CHAPTER 3
WATERSHED ANALYSIS

3.0 Introduction

This analysis looks at the current conditions within the Upper Clinton Subwatershed, and identifies trends and potential future water quality issues. The analysis was developed by the Core Group of communities within the subwatershed. A draft was then sent to the members of the broader Steering Committee for their comments and input. This input was collected at a Steering Committee meeting held on August 24, 2004. The document was then revised based on the comments collected.

3.1 Growth Trends, Land Use Analysis and Community Profiles

The Upper Clinton subwatershed is nearly 86.24 square miles in area and is located within the central portion of Oakland County. A total of eleven (11) communities make up the subwatershed, ten (10) of which have participated in the creation of this subwatershed plan. See the map on the following page that shows where this subwatershed (called the "Headwaters" subwatershed) is located within the Clinton River Watershed.

A summary of each of the communities is provided in the following table as well as in the descriptions that follow. With the exception of the City of the Village of Clarkston, no single community is contained entirely within the Upper Clinton subwatershed.

Table 3.1
Community Area in Subwatershed

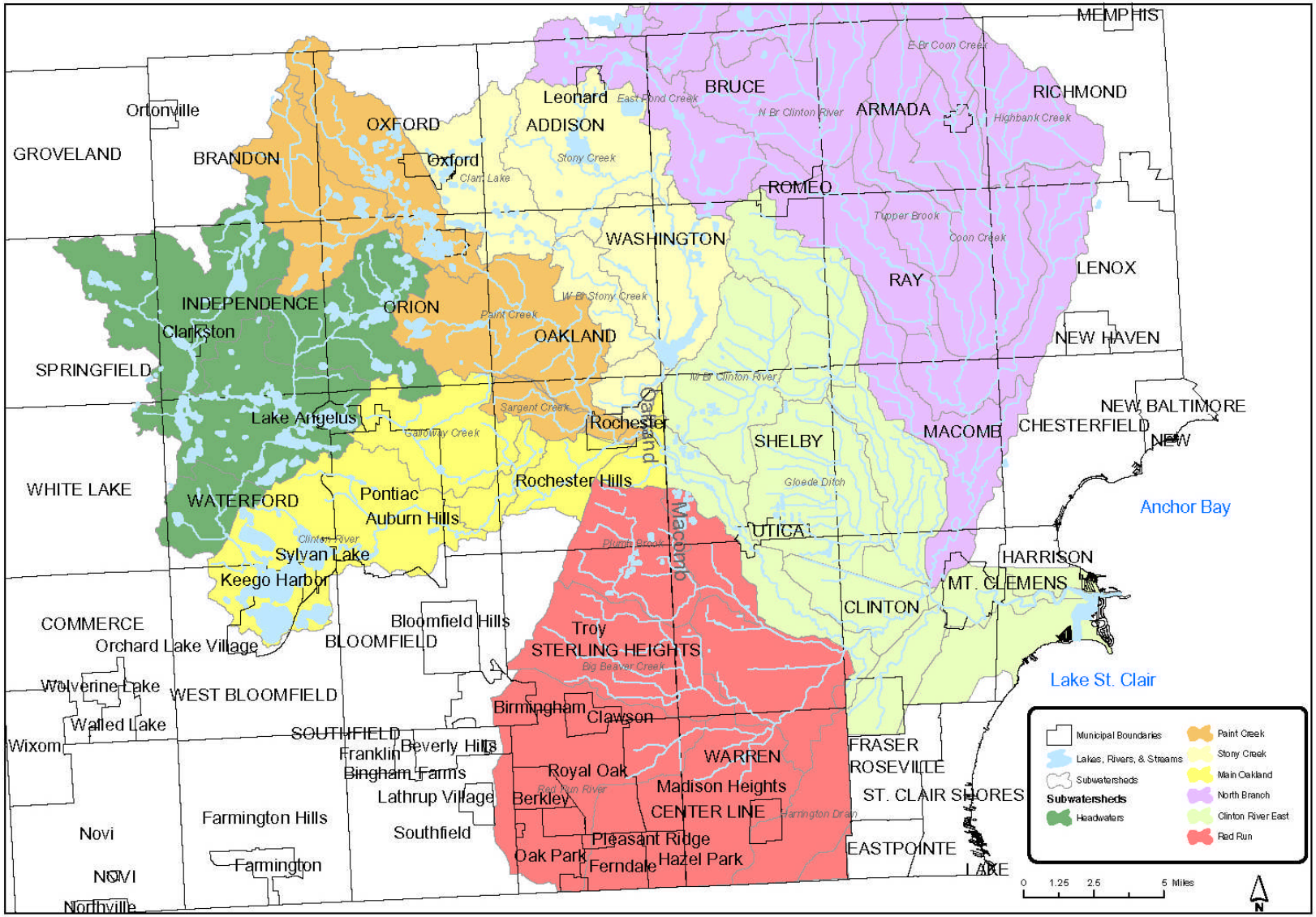
Community	Acres in Subwatershed	Percent of Community in Subwatershed
Charter Township of Springfield	6,265	27%
Charter Township of White Lake	827	3%
Charter Township of Brandon	1,127	5%
Charter Township of Independence	20,070	86%
City of the Village of Clarkston	328	100%
Charter Township of Waterford	14,620	65%
City of Lake Angelus	956	91%
Charter Township of Orion	9,887	45%
City of Auburn Hills	782	7%
City of Pontiac	332	3%
Total	**55,194 ***	

* 12 acres are contained within Groveland Township for a total of 55,206 acres in the subwatershed.

The Clinton River Watershed

This map is provided by the Environmental Stewardship Group
of Oakland County Planning & Economic Development Services

L. Brooks Patterson, County Executive



Growth Trends

In order to understand the land use changes within the Upper Clinton subwatershed, it is helpful to understand the growth trends observed within the Southeast Michigan Council of Government (SEMCOG) region. SEMCOG evaluated the changes that have occurred between the 1990 and 2000 census years. A summary of the findings is as follows:

- Developed land in the region has increased by 17% (159,300 acres). Thirty-seven percent (37%) of the region is now considered developed.
- The region's population grew by 5% (243,000 people).
- Between 1990 and 2000 the density of residential development decreased from 2.84 units per acre to 1.26 units per acre, or 55.6%.
- Average household size has decreased and the average home size has increased.
- The results of these changes are larger homes on larger pieces of land with fewer occupants.

The trends identified by SEMCOG are indicative of a growing region. The proximity of the subwatershed to the rapidly growing metropolitan Detroit region is reflective of these trends. SEMCOG projects that similar trends will prevail over the next thirty (30) years. Table 3.3 illustrates the population and housing profiles for each of the ten (10) communities. Note that this data is for the entire community, not just the area within the Upper Clinton subwatershed.

Table 3.2a
Population and Housing Profiles

	Springfield Township	White Lake Township	Brandon Township	Independence Township	Clarkston
Population					
1990 Population	9,927	22,677	10,799	23,717	1,005
2000 Population	13,338	28,219	13,230	32,581	962
2030 Population	20,326	34,313	18,509	38,103	957
Households					
1990 Households	3,276	7,805	3,535	7,977	431
2000 Households	4,619	10,092	4,475	11,765	406
2030 Households	7,854	13,580	6,738	15,381	411
2000 Housing Units	4,794	10,616	4,718	12,375	424
2000 Household Size	2.87	2.77	2.94	2.75	2.37
2030 Household Size	2.58	2.50	2.73	2.45	2.33
2000 Median Household Income	$71,977	$65,894	$66,895	$74,993	$62,667
2000 Median Housing Value	$209,100	$190,900	$195,000	$203,600	$231,300
Educational Attainment					
No High School	730	2,250	865	1,707	72
High School	2,345	5,917	2,607	4,775	106
Some College	2,334	4,767	2,439	5,494	167
Associates	752	1,439	803	1,576	46
Bachelor's	1,443	2,989	1,223	5,018	179
Graduate/Professional	956	1,295	434	2,670	125
Housing Types					
One-Family Detached	3,816	8,557	3,659	9,447	301
One-Family Attached	194	102	19	362	29
Two-Family / Duplex	21	15	0	59	25
Multi-Unit Apartments	224	354	23	1,899	85
Mobile Homes	538	1,590	1,011	584	2
Other	0	29	0	6	0
Total	4,794	10,616	4,718	21,375	424
2003 Residential Building Permits					
Single Family	93	175	82	166	0
Townhouse / Attached Condos	6	64	0	43	0
Two-Family / Duplex	0	0	0	0	0
Multi-Family	0	0	0	0	0
Total New Units	99	239	82	209	0

Table 3.2b
Population and Housing Profiles

	Waterford Township	Lake Angelus	Orion Township	Auburn Hills	Pontiac
Population					
1990 Population	66,692	328	21,019	17,076	71,136
2000 Population	71,981	326	30,748	19,837	67,506
2030 Population	72,863	264	40,948	21,013	75,544
Households					
1990 Households	25,476	122	7,331	6,453	24,763
2000 Households	29,387	132	11,048	8,064	24,234
2030 Households	33,287	139	16,030	9,753	30,204
2000 Housing Units	30,404	146	11,517	8,822	26,336
2000 Household Size	2.42	2.47	2.77	2.25	2.68
2030 Household Size	2.12	1.90	2.54	1.97	2.44
2000 Median Household Income	$55,008	$114,524	$73,755	$51,376	$31,207
2000 Median Housing Value	$144,400	$814,800	$199,100	$137,200	$74,300
Educational Attainment					
No High School	6,414	0	1,492	1,521	12,207
High School	15,155	28	4,280	3,263	12,775
Some College	12,718	55	4,767	2,696	8,442
Associates	3,909	8	1,797	990	1,819
Bachelor's	8,684	100	4,941	2,856	2,842
Graduate/Professional	3,330	56	2,292	1,278	1,212
Housing Types					
One-Family Detached	22,469	146	9,047	3,447	16,237
One-Family Attached	1,206	2	530	544	1,361
Two-Family / Duplex	222	0	38	64	1,210
Multi-Unit Apartments	2,689	0	1,448	3,912	6,996
Mobile Homes	191	0	456	888	517
Other	6	0	0	0	15
Total	30,404	148	11,517	8,822	26,336
2003 Residential Building Permits					
Single Family	132	1	164	64	272
Townhouse / Attached Condos	44	0	16	134	37
Two-Family / Duplex	0	0	4	0	0
Multi-Family	0	0	0	4	0
Total New Units	176	1	184	202	309

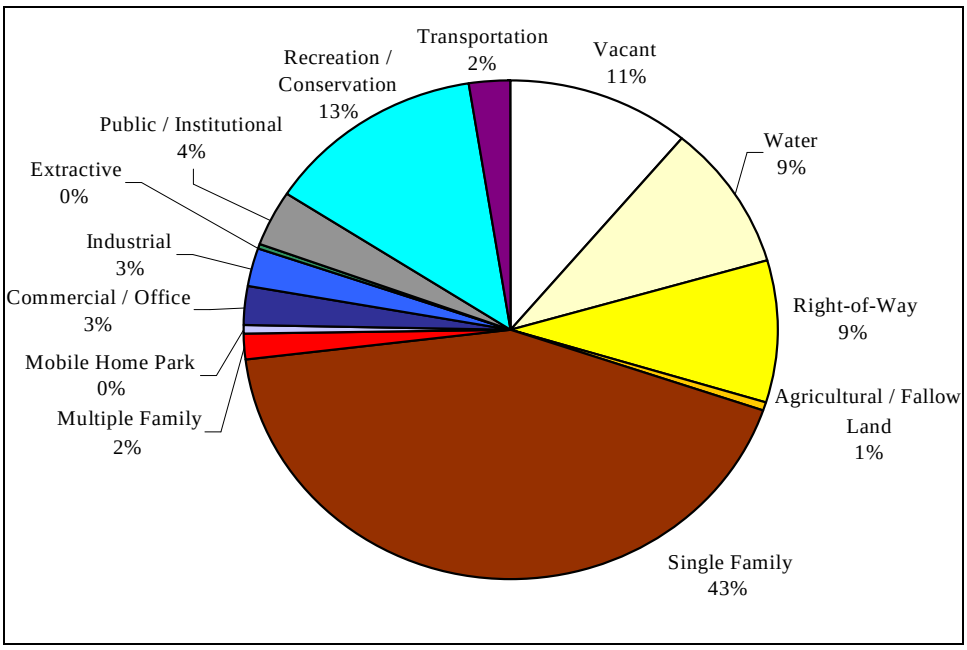
Land Use Analysis

The Upper Clinton subwatershed contains a wide range of existing land uses from single family to extractive. The twelve (12) land use categories used by Oakland County can be summarized in the following table and figure, and depicted in the map on the following page (see Map 1). A few of the categories have been combined for ease of use.

Table 3.3
2000 Existing Land Use Designations

Land Use Category	Total Acres	Percent Total
Single Family	23,514	42.6%
Recreation / Conservation	7,360	13.3%
Vacant	6,097	11.0%
Water	5,241	9.6%
Right-of-Way	5,110	9.3%
Public / Institutional	2,039	3.7%
Industrial	1,483	2.7%
Commercial / Office	1,404	2.5%
Transportation	1,338	2.4%
Multiple Family	948	1.7%
Agricultural/Fallow Land	332	0.6%
Mobile Home Park	245	0.4%
Extractive	95	0.2%
Total	**55,206**	**100%**

Figure 3.1
2000 Existing Land Use Designations



Map 2
Existing Land Use

The top three land uses in the Upper Clinton subwatershed are single family, vacant/water/right-of-way, and recreation/conservation, which combined represent nearly 86% of the total subwatershed land area. The high quantity of vacant/water/right-of-way land (29.9%) is reflective of the abundant lakes, ponds and streams within the subwatershed. The generally high water quality and stream corridor conditions within much of the area are also reflective of the low impact land uses. However, it appears that some lake and stream sections within the subwatershed are experiencing water quality problems as a result of the cumulative effects of the existing and expanding residential and other active land uses along their banks.

Over 13%, or 7,360 acres, of the subwatershed is contained within the recreation/conservation land use designation. The communities within the subwatershed have had the benefit of large tracks of land being maintained in public ownership through State and County park Master Plans. Many of these areas were previously identified as wetland and/or woodland ecosystems. The municipalities have also preserved other sensitive areas through the acquisition of local parkland.

Community Profiles

As the Upper Clinton communities continue to develop, the potential for negative environmental impacts increases; including water quality impacts resulting from erosion, sedimentation, and increased input of stormwater pollutants, as well as water quality impacts resulting from loss of wetlands, woodlands, and riparian vegetation, and increased impervious surfaces. The following are brief profiles of each of the ten (10) Upper Clinton subwatershed communities, highlighting their existing land uses and growth trends. The communities are generally listed from north to south and from west to east to reflect the changes in land use as one moves from the headwaters to the lower reaches of the creek.

In addition to each community's general land use features and trends, reference is also made to the results of the Michigan Natural Features Inventory (MNFI) study, which assesses the quality and extent of the natural areas in Oakland County (see Map 7).

Springfield Township – The majority of the northeast quadrant of the Township is located within the subwatershed. A total of 6,265 acres, or 27% of the Township, make up the western portion of the subwatershed. Approximately 75% of the area is occupied by single family residential developments. A few large parcels are contained within the private recreation and educational institutional land use designation. Other smaller parcels are being preserved as conservation areas. However, there is limited correlation between these areas and those identified by the Michigan Natural Features Inventory (MNFI). The MNFI has identified five (5) areas as Priority Three preservation areas, each located at the periphery of the subject area, three Priority Two areas have been identified within the central portions of the subject area. Two of the Priority Two areas consist of palustrine wetland ecosystems, but due to their desirable locations, have been developed for residential use. These wetlands were preserved as part of the residential developments by the use of clustering.

The greatest concentration of non-residential uses is along the Dixie Highway corridor where over the years several pockets of commercial/office uses have developed. A similar but more intensive pattern exists as Dixie Highway traverses the southwest corner of Independence

Township and extends into Waterford Township. The lack of sewer services places some limitations or additional requirements on non-residential developments in other portions of the Township. There are no plans to provide service to this portion of the Township. Capacity in the Clinton Oakland system is not available to Springfield.

The population within Springfield Township is projected to increase at a fairly steady pace over the next thirty (30) years with a slightly less dramatic increase in the number of households. The result of the different rate of growth between population and households is a projected decrease is household size. As of 2003 the number of residential building permits was still relatively low compared to that of the other communities within the subwatershed, but as compared to the base population figures, the percent increase is commensurate with that of the subwatershed as a whole.

White Lake Township – White Lake Township, along with the City of Pontiac, has the smallest quantity of their land area within the subwatershed. Only 3% (827 acres) of the Township is contained within the subwatershed. Nearly half of the area is occupied by a State recreation area which extends into Waterford Township. The majority of this area has been identified by the Michigan Natural Features inventory as a Priority One and Priority Two preservation area. Each of these areas also contains pockets of wetland ecosystems.

The population within White Lake Township is projected to increase at a slow but steady pace over the next thirty (30) years with a slightly less dramatic increase in the number of households. The result of the different rates of growth between population and households is a projected decrease in household size. Much like Springfield Township, the total number of residential building permits in 2003 was relatively low compared to that of the other communities within the subwatershed, but as compared to the base population figures, the percent increase is commensurate with that of the rest of the subwatershed. However, because these areas will never be sewered, the density levels will only be able to increase at a rate commensurate with the Oakland County Drain Commission standards.

Brandon Township – Brandon Township is located within the northern most reaches of the subwatershed. With only 5%, or 1,127 acres, of its land area within the subwatershed, it is the third smallest community within the subwatershed. Nearly all of the land area is occupied by single-family residential developments with a few pockets of commercial, agricultural and public/institutional land uses. Despite the limited land area, two (2) large areas have been identified by the Michigan Natural Features Inventory as Priority Two and Priority Three preservation areas. These designations are indicative of areas containing large Palustrine wetlands.

The population within Brandon Township is projected to increase at a slow but steady pace over the next thirty (30) years with a less dramatic increase in the number of households. The result of different rates of growth between population and households is a projected decrease in household size. The Township previously had the highest number of persons per household within the subwatershed. As of 2003 the number of residential building permits was relatively low compared to that of the other communities within the subwatershed, but as compared to the base population figures, the percent increase is commensurate with the rest of the subwatershed.

Independence Township – Independence Township has the third largest quantity of its land area contained within the subwatershed. A total of 20,398 acres (86%) of Independence Township is located within the subwatershed, of which the majority is occupied by single-family residential developments. Several large pockets of land are contained within County, educational institutions, municipal and private land holdings. The majority of the County parkland has been identified as a Priority One preservation area by the Michigan Natural Features Inventory. A large portion of the eastern perimeter of the Township, and extending into Orion Township, has also been designated as a Priority One preservation area. Pockets of Priority Two and Priority Three preservation areas are scattered throughout the Township. The highly sensitive environment within the Township is indicative of areas with extensive wetland ecosystems, abundant lakes and streams, and expansive floodplains. These sensitive areas are located primarily within the northern half of the Township. The lack of sewer connections within this area will ensure that the density is kept relatively low.

The greatest concentration of non-residential uses is along the Dixie Highway corridor where over the years several pockets of commercial/office uses have developed. A similar pattern exists as Dixie Highway extends to the south into Waterford Township. Other pockets of commercial and office uses are scattered along the principal arterials, primarily the Ortonville and Sashabaw Road corridors. The limitations associated with non-residential developments within the northern portions of the Township are associated with the lack of sewer service. Presently there are no plans to provide service to this portion of the Township.

The population within Independence Township is projected to increase at a steady pace over the next thirty (30) years with a commensurate increase in the number of households. However, the persons per household are projected to decrease over the same time frame. In 2003 the Township witnessed one of the highest growth rates for new residential construction. A total of 209 residential permits were issued that year. Based upon the population projections, and the availability of land within the Township, this number is expected to outpace the majority of the communities within the subwatershed.

City of the Village of Clarkston – The 328 acre City is located entirely within the subwatershed, and consists of predominantly single-family developments with a commercial core located in its center. Approximately 30% of the City consists of woodlands, wetlands and open water. A large municipal park exists within the southwest quadrant of the City and includes the stream between Mill Pond Lake and Deer Lake. According to the Michigan Natural Features Inventory, this land has been identified as a Priority Three preservation area because of the significance of its wetlands and proximity to the adjacent chain of lakes that extend into Independence and Waterford Townships.

The City has experienced a decline in population and households, a trend which is projected to continue over the next thirty (30) years. Based upon the correlation between these two indicators, the household size is projected to remain nearly the same.

Waterford Township – Waterford Township has nearly 65% of its land area within the subwatershed. A large quantity of the 14,620 acres is occupied by single family residential developments, but unlike the majority of the other communities within the subwatershed, a large quantity of non-residential uses are scattered throughout its confines. Dixie Road and Highland Road corridors contain the greatest quantity of commercial and office uses with a large pocket of industrial land located in and around the airport. Limited recreational land remains with the Township, the majority of which are contained within municipal park holdings and/or educational institutions. A small pocket of private recreation land exists to the southwest of Lake Angelus and a small pocket of State land exists within the northwest quadrant of the Township. There is also a large County park complex known as Waterford Oaks. The Michigan Natural Features Inventory has identified several pockets of priority preservation areas, the majority of which correlate closely with the previously noted parkland. With only a few exceptions in the southwest corner of the Township, each of these areas is being preserved through the parkland designation. Only one of these areas is designated as a Priority One preservation area and is contained at the extreme southern portion of the subwatershed. Three hundred and thirty (330) acres of the Priority One area has been preserved as the Elizabeth Lake Woods Conservation Area (Township Park). The density and intensity of development over the past several decades has had an impact on the environment within the Township, but the majority of the most sensitive lands have been preserved. The availability of sewer service has also perpetuated this land development pattern.

The population within Waterford Township is projected to be nearly constant between 2000 and 2030. The growth rate for the number of households is projected to increase slightly over the same time frame. Therefore, the persons per household should continue to decline. In 2003 the Township granted 176 residential building permits, a rate that is commensurate with several of the other communities within the subwatershed.

City of Lake Angelus – A total of 91% of the City is contained within the subwatershed. As the second smallest community within the subwatershed it also has the second largest quantity of its land area contained within the subwatershed. The predominant land use is the lake with a circle of single-family residential development around its confines. There are also two pockets of municipal recreational land at the northern and southern perimeters of the community and a pocket of commercial/office land to the northeast of the lake. The Michigan Natural Features Inventory designates each of the recreational areas as Priority Two and Priority Three preservation areas. Another Priority Three preservation area is located at the terminus of Rohr Road, but this area was previously developed for single-family residential use.

The City has experienced a slight decline in population with a slight increase in the number of households between 1990 and 2000. This pattern is projected to continue but at a slower pace over the next thirty (30) years. The household size is projected to decrease between 2000 and 2030 to the lowest rate within the subwatershed.

Orion Township – Just under half of Orion Township is located within the subwatershed. The majority of the 9,887 acres contained within the subwatershed have been developed for single-family residential use. The second largest land use category is recreation/conservation which is inclusive of several large County, municipal, private, State and educational institution land uses. A few of these areas have been identified as priority preservation areas by the Michigan Natural

Features Inventory. The eastern most preservation area has been designated as Priority One due to its abundant wetland ecosystems while a large quantity of the western preservation area has been lost to residential development. The Priority Two and Three preservation areas are located in close proximity to, or contain wetland ecosystems or open water. Large pockets of land within the Township will not have access to municipal sewer service to ensure that these highly sensitive areas are protected. However, the majority of the area within the subwatershed already has sewer service or it is planned for the near future.

The greatest concentration of non-residential uses is along the Baldwin Road corridor where over the years several pockets of commercial/office uses have developed. A large pocket of industrial and transportation uses are also located within the southeast quadrant of the subwatershed. Other small pockets of commercial uses are located at major intersections within the Township. There are few limitations associated with non-residential developments in this portion of the Township; therefore, this pattern of development is projected to expand into vacant or under-developed portions of the Township.

The population within Orion Township is projected to increase dramatically over the next thirty (30) years with a commensurate increase in the number of households. However, like the rest of the communities in the subwatershed, the persons per household are projected to decrease over the same time frame. In 2003 the Township witnessed one of the highest growth rates for new residential construction. A total of 184 residential permits were issued that year. Based upon the population projections, and the limited availability of land within the Township, this number is expected to be commensurate with the majority of the communities in the subwatershed.

City of Auburn Hills – Only 7% of the City, or 782 acres, is contained within the subwatershed. The predominant land use is industrial located contiguous to the industrial land in Orion Township. The rest of the City is occupied by a mix of residential and commercial/office uses. The land uses along Brown Road are nearly a mirror image of those in Orion Township. There is no recreational land and limited wetland ecosystems within this portion of Auburn Hills, but the Michigan Natural Features Inventory has identified one Priority Three preservation area just south of Lake Angelus.

The City has experienced a slight increase in population with a commensurate increase in the number of households between 1990 and 2000. This pattern is projected to continue at a similar pace over the next thirty (30) years. As exhibited in each of the communities within the subwatershed, the persons per household is projected to decrease between 2000 and 2030. The decrease is in part due to the high number of residential permits, in particular townhouse/ attached condominiums. In 2003 the City issued 202 residential building permits, one of the highest volumes within the subwatershed.

City of Pontiac – The City is tied with White Lake Township for the smallest quantity of land contained within the subwatershed. The 332 acres are located within the extreme northwest corner of the City and are occupied by single family residential, municipal recreation, and institutional uses along with a very small pocket of commercial uses along Walton Road. A portion of the southern most recreation area is contained within a Michigan Natural Features Inventory Priority Three preservation area and a portion of the northern conservation area is part of the southern preservation area in Lake Angelus.

The City has experienced a decline in population and the number of households between 1990 and 2000. This pattern is projected to change with an upswing projected over the next thirty (30) years. Therefore, the household size is projected to decrease but at a slower rate than that of the majority of the other communities within the subwatershed. In 2003 the City issued more residential building permits than any other community within the subwatershed, but it was not enough to maintain the growth levels exhibited during the 1980's and early 1990's.

3.2 Sanitary Sewer System and On-Site Sewage Disposal Systems

Wastewater is dealt with by either a system of sanitary sewers leading to a wastewater treatment plant or by on-site sewage disposal systems (OSDS). On-site sewage disposal systems typically include a septic tank and an absorption field. OSDS generally serve single family residences in less urbanized settings, although community septic systems are becoming more common in newer developments. The Sewer Service Areas Map (see Map 3) depicts the areas within the subwatershed that are currently serviced by sanitary sewers, are planned to be serviced by sewers, or are not planned to receive sewers. Table 3.4 depicts the present and planned status of wastewater disposal systems. Over half of the subwatershed is currently sewered; an additional small amount of unsewered area is also planned for conversion. The majority of the unsewered areas are found in the headwaters areas of the subwatershed, mainly in Springfield and Independence Townships and to a lesser degree in Orion and Waterford Townships.

If properly designed, constructed and maintained, both OSDS and sanitary sewers can provide for disposal of sewage in a safe and environmentally responsible manner. If either type of system fails, inadequately treated sewage can be a threat to aquatic ecosystems and human health due to harmful bacteria and excess nutrients.

The installation and maintenance of septic systems within the watershed are regulated by the Oakland County Health Division. However, there is no system currently in place to monitor the functioning and maintenance of these systems following installation. While there have been no confirmed cases of septic systems contaminating surface waters in the Upper Clinton subwatershed, it remains a potential concern. Oakland County is currently considering enactment of regulations that would mandate professional inspection of OSDS at the time of the sale of a property or every five years, whichever comes first. Along with regulation, education is often considered central to addressing potential issues with OSDS. Owners, particularly those moving from areas with sanitary sewers to those with OSDS, often have limited understanding of the functioning and maintenance of OSDS. This lack of knowledge can lead to poor function and premature failure, leading to contamination of the ground and surface waters. The use of community septic systems can mitigate this situation by having written maintenance requirements in the condominium documents and making them the responsibility of the homeowners association.

Discharges from sanitary sewer systems have historically been a problem, but modern standards and regulations for these systems have reduced the most harmful discharges. Damaged sewer pipes may leak sewage into the ground or nearby storm drains and thereby contaminate ground or surface water. A sanitary sewer system may also be overloaded and overflow into local lakes or streams. Illicit connections are another potential source of water contamination. These connections are usually sanitary sewer pipes from a building that have been accidentally or purposefully connected to a storm drain. The locations of such discharges are usually identified by systematic water sampling and/or physical inspection of the banks of streams and lakes. The processes for the detection and correction for such discharges are required to be outlined in each community's Illicit Discharge Elimination Plan (IDEP). Communities are required to inspect their sanitary sewer systems and correct any sewage discharges into waterways under the NPDES Phase II stormwater regulations.

Table 3.4
Status of Sewer Systems within the Upper Clinton Subwatershed by Community

Sewer Status	Sub-watershed	Auburn Hills	Brandon Township	Clarkston	Independence Township	Waterford Township
Currently Sewered	55%	81%	0%	96%	55%	79.5%
Planned Sewer 2010	1%	9%	0%	0%	0%	0.4%
Planned or Forecasted Sewer 2030	1%	0%	0%	0%	3%	0%
Potential Sewer	1%	0%	0%	0%	2%	0.1%
No Sewer Planned	42%	10%	100%	4%	40%	20%

Sewer Status	Sub-watershed	Lake Angelus	Orion Township	Pontiac	Springfield Township	White Lake Township
Currently Sewered	55%	0%	70%	8%	1%	0%
Planned Sewer 2010	1%	0%	4%	0%	0%	14%
Planned or Forecasted Sewer 2030	1%	0%	0%	0%	0%	13%
Potential Sewer	1%	0%	2%	43%	0%	0%
No Sewer Planned	42%	100%	24%	49%	99%	73%

Map 3
Sewer Service Area

3.3 Baseline Stream, Lake and Riparian Conditions

An assessment of the existing conditions of the streams, lakes and riparian corridors was completed to determine the nature and extent of any water quality issues present in the Upper Clinton subwatershed. The assessment incorporated a range of existing chemical, biological, and physical condition data gathered from a variety of sources. The Water Sampling Stations Map (see Map 4) depicts the locations of the sampling stations used for all the data sources consulted in the preparation of this report. The data sources and results are summarized in the following sections.

The following is a list of each of the consulted data sources:

USGS Stream Flow and Water Quality Data – The available USGS data contains water quality data for eleven sites within the Upper Clinton subwatershed and stream flow data for two (2) of those sites. The data collection time frames and water quality parameters vary from site to site, but in total extend between 1967 and 2003. Data for nine (9) of these sites are from the late 1960's and are mainly useful as a historic baseline for evaluating more current data on the subwatershed. Two (2) of the sites provide water quality and stream flow data over an extended period. The latter two (2) sites are located as follows: 1) in the Sashabaw Creek about one (1) mile north of its confluence with the Clinton River (Site J), and 2) in the Clinton River at the M-59 bridge near the outflow point of the subwatershed (Site Q).

MDEQ Water Quality Data on the EPA STORET Database – The EPA STORET Database contains water quality data for ten (10) sites within the Upper Clinton subwatershed. The data collection time frames and parameters vary from site to site, but in total cover the years 1974 to 1996. The data provides an historic baseline for evaluating more current data on the subwatershed.

CRWC Stream Leaders Stream Monitoring Data/Reports – The Clinton River Watershed Council coordinates a school-based volunteer water quality monitoring program called Stream Leaders. The Stream Leaders program has three (3) sampling locations within the Upper Clinton subwatershed. Beginning in 1995 the Clarkston High School students have been performing chemical water quality monitoring and macroinvertebrate inventories at a site near the intersection of Sashabaw and Fowler Roads (Site V). In 2003 the Cedar Crest Academy began performing macroinvertebrate surveys at a site on the main branch of the Clinton River northwest of Deer Lake (Site W). Waterford Mott High School carried out water quality sampling in 1999 and 2000 on the Clinton River just east of Crescent Lake Road (Site X). The CRWC provides teachers with training in sampling protocols and analysis techniques to ensure the quality and consistency of the product.

MDNR Fisheries Data/Reports – A variety of Michigan Department of Natural Resources maps, reports, and databases were consulted in order to gain information on the status of the Upper Clinton subwatershed fisheries status. The consulted materials include the Trout Stream and Lake Map, Fish Atlas, and Fish Stocking Records.

Map 4
Water Sampling Stations

Oakland County Health Division Beach Closure Reports – The Oakland County Health Division beach closing information for 2001, 2002 and 2003 was consulted for additional information related to fecal coliform levels in the subwatershed.

Local Municipal Water Quality Studies – A number of local municipal documents and studies/reports were consulted with regard to water quality of specific water bodies within those jurisdictions. These documents were all prepared within the last three (3) years.

Other Sources – Additional miscellaneous sources were utilized that contained information relevant to water quality in the Upper Clinton subwatershed. These sources include a Nature Conservancy report on freshwater mussels in the Upper Clinton River, an EPA report titled "Clinton River Area of Concern," and an MNFI Site Ecological Summary for an area within the subwatershed.

3.3.1 Water Chemistry

The only recent water chemistry data identified for the Upper Clinton subwatershed was collected by the USGS and CRWC's Stream Leaders water quality monitoring programs. The sampling sites for these sources are identified as Sites J, Q, V, W and X on the Water Sampling Stations Map (see Map 4). Where available, the following parameters were examined: pH, dissolved oxygen (DO), nitrates (N), phosphorus (P), turbidity (water clarity), fecal coliform bacteria (FC) and temperature. The water quality data and results are summarized in Table 3.5 on the following page.

pH – The pH of water is a measure of the hydrogen ion (H+) concentration in water. pH affects a wide variety of chemical and biological processes in streams and lakes. pH is measured on a scale from 0 to 14, 0 being a very acidic condition and 14 being a very basic condition. A pH of 7 is considered "neutral" and is the pH of pure deionized water. Michigan Water Quality Standards establish a pH standard of 6.5 to 9.0 for all waters of the State. This pH range will sustain the reproduction, growth and health of most aquatic organisms.

The data indicates that the pH for all water quality sample sites within the subwatershed fall within the desired range set by the State. It does not appear that high or low pH levels are a substantial problem within the Upper Clinton subwatershed.

Dissolved Oxygen (DO) – Dissolved oxygen is the quantity of oxygen that is contained in a body of water. DO is measured in milligrams of dissolved oxygen per liter of water or parts per million (ppm). The respiration of plants and animals, photosynthesis, natural chemical processes, and decomposition of organic matter within a stream or lake are all influenced by the concentration of dissolved oxygen. Dissolved oxygen levels of 5 to 6 ppm or greater are required for the normal growth and activity of most aquatic organisms. Levels of dissolved oxygen below 2 ppm for one (1) to four (4) days will kill many of the same aquatic organisms.

The data indicates that the dissolved oxygen levels for nearly all water quality sample sites within the subwatershed are above the 5 ppm threshold. It does not appear that low DO levels are a substantial problem within the Upper Clinton subwatershed.

Table 3.5
Summary of Recent Water Quality Data

Year	Month	Location	Temp (C)	Turbidity	Dissolved Oxygen (ppm)	pH	Nitrate (ppm)	Phosphorus (ppb)	Fecal Coliform (colonies/100ml)	Parameters of Concern
1973	May	Site Q	14	25	8.4	7.8	0.28	100	940	High P, High FC
	Sept.	Site Q	15	30	7	7.9	0.36	100	300	High P, High FC
1978	May	Site Q	17	2.8	9.1	8.2	0.159	24	30	High P
	Sept.	Site Q	19	4.9	5	7.7	0.25	20	900	High FC
1983	May	Site Q	15	3.7	8.8	8.3	0.085	25	NA	High P
	Sept.	Site Q	17	2.2	8.3	8.3	0.076	11	NA	None
1988	May	Site Q	18.5	2.3	8.4	8.2	0.098	21	NA	High P
	Sept.	Site Q	16	3.3	4.1	7.8	0.121	33	NA	Somewhat High P, Low DO
1993	May	Site Q	15	2.8	8.4	8.17	0.135	30	NA	High P
	Sept.	Site Q	20	1.6	7	8.15	0.062	19	NA	None
2001	June	Cranberry Lake							452	High FC
	July	Crooked L.							537	High FC
		Deer L.							488	High FC
	Aug.	Crooked L.							349	High FC
	Sept.	Site Q	13.5	NA	5.5	7	0.13	19	NA	None
		Site J	12.8	NA	7.8	7.6	0.11	10	NA	None
	Nov.	Site Q	8.9	NA	10.5	7.7	0.06	4	NA	None
		Site J	8.2	NA	10	7.8	3.33	4	NA	None
2002	Jan.	Site Q	0.7	NA	12.2	7	0.14	3	NA	None
	.	Site J	0.5	NA	12.6	6.8	0.12	4	NA	None
	March	Site Q	1.8	NA	13	7.6	0.15	4	13	None
		Site J	2.2	NA	13.2	7.4	0.12	4	3	None
	April	Site Q	8.2	NA	10.9	7.5	0.14	50	120	High P
		Site J	NA	NA	NA	8.1	0.04	60	46	High P
	May	Lake Oakland	105	Low	11	8.7	NA	24	NA	High P
	June	Site Q	15.1	NA	6.7	7.7	0.23	4	9,700	Very High FC
		Site J	7.6	NA	13.5	7.6	0.17	3	9,500	Very High FC
	July	Site Q	NA	NA	NA	7.9	0.07	4	NA	None
		Site J	NA	NA	NA	8.2	0.23	30	NA	High P
		Greens L.							510	High FC
		Eagle L.							452	High FC
		Pleasant L.							320	High FC
		Lake Oakland	26.5	Low	7	8.8	NA	11	NA	None
	Aug.	Site Q	NA	NA	NA	NA	0.13	13	850	High FC
	.	Site J	NA	NA	NA	8.1	0.23	54	770	High P, High FC
	Sept	Lake Oakland							687	High FC at Sashabaw Creek
2003	June	Eagle L.							1,621	Very High FC
	July	Maceday L.							332	High FC

Nitrogen – All plants and animals require nitrogen in order to build proteins. In water, nitrogen is usually measured as milligrams per liter (ppm) of nitrate (a water soluble ionic form of nitrogen). Excess nitrogen can cause rapid algal and aquatic plant growth if it is the limiting nutrient in a water body. Unpolluted waters usually have less than four (4) ppm of nitrate, and ten (10) ppm of nitrate is considered unsafe as drinking water. Nitrate concentrations above 2.5 to 5 ppm can also accelerate plant and algae growth and promote eutrophication.

The data indicates that the nitrate concentrations for all water quality sample sites within the subwatershed fall below four (4) ppm, and nearly all are below one (1) ppm. In addition, phosphorus, not nitrogen, is usually the limiting nutrient in aquatic ecosystems in this part of Michigan. Therefore, it appears that nitrogen levels are not a substantial problem within the Upper Clinton subwatershed.

Phosphorus – Phosphorus is an essential nutrient for all plants and animals. Phosphorus occurs in streams and lakes in the form of phosphates (measured in micrograms per liter or parts per billion, ppb). Typically, phosphorus is in short supply in lakes and streams, and is thus the limiting nutrient controlling plant growth in these aquatic systems. Artificial increases in the phosphorus level of a water body can create excessive algae and plant growth, which can in turn deplete the dissolved oxygen and cause fish kills or other associated problems. The excessive algae and plant growth can also cause reduced water quality, unpleasant swimming conditions, bad odors, algal blooms, and interference for boating activities. Excess phosphorus in water bodies typically comes from point sources such as sewage treatment plants, septic systems and industry or nonpoint sources like stormwater runoff from agricultural and urban/residential areas. Phosphate concentrations greater than 20 ppb are indicative of a eutrophic condition in which excessive algae and plant growth is likely.

Water quality samples in the last few years from Sashabaw Creek (Site J), the main branch of the Upper Clinton (Site Q), Clarkston Mill Ponds and Lake Oakland, indicate phosphorus concentrations that occasionally rise to the eutrophic level during the growing season. Fourteen (14) lakes in the subwatershed are confirmed to have problems with excessive algae or plant growth:

- Dixie Lake – Springfield Township
- Softwater Lake – Springfield Township
- Susin Lake – Springfield Township
- Waumegah Lake – Springfield Township
- Square Lake – Orion Township
- Lake Oakland – Independence and Waterford Townships
- Williams Lake – Waterford Township
- Scott Lake – Waterford Township
- Huntoon Lake – Waterford Township
- Pleasant Lake – Waterford Township
- Maceday Lake – Waterford Township
- Lotus Lake – Waterford Township
- Watkins Lake – Waterford Township
- Upper Mill Pond – Clarkston

Special Assessment Districts for the management of nuisance algae or aquatic plants have been implemented or are under consideration for most of the lakes listed above. The areas around these lakes are mainly occupied by single-family residences. It is likely that stormwater runoff from the surrounding residential properties, containing fertilizers and waterfowl feces, is contributing to the algae and weed problems. Both fertilizers and waterfowl wastes are known contributors to phosphorus pollution in many of Michigan's lakes and streams. Poorly maintained or failing septic systems are another potential source of phosphorus contamination found commonly in southeast Michigan. However, there are no confirmed cases of septic systems contaminating surface waters in the Upper Clinton Subwatershed. The lack of any systematic monitoring of septic systems makes it difficult to assess this as a pollution source. As the areas adjacent to many of the lakes and streams in the subwatershed are serviced by sanitary sewers, and some are still showing elevated phosphorus levels, direct inputs from stormwater runoff appears the most likely source of the contamination.

Turbidity or Sedimentation – Turbidity is a measure of water clarity. A high turbidity indicates a lower level of water quality that results from the suspended solids, or sedimentation, that reduce the penetration of light into the water. These suspended solids enter the water as a result of soil erosion, urban runoff, algal blooms, disturbance of bottom sediments, industrial discharges, and sewage. Excessive suspended solids can have a variety of negative impacts on a stream or lake, including but not limited to the following:

- Clogging fish gills
- Reducing growth rates
- Reducing disease resistance
- Decreasing photosynthesis
- Reducing dissolved oxygen levels
- Prevention of egg and larval development
- Increased heat absorption for sunlight (increased temperature)
- Increased sedimentation on the stream bottom (smothering important egg laying and habitat areas for fish and aquatic insects).

A variety of turbidity measures have been used within the subwatershed; including Jackson Turbidity Units (JTU), Nephelometric Turbidity Units (NTU), Formazin Turbidity Units (FTU), and Secchi Disk measurements. The most recent stream measurements do not indicate any substantial turbidity problems in Lake Oakland, Sashabaw Creek (Site J) or the main branch of the Upper Clinton (Site Q). Deer Lake and the Mill Ponds in Clarkston have recently shown some potentially problematic turbidity levels (clarity measurements consistent with a eutrophic lake condition). Recent turbidity measurements for other lakes in the subwatershed are not available.

While concrete data regarding sedimentation is currently unavailable, local residents and community leaders perceive it as a problem. One main source could be the gravel roads within the subwatershed. Sediments enter the stream at bridge crossings as a result of poor construction and maintenance practices, and via road ditches which convey sediment from gravel roads into the streams. Sedimentation is also increasing as stormwater flows increase, scouring the banks

and depositing sediments downstream. Construction sites adjacent to streams could be another potential source of sediments due to improper erosion and sedimentation controls. In addition, pollutants such as phosphorus enter waterways on eroding soils.

Fecal Coliform Bacteria (FC) – Bacteria are microscopic, single-celled organisms and are the most common type of organism on the earth. Fecal coliforms are a type of bacteria found in the digestive tract of humans and other warm-blooded animals. These bacteria are usually harmless in and of themselves, but are considered an indicator of contamination by human or animal wastes. Human and animal wastes may contain a variety of harmful bacteria or parasites that may infect those who have contact with the contaminated material. The species *Escherichia coli* is used as the specific indicator of waste contamination. A water sample is cultured and the number of growing bacterial colonies is counted to determine the level of contamination. The standards below are used to judge the contamination level.

- 0 total coliforms/100 ml for drinking water
- 300 *E. coli*/100 ml at any time or 130 coliforms/100 ml as a 30 day average for full body contact
- 1000 *E. coli*/100 ml at any time for partial body contact
- 200 fecal coliforms/100 ml as a monthly average or 400 fecal coliforms/100 ml as a seven (7) day average for discharges containing treated or untreated sewage.

In the last three (3) years, Lake Oakland, Crooked, Deer, Cranberry, Maceday, Greens, Eagle, and Pleasant Lakes have had *E. coli* levels above the full or partial body contact standards. In addition, the main in-stream sampling sites for Sashabaw Creek (Site J) and main branch of the Upper Clinton (Site Q) have both had *E. coli* levels in excess of the full and partial body contact standards in June and August of 2002. This data seems to indicate a recent problem with human and/or animal waste contamination of some of the surface waters in the subwatershed. As there is little or no livestock-based agriculture in the subwatershed, the source of contamination must be waterfowl, pet or human waste. Point sources such as sanitary sewer overflows and combined sewer overflows could be contributing to the problem and should be investigated. Nonpoint sources such as runoff from adjacent properties containing waterfowl or pet wastes are also likely contributors to the problem. The clearing of waterfront property for lawn creates ideal habitat for waterfowl such as Canadian geese. These birds can become resident in large numbers and can create substantial impacts on the water quality in an area. Illicit connections and poorly maintained or failing septic systems are also possible contributors to the problem, but there are no confirmed cases of either.

Temperature – Water temperature affects many of the chemical and biological characteristics of a stream or lake. Temperature affects the amount of dissolved oxygen in water, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic waste, parasites, and diseases. Streams and lakes may be detrimentally impacted when their water temperature rises. Common sources of such warming include discharge of heated water by industrial operations, stormwater runoff from paved areas, heat absorption due to excessive suspended solids, and extra heating due to tree and vegetation removal. Generally, temperatures below 13 degrees centigrade during the warm season are required for a high quality cold water fishery and minimal plant life. Temperatures above 20 degrees centigrade lead to the development of a warm water

fishery and ample plant life. The streams in the Upper Clinton Subwatershed appear to fall in between these two (2) extremes, and should support some cold and warm water fish as well as some plant life. The available data on water temperatures beginning in the 1960's indicates that warm season surface water temperatures have tended to exceed 20 degrees centigrade.

3.3.2 Biological Community

An analysis of the macroinvertebrates, fish and mussels found in the streams and lakes of the Upper Clinton River can provide insight into the water quality of the subwatershed.

Macroinvertebrates – The *Stream Leaders* program run by the Clinton River Watershed Council includes three (3) sites within the Upper Clinton subwatershed. Two (2) of the sites are in the main branch of the Upper Clinton (Sites V and X) and the other is up stream of Deer Lake (Site W). In 2003, sites V and W were given a water quality index rating of good (3 on a 1-4 scale), based on the presence and abundance of pollution sensitive, and moderately pollution tolerant macroinvertebrates such as caddisflies, beetles and damselflies. Site V was given a water quality index rating of good in both 1999 and 2000. Since most macroinvertebrates do not move great distances, they cannot escape polluted environments. As a result, the presence of large quantities of certain pollution sensitive species indicates a relatively high-quality, unpolluted stream.

Fish – The Michigan Department of Natural Resources (MDNR) Trout Maps indicate that no trout streams are present within the Upper Clinton subwatershed. The lack of trout streams is consistent with the lack of coldwater streams noted in the water chemistry analysis. The temperature of a stream is primarily determined by its size, shading and water sources.

Only one (1) recent fish survey was found for the study area. This survey was done in Crooked Lake during 2002 (J. T. Francis, 2004, Crooked Lake, *Status of the Fishery Resource Report*, No. 2004-1, MDNR). The fish community consisted of bluegill, pumpkinseed, rock bass, green sunfish, and yellow perch, with largemouth bass, bullhead, and northern pike as the dominant predators. Least darter, blacknose shiner, grass pickerel, central minnow and brook silverside were also found in the lake. The fish community benefits from the lack of fish such as suckers and carp, which compete with game fish, and can have negative environmental impacts. The survey concluded that the lake "…supports a balanced fish community and provides a good fishery for panfish and largemouth bass."

The MDNR Fisheries Division has done substantial fish stocking in two (2) of the lakes through which the Upper Clinton River passes. Records of the fish stocking over the last ten (10) years are depicted in the table on the following page (see Table 3.6). Records of the MDNR actively stocking fish in these two (2) lakes extend back to 1981. The active level of fish stocking of these lakes raises the question of whether or not the existing fish communities in these lakes are self-sustaining. The need for stocking could be due to strong fishing pressure, environmental conditions that are impairing the native fish population, or a combination of these factors. The stocking records for Maceday Lake explain how it achieves its trout lake designation in an area otherwise devoid of trout lakes and streams, and an area that does not generally support a coldwater fishery.

The MDNR Fish Atlas catalogues the distribution of current and historic fish species in the State. According to the atlas, Maceday and Loon Lakes have supported a diverse fish community by supporting twenty-four (24) species of fish. These two (2) lakes, and the one (1) Clinton River site, all support some species of darters. Darters are a group of fish that are considered important indicators of biological integrity and water quality. Their presence indicates that both lakes and some portions of the river would have been considered good to excellent quality sites at the time the darters were sampled. In addition, the presence of various darter species was noted during a field survey performed for Waterford Township by Applied Science and Technology, Inc. in 2001.

Table 3.6
MDNR Fish Stocking History in the
Upper Clinton Subwatershed, 1994-2004

Site	Species	Date	Quantity
Loon Lake	Northern Pike	6/13/1995	2,000
Loon Lake	Northern Pike	5/25/1996	5,971
Loon Lake	Northern Pike	5/20/1997	2,483
Loon Lake	Northern Pike	5/21/1997	1,292
Loon Lake	Northern Pike	5/22/1997	150
Loon Lake	Northern Pike	5/29/1997	272
Loon Lake	Northern Pike	5/23/2001	510
Loon Lake	Northern Pike	5/14/2003	1,500
Loon Lake	Bluegill	5/23/2003	1,000
Loon Lake	Walleye	5/23/2003	1,000
Loon Lake	Yellow Perch	5/23/2003	1,500
Maceday Lake	Rainbow Trout	4/13/1994	20,000
Maceday Lake	Splake	4/26/1994	14,998
Maceday Lake	Lake Trout	11/1/1994	400
Maceday Lake	Splake	4/3/1995	11,500
Maceday Lake	Rainbow Trout	4/10/1995	18,000
Maceday Lake	Lake Trout	4/24/1995	1,400
Maceday Lake	Walleye	6/20/1995	23,372
Maceday Lake	Splake	4/11/1996	15,000
Maceday Lake	Rainbow Trout	4/18/1996	12,496
Maceday Lake	Lake Trout	5/17/1996	2,000
Maceday Lake	Rainbow Trout	4/8/1997	13,800
Maceday Lake	Splake	4/15/1997	10,320
Maceday Lake	Splake	4/6/1998	11,700
Maceday Lake	Rainbow Trout	5/7/1998	10,000
Maceday Lake	Splake	4/15/1999	15,000
Maceday Lake	Rainbow Trout	4/16/1999	11,600
Maceday Lake	Splake	3/27/2000	9,000
Maceday Lake	Rainbow Trout	4/13/2000	12,000
Maceday Lake	Rainbow Trout	4/2/2001	12,090
Maceday Lake	Splake	4/10/2001	10,550
Maceday Lake	Splake	4/2/2002	11,500

Maceday Lake	Rainbow Trout	4/3/2002	19,490
Maceday Lake	Splake	4/10/2003	11,000
Maceday Lake	Rainbow Trout	4/30/2003	7,200
Maceday Lake	Rainbow Trout	4/30/2003	12,000
Maceday Lake	Lake Trout	10/27/2003	250
Maceday Lake	Lake Whitefish	10/27/2003	50
Maceday Lake	Splake	3/31/2004	12,060

Although data on the fish community in the subwatershed is scattered and lacks depth, the available data implies a reasonably healthy and diverse community.

Freshwater Mussels – Freshwater mussels are considered a good indicator of water quality. The mussels filter water as they feed and are thus particularly sensitive to reductions in water quality. Three (3) surveys covering areas in the Clinton River near the outfall of the subwatershed indicate the presence of several mussel species, including two (2) State endangered, one (1) State threatened, and two (2) State special concern species. The surveys were performed by the Michigan Natural Features Inventory (1988), ASTI (2001) and the Nature Conservancy (2003). The identified species and their status are summarized in the following table:

Table 3.7
Freshwater Mussels in the Main Branch of the Upper Clinton

Scientific Name	Common Name	Status*
Villosa fabalis	Rayed bean mussel	E
Epioblasma triquetra	Snuffbox mussel	E
Lampsilis fasciola	Wavy-rayed lamp-mussel	T
Elliptio dilatata	Spike mussel	
Lampsilis siliquoidea	Fatmucket mussel	
Pleurobema sintoxia	Round pigtoe mussel	SC
Ptychobranchus fasciolaris	Kidneyshell mussel	
Strophitus undulates	Creeper mussel	
Villosa iris	Rainbow mussel	SC

*(E=State endangered, T=State threatened, SC=State special concern species)

The presence of these mussels near the outlet for the subwatershed indicates that water flowing out of the subwatershed must be of reasonably good quality.

3.3.3 Hydrology and Physical Conditions

Hydrology – Since 1960 the United States Geological Survey (USGS) has monitored stream flow at two (2) sites in the Upper Clinton subwatershed, one (1) near the outlet of Sashabaw Creek (Site J) and one (1) in the southern portion of the main branch of the Upper Clinton (Site Q). By looking at the monthly stream flows over the last four (4) decades it became evident that, on average, April was the highest stream flow month and August was the lowest stream flow month. The following figures (see Figures 3.2 and 3.3) show the April and August average daily stream flows since 1960.

Figure 3.2
Sashabaw Creek Site
Average Daily Stream Flow, 1960-2003

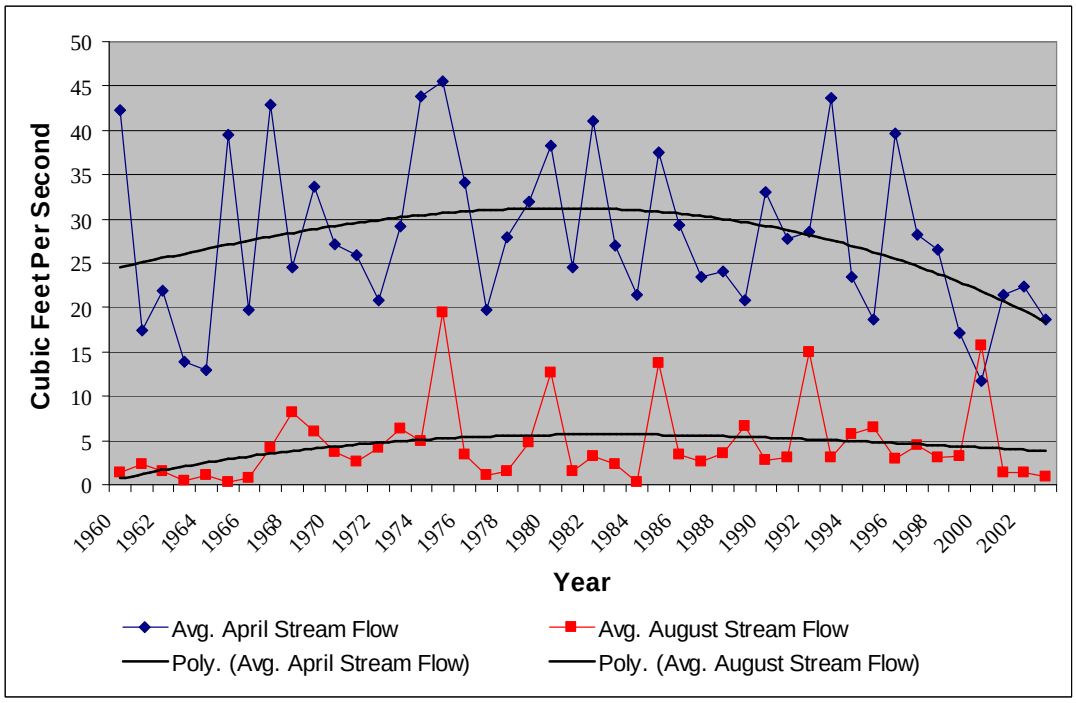
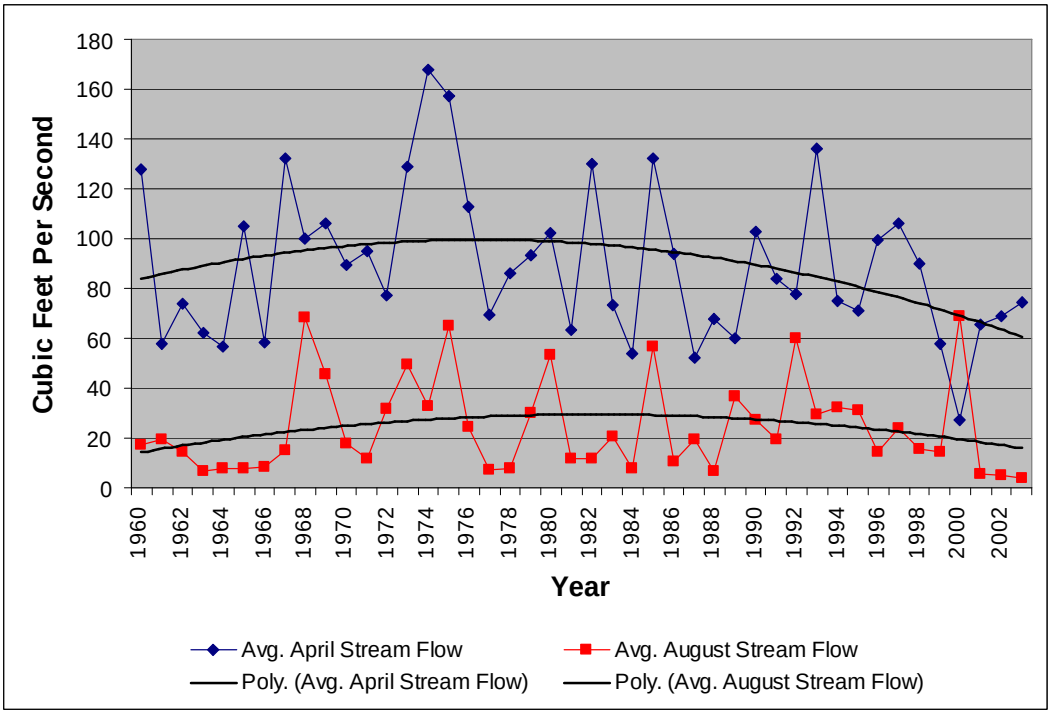


Figure 3.3
Main Branch Clinton River Site
Average Daily Stream Flow, 1960-2003



A second order polynomial regression was used to fit a line to the data in order to make the trends in the data more identifiable. It appears that stream flow increased after 1960, peaking in the late 1970's and early 1980's, and has declined in more recent years. A comparison of the stream flow data to precipitation was performed to determine if these trends were of any likely significance. The following figures (see Figures 3.4 and 3.5) depict the average daily precipitation for April and August over the same period from a weather station in Pontiac. It appears that the trends in average daily stream flow are generally tracking trends in average daily precipitation.

Figure 3.4
April Average Daily Precipitation, 1960-1998

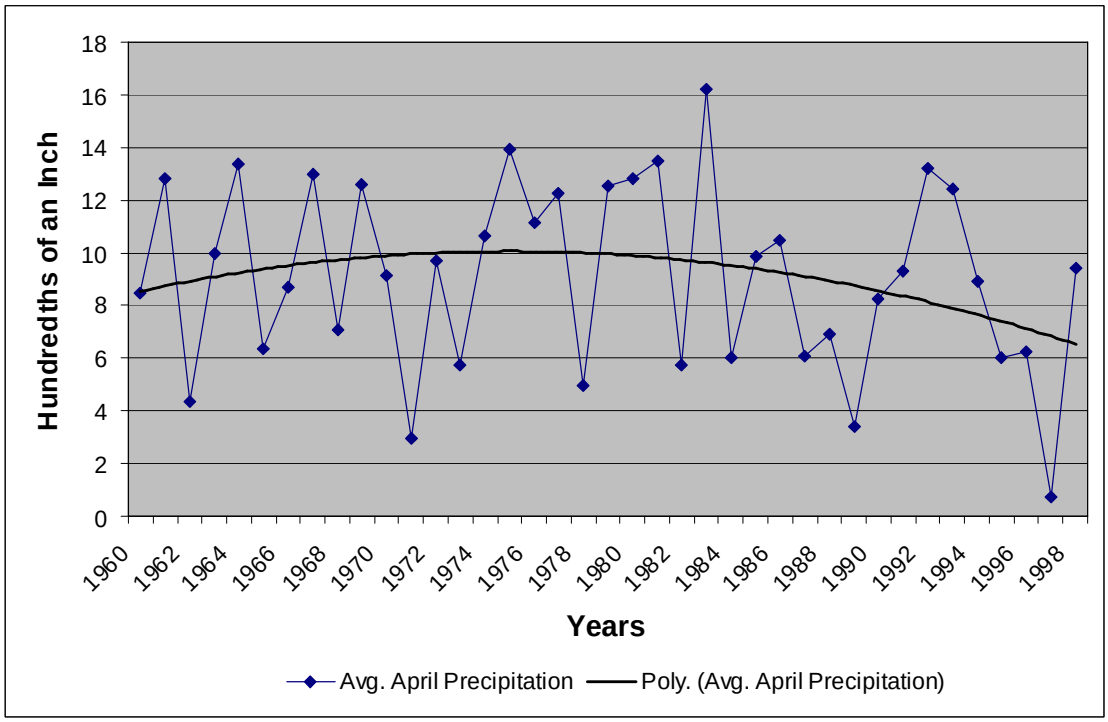
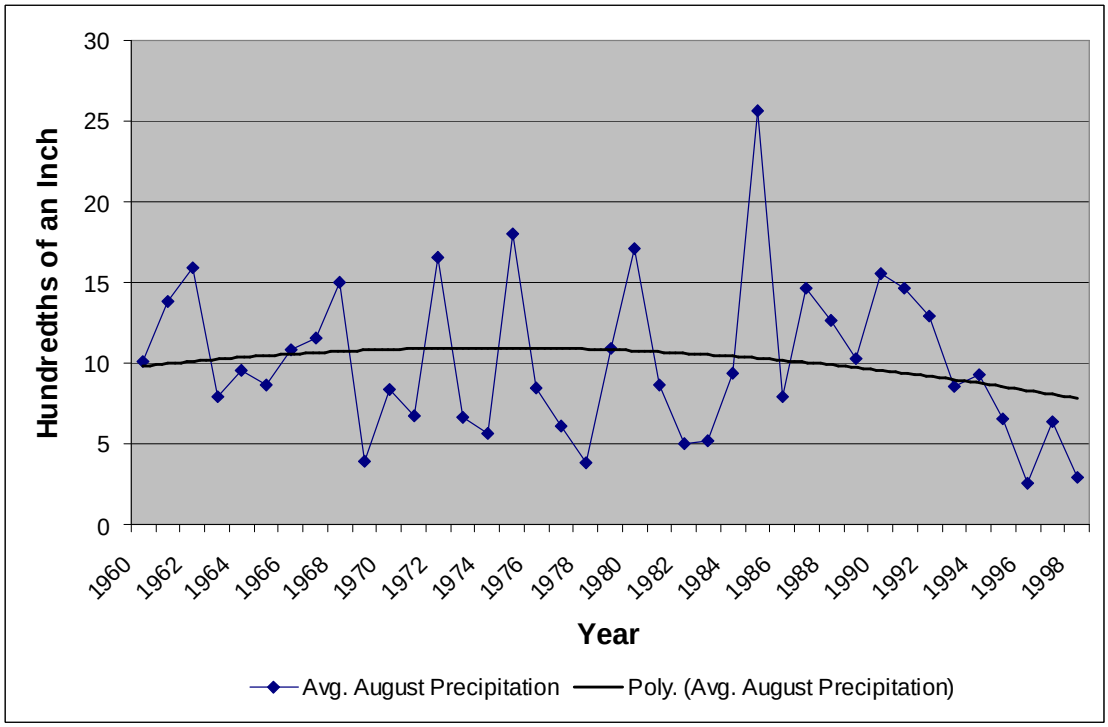


Figure 3.5
August Average Daily Precipitation, 1960-1998



An increase in stream flows following storms is a common problem in urbanizing areas, resulting from the increased quantity and speed of stormwater runoff reaching those streams. To examine the possibility that this might be an issue in the Upper Clinton subwatershed, peak stream flows were examined. Annual peak stream flows for the Sashabaw Creek and Main Branch sites are shown in the following figures (see Figures 3.6 and 3.7).

Figure 3.6
Sashabaw Creek Site
Annual Peak Stream Flow, 1960-2002

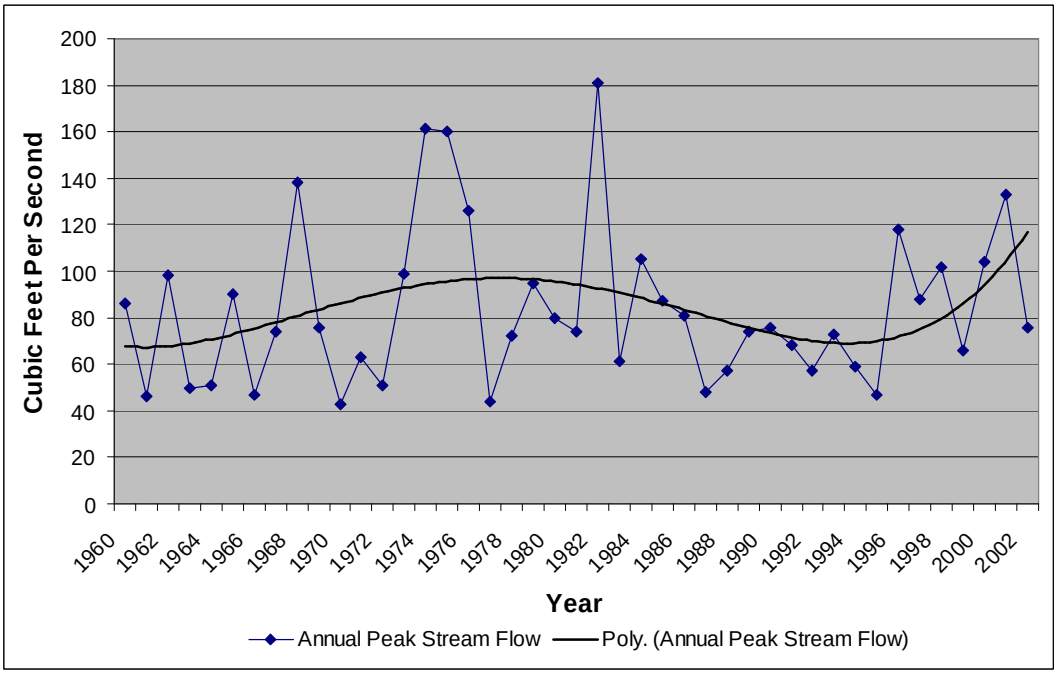
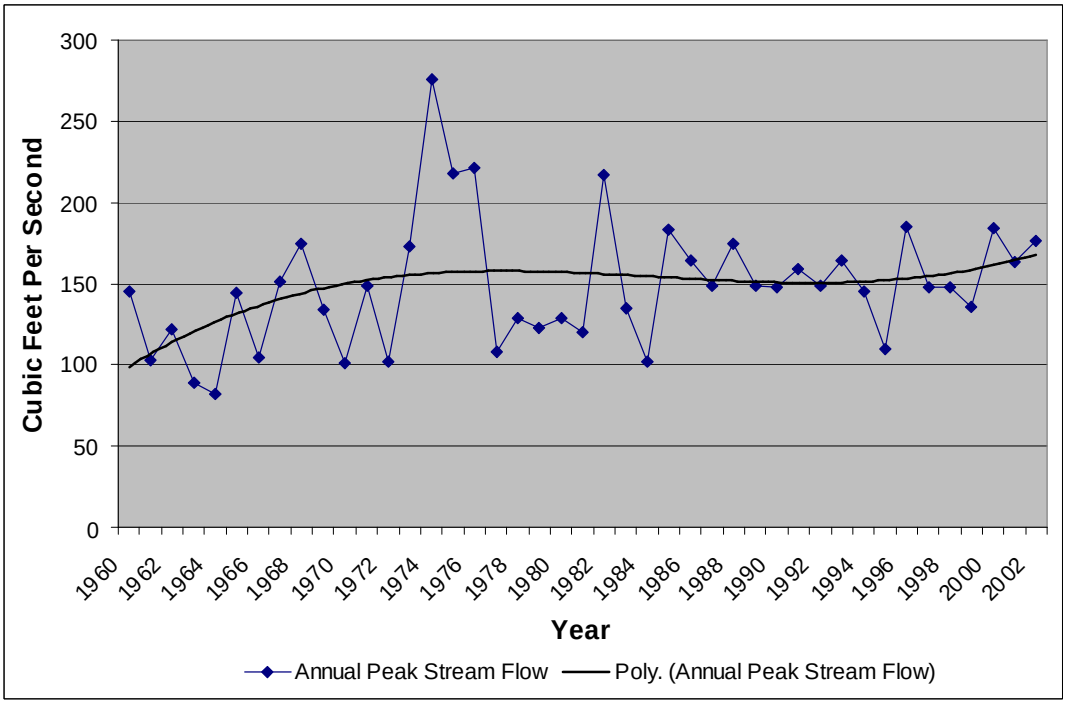


Figure 3.7
Main Branch Clinton River Site
Annual Peak Stream Flow, 1960-2002



When compared to average stream flow and precipitation, peak stream flow appears to show similar trends from 1960 until 1990. In the 1990's peak stream flow began an upward trend that is counter to the downward trends in average stream flow and precipitation. This indicates that the streams at these monitoring sites may be becoming more "flashy," i.e. experiencing increased stream flows following storms. This trend is consistent with the recent land use shift from a more agrarian to a more urban environment.

Physical Conditions – There are no recent surveys of the physical condition of the streams and lakes in the Upper Clinton. The generally high water quality noted in the water chemistry section, provide indirect evidence that stream bank erosion and undercutting are not substantial problems at present. On the other hand, the peak stream flow trends noted above indicate that the streams may be becoming more "flashy." This change would result in stream bank erosion, which undercuts banks and increases the frequency of flooding in these streams.

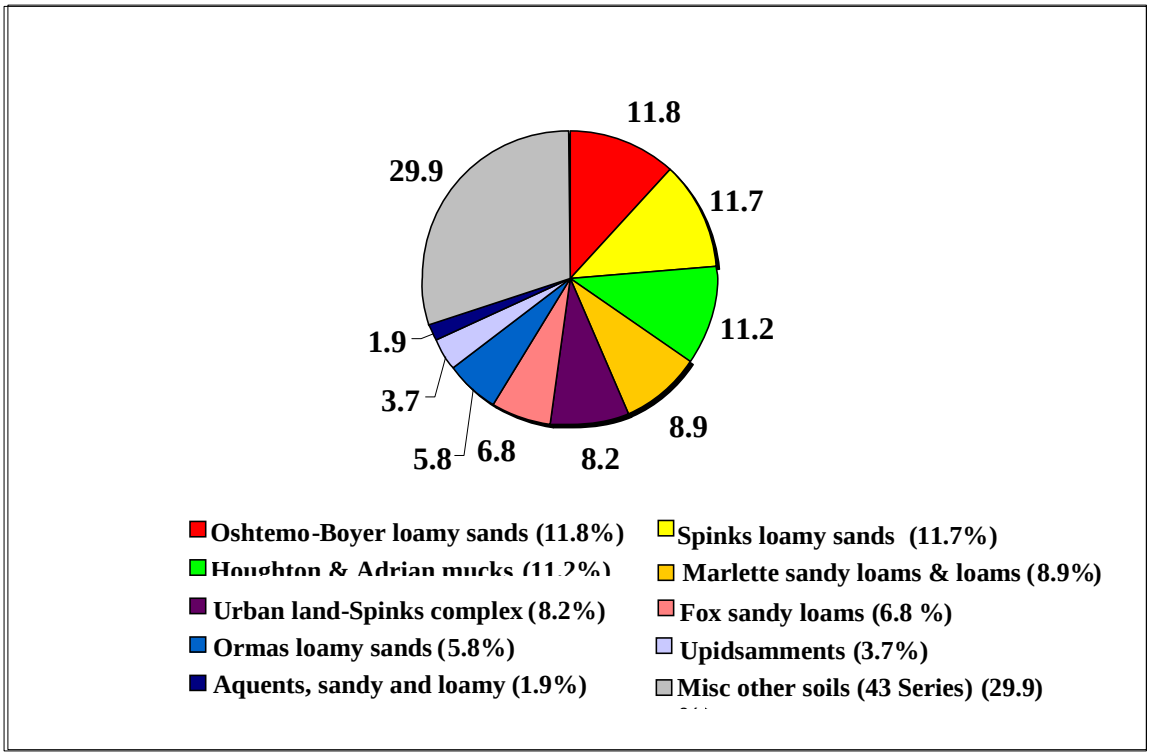
3.4 Environmental Context

3.4.1 Geology and Soils

The Upper Clinton subwatershed is located in an area of the State that was shaped by glaciers approximately 13,000 to 16,000 years ago. The subwatershed contains broad expanses of outwash sands that surround sandy and gravelly end and ground moraines. The moraines remain as coarse textured ridges and island-like hills surrounded by flat outwash. In addition, the area includes ice contact landforms such as kettle lakes, kames, eskers and segments of outwash channel. The soils of the moraines and upland ice contact areas tend to be well drained while kettles, outwash channels and some outwash areas tend to have less well drained to poorly drained soils due to the accumulation of fine textured till, lacustrine deposits or organic soils in low lying areas. This has been a key factor in the formation of the many lakes and wetlands that occur in the subwatershed.

Although forty-three (43) soil series are found within the Upper Clinton Subwatershed, only nine (9) are common. The figure on the next page (see Figure 3.8) summarizes the prevalence of the key soil types within the subwatershed.

Figure 3.8
Dominant Soils in the Upper Clinton Subwatershed (by Percentage)



Sands and loams are the most common soil textures, making up at least 47 % of all soils in the subwatershed. Their predominance explains the presence of soils with high to moderate infiltration rates as shown in the Hydrological Soil Groups map (see Map 5). The muck soils typically associated with wetlands are also relatively common (11.2 %), and help to explain the substantial quantity of wetlands found in the subwatershed.

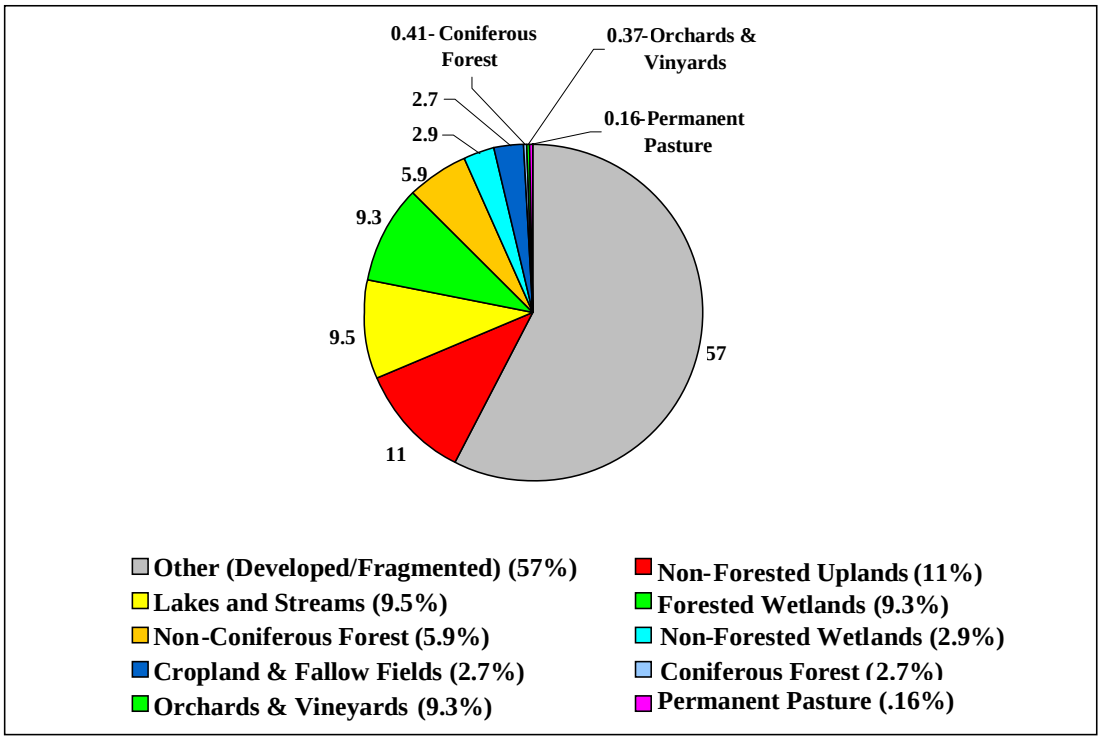
3.4.2 Vegetation

The current extent of vegetative cover in the Upper Clinton subwatershed is shown in the Vegetative Land Cover Map (see Map 6). The percent coverage by type of vegetation is also summarized on a subsequent page (see Figure 3.9).

Map 5
Hydrological Soil Groups

Map 6
Vegetative Land Cover

Figure 3.9
Percentage of Vegetative Land Cover in the Subwatershed



The above noted figure is based upon a very generalized analysis of the vegetative land cover. It focuses on large, contiguous areas of agricultural or natural vegetation. The existing woodlands make up approximately 6.3% of the land cover in the subwatershed and the existing wetlands make up approximately 12% of the land cover in the subwatershed. Much of the area falling in the "Other" category is clearly correlated with the developed areas of the subwatershed when compared to the Existing Land Use Map (see Map 2). Single family residential uses dominate in the areas classified as "Other" in the Vegetation Map (see Map 6), indicating that lawn and other manicured vegetation are common in these areas. An examination of the Existing Land Use Map (Map 2) indicates that a substantial portion of the large blocks of natural upland, forest, and wetland vegetation are associated with existing recreation and conservation areas within the subwatershed or are found along the Clinton River and its tributaries.

Historically, the presettlement vegetation of the subwatershed was closely tied to the glacially shaped landforms and soils. The sandy moraines of the subwatershed would have been dominated by black oak barrens and mixed oak savannas. The wetlands would have been, and for the most part still are, dominated by shrubs, mixed hardwoods, and/or mixed conifers.

3.4.3 High Quality Natural Communities and Unique Flora and Fauna

The Michigan Natural Features Inventory has completed an extensive analysis of Oakland County. The MNFI has identified potential conservation/natural areas and recording of the presence of endangered, threatened and special concern species. Natural areas within the county were ranked based on the following criteria:

- Size
- Core area
- Stream corridor
- Landscape connectivity
- Restorability
- Element occurrences (presence of quality communities and rare species)

Upon determining the prominence of these criteria within the County, the sites were assigned a priority for consideration for conservation measures. The MNFI Natural Areas Map (see Map 7) illustrates all the Priority One, Two and Three sites in the Upper Clinton subwatershed. A substantial portion of the Priority One areas appear to have already received some protection by inclusion within existing recreation and conservation areas, although a significant portion of Sashabaw Creek does not have such protection. In addition, many of the Priority Two and Three areas lie partially or wholly outside the established recreation and conservation areas in the subwatershed.

A variety of threatened, endangered, and special concern species, and high quality natural communities have been identified by the MNFI to be located within the Upper Clinton subwatershed. The following tables (see Tables 3.8, 3.9 and 3.10) summarize the high quality communities and rare species known to occur within the subwatershed.

Table 3.8
Threatened, Endangered and Special Concern Plants in the Subwatershed

Scientific Name	Common Name	State Status*
Carex richardsonii	Richardson's Sedge	SC
Cypripedium candidum	White Lady-slipper	T
Drosera anglica	English Sundew	SC
Linum virginianum	Virginia Flax	T
Platanthera ciliaris	Orange or Yellow Fringed Orchid	T
Trichostema dichotomum	Bastard Pennyroyal	T

* (E=Endangered, T=Threatened, SC=State Special Concern)

Map 7
MNFI Sites

Table 3.9
Threatened, Endangered and Special Concern Animals in the Subwatershed

Scientific Name	Common Name	Federal Status*	State Status*
Buteo lineatus	Red-shouldered Hawk		T
Erynnis baptisiae	Wild Indigo Duskywing		SC
Oecanthus laricis	Tamarack Tree Cricket		SC
Oecanthus pini	Pinetree Cricket		SC
Sistrurus catenatus catenatus	Eastern Massasauga	C	SC
Villosa fabalis	Rayed bean mussel		E
Epioblasma triquetra	Snuffbox mussel		E
Lampsilis fasciola	Wavy-rayed lamp-mussel		T
Pleurobema sintoxia	Round pigtoe mussel		SC
Villosa iris	Rainbow mussel		SC

* (FE=Federal endangered, C=Federal concern, E=State endangered, T=State threatened, SC=State special concern)

Table 3.10
High Quality Natural Communities and Unique Geographical Features in the Subwatershed

Name	Type/Description
Emergent Marsh	Community Type
Great Blue Heron Rookery	Habitat Type
Hardwood-conifer Swamp	Community Type
Mesic Southern Forest	Rich Forest, Central Midwest Type
Outwash	Geographical Feature
Prairie Fen	Alkaline Shrub/Herb Fen, Midwest Type
Relict Conifer Swamp	Forested Bog, Central Midwest Type
Southern Wet Meadow	Wet Meadow, Central Midwest Type
Submergent Marsh	Community Type

3.4.4 Wetlands, Woodlands and Riparian Corridors

The wetlands, woodlands and riparian corridors within the Upper Clinton subwatershed play a key role in determining the water quality in the Clinton River. This is particularly true in the Upper Clinton because it is one of the headwater areas of the Clinton River. The protection, enhancement, and restoration of these natural areas are central to any successful plan to improve or maintain the quality of the River and its tributaries.

Wetlands – Wetlands and water bodies cover approximately 21.5% of the Upper Clinton subwatershed. Wetlands serve a variety of recognized and valuable functions; the most important of these are listed below:

- Plant diversity and wildlife habitat
- Fishery, reptile, and amphibian habitat
- Flood and stormwater storage
- Runoff reduction

- Water quality protection
- Shoreline and stream bank protection
- Aesthetics and recreation

Given the prevalence of wetlands in the subwatershed, and the fact that the majority of them are associated with streams and lakes, it is likely that to some degree most of the wetlands serve all of the above noted functions. The majority of wetland areas within the subwatershed are forested and associated with streams, making them a significant component of the riparian corridor.

Woodlands and Riparian Corridor – Woodlands provide food, shelter and breeding grounds for a variety of wildlife, as well as providing important water quality benefits. Intact woodlands are extremely efficient at reducing stormwater runoff. The trees intercept rainwater as it falls and promote the infiltration of stormwater into the soil before it can reach nearby streams. Woodlands also provide aesthetic benefits and may be used for passive or active recreation. Woodlands and wooded wetlands along streams are commonly called riparian corridors. These corridors provide the previously noted benefits as well as maintaining a lower water temperature which is critical to fish survival.

3.5 Summary of Water Quality Impairments, Sources and Causes

The analysis of available water quality and environmental data for the Upper Clinton subwatershed indicates that the Upper Clinton River, its tributaries and associated lakes, make up a generally high quality waterway that has begun to show some signs of impairment. The noted impairments have been prioritized based on how widespread and consistent they have been, the degree of impact they are currently having or may have in the future, and how they interrelate. The sources and causes of the impairments were also prioritized based upon the level of certainty attached to each. The impairments are discussed below in order of priority and the impairments, and the sources and causes are summarized in a table at the end of this section (see Table 3.11).

3.5.1 Bacteria

Bacterial levels in the subwatershed have been high enough to limit full body contact in Sashabaw Creek (Site J), the main branch of the Upper Clinton (Site Q) and several other lakes (see Table 3.5). On at least one (1) occasion, the bacterial levels in the Sashabaw Creek (Site J), the main branch (Site Q) and one (1) of the lakes, were high enough to preclude safe partial body contact with the water. This has led to beach closures and has made other recreational uses of the streams and lakes more risky.

The prevalence of single family residential land uses in the subwatershed has led to substantial clearing of riparian vegetation along creeks, ponds and lakes. Open water bodies lacking natural perimeter vegetation can attract large numbers of Canadian geese. The overabundance of Canadian geese and their detrimental effect on water quality is well documented, and is considered a known source of bacterial contamination in the subwatershed. Similarly, though to a much lesser degree, pet wastes can also be a contributing factor to bacterial contamination of water bodies.

Poorly maintained or failing sanitary systems, either septic or sewer, can leak wastes into adjacent water bodies. There have been no confirmed cases of such systems contaminating adjacent water bodies in the Upper Clinton subwatershed; but given the very high levels of bacteria detected in a small number of locations, there may be some cases of leaking systems. Other possible sources of high levels of bacterial contamination include illicit connections, municipal sanitary sewer overflows, and combined sewer overflows. These are not known to exist within the subwatershed, but should be investigated further if localized areas of bacterial contamination are found.

3.5.2 Hydrology

The flow characteristics and quantity of water are critical determinants of the long-term health of rivers, streams and lakes. Changes in the flow and quantity of water can have substantial negative effects on water quality. In an undisturbed watershed, precipitation rarely enters waterways in large quantities as surface runoff. Precipitation would normally be intercepted by leaves, absorbed by roots, infiltrated into the ground, detained or retained in wetlands, and then be slowly released into the surface waters. As vegetation is cleared and replaced with buildings, pavement and lawns, much more of the precipitation is shunted directly to surface waters via surface runoff. This leads to large quantities of stormwater more rapidly reaching streams during storms, and causing the streams to flow faster and with greater depth than indicated by historic data. The existing form of the stream channels was created by the historic water flow levels and cannot accommodate the new faster and higher water flows. As a result, flooding, bank erosion and bank undercutting may occur as the extra water carves a new physical profile for the stream. Increased turbidity and sedimentation, along with a host of related secondary effects, may become substantial problems downstream of the impacted areas. Streams with this problem are typically described as having "flashy flow."

In the Upper Clinton subwatershed, stream flow data indicates that over the past two (2) decades the streams have started becoming "flashy." Examination of current and historic land use/land cover maps indicates that there has been an approximately one third (1/3) reduction in undeveloped open lands (from about 60% of the subwatershed to about 40%). Most of the lost undeveloped open lands have been converted to single-family residential uses. This has led to an increase in impervious surfaces in the Upper Clinton Subwatershed. Increases in impervious surface have been well documented as one of the most important causes of "flashy" stream flow. The removal of vegetation, particularly around streams and lakes, and poor stormwater management practices, typically accompany the type of development that has occurred in the subwatershed, are both known contributors to "flashy" stream flow.

3.5.3 Nutrients

Phosphorus is the primary nutrient of concern in the Upper Clinton subwatershed, and in southeast Michigan as a whole. It is the limiting nutrient controlling the growth of aquatic plants in most of the inland lakes and streams of southeast Michigan. Excess phosphorus can cause algal blooms and problematic growth in other aquatic plants.

At present Dixie Lake, Softwater Lake, Susin Lake, Waumegah Lake, Square Lake, Lake Oakland, Williams Lake, Scott Lake, Huntoon Lake, Pleasant Lake, Maceday Lake, Lotus Lake, Watkins Lake and the Mill Ponds in Clarkston are confirmed to have algal blooms and/or excessive aquatic plant growth. In addition, elevated levels of phosphate have been detected via recent water sampling in the Lake Oakland, Clarkston Mill Ponds, Sashabaw Creek (Site J) and main branch of the Upper Clinton (Site Q). The excessive weed growth and limited water sampling data indicate that phosphorus contamination may be a problem in several areas of the subwatershed. Common sources of phosphorus contamination include residential fertilizer use, stormwater runoff, and failing and/or poorly maintained septic systems. The elevated phosphorus levels indicate that some of these nutrient sources are present within the subwatershed, and may get worse as development continues. Illicit connections to streams or lakes are another possible source of nutrient contamination, but there are no confirmed reports of these in the subwatershed.

3.5.4 Sediments

While the existing data does not indicate that excess sedimentation is currently a serious problem within the subwatershed, residents and public officials have observed sedimentation problems in their own communities. Also, it is seen that this problem will only increase as development throughout the upper reaches of the subwatershed continue to increase. As a proactive measure, the subwatershed communities want to consider sedimentation in this watershed management plan so that the development that does occur is constructed in a way that mitigates the impacts of impervious surface, and focuses on effective soil erosion and sedimentation control measures.

Table 3.11
Upper Clinton Subwatershed
Pollutants, Sources and Causes

Pollutants	Sources*	Causes*
Bacteria	**Waterfowl (k)**	**Removal of vegetation (k)**
	Failing and/or poorly maintained septic systems (s)	**Improper construction/maintenance (k)**
	Illicit connections (s)	
	Combined sewer overflows (s)	**Combined stormwater and sanitary sewers (s)** **Inadequate capacity (s)**
	Sanitary sewer overflows (s)	**Inadequate capacity (s)**
Hydrology	**Stormwater runoff (k)**	**Increased impervious surface (k)** **Removal of vegetation (k)** **Poor stormwater management practices (k)**
Phosphorus	**Residential fertilizer use (k)**	**Improper or excessive application (k)**
	Stormwater runoff (k)	**Increased impervious surface (k)** **Removal of vegetation (k)** **Poor stormwater management practices (k)**
	Failing and/or poorly maintained septic systems (s)	**Improper construction/maintenance (k)**
	Illicit connections (s)	
Sediments	**Road-stream crossings (s)**	**Poor road/bridge maintenance (s)**
	Conveyance via road-side ditches	**Removal of vegetation (s)**
	Flashy flows and stream bank erosion (s)	**Increased storm water runoff (s)**
	Construction runoff (s)	**Improper erosion and sedimentation controls (s)**

* (k=known, s=suspected)

3.6 Identification of Critical Areas

In order to efficiently address the water quality issues identified in the watershed analysis, it is necessary to identify critical areas that will receive priority for the application of available resources. The areas of critical concern for the Upper Clinton subwatershed are classified as existing (those that address specific, known issues) and potential (those that address suspected, future or more general issues). The critical areas are shown on Map 8, and the factors used to identify them are summarized below.

Factors Defining the Existing and Potential Areas of Critical Concern:

- Existing Areas of Critical Concern.
  - Lakes with Known Impairments.
    - Lakes with beach closures due to high fecal coliform counts (bacteria).
    - Lakes with nuisance weed or algae growth (phosphorus).
  - Stream Sampling Sites.
    - Sites showing increasing peak flow (hydrology).

- Potential Areas of Critical Concern.
  - 250 Foot Areas Around All Lakes.
    - Contribution to known lake impairments (bacteria, phosphorus).
    - Possible contribution to other current or future lake impairments.
    - Contribution to increasing stream peak flow (hydrology).
  - 250 Foot Areas Around All Streams.
    - Contribution to increasing stream peak flow (hydrology).
    - Possible contribution to other current or future stream impairments.
    - Possible contribution to lake impairments (bacteria, phosphorus).
  - Priority One MNFI Areas.
    - Incorporate many headwater, woodland and wetland areas important to long term water quality.
  - Priority Two MNFI Areas.
    - Incorporate many headwater, woodland and wetland areas important to long term water quality.
  - Other Potential Areas of Hydrological Significance.
    - Includes wetlands not included in the MNFI Areas that appear to have some significance in the hydrological functioning of the subwatershed.

The inclusion of the potential areas of critical concern reflects an effort to address long term threats to the water quality of the Upper Clinton subwatershed while addressing the current issues. As a result, the inclusion of areas adjacent to streams and lakes and substantial natural resource complexes is considered important to the protection of the subwatershed's water resources.

Identifying the critical areas, and the character of these areas, points to tools and mechanisms that can be used to improve water quality and protect significant water resources. The table on the following page shows that the majority of critical areas are in the hands of private residential land owners. Knowing this indicates that subwatershed communities have an opportunity to impact water quality through resident education, volunteer participation in monitoring programs, and other mechanisms. Vacant lands also make up a significant portion of the critical areas. This shows how significant it will be for Communities to use their Zoning Ordinance and other development tools to protect these critical areas as the uplands are developed in the future.

Table 3.12
Upper Clinton Subwatershed
Land Uses in Critical Areas

Land Use Type	Acres	Percent of Critical Areas
Single-Family Residential	7,556	41%
Recreation/Conservation	5,600	30%
Vacant	3,440	18%
Water	516	3%
Public/Institutional	412	2%
Multi-Family Residential	347	2%
Transportation	281	2%
Commercial/Office	271	1%
Industrial	75	<1%
Agriculture	65	<1%
Extractive	20	<1%
Mobile Home Park	17	<1%

Data Source: Oakland County Planning & Economic Development.

Map 8
Areas of Critical Concern