Little Conestoga Creek

Watershed Assessment and Restoration Plan

Prepared by:

RETTEW ASSOCIATES INC.

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Prepared for:

Little Conestoga Watershed Alliance
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Funded by:

Pennsylvania is Growing Greener — Growing Greener Program — DEP

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January 2003

Little Conestoga Watershed Alliance

"Restoring & Preserving Our Water & Wildlife"

P.O. Box 6355
Lancaster, Pennsylvania 17607

www.littleconestoga.org

THE MISSION

To preserve and enhance the watershed for its citizens and the environment through education and restoration projects

OBJECTIVES

Restore Little Conestoga Creek and its tributaries by:

1. Providing watershed education to citizens
2. Involving municipal and county officials in restoration endeavors
3. Assisting agricultural professionals with streambank fencing and water management programs
4. Securing funding for restoration activities and projects
5. Utilizing native plant species in restoration projects

The Little Conestoga Water Alliance (LCWA) is a non-profit Pennsylvania organization founded in October 2000. The LCWA is a group of citizens, businesses, non-profit conservation organizations, academic institutions, and local, state and federal government representatives that have joined together and are committed to a common purpose:

A comprehensive approach to continual enhancement of water quality, stream restoration, and preservation of natural resources within the Little Conestoga Creek Watershed.

2002 OFFICERS AND BOARD MEMBERS

Michelle Spitko, President
Michael Kyle, Treasurer
Beth Walters, Secretary

Roy Baldwin
Peter Byrne
Dr. Dorothy Merritts

Daniel Synoracki

LITTLE CONESTOGA CREEK WATERSHED ALLIANCE


Belted King Fisher


Great Blue Heron

THE MISSION

To preserve and enhance the watershed for its citizens and the environment through education and restoration projects

Municipalities: *East Hempfield Township, East Petersburg Borough, Lancaster City, Lancaster Township, Lititz Borough, Manheim Township, *Manor Township, Millersville Borough, Mountville Borough, *Penn Township, *Warwick Township, West Hempfield Township (*=Predominantly Agricultural)

Little Conestoga Tributaries: Bachman Run, Swarr Run, Millers Run, Brubaker Run,West Branch, Indian Run

Size: 65.5 square miles (41,920 acres)

Location: State Water Plan - Basin 07J

COMMON FISH
Species Found in the Little Conestoga Creek Watershed


Pumpkinseed (*Lepomis gibbosus*)


Blacknose dace (*Rhinichthys atratulus*)


Spottail shiner (*Notropis hudsonius*)


Redbreast sunfish (*Lepomis auritus*)


Smallmouth bass (*Micropterus dolomieu*)


Common shiner (*Luxilus cornutus*)


Northern Hog Sucker (*Hypentelium nigricans*)


Green sunfish (*Lepomis cyanellus*)


Catlips minnow (*Exoglossum maxillingua*)


Bluegill (*Lepomis macrochirus*)


Common carp (*Cyprinella spiloptera*)


Longnose dace (*Rhinichthys cataractae*)

ABUNDANT FISH
Species Found in the Little Conestoga Creek Watershed


White sucker (*Catostomus commersoni*)


Rock bass (*Ambloplites rupestris*)


Bluntnose minnow (*Pimephales notatus*)


Tessellated darter (*Etheostoma olmstadi*)


Creek chub (*Semotilus atromaculatus*)

STOCKED GAMEFISH


Brown trout (*Salmo trutta*)


Rainbow trout (*Oncorhynchus mykiss*)

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Typical Benthic Macroinvertebrates in the Little Conestoga Creek Watershed


Crayfish


Leech


Midge

Scud


Mayfly

Black fly

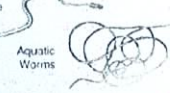
Damselfly


Riffle Beetle

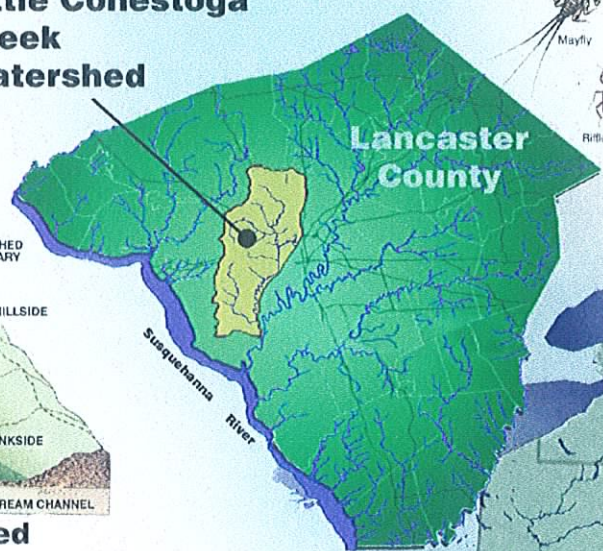

Caddis Fly


Sowbug


Asiatic Clam

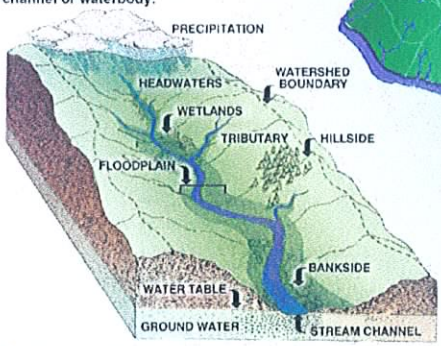

Aquatic Worms

Little Conestoga Creek Watershed



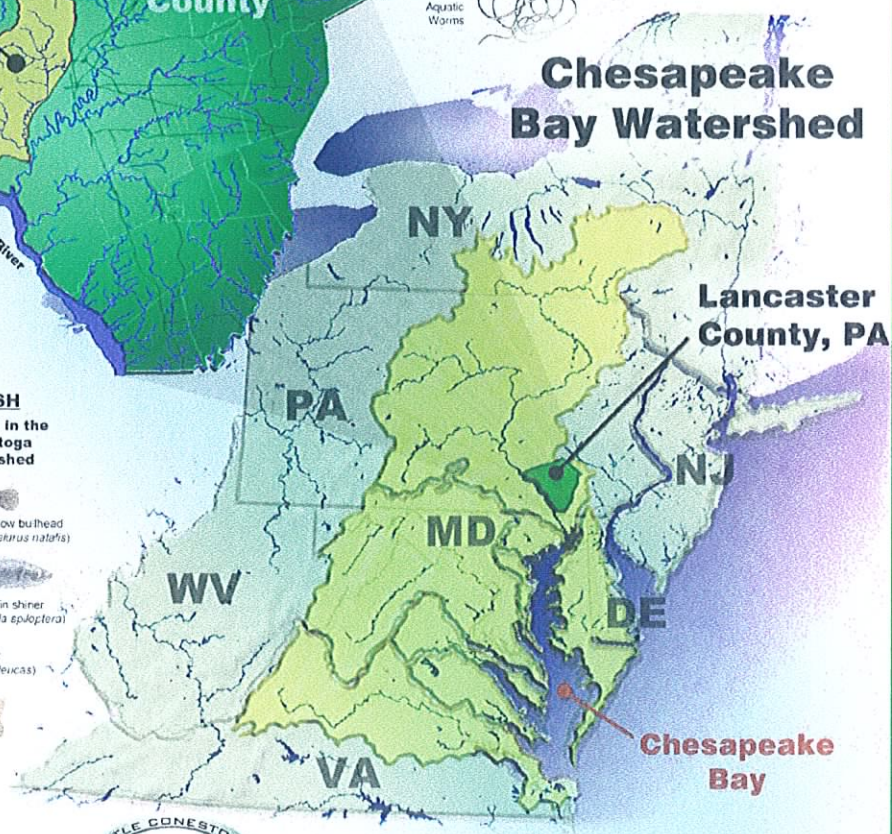
WHAT IS A WATERSHED ?

A watershed is an area of land that draws water, sediment and dissolved materials to a common outlet at some point along a stream channel or waterbody.



Conceptual Watershed Cross Section

Chesapeake Bay Watershed



RARE FISH
Species Found in the Little Conestoga Creek Watershed


Satinfin shiner (*Cyprinella analostana*)


Largemouth bass (*Micropterus salmoides*)


Fallfish (*Semotilus corporalis*)


Yellow bullhead (*Ameiurus natalis*)

Banded darter (*Etheostoma zonale*)

Quillback (*Carpiodes cyprinus*)

Spotfin shiner (*Cyprinella spiloptera*)

Banded killifish (*Fundulus diaphanus*)

Central stoneroller (*Campostoma anomalum*)

Fathead minnow (*Pimephales promelas*)

Golden shiner (*Notemigonus crysoleucas*)

Greenside darter (*Etheostm blennioides*)

WHAT IS STREAM RESTORATION?

BEFORE

AFTER

Growing Greener Program

RETTEW ASSOCIATES INC

EXECUTIVE SUMMARY

The Little Conestoga Creek watershed is located in the east-central portion of Lancaster County, Pennsylvania. Forty different stream segments within this 65.5-mi² drainage are listed as impaired waters (Commonwealth of Pennsylvania - 303 (d) List of Impaired Waters). The 40 segments collectively include some 53 linear miles of impaired water. Nutrients and siltation are listed as the two main causes of impairment and are identified as resulting from poorly managed agricultural practices. Industrial and residential landuse are also credited as sources of impairment, but to a lesser degree.

In March of 2000, a handful of people concerned with the ailing health of the Little Conestoga Creek met for the first time in the interest of possibly forming a watershed organization. As a result, the **Little Conestoga Watershed Alliance** was founded as a non-profit Pennsylvania organization in October of 2000.

The Alliance had a general awareness and understanding of the problems facing their namesake and was indeed aware of various water quality studies performed by others, but a holistic watershed assessment necessary for supporting the development of a restoration plan on a watershed basis did not exist. There were various studies that explored certain interests to quite respectable detail, but none captured the complete view sought by the Alliance. The Alliance needed a guidance tool, a "road map" of sorts, to help them organize and prioritize their energies and efforts.

With the above in mind, the Little Conestoga Watershed Alliance proposed the development of a **watershed assessment and restoration plan**. The assessment was to focus on discovering site specific sources and causes of stream impairment to the degree of detail necessary for developing a restoration plan. The restoration plan would in turn serve as the Alliance's road map, steering and guiding the group through coming years and future projects. In March of 2001, the Alliance applied to the Commonwealth of Pennsylvania for a Growing Greener Grant to fund the study and in August of 2001 received word that the grant request in the order of $95,000.00 had been approved.

This resulting report, appropriately titled "Little Conestoga Creek – Watershed Assessment and Restoration Plan", discusses the findings and brings conclusion to the Growing Greener funded study.

The assessment portion of the study involved the following:

1) Investigation of the sub-watersheds and specifically the 40 stream segments identified on the 303 (d) List of Impaired Waters
   a) Identification of the type and severity of impairments
   b) Identification of specific on-site causes/sources of impairments

c) Level I Fluvial Geomorphology Classification determination (only for impairments relating to stream bank stability)

2) Investigation of the status and composition of the fish and macroinvertebrate community for the entire watershed on a sub-watershed sampling basis to be used as baseline data for tracking future recovery progress and possible development of a greater sport fishery

3) Investigation of local stormwater management, zoning and comprehensive landuse planning and/or the lack thereof for each municipality within the watershed with an emphasis on water quality, water quantity and water usage

4) Collection of polling data from stakeholders regarding their thoughts, concerns and objectives as related to the watershed and its protection

5) Identification of critical habitats and ecosystems including known Pennsylvania Natural Diversity Inventory (PNDI) sites, wetlands and forestlands

6) Identification and investigation of other known or likely causes/sources of impairment outside those generally described in the 303 (d) List – i.e., localized flooding, thermal pollution sources, point sources, etc.

7) Investigation of established "wellhead protection programs" within the watershed and assimilation of any relevant information

8) Further investigation of all relevant data from previously known and discovered sources and assimilated as appropriate – i.e., Pennsylvania Fish and Boat Commission studies

9) Exploration and discovery of other restoration type endeavors undertaken from outside groups –develop working relationship and share data as appropriate – i.e., Chesapeake Bay Foundation, Lancaster Healthy Communities, Donegal Chapter of Trout Unlimited, etc.

The restoration plan portion of the study includes the following:

1. A description and prioritization of the discovered problem areas (with emphasis on non-point source water quality related problems)

2. Solutions and alternatives for correcting the discovered problems

3. Estimation of costs associated with correcting the discovered problems

4. Fishery management options

5. Ideas for building public support

6. Suggested plan for engaging municipalities in regards to lacking stormwater management, zoning and land development ordinances

7. A means of monitoring progress

RETTEW Associates, Inc. was selected as the environmental consulting firm to oversee and conduct the majority of the study. Volunteer expertise was also utilized, most notably the spring 2002 "Environmental Problems" class from Franklin and Marshall College under the direction of Dr. Philip J. Nyhus. The advanced class of junior and senior environmental students divided into four research teams consisting of a social science, biological science, physical science and spatial science team. The class compiled their data and presented their findings in both a public presentation and written report. Findings from the Franklin and Marshall research were then given to RETTEW for incorporation into this very report.

Research began in August of 2001 and concluded in September of 2002, with the majority of the field investigations being performed between April and August of 2002.

The following pages of this report detail the findings of the various assessment investigations and suggested restoration priorities. Any questions regarding the content of this report can be asked of:

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LITTLE CONESTOGA CREEK ASSESSMENT AND RESTORATION PLAN FINAL REPORT

Little Conestoga Watershed Alliance

Executive Summary

General Location Map

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INTRODUCTION

The Little Conestoga Creek watershed is located in the east-central portion of Lancaster County, Pennsylvania. Forty different stream segments within this 65.5-mi² drainage are listed as impaired waters (Commonwealth of Pennsylvania - 303 (d) List of Impaired Waters). The 40 segments collectively include some 53 linear miles of impaired water. Nutrients and siltation are listed as the two main causes of impairment and are identified as resulting from poorly managed agricultural practices. Industrial and residential landuse are also credited as sources of impairment, but to a lesser degree.

In September 1998, the United States Geological Survey and the Alliance for the Chesapeake Bay completed a water quality study within the Little Conestoga Creek watershed. The general landuse survey revealed that the basin is predominantly comprised of agricultural lands. Water quality was evaluated taking into account the existing agricultural influences. Water samples from 15 different sites were evaluated for nitrate and sulfate concentrations. No significantly high concentrations of sulfates were found in the watershed, but nitrate levels were a different matter. The greatest concentrations of nitrates were found in streams in the lower basin where agriculture comprises nearly 80% of the landuse. Nitrate concentrations often exceeded the United States Environmental Protection Agency "maximum contaminant level" of 10-mg/L, while ammonia concentrations were found at levels known to be acutely toxic to aquatic life.

As part of this same study, Lancaster County Academy, Millersville University and the United States Geological Survey also collected aquatic insects using the United States Environmental Protection Agency's "rapid bioassessment protocols". The results of those studies, along with additional benthic macroinvertebrate studies conducted by the United States Environmental Protection Agency, found it difficult if not nearly impossible to locate healthy streams in the Lowlands ecoregion because of past and present farming practices. Sadly, the completed biometric studies revealed that among the sampling locations, not one produced more than three pollution-sensitive benthic macroinvertebrate varieties within the Little Conestoga Creek basin.

In March of 2000, a handful of people concerned with the ailing health of the Little Conestoga Creek met for the first time in the interest of possibly forming a watershed organization. As a result, the **Little Conestoga Watershed Alliance** was founded as a non-profit Pennsylvania organization in October of 2000.

The Little Conestoga Watershed Alliance's membership consists of a diverse cross-section of watershed stakeholders. Citizens, landowners, businesses, conservation organizations, academic institutions and local and state government representatives comprise the Alliance body and in turn bring specific interests and expertise to bear thus complimenting and completing the group.

As are most watershed organizations, the Little Conestoga Watershed Alliance was anxious to see some actual restoration work performed in and along the creek. Some problems and problem areas are quite evident and the solution obvious. In these situations, the Alliance has chosen to move ahead and address each on an independent basis provided the effort doesn't pose potential complications to future up and downstream projects.

The Alliance had a general awareness and understanding of the problems facing their namesake and was indeed aware of various water quality studies performed by others, but a holistic watershed assessment necessary for supporting the development of a restoration plan on a watershed basis did not exist. There were various studies that explored certain interests to quite respectable detail, but none captured the complete view sought by the Alliance. The Alliance needed a guidance tool, a "road map" of sorts, to help them organize and prioritize their energies and efforts.

Likewise, factors that influence watershed health simply change with time; thus details of past studies may or may not be relevant in the present day. Indeed this is often the case in Lancaster County where rapid land development has been the norm since the mid '80s (prior to most municipalities adopting land development and stormwater management ordinances in Lancaster County). This certainly was and is the case within two watershed municipalities - Manor and East Hempfield Townships. It's understandable these two municipalities often experience public outcry for relief after sizable storm events. Case in point – the following newspaper article:

E. Hempfield offers little hope for victims of flooding, erosion

Residents of East Hempfield's Chestnut Valley development want the township to help them solve flooding and erosion problems that have plagued them for years.

But township officials said Wednesday there's little they can do, since the development near Centerville was approved by the county, and East Hempfield had little input on where the homes were built.

A dozen residents attended Wednesday's township supervisors meeting to vent their gripes about flooding and soil erosion linked to Millers Run, a stream that winds through the upscale housing development between Spring Valley and Nolt roads.

One resident said flooding has become worse since the township installed new storm sewers last year along Spring Valley that drain into the stream.

Another man said he has lost 10 feet of his property on Chestnut Valley Drive to erosion in the past 10 years. The stream now is eight feet deep and 18 feet wide after heavy rains.

Plans for Chestnut Valley were approved in the mid-1980s, before East Hempfield adopted a land-development ordinance. The county Planning Commission approved the project, after the developer decided the location of the homes.

The supervisors on Wednesday agreed to look at the issue again after the county and the county conservation district become involved.

It is not coincidental the area discussed in the above article just happens to correspond with a certain stream segment identified in the 303 (d) List of Impaired Waters (one which notes stormwater sewers as a source of impairment).

Though the 303 (d) List of Impaired Waters identified this stream segment as being impaired, it doesn't clarify who the 40 plus landowners are, details about an existing sewer easement within the floodway that limit possible restoration practices, municipal plans to reconstruct a bridge and realign a portion of road, details regarding a vacant tract of land perfect for retrofitting stormwater retention into a subdivision that never had any and other such pertinent

details necessary for developing a restoration plan - nor does any other existing study for that matter!

With the above in mind, the Little Conestoga Watershed Alliance proposed the development of a **watershed assessment and restoration plan**. The assessment was to focus on discovering site specific sources and causes of stream impairment to the degree of detail necessary for developing a restoration plan. The restoration plan would in turn serve as the Alliance's road map, steering and guiding the group through coming years and future projects. In March of 2001, the Alliance applied to the Commonwealth of Pennsylvania for a Growing Greener Grant to fund the study and in August of 2001 received word that the grant request in the order of $93,100.00 had been approved.

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RETTEW began its research in August of 2001 and concluded in September of 2002, with the majority of the field investigations being performed between April and August of 2002. One of the larger undertakings took place in March of 2002 and involved the aerial video-logging of the impaired stream segments as identified by the Commonwealth of Pennsylvania – 303 (d) List of Impaired Waters. A pre-flight plan was prepared and a test flight was taken prior to the main video-logging flight day. As part of the flight plan preparation, coordinates for the impaired stream segments were determined using available Geographic Information System

(GIS) mapping. Once in the air, an onboard Global Positioning System (GPS) unit was used to locate the subject stream segments. The GPS unit and the onboard video camera are connected and work together in such fashion that it's easy to determine exactly where and what segment of stream one is looking at when back in the lab. Recorded images were then analyzed and used to help determine stream conditions.

Field investigation of the fish and macroinvertebrate communities took place between April and June of 2002. Sampling took place at 23 different sites strategically located through the entire watershed. The United States Environmental Protection Agency's (EPA) "rapid bioassessment protocols" were utilized during this investigation. Aquatic habitat assessments were also completed at these same 23 sites between April and July of 2002, again using the EPA rapid bioassessment protocols. Five additional sites had been previously assessed in July of 2001 (in the same fashion) and their data was considered as part of this study.

During the spring of 2002, RETTEW had several interactions with the previously mentioned "Environmental Problems" class from Franklin and Marshall College. RETTEW staff made several trips to the college campus in order to communicate and coordinate assessment efforts. Likewise several of the students found their way to RETTEW's office.

During the assessment process, RETTEW gave several updates and status reports to the Little Conestoga Watershed Alliance at their monthly meetings. Both the Pennsylvania Department of Environmental Protection's Regional Watershed Manager (Ms. Jineen K. Boyle) and the Lancaster County Conservation District's Watershed Specialist (Mr. Matthew W. Kofroth) were normally present at these meetings and had opportunity to comment and aid in the assessment process.

Aside from the actual fieldwork, much of the assessment involved some form of communication and/or research of already available information – the task being the discovery and assimilation of it. A variety of sources, such as municipalities, Lancaster County GIS Department, Lancaster County Engineers Office and the Pennsylvania Fish and Boat Commission to name a few, were questioned and probed for sought information.

Desired outcomes as a result of this study include the following:

- Preparation of an assessment and restoration plan
- Improved public awareness and education
- Improved communication and cooperation between the Little Conestoga Watershed Alliance and the municipalities
- Growth of the Little Conestoga Watershed Alliance membership

- Data/information made available to the Pennsylvania Department of Environmental Protection for Total Maximum Daily Load preparation

WATERSHED ASSESSMENT AND RESTORATION PLANNING

A stream evolves in response to changes within its watershed. In natural, pristine conditions, stream systems operate within a unique balance of flow, sediment transportation, temperature, chemical composition and the indigenous aquatic life therein among other things. This unique, natural balancing act is referred to as "dynamic equilibrium". Such a balanced stream system is not static, but is ever changing at a natural pace. Though elements within the watershed (physical, chemical or biological) change and therefore effect and cause a reaction in the stream, these changes to the watershed occur at nature's pace and the stream in turn can keep up with the changes at nature's prescribe pace.

But when physical, chemical or biological changes occur in the watershed at an accelerated rate determined by man's activities, a stream system will surely loose its ability to keep up with the rapidly changing set of watershed influencing factors it has been dealt. Mankind's successful, rapid alteration of the watershed in most circumstances cannot be successfully counter-balanced by a stream system making counter-adjustments at Nature's prescribed pace. Simply put, mankind can alter a watershed faster than a stream can adequately adjust for it – equilibrium is lost and the stream's health compromised.

In the past (as well as the present and future), humans generally have a poor reputation for considering how their activities on land may negatively effect water resources both in quantity and quality. All to often, projects are completed on the landscape without proper consideration of possible impact to water resources.

Watershed assessment and restoration planning therefore is an effort to recognize, avoid, abate and reverse the above. "Restoration is a complex endeavor that begins by recognizing natural or human-induced disturbance that are damaging the structure and functions of the ecosystem or preventing its recovery to a sustainable condition." (Pacific Rivers Council 1996)

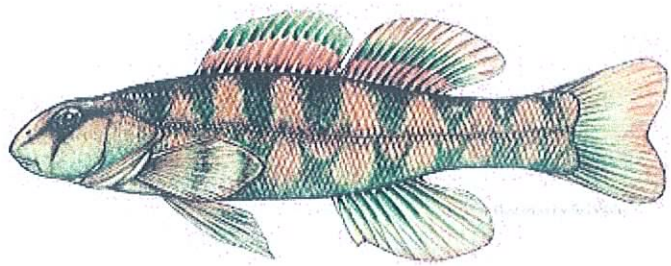
Restoration "requires an understanding of the structure and functions of stream corridor ecosystems and the physical, chemical and biological processes that shape them." (Dunster and Dunster 1996)

It is important to recognize that no two stream systems are alike, and likewise no two restoration endeavors are identical. Attempting to "pigeon hole" a stream into one particular type or force its dimension into a chosen mold is to exhibit a total lack of understanding for the complexity of the task. There are unfortunate examples of well-intended restoration projects that address a particular interest while at the same time create, increase and/or ignore other stream ailments. In the end, the initial concern has possibly been addressed, but a new problem has risen to take its place and/or previous problems still exist which in of their own

account are able of rendering the stream impaired. The more complex and diverse the landuse, the more troublesome and complex the restoration endeavor.

It is with these thoughts in mind, the Little Conestoga Creek assessment and restoration plan was conducted and prepared (as best could be given the limitations of funding and available time).

The conducted assessment was intended to be holistic in its gathering and consideration of all the possible elements shaping and influencing the Little Conestoga Creek. The restoration plan was in turn developed around the findings of the assessment and is intended to provide a strategy for protecting and enhancing valued components (flora, fauna and habitats) and correcting discovered problems serving to damage the stream's well-being.



Greenside darter *(Etheostoma blennioides)*
Pollution intolerant fish species found in the main stem of the Little Conestoga Creek near its confluence with the Conestoga River

SUB-WATERSHEDS

The Little Conestoga Creek drains a total of 65.5-square miles. Major sub-watersheds within the basin include Brubaker Run, Indian Run, Millers Run, Swarr Run, West Branch and the main stem of the Little Conestoga Creek (including the headwaters and Bachman Run tributary). Millers Run is actually a sub-watershed of Swarr Run.

SUB-WATERSHED LANDCOVER/LANDUSE IN ACRES

LANDCOVER & LANDUSE	BRUBAKER RUN	INDIAN RUN	MILLERS RUN	SWARR RUN	WEST BRANCH	MAIN STEM
Total area	**1,845-acres** *(2.879-sq. miles)*	**2,054-acres** *(3.206-sq. miles)*	**791-acres** *(1.236-sq. miles)*	**4,891-acres** *(7.630-sq. miles)*	**7,893-acres** *(12.310-sq. miles)*	**24,541-acres** *(38.272-sq. miles)*
Commercial & Services	135.9	3.2	6.0	63.9	57.2	885.5
Coniferous Forest		0.3			0.4	17.8
Cropland	420.8	**1371.1**	143.5	**1572.4**	**5153.8**	**8755.7**
Deciduous Forest	29.5	296.9	51.2	183.0	210.6	934.2
Farmsteads	12.7	27.1	7.3	25.1	81.5	241.8
Forested Wetland		1.5			0.06	17.9
Herbaceous	82.3	34.2	37.7	268.1	239.8	1457.0
Industrial	8.7	1.4		154.2	20.6	227.0
Industrial & Commercial Complex	**467.5**			74.4	291.7	1406.2
Institutional	44.2	5.0	25.9	109.8	77.2	438.1
Large Confined Feeding	1.2	41.8		17.1	130.4	126.8
Mines, Quarries, Pits						267.5
Mixed Barren & Vegetated	21.9			4.2	2.1	30.2
Mixed Cover		6.8			41.4	93.8
Mixed Forest					1.6	27.3
Mixed Urban, Built-up Land						105.7
Non-Forested Wetlands	10.3	1.7		20.2	3.6	97.8
Open Water	1.0	3.5	0.2	13.7	24.8	174.3
Orchards, Horticultural		2.2		60.3	19.7	264.0
Other		0.1			1.0	1.4
Other Agricultural		0.7			1.5	1.9
Pasture	31.7	150.8	8.3	123.4	509.1	500.5
Recreational	15.2	0.4	35.7	270.0	80.5	936.9
Residential 2.1 – 7 units/acre	464.6	53.6	**430.8**	1505.1	741.5	5463.7
Residential < 2 units/acre	2.5	37.0	39.7	246.4	113.5	721.0
Residential > 7 units/acre	34.7			47.9	31.4	391.0
Scrub/Brush	6.8	14.4	4.5	50.4	12.9	137.2
Transitional (construction)	2.4			6.7	10.4	246.3
Transportation & Utilities	51.0			74.8	34.2	571.5

Large floodplain valleys and moderately sloped hills sides comprise the Little Conestoga Creek Watershed. The lowest point in elevation within the watershed is at the Little Conestoga Creek / Conestoga River confluence approximately 185-feet above sea level USGS datum. The highest point in elevation is on an unnamed hill near Manheim at 560-feet. The Little Conestoga Creek is by no means a fast moving, white water stream. Rather the stream bed averages a nearly flat 0.5 % slope.

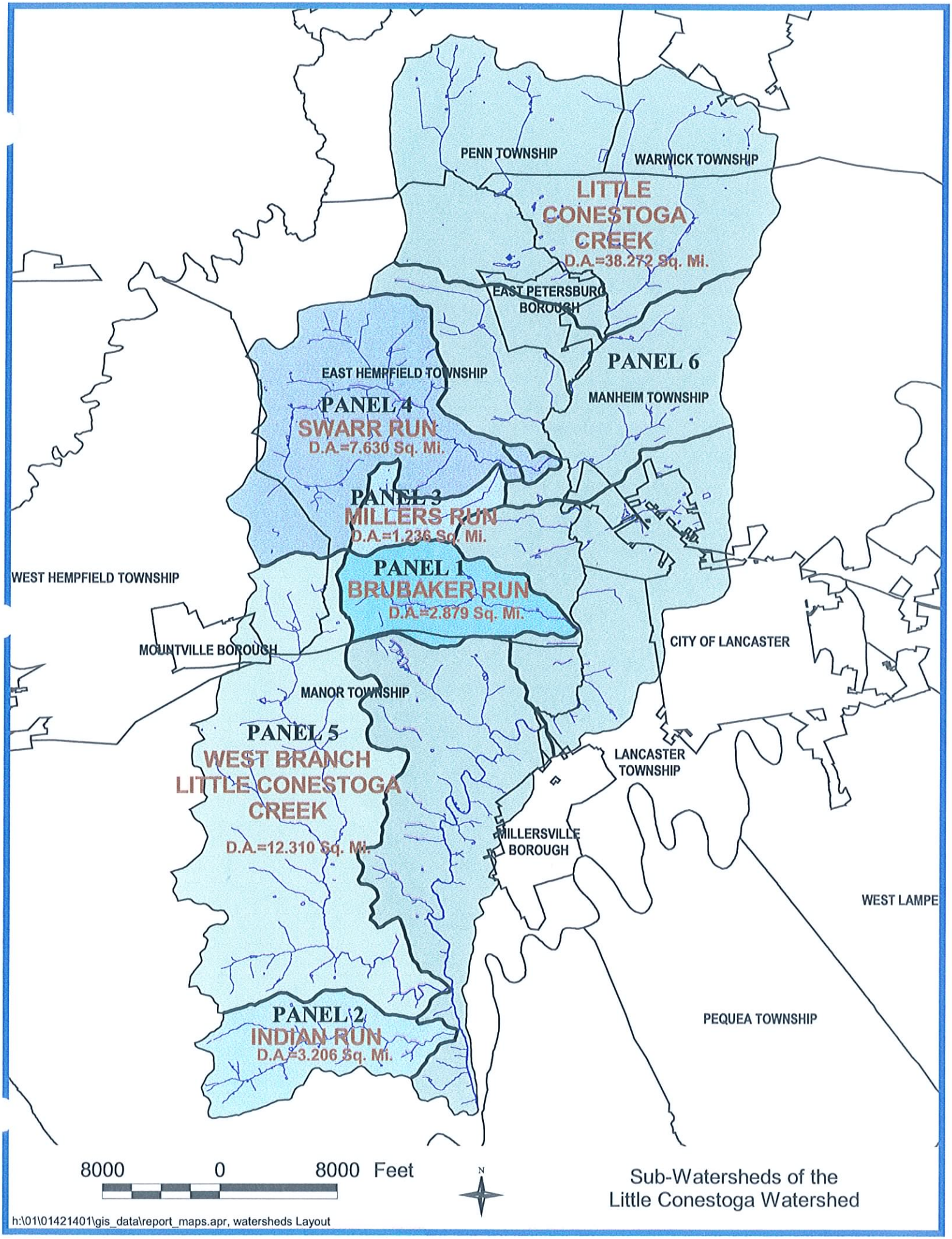
According to D.L. Rosgen's 1994 *"A Classification of Natural Rivers"*, much of the Little Conestoga Creek can be classified into the three following stream types:

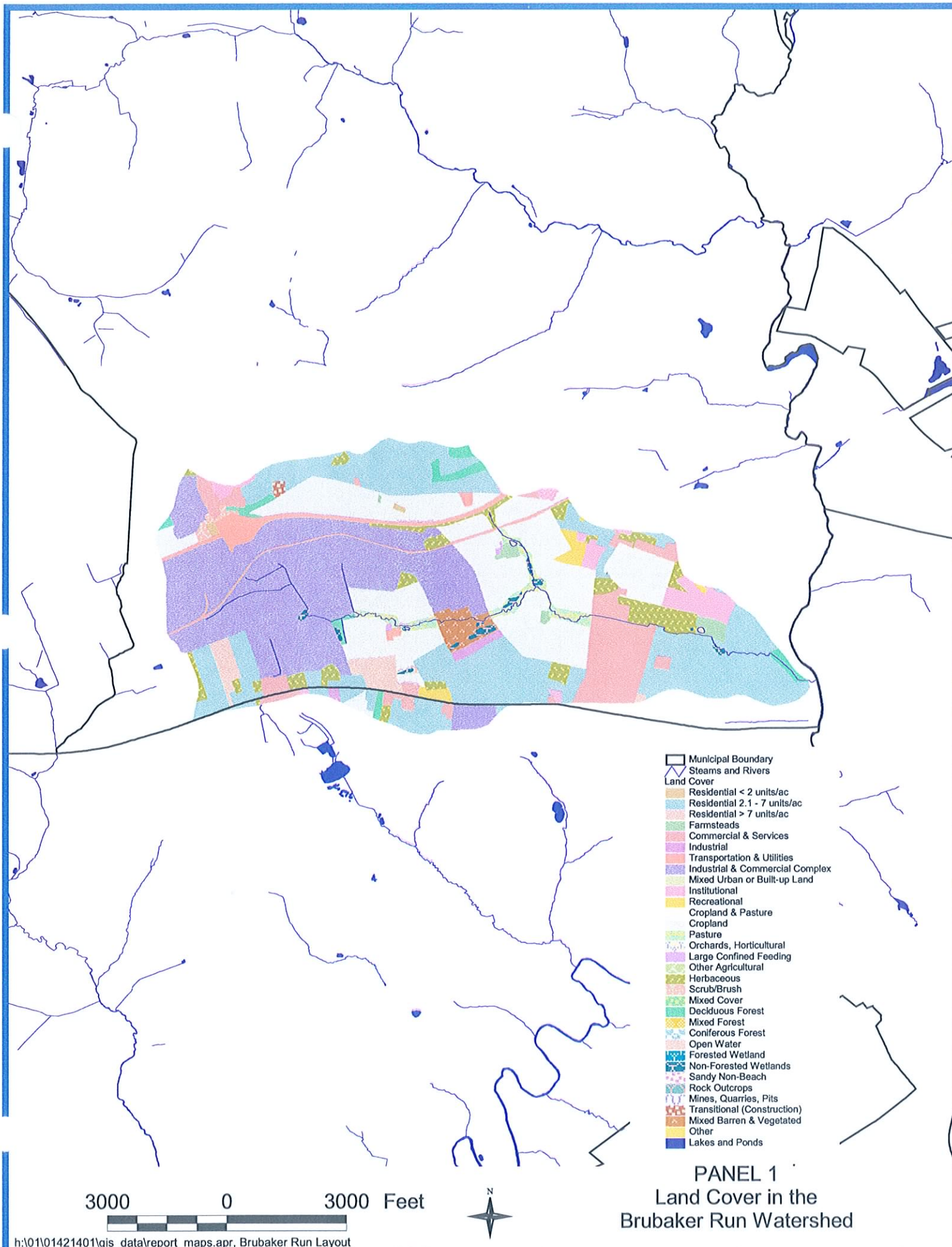
Stream Type "C" (C4 and C5)
Type "C' streams are riffle/pool streams with a well-developed floodplain, meanders, and point bars. These streams are wide with a width/depth ratio greater than 12. Type "C" streams are moderately entrenched, and therefore use their floodplains during large storm events.

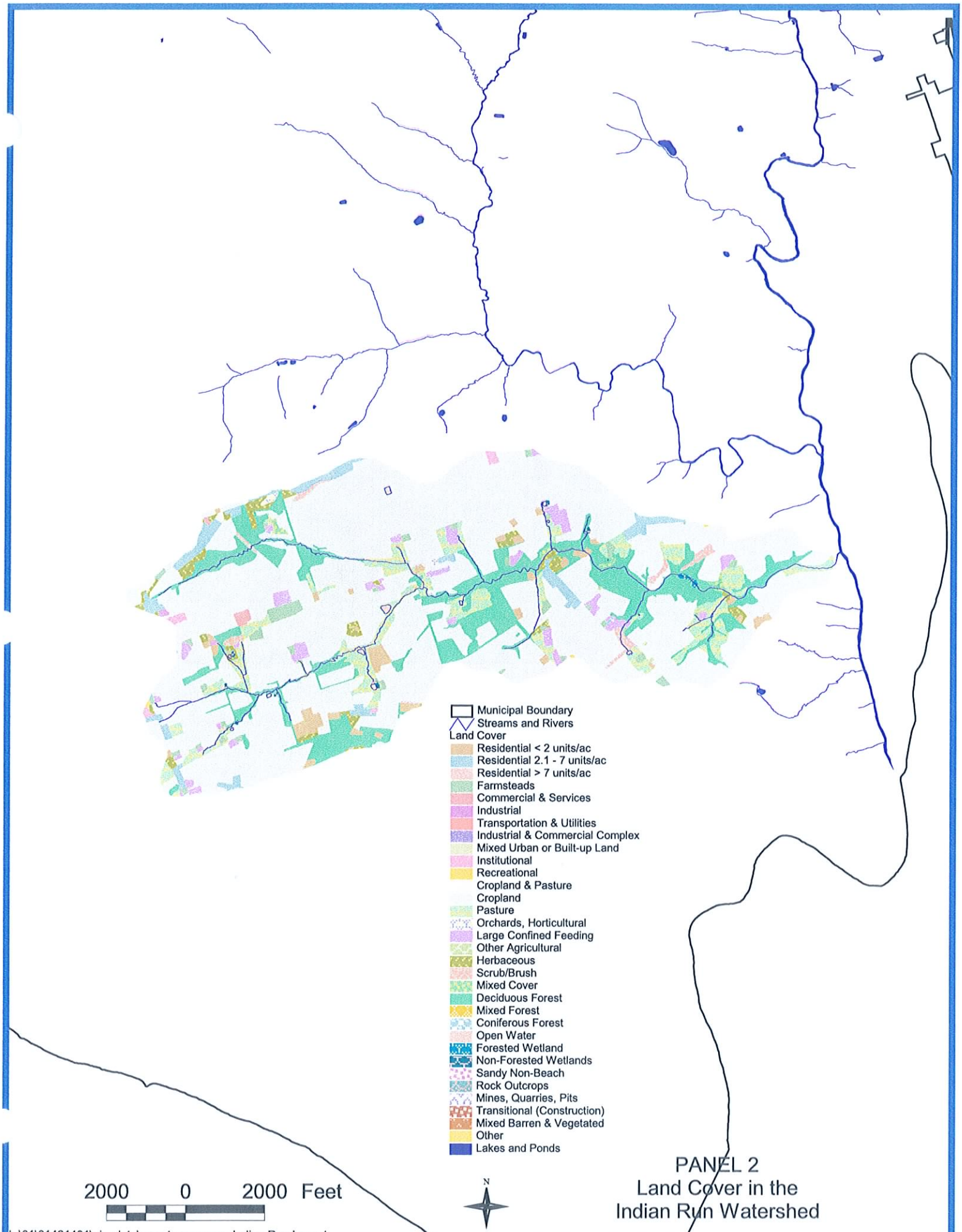
Stream Type "F" (F4 and F5)
Type "F" streams are deeply entrenched, often meandering stream with a high width/depth ratio (greater than 12). These stream types are typically working to create a new floodplain at a lower elevation and will often evolve into "C" type streams. The micro-evolutionary process leads to very high levels of bank erosion, bar developments, and sediment transport.

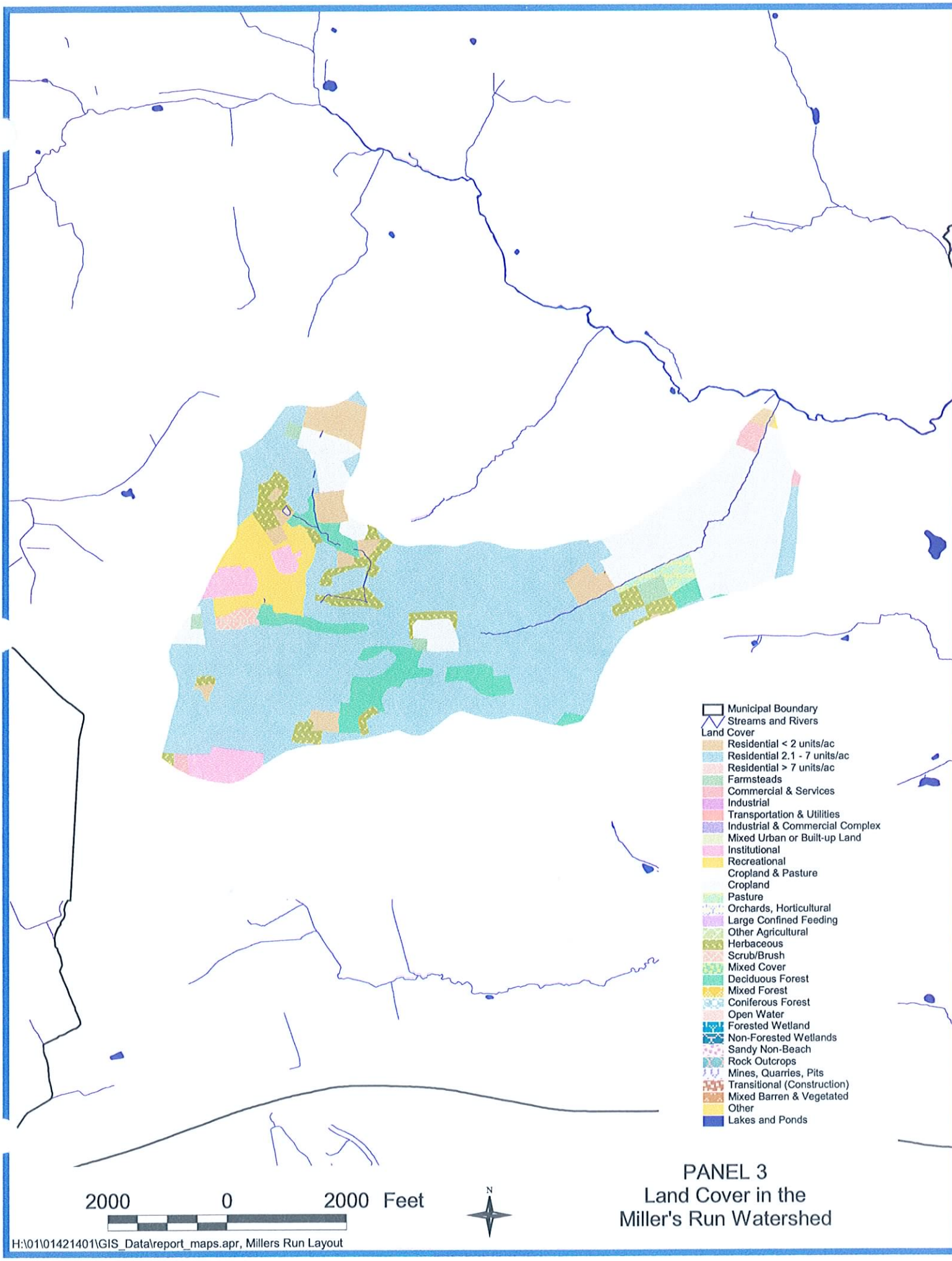
Stream Type "G" (G4 and G5)
Type "G" streams or gully stream types are similar to the "F" types but with low width/depth ratios. With a few exceptions, "G" streams possess high rates of bank erosion as they try to widen into an "F". "G" streams are found in a variety of landforms, including meadows, urban areas, and new channels within relic channels.

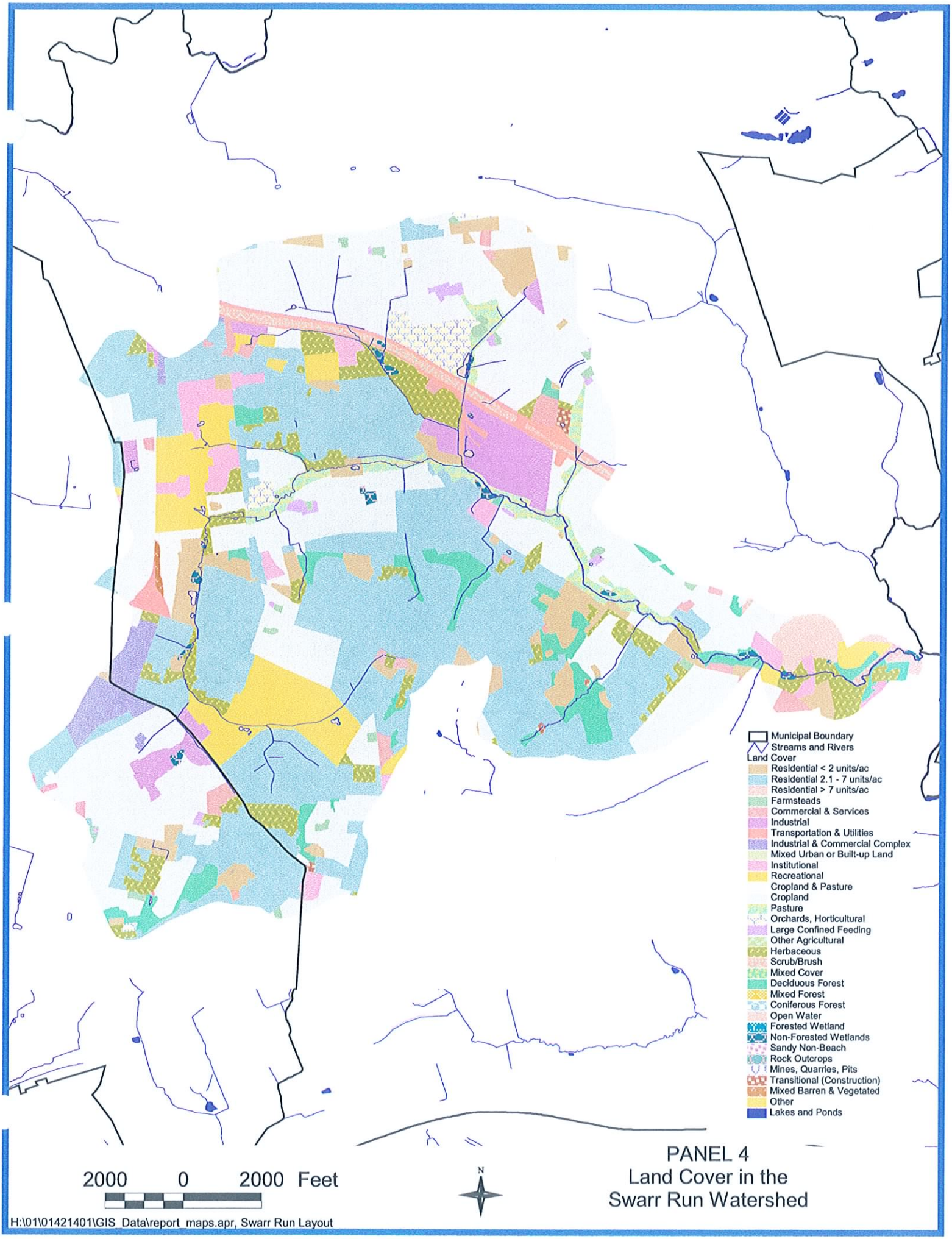
Approximately 95% of the Little Conestoga Creek Watershed has underlying carbonate geology and is comprised of "Letort-Pequea-Conestoga" and "Duffield-Hagerstown" soil types. These rich limestone soils are prime for farming and are typically well drained. "Manor-Chester-Glenelg" soils account for the other 5% and are formed from mica schist, schist, gneiss and quartzite. This soil is found in western East Hempfield Township and most of West Hempfield Township. A small area of "Bedington" exists on the ridge tops in Penn and Warwick Townships. Bedington soils are formed in the residuum of acid shale.

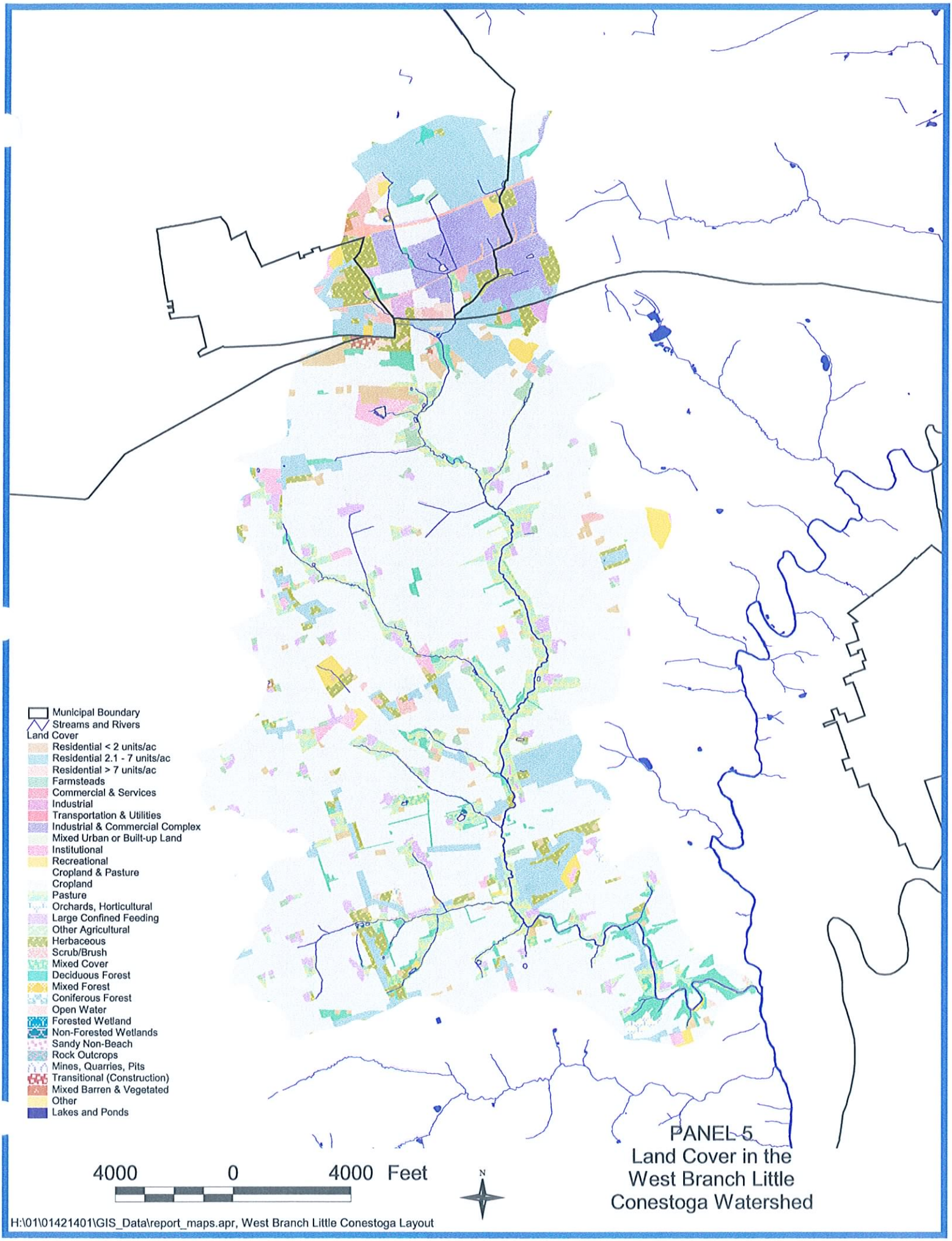

PENN TOWNSHIP
WARWICK TOWNSHIP
LITTLE CONESTOGA CREEK
D.A.=38.272 Sq. Mi.
EAST PETERSBURG BOROUGH
EAST HEMPFIELD TOWNSHIP
PANEL 6
MANHEIM TOWNSHIP
PANEL 4
SWARR RUN
D.A.=7.630 Sq. Mi.
PANEL 3
MILLERS RUN
D.A.=1.236 Sq. Mi.
PANEL 1
BRUBAKER RUN
D.A.=2.879 Sq. Mi.
WEST HEMPFIELD TOWNSHIP
MOUNTVILLE BOROUGH
CITY OF LANCASTER
MANOR TOWNSHIP
PANEL 5
WEST BRANCH LITTLE CONESTOGA CREEK
D.A.=12.310 Sq. Mi.
LANCASTER TOWNSHIP
MILLERSVILLE BOROUGH
WEST LAMPE
PEQUEA TOWNSHIP
PANEL 2
INDIAN RUN
D.A.=3.206 Sq. Mi.
8000 0 8000 Feet
N
Sub-Watersheds of the Little Conestoga Watershed
h:\01\01421401\gis_data\report_maps.apr, watersheds Layout

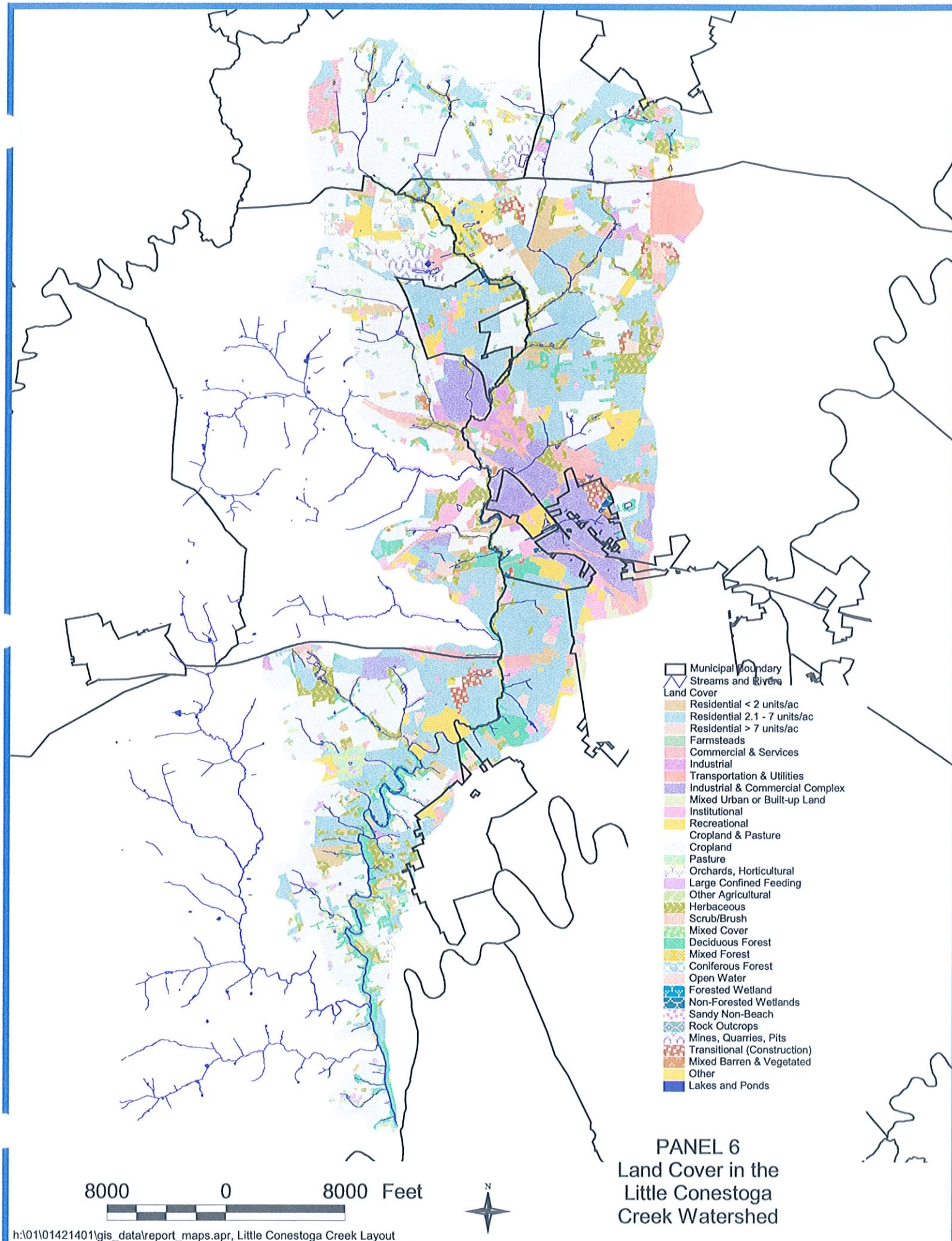

Municipal Boundary
Steams and Rivers
Land Cover
Residential < 2 units/ac
Residential 2.1 - 7 units/ac
Residential > 7 units/ac
Farmsteads
Commercial & Services
Industrial
Transportation & Utilities
Industrial & Commercial Complex
Mixed Urban or Built-up Land
Institutional
Recreational
Cropland & Pasture
Cropland
Pasture
Orchards, Horticultural
Large Confined Feeding
Other Agricultural
Herbaceous
Scrub/Brush
Mixed Cover
Deciduous Forest
Mixed Forest
Coniferous Forest
Open Water
Forested Wetland
Non-Forested Wetlands
Sandy Non-Beach
Rock Outcrops
Mines, Quarries, Pits
Transitional (Construction)
Mixed Barren & Vegetated
Other
Lakes and Ponds
3000 0 3000 Feet
N
PANEL 1
Land Cover in the
Brubaker Run Watershed
h:\01\01421401\gis_data\report_maps.apr, Brubaker Run Layout


Municipal Boundary
Streams and Rivers
Land Cover
Residential < 2 units/ac
Residential 2.1 - 7 units/ac
Residential > 7 units/ac
Farmsteads
Commercial & Services
Industrial
Transportation & Utilities
Industrial & Commercial Complex
Mixed Urban or Built-up Land
Institutional
Recreational
Cropland & Pasture
Cropland
Pasture
Orchards, Horticultural
Large Confined Feeding
Other Agricultural
Herbaceous
Scrub/Brush
Mixed Cover
Deciduous Forest
Mixed Forest
Coniferous Forest
Open Water
Forested Wetland
Non-Forested Wetlands
Sandy Non-Beach
Rock Outcrops
Mines, Quarries, Pits
Transitional (Construction)
Mixed Barren & Vegetated
Other
Lakes and Ponds
2000 0 2000 Feet
N
PANEL 2
Land Cover in the
Indian Run Watershed
h:\01\01421401\gis_data\report_maps.apr, Indian Run Layout


Municipal Boundary
Streams and Rivers
Land Cover
Residential < 2 units/ac
Residential 2.1 - 7 units/ac
Residential > 7 units/ac
Farmsteads
Commercial & Services
Industrial
Transportation & Utilities
Industrial & Commercial Complex
Mixed Urban or Built-up Land
Institutional
Recreational
Cropland & Pasture
Cropland
Pasture
Orchards, Horticultural
Large Confined Feeding
Other Agricultural
Herbaceous
Scrub/Brush
Mixed Cover
Deciduous Forest
Mixed Forest
Coniferous Forest
Open Water
Forested Wetland
Non-Forested Wetlands
Sandy Non-Beach
Rock Outcrops
Mines, Quarries, Pits
Transitional (Construction)
Mixed Barren & Vegetated
Other
Lakes and Ponds
2000 0 2000 Feet
N
PANEL 3
Land Cover in the
Miller's Run Watershed
H:\01\01421401\GIS_Data\report_maps.apr, Millers Run Layout


Municipal Boundary
Streams and Rivers
Land Cover
Residential < 2 units/ac
Residential 2.1 - 7 units/ac
Residential > 7 units/ac
Farmsteads
Commercial & Services
Industrial
Transportation & Utilities
Industrial & Commercial Complex
Mixed Urban or Built-up Land
Institutional
Recreational
Cropland & Pasture
Cropland
Pasture
Orchards, Horticultural
Large Confined Feeding
Other Agricultural
Herbaceous
Scrub/Brush
Mixed Cover
Deciduous Forest
Mixed Forest
Coniferous Forest
Open Water
Forested Wetland
Non-Forested Wetlands
Sandy Non-Beach
Rock Outcrops
Mines, Quarries, Pits
Transitional (Construction)
Mixed Barren & Vegetated
Other
Lakes and Ponds
2000 0 2000 Feet
N
PANEL 4
Land Cover in the
Swarr Run Watershed
H:\01\01421401\GIS_Data\report_maps.apr, Swarr Run Layout


Municipal Boundary
Streams and Rivers
Land Cover
Residential < 2 units/ac
Residential 2.1 - 7 units/ac
Residential > 7 units/ac
Farmsteads
Commercial & Services
Industrial
Transportation & Utilities
Industrial & Commercial Complex
Mixed Urban or Built-up Land
Institutional
Recreational
Cropland & Pasture
Cropland
Pasture
Orchards, Horticultural
Large Confined Feeding
Other Agricultural
Herbaceous
Scrub/Brush
Mixed Cover
Deciduous Forest
Mixed Forest
Coniferous Forest
Open Water
Forested Wetland
Non-Forested Wetlands
Sandy Non-Beach
Rock Outcrops
Mines, Quarries, Pits
Transitional (Construction)
Mixed Barren & Vegetated
Other
Lakes and Ponds
4000 0 4000 Feet
N
PANEL 5
Land Cover in the
West Branch Little
Conestoga Watershed
H:\01\01421401\GIS_Data\report_maps.apr, West Branch Little Conestoga Layout


Municipal Boundary
Streams and Rivers
Land Cover
Residential < 2 units/ac
Residential 2.1 - 7 units/ac
Residential > 7 units/ac
Farmsteads
Commercial & Services
Industrial
Transportation & Utilities
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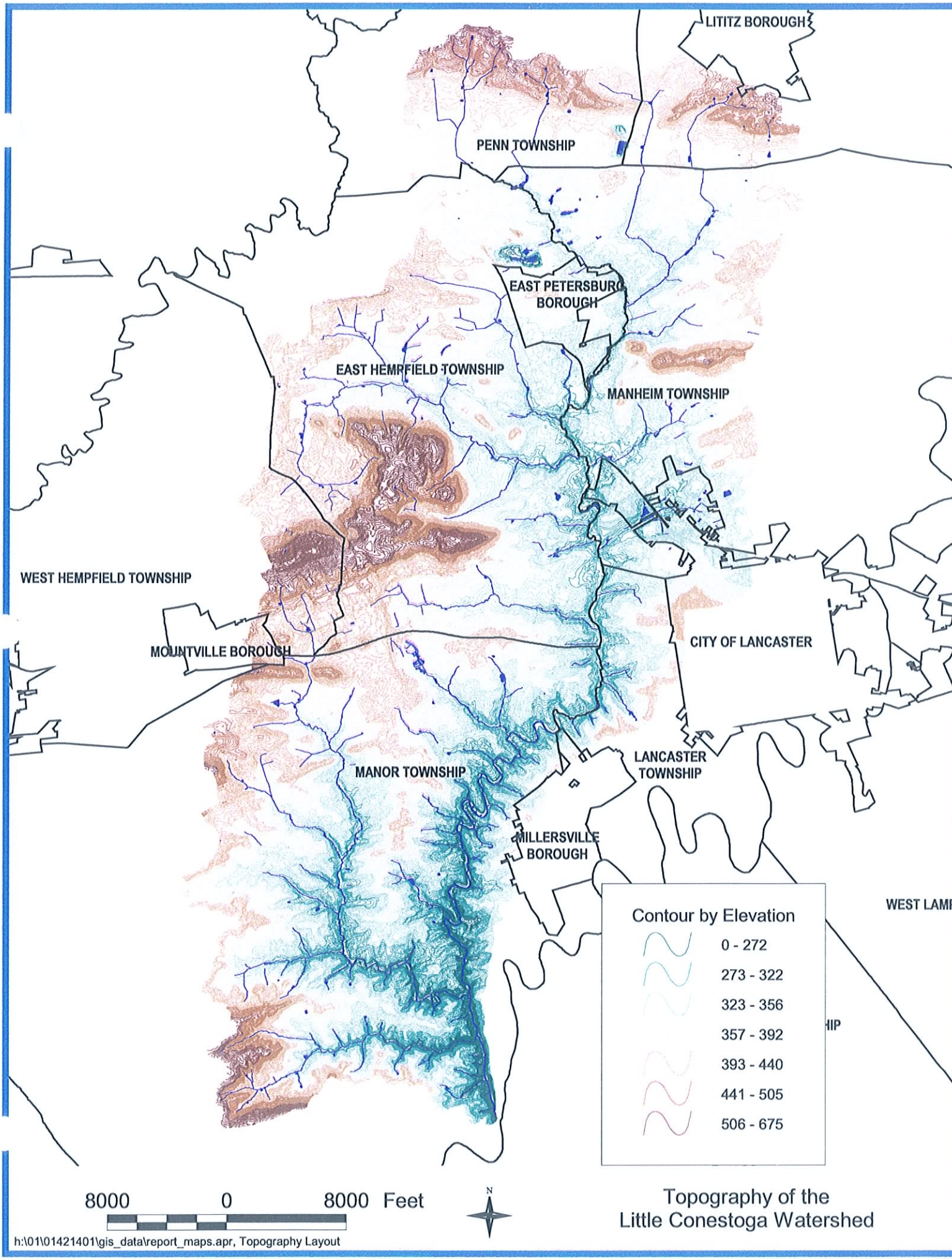
Mixed Forest
Coniferous Forest
Open Water
Forested Wetland
Non-Forested Wetlands
Sandy Non-Beach
Rock Outcrops
Mines, Quarries, Pits
Transitional (Construction)
Mixed Barren & Vegetated
Other
Lakes and Ponds
8000 0 8000 Feet
N
PANEL 6
Land Cover in the
Little Conestoga
Creek Watershed
h:\01\01421401\gis_data\report_maps.apr, Little Conestoga Creek Layout


LITITZ BOROUGH
PENN TOWNSHIP
EAST PETERSBURG BOROUGH
EAST HEMPFIELD TOWNSHIP
MANHEIM TOWNSHIP
WEST HEMPFIELD TOWNSHIP
MOUNTVILLE BOROUGH
CITY OF LANCASTER
MANOR TOWNSHIP
LANCASTER TOWNSHIP
MILLERSVILLE BOROUGH
WEST LAMP
Contour by Elevation
0 - 272
273 - 322
323 - 356
357 - 392
393 - 440
441 - 505
506 - 675
8000 0 8000 Feet
N
Topography of the Little Conestoga Watershed
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