IV. Watershed Description

Methods

The SCW is the area of land that drains to the Swartz Creek and its tributaries. Identifying priority pollutants, source areas, and specific causes of pollution affecting the watershed requires an understanding of the physical characteristics of a watershed. The following section of the watershed management plan is intended to provide specific information about the historic, current and future physical condition of the watershed. In order to characterize the physical condition of the SCW, CAER and its partners engaged in several activities during the planning effort. These activities included:

1. Conducting literature reviews of historic studies of the watershed and its tributaries
2. Soliciting public input about the watershed's physical condition
3. Conducting road/stream crossing data collection
4. Wading channels in specific areas of concern
5. Reviewing aerial photography and other GIS data
6. Conducting reviews of existing and future land use within the watershed
7. Conducting reviews of local community ordinances
8. Identifying specific areas of concern and specific sites for BMP implementation

Study Area

The Swartz Creek Watershed (SCW) is a 129 mi^2 area of land located in southern Genesee and northern Oakland Counties. (Figure 1.) The stream flows north approximately 15 miles from its headwaters in Oakland County into Genesee County and ultimately to its confluence with the Flint River in the City of Flint. The SCW is comprised of seven sub-watersheds (Figure 2.) and contains a number of small lakes (Table 1). The headwaters are primarily dominated by forest and wetlands and appear to exhibit relatively good water quality and natural channel forms. As the stream flows north into southern Genesee County, water quality reduces significantly as the landscape changes from forest and wetland land uses and to agricultural and urban land uses. The watershed includes ten municipalities including: City of Flint, City of Fenton, Flint Twp, Gains Twp., Mundy Twp., Grand Blanc Twp, Fenton Twp., in Genesee County and Holly Twp., Groveland, Twp, in Oakland County. (Figure 3.)

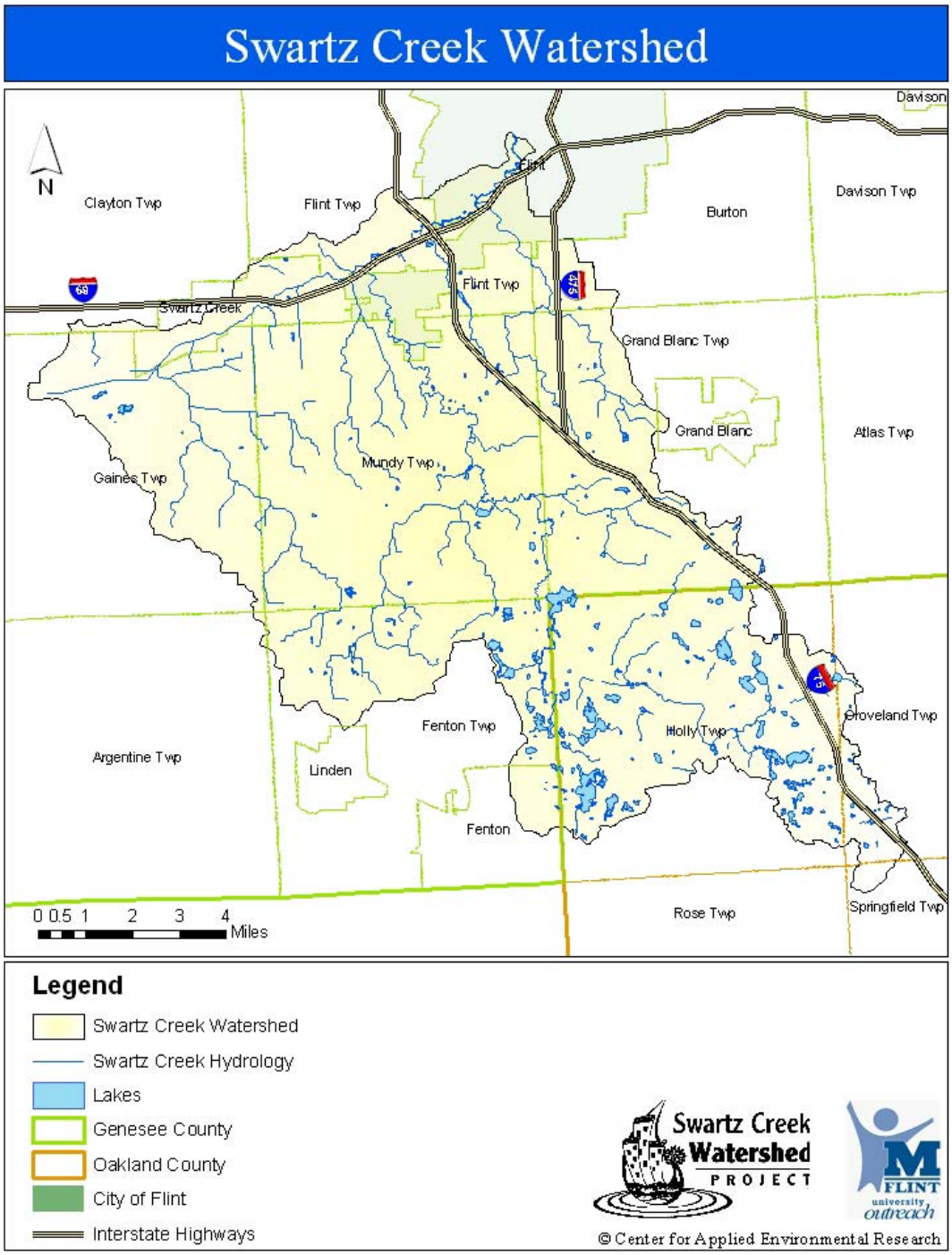
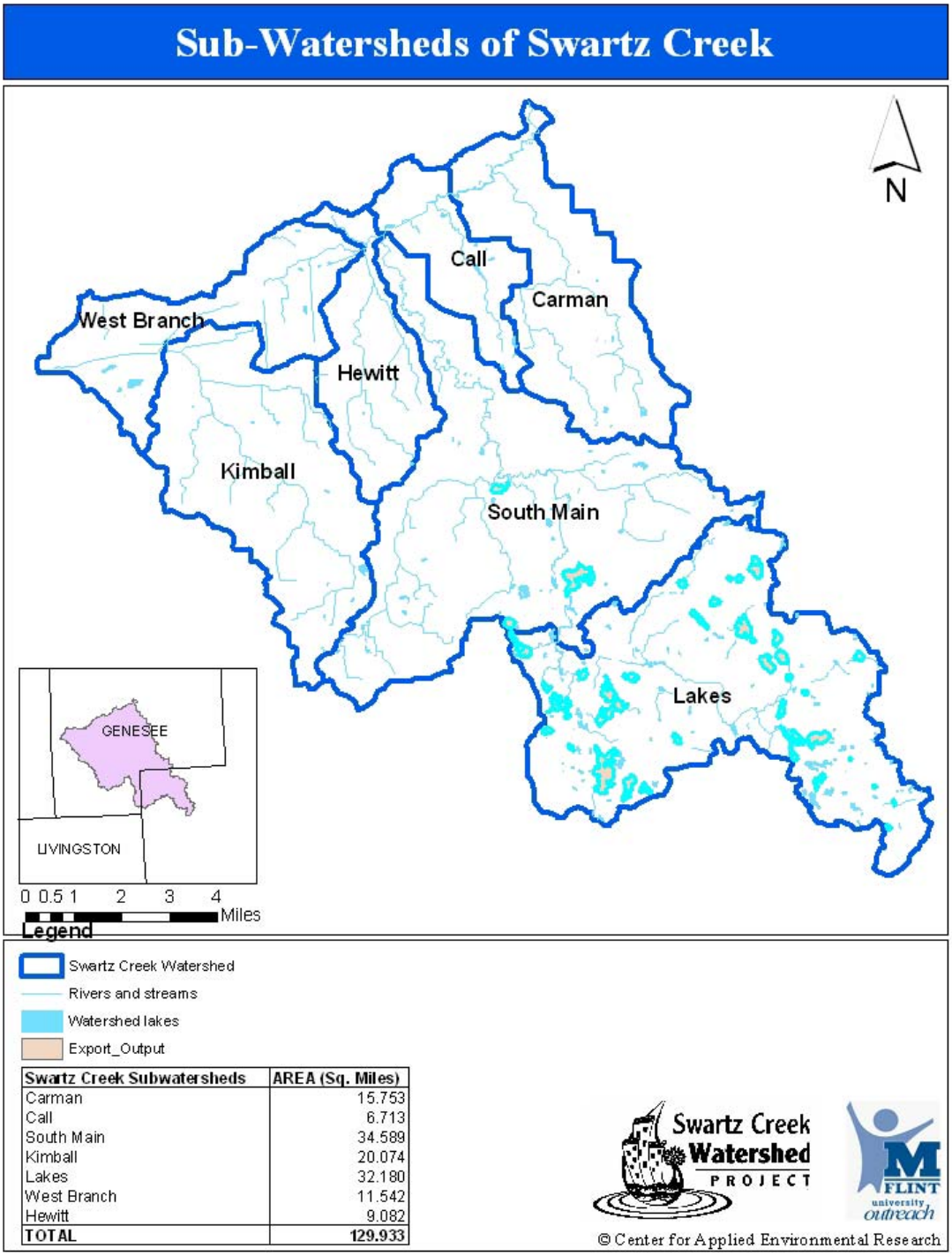

Swartz Creek Watershed
N
Clayton Twp
Flint Twp
Flint
Davison
Davison Twp
Burton
Flint Twp
Swartz Creek
Grand Blanc Twp
Grand Blanc
Atlas Twp
Mundy Twp
Gaines Twp
Fenton Twp
Holly Twp
Groveland Twp
Argentine Twp
Linden
Fenton
Springfield Twp
Rose Twp
0 0.5 1 2 3 4
Miles
Legend
Swartz Creek Watershed
Swartz Creek Hydrology
Lakes
Genesee County
Oakland County
City of Flint
Interstate Highways
Swartz Creek Watershed PROJECT
FLINT university outreach
© Center for Applied Environmental Research

Figure 1



Swartz Creek Subwatersheds	AREA (Sq. Miles)
Carman	15.753
Call	6.713
South Main	34.589
Kimball	20.074
Lakes	32.180
West Branch	11.542
Hewitt	9.082
TOTAL	**129.933**

Figure 2

9

Case Lake	Little Lake
Slack Lake	Pine Lake
Copneconic Lake	Holdridge Lakes
Barnum Lake	Lake Iroquois
Little Long Lake	Marl Lake
Dollar Lake	Cady Lake
McCully Lake	Crotched Lake
Crooked Lake	Little Crotched Lake
Petts Lake	Spring Lake
Nichols Lake	Minnock Lake
Slack Lake	Seven Lakes
Bloat Lake	Burns Lake
Martin Lake	Crystal Lake
Kennedy Lake	Dickinson Lake
Baldwin Lake	Spring Lake
Mitchell Lake	Minnie Lake
Fagan Lake	Mud Lake
Mud Lake	Pier Lake
Round Lake	Halstead Lake
Strawberry Lake	Oyster Lake
Horton Lake	Hollyshire Lake
Gravel Lake	

Table 1. Lakes of the Swartz Creek Watershed

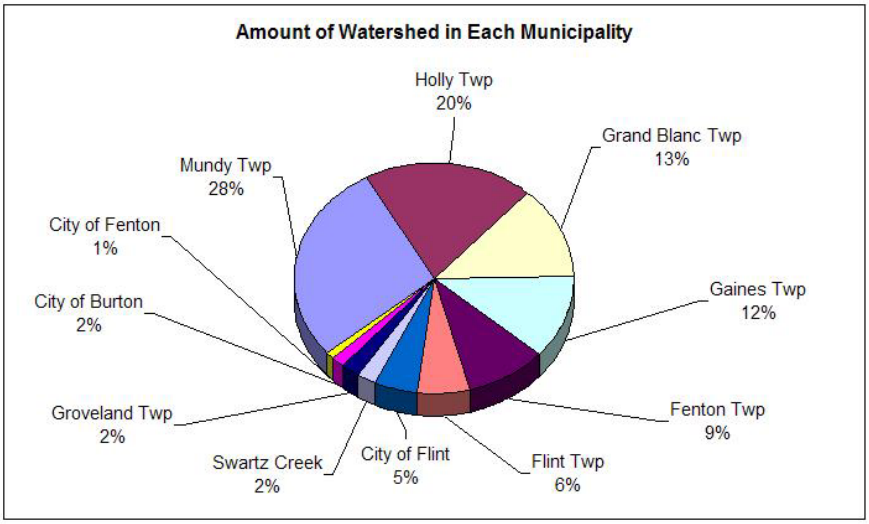


Figure 3. Percentage of Swartz Creek Watershed by Municipality

Climate

The Swartz Creek Watershed is located in the Lansing Ecoregion which has the following climate characteristics. The growing season is 140 to 150 days, generally decreasing to the north (Eichenlaub *et al*. 1990). Danger of late spring frosts is great due to numerous lowland depressions (outwash and kettle lakes). Average snowfall is 40 to 50 inches; greatest amounts are in the extreme north and extreme south. Annual precipitation is 30 to 32 inches, with highest amounts in the south. Extreme minimum temperature ranges from -22½F to -28½F, while highs range from 63F to 101F.

Geology

Understanding the geology of the SCW is important because of its implications for understanding how the drainage system works. This includes identifying areas that have the greatest potential for infiltration and understanding the capabilities and constraints upon any planned BMPs.

The geology of the SCW is dominated by landforms associated with the Wisconsinan glacial period. The glacial landforms found in the Swartz Creek Watershed are derivatives of the Laurentide ice sheet that reached its maximum at the Ohio River Valley approximately 18,000 years ago. Specifically, the local formations are associated with the glacier's Saginaw lobe that advanced from the Chesapeake Bay and retreated through the Lake Huron Basin. The glacial structures found in the Swartz Creek Watershed primarily include end moraines, outwash plains, till plains, and lake bed deposits. Each one of these forms is described briefly below.

End moraines - are depositional structures formed at the head of a glacier at undulating ice positions due to fluctuations in climate. The end moraines were formed as the retreat of the Saginaw Lobe stalled at various positions in the Swartz Creek Watershed. They are comprised of unsorted glacial till with large amounts of sand and gravel as well as lesser amount of clay and silt. These areas are important to increasing infiltration in the watershed.

Outwash plains are formed as a result of the glacial drainage system and collect when the glacier is stalled. They are comprised of well sorted sands and gravels and they typically slope downstream from the moraine. These areas are important to increasing infiltration in the watershed.

Till plains are formed as a glacier deposits materials in its path. They are composed of unsorted glacial till that has large amounts of clay and lesser amounts of sands, silts, and gravels. These areas are limited in their ability to infiltrate water in the watershed.

Lake bed deposits occur when melt water collects behind a previously formed end moraine. They consist of till that has localized deposits of clays and silts associated with underwater environments. These areas are limited in their ability to infiltrate water in the watershed.

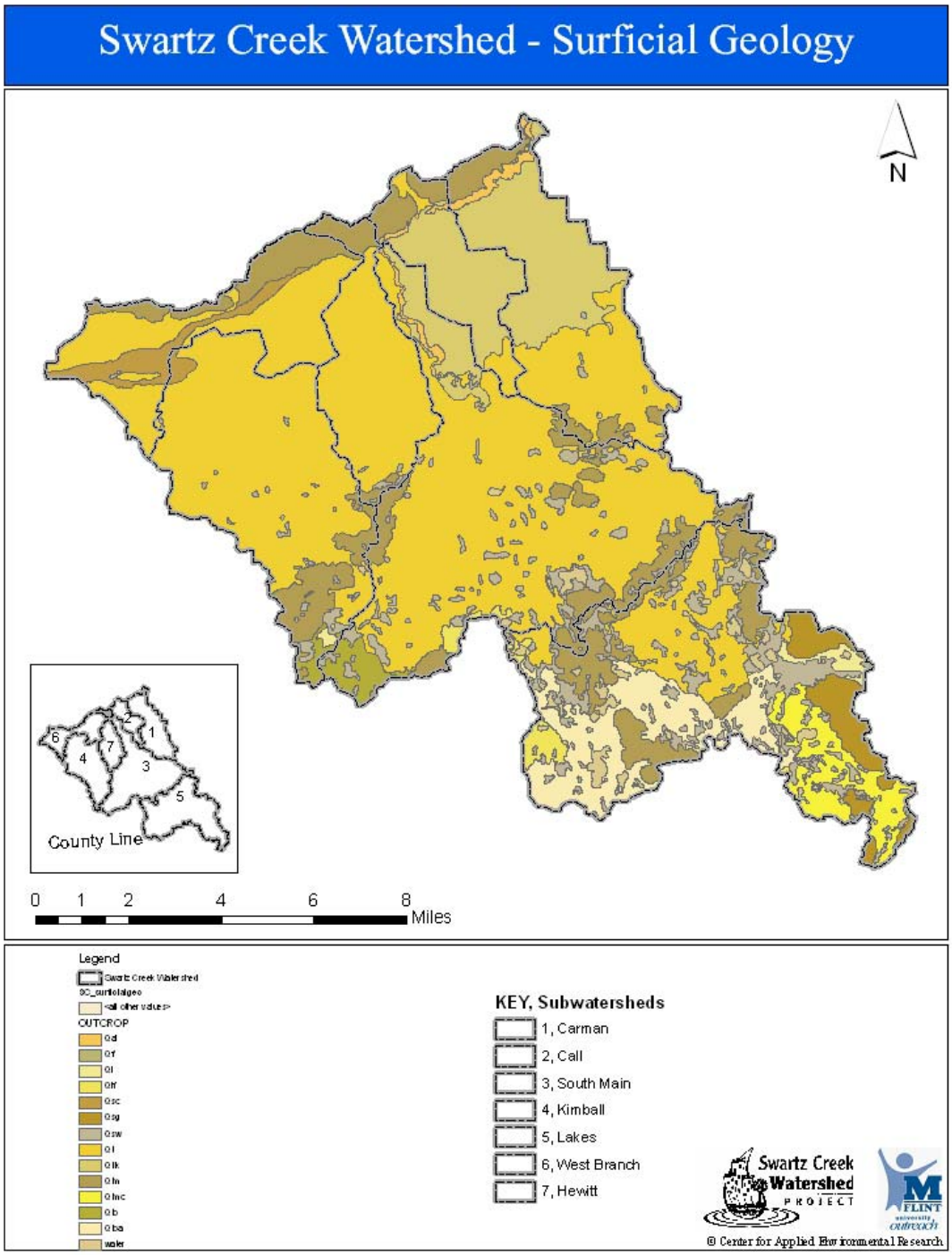

Swartz Creek Watershed - Surficial Geology
N
County Line
0 1 2 4 6 8
Miles
Legend
Swartz Creek Watershed
SC_surficialgeo
<all other values>
OUTCROP
Qd
Qf
Ql
Qlf
Qsc
Qsg
Qsw
Qt
Qtk
Qtn
Qtnc
Qtb
Qtba
water
KEY, Subwatersheds
1, Carman
2, Call
3, South Main
4, Kimball
5, Lakes
6, West Branch
7, Hewitt
Swartz Creek Watershed PROJECT
FLINT
© Center for Applied Environmental Research

Figure 4

Soils

Soils of the Swartz Creek Watershed are described as sandy loam moraines interspersed with clay-rich loam depressions. Soil associations of the SCW are shown in Table 2 and hydrologic soil groups in Table 3. A review of the hydrologic soil groups reveals that approximately 50% if the soils in the watered are rated as "C" type soils. These soils are generally limited with regards to their infiltration capacity. There are, however, pockets of soils that have increased capacity for infiltration. (Figure 5.)

Soil Association	Acres
BOYER-OAKVILLE-COHOCTAH (MI024)	122,351
CONOVER-BROOKSTON-PARKHILL (MI025)	464,108
LENAWEE-DEL REY-KIBBIE (MI009)	61,259
LENAWEE-TOLEDO-FULTON (MI008)	152,545
MARLETTE-CAPAC-PARKHILL (MI035)	716,259
MIAMI-CONOVER-BROOKSTON (MI017)	554,756
MIAMI-MARLETTE-LAPEER (MI016)	302,252
MIAMI-SPINKS-OAKVILLE (MI015)	23,632
SPINKS-HOUGHTON-BOYER (MI014)	1,045,162

Table 2: Soil Associations within the SCW

Entire Watershed	Area (Sq. Miles)	Percentage
A	2.8178	2.17%
B	30.4676	23.45%
C	62.8782	48.40%
D/A	7.7883	5.99%
D/B	17.6888	13.62%
D/C	0.1069	0.08%
Unknown	3.5245	2.71%
No data	4.6470	3.58%
Total	**129.9192**	**100.00%**

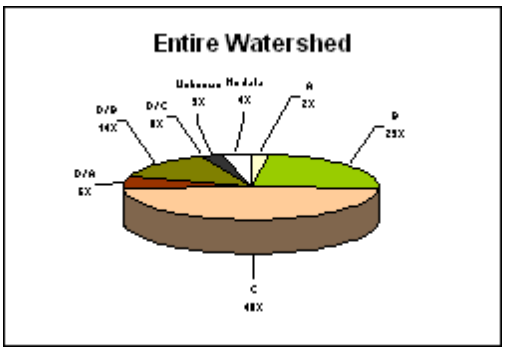


Table 3. Hydrologic Soil Groups of the Swartz Creek Watershed

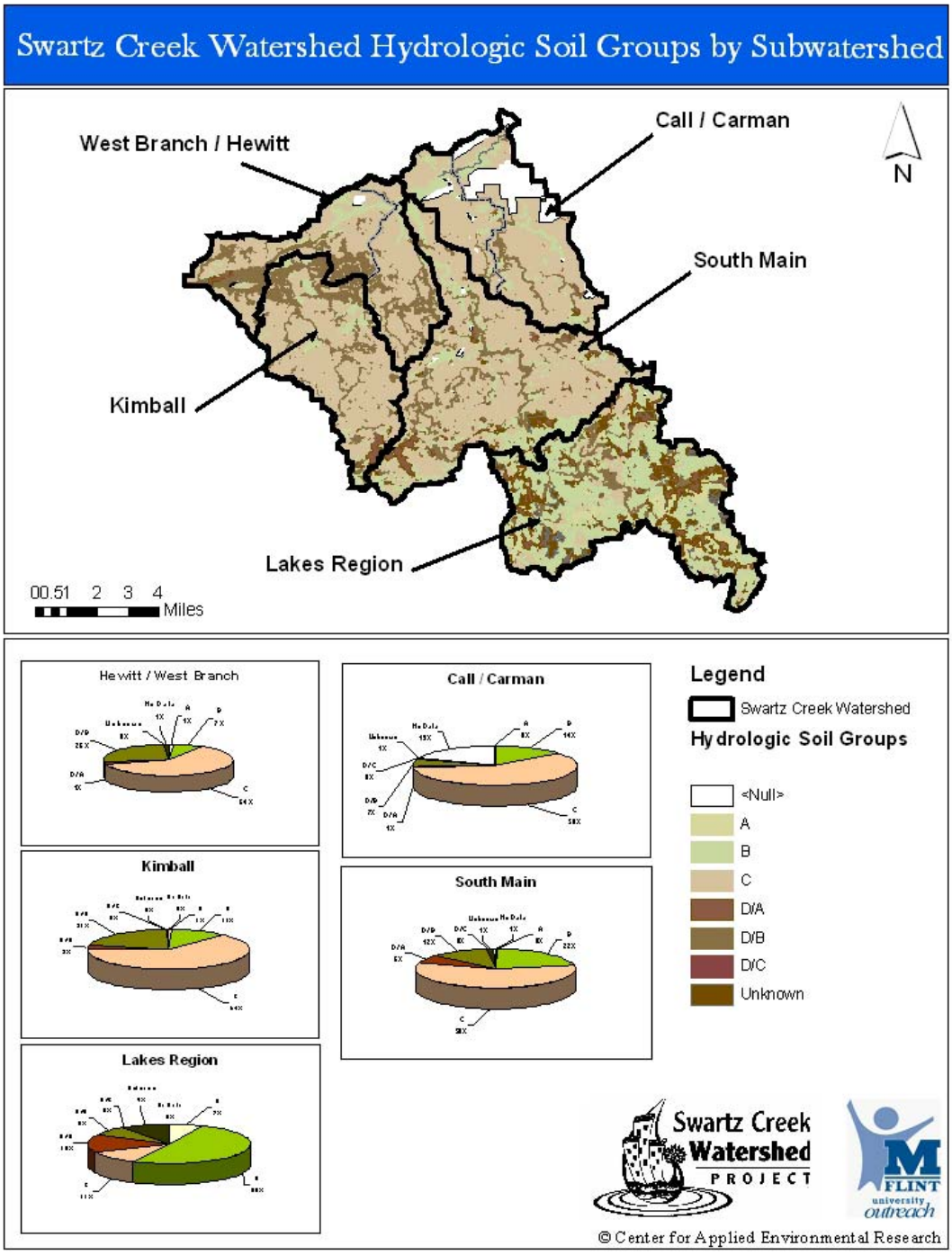

Swartz Creek Watershed Hydrologic Soil Groups by Subwatershed
West Branch / Hewitt
Call / Carman
South Main
Kimball
Lakes Region
N
00.51 2 3 4
Miles
Hewitt / West Branch
Call / Carman
Kimball
South Main
Lakes Region
Legend
Swartz Creek Watershed
Hydrologic Soil Groups
<Null>
A
B
C
D/A
D/B
D/C
Unknown
Swartz Creek Watershed PROJECT
FLINT university outreach
© Center for Applied Environmental Research

Figure 5

Upland Habitat

Historically, the Swartz Creek Watershed consisted of Oak-Hickory forests in the southern portions and Beech-Sugar Maple forests in the north. Patches of mixed hardwood swamp, wet prairie, and black ash swamp existed in areas where the water table was in close proximity to the surface. In the south patches of mixed oak savannas, black oak barrens existed, with small patches of mixed conifer swamp, wet prairie, and mixed hardwood swamp in areas with a high water table.

Biological and Aquatic Habitat Assessments

Assessment of the biological and physical habitat of the Swartz Creek Watershed was determined to be necessary to characterize water quality and to make recommendations on the management of the watershed. Existing biological and habitat assessments conducted by state agencies were reviewed and evaluated. The combination of these assessments with field investigations conducted in the physical inventory process provided sufficient information to identify implementation activities. However, a more complete biological and chemical assessment should be conducted based upon the findings of our physical inventory.

Macro invertebrate and Mussel Community Assessments

MDEQ 1998 Assessment

The MDEQ Surface Water Quality Division conducted biological and chemical sampling at four locations in the Swartz Creek Watershed between July and September of 1998. Sampling was conducted on the Western Branch near the Miller Rd and US-23 interchange, Grand Blanc Rd and Main Branch crossing, Cook Road and Indian Creek Crossing and the Fenton Rd and Main Branch Crossing.

Macroinvertbrate communities at all sampling locations were rated as acceptable but near the low range of acceptable results. Little narrative or qualitative information regarding habitat and or hydrologic cues were present in the report. Water chemistry samples were also included within the report. Only one notable anomaly was identified in the report, which consisted of high arsenic levels at the Cook Road Crossing south of the Citizens Disposal Landfill. According the report these high arsenic levels were localized and no source was identified. (MDEQ 2001)

MDEQ 2003 Assessment

The MDEQ Surface Water Quality Division conducted biological sampling at four stations in the Swartz Creek between June 30th and August 8th 2003. The stations were located at the crossings of Cook Road and Indian Creek, Baldwin Road and Dawe Drain south of Citizens Disposal landfill, Reid Road and Kimball Drain and on the West Branch near Dye Road. The Western Branch Station was typical of heavily modified system with evidence of hydrologic dysfunction. The stream was extremely turbid on both sampling dates and substrates were limited and heavily embedded in a layer of

clayey slit. The macro invert community was dominated by taxa that are indicative of poorer water quality and scored at the lower end of the acceptable rating. (Cooper 2004)

Water chemistry samples were taken in Indian Creek upstream and down stream of Dawe Drain (stations 46 and 47 respectively). Station 46 contained dense communities of algae and Cladophora on July 1, indicating chronically high nutrient concentrations. However this portion of the channel was dry in August and not sampled for macroinvertebrates. Macroinvertebrate communities at station 47 were rated as acceptable while nutrient concentrations, especially phosphorus were highly elevated (Cooper 2004)

Chemistry and macroinvertertbrate sampling was conducted in the Kimball Drain Subwatershed. This low gradient stream has been degraded along its entire length and heavily influenced by agricultural land uses. The overall riverine habitat at this station was rated as good and supported macro invertebrate community that, although acceptable, contained very low densities. There was almost no discernable flow on the date sampled. Stream banks were relatively stable with numerous undercut banks that provided ample fish cover. Upstream portions of the stream had little to no canopy and are intermittent in nature. Chemistry sampling indicated that soluble reactive phosphorous made up approximately 75% of the total phosphorous found in the stream indicating that there may be little assimilative capacity left within the stream channel. (Cooper 2004)

Fisheries Assessments

MDNR Fisheries classifies the Swartz Creek and its tributaries as a second quality warm water stream. Second quality warm water streams are those that have limited sport fish populations due to pollution, competitions, inadequate reproduction, or lack of suitable habitat. No fisheries management has occurred in on the Swartz Creek or any of its tributaries. Prior to 1997 no fisheries assessment records were collected for the Swartz Creek.

Flint River Community assessment March 1997

In 1997 MDNR collected fisheries information on the Swartz Creek near its confluence with the Flint River. According to Leonardi the fish community at the sampling location appears to be slightly influenced by the proximity to the Flint River. The presence of sand, spotfin, and emerald shiners and gizzard shad suggest these species are migrating into the Swartz Creek from the Flint River. High species diversity in relatively high abundance and the presence of intolerant species suggest that fair to good water quality and habitat conditions exist. These conditions are influenced by good in stream cover and good water level. Fish community structure in the upper reaches of the Swartz Creek tributaries where water levels are low and dredging has occurred are most likely less diverse and dominated by tolerant species. Spawning migration of carp, suckers, and northern pike are known to occur in the Swartz Creek. High sediment load is most likely affecting egg development of certain species (northern pike) (Leonardi 2001).

MDNR Fisheries Status and Trends Monitoring Program 2003
A single site was selected for sampling that was located along the entrance road to Camp Copneconic, approximately three miles east of Holly and two miles north of Fenton. This sampling site was selected as a representative site for the upper Swartz Creek aquatic ecosystem. The fish community found at this site is typical of warm water stream in Lower Michigan where water quality may be considered good but other factors limit species presence and abundance. The most significant limiting factor at this site appeared to be lack of suitable habitat due to low water levels. Although low stream conditions at this site appear to be more stable than downstream stretches.

A review of fishers information from the Swartz Creek indicates that a total of 28 species have been collected from the Swartz Creek. Sport fish constitute a small potation of the fishery and little recreational angling opportunities are available. Species diversity and abundance are higher in the lower portions of the watershed due to greater flow, better habitat and movement from the Flint River. (Leonardi 2003)

Human Population Trends

The communities of the Swartz Creek Watershed have experienced increased growth due to immigrations from the Detroit suburbs of Oakland County and from the northern Flint area. U.S. Census data from years 1990 and 2000 show all communities gaining in population with the exception of Flint Township. (Table 4) Population data was summarized from the Middle Flint Watershed Storm Water Management Plan.

Community	1990 Population In Watershed	2000 Population In Watershed	% Change
Gaines Township	2171	2614	20.4
Grand Blanc Township	25392	29827	17.5
Holly Township	2998	3400	13.4
Mundy Township	11511	12191	5.9
Fenton Township	3718	4796	29
Flint Township	10228	10115	-1.1
Total	**56018**	**62943**	**12.36**

Table 4: Population in the SCW

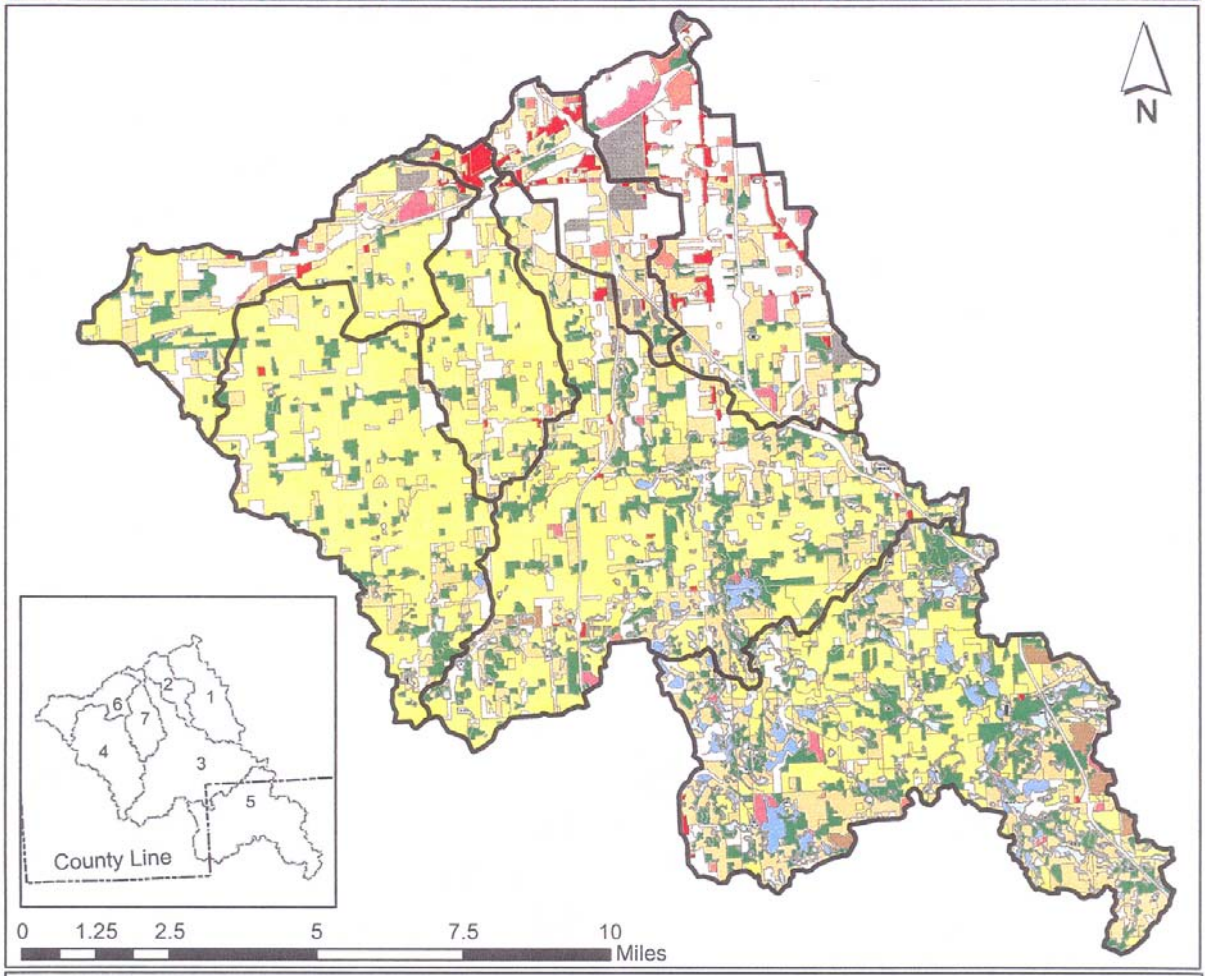
Land use

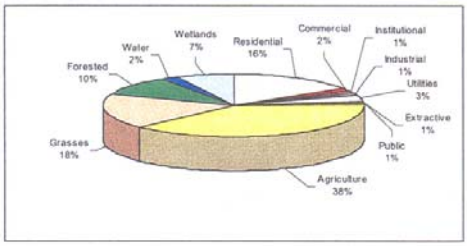
By definition a watershed is the area of land that drains to a particular water body. Given that definition, it is understandable how the way the land is used within a watershed will have a tremendous impact upon the water quality of a river and on how that river should be managed for future generations. Because of the importance of linkages between land use and water quality the planning team felt it important to examining the historic, current and future potential land use makeup of the SCW. This examination will allow better planning decisions to be made in the SCW.

Historic Urbanization (pre 1978)

Historically land development has taken place in the lower portions of the watershed including the Call and Carman Drain Watersheds and the I69/Miller Road Corridor in the Western Branch Watershed (Figure 6). This initial urbanization that took place prior to 1978, has primarily impacted only the furthest downstream portions of the watershed. The most intensive impacts are from large commercial and residential land uses in these areas of the watershed. These land uses have resulted in a large amount of impervious cover from roof tops, parking lots and roadways. The remainder of the watershed has historically been dominated by rural land uses including agricultural, forest, wetland and rural residential. These areas have seen some water quality reductions associated with agricultural land uses and drain maintenance but have historically not been impacted by high percentages of impervious coverage.

Swartz Creek Watershed - 1978 Land Use / Cover





Entire Watershed	Area (sq mi)	Percent
Residential	20.4980	15.78%
Commercial	2.0520	1.58%
Institutional	1.2780	0.98%
Industrial	1.7230	1.33%
Utilities	4.1300	3.18%
Extractive	0.7410	0.57%
Public	1.4420	1.11%
Agriculture	49.6850	38.24%
Grasses	23.6000	18.16%
Forested	12.9980	10.00%
Water	2.3090	1.78%
Wetlands	9.4720	7.29%
Total Area	129.9280	100.00%

Legend

Class

- Residential
- Commercial
- Institutional
- Industrial
- Utilities
- Extractive
- Public
- Agricultural
- Grasses
- Forested
- Water
- Nonforested Wetlands
- Barren

Watershed Boundaries

Key, Sub watershed

1, Carman
2, Call
3, South Main
4, Kimball
5, Lakes
6, West Branch
7, Hewitt

Data Sources:
2003 Land Use Data produced by CAER in 2005 from 2003 AirPhoto USA true color aerial photos with a 1 acre minimum mapping unit.

Swartz Creek Watershed PROJECT

FLINT university outreach

Figure 6

19

Current Land use (1978-2003)

In the more recent past, urbanization has begun to expand into other portions of the watershed. During the planning process for the SCW, CAER was engaged in updating land use for portions of the Genesee County including those areas in the Swartz Creek Watershed. The new data set generated by CAER has given us the ability to make direct comparisons about the changes in land use within the watershed over the past three decades. In addition, this information provides a basis for evaluating the success of land use strategies implemented to protect and restore the water quality of the Swartz Creek Watershed. An examination of the current land use presented in Tables 5 & 7 reveal several key trends that should be of consideration in regards to the management of the Swartz Creek Watershed including:

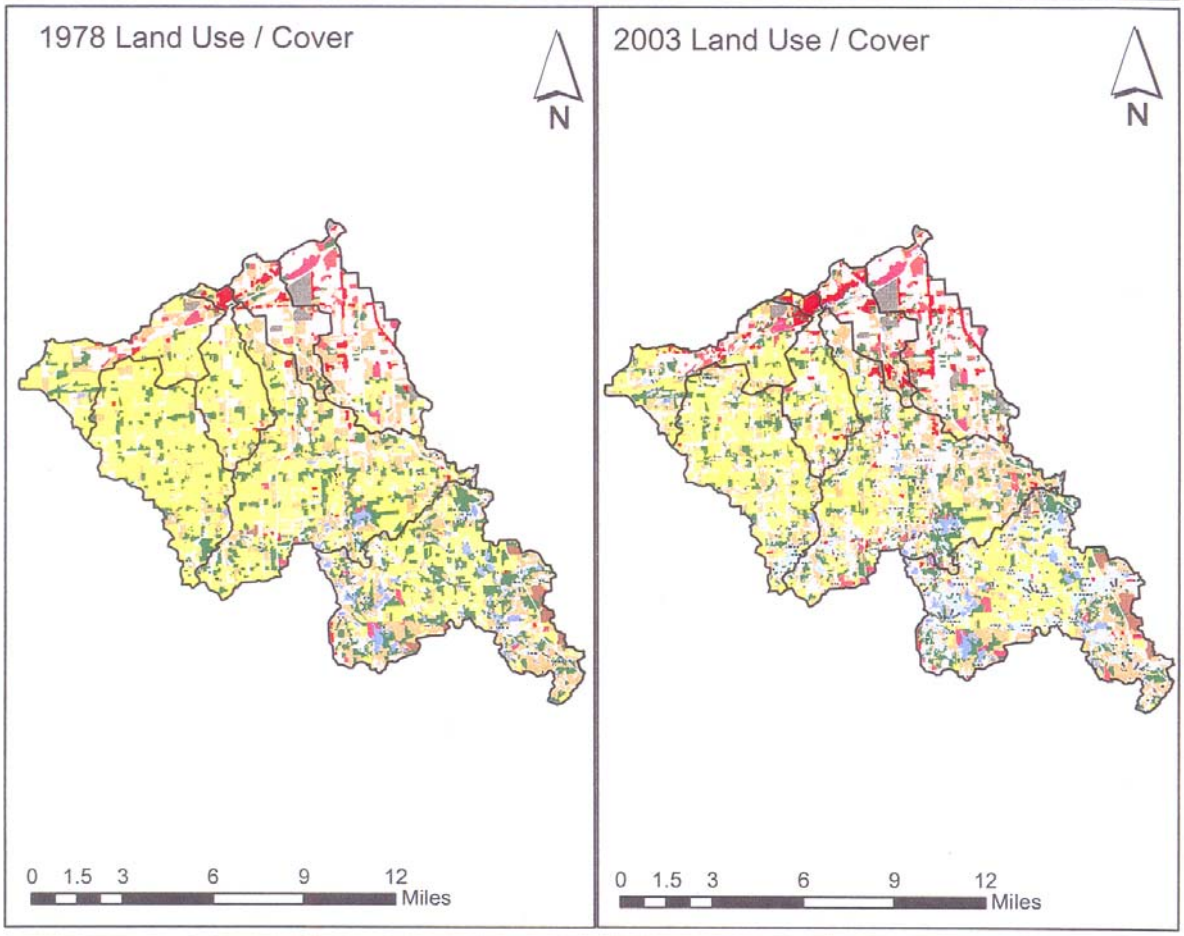
1. The land uses within the major tributaries of the Swartz Creek are transitioning from rural/agricultural to residential. Since 1978 Hewitt, Kimball and the South Main Branch all experienced losses of agricultural land above 45% and increases in residential land uses ranging from 22 to 26 percent. The Swartz Creek Watershed as a whole experienced a loss of over 44% of its agricultural lands.

2. There appears to be a net increase in the amount of wetlands in the watershed. It is speculated that this increase in wetland is a result of reductions in the drainage of agricultural lands. Some increases are due to improved image/mapping techniques allowing for a one acre minimum mapping unit for the 2003 data. The 1978 data was generated with a 2.5 acre minimum mapping unit.

Class	West Branch	Call Drain	Carman	Hewitt	Kimball	Lakes	South Main	Entire Watershed
Agriculture	-38.20%	-7.27%	-22.53%	**-45.13%**	**-48.95%**	- 24.11%	**-48.93%**	**-44.20%**
Barren					0.05%			.01%
Commercial	7.20%	20.16%	7.62%	6.52%	0.27%	1.26%	1.51%	4.14%
Extractive			1.07%			1.65%	-0.71%	0.12%
Forested	5.08%	5.58%	9.31%	5.40%	-0.47%	-3.92%	3.64%	2.92%
Grasses	-11.72%	-40.86%	-27.55%	-4.72%	12.06%	-22.06%	6.53%	-5.45%
Industrial	1.08%	-1.20%	8.48%	-1.47%		2.63%	0.90%	1.53%
Institutional	1.87%	1.96%	4.31%	2.65%	0.33%	1.63%	2.60%	2.31%
Public	1.96%	5.31%	1.42%	1.86%	0.04%	5.12%	0.96%	2.07%
Residential	23.11%	2.99%	15.54%	24.60%	26.00%	19.29%	22.20%	23.80%
Utilities	-0.21%	2.01%	-0.16%		-0.70%	-0.03%	2.34%	0.81%
Water	0.80%	0.58%			0.53%	0.88%	1.32%	0.89%
Wetlands	8.77%	12.09%	2.01%	7.67%	10.65%	17.42%	8.37%	11.04%

Table 5: Land use change in the SCW from 1978 - 2003

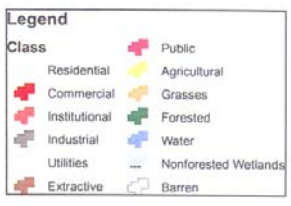
Swartz Creek Watershed
1978/2003 Land Use / Cover Change



Swartz Creek Watershed Land Use Change 1978-2003

Entire Watershed

Class	1978	2003	Change (Sq mi)	Change (Acres)	Percent Change
Agriculture	49.69	32.44	-17.25	-11038.08	-44.20%
Barren		0.00	0.00	2.56	0.01%
Commercial	2.05	3.67	1.61	1032.96	4.14%
Extractive	0.74	0.79	0.05	28.80	0.12%
Forested	13.00	14.14	1.14	729.60	2.92%
Grasses	23.60	21.48	-2.13	-1360.00	-5.45%
Industrial	1.72	2.32	0.60	382.08	1.53%
Institutional	1.28	2.18	0.90	576.64	2.31%
No Data		0.28	0.28	181.76	0.73%
Public	1.44	2.25	0.81	515.84	2.07%
Residential	20.50	29.78	9.29	5943.04	23.80%
Utilities	4.13	4.45	0.32	202.88	0.81%
Water	2.31	2.66	0.35	222.08	0.89%
Wetlands	9.47	13.78	4.31	2758.40	11.04%
Total Drainage Area		130.1999			



Data Sources:
2003 Land Use Data produced by CAER in 2005 from 2003 AirPhoto USA true color aerial photos with a 1 acre minimum mapping unit.

Swartz Creek Watershed PROJECT

FLINT university outreach

Figure 7

21

Future estimates

In addition to examining historic and current land uses within the watershed, the planning team examined information that provides some insights into the future land use makeup of the Swartz Creek Watershed. This was facilitated by examining future land use information from community master plans, zoning maps and ordinance manuals. This method has significant limitations that need to be considered but can provide information about the general future land use goals of the community.

The process used to estimate future land use assumes that full build out will occur of the existing land use plan. This examination fails to account for partial build out or for variances granted by agencies charged with making land use decisions. It should also be stated that this examination of land use was conducted at the watershed scale and therefore does not reflect nor should it be used for making site specific recommendations. Rather the information reflects the general intentions of the community with regards to future land uses.

During the investigation of community master plans and zoning ordinances it became apparent that there was the need to develop a uniform zoning classification system that could be applied to the entire watershed. In order to facilitate this comparison, CAER reviewed the zoning criteria of the municipalities within the watershed and developed a uniform system. Specifics about how the classification system was developed are included in the appendix. Once the master plans and zoning maps of the communities were uniformly classified they were examined at a watershed and sub-watershed scale (See figure 8).

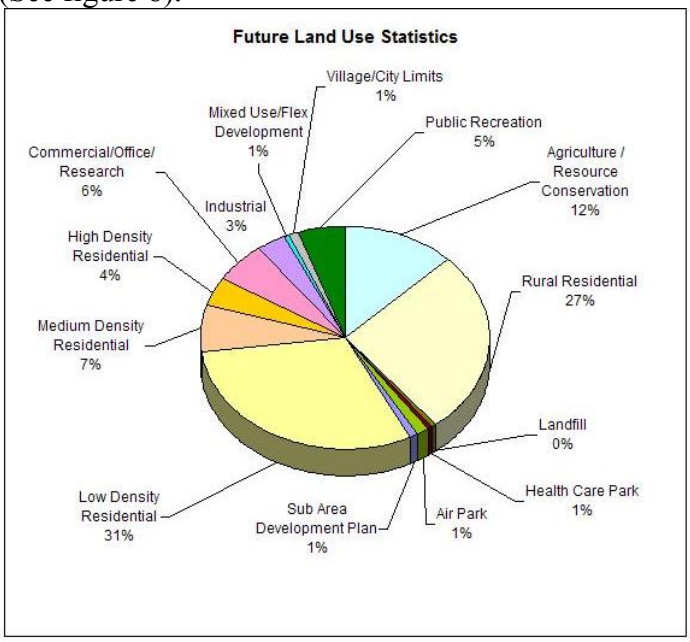


Figure 8. Hypothetical future land use of the Swartz Creek Watershed

A review of "future" land use information illustrates that a large percentage of the watershed is classified as "transitional", which includes agricultural and residential land uses. It appears that the headwaters portion of the watershed including Kimball Drain, Sever Drain, Indian Creek and Hewitt will likely continue to see significant increases in residential construction. These areas are made up largely of Gaines, Mundy and Holly Townships. These transitional areas are identified as having the highest development pressure because of their large parcel size and prices.

Local ordinance reviews and policies

Home Rule is at the heart of land use decisions and local building ordinances in the State of Michigan. This traditional local control of land use decisions by local planning commissions and township boards will play a major role in determining the success or failure of the Swartz Creek Watershed Plan. Local policies are directly related to and/or responsible for determining future land uses within the SCW. As a result the planning team examined the local land use policies and ordinances that influence land use and storm water management within the watershed. This examination was conducted to uncover opportunities for improvements in local policies and practices that will assist in protecting and restoring water quality in the Swartz Creek Watershed. Each community's zoning and building policies were entered into a matrix and awarded points for policies that are considered positive for water quality (Table 5.)

Community Zoning Ordinances and Stormwater Management

(0 = hinder 1 = help)

Community	Landscaping Standards	Buffer Zones Required Near Sensitive Lands	Parking Lot Runoff Controls	Required Parking Lot Vegetation	Open Space Cluster Options	Lot Grading	Floodplain Development	Paving Options / Shared Driveways	Curb / Swale Options	Feedlot / Animal Waste Control	Fertilizer Controls (Golf)	Septic Controls	Totals
Fenton Twp.	1	1	1	1	1	1	0	0	0	0	0	1	7
Flint	0	0	0	1	1	0	0	0	0	0	0	0	2
Flint Twp	1	1	1	1	1	1	1	0	0	0	0	0	7
Grand Blanc Twp.	1	0	1	1	1	0	0	0	0	0	0	1	5
Holly Twp.	1	0	1	1	1	1	0	0	0	1	0	0	6
Mundy Twp.	0	0	0	0	1	1	0	0	0	0	0	1	3
Swartz Creek	1	1	1	1	1	0	1	1	0	0	0	0	7
Totals	5	3	5	6	7	4	2	1	0	1	0	3	

Table 5.

Implementing progressive policies to protect water quality is most important in those areas identified in the future land use examination, mainly Mundy, Gaines and Holly Townships. Based on our review of the matrix containing existing policies and information gathered from communications with township residents and leaders several key findings were identified:

1. Little consistency exists across jurisdictional lines regarding zoning classifications.
2. Current ordinances within the Swartz Creek watershed revealed that most attention to water resources followed traditional zoning concerns, such as density and open space.
3. Local policies fail to recognize the linkage between water quality and water quantity.
4. Mundy Township's ordinances are the weakest with regards to protecting water quality. Specifically the township has no ordinances regarding landscaping standards, buffer zones near sensitive lands, parking lot runoff controls, parking lot vegetation, flood plain development or fertilizer controls. This fact in combination with its large area in the watershed makes it a high priority municipality to work with in strengthening water related policies.
5. Watershed planning is not currently incorporated into other township planning efforts (parks, master, transportation etc).
6. Mundy, Holly, Grand Blanc and Flint Twp. should consider implementing natural features setback ordinances. This finding is also supported by the physical inventory portion of the planning process which found significant need for this policy change.

These findings are important to consider in the management of the Swartz Creek Watershed. The lack of consistency in the communities zoning policies presents a significant hurdle in attempting to manage land use to protect water quality. The weakness of Mundy Township's ordinances, its continued growth and its location within the watershed make it a top priority for new policy development and implementation specifically with regards to stormwater management and riparian land management. Holly Township is the second highest priority township in the watershed because of its relatively good water quality and expected continued development. Holly Township's policies are relatively good when companied to the other municipalities including the requirement for parking lot vegetation and runoff controls. The focus of new policy development in Holly Twp should be focused on the development of natural feature setbacks and standards that allow for the use of low impact development such as no curb/swale options, road narrowing, etc. These findings directly influenced the development of several education and managerial BMPs identified in the implementation portion of the watershed plan.

Future land use/policy research

Several opportunities exist in the watershed for land use and policy research and/or work. During the watershed planning process no examination of the enforcement of the communities' policies was conducted. Future research should be conducted to examine the performance of the communities with regards to zoning ordinance and code enforcement.