	77.7	75.2	73.0	70.3	67.2
	W222	68.0	69.1	66.1	63.5	60.5	57.0
	W224	73.0	70.9	67.3	63.4	59.2	54.2
	W226	70.9	71.9	67.6	63.7	59.6	54.7
	W228	71.0	73.9	69.9	67.0	63.5	59.8
	W230	68.2	69.3	66.3	63.7	60.6	57.1
	W232	70.3	71.4	68.5	65.9	63.0	59.5
	W234	66.7	73.9	70.5	65.6	62.2	58.7
	W236	67.2	68.3	65.3	62.6	59.5	56.0

Hydrologic Results for Upper Slippery Rock Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	P228	1394210.2	644442.2	2.94	258	436	577	646	673	258	436	577	646	673
2	P061	1386670.9	659917.6	3.52	274	458	603	679	702	274	458	603	679	702
3	J4646	1383832.2	659063.0	8.60	535	968	1,275	1,444	1,506	535	968	1,275	1,444	1,506
4	J4651	1372965.9	662420.6	7.37	534	994	1,306	1,493	1,581	534	994	1,306	1,493	1,581
5	J4686	1355323.3	674813.1	4.08	276	564	732	818	811	276	564	732	818	811
6	J4689	1362160.6	668342.1	10.52	765	1,484	1,878	2,157	2,281	765	1,484	1,878	2,157	2,281
7	J4618	1365457.1	655674.9	15.07	973	1,857	2,318	2,656	2,828	973	1,857	2,318	2,656	2,828
8	J4674	1349401.7	659765.0	2.49	192	406	533	620	676	192	406	533	621	677
9	J4615	1353522.4	655461.2	8.93	646	1,349	1,770	2,049	2,187	652	1,359	1,783	2,064	2,203
10	J4583	1356147.4	650485.9	11.38	560	1,121	1,462	1,690	1,808	564	1,128	1,470	1,700	1,820
11	P229	1387861.3	631713.9	1.58	152	277	291	302	308	152	277	291	302	308
12	J4389	1369852.5	625334.5	3.26	327	632	690	760	818	327	633	690	760	819
13	J4344	1388563.4	620511.8	5.45	494	1,016	1,252	1,301	1,300	495	1,018	1,253	1,303	1,302
14	J4358	1385083.7	626463.9	11.36	967	1,962	2,400	2,480	2,467	967	1,963	2,402	2,482	2,469
15	J4418	1384195.2	629037.4	16.37	1,210	2,314	2,801	2,928	2,970	1,211	2,315	2,802	2,930	2,971
16	J4431	1380047.3	632721.2	18.82	1,031	1,916	2,311	2,420	2,448	1,032	1,916	2,312	2,421	2,449
17	J4479	1376170.8	637849.2	24.48	1,335	2,496	2,992	3,140	3,167	1,341	2,508	3,006	3,156	3,184
18	P047	1365029.8	638734.3	28.96	1,131	1,995	2,367	2,500	2,553	1,136	2,002	2,376	2,510	2,563
19	J4463	1364633.0	636841.9	30.97	1,169	2,060	2,449	2,592	2,653	1,174	2,068	2,457	2,601	2,663
20	J4415	1363595.2	635010.5	37.28	1,339	2,375	2,822	3,005	3,097	1,345	2,383	2,832	3,016	3,108
21	P050	1357948.3	637421.8	38.83	1,300	2,305	2,736	2,920	3,019	1,305	2,313	2,745	2,930	3,029
22	P051	1355933.8	630523.5	1.88	197	390	427	475	521	197	390	427	475	521
23	J4341	1352881.4	620420.2	5.36	430	851	1,012	1,083	1,190	430	851	1,012	1,083	1,190
24	P099	1350073.3	616146.9	2.32	232	461	512	555	604	235	467	519	562	612
25	J4334	1347082.0	617093.2	3.72	334	671	776	837	899	338	677	784	846	908
26	J4324	1333743.2	614926.0	5.27	463	821	973	1,068	1,145	463	821	973	1,068	1,145
27	J4564	1393935.5	649264.9	5.70	414	817	953	1,098	1,170	414	817	953	1,098	1,170
28	J4549	1388593.9	650394.3	11.65	651	1,234	1,539	1,740	1,844	651	1,234	1,539	1,740	1,844
29	J4561	1385968.9	650455.4	14.21	662	1,251	1,550	1,752	1,859	662	1,251	1,550	1,752	1,859
30	J4569	1378612.7	655186.5	27.11	1,316	2,411	3,065	3,438	3,585	1,316	2,411	3,065	3,438	3,585
31	J4598	1371744.9	655064.4	37.26	1,849	3,370	4,309	4,840	5,075	1,849	3,370	4,309	4,840	5,075
32	J4589	1367593.7	650333.3	54.94	2,878	5,315	6,729	7,608	8,016	2,878	5,315	6,729	7,608	8,016
33	J4554	1357765.2	642916.1	70.74	2,675	4,917	6,182	6,963	7,351	2,677	4,920	6,186	6,967	7,357
34	J_Northern_Slippery_Rock	1353515.3	637123.9	71.79	2,437	4,432	5,554	6,248	6,604	2,439	4,435	5,558	6,253	6,609

Hydrologic Results for Upper Slippery Rock Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J4476	1353583.5	636567.2	111.36	3,704	6,678	8,218	9,093	9,548	3,711	6,689	8,230	9,106	9,563
36	J4460	1351385.8	637147.1	115.47	3,784	6,826	8,403	9,301	9,776	3,791	6,836	8,416	9,315	9,791
37	J4428	1350195.3	631561.3	119.40	3,712	6,657	8,193	9,103	9,585	3,719	6,667	8,206	9,116	9,600
38	J4451	1346746.2	633209.6	123.54	3,786	6,791	8,361	9,293	9,793	3,793	6,801	8,374	9,307	9,808
39	J4446	1346196.8	632385.4	125.21	3,801	6,823	8,401	9,339	9,846	3,808	6,833	8,414	9,352	9,861
40	J4364	1343785.4	624357.8	134.14	3,818	6,902	8,508	9,460	10,000	3,825	6,912	8,521	9,473	10,014
41	J4367	1337894.4	622831.6	145.18	3,938	7,097	8,741	9,716	10,282	3,946	7,109	8,756	9,731	10,299
42	J4383	1331057.1	624846.1	147.29	3,957	7,126	8,777	9,759	10,331	3,965	7,138	8,791	9,774	10,348
43	J4399	1327760.6	626097.6	157.38	4,042	7,273	8,958	9,960	10,569	4,051	7,285	8,972	9,975	10,586
44	J_UpperSlipperyRock_Outlet	1320177.9	630849.7	159.82	4,041	7,269	8,956	9,959	10,570	4,049	7,280	8,970	9,974	10,587

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Bear Run	W330	3.41	74.7	76.2	74.7	76.2
Big Run near Lake Arthur	W314	1.11	75.0	55.4	75.0	55.4
	W316	0.90	68.1	46.5	68.1	46.5
	W318	1.31	69.5	63.6	69.5	63.6
	W320	1.64	74.2	60.1	74.2	60.1
	W324	0.10	83.5	15.9	83.5	15.9
	W326	2.03	73.2	61.7	73.2	61.7
	W328	0.30	83.7	26.6	83.7	26.6
Black Run	W342	1.22	76.5	43.3	76.5	43.3
	W348	3.54	74.6	88.3	74.6	88.3
	W350	2.18	74.2	86.4	74.2	86.4
	W352	0.76	79.9	53.5	79.9	53.5
Cheeseman Run	W398	2.34	76.1	54.8	76.1	54.8
Hell Run	W400	2.50	77.3	71.7	77.3	71.7
	W402	3.49	73.6	84.3	73.6	84.3
Jamison Run	W336	1.27	71.7	78.0	71.7	78.0
	W338	3.21	75.8	116.7	75.8	116.7
	W340	2.11	78.2	88.8	78.2	88.8
	W376	2.38	77.2	128.5	77.2	128.5
	W378	0.71	77.3	59.9	77.3	59.9
	W380	1.06	74.8	66.6	74.8	66.6
	W382	1.71	71.3	89.6	71.3	89.6
Muddy Creek	W300	2.49	59.4	102.8	59.4	102.8
	W332	1.34	65.1	63.6	65.1	63.6
	W334	2.07	68.9	78.2	68.8	78.4
	W408	0.90	71.8	44.0	71.8	44.0
	W410	4.31	67.2	99.0	67.2	99.0
	W412	4.56	65.3	85.0	65.3	85.0
	W414	4.75	66.1	107.5	66.1	107.5
	W416	1.84	72.9	59.6	72.9	59.6
	W418	0.09	90.1	17.0	90.1	17.0
	W420	4.21	73.0	71.7	73.0	71.7
	W424	2.65	77.9	85.8	77.9	85.8
	W426	0.35	79.6	49.8	79.6	49.8
	W428	0.01	98.0	14.6	98.0	14.6
	W430	0.03	98.0	89.9	98.0	692.8
	W432	0.13	78.4	30.5	78.4	30.5
	W434	3.73	74.0	93.6	74.0	93.4
	W436	3.51	74.0	95.5	73.9	95.7
Shannon Run	W306	1.00	72.6	64.5	72.6	64.5
	W308	1.45	71.6	52.6	71.5	52.8
	W310	1.08	68.9	63.0	68.9	63.0
	W312	0.66	75.4	37.8	75.4	37.8
Skunk Run	W404	1.74	74.2	68.2	74.2	68.2

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Slippery Rock Creek	W344	1.03	72.3	49.0	72.3	49.0
	W346	1.18	74.9	63.5	74.9	63.5
	W354	0.52	72.2	38.0	72.2	38.0
	W356	1.25	72.2	62.8	72.2	62.8
	W372	4.92	75.3	108.2	75.4	108.2
	W374	3.51	73.1	107.4	73.1	107.4
	W384	0.16	67.8	42.6	67.8	42.6
	W385	0.05	64.3	19.9	64.3	19.9
	W386	2.43	69.2	83.6	69.2	83.6
	W388	3.07	71.1	88.2	71.1	88.2
	W390	0.63	69.1	48.9	69.1	48.9
	W392	1.86	76.2	79.3	76.2	79.3
	W394	4.02	75.3	79.7	75.3	79.7
	W396	0.12	74.0	24.8	74.0	24.8
	W406	3.49	70.8	65.9	70.8	65.9
	W438	0.74	68.7	46.9	68.7	46.9
	W440	2.98	74.7	63.6	74.8	63.3
	W442	3.02	72.6	55.1	72.6	55.1
	W444	2.35	71.4	49.5	71.4	49.5
	W446	3.09	69.7	59.6	69.7	59.6
	W448	2.94	70.7	55.9	70.7	55.9
	W450	1.66	69.6	50.9	69.6	50.9
Swamp Run	W302	2.72	66.2	72.2	66.6	71.3
	W304	3.78	71.3	80.4	71.3	80.4
Taylor Run	W358	1.58	77.9	59.8	77.9	59.8
	W360	1.12	76.4	62.8	76.4	62.8
	W362	1.70	78.1	71.8	78.1	71.8
	W364	4.08	76.8	87.4	76.8	87.4
	W366	2.33	77.0	90.5	77.0	90.5
	W368	0.08	69.6	19.7	69.6	19.7
	W370	2.52	68.6	104.8	68.6	104.8

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Bear Run	W330	74.7	68.6	62.0	59.0	55.3	55.3
Big Run near Lake Arthur	W314	75.0	71.6	68.2	65.8	63.1	58.3
	W316	68.1	66.7	63.3	60.9	58.3	54.0
	W318	69.5	69.1	64.2	61.1	57.5	51.5
	W320	74.2	71.5	68.0	65.7	63.1	57.9
	W324	83.5	82.6	80.4	78.7	76.8	73.5
	W326	73.2	67.7	60.7	57.3	53.4	53.4
	W328	83.7	82.8	80.5	78.9	77.0	73.8
Black Run	W342	76.5	71.3	67.6	65.3	62.6	58.1
	W348	74.6	72.5	69.4	67.2	64.7	59.8
	W350	74.2	73.0	70.3	68.4	66.2	61.9
	W352	79.9	78.8	76.2	74.3	72.2	68.5
Cheeseman Run	W398	76.1	71.7	68.0	65.7	63.0	58.8
Hell Run	W400	77.3	72.9	70.0	67.9	65.5	61.6
	W402	73.6	72.6	69.8	67.7	65.4	60.0
Jamison Run	W336	71.7	68.5	62.1	58.2	54.2	52.0
	W338	75.8	73.9	71.4	69.4	67.1	62.7
	W340	78.2	74.3	72.4	70.6	68.6	64.5
	W376	77.2	75.8	74.8	73.5	72.1	68.8
	W378	77.3	76.1	73.3	71.3	69.0	65.1
	W380	74.8	73.3	71.3	69.7	67.9	63.8
	W382	71.3	76.1	73.7	71.0	69.4	66.4
Muddy Creek	W300	59.4	71.8	68.6	66.0	62.9	58.0
	W332	65.1	71.6	64.7	61.9	58.7	53.0
	W334	68.9	72.1	66.4	63.8	60.7	55.5
	W408	71.8	70.5	67.3	65.0	62.5	58.3
	W410	67.2	73.1	67.2	64.7	61.9	57.2
	W412	65.3	72.1	66.7	63.3	60.3	55.0
	W414	66.1	72.1	65.1	62.2	58.8	53.6
	W416	72.9	68.2	61.7	57.7	53.7	53.0
	W418	90.1	89.5	88.0	86.9	85.6	83.3
	W420	73.0	67.0	59.7	56.7	53.2	53.2
	W424	77.9	67.7	62.8	61.3	59.7	59.7
	W426	79.6	78.6	75.9	74.1	71.9	68.2
	W428	98.0	97.9	97.5	97.3	97.0	96.4
	W430	98.0	97.9	97.5	97.3	97.0	96.4
	W432	78.4	77.4	74.6	72.6	70.4	66.6
	W434	74.0	72.8	70.0	67.8	65.3	60.3
	W436	74.0	73.3	70.8	69.0	66.8	62.8
Shannon Run	W306	72.6	71.5	68.0	65.7	63.1	58.4
	W308	71.6	71.0	67.7	65.5	63.0	58.0
	W310	68.9	70.8	65.3	62.6	59.4	54.3
	W312	75.4	74.2	71.2	69.1	66.7	62.7
Skunk Run	W404	74.2	72.6	70.1	68.2	66.1	62.0

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Slippery Rock Creek	W344	72.3	70.8	67.2	64.8	62.1	56.9
	W346	74.9	73.1	70.9	69.3	67.4	63.5
	W354	72.2	70.9	67.7	65.4	62.9	58.7
	W356	72.2	69.9	65.0	62.1	58.7	53.8
	W372	75.3	73.5	71.0	69.1	66.8	62.1
	W374	73.1	75.0	72.1	70.5	68.7	65.5
	W384	67.8	66.4	63.0	60.6	57.9	53.6
	W385	64.3	62.9	59.3	56.8	54.1	49.7
	W386	69.2	74.8	71.7	68.6	66.6	63.3
	W388	71.1	74.2	70.1	68.2	66.1	61.6
	W390	69.1	67.8	64.4	62.0	59.4	55.1
	W392	76.2	73.6	71.3	69.5	67.5	63.2
	W394	75.3	72.5	69.4	67.2	64.6	59.8
	W396	74.0	72.8	69.7	67.5	65.0	60.9
	W406	70.8	71.8	68.0	65.9	63.4	58.5
	W438	68.7	67.3	63.9	61.6	58.9	54.6
	W440	74.7	71.0	66.9	64.3	61.3	56.7
	W442	72.6	70.7	67.0	64.6	61.8	55.9
	W444	71.4	70.6	66.9	64.6	62.0	57.3
	W446	69.7	72.0	67.4	65.2	62.6	57.7
	W448	70.7	70.9	67.5	65.2	62.5	58.4
	W450	69.6	72.8	68.1	66.1	63.9	59.8
Swamp Run	W302	66.2	73.1	69.3	65.6	63.3	59.1
	W304	71.3	68.0	61.7	57.2	53.4	51.1
Taylor Run	W358	77.9	72.6	69.5	67.3	64.7	60.7
	W360	76.4	73.1	70.7	68.9	66.9	62.1
	W362	78.1	73.4	70.9	68.9	66.7	63.1
	W364	76.8	72.6	69.0	66.7	63.9	59.4
	W366	77.0	74.1	72.0	70.2	68.2	63.9
	W368	69.6	68.2	64.9	62.5	59.9	55.6
	W370	68.6	75.0	72.0	68.7	66.8	62.6

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Bear Run	W330	74.7	68.6	62.0	59.0	55.4	55.4
Big Run near Lake Arthur	W314	75.0	71.6	68.2	65.8	63.1	58.3
	W316	68.1	66.7	63.3	60.9	58.3	54.0
	W318	69.5	69.1	64.2	61.1	57.5	51.5
	W320	74.2	71.5	68.0	65.7	63.1	57.9
	W324	83.5	82.6	80.4	78.7	76.8	73.5
	W326	73.2	67.7	60.7	57.3	53.4	53.4
	W328	83.7	82.8	80.5	78.9	77.0	73.8
Black Run	W342	76.5	71.3	67.6	65.3	62.6	58.1
	W348	74.6	72.5	69.4	67.2	64.7	59.8
	W350	74.2	73.0	70.3	68.4	66.2	61.9
	W352	79.9	78.8	76.2	74.3	72.2	68.5
Cheeseman Run	W398	76.1	71.7	68.0	65.7	63.0	58.8
Hell Run	W400	77.3	72.9	70.0	67.9	65.5	61.6
	W402	73.6	72.6	69.8	67.7	65.4	60.0
Jamison Run	W336	71.7	68.5	62.1	58.2	54.2	52.0
	W338	75.8	73.9	71.4	69.4	67.1	62.7
	W340	78.2	74.3	72.4	70.6	68.6	64.5
	W376	77.2	75.8	74.8	73.5	72.1	68.8
	W378	77.3	76.1	73.3	71.3	69.0	65.1
	W380	74.8	73.2	71.3	69.7	67.9	63.8
	W382	71.3	76.1	73.7	71.0	69.4	66.4
Muddy Creek	W300	59.4	71.8	68.6	66.0	62.9	58.0
	W332	65.1	71.6	64.7	61.9	58.7	53.0
	W334	68.8	72.0	66.4	63.7	60.6	55.4
	W408	71.8	70.5	67.3	65.0	62.5	58.3
	W410	67.2	73.1	67.2	64.7	61.9	57.2
	W412	65.3	72.1	66.7	63.3	60.3	55.0
	W414	66.1	72.1	65.1	62.2	58.8	53.6
	W416	72.9	68.2	61.7	57.7	53.7	53.0
	W418	90.1	89.5	88.0	86.9	85.6	83.3
	W420	73.0	67.0	59.7	56.7	53.2	53.2
	W424	77.9	67.7	62.8	61.3	59.7	59.7
	W426	79.6	78.6	75.9	74.1	71.9	68.2
	W428	98.0	97.9	97.5	97.3	97.0	96.4
	W430	98.0	97.9	97.5	97.3	97.0	96.4
	W432	78.4	77.4	74.6	72.6	70.4	66.6
	W434	74.0	72.9	70.0	67.9	65.4	60.4
	W436	73.9	73.2	70.8	68.9	66.8	62.7
Shannon Run	W306	72.6	71.5	68.0	65.7	63.1	58.4
	W308	71.5	70.9	67.6	65.4	62.9	57.9
	W310	68.9	70.8	65.3	62.6	59.4	54.3
	W312	75.4	74.2	71.2	69.1	66.7	62.7
Skunk Run	W404	74.2	72.6	70.1	68.2	66.1	62.0

Hydrologic Parameters for Lower Slippery Rock Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Slippery Rock Creek	W344	72.3	70.8	67.2	64.8	62.1	56.9
	W346	74.9	73.1	70.9	69.3	67.4	63.5
	W354	72.2	70.9	67.7	65.4	62.9	58.7
	W356	72.2	69.9	65.0	62.1	58.7	53.8
	W372	75.4	73.5	71.0	69.1	66.8	62.1
	W374	73.1	75.0	72.1	70.5	68.7	65.5
	W384	67.8	66.4	63.0	60.6	57.9	53.6
	W385	64.3	62.9	59.3	56.8	54.1	49.7
	W386	69.2	74.8	71.7	68.6	66.6	63.3
	W388	71.1	74.2	70.1	68.2	66.1	61.6
	W390	69.1	67.8	64.4	62.0	59.4	55.1
	W392	76.2	73.6	71.3	69.5	67.5	63.2
	W394	75.3	72.5	69.4	67.2	64.6	59.8
	W396	74.0	72.8	69.7	67.5	65.0	60.9
	W406	70.8	71.8	68.0	65.9	63.4	58.5
	W438	68.7	67.3	63.9	61.6	58.9	54.6
	W440	74.8	71.2	67.1	64.5	61.4	56.8
	W442	72.6	70.7	67.0	64.6	61.8	55.9
	W444	71.4	70.6	66.9	64.6	62.0	57.3
	W446	69.7	72.0	67.4	65.2	62.6	57.7
	W448	70.7	70.9	67.5	65.2	62.5	58.4
	W450	69.6	72.8	68.1	66.1	63.9	59.8
Swamp Run	W302	66.6	73.5	69.8	66.1	63.8	59.6
	W304	71.3	68.0	61.7	57.2	53.4	51.1
Taylor Run	W358	77.9	72.6	69.5	67.3	64.7	60.7
	W360	76.4	73.1	70.7	68.9	66.9	62.1
	W362	78.1	73.4	70.9	68.9	66.7	63.1
	W364	76.8	72.6	69.0	66.7	63.9	59.4
	W366	77.0	74.1	72.0	70.2	68.2	63.9
	W368	69.6	68.2	64.9	62.5	59.9	55.6
	W370	68.6	75.0	72.0	68.7	66.8	62.6

Hydrologic Results for Lower Slippery Rock Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J4370	1316375.3	621763.3	3.54	268	526	686	779	753	268	526	686	779	753
2	J4361	1311918.9	623991.5	6.94	454	881	1,155	1,322	1,302	454	881	1,155	1,322	1,302
3	J4586	1313261.9	650699.5	3.65	237	463	600	693	750	237	463	600	693	750
4	J4532	1312315.7	644716.9	7.57	503	969	1,255	1,440	1,505	503	969	1,255	1,440	1,505
5	J4509	1313200.9	637299.7	10.74	697	1,335	1,732	1,993	2,068	697	1,335	1,732	1,993	2,068
6	J4539	1299526.3	647097.8	5.66	450	854	1,109	1,249	1,245	450	854	1,109	1,250	1,246
7	J4502	1304043.8	639802.7	9.11	687	1,320	1,724	1,966	1,972	687	1,320	1,724	1,967	1,973
8	J4486	1303799.6	638062.8	10.89	790	1,517	1,983	2,267	2,290	790	1,517	1,983	2,268	2,291
9	P057	1350470.1	595970.9	2.72	254	466	550	640	640	267	486	574	668	669
10	P054	1339664.7	588950.5	1.45	137	278	369	423	399	135	274	366	419	395
11	J4212	1337619.7	593376.4	3.53	302	576	761	861	813	300	573	757	856	809
12	J4185	1327852.1	586417.1	2.75	256	501	658	746	702	256	500	658	745	702
13	J4201	1326875.4	588614.7	3.75	236	470	626	715	679	236	470	626	714	679
14	J4228	1324921.9	594566.8	7.09	283	518	682	756	788	283	518	682	756	788
15	P226	1377758.1	609614.9	0.90	92	189	252	289	289	92	189	252	289	289
16	J4307	1365335.0	602869.2	7.70	539	934	1,218	1,366	1,332	539	934	1,218	1,366	1,332
17	J4282	1355537.0	603784.9	12.26	710	1,200	1,540	1,724	1,666	710	1,200	1,540	1,724	1,666
18	J4287	1339206.9	602197.7	17.01	624	1,000	1,259	1,398	1,353	624	1,000	1,259	1,398	1,353
19	J4244	1337528.1	597588.7	25.35	782	1,260	1,564	1,743	1,724	785	1,264	1,569	1,748	1,730
20	J4236	1335940.9	597039.2	29.63	849	1,376	1,713	1,914	1,898	852	1,380	1,718	1,920	1,905
21	J4251	1324982.9	598016.0	41.23	975	1,600	2,010	2,247	2,276	978	1,606	2,016	2,255	2,285
22	J4233	1315581.7	600335.8	47.29	1,025	1,689	2,125	2,371	2,462	1,029	1,694	2,131	2,378	2,470
23	J4276	1314452.3	603937.5	48.98	1,043	1,714	2,154	2,402	2,500	1,047	1,719	2,160	2,409	2,507
24	J4279	1314299.7	603479.7	51.06	1,070	1,755	2,206	2,459	2,562	1,073	1,760	2,212	2,466	2,569
25	USGS 03106300	1312651.4	602594.5	51.22	51	84	115	132	144	51	84	115	132	144
26	J4273	1303708.1	606959.4	54.95	280	550	718	818	786	282	554	722	824	792
27	J4290	1295527.8	605341.6	5.88	499	983	1,289	1,478	1,455	499	983	1,289	1,478	1,455
28	J4239	1277488.4	595970.9	2.50	230	452	593	680	699	230	452	593	680	699
29	J4425	1319606.3	630829.2	264.21	6,206	11,357	14,308	16,075	17,635	6,215	11,369	14,322	16,091	17,652
30	P289	1317596.3	629150.0	265.24	6,215	11,371	14,326	16,094	17,654	6,223	11,383	14,340	16,110	17,672
31	J4386	1311064.2	625059.8	274.12	6,191	11,295	14,217	15,964	17,500	6,199	11,306	14,231	15,979	17,517
32	J4394	1308988.6	628142.7	287.09	6,298	11,466	14,427	16,204	17,761	6,307	11,477	14,441	16,219	17,777
33	J4402	1305203.7	626250.2	288.50	6,310	11,484	14,449	16,229	17,786	6,318	11,495	14,463	16,244	17,803
34	J4331	1304043.8	626738.1	301.96	6,446	11,714	14,739	16,561	18,143	6,455	11,726	14,753	16,577	18,160

Hydrologic Results for Lower Slippery Rock Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J4139	1298335.9	621580.1	309.31	6,522	11,842	14,897	16,743	18,337	6,530	11,854	14,911	16,758	18,354
36	J4321	1295314.1	614498.7	315.89	6,590	11,953	15,036	16,904	18,512	6,598	11,965	15,050	16,919	18,529
37	J4312	1297694.9	609126.5	374.98	6,625	12,036	15,151	17,038	18,656	6,633	12,047	15,164	17,053	18,673
38	J4295	1297084.5	605891.0	381.72	6,686	12,140	15,281	17,187	18,814	6,694	12,151	15,295	17,202	18,831
39	J4220	1297542.3	594047.9	387.04	6,724	12,213	15,372	17,289	18,923	6,733	12,224	15,386	17,304	18,940
40	J4209	1287255.9	585898.2	396.05	6,792	12,347	15,540	17,480	19,122	6,800	12,358	15,554	17,496	19,139
41	J4180	1284325.6	581380.7	400.14	6,799	12,387	15,594	17,542	19,187	6,807	12,399	15,607	17,558	19,205
42	USGS 03106500	1281792.2	574604.5	403.23	6,811	12,428	15,646	17,602	19,250	6,819	12,440	15,660	17,618	19,267
43	J4059	1281151.2	566668.4	409.66	6,741	12,360	15,606	17,573	19,219	6,750	12,371	15,620	17,588	19,237
44	J_LowerSlipperyRock_Outlet	1275587.5	565396.1	411.32	6,742	12,374	15,631	17,603	19,254	6,751	12,385	15,644	17,619	19,271

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Bonnie Brook	W584	1.11	70.8	46.0	70.8	46.0
	W586	1.84	70.1	52.4	70.1	52.4
	W588	0.74	65.1	48.8	65.1	48.8
	W590	2.30	63.7	74.2	63.7	74.2
	W592	1.58	60.9	55.1	60.9	55.1
	W594	3.14	66.2	77.0	66.2	77.0
	W596	1.95	67.0	67.8	67.0	67.8
	W598	3.48	68.1	84.1	68.2	84.1
	W600	4.17	67.5	98.7	67.5	98.6
Butcher Run	W614	4.12	75.6	74.7	75.7	74.6
Coal Run	W602	3.32	74.5	54.9	74.5	54.9
	W604	2.21	67.0	75.6	67.0	75.6
	W606	1.02	73.9	46.1	74.0	46.0
Connoquenessing Creek	W558	2.33	65.1	63.1	65.1	63.1
	W560	3.79	65.1	87.0	65.2	86.7
	W572	1.86	73.9	56.6	74.1	56.2
	W658	1.18	71.7	71.1	71.7	71.1
	W660	1.02	73.8	77.7	73.6	78.2
	W662	1.93	76.8	85.8	76.8	85.8
	W664	1.43	72.3	71.0	72.4	70.7
	W666	0.60	59.2	51.7	59.1	51.8
	W668	1.36	70.5	56.0	70.1	56.6
	W704	1.04	72.1	43.6	72.1	43.6
	W706	2.49	69.3	65.4	69.3	65.4
	W708	0.04	67.0	19.6	67.0	19.6
	W710	4.68	67.4	80.2	67.4	80.2
	W712	2.89	68.4	78.3	68.4	78.3
	W714	0.49	64.0	45.9	64.4	45.4
	W716	1.50	70.1	50.7	70.1	50.7
	W718	1.08	71.7	44.4	71.7	44.4
	W720	0.75	71.5	33.2	71.6	33.2
	W722	2.22	74.9	55.6	76.6	52.9
	W724	0.89	73.4	57.5	73.4	57.5
	W726	0.90	85.3	34.1	85.3	34.1
	W728	2.09	79.4	47.9	79.4	47.9
	W730	1.83	75.3	47.5	76.8	45.4
	W732	0.06	68.3	15.9	68.3	15.9
	W734	1.52	65.3	57.6	65.3	57.6
	W736	0.77	66.3	35.7	66.3	35.7
	W738	0.54	60.3	48.3	60.4	48.3
	W740	1.85	64.0	78.6	64.0	78.6
	W742	1.22	60.7	75.4	60.7	75.4
	W744	1.57	77.9	49.2	78.1	48.9
	W746	2.87	66.3	99.5	66.3	99.4

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Connoquenessing Creek	W748	1.53	64.9	63.4	64.9	63.4
	W750	3.53	73.1	84.0	73.1	84.0
Davis Run	W622	2.44	73.2	66.9	73.1	67.0
	W640	2.66	78.2	63.4	78.4	63.0
	W642	0.12	70.0	16.5	70.0	16.5
Glade Run	W670	3.04	72.0	74.7	72.0	74.6
	W672	1.33	72.9	55.3	73.3	54.6
	W674	3.47	73.7	90.0	74.0	89.1
	W676	2.93	74.3	80.3	74.5	79.9
	W678	2.13	70.5	65.3	70.6	65.1
	W680	4.47	71.2	89.7	71.5	88.9
	W682	0.19	61.9	35.2	61.9	35.2
	W684	4.81	67.6	107.9	67.7	107.7
	W686	1.05	72.3	47.0	72.3	46.9
	W688	3.27	68.9	91.2	68.6	92.0
	W690	4.00	72.2	84.7	72.2	84.7
	W692	1.20	77.6	47.9	79.0	45.9
	W694	2.63	72.3	68.5	72.3	68.5
	W696	1.20	64.9	64.4	64.9	64.4
	W698	3.53	68.3	80.0	68.3	79.9
	W700	0.47	64.7	38.4	64.7	38.4
	W702	1.32	67.4	55.0	67.3	55.1
Patterson Run	W650	3.59	69.2	88.1	69.2	88.2
Pine Run	W562	3.84	68.5	83.7	68.5	83.7
Robinson Run	W632	2.52	70.1	74.6	70.3	74.3
Rocklick Run	W620	1.10	72.6	57.7	72.6	57.7
Sawmill Run	W616	2.82	76.5	78.7	76.5	78.7
	W618	0.48	74.6	31.3	79.8	26.8
Stony Run	W564	3.08	70.2	71.1	70.2	71.1
	W566	4.36	68.3	75.0	68.3	74.9
	W568	1.34	70.4	61.7	70.4	61.7
	W570	0.38	59.9	37.9	59.9	37.9
Sullivan Run	W608	2.43	76.2	56.0	77.0	54.7
	W610	2.62	75.4	61.3	76.0	60.4
	W612	1.55	83.6	38.2	83.9	38.0
Thorn Creek	W574	1.29	74.2	41.4	74.2	41.4
	W576	1.04	70.7	40.6	70.7	40.6
	W578	2.63	65.7	78.6	65.7	78.6
	W580	1.51	71.8	50.0	71.8	50.0
	W582	1.22	70.1	51.1	70.2	51.1
	W626	3.96	78.8	77.8	78.8	77.8
	W628	4.56	78.6	82.4	78.6	82.4
	W630	1.64	78.9	62.9	79.5	61.7
	W634	1.84	77.8	48.2	77.8	48.2

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Thorn Creek	W636	2.10	69.5	67.1	69.6	67.0
	W638	2.17	75.0	87.6	75.3	87.0
	W644	2.37	73.5	70.4	73.5	70.4
	W646	3.73	73.0	64.6	73.0	64.6
	W648	1.96	72.1	57.7	72.1	57.7
	W652	1.44	64.4	56.4	64.4	56.4
	W654	0.95	72.8	45.1	74.0	43.6
	W656	1.58	66.0	57.3	66.0	57.2
Vaur Run	W624	2.73	79.5	77.8	79.7	77.3

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Bonnie Brook	W584	70.8	70.1	65.9	63.5	60.6	57.8
	W586	70.1	70.0	65.7	63.2	60.5	57.5
	W588	65.1	64.6	60.8	58.1	54.9	52.8
	W590	63.7	72.0	67.5	64.6	62.6	60.8
	W592	60.9	70.6	66.0	63.1	60.3	58.7
	W594	66.2	72.4	67.1	64.5	62.2	59.7
	W596	67.0	72.7	67.8	65.3	63.1	60.9
	W598	68.1	72.9	67.7	65.5	63.0	60.3
	W600	67.5	73.7	69.4	66.8	65.0	62.8
Butcher Run	W614	75.6	71.5	67.1	62.9	58.8	57.2
Coal Run	W602	74.5	70.1	65.0	62.2	58.9	57.1
	W604	67.0	72.9	68.1	65.6	63.5	60.9
	W606	73.9	70.4	65.7	63.1	60.0	57.5
Connoquenessing Creek	W558	65.1	71.8	66.6	63.8	61.5	58.9
	W560	65.1	72.4	67.6	64.5	62.6	60.3
	W572	73.9	70.8	66.4	63.8	60.8	58.1
	W658	71.7	73.2	69.8	67.2	64.2	62.2
	W660	73.8	73.2	71.1	68.7	65.9	64.7
	W662	76.8	73.2	70.3	67.4	63.7	61.3
	W664	72.3	72.2	69.2	66.4	63.2	60.8
	W666	59.2	58.6	54.7	51.9	48.7	46.5
	W668	70.5	71.3	67.3	64.2	60.5	59.1
	W704	72.1	70.4	66.4	63.1	59.2	56.8
	W706	69.3	71.8	66.5	64.1	61.4	59.5
	W708	67.0	66.4	62.8	60.1	57.0	54.8
	W710	67.4	72.1	66.1	63.5	60.4	57.4
	W712	68.4	68.7	62.2	58.8	54.7	50.8
	W714	64.0	63.4	59.7	56.9	55.9	51.6
	W716	70.1	70.6	66.4	64.1	61.4	60.0
	W718	71.7	70.4	66.3	63.9	61.3	58.9
	W720	71.5	71.0	67.6	65.0	62.1	60.0
	W722	74.9	70.7	66.0	63.3	60.2	57.2
	W724	73.4	72.9	69.6	67.1	64.3	62.2
	W726	85.3	84.9	82.8	81.1	79.1	77.6
	W728	79.4	71.5	66.6	64.6	62.4	61.8
	W730	75.3	69.1	62.5	59.9	56.8	56.1
	W732	68.3	67.8	64.2	61.5	58.5	56.4
	W734	65.3	72.1	67.2	63.8	61.2	59.1
	W736	66.3	65.8	62.1	59.3	56.2	54.1
	W738	60.3	59.7	55.8	53.0	49.8	47.7
	W740	64.0	73.0	69.6	65.9	62.8	61.1
	W742	60.7	72.9	70.3	67.3	63.6	60.7
	W744	77.9	72.0	67.9	63.9	59.7	59.7
	W746	66.3	74.3	70.8	67.3	64.8	63.5

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Connoquenessing Creek	W748	64.9	72.6	68.4	64.7	62.5	60.8
	W750	73.1	72.3	68.9	65.9	62.2	59.3
Davis Run	W622	73.2	71.4	67.4	64.0	59.9	58.3
	W640	78.2	71.9	67.5	64.4	60.8	60.5
	W642	70.0	69.5	66.0	63.4	60.4	58.3
Glade Run	W670	72.0	71.4	67.7	64.5	60.7	58.0
	W672	72.9	71.2	67.4	64.2	60.3	57.7
	W674	73.7	72.5	69.2	66.1	62.4	60.0
	W676	74.3	72.0	68.5	65.3	61.3	58.1
	W678	70.5	72.0	67.6	64.5	60.9	58.6
	W680	71.2	72.5	68.3	65.3	61.5	59.5
	W682	61.9	61.3	57.4	54.6	51.4	49.3
	W684	67.6	74.0	70.0	66.8	64.5	62.5
	W686	72.3	70.8	67.0	63.9	60.0	56.9
	W688	68.9	73.8	69.2	66.4	63.4	61.2
	W690	72.2	70.9	66.4	62.2	57.9	55.3
	W692	77.6	71.6	67.5	63.4	59.2	59.2
	W694	72.3	71.4	67.7	64.5	60.6	58.3
	W696	64.9	72.7	68.9	64.9	62.8	61.3
	W698	68.3	73.3	68.1	65.3	61.9	61.4
	W700	64.7	64.1	60.4	57.6	54.5	52.3
	W702	67.4	72.6	67.7	64.8	61.7	59.4
Patterson Run	W650	69.2	73.5	68.4	65.4	61.9	59.5
Pine Run	W562	68.5	73.1	67.6	65.4	62.9	60.7
Robinson Run	W632	70.1	72.4	67.6	64.6	60.9	57.7
Rocklick Run	W620	72.6	71.5	68.1	65.2	61.6	58.6
Sawmill Run	W616	76.5	71.9	67.8	63.6	59.4	57.8
	W618	74.6	74.1	70.9	68.5	65.7	63.7
Stony Run	W564	70.2	71.5	66.9	64.5	61.8	59.5
	W566	68.3	72.2	66.3	63.7	60.8	58.4
	W568	70.4	72.2	67.8	65.7	63.4	60.8
	W570	59.9	59.3	55.4	52.5	49.3	47.2
Sullivan Run	W608	76.2	71.1	66.4	63.8	60.8	59.3
	W610	75.4	71.1	66.7	64.1	61.1	58.9
	W612	83.6	72.8	71.0	69.9	68.8	68.2
Thorn Creek	W574	74.2	70.1	65.4	62.8	59.8	58.2
	W576	70.7	69.4	64.7	62.0	59.0	56.5
	W578	65.7	72.7	67.9	65.1	63.3	60.9
	W580	71.8	70.0	65.4	62.8	59.7	57.7
	W582	70.1	69.4	64.2	61.3	58.0	55.7
	W626	78.8	72.2	67.5	64.8	61.6	60.9
	W628	78.6	72.5	68.2	65.1	61.3	61.0
	W630	78.9	72.6	68.7	65.6	61.7	61.1
	W634	77.8	71.0	66.2	63.4	60.2	59.5

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Thorn Creek	W636	69.5	72.7	67.4	64.4	60.9	57.6
	W638	75.0	72.8	69.6	66.7	63.2	60.4
	W644	73.5	71.8	68.2	65.1	61.3	58.4
	W646	73.0	70.6	66.1	62.1	58.1	56.1
	W648	72.1	70.9	66.8	63.6	59.6	56.7
	W652	64.4	71.9	67.1	63.5	61.0	58.1
	W654	72.8	72.3	69.0	66.5	63.6	61.6
	W656	66.0	72.0	67.1	63.9	60.7	57.9
Vaur Run	W624	79.5	72.9	68.9	66.0	62.6	62.6

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Bonnie Brook	W584	70.8	70.1	65.9	63.5	60.6	57.8
	W586	70.1	70.0	65.7	63.2	60.5	57.5
	W588	65.1	64.6	60.8	58.1	54.9	52.8
	W590	63.7	72.0	67.5	64.6	62.6	60.8
	W592	60.9	70.6	66.0	63.1	60.3	58.7
	W594	66.2	72.4	67.1	64.5	62.2	59.7
	W596	67.0	72.7	67.8	65.3	63.1	60.9
	W598	68.2	73.0	67.8	65.6	63.1	60.3
	W600	67.5	73.7	69.4	66.8	65.0	62.8
Butcher Run	W614	75.7	71.5	67.2	63.0	58.9	57.3
Coal Run	W602	74.5	70.1	65.0	62.2	58.9	57.1
	W604	67.0	72.9	68.1	65.6	63.5	60.9
	W606	74.0	70.5	65.8	63.2	60.2	57.6
Connoquenessing Creek	W558	65.1	71.8	66.6	63.8	61.5	58.9
	W560	65.2	72.5	67.7	64.6	62.7	60.5
	W572	74.1	71.0	66.7	64.1	61.1	58.4
	W658	71.7	73.2	69.8	67.2	64.2	62.2
	W660	73.6	73.0	70.8	68.4	65.6	64.5
	W662	76.8	73.2	70.3	67.4	63.7	61.3
	W664	72.4	72.3	69.3	66.6	63.3	60.9
	W666	59.1	58.5	54.6	51.7	48.5	46.4
	W668	70.1	70.8	66.8	63.7	60.0	58.6
	W704	72.1	70.4	66.4	63.1	59.1	56.8
	W706	69.3	71.8	66.5	64.1	61.4	59.5
	W708	67.0	66.4	62.8	60.1	57.0	54.8
	W710	67.4	72.1	66.1	63.5	60.4	57.4
	W712	68.4	68.7	62.2	58.8	54.7	50.8
	W714	64.4	63.8	60.1	57.3	56.3	52.0
	W716	70.1	70.7	66.4	64.1	61.5	60.0
	W718	71.7	70.4	66.3	63.9	61.3	58.9
	W720	71.6	71.0	67.7	65.1	62.2	60.1
	W722	76.6	72.6	68.1	65.5	62.4	59.5
	W724	73.4	72.9	69.6	67.1	64.3	62.2
	W726	85.3	84.9	82.8	81.1	79.1	77.6
	W728	79.4	71.5	66.6	64.6	62.4	61.8
	W730	76.8	70.8	64.5	61.9	58.8	58.2
	W732	68.3	67.8	64.2	61.5	58.5	56.4
	W734	65.3	72.1	67.2	63.8	61.2	59.1
	W736	66.3	65.8	62.1	59.3	56.2	54.1
	W738	60.4	59.7	55.9	53.0	49.8	47.7
	W740	64.0	73.0	69.6	65.9	62.8	61.1
	W742	60.7	72.9	70.3	67.3	63.6	60.7
	W744	78.1	72.2	68.1	64.1	60.0	60.0
	W746	66.3	74.3	70.9	67.3	64.8	63.5

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Connoquenessing Creek	W748	64.9	72.6	68.4	64.7	62.5	60.8
	W750	73.1	72.3	68.9	65.9	62.2	59.3
Davis Run	W622	73.1	71.3	67.3	64.0	59.9	58.3
	W640	78.4	72.1	67.7	64.7	61.1	60.8
	W642	70.0	69.5	66.0	63.4	60.4	58.3
Glade Run	W670	72.0	71.4	67.7	64.6	60.7	58.0
	W672	73.3	71.6	67.9	64.7	60.8	58.2
	W674	74.0	72.8	69.5	66.5	62.8	60.4
	W676	74.5	72.2	68.7	65.5	61.5	58.3
	W678	70.6	72.1	67.7	64.7	61.0	58.8
	W680	71.5	72.8	68.7	65.6	61.9	59.9
	W682	61.9	61.3	57.4	54.6	51.4	49.3
	W684	67.7	74.1	70.0	66.8	64.6	62.5
	W686	72.3	70.9	67.1	63.9	60.1	57.0
	W688	68.6	73.6	68.9	66.1	63.0	60.8
	W690	72.2	71.0	66.4	62.2	57.9	55.3
	W692	79.0	73.2	69.3	65.3	61.2	61.2
	W694	72.3	71.4	67.7	64.5	60.6	58.4
	W696	64.9	72.7	68.9	64.9	62.8	61.3
	W698	68.3	73.3	68.2	65.4	62.0	61.4
	W700	64.7	64.1	60.4	57.6	54.5	52.3
	W702	67.3	72.6	67.6	64.8	61.6	59.4
Patterson Run	W650	69.2	73.5	68.3	65.4	61.9	59.5
Pine Run	W562	68.5	73.1	67.6	65.4	62.9	60.7
Robinson Run	W632	70.3	72.5	67.8	64.7	61.1	57.9
Rocklick Run	W620	72.6	71.5	68.1	65.2	61.6	58.6
Sawmill Run	W616	76.5	71.9	67.8	63.6	59.4	57.8
	W618	79.8	79.3	76.6	74.5	72.0	70.2
Stony Run	W564	70.2	71.5	66.9	64.5	61.8	59.5
	W566	68.3	72.2	66.3	63.8	60.9	58.4
	W568	70.4	72.2	67.8	65.7	63.4	60.8
	W570	59.9	59.3	55.4	52.5	49.3	47.2
Sullivan Run	W608	77.0	72.0	67.4	64.9	61.9	60.4
	W610	76.0	71.7	67.3	64.8	61.9	59.6
	W612	83.9	73.1	71.3	70.3	69.1	68.6
Thorn Creek	W574	74.2	70.1	65.4	62.8	59.8	58.2
	W576	70.7	69.4	64.7	62.0	59.0	56.5
	W578	65.7	72.7	67.9	65.1	63.3	60.9
	W580	71.8	70.0	65.4	62.8	59.7	57.7
	W582	70.2	69.4	64.2	61.3	58.0	55.7
	W626	78.8	72.2	67.5	64.8	61.6	60.9
	W628	78.6	72.5	68.2	65.1	61.3	61.0
	W630	79.5	73.4	69.5	66.4	62.6	62.0
	W634	77.8	71.0	66.2	63.4	60.2	59.5

Hydrologic Parameters for Upper Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Thorn Creek	W636	69.6	72.8	67.5	64.5	60.9	57.6
	W638	75.3	73.0	69.9	67.0	63.5	60.7
	W644	73.5	71.8	68.2	65.1	61.3	58.4
	W646	73.0	70.6	66.1	62.1	58.1	56.1
	W648	72.1	70.9	66.8	63.6	59.6	56.7
	W652	64.4	71.9	67.1	63.5	61.0	58.1
	W654	74.0	73.5	70.3	67.8	65.0	63.0
	W656	66.0	72.0	67.2	63.9	60.8	58.0
Vaur Run	W624	79.7	73.1	69.1	66.3	62.9	62.9

Hydrologic Results for Upper Connoquenessing Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J4223	1373912.1	590171.4	4.36	363	568	746	834	948	364	571	750	837	951
2	J4206	1376720.3	588828.4	8.78	723	1,204	1,591	1,799	2,043	725	1,207	1,595	1,803	2,048
3	J4171	1390822.1	583975.2	3.92	301	524	674	794	918	301	524	674	794	918
4	J4136	1384625.9	577504.2	6.47	421	736	951	1,096	1,273	421	736	951	1,096	1,273
5	O050	1397476.2	558396.5	1.84	156	296	395	447	489	156	296	395	447	489
6	J4142	1403275.7	576863.2	3.41	268	487	626	734	849	268	487	626	734	849
7	P109	1402390.5	571552.1	4.99	393	712	914	1,059	1,239	393	712	914	1,059	1,239
8	J4079	1400345.5	564867.5	8.13	641	1,113	1,434	1,660	1,920	641	1,113	1,434	1,660	1,920
9	J4041	1396926.8	563432.9	12.66	865	1,495	1,933	2,230	2,561	865	1,495	1,933	2,230	2,561
10	J4053	1388899.1	568530.3	16.14	983	1,670	2,159	2,483	2,830	984	1,671	2,160	2,484	2,831
11	J3993	1386762.5	554367.4	3.32	275	485	630	685	823	275	485	630	685	823
12	P111	1383282.8	560319.5	5.53	470	817	1,059	1,189	1,389	470	817	1,059	1,189	1,389
13	J4093	1371989.1	565447.4	5.05	446	805	1,052	1,168	1,381	490	875	1,139	1,265	1,491
14	J3965	1390059.0	538739.4	3.96	319	555	711	778	995	319	555	711	778	995
15	J3856	1391280.0	527659.3	11.25	879	1,542	1,939	2,082	2,703	884	1,550	1,948	2,092	2,715
16	P030	1373149.0	544508.3	1.84	185	330	426	465	603	184	329	426	464	602
17	J4710	1388288.7	520669.4	5.10	442	812	1,007	1,048	1,331	447	820	1,017	1,060	1,344
18	J3839	1388136.1	522256.7	18.11	1,339	2,361	2,939	3,117	4,016	1,355	2,385	2,967	3,148	4,051
19	J4743	1382031.4	529643.4	20.48	1,408	2,521	3,150	3,344	4,268	1,423	2,547	3,181	3,378	4,307
20	J3862	1379314.8	530986.4	24.21	1,546	2,779	3,463	3,671	4,665	1,562	2,807	3,497	3,708	4,707
21	J3859	1374949.9	535412.3	26.17	1,602	2,880	3,589	3,805	4,816	1,619	2,909	3,624	3,844	4,863
22	J3886	1371500.8	536846.9	32.28	1,671	3,008	3,763	4,004	4,992	1,687	3,036	3,797	4,041	5,035
23	J3889	1366067.6	540998.1	37.66	1,800	3,213	4,017	4,285	5,323	1,817	3,242	4,053	4,324	5,369
24	J3912	1363198.4	542066.4	40.78	1,815	3,211	4,001	4,278	5,280	1,833	3,240	4,035	4,319	5,326
25	J4004	1350561.6	553238.0	1.93	161	312	385	408	461	161	312	385	408	461
26	J3971	1349981.7	547835.4	4.38	365	722	905	979	1,126	364	721	904	978	1,125
27	J4621	1358497.7	504278.3	7.40	562	1,032	1,275	1,334	1,505	579	1,060	1,308	1,370	1,546
28	J4654	1356422.1	505102.5	9.72	625	1,136	1,410	1,481	1,681	641	1,162	1,442	1,516	1,721
29	J4659	1367807.4	513710.1	7.04	498	921	1,097	1,121	1,261	499	923	1,099	1,123	1,263
30	J4662	1364022.5	514686.8	9.57	663	1,227	1,466	1,502	1,724	677	1,247	1,490	1,529	1,754
31	J3833	1355262.3	518441.2	15.67	1,079	2,008	2,429	2,514	2,887	1,108	2,053	2,484	2,574	2,956
32	J4717	1351507.9	520059.0	31.40	1,952	3,535	4,307	4,587	5,247	1,987	3,589	4,373	4,661	5,331
33	J3842	1346776.7	528361.4	35.98	2,096	3,757	4,579	4,884	5,617	2,132	3,813	4,648	4,961	5,704
34	J3850	1346288.3	530711.7	39.72	2,219	3,978	4,861	5,200	5,986	2,254	4,034	4,929	5,276	6,072

Hydrologic Results for Upper Connoquenessing Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J4300	1394301.8	599450.6	6.28	491	830	1,061	1,242	1,441	496	838	1,071	1,252	1,453
36	J4262	1394423.9	598687.5	8.65	651	1,096	1,405	1,645	1,894	655	1,103	1,414	1,655	1,905
37	J4217	1382000.8	586508.6	20.06	916	1,544	2,005	2,311	2,621	919	1,549	2,011	2,318	2,629
38	J4188	1379986.3	585409.8	29.71	1,272	2,122	2,796	3,173	3,599	1,275	2,128	2,800	3,181	3,607
39	J4161	1377941.2	580129.2	33.07	1,353	2,268	2,987	3,382	3,820	1,356	2,273	2,993	3,389	3,828
40	J4131	1380718.8	571948.9	42.59	828	1,945	2,692	3,141	3,625	834	1,953	2,702	3,151	3,637
41	J4084	1380810.4	566149.5	65.12	1,894	3,105	3,961	4,711	5,539	1,901	3,115	3,977	4,731	5,562
42	J4023	1378368.5	562578.2	72.56	2,166	3,549	4,520	5,207	6,073	2,174	3,560	4,533	5,225	6,096
43	J_UpperConno_ButlerCity	1372434.0	560573.1	80.06	2,386	3,922	5,004	5,707	6,581	2,400	3,943	5,029	5,735	6,611
44	J4033	1372280.2	560287.4	80.06	2,386	3,922	5,004	5,707	6,581	2,400	3,943	5,029	5,735	6,611
45	J3996	1368143.2	556809.3	86.27	2,491	4,145	5,280	6,010	6,933	2,509	4,174	5,315	6,046	6,969
46	J4009	1362862.6	551711.8	91.40	2,502	4,181	5,381	6,150	7,176	2,527	4,219	5,425	6,196	7,225
47	J3978	1361611.1	550887.7	92.56	2,512	4,204	5,409	6,184	7,216	2,538	4,244	5,455	6,231	7,267
48	J4349	1358223.0	544477.8	136.44	4,357	7,473	9,476	10,516	12,521	4,406	7,550	9,567	10,618	12,635
49	J3962	1353980.3	545363.0	138.39	4,265	7,278	9,192	10,250	12,195	4,316	7,356	9,287	10,354	12,311
50	J3947	1351233.1	542310.6	143.91	4,364	7,467	9,431	10,511	12,501	4,417	7,547	9,528	10,619	12,621
51	J3925	1346654.6	542585.3	147.12	4,404	7,526	9,497	10,581	12,577	4,456	7,606	9,594	10,689	12,698
52	J3853	1339725.8	536633.2	189.38	5,659	9,855	12,391	13,675	16,179	5,752	9,993	12,563	13,866	16,393
53	P186	1337650.2	537732.1	190.95	5,619	9,728	12,203	13,462	15,886	5,708	9,861	12,366	13,642	16,088
54	P184	1334414.7	542219.0	193.82	5,666	9,797	12,278	13,547	15,979	5,755	9,930	12,440	13,727	16,181
55	J3940	1329653.0	544660.9	196.39	5,491	9,396	11,737	12,950	15,198	5,572	9,514	11,879	13,107	15,373
56	J_UpperConnoqueness_Outlet	1319920.0	542429.9	199.92	5,524	9,441	11,787	13,004	15,248	5,605	9,558	11,928	13,159	15,422

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Brush Creek	W841	3.49	80.6	71.1	81.0	70.1
	W842	2.00	72.2	57.1	72.2	57.1
	W843	2.45	72.5	51.1	72.5	51.1
	W844	1.75	73.4	46.0	73.4	46.0
	W845	1.88	74.6	52.6	74.6	52.6
	W846	1.69	73.8	51.9	73.8	51.9
	W847	3.50	70.3	70.0	70.3	70.0
	W848	2.73	70.8	91.2	70.8	91.2
	W849	4.23	78.5	79.9	79.5	77.3
	W850	2.64	81.0	65.3	81.3	64.7
	W851	3.57	79.3	82.8	80.7	79.4
	W852	4.74	78.0	61.2	78.4	60.4
	W853	3.47	76.4	74.1	76.4	73.9
	W854	3.44	75.1	59.8	75.1	59.8
	W855	1.53	74.3	49.1	74.3	49.1
	W856	1.61	72.8	48.6	72.8	48.6
	W857	2.47	72.9	72.3	72.9	72.3
	W858	1.57	73.1	55.6	73.1	55.6
	W859	3.72	73.5	57.0	73.5	57.0
	W860	3.67	73.5	61.2	73.5	61.2
	W861	0.06	74.4	18.0	74.4	18.0
Camp Run	W836	1.86	68.8	48.4	68.8	53.8
	W837	4.64	73.3	59.7	73.3	66.3
	W838	3.64	70.6	65.8	70.6	73.1
	W839	4.66	72.8	95.6	72.8	106.2
Connoquenessing Creek	W804	1.19	71.5	35.4	71.5	39.3
	W835	1.43	72.9	40.1	72.9	44.6
	W862	1.11	72.5	45.8	72.5	45.8
	W876	0.02	76.2	9.2	76.2	10.2
	W877	0.06	77.5	11.7	77.5	13.0
	W878	1.15	78.7	40.0	78.7	44.4
	W879	1.32	81.4	42.4	81.8	46.5
	W881	0.64	75.4	33.0	75.4	36.6
	W882	0.99	74.5	40.2	74.5	44.7
	W883	2.49	74.8	54.5	74.8	60.6
	W884	4.73	73.2	79.8	73.2	88.7
	W885	0.77	75.5	41.4	75.5	46.0
	W886	0.46	72.4	32.7	72.4	32.7
	W887	2.42	73.5	60.6	73.5	60.6
	W888	2.55	75.3	67.3	75.3	67.3
	W898	0.57	71.2	25.5	71.2	25.5
	W899	2.02	75.6	52.8	75.6	52.8
	W900	2.89	73.5	64.4	73.5	64.4
Crab Run	W817	1.13	72.6	59.4	72.6	66.0

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Crab Run	W818	1.07	69.1	46.9	69.1	52.1
	W819	2.38	70.9	64.0	70.9	71.2
	W820	3.17	73.6	66.4	73.6	73.6
	W821	2.18	67.1	66.0	67.1	73.3
Crooked Run	W866	1.51	73.7	46.9	73.7	52.1
	W867	1.42	75.8	44.0	75.8	48.9
Doe Run	W834	4.41	74.6	71.8	74.7	79.6
Duck Run	W864	3.21	73.6	91.6	73.6	91.6
	W865	0.23	72.2	18.3	72.2	18.3
Glade Run	W832	4.70	77.6	65.6	78.1	71.6
Hazen Run	W840	2.33	71.1	59.3	71.1	65.9
Little Connoquenessing Creek	W805	1.03	73.5	48.4	73.5	53.7
	W806	1.82	73.4	52.1	73.4	57.9
	W807	2.12	67.5	66.3	67.5	73.7
	W808	1.42	81.2	38.9	81.5	42.9
	W812	1.76	71.1	58.5	71.1	65.0
	W816	0.80	60.4	53.0	60.4	58.8
	W868	0.37	72.9	22.3	73.5	24.3
	W869	2.71	72.6	77.4	72.6	85.9
	W870	0.20	61.4	24.7	61.4	27.5
	W871	1.53	68.4	48.6	68.5	53.9
	W872	3.78	65.8	80.6	65.8	89.6
	W873	1.54	63.8	52.7	63.8	58.5
	W874	1.49	60.2	61.9	60.2	68.8
	W875	1.97	74.8	72.2	74.8	80.2
Little Yellow Creek	W823	3.14	70.9	62.5	71.0	69.2
	W824	2.02	64.0	59.2	64.0	65.8
Mulligan Run	W809	1.64	72.0	82.6	72.1	91.5
	W810	2.81	75.1	90.6	75.2	100.3
	W811	1.98	68.2	73.4	68.3	81.3
Muntz Run	W833	2.01	73.3	50.0	73.4	55.6
	W880	0.12	76.0	20.3	76.0	22.6
Scholars Run	W830	3.23	67.5	70.3	67.5	78.1
	W831	3.82	72.8	74.7	73.5	81.4
Semiconon Run	W813	0.86	75.6	55.4	75.6	61.5
	W814	1.50	73.3	66.7	73.8	73.1
	W815	2.78	68.7	86.9	68.7	96.6
Squaw Run	W863	2.44	73.0	70.7	73.0	70.7
Yellow Creek	W822	2.79	64.6	69.0	64.6	76.7
	W825	2.48	74.4	47.6	74.5	52.8
	W826	0.45	70.1	31.2	70.1	34.7
	W827	1.75	68.3	48.6	68.3	53.9
	W828	1.86	67.9	62.1	67.9	69.0
	W829	2.66	66.7	59.7	66.7	66.4

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Brush Creek	W841	80.6	71.9	70.7	68.5	65.9	63.2
	W842	72.2	70.2	68.5	66.5	64.1	61.8
	W843	72.5	69.6	67.4	65.2	62.6	60.1
	W844	73.4	69.7	67.8	65.6	63.1	60.7
	W845	74.6	70.4	68.6	66.5	64.0	61.6
	W846	73.8	70.3	68.8	66.8	64.5	62.3
	W847	70.3	70.2	68.2	66.1	63.6	61.3
	W848	70.8	73.5	71.6	69.5	67.6	65.8
	W849	78.5	71.8	70.6	68.5	66.1	63.8
	W850	81.0	72.1	70.9	68.8	66.3	63.9
	W851	79.3	72.5	71.6	69.7	67.5	65.3
	W852	78.0	70.5	68.4	65.9	63.1	60.4
	W853	76.4	71.4	70.2	68.1	65.8	63.4
	W854	75.1	70.3	68.3	66.0	63.4	61.0
	W855	74.3	70.4	68.8	66.7	64.3	62.3
	W856	72.8	70.1	68.3	66.3	63.9	61.8
	W857	72.9	71.4	70.2	68.3	66.2	64.2
	W858	73.1	70.6	69.2	67.3	65.1	62.9
	W859	73.5	69.8	67.7	65.4	62.7	60.0
	W860	73.5	70.2	68.3	66.0	63.4	61.1
	W861	74.4	71.5	70.1	67.4	64.3	60.3
Camp Run	W836	68.8	68.1	65.9	61.4	57.4	50.0
	W837	73.3	68.1	65.5	62.2	58.2	56.4
	W838	70.6	69.1	67.1	62.7	58.6	51.9
	W839	72.8	71.3	70.5	67.5	63.7	57.5
Connoquenessing Creek	W804	71.5	67.8	65.7	61.0	56.8	52.0
	W835	72.9	68.1	65.9	60.6	56.6	55.1
	W862	72.5	68.7	67.0	65.7	64.3	63.2
	W876	76.2	73.4	72.0	69.5	66.4	62.6
	W877	77.5	74.8	73.5	71.0	68.0	64.3
	W878	78.7	69.5	68.4	65.6	62.3	61.4
	W879	81.4	69.6	68.4	68.0	67.7	65.4
	W881	75.4	72.6	71.2	68.6	65.5	61.6
	W882	74.5	71.6	70.2	67.5	64.4	60.5
	W883	74.8	69.2	67.6	62.9	58.7	57.1
	W884	73.2	70.3	68.9	65.4	61.0	56.7
	W885	75.5	72.7	71.3	68.8	65.7	57.4
	W886	72.4	69.3	67.9	65.1	61.9	57.8
	W887	73.5	68.4	66.0	64.4	62.7	61.3
	W888	75.3	69.2	67.4	66.0	64.4	63.2
	W898	71.2	68.0	66.5	63.7	60.4	56.4
	W899	75.6	69.1	67.5	66.2	64.8	63.9
	W900	73.5	69.6	68.2	67.0	65.7	64.6
Crab Run	W817	72.6	70.1	68.8	65.6	61.7	55.3

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Crab Run	W818	69.1	68.7	67.0	63.6	59.3	52.6
	W819	70.9	69.2	67.5	63.5	59.4	53.2
	W820	73.6	69.4	67.6	63.0	58.8	55.5
	W821	67.1	69.7	68.5	64.9	61.5	53.5
Crooked Run	W866	73.7	68.4	66.3	61.0	56.9	55.0
	W867	75.8	68.4	66.5	63.4	59.6	58.4
Doe Run	W834	74.6	68.3	65.3	61.2	57.2	55.3
Duck Run	W864	73.6	70.8	69.6	68.5	67.2	66.1
	W865	72.2	69.1	67.6	64.9	61.6	57.6
Glade Run	W832	77.6	69.4	67.7	64.4	60.5	59.2
Hazen Run	W840	71.1	69.3	67.6	63.7	59.6	52.4
Little Connoquenessing Creek	W805	73.5	68.7	66.7	61.8	57.6	56.1
	W806	73.4	68.6	66.4	60.7	56.9	55.0
	W807	67.5	69.6	68.0	64.6	60.9	51.2
	W808	81.2	68.7	66.9	65.7	64.5	64.5
	W812	71.1	69.3	67.8	63.9	59.8	52.8
	W816	60.4	56.8	55.1	51.9	48.6	44.4
	W868	72.9	69.9	68.4	65.7	62.5	58.5
	W869	72.6	70.5	69.2	65.9	61.8	54.9
	W870	61.4	57.9	56.2	53.1	49.6	45.4
	W871	68.4	68.7	66.7	63.2	58.9	49.3
	W872	65.8	69.4	67.4	63.6	60.1	51.5
	W873	63.8	68.7	67.1	63.0	60.3	53.0
	W874	60.2	69.3	68.6	64.1	59.8	52.8
	W875	74.8	71.4	71.0	68.2	64.7	58.6
Little Yellow Creek	W823	70.9	68.5	66.0	60.9	56.8	52.2
	W824	64.0	68.9	67.5	63.3	60.5	57.4
Mulligan Run	W809	72.0	71.4	70.8	68.0	64.6	56.6
	W810	75.1	71.2	70.3	66.9	62.7	59.0
	W811	68.2	70.3	69.3	66.0	62.7	57.4
Muntz Run	W833	73.3	68.5	66.3	61.3	57.1	55.3
	W880	76.0	73.2	71.9	69.3	66.2	62.4
Scholars Run	W830	67.5	69.4	67.4	64.0	59.8	50.7
	W831	72.8	69.9	68.3	64.2	60.0	55.6
Semiconon Run	W813	75.6	72.8	71.4	68.7	65.7	61.8
	W814	73.3	70.0	68.5	65.0	60.6	56.2
	W815	68.7	70.8	69.6	66.3	63.0	55.4
Squaw Run	W863	73.0	69.7	68.2	66.8	65.4	64.4
Yellow Creek	W822	64.6	69.3	67.6	63.5	60.5	52.0
	W825	74.4	67.6	64.9	61.4	57.3	55.3
	W826	70.1	66.9	65.4	62.4	59.2	55.1
	W827	68.3	68.3	66.1	62.3	58.2	51.3
	W828	67.9	69.8	68.2	65.0	61.4	52.9
	W829	66.7	68.9	67.0	63.6	59.7	51.0

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Brush Creek	W841	81.0	72.5	71.3	69.1	66.6	63.9
	W842	72.2	70.2	68.5	66.5	64.1	61.8
	W843	72.5	69.6	67.4	65.2	62.6	60.1
	W844	73.4	69.7	67.8	65.6	63.1	60.7
	W845	74.6	70.4	68.6	66.5	64.0	61.6
	W846	73.8	70.3	68.8	66.8	64.5	62.3
	W847	70.3	70.2	68.2	66.1	63.6	61.3
	W848	70.8	73.5	71.6	69.5	67.6	65.8
	W849	79.5	73.1	71.9	69.9	67.6	65.3
	W850	81.3	72.5	71.3	69.2	66.7	64.3
	W851	80.7	74.2	73.3	71.5	69.4	67.2
	W852	78.4	71.0	68.9	66.5	63.7	61.0
	W853	76.4	71.5	70.2	68.2	65.8	63.5
	W854	75.1	70.3	68.3	66.1	63.5	61.0
	W855	74.3	70.4	68.8	66.7	64.3	62.3
	W856	72.8	70.1	68.3	66.3	63.9	61.8
	W857	72.9	71.4	70.2	68.3	66.2	64.2
	W858	73.1	70.6	69.2	67.3	65.1	62.9
	W859	73.5	69.8	67.7	65.4	62.7	60.0
	W860	73.5	70.2	68.3	66.0	63.4	61.1
	W861	74.4	71.5	70.1	67.4	64.3	60.3
Camp Run	W836	68.8	68.1	65.9	61.4	57.4	50.0
	W837	73.3	68.1	65.5	62.2	58.2	56.4
	W838	70.6	69.1	67.1	62.7	58.6	51.9
	W839	72.8	71.3	70.5	67.5	63.7	57.5
Connoquenessing Creek	W804	71.5	67.8	65.7	61.0	56.8	52.0
	W835	72.9	68.1	65.9	60.6	56.6	55.1
	W862	72.5	68.7	67.0	65.7	64.3	63.2
	W876	76.2	73.4	72.0	69.5	66.4	62.6
	W877	77.5	74.8	73.5	71.0	68.0	64.3
	W878	78.7	69.5	68.4	65.6	62.3	61.4
	W879	81.8	70.2	69.0	68.6	68.2	66.0
	W881	75.4	72.6	71.2	68.6	65.5	61.6
	W882	74.5	71.6	70.2	67.5	64.4	60.5
	W883	74.8	69.2	67.6	62.9	58.7	57.1
	W884	73.2	70.3	68.9	65.4	61.0	56.7
	W885	75.5	72.7	71.3	68.8	65.7	57.4
	W886	72.4	69.3	67.9	65.1	61.9	57.8
	W887	73.5	68.4	66.0	64.4	62.7	61.3
	W888	75.3	69.2	67.4	66.0	64.4	63.2
	W898	71.2	68.0	66.5	63.7	60.4	56.4
	W899	75.6	69.1	67.5	66.2	64.8	63.9
	W900	73.5	69.6	68.2	67.0	65.7	64.6
Crab Run	W817	72.6	70.1	68.8	65.6	61.7	55.3

Hydrologic Parameters for Lower Connoquenessing Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Crab Run	W818	69.1	68.7	67.0	63.6	59.3	52.6
	W819	70.9	69.2	67.5	63.5	59.3	53.2
	W820	73.6	69.5	67.7	63.1	58.9	55.6
	W821	67.1	69.7	68.5	64.9	61.5	53.5
Crooked Run	W866	73.7	68.4	66.3	61.0	56.9	55.0
	W867	75.8	68.4	66.5	63.4	59.6	58.4
Doe Run	W834	74.7	68.4	65.4	61.3	57.3	55.4
Duck Run	W864	73.6	70.8	69.6	68.5	67.2	66.1
	W865	72.2	69.1	67.6	64.9	61.6	57.6
Glade Run	W832	78.1	70.2	68.4	65.2	61.3	60.0
Hazen Run	W840	71.1	69.3	67.6	63.7	59.6	52.4
Little Connoquenessing Creek	W805	73.5	68.7	66.7	61.8	57.6	56.1
	W806	73.4	68.6	66.4	60.7	56.9	55.0
	W807	67.5	69.6	68.0	64.6	60.9	51.2
	W808	81.5	69.1	67.3	66.1	64.9	64.9
	W812	71.1	69.3	67.8	63.9	59.8	52.8
	W816	60.4	56.8	55.1	51.9	48.6	44.4
	W868	73.5	70.5	69.1	66.4	63.2	59.2
	W869	72.6	70.5	69.2	65.9	61.8	55.0
	W870	61.4	57.9	56.2	53.1	49.6	45.4
	W871	68.5	68.8	66.8	63.3	59.1	49.4
	W872	65.8	69.4	67.4	63.6	60.1	51.5
	W873	63.8	68.7	67.1	63.0	60.3	53.0
	W874	60.2	69.3	68.6	64.2	59.8	52.8
	W875	74.8	71.4	71.0	68.2	64.7	58.6
Little Yellow Creek	W823	71.0	68.7	66.2	61.1	57.1	52.4
	W824	64.0	69.0	67.6	63.3	60.5	57.4
Mulligan Run	W809	72.1	71.5	70.9	68.1	64.7	56.7
	W810	75.2	71.3	70.4	67.1	62.9	59.2
	W811	68.3	70.4	69.4	66.1	62.8	57.5
Muntz Run	W833	73.4	68.5	66.3	61.3	57.1	55.3
	W880	76.0	73.2	71.9	69.3	66.2	62.4
Scholars Run	W830	67.5	69.4	67.4	64.0	59.8	50.7
	W831	73.5	70.7	69.0	65.0	60.8	56.4
Semiconon Run	W813	75.6	72.8	71.4	68.7	65.7	61.8
	W814	73.8	70.5	69.0	65.6	61.2	56.8
	W815	68.7	70.8	69.6	66.3	63.0	55.4
Squaw Run	W863	73.0	69.7	68.2	66.8	65.4	64.4
Yellow Creek	W822	64.6	69.3	67.6	63.5	60.5	52.0
	W825	74.5	67.6	64.9	61.5	57.3	55.4
	W826	70.1	66.9	65.4	62.4	59.2	55.1
	W827	68.3	68.3	66.1	62.3	58.2	51.3
	W828	67.9	69.8	68.2	65.0	61.4	52.9
	W829	66.7	68.9	67.0	63.6	59.7	51.0

Hydrologic Results for Lower Connoquenessing Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	P198	1362496.3	578816.7	1.51	114	280	291	294	355	114	280	291	294	355
2	J4150	1346746.2	575337.0	4.45	300	713	871	909	843	304	721	880	919	854
3	J4117	1339481.6	573719.3	2.36	197	455	555	581	582	206	470	574	601	603
4	J4101	1328737.3	571887.9	3.51	248	602	713	727	606	248	601	712	727	606
5	J4026	1328432.1	562303.5	7.75	492	1,157	1,340	1,365	1,254	494	1,160	1,344	1,370	1,259
6	J4090	1315490.1	570209.1	3.14	197	456	487	495	462	202	464	497	506	472
7	P052	1315886.9	579732.4	2.48	165	398	491	494	592	167	401	495	498	597
8	J4147	1318237.2	576161.2	5.72	358	868	1,036	1,101	1,018	360	870	1,039	1,104	1,023
9	P240	1319763.4	569201.8	7.47	433	1,027	1,224	1,294	1,174	435	1,030	1,228	1,297	1,179
10	J4062	1318756.1	562883.4	14.49	809	1,867	2,173	2,296	2,096	815	1,877	2,186	2,309	2,111
11	J3883	1318450.9	542066.4	241.67	6,364	11,226	13,978	15,368	17,914	6,460	11,372	14,154	15,564	18,134
12	J3917	1317443.6	542096.9	242.88	6,376	11,249	14,003	15,395	17,942	6,472	11,395	14,180	15,591	18,162
13	J100	1309751.7	559129.1	3.23	206	484	590	598	375	206	483	589	598	375
14	J4126	1298763.3	575672.8	4.64	285	669	830	849	1,028	286	670	831	850	1,030
15	J4071	1296168.8	563493.9	10.14	570	1,288	1,523	1,561	1,589	571	1,289	1,525	1,563	1,591
16	J4518	1321991.6	489688.1	3.50	247	564	748	860	978	247	564	748	860	978
17	J4515	1317382.6	493381.4	6.23	453	975	1,278	1,482	1,697	453	975	1,278	1,482	1,697
18	J4523	1313170.3	500401.8	10.46	421	867	1,132	1,315	1,509	430	878	1,146	1,333	1,530
19	J4635	1312834.6	502294.3	16.59	830	1,887	2,451	2,791	3,125	920	2,038	2,637	3,001	3,361
20	J4576	1307523.5	511115.6	20.16	1,094	2,467	3,203	3,657	4,104	1,228	2,685	3,469	3,957	4,440
21	J4643	1306455.2	513099.6	24.90	1,158	2,594	3,373	3,848	4,321	1,283	2,804	3,632	4,140	4,649
22	J4692	1299953.7	517098.2	28.37	1,305	2,905	3,779	4,313	4,848	1,433	3,119	4,043	4,613	5,185
23	J4704	1298519.1	518960.1	31.81	1,316	2,898	3,765	4,296	4,831	1,432	3,088	3,998	4,560	5,127
24	J3836	1293391.1	520516.8	35.34	1,412	3,094	4,020	4,589	5,166	1,529	3,287	4,259	4,860	5,472
25	J4736	1288446.3	523752.3	39.40	1,493	3,241	4,209	4,804	5,410	1,609	3,432	4,443	5,071	5,711
26	J3845	1282982.6	528452.9	43.62	1,594	3,437	4,462	5,097	5,745	1,710	3,628	4,698	5,366	6,049
27	J3868	1280327.1	532878.8	45.19	1,520	3,345	4,357	4,984	5,626	1,619	3,511	4,562	5,219	5,891
28	J3871	1279838.7	538708.8	50.79	1,527	3,292	4,271	4,881	5,507	1,610	3,426	4,435	5,067	5,716
29	J3955	1276511.6	550796.1	56.15	1,606	3,443	4,466	5,104	5,762	1,690	3,577	4,629	5,290	5,971
30	J_BrushCreek	1277420.3	551047.9	56.21	1,597	3,416	4,429	5,061	5,713	1,679	3,547	4,587	5,242	5,916
31	J4153	1273367.7	571948.9	5.65	352	834	1,166	1,424	1,728	352	834	1,166	1,424	1,728
32	J4168	1356818.9	582388.0	2.85	208	504	521	535	652	208	504	521	535	653
33	J4156	1356361.1	574207.7	7.90	525	1,250	1,387	1,436	1,494	525	1,250	1,387	1,436	1,494
34	J4087	1354896.0	571155.3	9.69	593	1,384	1,575	1,663	1,768	596	1,386	1,578	1,666	1,772

Hydrologic Results for Lower Connoquenessing Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J4096	1345128.4	566271.5	18.83	1,134	2,612	3,099	3,276	3,222	1,142	2,626	3,116	3,294	3,240
36	J4038	1343632.8	563432.9	20.79	1,207	2,768	3,292	3,480	3,389	1,215	2,782	3,309	3,498	3,408
37	J4044	1340855.2	560868.9	27.46	1,556	3,549	4,294	4,562	4,307	1,569	3,575	4,328	4,601	4,345
38	J3990	1332797.0	553482.2	32.04	1,085	2,343	2,792	2,966	2,781	1,094	2,358	2,810	2,985	2,801
39	J3999	1325990.2	553146.4	43.51	1,315	2,809	3,357	3,576	3,339	1,324	2,825	3,376	3,598	3,361
40	J3983	1317871.0	552322.3	62.15	1,762	4,053	4,762	5,032	4,314	1,770	4,068	4,781	5,053	4,335
41	J3920	1316009.0	542737.9	307.06	7,703	14,028	17,291	18,902	21,320	7,814	14,195	17,497	19,131	21,574
42	J3935	1308256.1	542799.0	315.26	7,588	13,766	16,967	18,550	20,839	7,693	13,923	17,158	18,763	21,075
43	J3895	1303555.4	539166.7	321.28	7,649	13,884	17,113	18,712	21,024	7,756	14,045	17,308	18,928	21,265
44	J3892	1301937.7	539258.3	323.41	7,636	13,856	17,075	18,670	20,970	7,742	14,015	17,268	18,884	21,208
45	J3909	1299221.1	544691.4	328.46	7,560	13,732	16,948	18,544	20,824	7,663	13,887	17,137	18,754	21,056
46	J3906	1295710.9	540998.1	330.88	7,569	13,742	16,957	18,554	20,830	7,671	13,896	17,144	18,762	21,061
47	J3932	1289911.4	546614.4	348.17	7,752	14,088	17,367	18,993	21,283	7,855	14,243	17,555	19,203	21,516
48	J3950	1282707.9	548934.2	355.23	7,632	13,839	17,045	18,639	20,822	7,729	13,985	17,222	18,835	21,039
49	USGS 03106000	1278678.8	550155.1	356.00	7,577	13,747	16,945	18,535	20,699	7,672	13,891	17,119	18,729	20,914
50	J3968	1277579.9	551131.9	412.67	8,434	15,480	19,174	21,069	23,496	8,544	15,649	19,379	21,297	23,751
51	J4014	1270590.1	557419.7	416.20	8,456	15,522	19,227	21,132	23,568	8,566	15,691	19,432	21,360	23,822
52	J4056	1275107.5	565661.1	830.07	14,257	26,487	33,417	37,361	41,546	14,352	26,633	33,597	37,564	41,772
53	J4076	1273184.6	568896.6	836.52	14,298	26,581	33,538	37,502	41,709	14,394	26,728	33,719	37,706	41,936
54	J4108	1268789.2	567706.2	838.54	14,287	26,592	33,552	37,518	41,728	14,383	26,738	33,733	37,722	41,955
55	J_ConnoquenessingOutlet	1257201.6	564306.8	841.43	14,293	26,630	33,602	37,577	41,797	14,390	26,777	33,783	37,781	42,024

Hydrologic Parameters for Breakneck Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Breakneck Creek	W532	1.37	67.0	50.5	67.0	50.5
	W533	2.14	74.5	59.3	74.6	59.2
	W539	1.43	72.5	57.4	73.2	56.4
	W542	2.46	70.2	71.1	70.2	71.1
	W543	2.71	76.2	63.2	76.2	63.2
	W544	3.17	74.6	87.1	74.7	86.8
	W545	3.68	76.7	77.1	76.7	77.1
	W546	1.15	75.8	49.6	76.0	49.3
	W547	3.38	76.0	67.1	76.0	67.0
	W548	1.53	76.9	43.4	77.2	43.0
	W549	0.01	71.2	11.6	71.2	11.6
	W550	2.22	72.8	56.4	73.6	55.2
Kaufman Run	W534	1.75	77.9	64.9	78.0	64.9
	W535	3.71	74.4	70.7	74.8	69.8
	W536	1.78	75.7	61.5	75.8	61.2
Likens Run	W540	2.28	75.6	48.3	76.0	47.8
	W541	1.34	71.3	50.2	71.3	50.2
Wolfe Run	W537	3.34	76.0	61.0	76.3	60.4
	W538	2.30	75.3	74.6	75.3	74.5

Hydrologic Parameters for Breakneck Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Breakneck Creek	W532	67.0	68.3	66.2	63.5	60.3	57.8
	W533	74.5	69.1	67.2	64.3	60.8	58.0
	W539	72.5	69.5	68.0	65.4	62.4	60.1
	W542	70.2	69.5	67.7	65.2	62.2	59.7
	W543	76.2	69.2	67.5	64.5	60.8	57.7
	W544	74.6	70.7	69.6	67.2	64.3	61.7
	W545	76.7	70.0	68.6	65.7	62.2	59.6
	W546	75.8	69.1	67.7	64.9	61.6	59.1
	W547	76.0	69.4	67.7	64.8	61.3	58.4
	W548	76.9	68.5	66.6	64.3	61.7	59.9
	W549	71.2	65.8	64.1	61.2	57.8	52.1
	W550	72.8	68.9	67.2	64.4	61.2	58.4
Kaufman Run	W534	77.9	70.1	69.0	66.3	63.1	60.4
	W535	74.4	69.2	67.1	64.2	60.6	57.8
	W536	75.7	69.7	68.5	65.7	62.5	60.1
Likens Run	W540	75.6	68.2	65.9	62.7	58.8	56.6
	W541	71.3	68.8	67.0	64.3	61.2	58.7
Wolfe Run	W537	76.0	68.7	66.6	63.4	59.6	57.1
	W538	75.3	70.5	69.4	67.0	64.2	61.8

Hydrologic Parameters for Breakneck Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Breakneck Creek	W532	67.0	68.3	66.2	63.5	60.3	57.8
	W533	74.6	69.2	67.3	64.4	60.9	58.1
	W539	73.2	70.1	68.7	66.1	63.2	60.9
	W542	70.2	69.5	67.7	65.2	62.2	59.7
	W543	76.2	69.2	67.5	64.5	60.8	57.7
	W544	74.7	70.8	69.8	67.3	64.4	61.8
	W545	76.7	70.0	68.6	65.7	62.2	59.6
	W546	76.0	69.4	67.9	65.1	61.8	59.3
	W547	76.0	69.4	67.8	64.9	61.4	58.4
	W548	77.2	68.8	67.0	64.7	62.1	60.3
	W549	71.2	65.8	64.1	61.2	57.8	52.1
	W550	73.6	69.7	68.0	65.3	62.1	59.4
Kaufman Run	W534	78.0	70.1	69.0	66.3	63.1	60.4
	W535	74.8	69.7	67.7	64.7	61.2	58.4
	W536	75.8	69.9	68.7	66.0	62.7	60.3
Likens Run	W540	76.0	68.7	66.3	63.1	59.3	57.1
	W541	71.3	68.8	67.0	64.3	61.2	58.7
Wolfe Run	W537	76.3	69.0	66.9	63.8	60.0	57.5
	W538	75.3	70.6	69.5	67.1	64.3	61.8

Hydrologic Results for Breakneck Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J4638	1333163.2	505712.9	5.46	359	856	1,082	1,163	1,289	376	887	1,120	1,205	1,336
2	J4699	1327119.6	515724.6	3.34	217	519	649	678	766	229	541	675	707	798
3	Dam_No. 2 Dam	1320007.6	530681.2	2.28	165	398	497	516	598	175	416	520	540	625
4	J4624	1345738.9	496647.5	3.83	244	585	759	840	948	244	585	759	840	948
5	J4512	1342442.4	504247.8	8.68	423	987	1,272	1,393	1,561	424	988	1,273	1,395	1,563
6	J4679	1338108.0	511329.3	19.09	977	2,345	3,009	3,278	3,662	995	2,381	3,052	3,326	3,715
7	J4724	1335605.1	521096.8	22.77	1,068	2,510	3,201	3,485	3,891	1,088	2,545	3,243	3,532	3,943
8	J4727	1334628.4	522043.0	29.56	1,211	2,838	3,621	3,943	4,418	1,234	2,878	3,670	3,998	4,479
9	P102	1329317.3	530192.8	32.94	1,221	2,792	3,545	3,860	4,320	1,241	2,829	3,589	3,909	4,375
10	J3865	1325746.0	532848.3	35.90	1,265	2,880	3,656	3,985	4,465	1,287	2,918	3,702	4,037	4,523
11	J3878	1325227.1	533336.7	39.53	1,299	2,934	3,735	4,075	4,573	1,321	2,973	3,782	4,128	4,632
12	J_BreakneckCreek_Outlet	1318684.1	541824.9	41.75	1,324	2,972	3,780	4,126	4,629	1,347	3,012	3,828	4,180	4,690

Appendix B – Supporting Calculations for the Design Example

The *Model Ordinance* has been developed to implement a variety of control standards in order to achieve a holistic approach to stormwater management. The overall design process has been addressed in *Section VIII* of this Plan. The following example calculations have been provided to further clarify the design method. These calculations parallel the calculations that are made on the worksheets provided in the *Pennsylvania Stormwater Best Management Practices Manual* (PA BMP Manual) a copy of which are provided at the back of this appendix.

SUPPORTING CALCULATIONS - DESIGN EXAMPLE 1

NON-STRUCTURAL BMP CREDITS

Protect Sensitive Natural Resources
(Refer to Worksheet 2 & Worksheet 3)

Stormwater Management Area = Total Drainage Area – Protected Area

= 9.78 – 1.31 (woods) – 0.37 (minimum disturbance)
= **8.1-Acres**

This is the total area used for pre-development and post-development volume calculations.

Minimum Soil Compaction
(Refer to *Worksheet* 3)

Lawn Area (post development) protected from compaction = 16,165-ft^2

16,165-ft^2 x 1/4" x 1/12 = **337-ft^3**

To be eligible for this credit, areas must not be compacted during construction and be guaranteed to remain protected from compaction. Minimum soil compaction credits for lawn area (Open Space) are applicable for this example because specific measures were utilized to protect the back yard lawn areas of Lots 9 & 10 and this area has been placed in a permanent minimum soil compaction easement. Credits for the meadow area can be applied for areas that are not disturbed during construction and will remain in pre-development vegetated cover condition.

Disconnect Non-Roof Impervious to Vegetated Areas
(Refer to *Worksheet* 3)

Lot Impervious Area = 10 (Lots) x 1,000 (ft^2/lot) = 10,000-ft^2.
10,000-ft^2 x 1/3" x 1/12 = **278-ft^3**

This credit is applied for the impervious surfaces (driveways and sidewalks) which direct runoff to vegetated surfaces and not directly into a stormwater collection system. The 1/3" credit is used because runoff discharges across the lawn area and is received by rain gardens, which are structures specifically placed to receive and infiltrate runoff. The 1/4" credit would be used for runoff not discharged to a specific infiltration structure or an area that has been protected from soil compaction.

Summation of Non-Structural BMP Credits
= 337-ft^3 + 278-ft^3 = **615-ft^3**

CHANGE IN RUNOFF VOLUME FOR THE 2-YEAR STORM EVENT

(Refer to *Worksheet 4*)

2-year, 24-hour Rainfall Depth = 2.76"

Pre-Development 2-yr Runoff Volume = 5,682 ft^3

Post-Development 2-yr Runoff Volume = 18,281 ft^3

Change in Runoff Volume for the 2-year, 24-hour storm event:

= 18,2813-ft^3 – 5,682-ft^3 = **12,599-ft^3**

This is the volume that must be managed through a combination of non-structural BMP credits and structural BMP credits.

25% LIMIT FOR NON-STRUCTURAL BMP CREDITS

(Refer to *Worksheet 5*)

*Per Chapter 8 of the Pennsylvania Stormwater BMP Manual, Non-Structural Credits may be **no greater than 25%** of the total required control volume.*

Check 25% Non-Structural Credit Limit:

= 615-ft^3 / 12,599-ft^3 = **4.9%**

Calculated credits are under the allowable 25% limit for non-structural credits.

STRUCTURAL CONTROL VOLUME REQUIREMENT

(Refer to *Worksheet 5*)

Required Structural BMP infiltration volume:

= Change in Runoff Volume – Non-Structural BMP Credits
= 12,599-ft^3 – 615-ft^3 = **11,984-ft^3**

STRUCTURAL BMP VOLUME CREDITS

The sizing of structural infiltration BMPs is based on two primary criteria:

1. Maximum loading ratios – There are two different loading ratios that are important when determining the size of a structural BMP. These ratios are derived from guidelines found in the *Pennsylvania Stormwater BMP Manual*.
   a. Maximum loading ratio of Impervious Area to Infiltration Area = 5:1
   b. Maximum loading ratio of Total Drainage Area to Infiltration Area = 8:1

2. Expected runoff volume loading – Structural BMPs must be sized to accommodate the runoff volume they are expected to receive from the contributing drainage area. Some of this volume will be removed and the remainder must be safely conveyed through an overflow device. The removed volume, or infiltration volume, is the important component for sizing the infiltration BMP. A good starting point for infiltration volume is to calculate the contributing area runoff volume for the 2-year, 24-hour design storm. This volume may not be suitable for a particular site design, but starting with this volume will usually result in a design that is close to what is appropriate, and it can be adjusted as necessary. Additional design restrictions may exist for certain BMPs, so these should be considered prior to using this sizing method.

Dry Wells
(Example calculations shown for Lot #1; Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum dry well surface area for each lot based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 2,150-ft^2 (typ.)
= 2,150-ft^2 / 5 = **430-ft^2**
= minimum surface area of dry well per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 2,590-ft^2 (typ.)
= 2,590-ft^2 / 8 = **324-ft^2**
= minimum surface area of dry well per pervious loading ratio

The larger of the two calculated areas is the total minimum surface area required for each lot. An individual dry well is placed at each of the four major corners of the house to promote distribution of impervious area runoff. However, the total surface area is used throughout the remaining volume credit calculations for simplicity. The surface area of each dry well is calculated below:

Total Minimum Dry Well Surface Area ÷ Number of Dry Wells
=430 ft^2 / 4 = **107.5-ft^2**

Each dry well will be 10' x 11' to meet the minimum surface area requirements.

Volume:
Find the infiltration volume for each dry well based on the expected runoff volume.

Land Use	Soil Type	Area	Area	CN	S	I_a	Runoff Depth$_{2\text{-}yr}$	Runoff Volume$_{2\text{-}yr}$
	(HSG)	(sf)	(acres)			(0.2*S)	(in)	(ft^3)
Open Space (good)	B	110	0.00	61	6.393	1.279	0.28	3
Impervious	B	540	0.01	98	0.204	0.041	2.53	114
TOTAL:		**650**	**0.01**				**2.81**	**116**

Runoff volume = **116-ft^3**

Depth:
Each dry well will be filled with aggregate. The in-place aggregate will have a 40% voids ratio; therefore the volume is divided by the available void space to get a total volume.

Depth = Total Volume / Surface Area

= (116-ft^3 / 0.40) / 110-ft^2 = **2.64-ft or approximately 2'-8"**

An overflow spillway or drain is then sized to convey any runoff that exceeds the design volume to the peak rate management facility.

Rain Gardens
(Example calculations shown for Lot #1; Refer to Worksheet 5A for additional calculations)

Surface Area:
Find the minimum surface area for each rain garden based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 1,000-ft^2
= 1,000-ft^2 / 5 = **200-ft^2**
= minimum surface area of rain garden per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 6,000-ft^2 (typ.)
= 4,775-ft^2 / 8 = **597-ft^2**
= minimum surface area of rain garden per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Rain Garden Surface Area = **597-ft^2**

Depth:
Design guidelines, from the *PA BMP Manual*, for rain gardens limit ponding depth within the facility to 12 inches or less. The rain gardens in this example have been designed with a total ponding depth of 12 inches. The overflow outlets are positioned 6 inches above the bottom elevation of the rain gardens and 6 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the rain garden is calculated by multiplying the surface area of the rain garden by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 700-ft^2 x 0.5-ft = **350-ft^3**

Bioretention
(Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum surface area for the bioretention facility based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 9,700-ft^2 (typ.)
= 9,700-ft^2 / 5 = **1,940-ft^2**
= minimum surface area of Infiltration Trench per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 41,400-ft^2
= 41,400-ft^2 / 8 = **5,175-ft^2**
= minimum surface area of Infiltration Trench per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Infiltration Trench Surface Area = **5,175-ft^2**

Depth:
The bioretention facility in this example has been designed with a total depth of 18 inches. The overflow outlets are positioned 6 inches above the bottom elevation, and 12 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the bioretention facility is calculated by multiplying the surface area by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 5,175-ft^2 x 0.5-ft = **2,487.5-ft^3**

STRUCTURAL CONTROL VOLUME REQUIREMENT CHECK

(Refer to *Worksheet 5*)

Check the total structural volume to be certain it is adequate to meet the structural volume requirement.

= Total Structural Volume - Structural Volume Requirement
=14,613-ft^3 – 11,984-ft^3 = 2,629-ft^3

The structural volume requirement has been exceeded by 2,629-ft^3 and no further BMP calculations are necessary.

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Engineering & Related Services

Project Name:	DESIGN EXAMPLE 1
Project ID:	MILL RUN RESIDENTIAL
Owner:	
Calculated:	Date:
Checked:	Date:

WORKSHEET 1. GENERAL SITE INFORMATION

INSTRUCTIONS: Fill out *Worksheet 1* for each watershed

Date: 2/29/2010

Project Name: DESIGN EXAMPLE 1

Municipality: ADAMS TOWNSHIP

County: BUTLER

Total Area (acres): 9.78

Major River Basin: OHIO RIVER BASIN
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/default.htm#newtopics

Watershed: BREAKNECK CREEK

Sub-Basin: BEAVER RIVER (from Ohio state line to confluence with Ohio River)

Nearest Surface Water(s) to Receive Runoff: MILL RUN

Chapter 93 - Designated Water Use: CWF
http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

		Yes	No
Impaired according to Chapter 303(d) List? http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/303d-Report.htm			X

List Causes of Impairment:

Is project subject to, or part of:

		Yes	No
Municipal Separate Storm Sewer System (MS4) Requirements? http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/GeneralPermits/default.htm			X
Existing or planned drinking water supply?			X
If yes, distance from proposed discharge (miles):			
Approved Act 167 Plan? http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/Approved_1.html		X	
Existing River Conservation Plan? http://www.dcnr.state.pa.us/brc/rivers/riversconservation/planningprojects/			X

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Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 2. SENSITIVE NATURAL RESOURCES

INSTRUCTIONS:

1. Provide Sensitive Resources Map according to non-structural BMP 5.4.1 in Chapter 5 of PA Stormwater BMP Manual. This map should identify waterbodies, floodplains, riparian areas, wetlands, woodlands, natural drainage ways, steep slopes, and other sensitive natural areas.

2. Summarize the existing extent of each sensitive resource in the Existing Sensitive Resources Table (below, using Acres). If none present, insert 0.

3. Summarize Total Protected Area as defined under BMPs in Chapter 5.

4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once.

EXISTING NATURAL SENSITIVE RESOURCE	MAPPED? yes/no/n/a	TOTAL AREA (Ac.)	PROTECTED AREA (Ac.)
Waterbodies	yes	0.00	
Floodplains	no	0.00	
Riparian Areas	no	0.00	
Wetlands	no	0.00	
Woodlands	yes	2.29	1.31
Natural Drainage Ways	N/A	0.00	
Steep Slopes, 15% - 25%	N/A	0.00	
Steep Slopes, over 25%	N/A	0.00	
Other:	N/A		
Other:	N/A		
TOTAL EXISTING:		**2.29**	**1.31**

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Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 3. NON-STRUCTURAL BMP CREDITS

PROTECTED AREA

1.1 Area of Protected Sensitive/Special Value Features (see WS 2)	**1.31**	**Ac.**
1.2 Area of Riparian Forest Buffer Protection	**0.00**	**Ac.**
3.1 Area of Minimum Disturbance/Reduced Grading	**0.37**	**Ac.**
TOTAL	**1.68**	**Ac.**

Site Area	*minus*	Protected Area	=	Stormwater Management Area
9.78	-	**1.68**	=	**8.10**

VOLUME CREDITS

3.1 Minimum Soil Compaction

Lawn	**16,165**	ft^2	x 1/4"	x 1/12	=	**337** ft^3
Meadow	**N/A**	ft^2	x 1/3"	x 1/12	=	**0** ft^3

3.3 Protect Existing Trees

For Trees within 100 feet of impervious area:

Tree Canopy	**N/A**	ft^2	x 1/2"	x 1/12	=	**0** ft^3

For Trees within 20 feet of impervious area:

Tree Canopy	**N/A**	ft^2	x 1"	x 1/12	=	**0** ft^3

5.1 Disconnect Roof Leaders to Vegetated Areas

For runoff directed to areas protected under 5.8.1 and 5.8.2

Roof Area	**N/A**	ft^2	x 1/3"	x 1/12	=	**0** ft^3

For all other disconnected roof areas

Roof Area	**N/A**	ft^2	x 1/4"	x 1/12	=	**0** ft^3

5.2 Disconnect Non-Roof Impervious to Vegetated Areas

For Runoff directed to areas protected under 5.8.1 and 5.8.2

Impervious Area	**10,000**	ft^2	x 1/3"	x 1/12	=	**278** ft^3

For all other disconnected non-roof impervious areas

Impervious Area	**N/A**	ft^2	x 1/4"	x 1/12	=	**0** ft^3

TOTAL NON-STRUCTURAL VOLUME CREDIT* **615** ft^3

** For use on Worksheet 5*

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Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 4. CHANGE IN RUNOFF VOLUME FOR 2-YR STORM EVENT

PROJECT: DESIGN EXAMPLE 1
Drainage Area: 8.10 (acres)
2-Year Rainfall: 2.76 inches *(From NOAA Atlas 14)*

Total Site Area: 9.78 acres
Protected Site Area: 1.68 acres
Stormwater Management Area: 8.10 acres *(From Worksheet 3)*

Existing Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Woods (good)	B	42,500	0.98	55	8.1818	1.6364	0.14	481
Meadow	B	310,255	7.12	58	7.2414	1.4483	0.20	5,201
								-
								-
								-
								-
TOTAL:		**352,755**	**8.10**					**5,682**

Developed Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Meadow	B	54,060	1.24	58	7.2414	1.4483	0.20	906
Open Space (good)	B	243,035	5.58	61	6.3934	1.2787	0.28	5,643
Impervious	B	55,660	1.28	98	0.2041	0.0408	2.53	11,732
								-
								-
								-
TOTAL:		**352,755**	**8.10**					**18,281**

2-Year Volume Increase (ft^3): 12,599

2-Year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume
= 18,281 - 5,682 = 12,599 ft^3

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where
   P = 2-Year Rainfall (in)
   S = (1000/ CN)-10

2. Runoff Volume (CF) = Q x Area x 1/12
   Q = Runoff (in)
   Area = Land use area (sq. ft)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSG. The use of a weighted CN value for volume calculations is not acceptable.

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Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5. STRUCTURAL BMP VOLUME CREDITS

SUB-BASIN: N/A

Check 25% Limit for Non-Structural BMP Credits: 615
÷ 12,599
4.9%

Required Control Volume (ft^3): 12,599
Allowable Non-structural Volume Credit (ft^3): - 615

Structural Volume Reqmt (ft^3): 11,984
(Required Control Volume minus Non-structural Credit)

Proposed BMP		Area (ft^2)	Infiltration Volume (ft^3)
6.4.1	Porous Pavement		
6.4.2	Infiltration Basin		
6.4.3	Infiltration Bed		
6.4.4	Infiltration Trench		
6.4.5	Rain Garden/Bioretention	11,915	8,827
6.4.6	Dry Well / Seepage Pit	4,400	5,787
6.4.7	Constructed Filter		
6.4.8	Vegetated Swale		
6.4.9	Vegetated Filter Strip		
6.4.10	Berm		
6.5.1	Vegetated Roof		
6.5.2	Capture and Re-use		
6.6.1	Constructed Wetlands		
6.6.2	Wet Pond / Retention Basin		
6.6.3	Dry Extended Detention Basin		
6.6.4	Water Quality Filters		
6.7.1	Riparian Buffer Restoration		
6.7.2	Landscape Restoration / Reforestation		
6.7.3	Soil Amendment		
6.8.1	Level Spreader		
6.8.2	Special Storage Areas		
Other			

Total Structural Volume (ft^3): 14,613
Structural Volume Requirement (ft^3): 11,984

DIFFERENCE: 2,629 *(excess)*

* Complete BMP Design Checklist for each measure proposed
NOTE: Provide supporting Volume Calculations for each Structural BMP

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Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5.A - INFILTRATION BMP SUPPORTING CALCULATIONS

Instructions: Complete this worksheet for each Point of Interest / Discharge (at a minimum)

Point of Interest / Discharge: *Basin Outfall*
Total Drainage Area to POI: 352,755 ft²
Total Impervious Area: 55,660 ft²

Proposed Infiltration BMP(s)	Infiltration Rate: Measured Infilt Rate[1] in/hr	Infiltration Rate: FOS	Infiltration Rate: Design Infilt Rate in/hr	Design Runoff Volume cu. ft.	Infiltration Period: Infilt. Period[2] hrs	Infiltration Period: Active Infilt.[3] hrs	Infiltration Period: Total Infilt Period hrs	Hydraulic Loading – Imperv. Drainage Area Loading: Imperv. DA sq. ft.	% area draining to BMP	Imperv Area Loading Ratio	Imperv Target Area sq. ft.	Hydraulic Loading – Total Drainage Area Loading: Total Drainage Area sq. ft.	% area draining to BMP[4]	Total Area Loading Ratio	Total Target Area sq. ft.	Target BMP Area[5] sq. ft.	Actual BMP Area[6] sq. ft.	Computed Infiltration Volume cu. ft.
BMP 6.4.1 Porous Pavement w. Infilt. Bed							Subtotal:			5				8				
BMP 6.4.2 Infiltration Basin							Subtotal:			5				8				
BMP 6.4.3 Subsurface Infiltration Bed							Subtotal:			5				8				
BMP 6.4.4 Infiltration Trench							Subtotal:			5				8				
BMP 6.4.5 Rain Garden/Bioretention							Subtotal:	19,700		5		89,585		8			11,915	5,827
Rain Garden (Lot #1)	0.93	2	0.47	350	12.9	6	18.9	1,000	100.0		200	4,775	100.0		597	597	700	513
Rain Garden (Lot #2)	0.95	2	0.48	350	12.6	6	18.6	1,000	100.0		200	5,600	100.0		700	700	700	516
Rain Garden (Lot #3)	0.98	2	0.49	350	12.2	6	18.2	1,000	100.0		200	5,080	100.0		635	635	700	522
Rain Garden (Lot #4)	1.01	2	0.51	300	11.9	6	17.9	1,000	100.0		200	3,625	100.0		453	453	600	452
Rain Garden (Lot #5)	1.02	2	0.51	468	11.8	6	17.8	1,000	100.0		200	7,005	100.0		876	876	915	691
Rain Garden (Lot #6)	1.08	2	0.54	350	11.1	6	17.1	1,000	100.0		200	5,310	100.0		664	664	700	539
Rain Garden (Lot #7)	0.91	2	0.46	300	13.2	6	19.2	1,000	100.0		200	4,385	100.0		549	549	600	437
Rain Garden (Lot #8)	0.99	2	0.50	238	12.1	6	18.1	1,000	100.0		200	3,000	100.0		375	375	475	355
Rain Garden (Lot #9)	1.05	2	0.53	300	11.4	6	17.4	1,000	100.0		200	4,520	100.0		565	565	600	458
Rain Garden (Lot #10)	1.03	2	0.52	375	11.7	6	17.7	1,000	100.0		200	4,975	100.0		622	622	750	568
Bioretention 1	0.92	2	0.46	2588	13.0	6	19.0	9,700	100.0		1,940	41,400	100.0		5,175	5,175	5,175	3,778
BMP 6.4.6 Dry Well / Seepage Pit							Subtotal:	21,500		5		25,900		8			4,400	5,787
Dry Well (Lot #1)	0.98	2	0.49	468	26.0	6	32.0	2,150	100.0		430	2,590	100.0		324	430	440	576
Dry Well (Lot #2)	0.91	2	0.46	468	28.1	6	34.1	2,150	100.0		430	2,590	100.0		324	430	440	568
Dry Well (Lot #3)	1.06	2	0.53	468	24.1	6	30.1	2,150	100.0		430	2,590	100.0		324	430	440	585
Dry Well (Lot #4)	1.02	2	0.51	468	25.0	6	31.0	2,150	100.0		430	2,590	100.0		324	430	440	580
Dry Well (Lot #5)	0.93	2	0.47	468	27.4	6	33.4	2,150	100.0		430	2,590	100.0		324	430	440	570
Dry Well (Lot #6)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
Dry Well (Lot #7)	0.97	2	0.49	468	26.3	6	32.3	2,150	100.0		430	2,590	100.0		324	430	440	575
Dry Well (Lot #8)	1.01	2	0.51	468	25.3	6	31.3	2,150	100.0		430	2,590	100.0		324	430	440	579
Dry Well (Lot #9)	1.04	2	0.52	468	24.5	6	30.5	2,150	100.0		430	2,590	100.0		324	430	440	582
Dry Well (Lot #10)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
BMP 6.4.7 Constructed Filter[7]										5				8				
BMP 6.4.8 Vegetated Swale[7]										5				8				
BMP 6.4.9 Vegetated Filter Strip[7]										5				8				
BMP 6.4.10 Infilt. Berm & Ret. Grading										5				8				
																	TOTAL:	14,613

[1] Assumes a soil testing procedure which finds hydraulic conductivity. (e.g. perc tests may also require a reduction factor)
[2] Time it takes for BMP to empty once it is full. (Minimum = 24 hrs, Maximum = 72 hours; Applicable to retention and detention facilities only.)
[3] Infiltration that occurs during the storm (before becoming full). Not to exceed 6 hours.
[4] A portion of the total area draining to BMP from non-pervious area may be diverted.
[5] Inherent in these calculations are the allowable loading ratios (5:1 and 8:1) from the BMP Manual. Higher loading ratios will need to be justified. In Karst Areas, the max. loading ratio should be 3:1.

PEAK RATE CONTROL ANALYSIS

According to the National Engineering Handbook (NRCS, 2008), the direct runoff for watersheds having more than one hydrologic soil-cover complex can be estimated in either of two ways. Runoff can be estimated for each complex and then weighted to get the watershed average. Alternatively, the CN values can be weighted, based on area, to obtain a single CN value to represent the entire drainage area. Then runoff is estimated with the single CN value. If the CN for the various hydrologic soil-cover complexes are close in value, both methods of weighting give similar results for runoff. However, if there exists a large difference in curve number value, the CN weighting method can provide drastically different results.

As described in the *National Engineering Handbook*, "the method of weighted runoff always gives the correct result (in terms of the given data), but it requires more work than the weighted CN method, especially when a watershed has many complexes. The method of weighted CN is easier to use with many complexes or with a series of storms. However, where differences in CN for a watershed are large, this method either under- or over-estimates runoff, depending on the size of the storm." This often occurs when impervious area exists in a subarea. When the relatively low curve number of lawn areas is combined with the high curve number of impervious areas, the weighted CN method will minimize the impact of the impervious surface and under-estimate the amount of runoff.

The spatial distribution of the different soil-cover complexes becomes the controlling factor in selection of the appropriate method. When different land uses behave as independent watershed the areas should be analyzed as separate drainage subareas. For example, when a large parking area is surrounded by lawn area that all flows to the same collection point, runoff from the impervious surface will occur much differently than runoff from the lawn. However, when impervious area is dispersed amongst other land uses and not directly connected to a stormwater collection system, the weighted CN method may be appropriate. The decision of whether or not to use a weighted curve number is often a site specific judgment that should be discussed between the designer and the Municipal Engineer in the early planning stages of a project.

Pre-Development Soil-Cover Complex Data

Because the wooded area along the north property line will remain unchanged, and will not be tributary to the stormwater facilities, this area has been removed from the peak rate analysis drainage areas. The weighted CN method was used for pre-development calculations in this example because Curve Numbers for the hydrologic soil-cover complexes are close in value. The drainage area and land cover information necessary to calculate the pre-development runoff is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Woods (good)	B	42,500	0.98	55
Meadow	B	310,255	7.12	58
TOTAL:		352,755	8.10	58

Pre-Development Time of Concentration

The *Model Ordinance* requires use of the NRCS Lag Equation for all pre-development time of concentration calculations unless another method is pre-approved by the Municipal Engineer.

$$T_{lag} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where:

T_{lag} = Lag time (hours)
L = Hydraulic length of the watershed (feet)
Y = Average overland slope of watershed (percent)
S = Maximum retention in the watershed, as defined by: S = [(1000/CN) – 10]
CN = NRCS Curve Number for the watershed

Lag time is related to time of concentration by the following equation:

Time of Concentration = T_c = [(T_{lag}/.6) * 60] (minutes)

One method of calculating the average overland slope of a watershed is to select locations that represent the various slopes found in the watershed and weight the slope based on the area it represents. This method is shown in the table on the following page.

Slope	End Elevation		Distance	Slope	Percent of	Product
Line	High	Low	(ft)	(%)	Total Area	(% x %)
AA	909	902	148	4.7%	5%	0.24%
BB	941	909	475	6.7%	50%	3.37%
CC	956	942	245	5.7%	15%	0.86%
DD	960	943	180	9.4%	15%	1.42%
EE	943	930	265	4.9%	15%	0.74%
					Sum of Products =	6.61%

This is an estimation of the land slope value, so the calculated number is rounded to the nearest whole number for use in the Lag Equation. The hydraulic length of the watershed was measured at 1050 ft. Therefore,

$$T_{lag} = (1050)^{0.8} \frac{((1000/CN)-10)+1)^{0.7}}{1900\sqrt{7}}$$

T_{lag} = 0.23 hours

Time of Concentration = T_C = (T_{lag} / 0.6) * 60
= (0.23 / 0.6) * 60
= 23 minutes

Pre-Development Peak Rate Flows

All of this information was used to perform a pre-development peak rate analysis using a software package based on the NRCS TR-20 procedures. The results of the analysis are as follows:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.6	4.1	7.6	11.1	15.3
Runoff Volume (ac-ft)	0.060	0.136	0.449	0.726	0.997	1.322
Runoff Depth (in)	0.09	0.20	0.66	1.08	1.48	1.96

Table B.1. Pre-Development Runoff Summary

Post-Development Soil-Cover Complex Data

Due to the disconnection of impervious areas and overland flow paths used in this design, the area weighted CN method was deemed appropriate and used to reduce the complexity of the model. The drainage area and land cover information for the drainage sub-area directly tributary to the bioretention facility is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Lawn (good condition)	B	9,700	0.22	61
Impervious	B	31,700	0.73	98
TOTAL:		41,400	0.95	70

Post-Development Time of Concentration

The Segmental Method was used for all post-development time of concentration calculations in this example. This method is covered in more detail in various NRCS publications (NRCS, 1986; NRCS, 2008). The following segments were used to calculate a time of concentration for the drainage sub-area directly tributary to the bioretention facility:

T_t-1: Sheet flow, 100' of lawn at 5% = 10.7 min
T_t-2: Shallow concentrated flow, 110' unpaved at 5.9% = 0.5 min
T_t-3: Channel flow, 80' at 4.0% = 0.2 min
T_t-4: Channel flow, 156' at 3.85% = 0.5 min
T_t-5: Pipe flow, 38' of 15" HDPE pipe at 5.2% = 0.1 min

$T_c = T_t\text{-}1 + T_t\text{-}2 + T_t\text{-}3 + T_t\text{-}4 + T_t\text{-}5 = 12$ minutes

Post-Development Peak Rate Flows

The hydrologic model for this example contains a considerable level of detail. Each structural BMP was modeled as a pond with a unique drainage area and time of concentration. Runoff was routed through each BMP and linked to downstream BMPs for subsequent routing. A detention basin with an outlet control structure was also added to the model. A graphical representation of the model is provided in *Figure B.1*.

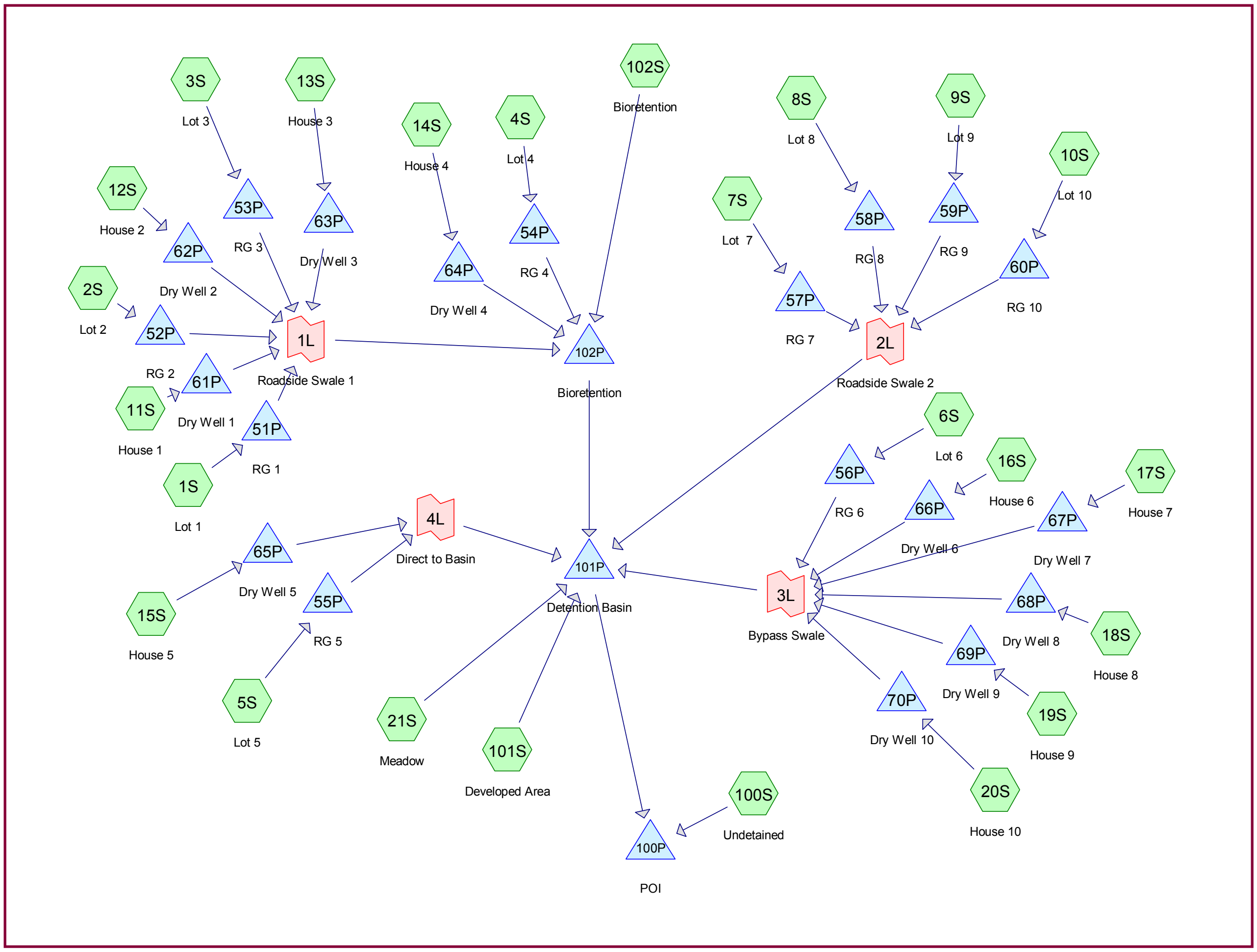

Figure B.1. Hydrologic Model of Post-Development Conditions

This model was used to estimate the post-development peak rate flows. The final configuration of the outlet structure was completed through an iterative process using the results of the model runs. This design meets the peak rate control requirements through a combination of volume removed by the structural `BMPs and the detention basin and outlet control structure. *Table B.2* shows a summary of the runoff results for the final post-development design:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.4	4.1	7.4	10.6	15.2
Runoff Volume (ac-ft)	0.079	0.147	0.445	0.717	1.011	1.367
Runoff Depth (in)	0.12	0.22	0.66	1.06	1.50	2.03

Table B.2. Summary of Post-Development Runoff with Stormwater Controls

INITIAL CONSTRUCTION COST - DESIGN EXAMPLE

Initial construction costs were estimated for each layout. The estimates include the costs incurred by the developer to complete earthwork, paving and curbing, and stormwater management facilities. All of these costs are summed to determine an initial construction cost for these facilities. This cost was then divided by the total sellable acreage of the project to determine a cost / sellable acre for each layout.

Estimate of Initial Construction Cost
Mill Run Residential – Traditional Layout

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
EARTHWORK				**Subtotal =**	**$ 23,950**
1	Clearing & Grubbing	2.3	AC	$ 6,000.00	$ 13,800
2	Topsoil Removal/Stockpiling	5.8	AC	$ 1,750.00	$ 10,150
STORM DRAINAGE				**Subtotal =**	**$ 102,769**
3	Storm Sewer, 18" HDPE	600	LF	$ 55.00	$ 33,000
4	Storm Inlets	7	EA	$ 2,100.00	$ 14,700
5	Swales	490	LF	$ 10.00	$ 4,900
6	Install Detention Basin	1,525	CY	$ 25.00	$ 38,125
7	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
8	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
9	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
10	DW Endwall 24"	1	EA	$ 2,750.00	$ 2,750
11	Rip Rap Apron	144	SF	$ 6.90	$ 994
PAVING & CURBING				**Subtotal =**	**$ 138,657**
12	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	2,325	SY	$ 30.00	$ 69,750
13	Curbing w/Excavation & Backfill	1,465	LF	$ 27.00	$ 39,555
14	Sidewalk plain w/4" - stone	4,285	SF	$ 6.85	$ 29,352
				Initial Construction Cost =	**$ 265,376**
				Cost / Sellable Acre =	**$ 42,734**

Table B.3. Estimate of Construction Cost for Residential Design Example (Traditional Layout)

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
	Estimate of Initial Construction Cost ***Mill Run Residential – LID Layout***				
	EARTHWORK			**Subtotal =**	**$ 14,925**
1	Clearing & Grubbing	1.0	AC	$ 6,000.00	$ 6,000
2	Topsoil Removal/Stockpiling	5.1	AC	$ 1,750.00	$ 8,925
	STORM DRAINAGE			**Subtotal =**	**$ 114,172**
3	Swales	1,620	LF	$ 10.00	$ 16,200
4	Storm Sewer, 18" HDPE	136	LF	$ 55.00	$ 7,480
5	DW Headwall 18"	1	EA	$ 2,750.00	$ 2,750
6	Storm Inlets	1	EA	$ 2,100.00	$ 2,100
7	Install Detention Basin	600	CY	$ 25.00	$ 15,000
8	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
9	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
10	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
11	Level Spreader	44	LF	$ 5.50	$ 242
12	Bioretention Area	5,175	SF	$ 12.00	$ 62,100
	PAVING & CURBING			**Subtotal =**	**$ 53,790**
13	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	1,645	SY	$ 30.00	$ 49,350
14	Gravel Shoulder	370	SY	$ 12.00	$ 4,440
				Initial Construction Cost =	**$ 182,887**
				Cost / Sellable Acre =	**$ 28,355**

Table B.4. Estimate of Construction Cost for Residential Design Example (LID Layout)

The cost of constructing the stormwater BMPs on each individual lot was not included in the comparison of initial construction costs. This is a cost that will be borne by the owner of each individual lot. This must be included in the cost comparison analysis. *Table B.5* shows an estimate of these costs.

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
	Estimate of Stormwater BMP Construction Cost ***Mill Run Residential – LID Layout***				
	STORMWATER BMPS				
1	Rain Gardens	6,740	SF	$ 10.00	$ 67,400
2	Dry Wells	450	CY	$ 32.00	$ 14,400
				Construction Cost =	**$ 81,800**
				Cost / Sellable Acre =	**$ 12,682**

Table B.5. Estimate of Stormwater BMP Construction Cost

Determining how this additional cost to homeowners will be reflected in the market value of developed land is presumptive at best. For this example, we have assumed that some of the cost of constructing the stormwater BMPs will result in a dollar for dollar reduction in the market value of the sellable land. So, the BMP construction cost per sellable acre is subtracted from the per acre market value price of the land.

The initial construction cost is subtracted from the land sale value to determine the developers profit for each layout.

Cost = Land Sale Value - Initial Construction Cost

Traditional Layout
Cost = $310,500 - $265,376
= $45,124

LID Layout
Cost = $240,701 – $182,887
= $57,814

The final cost comparison is completed by determining the difference in profit between the two layouts. For this example, a total profit increase of $12,690 is realized by the developer using the LID layout with no additional cost to the individual homeowners.