D. Soils

The NRCS State Soil Geographic (STATSGO) data base is compiled by generalizing more detailed soils survey maps, such as a County Soils Survey. Map unit composition for a STATSGO map is determined by transecting or sampling areas on the more detailed maps and expanding the data statistically to characterize the whole map unit. A generalized soils group can consist of up to 21 different soil components; however the naming convention is typically based upon the three largest components which make up the group. In the Maiden Creek watershed, five generalized soil groups were identified. Below is a listing of the five generalized soils groups within the watershed and a description of the three largest components. The distribution of the generalized soil groups in the Maiden Creek Watershed is shown in Figure III-3.

1. <u>Hazleton-Dekalb-Buchanan (PA022)</u>

HAZLETON - The Hazleton series consists of deep and very deep, well drained soils formed in residuum of acid gray, brown or red sandstone on uplands. Slope ranges from 0 to 80 percent. Permeability is moderately rapid to rapid.

DEKALB - The Dekalb series consists of moderately deep, excessively drained soils formed in material weathered from gray and brown acid sandstone in places interbedded with shale and graywacke. Slope ranges from 0 to 80 percent. Permeability is rapid.

BUCHANAN - Soils of the Buchanan series are very deep, moderately well drained, and slowly permeable. They formed in colluvium on mountain footslopes, sideslopes and in valleys that is weathered from acid sandstone, quartzite, siltstone, and shale. Slope ranges from 0 to 45 percent.

2. <u>Berks-Weikert-Bedington (PA033)</u>

BERKS - The Berks series consists of moderately deep, well drained soils formed in residuum weathered from shale, siltstone and fine grained sandstone on rounded and dissected uplands. Slope ranges from 0 to 80 percent. Permeability is moderate or moderately rapid.

WEIKERT - The Weikert series consist of shallow, well drained soils formed in material that weathered from interbedded gray and brown acid shale, siltstone, and fine-grained sandstone on gently sloping to very steep areas on uplands. Slope ranges from 0 to 90 percent. Permeability is moderately rapid.

BEDINGTON - The Bedington series consists of very deep, well drained soils. Bedington soils formed in residuum from dark brown, gray and olive acid, sedimentary, siltstone and shale, with some sandstone interbeds. They are on nearly level to steep convex uplands and on the sideslopes of hills and ridges. Permeability is moderate.

3. Hagerstown-Duffield-Clarksburg (PA058)

HAGERSTOWN - Typically, Hagerstown soils have a brown to dark brown silt loam Ap horizon, yellowish red clay Bt horizons, and yellowish brown clay C horizons. Well drained. Permeability is moderate. Runoff is moderate to rapid.

DUFFIELD - The Duffield series consists of deep and very deep, well drained soils formed in residuum from limestone bedrock. Slopes range from 0 to 35 percent. Permeability is moderate.

CLARKSBURG - The Clarksburg series consists of very deep, moderately well drained soils formed in colluvium, glacial till, or residuum from limestone, calcareous and noncalcareous shale, and sandstone. They are on uplands. Slope ranges from 0 to 25 percent. Permeability is slow to moderately slow.

4. Chester-Glenelg-Manor (PA061)

CHESTER - The Chester series consists of very deep, well drained, moderately permeable soils on uplands. They formed in materials weathered from micaceous schist. Slopes range from 0 to 65 percent.

GLENELG - The Glenelg series consists of very deep, well drained, moderately permeable soils on uplands formed in residuum weathered from micaceous schist. Slopes range from 0 to 55 percent.

MANOR - The Manor series consists of very deep, well drained to somewhat excessively drained, moderately permeable soils on uplands. They formed in materials weathered from micaceous schist. Slopes range from 0 to 65 percent.

5. Ryder-Clarksburg-Berks (PA068)

RYDER	The Ryder series consists of moderately deep, well drained soils. They formed in residuum weathered from thin bedded shaly limestone. They are on convex upland slopes of 0 to 25 percent. Permeability is moderate.
CLARKSBURG	The Clarksburg series consists of very deep, moderately well drained soils formed in colluvium, glacial till, or residuum from limestone, calcareous and noncalcareous shale, and sandstone. They are on uplands. Slope ranges from 0 to 25 percent. Permeability is slow to moderately slow.
BERKS	The Berks series consists of moderately deep, well drained soils formed in residuum weathered from shale, siltstone and fine grained sandstone on rounded and dissected uplands. Slope ranges from 0 to 80 percent. Permeability is moderate or moderately rapid.

Soil properties influence the runoff generation process. The USDA, Natural Resources Conservation Service (NRCS) has established a criterion determining how soils will affect runoff by placing all soils into Hydrologic Soil Groups (HSGs). HSGs are broken down into four sub-groups (A through D) based on infiltration rate and depth.

The majority of the soils in the watershed fall in Group B and C. There is a very small portion (less than 1%) of hydrologic soils group A in the Maiden Creek watershed. A large area of Group B soils are found in the southern portion of the watershed and in the upper middle portion of the watershed and along the Maiden Creek and its tributaries. Group B is characterized as having moderate infiltration rates and consist primarily of moderately deep to deep, moderately well to well drained soils that exhibit a moderate rate of water transmission. Group C soils occupy most of the upper two-third of the watershed along of the occurrence of group B soils. Two bands of group C soils are found in the watershed, one within the group B soil in the southern portion of the watershed and one near the northern boundary of the watershed along the Schuylkill County. Group C has slow infiltration rates when thoroughly wetted and contain fragipans, a layer that impedes downward movement of water and produces a slow rate of water transmission. Group D soils are found mainly in the north and south portions of the watershed. D soils are tight, low permeable soils with high runoff potential and are typically clay soils. Soils mixed with group B and D soils are found in the northeastern portion of the watershed, primarily in the Lehigh County. This information was incorporated into the GIS and, from this, the watershed HSG map was developed as shown in Figure III-4.

MAIDEN CREEK WATERSHED
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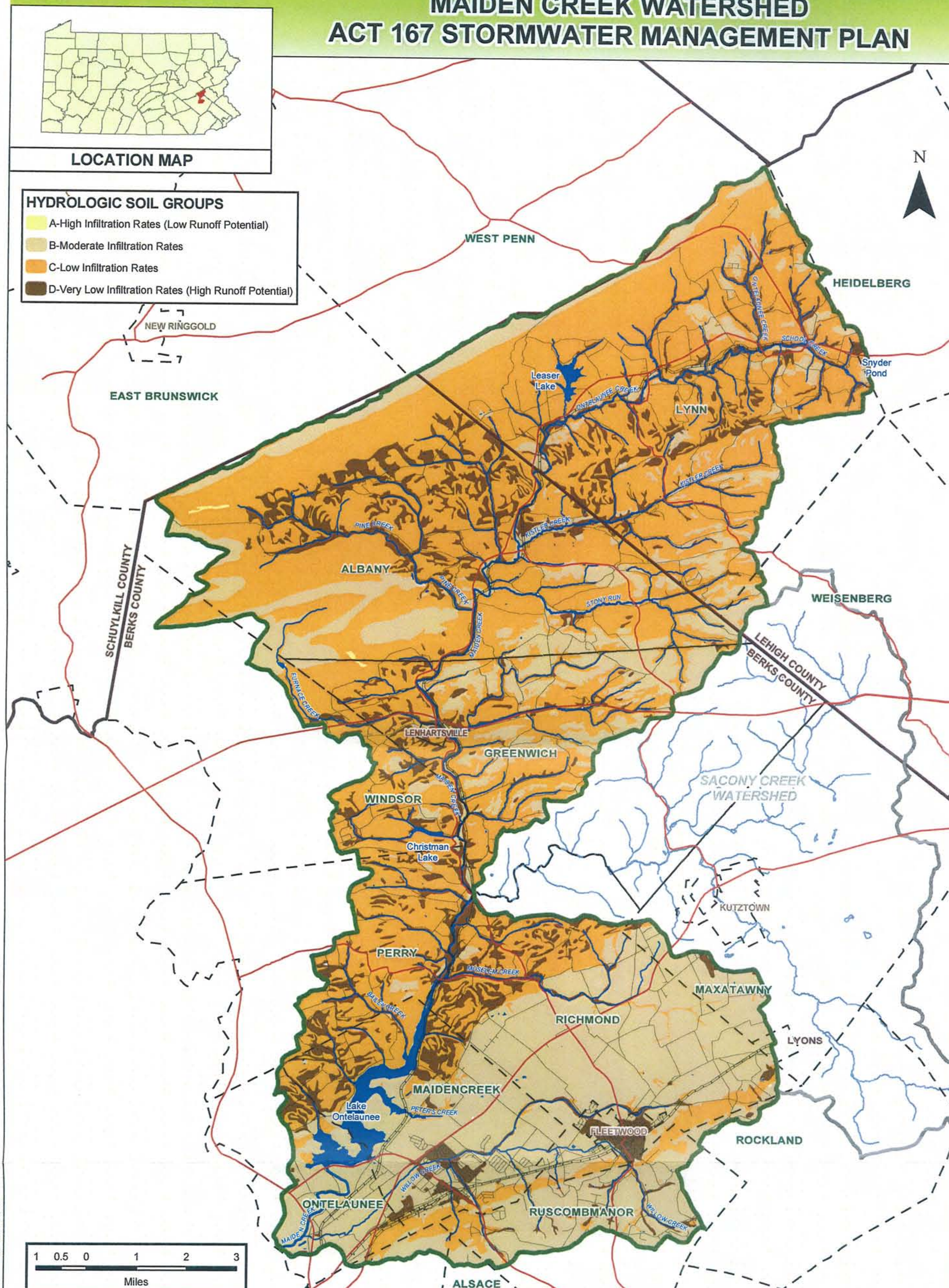

Figure III-4
HYDROLOGIC SOIL GROUPS

Map Legend
- WATERSHED BOUNDARY
- STREAMS
- WATER BODIES
- COUNTY BOUNDARIES
- MUNICIPAL BOUNDARIES
- HIGHWAYS
- OTHER ROADS
- RAILROADS

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NOTE:
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Streams - PaDEP
Lakes - US Fish and Wildlife Service (Extracted from NWI Coverages)
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Railroads - Berks Co. & Lehigh Valley Regional Planning Commissions
Counties - Berks County Planning Commission
Municipalities - Berks Co. & Lehigh Valley Regional Planning Commissions, PennDOT
Hydrolic Soil Groups - USDA/NRCS Soil Survey Geographic (SSURGO) Database

Borton Lawson ENGINEERING
Corporate Office
613 Baltimore Drive
Wilkes-Barre, PA 18702
Tel: 570-821-1999
Lehigh Valley Office
6814 Chrisphalt Drive
Bath, PA 18014
Tel: 610-837-5916

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DATE: 12/10/2004 | PROJECT NO. 2003-1349-01

FILE: \\WBData\Projects\2003\1349\01\DATA\GIS\ArcMap\FINAL_MAPS\FigureIII-04_HSG(Maiden).mxd

E. Geology

Geology plays a direct role in surface runoff in Maiden Creek because it affects its soil types within the watershed through parent material breakdown. Limestone surface geology is found in the southern most portion of the Maiden Creek Watershed in Richmond, Ontelaunee and Maidencreek Townships; therefore limestone sinkholes may be present in these areas. The geologic map of the watershed can be found in Figure III-5 and highlights the limestone surface geology within the watershed. Below are general descriptions of the geologic formations in the watershed.

1. **Allentown Formation (Cal)** – Medium-gray dolomite and impure limestone; dark-gray chert stringers and nodules; laminated; some oolite and sharpstone conglomerate; maximum thickness is about 2,000 feet; good subsurface drainage; poor surface drainage; sinkholes are common.

2. **Epler Formation (Oe)** - Very finely crystalline, medium-gray limestone interbedded with gray dolomite; coarsely crystalline limestone lenses present; approximately 1,000 feet thick; good subsurface drainage; sinkholes and caves are characteristic.

3. **Felsic and intermediate gneiss (ggd)** – Medium grained; light pink to green; largely quartz, feldspar, and mica; commonly gneissic; good surface drainage.

4. **Felsic to mafic gneiss (gn)** – Light buff to light pink; fine to medium grained; most mineral grains are about 1mm in diameter; primary minerals are quartz, microcline, hornblende, and occasional biotite; good surface drainage.

5. **Graphitic felsic gneiss (gg)** – Light to medium gray; includes the minerals quarts, orthoclase, hornblende, biotite, and graphite; graphite occurs as flakes 1 to 2 mm in diameter, somewhat larger than the usual grain size of the rock, and is disseminated throughout the gneiss; graphite shows a glistening luster; includes Pickering Gneiss; good surface drainage.

6. **Graywacke and shale of Martinsburg Formation (Omgs)** – Gray to dark gray, buff-weathering shale; abundant impure sandstone (greywacke) interbeds.

7. **Hamburg sequence rocks (Oh)** – Transported rocks of the Hamburg overthrust; gray, greenish-gray, and maroon shale, silty and siliceous in many places; dark-gray impure sandstone; medium- to light-gray, finely crystalline limestone and shaly limestone; total thickness is about 3,000 feet; good surface drainage.

8. **Hardyston Formation (Cha)** – Light-gray quartzite; weathers yellow brown; porous and limontic in many places; quartz-pebble conglomerate occurs at base; maximum thickness is 800 feet; good surface drainage.

9. **Hornblende gneiss (hg)** – Dark-gray to black; horneblende makes up about 50 percent of the rock; the other 50 percent is labradorite (feldspar); rock is extremely resistant to abrasion and very resistant to rupture, but may be susceptible to crumbling; good surface drainage.

10. **Jacksonburg Formation (Ojk)** – Medium- to dray-gray limestone, coarsely crystalline; thin silty layers; fossiliferous; commonly called "cement limestone"; maximum thickness is 375 feet; "cement rock" portion of formation is composed of silty limestone, dark-gray to black, fine-grained; thin pyrite seams; fossiliferous; 830 feet thick; good surface drainage; minor subsurface drainage.

11. **Juniata and Bald Eagle Formations, undivided (Ojb)** - Includes, in descending order, the Juniata (Oj) and Bald Eagle (Obe) Formations. Juniata formation – Brownish-red, fine grained to conglomeratic, quartzitic sandstone having well-developed crossbedding; interbedded red shale; maximum thickness is 1,125 feet; good surface drainage. Bald Eagle Formation – Gray to reddish-gray to brownish-gray, fine- to coarse-grained, crossbedded sandstone, and quartz-pebble conglomerate; maximum thickness about 1,000 feet; surface drainage is good.

12. **Leithsville Formation (Clv)** – Dark-gray to medium-gray dolomite; some calcareous shale and sandy dolomite; cherty; 1,500 feet thick; good surface drainage; little subsurface drainage.

13. **Limestone of Hamburg sequence (Ohl)** – Hamburg sequence rocks (Oh) with conspicuous limestone.

14. **Martinsburg Formation (Om)** – Buff-weathering, dark-gray shale, and thin interbeds of siltstone, metabentonite, and fine-grained sandstone; brown-weathering, medium-grained sandstone containing shale and siltstone interbeds occurs in the middle of the formation; basal part grades into limy shale and platy-weathering, silty limestone; may be 12,800 feet thick; good surface drainage.

15. **Ontelaunee Formation (Oo)** – Light- to dark- gray, very fine to medium-crystalline dolomite; interbedded and nodular dark-gray chert at base; average thickness is about 750 feet; good subsurface drainage; minor surface drainage.

16. **Rickenbach Formation (Ori)** - Gray, very finely to coarsely crystalline, laminated dolomite; dark-gray chert in irregular beds, stringers, and nodules; bands of quartz-sand grains in lower half; thickness of at least 350 feet is present; good subsurface drainage; minor surface drainage.

17. **Shale and graywacke of Hamburg sequence (Ohsg)** – Hamburg sequence rock (Oh); shale containing zones of conspicuous greywacke (sandstone).

18. **Shawangunk Formation (Ss)** – Light to dark-gray, fine- to very coarse grained sandstone and conglomerate containing thin shale interbeds; crossbedded; tightly cemented; maximum thickness is 1,600 feet; good surface drainage.

19. **Stonehenge Formation (Os)** - Gray, finely crystalline limestone and dark-gray silty laminated limestone; contains numerous flat-pebble breccia beds and shaly interbeds; maximum thickness is 1,500 feet; good subsurface drainage; sinkholes are characteristic.

MAIDEN CREEK WATERSHED
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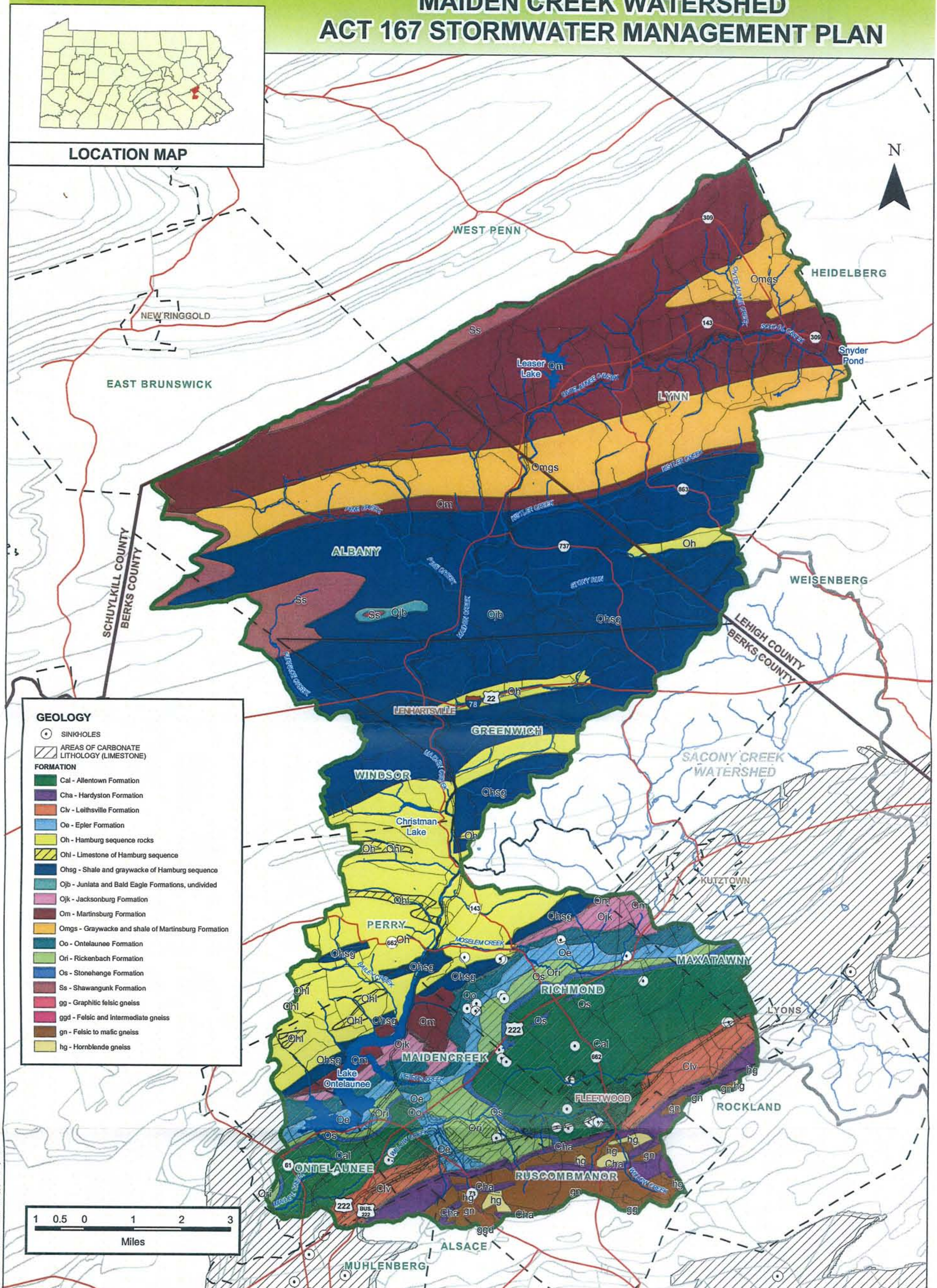

GEOLOGY

- SINKHOLES
- AREAS OF CARBONATE LITHOLOGY (LIMESTONE)

FORMATION

- Cal - Allentown Formation
- Cha - Hardyston Formation
- Clv - Leithsville Formation
- Oe - Epler Formation
- Oh - Hamburg sequence rocks
- Ohl - Limestone of Hamburg sequence
- Ohsg - Shale and graywacke of Hamburg sequence
- Ojb - Juniata and Bald Eagle Formations, undivided
- Ojk - Jacksonburg Formation
- Om - Martinsburg Formation
- Omgs - Graywacke and shale of Martinsburg Formation
- Oo - Ontelaunee Formation
- Ori - Rickenbach Formation
- Os - Stonehenge Formation
- Ss - Shawangunk Formation
- gg - Graphitic felsic gneiss
- ggd - Felsic and intermediate gneiss
- gn - Felsic to mafic gneiss
- hg - Hornblende gneiss

Figure III-5 GEOLOGY AND LIMESTONE

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County Services Center
633 Court Street
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610-476-6300

Map Legend

- WATERSHED BOUNDARY
- STREAMS
- WATER BODIES
- COUNTY BOUNDARIES
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Counties - Berks County Planning Commission
Municipalities - Berks Co. & Lehigh Valley Regional Planning Commissions, PennDOT
Geology, Limestone and Sinkholes - PaDCNR

Borton Lawson ENGINEERING
Corporate Office
613 Baltimore Drive
Wilkes-Barre, PA 18702
Tel: 570-821-1999
Lehigh Valley Office
6814 Chrisphalt Drive
Bath, PA 18014
Tel: 610-837-5916

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F. Climate

n/a

~~Berks County has a fairly moderate, hum[illegible] continental climat[illegible] its location on the leeward side of the mountains in the east-[illegible]tral part of Pen[illegible]vania, w[illegible]e comparatively short and mild while the warm season is l[illegible] and frequent[illegible]umid. In the [illegible]er, the relative humidity drops to 35 to 45 percent during [illegible]e afternoons. [illegible]he average [illegible] humidity for the year is generally higher than 65 perce[illegible] About tw[illegible]s of the [illegible]e, [illegible] are clear to partly cloudy, and the average amount of [illegible]shine is abou[illegible] perce[illegible] of the [illegible]e amount. Storms are generally numerous enough tha[illegible]ey insure an adequa[illegible] and depen[illegible]upply of moisture throughout the year.~~

~~The county is [illegible] the major wea[illegible]r systems that m[illegible]ross the r[illegible]on[illegible]fore, the we[illegible]her i[illegible]ariable. [illegible]s in the temp[illegible]ture, the velocity [illegible] humidity, and oth[illegible] th[illegible] elements t[illegible]occur form [illegible] to day and from [illegible]ek, and seasonal v[illegible]s from year to [illegible] During wint[illegible] and spring, changes [illegible] almost daily. During summ[illegible] fall, changes ar[illegible] frequent be[illegible]use the high and low pressure systems that are respons[illegible] the weather mo[illegible]e slowly [illegible]hese seasons than they do in winter and spring.~~

~~From June [illegible]h October, the w[illegible] remain[illegible]pproximately the same for a week or more at a time. Hot [illegible]ays and mild n[illegible]ally result when a pressure system remains stagnant for several da[illegible]he summer. C[illegible]ghts are typical when a pressure system remains stagnant for several da[illegible]he fall. [illegible]veral of these spells can be expected in most years, though extreme heat is [illegible] absent in some summers. During winter and spring, unseasonably cold spells last [illegible]y a few days because the weather systems move more rapidly than in summer and f[illegible]~~

G. Land Use

The major land use categories within the Maiden Creek Watershed include residential, commercial, industrial, agricultural and forestland, and non-profit/public. Agriculture is predominant throughout the SR 222 and I-78 corridor along with most of the land area north and west of Lake Ontelaunee and the Maiden Creek. Large areas of agriculture can also be found in the central portion of Greenwich Township and in Albany Township extending into Northern Lehigh County. Forested areas and steep slopes can be found all along the very northern tier of the watershed that includes thousands of acres owned by both non-profits (Appalachian Trail Conference and Hawk Mountain Sanctuary) and public entities such as Pennsylvania State Forests, Gamelands and Parks. Forested areas and steep slopes are also found in pockets east of the Maiden Creek and north of Kutztown Borough and throughout Albany Township extending eastward into northern Lehigh County.

The majority of development exists in and around the Boroughs and Villages with small developed "crossroads" scattered throughout the entire watershed. One of the most densely populated areas of the watershed can be found north of the City of Reading in the Maidencreek Township, Ontelaunee Township, southern Richmond Township and the Fleetwood Borough area. The majority of development pressure currently is along the SR 222 corridor spreading north of the City of Reading.

Figure III-6 displays the existing land use of the watershed while Table III-3 shows the overall land use by category within the Maiden Creek Watershed.

TABLE III-3
Land Use Status by Category

LANDUSE	MAIDEN CREEK SQ MI.	PERCENT
Agriculture	72.0	44.8
Commercial	1.0	0.6
Farmstead	3.3	2.1
Forest	56.8	35.3
Industrial	1.5	0.9
Institutional	0.5	0.3
Interstate	0.2	0.1
Mining	0.7	0.4
Meadow	2.1	1.3
Orchard	0.1	0.1
Open Space	1.7	1.1
Paved Area	0.1	0.1
R1- (2 to 4 acres)	9.9	6.2
R2- (1/2 to 1 acre)	1.8	1.1
R3 (1/4 to 1/3 acre)	1.0	0.6
R4 (1/8 acre or less	0.2	0.1
Right-Of-Way	5.2	3.2
Water	2.7	1.7
Total	**160.8**	**100.0**

MAIDEN CREEK WATERSHED
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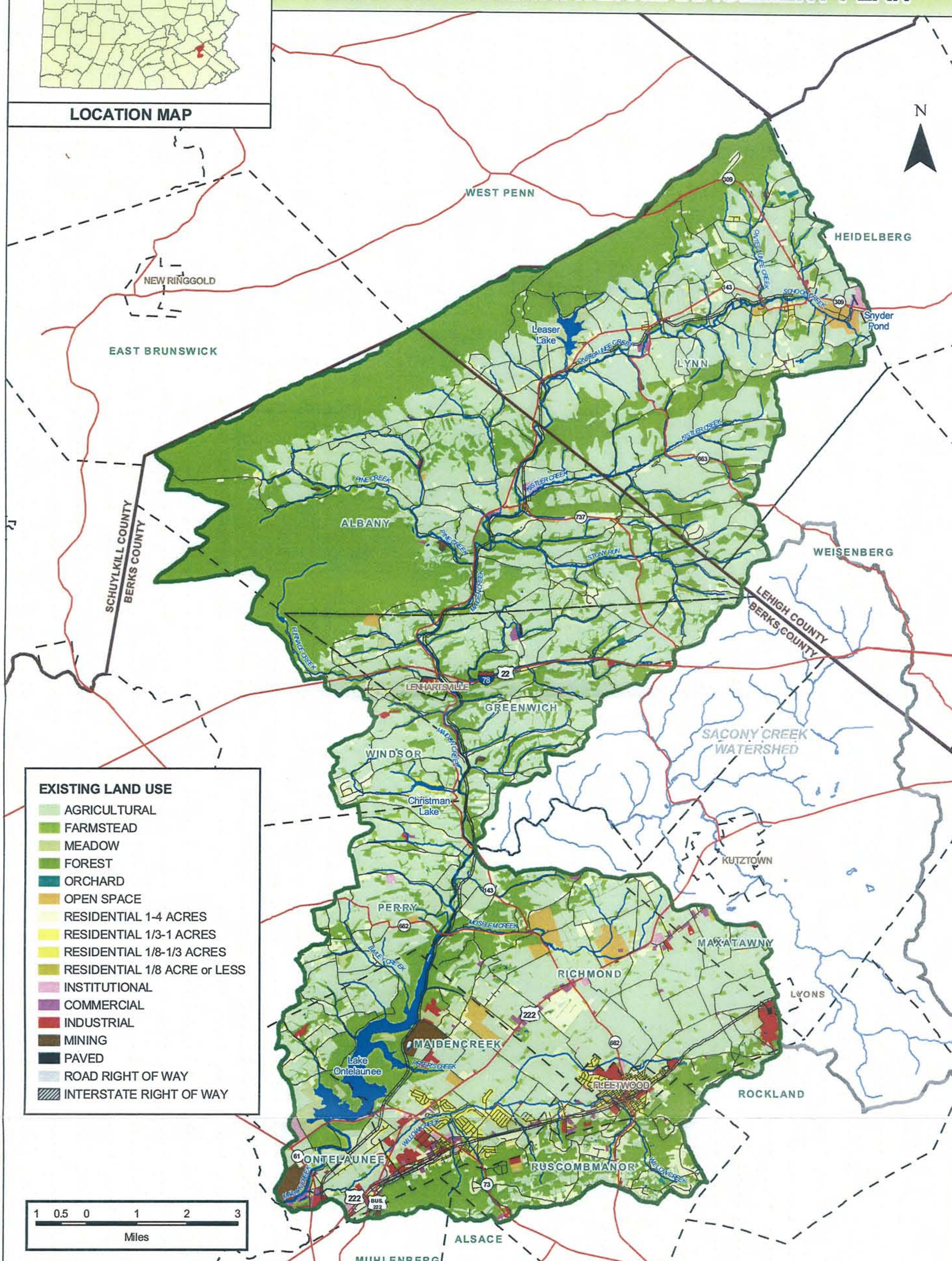

Figure III-6 EXISTING LAND USE

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Map Legend
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Counties - Berks County Planning Commission
Municipalities - Berks Co. & Lehigh Valley Regional Planning Commissions, PennDOT
Streams - PaDEP
Lakes - US Fish and Wildlife Service (Extracted from NWI Coverages)
Watershed Boundary - PADEP/ Modified by Borton-Lawson
Existing Land Use - Berks County Planning Commission

Borton Lawson ENGINEERING

Corporate Office
613 Baltimore Drive
Wilkes-Barre, PA 18702
Tel: 570-821-1999

Lehigh Valley Office
6814 Chrisphalt Drive
Bath, PA 18014
Tel: 610-837-5916

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H. Land Development Patterns

The watershed is predominantly agricultural and forested. Low density residential development is found along highways and other state-maintained roads throughout the watershed. The greatest amount of concentrated development is found in the southern portion, especially along the railroad corridor passing through lower Ontelaunee, Maidencreek, Richmond Townships and Fleetwood Borough. These areas and areas along the Interstate 78 corridor are expected to experience the greatest amount of development in the near future.

Table III-4 provides an overview of the types of development that will occur when existing patterns are considered for each municipality within the watershed.

TABLE III-4
Development Potential by Municipality
Based Upon Existing Patterns in the Maiden Creek Watershed

Municipality		R-4	R-3	R-2	R-1	I	C	OS	F
Berks County									
Albany Township		---	---	X	X	X	X	r	r
Alsace Township		---	---	---	---	---	---	---	---
Fleetwood Borough		---	---	---	O	O	O	r	r
Greenwich Township		---	---	---	X	X	X	---	r
Lenhartsville Borough		---	---	---	X	O	O	---	r
Lyons Borough		---	---	---	---	O	O	---	---
Maidencreek Township		O	X	X	X	O	X	r	r
Maxatawny Township		---	---	---	X	O	O	---	---
Muhlenberg Township		---	---	---	---	O	O	---	r
Ontelaunee Township		---	O	X	O	X	X	---	r
Perry Township		---	---	---	X	---	---	r	r
Richmond Township		---	---	---	X	O	O	r	r
Rockland Township		---	---	---	---	---	---	---	---
Ruscombmanor Township		O	---	X	X	X	O	---	r
Windsor Township		---	r	X	X	O	O	---	r
Lehigh County									
Heidelberg Township		---	---	---	O	---	---	---	---
Lynn Township		X	---	---	X	---	X	r	r
Weisenberg Township		---	---	---	---	---	---	---	---

R-4 Residential Lots (1/8 acre or less)
R-3 Residential Lots (1/4 ac. - 1/3 ac)
R-2 Residential Lots (1/2 ac. - 1 ac.)
R-1 Residential Lots (greater than 1 acre)
I Industrial
C Commercial
OS Open Space
F Forest

--- No Impact
O Minor Impact
X Major Impact
r Reduction in Land Use

The future land use (FLU) GIS coverage for the Maiden Creek Watershed is a potential 10 year development scenario generated to estimate future stormwater runoff characteristics. The FLU coverage was created by combining the existing land use coverage with parcel data, zoning, open space data (parks, gamelands, preserved lands with easements, etc.) and future land use data for Berks County from the Berks County Comprehensive Plan (Future 2020) and comprehensive plan data for Lehigh County from the Lehigh Valley Planning Commission. The future land use map is shown in Figure III-7. These increased impervious areas were then included in the HEC-HMS model to develop a future condition flows for the 100-year storm. A comparison of peak flows for the 100-year storm for future and existing conditions can be found in Table III-5.

The future 100-year storm hydrograph peak was found to be an average of **107%** of the present 100-year storm hydrograph at the Maiden Creek outlet. Table III-5 summarizes the flows for each subwatershed for existing conditions and for the future land use projection, assuming proper stormwater management facilities are not installed.

Increased development in a watershed increases runoff peaks, volumes and velocities. This decreases the time to peak, worsening the frequency of flooding.

MAIDEN CREEK WATERSHED
ACT 167 STORMWATER MANAGEMENT PLAN

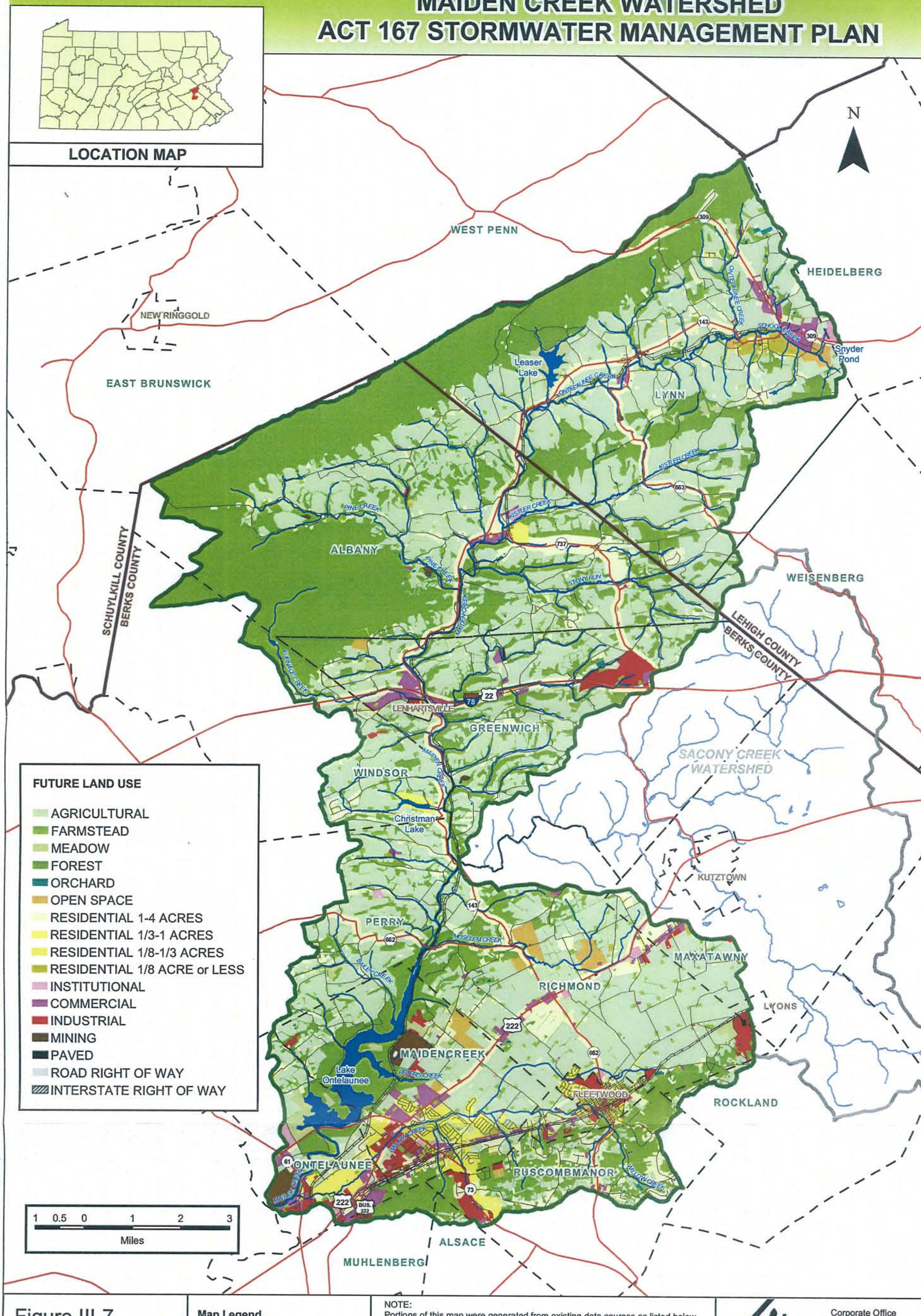

Figure III-7
FUTURE LAND USE

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Map Legend
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Watershed Boundary - PADEP/ Modified by Borton-Lawson
Future Land Use - Modeled by BLE using Exisitng Landuse, Zoning, Parcels and preserved areas

Borton Lawson ENGINEERING
Corporate Office
613 Baltimore Drive
Wilkes-Barre, PA 18702
Tel: 570-821-1999
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TABLE III-5
Present Versus Future Combined Peak Flows – 100-Year 24-Hour Storm
(Please refer to Appendix D of the Model Ordinance for Subarea Locations)

Subarea No.	Subarea Area (sq. mi.)	Cumulative Area (sq. mi.)	Existing Peak Q (cfs)	Future Peak Q (cfs)
1	3.69	3.69	1,361	1,376
2	1.28	9.75	3,001	3,167
3	4.78	4.78	1,324	1,437
4	4.48	17.87	4,872	5,057
5	3.65	3.65	1,105	1,119
6	3.03	20.90	5,499	5,686
7	2.88	2.88	1,170	1,172
8	0.17	3.04	655	657
9	0.77	24.71	6,072	6,263
10	2.04	2.04	871	871
11	1.57	28.31	6,444	6,632
12	7.67	7.67	3,109	3,647
13	2.12	9.79	3,357	3,903
14	0.50	45.40	7,970	8,192
15	6.81	6.81	1,906	1,902
16	1.09	46.50	8,038	8,260
17	5.69	5.69	2,637	2,792
18	3.28	8.97	3,355	3,542
19	0.52	55.47	9,736	10,397
20	3.84	3.84	1,254	1,254
21	11.65	11.65	2,319	2,319
22	2.37	17.86	3,438	3,438
23	2.38	76.22	13,324	13,946
24	2.60	2.60	939	940
25	0.82	78.82	13,649	14,278
26	1.42	1.42	413	413
27	2.21	3.63	1,075	1,107
28	0.32	83.59	14,430	15,070
29	7.54	7.54	2,796	2,844
30	6.22	99.91	16,583	17,259
31	2.46	2.46	1,322	1,323
32	0.10	2.56	1,300	1,301
33	1.35	101.26	16,679	17,354
34	1.99	158.55	20,379	20,590
35	3.36	175.41	21,110	22,059
36	8.18	8.18	1,515	2,241
37	3.25	11.43	2,006	2,930
38	2.07	13.50	2,400	3,375

TABLE III-5 (cont.)
Present Versus Future Combined Peak Flows –
100-Year 24-Hour Storm
(Please refer to Appendix D of the Model Ordinance for Subarea Locations)

Subarea No.	Subarea Area (sq. mi.)	Cumulative Area (sq. mi.)	Existing Peak Q (cfs)	Future Peak Q (cfs)
39	0.03	175.43	21,109	22,060
40	0.81	0.81	295	296
41	2.91	2.91	1,429	1,477
42	13.20	192.35	23,061	24,837
43	1.67	194.01	21,145	21,756
44	3.95	3.95	751	1,066
45	3.33	7.28	1,186	1,735
46	3.12	3.12	1,348	1,357
47	2.51	5.63	1,809	2,105
48	1.30	1.30	630	630
49	0.08	1.38	649	655
50	0.04	7.05	2,137	2,443
51	1.21	15.54	2,533	3,323
52	1.44	1.44	716	867
53	0.29	1.73	837	1,021
54	0.68	0.68	419	431
55	0.01	2.42	1,209	1,423
56	3.73	21.69	3,508	4,356
57	0.41	216.12	22,661	24,137

Note: The computed flow values were derived for watershed planning purposes and should not be considered regulatory values for permitting purposes. While they may be used for comparison or checking purposes, additional hydrologic computations may be needed for the design of bridges, culverts and dams.

One of the biggest problems in floodplai[illegible] management is the [illegible]ease in peak flow caused by development in the watershed. Recognizi[illegible] this, the Na[illegible] Insurance Program (NFIP) has developed a Community Rating Syste[illegible] (CRS) to [illegible]ve comm[illegible]ies credit for floodplain management activities that exceed the mi[illegible]num requ[illegible]ents. A[illegible] of this rating system, credit points can be awarded to communities [illegible] they imp[illegible]ent th[illegible]oll[illegible]g:

- regulatory language (ordinance) requ[illegible]ng peak rate [illegible]unoff fro[illegible]ve[illegible]pment to be no greater than the [illegible]ndition run[illegible]f.
- a stormw[illegible]er m[illegible]ter p[illegible]ch as this [illegible]ct 167 Plan)
- state re[illegible] the storm[illegible] manage[illegible]nt plan
- requ[illegible]r a building[illegible]vest floo[illegible]to be elevated above flood levels
- erosion an[illegible]iment contr[illegible]ulation[illegible](such as Chapter 102)
- water qualit[illegible]ulations

The more credits a co[illegible]unity can a[illegible]mulate, the less its residents will have to pay for flood insurance. For further [illegible]ation on the community rating system, the publication "*CRS Credit for Stormwater Manag[illegible]*", July 1996, published by FEMA, is available at the County Planning Commission [illegible]ffice.

J. Obstructions

Locations of significant waterway obstructions (i.e., culverts, bridges, etc.) were obtained by inspection of the U.S.G.S. topographic base map. Data on these obstructions was then obtained from the Pennsylvania Department of Transportation (PaDOT), F.E.M.A. Flood Insurance Studies, and field surveys.

The obstruction flow capacities were then compared to the peak flow at that point derived through the modeling process for each design storm frequency. The obstructions were then classified into seven categories as follows:

* Those obstructions which are able to pass the 100-year, 24-hour storm without obstructing the flow.

* Those obstructions which are able to pass the 50-year, 24-hour storm and greater without obstructing the flow.

* Those obstructions which are able to pass the 25-year, 24-hour storm and greater without obstructing the flow.

* Those obstructions which are able to pass the 10-year, 24-hour storm and greater without obstructing the flow.

* Those obstructions which are able to pass the 5-year, 24-hour storm and greater without obstructing the flow.

* Those obstructions which are able to pass the 2-year, 24-hour storm and greater without obstructing the flow.

* Those obstructions which are <u>NOT</u> able to pass the 2-year, 24-hour storm and greater without obstructing the flow.

The locations of all obstructions, including those that fall into the seven categories above, can be found in Figure III-9. The obtained data and the obstruction flow capacities can be found in the Technical Appendix.

MAIDEN CREEK WATERSHED
ACT 167 STORMWATER MANAGEMENT PLAN

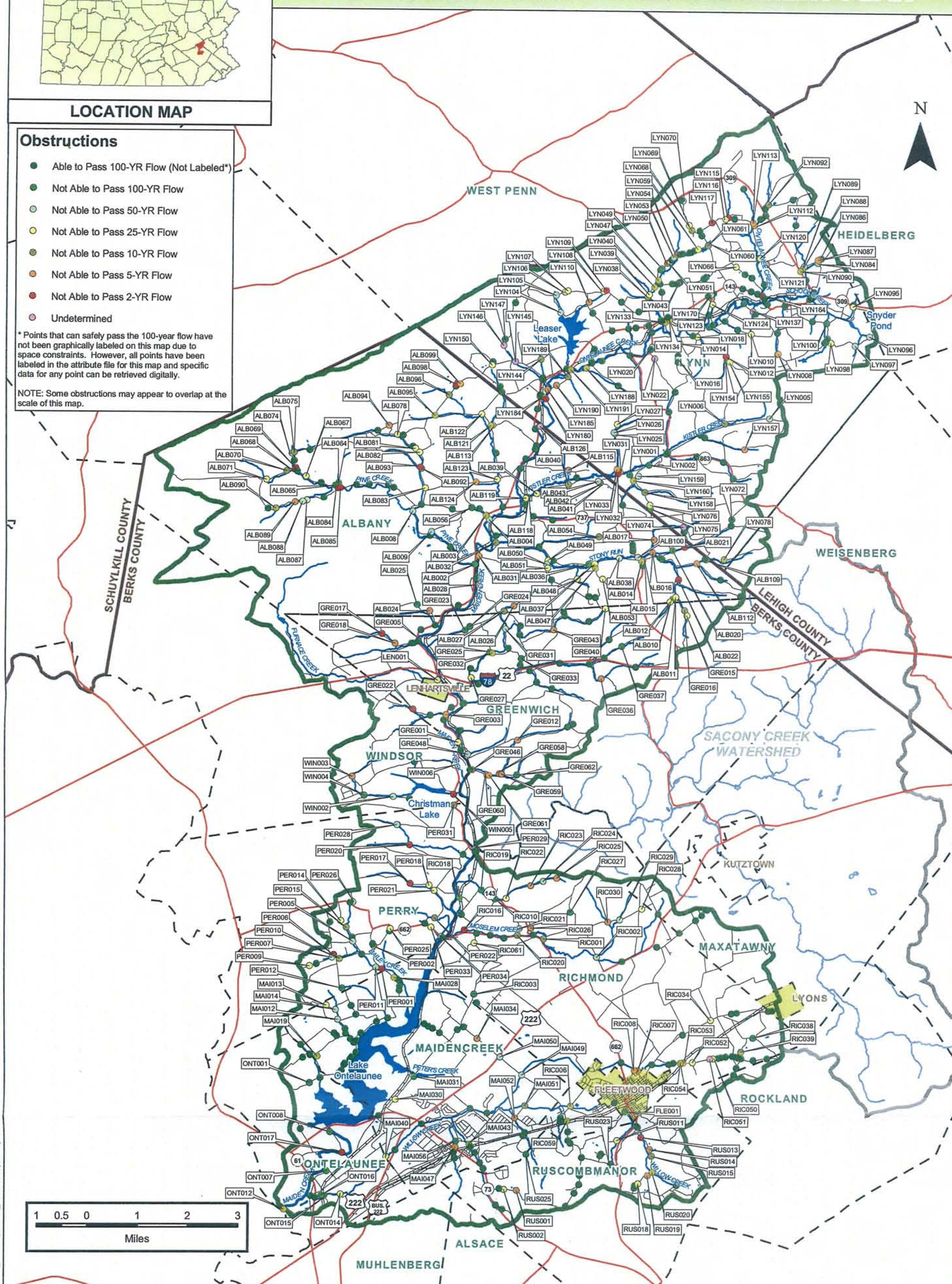

Figure III-9
OBSTRUCTIONS

Prepared For:
Berks County Planning Commission
County Services Center
633 Court Street
Reading, PA 19601
610-478-6300

Map Legend

- WATERSHED BOUNDARY
- STREAMS
- WATER BODIES
- COUNTY BOUNDARIES
- MUNICIPAL BOUNDARIES
- BOROUGHS
- HIGHWAYS
- OTHER ROADS
- RAILROADS

NOTE:
Portions of this map were generated from existing data sources as listed below. This data is shown on the maps for spatial reference only. This data did not enter into any computations or affect the reliability of the hydrologic analysis. Borton-Lawson Engineering has found some inaccuracies in some of this data and has corrected the data in locations where discrepancies were obvious, however, it was not a part of this ACT 167 Plan to correct all of the mapping data.

DATA SOURCES:
Watershed Boundary - PADEP/ Modified by Borton-Lawson
Streams - PaDEP
Lakes - US Fish and Wildlife Service (Extracted from NWI Coverages)
Roads - Berks Co. & Lehigh Valley Regional Planning Commissions, PennDOT
Railroads - Berks Co. & Lehigh Valley Regional Planning Commissions
Counties - Berks County Planning Commission
Municipalities - Berks Co. & Lehigh Valley Regional Planning Commissions, PennDOT
Obstructions - Berks County Planning Commission

Borton Lawson ENGINEERING
Corporate Office
613 Baltimore Drive
Wilkes-Barre, PA 18702
Tel: 570-821-1999
Lehigh Valley Office
6814 Chrisphalt Drive
Bath, PA 18014
Tel: 610-837-5916

PREPARED BY: SJD CHECKED BY:

DATE: 12/10/2004 PROJECT NO. 2003-1349-01

FILE: \\WBData\Projects\2003\134901\DATA\GIS\ArcMap\FINAL_MAPS\FigureIII-09_Obstructions(Maiden).mxd

Erosion and Sedimentation (E & S)

The Berks, Lehigh and Schuylkill County Conservation Districts are responsible for administering Title 25, Chapter 102 (Erosion Control Regulations). These regulations address accelerated erosion and the resulting sedimentation from earthmoving activities. Permanent stabilization of exposed areas and pro[illegible] stabilization of chann[illegible] conveyance will reduce erosion problems.

Storm Sewers, Culverts, and Outlets

Some of the problems identified in Table III-7 are the result of inadequately s[illegible] storm culverts, and/or unstable outlets that traverse state, township, or private roads. The [illegible]al solution involves performing a hydrologic study to determine pipe size and replacing the pipe with a properly sized unit. Costs are typically borne by the owner of the road.

Bridges

Because of the high bed[illegible] of streams within the watershed, g[illegible]sits threaten bridge [illegible] addition to the inadequate waterway opening. The proposed solution typically involves performing a hydr[illegible] study and increasing the hydraulic capacity underneath the roadway. Costs are typically borne by the owner of the bridge.

Flooding

Maiden Creek and its tributaries have caused flooding conditions in the Maiden Creek Watershed. The areas within the watershed immediately adjacent to Maiden Creek and various wetland areas a[illegible]y low lying areas and are subject to minor flooding after rain or thaw conditions. Flooding in the watershed can be classified into two categories: 1) local flooding caused by inadequately sized storm sewers or culverts; and 2) location of structures within the floodplain of the major tributaries. Of the sites identified in Table III-7, most are caused by overbank flooding, inadequate conveyance systems and obstructions in the system.

L. Existing and Proposed Stormwater Collection Systems

Of the municipalities that were surveyed, only Maidencreek Township submitted data collection forms G and H relating to Existing and Proposed Stormwater Collection Systems. Based upon these forms, Maidencreek Township has miles of storm sewer systems that consists of open channels, swales, and pipes. The storm sewer systems are comprised of 12-inch to 120 inch diameter pipes.

The Maidencreek Township also has proposed stormwater collected systems. The majority of the proposed systems are pipes ranging from 15-inch to 48-inch. Several swales are also proposed.

M. Existing and Proposed State, Federal and Local Flood Control Projects

Of the municipalities that were surveyed, only Maidencreek Township submitted data collections forms C and D for existing and proposed flood control projects. There are no existing or proposed flood control projects in Maidencreek Township.

N. Existing and Proposed Stormwater Control Facilities

Of the municipalities were surveyed, only Maidencreek Township submitted data collections forms E and F for existing and proposed stormwater control facilities. Based on the forms collected, there are thirty-one control facilities which is all privately-owned. There are no municipal-owned stormwater control facilities.

There are five proposed stormwater control facilities in Maidencreek Township. All of them are private-owned detention ponds.

SECTION IV

WATERSHED TECHNICAL ANALYSIS

A. Watershed Modeling

An initial step in the preparation of this stormwater management plan was the selection of a stormwater simulation model to be utilized. It was necessary to select a model which:

- Modeled design storms of various durations and frequencies to produce routed hydrographs which could be combined.

- Was adaptable to the size of subwatersheds in this study.

- Could evaluate specific physical characteristics of the rainfall-runoff process.

- Did not require an excessive amount of input data yet yielded reliable results.

The model decided upon was the U. S. Army Corps of Engineers, Hydrologic Engineering Center, Hydrologic Modeling System (HEC-HMS) for the following reasons:

- It had been developed at the Hydrologic Engineering Center specifically for the analysis of the timing of surface flow contributions to peak rates at various locations in a watershed.

- Although originally developed as an urban runoff simulation model, data requirements make it easily adaptable to a rural situation.

- Input parameters provide a flexible calibration process.

- It has the ability to analyze reservoir or detention basin routing effects and location in the watershed.

- It is accepted by the Pennsylvania Department of Environmental Protection.

Although other models, such as TR-20, may provide essentially the same results as the HEC-HMS, HMS's ability to compare subwatershed contributions in a peak flow presentation table make it specifically attractive for this study. The HEC-HMS Model generates runoff flows for selected subareas along the drainage course and compares subarea contributions to the total runoff. The model generates runoff quantities for a specified design storm based upon the physical characteristics of the subarea, and routes the runoff flow through the drainage system in relation to the hydraulic characteristics of the stream. The amount of runoff generated from each subarea is a function of its slope, soil type or permeability, percent of the subwatershed that is developed, and its vegetative cover. Composite runoff curve numbers were generated using the Geographic Information System (GIS) by overlaying the land use map with the subarea and hydrologic soil group maps. The generated curve numbers were then used for input into the computer model. Figure IV-1 displays the subarea delineation for Maiden Creek watershed on digital USGS Quadrangles or digital raster graphics (DRG's).

Figure IV-1 Maiden Creek Subareas

MAIDEN CREEK WATERSHED
ACT 167 STORMWATER MANAGEMENT PLAN

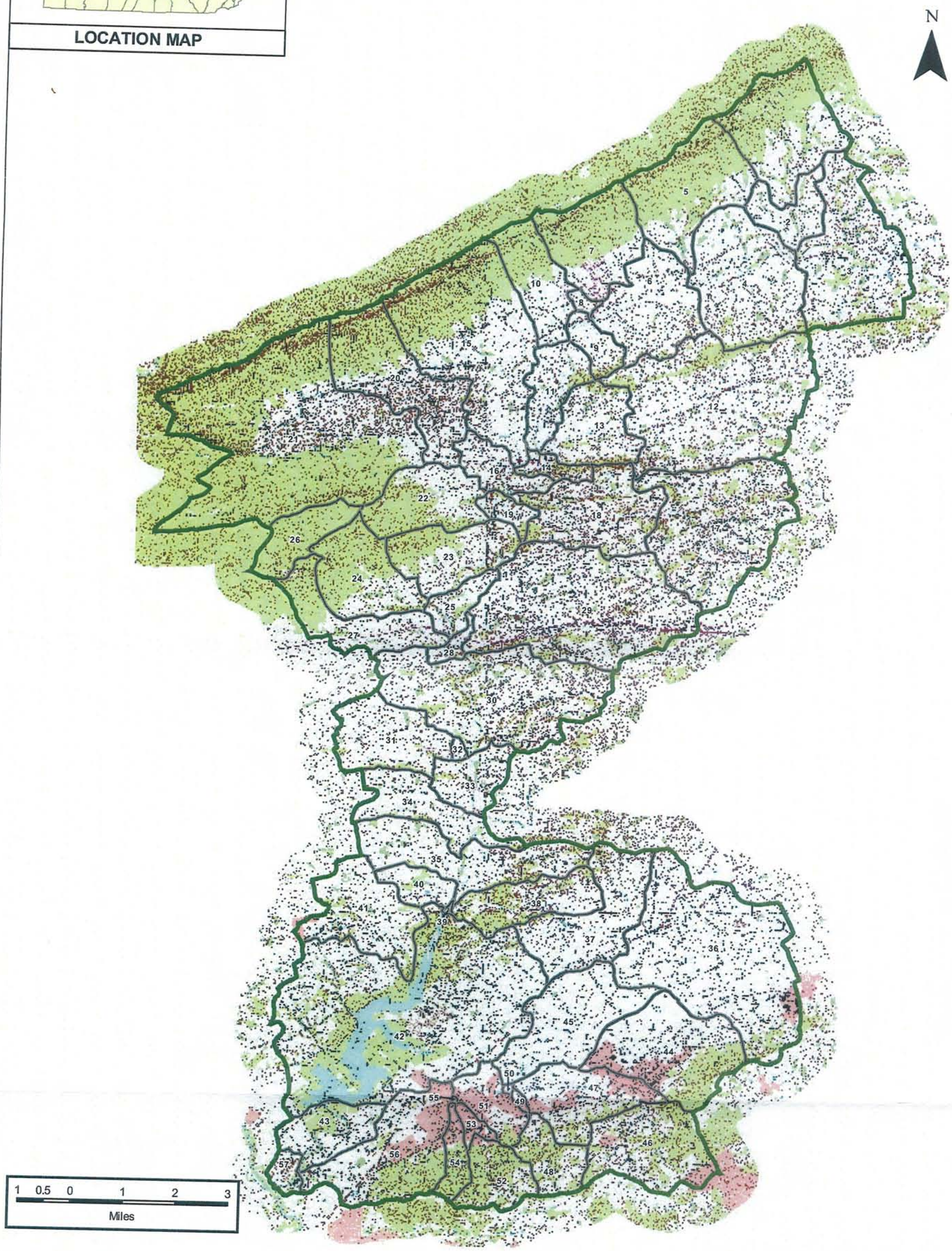

Figure IV-1
MAIDEN CREEK SUBAREAS

Map Legend
- WATERSHED BOUNDARY
- SUBAREAS

NOTE:
Portions of this map were generated from existing data sources as listed below. This data is shown on the maps for spatial reference only. This data did not enter into any computations or affect the reliability of the hydrologic analysis. Borton-Lawson Engineering has found some inaccuracies in some of this data and has corrected the data in locations where discrepancies were obvious, however, it was not a part of this ACT 167 Plan to correct all of the mapping data.

DATA SOURCES:
Watershed Boundary - PADEP/ Modified by Borton-Lawson
Subareas - Borton-Lawson
Topographic Map - Merged USGS Digital Raster Graphics for Maiden Creek Region

Prepared For:
Berks County
Planning Commission
County Services Center
633 Court Street
Reading, PA 19601
610-476-6300

Borton Lawson ENGINEERING

Corporate Office
613 Baltimore Drive
Wilkes-Barre, PA 18702
Tel: 570-821-1999

Lehigh Valley Office
6814 Chrisphalt Drive
Bath, PA 18014
Tel: 610-837-5916

PREPARED BY: SJD	CHECKED BY:
DATE: 12/10/2004	PROJECT NO. 2003-1349-01

FILE \\WBData\Projects\2003\13490\1\DATA\GIS\ArcMap\FINAL_MAPS\Figure IV-1 Maiden Creek Subareas.mxd

B. Modeling Process

The Sacony Creek portion of the Maiden Creek watershed had already a developed ACT 167 plan and a calibrated hydrologic watershed model using the Penn State Runoff Program (PSRM), therefore additional efforts to model this portion of the Maiden Creek were not necessary. However, the calibration Sacony Creek PSRM model was obtained from the Berks County Planning Commission for integration into the HEC-HMS model developed for the Maiden Creek portion of the watershed. The Sacony Creek portion of the Maiden Creek watershed was not remodeled as part of this study.

After delineating the Maiden Creeks watershed on the U.S.G.S. topographic map, the Maiden Creek watershed was further subdivided into subwatersheds for modeling purposes. The main considerations in the subdivision process were the location of obstructions problem areas, and tributary confluences. The most downstream point of each of these areas is considered a "point of interest" where increased runoff must be analyzed for its potential impact.

The reason points of interest are selected is to provide watershed runoff control through effective control of individual subarea runoff. Thus, control of stormwater runoff in the entire watershed can be achieved through stormwater management in each subbasin.

Drainage areas, curve numbers and flow travel times generated in the GIS were inputted into the HEC-HMS program for each delineated Subwatershed. The subwatersheds were then modeled to determine the hydrologic response for the 2-, 5-, 10-, 25-, 50-, and 100-year for the 24-hour design storm events. Design storm hydrographs generated by the Sacony Creek PSRM model for the above mentioned 24- hour storm events were extracted from the PSRM model and inputted into the HEC-HMS model at the junction of Maiden and Sacony Creeks. The results of the final HEC-HMS model are shown in Volume III, Technical Appendix available at the County Office.

The modeling process addressed:

- peak discharge values at various locations along the stream and its tributaries;
- time to peak for the above discharges;
- runoff contributions of individual subareas at selected downstream locations; and
- overall watershed timing.

C. Calibration

In order to simulate storm flows for a watershed with confidence and reliability, the computer model must first be calibrated. This involves "fine tuning" the model to provide the most accurate representation of the real runoff and timing conditions of a watershed. Calibration of a model involves the adjustment of input parameters (within acceptable value ranges) to reproduce the recorded response of storm events.

When actual storm event data is available (i.e. stream flow and rain gauge data), this information can be input into the model and simulated "hydrographs" developed by the model. Hydrographs are simply a plot of time versus flow in cubic feet per second. To simulate a specific event, antecedent moisture conditions and rainfall distribution must be duplicated in the model input. Adjustments to other parameters are then made to attempt to duplicate hydrograph shapes and peak flow rates at points in the watershed where flow recordings were made. In order to utilize actual stream flow and rain gauge data for calibration, sufficient data must be available. Rain gauges must be in close proximity to the watershed so that actual rainfall conditions from these gages are representative of the actual rainfall that occurs over the watershed. Localized events, snowmelt and unique conditions are typically not used for calibration due to their unique circumstances. If this type of data is not readily available, or if the available data is not sufficient (i.e. inadequate or incomplete rainfall data, or lack of recent storm data), target flow values will be developed at several points of interest throughout the watershed using regression methods typically used by agencies such as the US Army Corps of Engineers, the Federal Emergency Management Agency or DEP. The various methods are then compared and averaged to develop the target values.

If suitable rain gauge and stream gauge data is not available, the model can be calibrated against a statistical analyses performed on annual flood peaks and/or regression methods. Oftentimes a combination of the various methods can be utilized to achieve the best results.

In order to maximize the accuracy of the HEC-HMS model, the model calibration effort was undertaken. At several essential points in the watershed, HEC-HMS generated flows were compared to historic event discharges from USGS gage data and developed from available regression models typically used in the estimation of design storm peak flow on large watershed.

FEMA Flood Insurance Studies were also referenced in areas where detailed floodplain information was available. FIS cross-sections were referenced for Manning's values, channel capacities, and channel and overbank velocities. Certain areas were field verified.

There are several potential calibration parameters within HEC-HMS. These include initial abstraction, subbasin time of concentration, runoff curve number, and hydrograph routing velocity and travel time. Several runs were performed for sensitivity analyses of each of these parameters. From these runs, it was determined that the initial rainfall abstraction and subarea travel time, were the most sensitive parameters. These numbers could be revised with confidence, while remaining within an acceptable range of values, for similar soil and sloped subareas, to arrive at flow values from the gage data. FEMA FIS cross-sections were referenced for Manning's values, channel capacities, and channel and overbank velocities. Certain areas were field verified.

For calibration purposes, the 2-, 10- and 100-year design storms were evaluated to compare HEC-HMS generated flows to flows developed by the regression models as well as in the available FEMA Flood Insurance Studies. It should be noted that regression methods oftentimes do not account for localized variables such as soils and topography. Therefore, on a subwatershed basis, the results may vary.

Historic Storm Calibration Results

Ideally, the hydrologic model would be calibrated to historic stream flow events on the watershed. This historic stream flow event data is typically available through stream gauging stations operated by the USGS at several locations throughout the United States. Within the Maiden Creek watershed, four USGS stream gauges (Table IV-1) were located, however only two of these gauges were located within the Maiden Creek portion of the watershed which was being modeled. It should be noted that all four gauges have been discontinued by the USGS. Of the two gauges located within the Maiden Creek portion of the watershed, the only gauge located on the main stem of Maiden Creek was below the confluence with Sacony Creek in Virginville. Since the Sacony Creek portion of the watershed was not modeled in this study, performing a calibration against historical stream flows below the confluence with Sacony Creek was not possible.

Table IV-1
Maiden Creek USGS Stream Gauges

USGS Gauge No.	Location	Years of Record
01470756	Maiden Creek at Virginville, PA	1973 – 1995
01470720	Maiden Creek Tributary at Lenhartsville, PA	1962 – 1979
01470748	Sacony Creek near Virginville, PA	1975 – 1985
01470729	Sacony Creek above Bowers, PA	1975 – 1977

The information from these gauges, however, was collected and a flood frequency analysis was performed on the gauge data using the HEC-FFA (Flood Frequency Analysis) program to determine anticipated stream flow values for various design storm events. These design storm event flows were utilized in the calibration process described below.

Design Storm Calibration Results

Due to the inability to calibrate the HEC-HMS model against historical events, various design event flood flows were generated using the analysis of the gauge data noted above, various regression models typically used in flow predictions, and predicted design flow values from available FEMA Flood Insurance Studies in the watershed. These design storm flows were generated at various points of interest throughout the watershed. At each of these points of interest, target flow values for each design event were developed from the design flow data.

The HEC-HMS was then calibrated against the target flow values at the points of interest throughout the watershed, until all results were optimized. Figures IV-2 through IV-4 show results of the peak flow values developed by the calibrated HEC-HMS model compared to target flow values at the various points of interest throughout the Maiden watershed. Table IV-2 compares the calibrated HEC-HMS model to flood flow values determined by FEMA at several locations throughout the watershed. It should be noted that regression methods oftentimes do not account for localized variables such as soils and topography. Therefore, on a subwatershed basis, the results may vary.

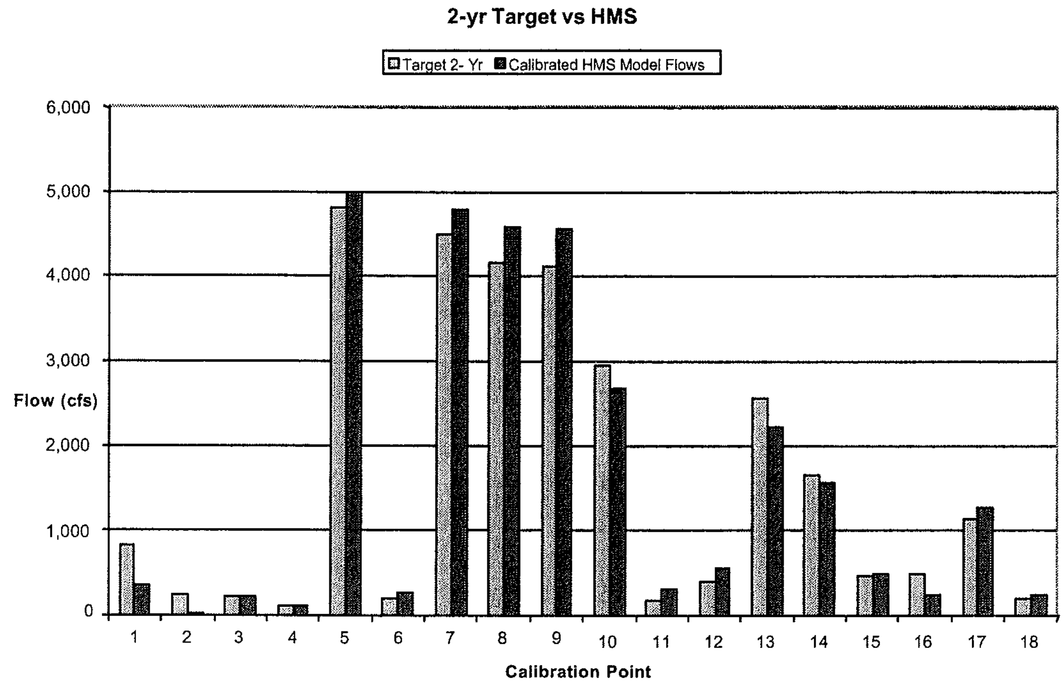

FIGURE IV-2 2-Year Calibrated Model Comparison

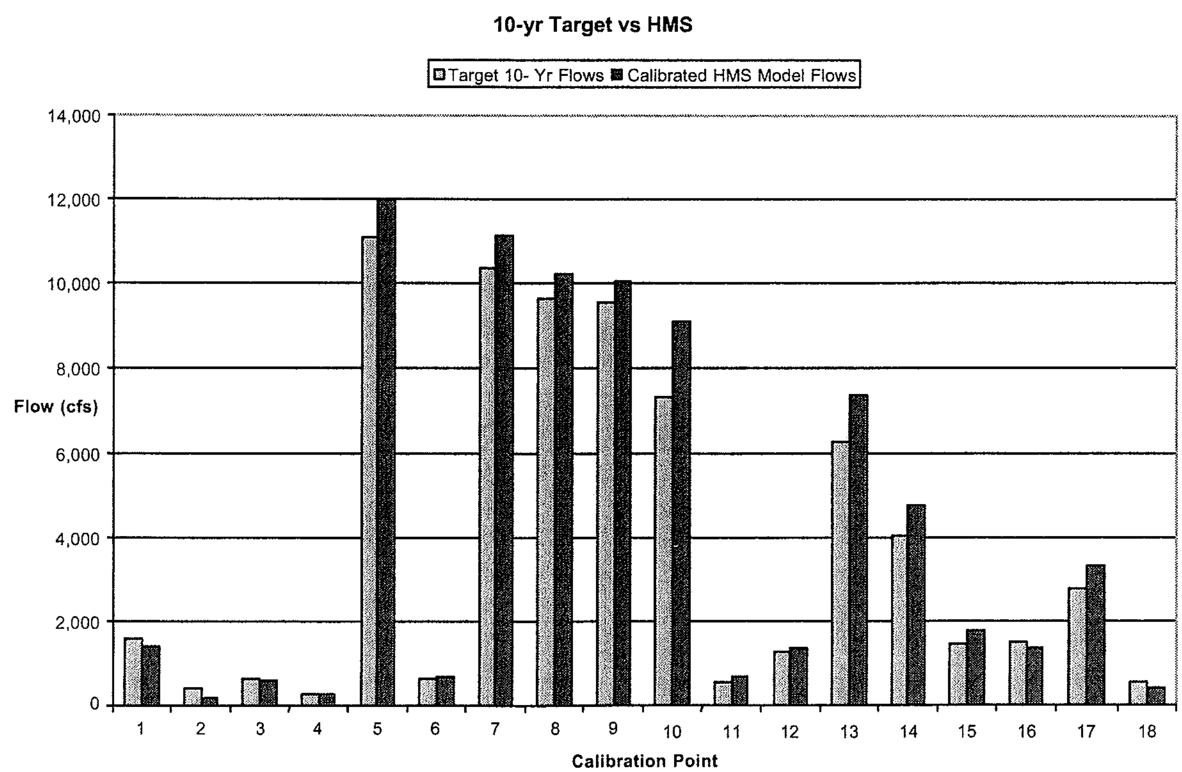

FIGURE IV-3 10-Year Calibrated Model Comparison

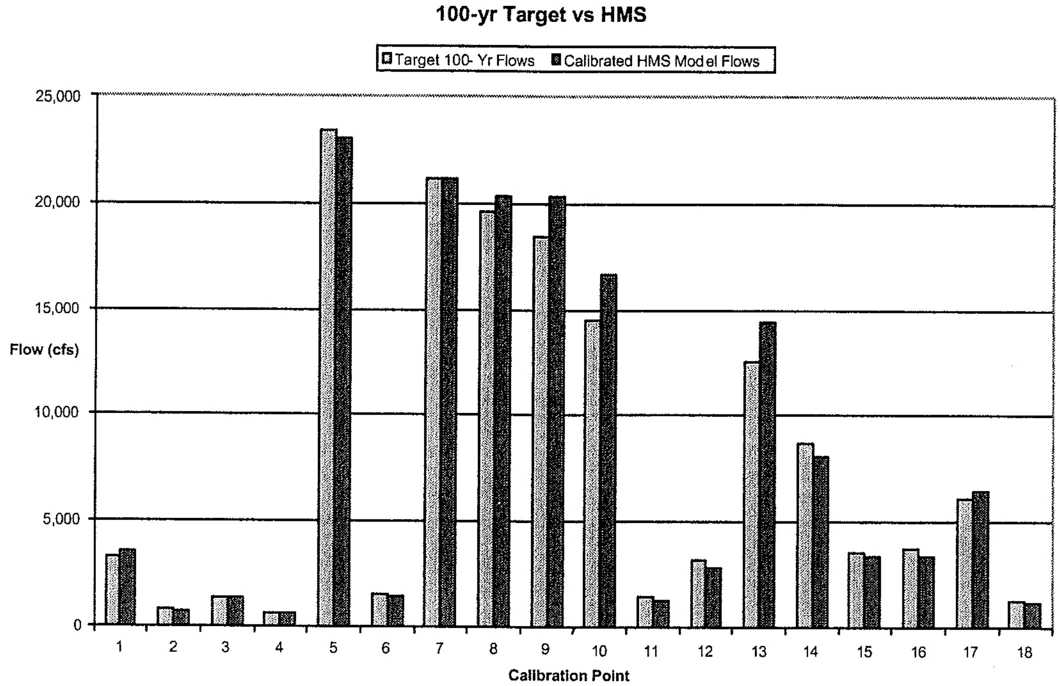

FIGURE IV-4 100-Year Calibrated Model Comparison

TABLE IV-2
Comparison of Calibrated Model To
100- Year FEMA Flow Values

Subarea No.	Drainage Area (sq. miles)	FEMA Flows (cfs)	Calibrated Model Flows (cfs)
11	28.31	5,710	6,444
16	46.50	8,070	8,038
44	2.31	770	751
46	3.12	960	1,348
48	1.06	440	630

D. Hydrologic Method Comparison

The calibrated model was also run under different scenarios to compare the results obtained by the model with the results from various other calculation methodologies. This evaluation was conducted in different areas of the watershed to determine the applicability of other engineering methods in generating stormwater flows within the watershed. These other methods, which included the SCS Tabular Method and Rational Method were analyzed for watershed areas from 0.5 to 2.0 square miles. For the Rational Method, various sources of Rational "C" coefficients were referenced. Results for these methods were then compared with results generated from runs on the calibrated HEC-HMS model. Figure IV-5 summarizes these comparisons for the Maiden Creek watershed. Results from this comparison show that either the curve number method or Rational Method could be used in determining pre- and post-development runoff peak rates. These results are valid when using the SCS curve numbers and Rational "C" values specified by Rawls, et.al (given in Ordinance Appendix B).

Figure IV-5
Hydrologic Method Comparison