Chapter 3
Existing Conditions and Characteristics

This chapter provides an overview of existing conditions of the subwatershed and will form the basis for goal setting and identification of structural and non-structural BMPs for implementation across the subwatershed. The information contained in this chapter was developed from a variety of sources including existing studies and field data collection efforts. Information compiled and utilized from existing studies and available information included community land use and planning information, landscape characteristics including wetlands, ecoregions and soil types, water quantity and water quality data as well as an understanding of the existing state of public opinion regarding watershed issues.

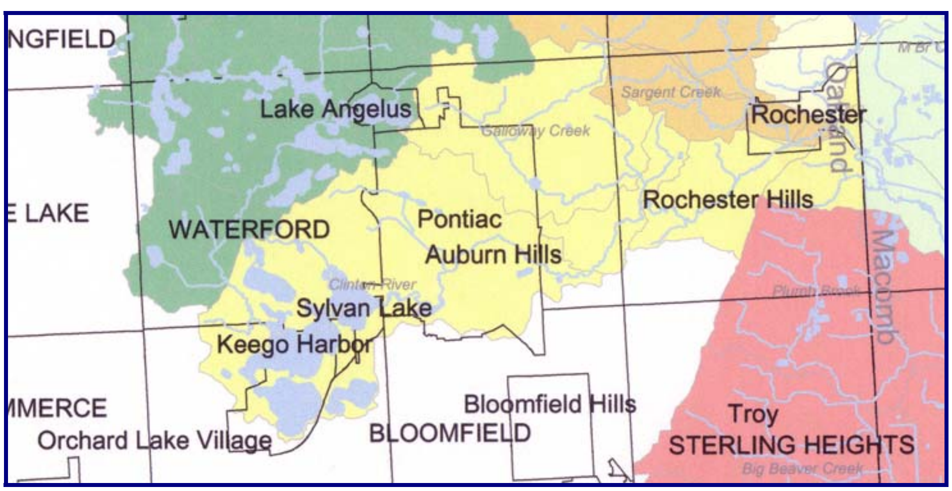
Field data collection efforts included conducting the MDEQ Road Stream Crossing Single Site Watershed Survey, the MDEQ Bank Erosion Hazard Index Survey and the MDEQ Instream Macroinvertebrate Survey at sixteen (16) road crossings throughout the subwatershed. In addition, a computer modeling program was employed to estimate pollutant loading for typical nonpoint source parameters across the subwatershed. This field and modeling data was subsequently compiled into a weighted scoring system to prioritize road crossing areas for further evaluation.

3.1 Land Use and Planning Analysis

This analysis looks at the current land use conditions and other community planning-related topics within the Clinton Main Subwatershed. It identifies trends and potential future water quality issues relative to land use. This section of the plan also evaluates each community's land use plans, programs and ordinances, and provides options to strengthen natural feature and water quality protection.

Growth Trends, Land Use Analysis and Community Profiles

The Clinton Main Subwatershed is over 70 square miles in area and is located within the central portion of Oakland County. A total of 13 communities are located within the subwatershed, of which six have chosen this subwatershed as their primary subwatershed for Phase II purposes. Oakland County and Oakland University are also participating in this subwatershed group as primary participants. Both Keego Harbor and Sylvan Lake are contained entirely within the Clinton Main Subwatershed.



A summary of each of the communities is provided in Table 3.1 on the following page as well as in the descriptions that follow. Note that the Oakland County campus is part of Waterford Township and the City of Pontiac, and that the Oakland University campus is located in Rochester Hills and Auburn Hills.

Table 3.1 Community Area in Subwatershed

Community	Acres in Subwatershed	Percent of Community in Subwatershed
City of Auburn Hills	9,433	20%
Bloomfield Township	366	<1%
City of Keego Harbor	360	<1%
Village of Lake Angelus	35	<1%
Oakland Township	.004	<1%
Orchard Lake Village	1,798	4%
Orion Township	546	1%
City of Pontiac	11,757	25%
City of Rochester	1,168	2%
City of Rochester Hills	9,600	20%
Sylvan Lake Village	516	1%
Waterford Township	8,348	18%
West Bloomfield Township	3,720	8%
Subwatershed Total	47,647	100%
Oakland County Campus	391	100%
Oakland University Campus	1,441	100%

While Oakland University and Oakland County are not technically communities, they both either own or have jurisdiction over considerable land area throughout the subwatershed. A state-supported institution of higher education, Oakland University covers 1,441 acres in the Cities of Rochester Hills and Auburn Hills. All of this acreage is within the Clinton Main watershed, and most is within the Galloway Creek subwatershed. The campus consists of 46 major buildings (3,000,000 total gross square feet), two golf courses, two biological preserves, the cultural/historical centers of Meadow Brook Hall, Meadow Brook Theatre, Meadow Brook Art Gallery, and Meadow Brook Music Festival, and 60 single-family residences.

Growing at 3% annually, the University serves nearly 17,000 students, 2,000 of whom reside on campus. A 2001 Master Plan forecasts "this growth to continue through 2020, focusing mostly on infill of the existing academic core."

Oakland County's campus spans the boundary between Waterford Township and the City of Pontiac and is approximately 391 acres in size. The Road Commission and Drain Commission have jurisdiction over 2,600 miles of County roads and more than 500 miles of County drains throughout the County. Oakland County Parks owns 145 acres of land within the subwatershed at Waterford Oaks County Park.

3.1.1 Growth Trends

To understand the land use changes within the Clinton Main Subwatershed, it is helpful to understand the growth trends observed within the southeast Michigan region. The Southeast Michigan Council of Governments (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 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. SEMCOG projects that similar trends will prevail over the next 30 years. Table 3.2 illustrates the population and housing profiles for each of the 13 communities. Note that this data is for the entire community, not just the area within the Clinton Main Subwatershed.

3.1.2 Subwatershed Community Trends

The growth trends in the Clinton Main Subwatershed are similar to trends in the region. Populations for all but five communities are increasing. Bloomfield Township, Keego Harbor, Lake Angelus, Orchard Lake Village, and Sylvan Lake's populations are stable or are predicted to decrease. One potential reason is because these communities are virtually built out, without significant land area left to develop. The number of people living in each housing unit is decreasing for almost all communities, between 3 – 23%. The City of Rochester is the only exception, where persons per housing unit is predicted to remain stable. In 2000, the average number of people living in each household within subwatershed communities is 2.53, and this number is predicted to fall by 9% to 2.29 by 2030 (SEMCOG 2030 Regional Development Forecast).

Table 3.2 Population and Housing Profiles

	Auburn Hills	Bloomfield Township	Keego Harbor	Lake Angelus	Oakland Township	Orchard Lake Village	Orion Township	Pontiac	Rochester	Rochester Hills	Sylvan Lake	Waterford Township	West Bloomfield Township
1990 Population	17,076	42,195	2,932	328	8,226	2,286	21,019	71,136	7,130	61,766	1,914	66,692	54,516
2000 Population	19,837	42,585	2,769	326	13,071	2,215	30,748	67,506	10,467	68,825	1,735	71,981	64,860
2030 Population	21,013	38,422	2,758	264	26,063	2,216	40,948	75,544	11,126	72,585	1,523	72,863	66,986
Households													
1990 Households	6,453	15,734	1,232	122	2,722	696	7,331	24,763	3,467	22,337	840	25,476	19,216
2000 Households	8,064	16,804	1,223	132	4,341	750	11,048	24,234	4,667	26,315	826	29,387	23,414
2030 Households	9,753	17,409	1,313	139	9,423	775	16,030	30,204	4,978	30,920	836	33,287	26,472
2000 Housing Units	8,822	17,455	1,317	146	4,529	805	11,517	26,336	5,056	27,263	855	30,404	24,410
2000 Household Size	2.25	2.53	2.26	2.47	3.01	2.95	2.77	2.68	2.22	2.59	2.09	2.42	2.74
2030 Household Size	1.97	2.21	2.14	1.90	2.77	2.85	2.54	2.44	2.22	2.31	1.82	2.12	2.47
2000 Median Household Income	$51,376	$103,897	$46,552	$144,524	$102,034	$121,126	$73,755	$31,207	$65,179	$74,912	$71,875	$55,008	$91,661
2000 Median Housing Value	$137,200	$356,800	$117,200	$814,800	$315,700	$571,700	$199,100	$74,300	$260,700	$226,200	$182,100	$144,400	$264,200
Educational Attainment													
No High School	1,521	1,197	294	0	411	98	1,492	12,207	133	1,033	63	6,414	2,982
High School	3,263	2,979	482	28	1,520	154	4,280	12,775	1,405	10,830	187	15,155	6,286
Some College	2,696	5,065	417	55	1,794	258	4,767	8,442	1,488	9,373	285	12,718	8,239
Associates	990	1,406	230	8	647	57	1,797	1,819	502	3,211	74	3,909	2,369
Bachelor's	2,856	10,277	313	100	2,387	467	4,941	2,842	2,354	13,148	418	8,684	12,819
Graduate/Professional	1,278	10,204	128	56	1,598	440	2,292	1,212	1,480	8,783	295	3,330	11,721
Housing Types													
One-Family Detached	3,447	13,711	856	146	4,160	805	9,047	16,237	2,592	18,052	795	22,469	18,396
One-Family Attached	544	1,573	45	2	8	0	530	1,361	458	2,508	5	1,206	2,916
Two-Family / Duplex	64	25	20	0	0	0	38	1,210	214	70	5	222	199
Multi-Unit Apartments	3,912	2,119	311	0	8	0	1,448	6,996	1,792	5,208	42	2,689	2,845
Mobile Homes	888	31	85	0	353	0	456	517	0	1,425	3	191	30
Other	0	0	0	0	0	0	0	15	0	9	0	6	0
Total	8,822	17,455	1,317	148	4,529	805	11,517	26,336	5,056	27,263	855	30,404	24,410
2003 Residential													
Single Family	64	46	13	1	260	6	164	272	58	227	2	132	188
Townhouse / Attached Condos	134	0	0	0	124	0	16	37	0	10	0	44	0
Two-Family / Duplex	0	0	0	0	44	0	4	0	0	16	0	0	0
Multi-Family	4	0	0	0	168	0	0	0	78	0	0	0	0
Total New Units	202	46	13	1	596	6	184	309	136	253	2	176	188

* Data from SEMCOG 2030 Regional Development Forecast, SEMCOG Community Profiles, and 2000 U.S. Census Bureau

3.1.3 Land Use Analysis

The Clinton Main Subwatershed contains a wide variety of existing land uses from single family to extractive. The 13 land use categories used by Oakland County can be summarized in the following table, and depicted on Map 4 located in Appendix A.

Table 3.3 2000 Existing Land Use Designations

Land Use Category	Total Acres	Percent Total
Single Family	12,915	27%
Road Right-of-Way	6,406	13%
Vacant	5,680	12%
Water	4,759	10%
Industrial	4,385	9%
Recreation / Conservation	3,719	8%
Public / Institutional	3,754	8%
Commercial / Office	2,850	6%
Multiple Family	1,800	4%
Transportation / Utility / Communication	605	1%
Mobile Home Park	501	1%
Railroad Right-of-Way	251	<1%
Extractive	22	<1%
Total	47,647	100%

The top land use in the Clinton Main Subwatershed is single family residential. This accounts for more than 27% of the subwatershed, and points to the importance of citizen action and education in the improvement of water quality. Road right-of-ways account for 13% of the land used within the subwatershed, showing the extent of intense development throughout the urban areas of the subwatershed. Another significant land use is vacant land, accounting for 12% of the subwatershed. This represents an important opportunity to apply contemporary solutions to storm water runoff through reduction, infiltration and filtration in development proposals.

A unique characteristic of this subwatershed is the amount of surface waters, or lakes. They account for 10% of the land area in the subwatershed. Many of the large lakes in the subwatershed were created by impounding streams in the western portion of the subwatershed. Historically, the shorelines of the lakes were developed as summertime retreats, with cottages and recreational amenities. Over time, communities were built up around the lakes, and the cottages were renovated into year-round homes. The impoundments present many challenges for water quality. These include runoff from lawns and roadways, lack of shoreline vegetation, water temperature, sediments built up behind dams, and dams acting as impediments to fish migration, among others.

Nine percent, or more than 4,000 acres of the subwatershed, is used for industrial businesses. The majority of industries fall within Auburn Hills, Pontiac, and Rochester Hills. It is most likely that many of these companies already have storm water permits for direct discharges. However, the large amounts of impervious surfaces associated with these businesses make significant contributions of nonpoint runoff into the Clinton River. Another important land use category includes over 3,700 acres in recreation/conservation. While it is possible that much of this land is used for active recreation (rather than left in a "natural" state), the infiltration ability of this land use would be greater than more developed land use categories.

3.1.4 Community Profiles

The following are brief profiles of each of the 12 Clinton Main Subwatershed communities, highlighting their existing land uses and growth trends. The communities are listed in alphabetical order.

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. Map 5 depicts Vegetative Land Cover and Map 6 shows the MNFI areas.

City of Auburn Hills – Eighty-eight percent of the City, or 9,433 acres, is contained within the Clinton Main Subwatershed. In addition, the City makes up 20% of the subwatershed's total land area. The predominant land use is industrial (1,857 acres), which is located throughout the community, but primarily along Lapeer Road and I-75. Auburn Hills has the most industrial development (as percent of the community land area) within the subwatershed. The second largest land use type is vacant (1,557 acres), giving the City an opportunity to use new methods of storm water reduction, infiltration, and filtration on new development sites. The rest of the City is occupied by a mix of residential, public, and commercial/office uses.

There are four large areas designated as recreational land as well as wetland ecosystems within Auburn Hills. The Michigan Natural Features Inventory (MNFI) shows seven areas identified as Priority Two preservation areas, and nine areas identified as Priority Three preservation areas throughout the City, many of which are along tributaries. Quite a few of the MNFI sites are located within already designated recreational lands.

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 almost all 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.

Bloomfield Township – Roughly half a square mile (366 acres) of Bloomfield Township lies within the Clinton Main Subwatershed. Although Bloomfield Township only makes up a small portion of the subwatershed, most of the land is designated as single-family residential and transportation/utility uses. There is also some commercial, public, and vacant township lands within the subwatershed. There are no MNFI sites identified in the subwatershed in this portion of the Township.

Over the past 10 years, the population has remained virtually constant, but is projected to decrease by almost 10% by 2030. The number of persons per household is suspected to decrease, similar to the rest of the subwatershed. For a community this size, the number of building permits in 2003 is relatively low, indicating a built-out character.

City of Keego Harbor – Keego Harbor is the fourth smallest community in population within the subwatershed, and the smallest in land area. One hundred percent of the City's land area is contained within the subwatershed. Single-family is the highest land use type within the community, followed by transportation/utility land uses, and then water. The remainder of the community is comprised of commercial, vacant, recreation/conservation, and multi-family uses. There are no MNFI sites identified in this community.

The population has decreased slightly since 1990, but is projected to stay the same for the next 30 years. However, the number of persons per household is projected to go down somewhat, but less than other communities. And as in other built-out communities, only a small number of building permits were issued in 2003.

<u>City of Lake Angelus</u> – Population wise, Lake Angelus is the smallest community within the subwatershed. In addition, only 9% (35 acres) of the City is contained within the subwatershed. The predominant land use within the subwatershed is recreation/conservation (12 acres), with eight acres vacant, and eight acres devoted to transportation/utility uses. The Michigan Natural Features Inventory designates one Priority Three preservation area at the eastern edge of the community.

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 30 years. The household size is projected to decrease significantly (23%) between 2000 and 2030 to one of the lowest rates within the subwatershed.

<u>Oakland University</u> – A state-supported institution of high education, Oakland University covers 1,441 acres in the Cities of Rochester Hills and Auburn Hills. All of this acreage is within the watershed, while most is within the Galloway Creek subwatershed. The campus consists of 46 major buildings (3 million total Gross Square Feet), two golf courses, two biological preserves, the cultural/historical centers of Meadow Brook Hall, Meadow Brook Theatre, Meadow Brook Art Gallery, and Meadow Brook Music Festival, and 60 single-family residences.

Growing at 3% annually, the University serves nearly 17,000 students, 2,000 of whom reside on campus. A 2001 master plan forecasts this growth to continue through 2020, focusing mostly on infill of the existing academic core.

<u>Orchard Lake Village</u> – The Village represents another relatively small community within the subwatershed. Sixty-nine percent of the village is contained within the subwatershed, which represents 4% of the subwatershed land total. The land uses within the subwatershed include water as the largest, and single-family residential being the next largest. The other main land uses are recreation/conservation and public land uses, which both cover similar amounts of land area. There are four Priority Three MNFI sites within the Village in the subwatershed boundaries. Three are located south and west of the lake, and one is located on Apple Island in the middle of Orchard Lake.

The population in the Village has not changed significantly since 1990, and is not projected to change in the near future. Similarly, the number of persons per household is also holding steady, only showing a very slight decrease.

<u>Orion Township</u> – Just under 3% (or 546 acres) of Orion Township is located within the subwatershed. These areas are located at the Brown Road and Joslyn Road intersection, and the Brown Road and Lapeer Road intersection. The largest land use is industrial, with almost half of the community's subwatershed area used for this purpose. The remaining land uses include single-family residential, vacant, mobile

home, and transportation/utility uses. There are two MNFI sites identified in this section of Orion Township. A Priority Two site on the east side of Joslyn Road, and a Priority Three site to the west of Joslyn Road.

The population within Orion Township is projected to increase dramatically over the next thirty years with a commensurate increase in the number of households. However, like many 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 higher growth rates for new residential construction. A total of 184 residential permits were issued that year.

City of Pontiac – The City has, by far, the largest quantity of land contained within the subwatershed. Almost all of the 12,900 acres of the City are located within the subwatershed, and are occupied by a wide variety of land uses. The most prevalent land use is single-family residential, with high-density residential (units less than 8,000 s.f.) being the most common type of residential development. The next largest is land used for transportation/utility/ communication uses, followed closely by vacant, industrial, and public land uses. All other land uses listed for the subwatershed are represented in the City by relatively smaller acreages (less than 1,000 acres). The City has one Priority Two MNFI site, which is located in the far northeast corner of the City. It also has seven Priority Three MNFI sites, scattered across the community.

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 years. Therefore, the household size is projected to decrease but at a slightly slower rate than that of most other communities within the subwatershed. In 2003 the City issued more residential building permits than almost all other communities within the subwatershed.

City of Rochester – Forty-eight percent of the community is contained within the Clinton Main Subwatershed. The largest land use is single-family residential, representing 33% of the subwatershed in this community. The next largest is vacant lands, followed by road right-of-ways. Other significant land uses within the subwatershed include industrial developments and recreation lands. A large Priority Two MNFI site is located along the Clinton River in the City.

Population in Rochester has grown steadily since 1990, representing a 47% increase over the past 10 years. This increase is predicted to continue, but at a slower rate. The number of people per housing unit is projected to stay the same over the next 30 years, the only community in the subwatershed where this is the case. Building activity in the City is healthy, with 238 building permits being issued in 2003, 45 permits for new construction.

City of Rochester Hills – Rochester Hills has a relatively large land area within the subwatershed, representing 20% of the entire subwatershed. (The subwatershed covers 46% of the community.) The primary land use is single-family residential, accounting for over 3,000 acres. The next largest land use is recreational land, much of which contains the main branch of the Clinton River or its tributaries. Road right-of-ways represent the third largest land use, followed by vacant and public lands. There are three large MNFI areas identified as Priority Two areas, two of which are located along the Clinton River main branch. Five Priority Three MNFI areas have also been identified throughout the community.

The population of the City has continued to rise over the past 10 years, increasing by 11%. SEMCOG predicts that the population will continue to increase over the next 30 years, and persons per household will decrease. The number of building permits for 2003 was in the top three communities throughout the subwatershed. All building permits were for residential dwellings.

City of Sylvan Lake – In land area, Sylvan Lake is the second smallest community in the subwatershed, and all of its land is located within the subwatershed. Water is the largest land use in Sylvan Lake, representing 38% of the community. Residential development is similar, in that it covers 33% of the community. The next largest land use is road right-of-ways. The remainder of the community is made up of commercial and office uses, public and vacant lands, recreation areas and a small area of industrial development. These land uses are concentrated along Orchard Lake Road, while the residential land uses are concentrated near the lake. There are no MNFI sites identified in the City.

Unlike most other communities, the population of Sylvan Lake Village has decreased over the past 10 years, and is predicted to continue to go down. Persons per household are also predicted to decrease by 13% from 2.09 persons per household to 1.82 persons per household. Two building permits were issued in 2003, which is indicative of a built-out community.

Waterford Township – Waterford Township has 37% of its land area within the subwatershed. The most significant land use is single family residential developments. Thirty-seven percent of the subwatershed is devoted to single-family dwellings. The next most prevalent land use is water, which is the center of many subdivisions. Road right-of-ways and vacant property are also significant land uses. Commercial, office and a small amount of industrial land uses are clustered along the major thoroughfares such as Highland Road and Elizabeth Lake Road. There is also a large amount of public and recreational lands within the subwatershed, including Waterford Oaks County Park along Scott Lake Road. The Michigan Natural Features Inventory has identified the only Priority One MNFI site in the subwatershed, which is located on the very western boundary in Waterford Township. A good deal of this MNFI site is already included in recreation lands. There are also four Priority Two MNFI sites in the Township, as well as six Priority Three sites.

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.

West Bloomfield Township – While only 18% of the Township is in this subwatershed, it potentially has a big impact on surface water quality since Cass Lake represents the largest land use (or 41%) of the community's land in the subwatershed. The next largest land use is single-family residential, followed by recreation lands and road right-of-ways. Within the subwatershed boundaries, the Township has very little commercial development, and no industrial development. There are two Priority Two MNFI sites, and four Priority Three sites in West Bloomfield. The Priority Two sites are contiguous with Waterford Township along a stream corridor.

The population in the Township has grown substantially since 1990, increasing by 19%. It is projected to continue growing to 2030, but at a much slower pace. Like other communities, the persons per household are going down, but at a slightly lower rate. Growth is still happening in the Township, which issued 188 building permits (all for single-family developments) in 2003. The number of building permits is similar to other townships within the subwatershed.

3.1.5 Planning Document Analysis

To help determine how well natural resources are currently being preserved and protected throughout the subwatershed, each of the six primary communities, and Oakland County and Oakland University evaluated their current planning documents, programs and practices using a checklist created by Oakland County Planning and Economic Development department, the Drain Commissioner's Office, and SEMCOG. (Note that checklists were not completed for Bloomfield Township, City of Lake Angelus, Orion Township, City of Rochester, Waterford Township or West Bloomfield Township. All of these communities are not "primary" participants in the Clinton Main Subwatershed). The checklist includes the following topics:

- Storm Water Management
- Impervious Surface Minimization
- Erosion and Sedimentation Control
- Wastewater Planning
- Open Space, Natural Areas, Native Vegetation and Community Greenways
- Wetlands and Woodlands Preservation
- Riparian Lands: Stream Corridors and Floodplains
- The Development Review Process
- Groundwater and Wellhead Protection
- Public Education

Because this is a checklist, the evaluation below cannot be a qualitative evaluation. A "Yes" to the same question across communities may not mean they have the same level of protection. For instance, asking whether or not "the community requires or encourages preservation of a natural drainage pattern to the greatest extent possible" could mean they have a simple statement in their site plan review criteria to this effect, or this statement could be backed up by a series of standards and guidelines for preserving natural drainage patterns. Therefore all "yes's" many not necessarily mean the same thing across communities.

One limitation of this questionnaire is that it is unclear (unless the community offers an explanation in the "Comments" column) whether protection mechanisms are "required" or "encouraged." While communities may be quite successful in convincing developers to create designs that meet the communities' desires for environmental protection, the developer is under no legal obligation to do so unless the idea or concept has been translated into a requirement under site plan review. Planned Unit Developments (PUDs), and other similar planning tools are the exception, as under this mechanism, the community has the discretion to ask for additional items that are not expressly required under the zoning ordinance.

The following summarizes the checklist evaluations, and provides comments on where each community may be able to strengthen their protection of environmental resources.

City of Auburn Hills – Responses to questions about the Master plan show that the City recognizes the importance of wetlands, woodlands, and riparian areas, giving them a policy basis upon which to build their zoning regulations about these topics. Issues where the City could add policy/goal statements include storm water quality and quantity, impervious surfaces, erosion control, and open space preservation. It is important to talk about these issues in the community's Master Plan to create a defendable position for development regulations.

One specific area that could benefit from additional discussion in the City's Master Plan is providing open space on private properties, and how these can be connected to publicly-owned open spaces. Inclusion of the MNFI data into this discussion will also support the City's open space vision. Another important topic for both the Master Plan and zoning ordinance is storm water management options for re-development proposals. The City is nearly built out, and it will most likely receive more re-development proposals in the future than proposals for development on previously undeveloped property. While the storm water quality and quantity standards may remain the same as for new development, solutions to reach these standards may be different for re-development. The City is planning to expand and update its current Master Plan within the next few years. This provides it with an opportunity to evaluate these topics and make decisions about the City's vision on these issues for the future.

Auburn Hills has many ordinances, standards and guidelines that protect natural features during development or re-development. Their planning documents discuss protection of wetlands, woodlands, and riparian buffers from development impacts. They also discuss waterway protection by prohibiting direct discharge, preserving natural drainageways, and providing specific design and performance standards for storm water. The City is almost completely sewered, and is on Detroit's water system, therefore minimizing the impacts of septic systems and reliance on drinking water wells. While drinking water is not an immediate issue, the City is also encouraging brownfield redevelopment, which ultimately protects groundwater from contamination. It has also been participating in the Rouge River Phase II efforts for the Main 1 and 2 subwatersheds, distributing educational materials to its residents.

One area where ordinances could be expanded consists of requiring BMPs that treat storm water through infiltration into the ground. Such facilities could include drainage swales, or infiltration areas (uplands) planted with deep-rooted plants. Another is requiring visually attractive storm water ponds that emulate natural ponds. Natural ponds with native vegetation improve water quality considerably through biological processes, unlike dry ponds planted in turf grass. Lastly, reducing impervious surfaces is key to helping control storm water quantity. The City currently requires that every development have at least 20% in green space. However, this standard alone could allow substantial imperviousness across the community. There are many new technologies available to create pervious surfaces in addition to green space, such as pervious pavements, bio-retention areas, and green roofs. An ordinance that outlines how reductions in imperviousness could be achieved should be considered.

City of Keego Harbor – While the Master Plan does not address most of the topics outlined in the checklist, many statements in the "comments" column indicate that the City would be willing to or is considering many of these topics for future discussion. The checklist topics may not be addressed because the community is almost completely built out, and does not have many of the natural resources listed in the checklist. The Recreation Master Plan does talk about the importance of open space in City parks, and has inventoried and mapped community greenways/open space, as well as discuss implementation for the greenway/open space plan.

In light of Phase II, it is recommended that the community consider adding background information, policies and goals to the City's Master Plan for the following topics: storm water management quality and quantity, impervious surface minimization for re-development projects, erosion and sedimentation control, riparian (stream and lake side) buffer restoration, and elimination of direct discharge of storm water into the lake.

The City's PUD ordinance addresses several topics in the checklist, including allowing open space/cluster design options and linking open space with adjacent open spaces. The City's site plan review process has also been successful in achieving the use of native vegetation, providing flexible parking designs, and replacing trees removed during construction. Ordinances, guidelines and standards could be added to include the following topics. Re-development projects should also be considered when looking at adding regulations to address the following concepts:

- ❖ Best Management Practices (BMPs) to improve infiltration of storm water
- ❖ Maintenance agreements for BMPs
- ❖ Design and performance standards for BMPs.
- ❖ Additional details for greenway/open space planning such as preservation priorities (private and public lands), timetable for implementation, long-term management, and relationship with a land conservancy.
- ❖ Natural feature protection (tree and wetland protection; riparian corridor and adjacent uplands), possibly through a natural feature overlay district.
- ❖ Add review criteria designed to protect natural features in the site plan approval process.

Oakland County – Oakland County is made up of several agencies including the Drain Commissioner, Road Commission, Health Department, Planning and Economic Development Department, and Oakland County Parks. Each agency has jurisdiction over different areas included in the checklist. For example, the Drain Commissioner has jurisdiction over storm water management if a community chooses to use the County's Drainage Design Standards, or if the storm water drains to a County drain. The Road Commission has jurisdiction over public roads, and the Health Department has jurisdiction over on-site sewerage disposal systems throughout the County. Oakland County Parks manages Waterford Oaks, the only County Park within the subwatershed. Any development at the County's campus or in the County Park is regulated by ordinances, guidelines and standards adopted by Waterford Township and the City of Pontiac.

Another group of Oakland County divisions also has input about storm water practices. In November, 2003, the Oakland County Stormwater Committee (OCSC) was formed under the direction of the Drain Commissioner's Environmental Unit staff to bring Oakland County into compliance with their Phase II permit. This group is made up of the departments listed above, plus the offices of the Oakland County Executive, Facilities Management, Waste Resource Management Division of the Community and Economic Development Department, Central Services, and the departments of Aviation and Transportation, and Information Technology. The group has been working to define the existing and needed programs that will meet the permit requirements and provides input on the materials submitted to MDEQ for Phase II compliance. It also promotes Best Management Practices (BMP's), open space, and natural area preservation on all County-owned lands.

The Drain Commissioner's Drainage Design Standards cover many of the checklist's points, including preservation of natural drainage patterns, requiring full design specifications in a site plan, using BMPs to improve infiltration of storm water, prohibiting direct discharge of storm water without pretreatment, and BMP maintenance agreements and performance standards. Areas that the Drainage Standards do not address include design standards for storm water BMPs relating to specific "c" factors, and guidelines to make storm water facilities visually attractive with improved functionality. These areas could be considered for addition to the Design Standards. Erosion control permits are also available through the Drain Commissioner, and the permit standards include all topics in the checklist for erosion and sedimentation control.

The Health Department's standards for installation of on-site sewerage disposal systems requires at least a 50' isolation distance between septic systems and water features. The checklist identifies a 100' isolation distance as being preferred. In addition, the Health Department inspects a new septic system when it is installed, or if they have received a complaint about a system. They do not require regular maintenance and inspections of septic systems otherwise.

The checklist items relating to open space and natural area preservation are generally covered by the Parks Department and relate to property already owned by Oakland County Parks. However, the Oakland County Stormwater Committee also promotes preservation of open space and natural features in the course of its work. Through the Parks Natural Areas Program, they have a park master plan that includes goals and policies for natural area preservation, and recognizes the importance of native vegetation. The plan also inventories and maps corridors for an interrelated network of open space, and prioritizes areas for preservation within the park. The Natural Areas Program also integrates MNFI information into its plan, provides for long-term management of the parks, and has a working relationship with local land conservancies. The Natural Areas Program could go further by including watershed information in their plan. Another important step would be to include information about adjacent community or regional greenways, and work with these communities to implement their greenways that connect to County parks.

Lastly, Oakland County Planning and Economic Development Services (OCPEDS) provides communities with information on planning topics and assists them in developing planning tools, including Geographic Information Systems (GIS) data and mapping services. The open space/natural area portion of the checklist indicates that OCPEDS encourages communities to link open spaces with adjacent open spaces when reviewing development plans, and also encourages protection of open spaces in developments through conservation easements or other mechanisms.

<u>Oakland University</u> – While Oakland University is not subject to local zoning regulations, they manage a considerable amount of property within the subwatershed and have developed a Physical Master Plan. The University's Master Plan outlines future projects that the University will undertake to support its academic mission, and provide for managed growth to the year 2020. And like a community master plan, this document includes Oakland University's approach to land development, as well as specific projects. The Plan provides goals and policies for the preservation of natural areas and open space, discusses the local watershed, and recognizes the importance of long-term stewardship of natural areas. They have also prioritized areas for preservation, inventoried these areas, and mapped them. The Plan includes an inventory of wetland and woodland functional values, and encourages woodland and tree protection, as well as provides for a natural feature setback.

One area that the Plan does not discuss is storm water quality and quantity that is generated by the University. A design for sediment forebays adjacent to the lake in the main area of the campus points in the direction the University is willing to go to protect water quality. However, there are many other areas on campus where direction for future improvements could be provided by the Plan. This discussion could also include goals and policies to restore steep banks and reduce erosion within drainageways. Another important topic is reduction of impervious surfaces throughout the campus. Being primarily a commuter school, there is a great deal of surface parking and parking structures. Goals and policies to reduce the impact of these surfaces, through new technology such as pervious pavements, bio-retention areas, or green roofs could be added to the Plan. Improvements in infiltration of storm water could also be considered as a solution to some of the issues mentioned above.

The University is completing a detailed study of storm water issues on its campus, identifying quantity and quality concerns. The report makes recommendations on:

- Correction of illicit discharges
- Correction of flooding, erosion and sedimentation
- Restoration of water features
- Creation of off-line detention
- Operation and maintenance practices
- Changes in development practices

Orchard Lake Village – The Village discusses many of the checklist topics in their Master Plan. Storm water management quality/quantity, the importance of open spaces and native vegetation, open space management, the watershed, wetlands, woodlands, and riparian area protection are all included in the Master Plan. It is important to talk about these issues in the community's Master Plan to create a defendable position for development regulations.
Topics that are not mentioned in the Master Plan include erosion and sedimentation control efforts, minimizing impervious surfaces, and groundwater protection. The community is almost completely built out, and is served by sewer and water systems. This eliminates some risks of groundwater contamination. It is recommended that the Village consider including some information about the importance of minimizing impervious surfaces and ways to minimize them in their Master Plan. Because of the Village's current development status, these regulations would be preparing the community for potential re-development proposals.

Similar to the Master Plan, the ordinance topics are also well covered by the Village. Additional storm water management concepts that could be considered include requiring full storm water design specifications in site plans, encouraging BMPs that improve a site's infiltration, and requiring maintenance agreements for BMPs. While some topics under the impervious surface category are covered in the Village's ordinances, allowing for facilities within parking lots to enhance infiltration, and making the parking requirements more flexible could reduce impervious surfaces within the community. The Village's open space planning includes most topics listed, except for a greenway plan. This may not be necessary, as the community already has a portion of a Regional Greenway within its boundaries. The other sections of the checklist show that the Village provides for the recommended items.

City of Pontiac – The City's Master Plan discusses several important topics on the checklist, including open space, wetland and woodland preservation. The document could be expanded to include the City's approach to storm water quality and quantity, although some storm water planning has been accomplished through Pontiac's involvement in the Rouge River watershed plan, and the Pontiac Creek Watershed Management Plan. The City is currently updating the Pontiac Creek plan, and has an Illicit Discharge Elimination Plan (IDEP) project for this watershed. Other goals that could be added to the Master Plan could include impervious surface minimization, erosion and sedimentation control, watersheds, the use of native vegetation, open space management, wetland and woodland inventories and assessments, riparian (stream and lake side) preservation, and groundwater protection. This last topic may not seem as relevant for the City, as it is served by the Detroit water system. However, groundwater protection is critical to the health of all natural surface water systems within the City, as rivers and lakes can be fed by groundwater. Pontiac currently does not have a greenway plan per se, but it does have a Rail-to-Trail pathway connecting the City to Kensington Metro Park.

Storm water management is covered by the City's ordinances by calling for preservation of natural drainage patterns, discouraging direct discharge to surface waters, and including design standards for specific "c" factors for storm water. These regulations could be strengthened by requiring full details of storm water facilities during site plan review, the use of BMPs that increase infiltration of storm water, maintenance agreements for BMP facilities, storm water performance standards, and design guidelines for making storm water facilities more aesthetically attractive while increasing their functionality. Pontiac is probably the most densely developed community within the subwatershed. For this reason, it is also most likely to be the community with the most impervious surface. A few mechanisms that could be used to reduce imperviousness is the use of infiltration BMPs in parking lots, or allowing setbacks and lot frontages to be reduced to minimize the amount of pavement necessary in new developments. The City should also look at ways that storm water infiltration could be retrofit into urban areas, or included in re-development projects.

Another closely related subject is reducing the amount of storm water. Many communities have had success in disconnecting downspouts to storm water facilities, drastically reducing the amount of runoff that enters the system. Another consideration is that the City currently does not have a wetlands ordinance, nor does it have tools to protect riparian zones (except floodplains). Protection of these two features could be combined to improve the quality of water coming off of properties adjacent to streams and lakes. Concepts such as variable building setbacks or naturally vegetated buffers could be used among other protections. The City could also work with riparian land owners to educate them about water quality, and ways in which they can manage their property to help protect this natural asset.

City of Rochester Hills – The City's Master Plan includes many of the topics in the checklist. The document has goals relating to storm water quality and quantity, erosion and sedimentation control, importance of natural areas and open space preservation, and wetlands and woodlands preservation. They are working to add goals for riparian area protection, and are considering adding a discussion on groundwater protection. Areas that could be considered in the future include minimizing impervious surfaces, and wastewater planning.

Like the Master Plan, the City's ordinances also cover a large number of topics included on the checklist. Recommended additions to the storm water regulations include preservation of natural drainage pathways and existing vegetation on development proposals, and guidelines to create visually attractive and more effective storm water facilities. Another area where improvement could be made includes regulations about minimizing impervious surfaces. Since the City is close to build-out, these regulations would be preparing the City for re-development proposals and potential urbanization along major thoroughfares. Wastewater planning and groundwater protection are other topics that the City may want to consider in their regulations. Currently, the City only has 5% of its properties being serviced by septic systems, and 20% by drinking water wells. However, if the septic systems are old, or are not maintained properly, they could be a significant source of ground and/or surface water contamination. Regular maintenance and inspection of septic systems are very important to their proper functioning, and is an important reason to consider some kind of septic maintenance program.

City of Sylvan Lake– Sylvan Lake addresses a number of checklist items in their Master Plan, including storm water quality and quantity, the importance of natural areas and open space, woodlands, and groundwater. It does not address wetlands, as the City has no wetlands. In addition, wastewater planning is covered in other policies. The City is currently 100% sewered, and has no septic systems. Topics that could be considered for the Master Plan include minimizing impervious surfaces, erosion and sedimentation control, and protection and/or restoration of riparian (stream and lake side) areas. This last topic is of particular importance, since the lake and the quality of its water, is paramount to the community. However, it will require a creative approach to implement this concept.

The City is currently working on a relatively new approach to storm water quality. It is drafting a fertilizer ordinance which will regulate the kinds and amounts of fertilizers to be used on lawns. Rather than try and filter the excess nutrients out of storm water before it reaches the lake, the City is working to reduce the amount of fertilizers placed on lawns in the first place. Other ordinances cover storm water management and minimizing impervious surfaces. However, the City could strengthen these rules by adding guidelines, or even public education materials, on how storm water can be directed to infiltration areas, such as rain gardens. The City is built-out, so approaches to storm water need to retrofit into the existing environment, or work in re-development proposals. Another effort underway by the City is identifying, mapping and planning for a network of open spaces within the City. An important idea to consider in this effort is how these open spaces will connect with adjacent open spaces in neighboring communities. Lastly, the City should consider some protection mechanism for woodlands and/or trees within its boundaries.

3.1.6 Planning Summary of the Subwatershed

Overall Results

Based on the community profiles, land use trends, and level of current development, several checklist items came forward as the most important challenges for this subwatershed. Beginning with the planning documents, all subwatershed communities were lacking Watershed Management Plans. Fortunately, the communities represented by this plan (primary and secondary) are all currently involved in one or more watershed planning efforts.

Another main topic that should be considered is impervious surface mitigation and infiltration enhancement. None of the subwatershed communities mention the impact that impervious surfaces have on water quality in their Master Plans, nor have ordinances to control or reduce the amount of impervious surfaces. New goals and policies should be added to Master Plans to address these concerns through site specific techniques such as French drains, disconnecting downspouts, rain gardens and barrels, among others. An impervious surface ordinance should also be added to regulate new development, but more importantly, address redevelopment proposals.

Because this subwatershed has a considerable amount of river/stream front and lakefront property, community efforts should be directed at creating riparian buffers of native vegetation along these shorelines. Goals and policies should be adopted to ensure that public riparian property is protected and, if necessary, revegetated as much as possible to demonstrate the positive benefits of riparian vegetation on water quality. As importantly, Master Plan goals and zoning regulations (through Natural Features Setbacks for example) should be used to protect existing riparian vegetation within each community.

A relatively easy, but important, addition to local plans and codes is encouraging the use of native plants in landscaping. This one element is an important feature of reducing the amount of storm water (through improved infiltration), and providing vegetative buffers to lakes and streams. While communities cannot require the use of native vegetation, they can demonstrate the aesthetic qualities of these plants on municipal properties, and educate property owners about the benefits native plants provide.

Checklist Summary

Checklist responses from the eight communities, the County and University were compiled, and "Yes" and "No" responses tallied. The compiled results are shown in Appendix E Clinton Main Subwatershed Planning Evaluation. Responses such as "Yes/No," and "Not Yet" were tallied in the "No" column, and responses such as "In Process" or "Soon" were tallied in the "Yes" column. The "Other" column received any additional responses, including "N/A." Questions that received a count of five or more "Yes" responses were considered areas where the subwatershed had strong planning tools for protecting water quality. Questions that received a count of four or less "Yeses" were considered areas that needed attention. (Note that while the subwatershed may be strong in a particular area, this shouldn't preclude an individual community from adopting Master Plan or ordinance language in this area to further strengthen their own community's planning documents.) Also note that not all questions apply to all communities/organizations, which is taken into consideration in the following discussion.

1) Community Snapshot.

Strengths: The majority of communities have plans for the following topics:

- Natural Areas/Open Space/Greenways
- Recreation
- Storm Water Management
- Wastewater
- Public Education

The following ordinances, guidelines and standards were also well represented throughout the subwatershed:

- Storm Water Management
- Cluster Developments
- Wetland and Woodland Protection
- Flexible Parking Requirement Standards
- Structural Best Management Practice (BMPs) Standards
- Criteria for Site Plan Review.

Challenges: In general, watershed management plans are not yet part of most community's planning documents. The other plans shown below may or may not apply to all communities throughout the subwatershed, and may be the reason why few of the subwatershed communities have these types of plans:

- Watershed Management
- Wellhead Protection (This is understandable, since almost all communities are on the Detroit Water system through the Detroit Water and Sewerage Department (DWSD))
- Illicit Discharge Elimination (Also understandable, since most of the communities are starting the Phase II process with this watershed planning effort)

The following ordinances/guidelines/standards are not used a great deal throughout the subwatershed:

- Impervious Surface/Infiltration
- Natural Features Setback
- Resource Protection Overlay District
- Native Vegetation
- Flexible Private Road Standards
- Native Vegetation Practice Standards

2) Storm Water Management.

Strengths: Most communities report that they have done some kind of storm water management planning, although not necessarily as part of their Master Plans. Oakland University has recently adopted a storm water management plan. The policies of most communities call for preservation of existing drainage pathways, require full design details of storm water facilities for site plans, discourage or prohibit direct discharge of storm water to surface water without pretreatment, and have BMP design standards.

Challenges: Some communities do not discuss the community's goals/policies regarding storm water in their Master Plans. In ordinances, most communities do not call for improvements to a sites infiltration potential, nor require maintenance agreements for storm water BMPs. In addition, engineering standards do not include performance standards, nor require that storm water ponds be constructed to increase treatment of pollutants through contouring and use of native plants.

3) Impervious Surface Minimization.

Strengths: This topic is a relatively new concept in planning, and is not typically used in most communities yet. However, it may become more important, and typical, as communities move to higher water quality standards. As of now, most subwatershed communities do have several mechanisms that tend to reduce pervious surfaces. Most communities have minimum required pavement widths to support travel lanes and other roadway uses. The same number provide flexibility in their parking requirements to avoid excessive pavement.

Challenges: Because this is such a new topic, it has not been included in the planning documents of the subwatershed communities. However, it is an approach that could greatly influence the quality of surface waters in the future. First, communities should consider including goals and policies about impervious surfaces in the community's Master Plan. As mentioned above, this will provide the basis for new zoning regulations. One possible technique for communities with most redevelopment proposals is to require some portion of parking facilities be dedicated to increasing infiltration of storm water. For communities that still have undisturbed areas that will be developed, they should incorporate ways to relax side yard setbacks and allow narrower frontages to minimize the amount of roadway necessary to serve a development, among other infiltration techniques.

4) Erosion and Sedimentation Control.

Strengths: All checklist participants have strong soil erosion regulations. This may be the case because they use the County Drain Commissioner's standards. In any event, they all require soil erosion control measures to be in place before construction begins, as well as require maintenance and monitoring of these systems.

Challenges: Few communities include soil erosion and sedimentation control as a topic in their Master Plans. Goals and policies about soil erosion should be included to further minimize the problem of sedimentation in water bodies.

5) Wastewater Planning.

Strengths: Wastewater planning was not well represented in most communities' Master Plans.

Challenges: Most communities within the subwatershed are almost completely sewered and served by the regional waste water treatment authority. The questions asked in the checklist discuss sewered and unsewered areas, and soils capable of handling septic systems. It is somewhat understandable that most answered "no" or "N/A" to these questions. However, discussing the condition, maintenance, and replacement of current sewer facilities should be included in a community's Master Plan.

6) Natural Areas/Open Space/Native Vegetation and Community Greenways.
Strengths: Most Master and/or Park Plans recognize the importance of natural areas and open space preservation. Many have or are working on inventorying and mapping potential corridors to create an interrelated network of mixed public access and natural area habitats. The plans also recognize that long-term stewardship and management of these areas is important. Development and redevelopment regulations require linking adjacent open spaces together, using conservation easements or other mechanisms to protect privately-held open spaces, and allow open space or cluster design options.

Challenges: Current watershed and native vegetation information and policies need to be added to most Master Plans, particularly in light of Phase II and the background information that should be in place to support storm water regulations. Greenway or open space plans as a way to identify and prioritize protection of natural areas, both private and public, are not being used to a great extent. The MNFI information is also not used in planning documents to identify important natural areas.

7) Wetlands and Woodlands Protection.
Strengths: Most communities call for protection of wetlands and woodlands in their Master Plan documents. In addition, most communities have a woodland/tree ordinance, require replacement of trees that are removed during construction, and have site plan criteria relative to wetlands, woodlands, and landmark trees.

Challenges: While most communities want wetlands and woodlands to be protected, the importance of these natural features within an ecosystem context is not included in most Master Plans. The features themselves are important, but how they interact with the surrounding ecosystems to continue functioning is generally not discussed. Also, most communities do not have a wetland or woodland inventory of their community, nor have they identified the functional values that these natural systems provide. Another area for growth is protection of wetlands below the state's protection criteria (five acres).

8) Riparian Lands: Stream Corridors and Floodplains.
Strengths: The strengths under this category include participation in water quality monitoring activities, restrictions on clearing within floodplains, and requiring a minimum setback from water features. Most communities include these activities in their planning documents.

Challenges: There is room to further advance the basic riparian protections mentioned above. Most community Master Plans could talk about riparian vegetation protection (including protection of lakeshore vegetation). They could also provide development regulations that protect adjacent steep slopes, or uplands next to streams or lakes, and the existing native vegetation within the riparian buffer. Riparian areas could also be better protected by allowing a flexible setback based on the sensitivity of the natural feature, or implementing an overlay district to protect stream corridors and lakeshore areas.

9) Development Review Process.
Strengths: The subwatershed is strong in requiring preapplication meetings before the site plan review process begins. Most communities within the subwatershed also require that all natural features be shown on the site plan. Another positive trend is that most communities require sufficient detail of storm water BMPs to allow a proper review for effectiveness.

Challenges: The subwatershed as a whole could strengthen their protections in this area by having site plan review criteria or standards from which to assess whether or not each development proposal is sufficiently protecting natural resources.

10) Groundwater and Wellhead Protection.
Strengths: This category was not well represented by community planning documents.

Challenges: Most communities answered the questions in this section by providing a "No" or "N/A." This may be because almost all residents within the subwatershed are serviced by the Detroit water system, and very few people depend on wells. However, groundwater feeds surface water features, such as streams and lakes, all year around. In fact, groundwater is an important source of water for these features during dry spells. Therefore, groundwater is an important resource to consider even if residents aren't drinking it directly. The subwatershed can address groundwater by improving infiltration of storm water, and by ridding their communities of potential groundwater contaminants. Both of these activities will have a positive effect on stream and lake water quality.

11) Public Education.
Strengths: The subwatershed faired very well in this category. Most communities are already delivering environmental protection and water quality messages to their residents, and coordinate with other organizations (watershed councils, etc.) to distribute this information. Currently, the subwatershed communities have partnered with the Clinton River Watershed Council to provide written communication pieces, presentations, cable messages, and opportunities for resident participation in water quality monitoring and river awareness activities.

Challenges: A few communities that don't currently educate their residents could begin by fulfilling the Public Education Plan of the Phase II process.

3.1.7 Recreational Opportunities

Recreational land within the Clinton Main Subwatershed comes in many types and uses. They range from school property to private parks and golf courses to state parks. Approximately 15% of the Clinton Main Subwatershed is designated parks and/or institutional.

Trail Signage

Recreational land affords opportunities for citizens to enjoy outdoor activities as well as provide desired green space for wildlife habitat. Recreational land along with wetlands, woodlots and other undeveloped spaces provide the linkages throughout the watershed for wildlife to move and live in as well as provide buffers and natural filters for our rivers and creeks.

Recreational Types

To understand the influence of recreational land within the subwatershed it's important to understand the composition of recreational types. Map 7 Recreational Opportunities and Table 3.4 demonstrate the percentage of recreational land types based on ownership within the subwatershed.

Table 3.4 Ownership of Recreational Land

Property Ownership	Percentage
Oakland County	2%
Educational Facility	43%
Multi-Jurisdictional Trail Land	2%
Local Municipality	38%
State of Michigan (Other than school property)	2%
Private Ownership	12%

The largest recreational type is Educational Facility and includes all public and private schools, along with Oakland University. The next largest is the Local Municipality Ownership with 38% of the holdings. This percentage comparison demonstrates that besides Educational Facilities, the individual communities hold the most recreational land with the state, county and private ownership holding a considerable amount less. The county owns land such as Waterford-Oaks County Park, while private ownership would include homeowner association maintained parks or businesses such as The Palace of Auburn Hills.

Community Recreational Opportunities

After understanding the types of recreational land within the subwatershed it is important to see the dynamic of individual community land holdings. There should be a natural curve between the size of the community and the percent of total recreational land.

Table 3.5 Percent Recreational Land in Each Community

Community	% of Community in Clinton Main Subwatershed	% Recreational Land
Auburn Hills	19%	16%
Keego Harbor	1%	1%
Village of Lake Angelus	1%	1%
Orchard Lake Village	4%	7%
Pontiac	25%	21%
Rochester	2%	3%
Rochester Hills	19%	32%
Sylvan Lake	1%	5%
Waterford	18%	14%
West Bloomfield	8%	5%

As demonstrated in Table 3.5, the communities with larger Clinton Main subwatershed land area have a larger percentage of the total recreational land. This is a sign of good distribution of recreational land within the subwatershed as a whole. Map 7 shows the distribution of the recreational land throughout the subwatershed. It can be seen that recreational lands are distributed considerably evenly.

Some example parks located within the Clinton Main identified from the Clinton River Watershed Council website (www.crwc.org) and described here include the following:

Waterford-Oaks County Park is located in Waterford Township and is the headquarters of the Oakland County Parks and Recreation Commission and Administration for the parks system. This 153-acre park offers multiple recreational opportunities.

Riverside Park is located in Auburn Hills this park features picnic pavilions, a children's play structure, and canoe launch.


Rochester Hills Trail

Bloomer Park is located in Rochester Hills and includes picnicking shelters, a playground, mountain biking, hiking and cross country skiing trails, a toboggan run, horseshoe pits, multi-purpose sports fields, and sand volleyball courts.

Helen V. Allen Park is located in Rochester Hills and offers two softball diamonds and playground equipment.

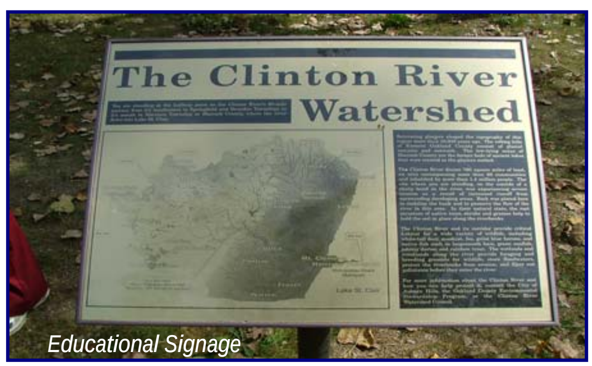
Orchard Lake Nature Sanctuary is located on Pontiac Trail on the west side of Orchard Lake Village. It is a 50-acre preserve of high quality natural areas with views of both Orchard Lake and Upper Straits Lake.

Park Signage

Pontiac City Beaudette Park is located in Pontiac and features boat launching, a fishing pier, tennis and horseshoe courts, a lighted softball diamond, picnic sites and a children's playground.

River Woods Park is located in Auburn Hills this park offers facilities for picnicking and canoeing and a pier for fishing.

Marshbank Park is located in West Bloomfield on Cass Lake, the park offers picnicking, a wildlife area, shelters, hiking, scenic views and children's play areas.



Educational Signage

Yates Roadside Park is located across from Yates Cider Mill in Rochester Hills and features a scenic turnout, picnic areas, and Clinton River access for fishing and boating.

Additional recreational opportunities, including boat launch sites, canoeing stretches, cold water and warm water fishing stretches, nature centers, land conservancy holdings, riverfront trails, public swimming beaches, mill sites and public golf courses may be found by visiting www.crwc.org.

3.1.8 Sanitary Sewer Service Areas

Within the Clinton Main Subwatershed, wastewater is managed either at wastewater treatment plants or within privately owned on-site sewage disposal systems (OSDS) (also referred to as septic systems). Sanitary sewers within each community transport wastewater to wastewater treatment plants as opposed to treating wastewater on privately owned property in OSDS. Thus, the existence of sanitary sewers within local communities provides opportunities to eliminate failing septic systems and potential sources of nonpoint source pollution, including bacteria and nutrients.

Map 8 shows the sanitary sewer service areas within the Clinton Main Subwatershed. This figure demonstrates that the majority of the subwatershed is currently sewered and there is a low percentage of OSDS throughout the subwatershed.

3.1.9 Tours of the Subwatershed

An important component of watershed planning efforts includes gaining insight to high priority restoration or preservation areas from the individual subwatershed representatives. Representatives, including community, county, school district and watershed council staff, have the most thorough knowledge of priority areas in their jurisdictions and this information, combined with the watershed data, translates into defining critical areas within the subwatershed. It is for this reason that individual subwatershed tours were conducted with various municipal staff to further expand knowledge of the subwatershed. Tours included the following subwatershed participants:

Clinton River in Rochester Hills

- Auburn Hills;
- Keego Harbor;
- Oakland County;
- Oakland University;
- Orchard Lake Village;
- Pontiac;
- Rochester Hills; and
- Sylvan Lake.

Auburn Hills

The City of Auburn Hills is located near the center of the Clinton Main subwatershed. The portion of the Clinton Main subwatershed located within the City of Auburn Hills consists mainly of industrial (80%) and residential (20%) land uses.

Constructed Wetland at Hawk Woods Nature Center

Eighty-four percent of the City, or 9,040 acres, is contained within the Clinton Main subwatershed. In addition, the City makes up 19% of the subwatershed's total land area. The predominant land use is industrial (1,860 acres), which is located throughout the community, but primarily along Lapeer Road and I-75. Auburn Hills has the most industrial development (as percent of the community land area) within the subwatershed. Although The City of Auburn Hills has the most industrial development within the subwatershed it does hold 1,101 acres of public and/or private recreational land. Within the subwatershed, Auburn Hills contains 16% of the recreational land.

Several areas of riparian wetland mitigation have been developed with the City of Auburn Hills, helping to increase pollutant uptake and improve overall water quality within the subwatershed (including the constructed wetland located at Hawk Woods Nature Center). In addition, several areas of river corridor have been or are being improved through the implementation of streambank stabilization projects.

Specific issues and areas of concern include the following: areas in need of streambank stabilization, general flashiness of the Clinton Main within the community, erosion problems at roadside storm sewer outfalls, sedimentation within the river, detention basins lacking maintenance and vegetated buffers, and several areas of frequent flooding (within subdivisions near Tienken and Squirrel Roads). Table 3.6 and Map 9 Subwatershed Tour Sites show the sites visited with community representatives and also highlights many of the concerns described previously.

Table 3.6 Auburn Hills Community Tour Sites

Site Number*	Community	Location	Description
AUB01	Auburn Hills	Auburn Road	Streambank erosion
AUB02	Auburn Hills	Auburn Court	Siltation and erosion
AUB03	Auburn Hills	River Woods Park	Streambank enhancement opportunity
AUB04	Auburn Hills	Volkswagen Headquarters	Direct storm water discharge
AUB05	Auburn Hills	Tienken and Squirrel Roads	Wetland mitigation area
AUB06	Auburn Hills	Hawk Woods Nature Center	Wetland mitigation Area
AUB07	Auburn Hills	Riverside Park (Auburn and Squirrel Roads)	Streambank erosion

*Site Number corresponds to locations identified on Map 9

Keego Harbor

Keego Harbor is located in central Oakland County and is referred to as the "Lakes Area." It is situated primarily on the southeast side of Cass Lake. Keego Harbor is located on the southwest side (upstream end) of the Clinton Main subwatershed and is the fourth smallest community in population within the subwatershed, and the smallest in land area. One hundred percent of the City's land area (360 acres) is contained within the

subwatershed. The highest land use type within the community is single family, followed by transportation/utility land uses, and then water. The remainder of the community is comprised of commercial, vacant, multi-family and 35 acres of recreation/conservation uses.

Specific issues and areas of concern include properly managing direct storm water discharges to Cass Lake along Cass Lake Road. In addition, there are direct storm water connections from impervious areas such as parking lots entering other water features. A pump station along Cass Lake Road (near Cass Lake Manor Apartments) pumps storm water runoff from Cass Lake Road directly to Cass Lake during large storm events. Table 3.7 and Map 9 show the sites visited with community representatives and also highlight many of the concerns described previously.

Table 3.7 Keego Harbor Community Tour Sites

Site Number*	Community	Location	Description
KH01	Keego Harbor	W. side of Cass Lake (Portman Street)	Direct storm water runoff to Cass Lake
KH02	Keego Harbor	W. side of Dollar Lake	Direct storm water drainage to Dollar Lake
KH03	Keego Harbor	Cass Lake Road (near Cass Lake Manor Apartments)	Pump station directs street drainage directly to Cass Lake during large rain events
KH04	Keego Harbor	Cass Lake Road	Dam between Sylvan and Cass Lake

*Site Number corresponds to locations identified on Map 9

Oakland County

Oakland County is the third most affluent county in the United States and the fastest growing county in Michigan. Oakland County houses facilities for nearly 200 Fortune 500 companies, including five world headquarters. More than 400 internationally owned companies also are located within the County. Oakland County's rolling hills, wetlands and woodlands provide beautiful neighborhoods and plenty of year-round recreation. The surrounding community also offers an abundance of entertainment, cultural and other social opportunities.

Priorities for the community include the following:

- enhanced focus on environmental and water resources stewardship;
- continued management of storm water on the Waterford Oaks City Park Headquarters and Road Commission properties;
- development of no-mow and native buffer zones within the County Campus;
- construction of wetland mitigation areas within the campus for use in future Road Commission projects; and
- using the recently completed native plant garden on the Campus property as a demonstration and model for construction of future Oakland County native plant gardens and buffers.

Table 3.8 and Map 9 show the sites visited with community representatives and also highlights many of the concerns described previously.

Table 3.8 Oakland County Tour Sites

Site Number*	Community	Location	Description
OAKCNTY01	Oakland County Campus	Waterford Oaks City Park Headquarters	Existing "no-mow" zones
OAKCNTY02	Oakland County Campus	Waterford Oaks City Park Headquarters	Existing "no-mow" zones
OAKCNTY03	Oakland County Campus	Oakland County Road Commission Headquarters	Continued stormwater management
OAKCNTY04	Oakland County Campus	DPW Salt Storage Building	Continued stormwater management
OAKCNTY05	Oakland County Campus	Oakland County Parks Commission	Possible no-mow areas
OAKCNTY06	Oakland County Campus	Oakland County Parks Commission	Possible no-mow areas
OAKCNTY07	Oakland County Campus	County Childcare Facility	Area of localized flooding
OAKCNTY08	Oakland County Campus	Native Plant Demonstration Garden	Continuing Environmental and water resources stewardship

*Site Number corresponds to locations identified on Map 9

Rochester Hills

The City of Rochester Hills is comprised of 32.2 square miles and has a relatively large land area within the subwatershed (8,845 acres), representing 19% of the entire subwatershed. (The subwatershed covers 42% of the community). Rochester Hills is located in the east central portion of Oakland County and is located within the downstream end of the Clinton Main subwatershed. The primary land use is single-family residential, accounting for over 3,000 acres. The next largest land use is recreational land which is approximately 2,146 acres, much of which contains the main branch of the Clinton River or its tributaries. All told Rochester Hills supports 32% of the subwatersheds recreational lands.

Clinton River Floodplain in Rochester Hills

Steep Slope Bank Erosion

The City of Rochester Hills Recreational Opportunities Plan will help manage and reduce impacts to the Clinton River and other natural features located within the City, as well as establish positive uses of these resources. In addition, several areas of riparian wetland mitigation have been constructed within the City of Rochester Hills, helping to increase pollutant uptake and improve overall water quality. A 25' natural features setback has been established along most of the Clinton within the City. Two (2) egret rookeries have been established and are protected along the river corridor on the west side of the City.

Watershed priorities for the community include the following:


Natural Features Setback Encroachment

- ❖ high water during rain events at several locations within residential areas;
- ❖ sedimentation within sections of the Clinton Main River;
- ❖ steep slope bank erosion on the upstream end of the community;
- ❖ high number of large, dead ash trees within the subwatershed;
- ❖ encroachment into the 25' natural features setback;
- ❖ use of chemicals, including fertilizers and herbicides adjacent to the river; and
- ❖ restricted flow due to beaver activity within the river corridor and within Galloway Creek.

Table 3.9 and Map 9 show the sites visited with community representatives and also highlights many of the concerns described previously.

Table 3.9 Rochester Hills Community Tour Sites

Site Number*	Community	Location	Description
ROCH01	Rochester Hills	Butler Ridge Subdivision	High bank erosion areas
ROCH02	Rochester Hills	Butler Ridge Subdivision	Areas of egret rookeries (wildlife conservation)
ROCH03	Rochester Hills	Quail Ridge Subdivision	Areas of encroachment into the 25' natural features setback
ROCH04	Rochester Hills	River Oaks Apartments (Galloway Creek)	Insufficient road freeboard during rain events
ROCH05	Rochester Hills	Confluence Galloway Creek/Clinton Main	Suspected residential herbicide use near river
ROCH06	Rochester Hills	Crooks and Hamlin Roads	Stormwater detention/mitigation areas
ROCH07	Rochester Hills	Crooks and Hamlin Roads	"Old" Hamlin Road bridge and mitigation wetland

*Site Number corresponds to locations identified on Map 9

Oakland University

Oakland University is a public university located within both Auburn Hills and Rochester Hills and is comprised of approximately 1,441 acres. The land was donated to the state for the purpose of establishing the University. Oakland University is located in the east central portion of Oakland County and lies within the downstream end of the Clinton Main


Potential Storm Water Detention

subwatershed. In 1957, at the time of the University's founding, the surrounding area was very rural. The property was made up of a mix of field areas, woodland, wetland and rolling topography. The property has been a county estate, mansion and farm. By the 1990's the area surrounding the University had developed the suburban character that exists today.


Wildlife at Oakland University

The campus includes university buildings, athletic facilities, two (2) golf courses, nineteen parking lots and on-campus student housing facilities. Oakland University was established in 1959 with only 570 students and continues to grow. Today, more than 16,000 students attend classes at OU each fall, and there are more than 62,000 alumni.

Watershed priorities include the following:

- implementing actions identified in a recently completed Storm Water Management Study;
- replacing undersized culverts located on University property;
- correcting streambank erosion and encouraging stricter management of soil erosion control measures from upstream developing areas;
- constructing off-line detention areas to minimize flooding of golf course and lower athletic field surfaces (located within the floodplain); and
- reducing nutrient loading from golf course areas.

Table 3.10 and Map 9 show the sites visited with community representatives and also highlights many of the concerns described previously.

Table 3.10 Oakland University Tour Sites

Site Number*	Community	Location	Description
OAKU01	Oakland University	Galloway Creek near Squirrel	Siltation/Sedimentation and streambank erosion
OAKU02	Oakland University	Pioneer Drive	Wetland swale
OAKU03	Oakland University	Lower athletic field area	Storm sewer outfall to wetlands
OAKU04	Oakland University	Lower athletic field area	Undersized culverts
OAKU05	Oakland University	Near Walton (University Drive)	Undersized culvert
OAKU06	Oakland University	Lower athletic field area	Possible off-line detention area
OAKU07	Oakland University	Golf course	Reduce nutrient loading from golf course areas
OAKU08	Oakland University	Golf course	Area of flooding/beaver activity
OAKU09	Oakland University	Golf course	Erosion and flooding area
OAKU10	Oakland University	Golf course	Galloway at University property boundary

*Site Number corresponds to locations identified on Map 9

City of Orchard Lake Village

The City of Orchard Lake Village represents another relatively small community within the Clinton Main subwatershed and is located among several lakes in Oakland County, Michigan, about 25 miles northwest of Detroit. Sixty-nine percent of the village is contained within the subwatershed, which represents 4% of the subwatershed land total. The City of Orchard Lake Village is approximately 95 percent developed and consists of approximately four (4) square miles (1/2 of which is lake area). This community is located in both the Clinton Main and Rouge Main 1-2 Subwatersheds.

View from Pine Lake to Orchard Lake

The land uses within the subwatershed include water as the largest (about 43 percent of the City is occupied by lakes and ponds), and single-family residential being the next largest. Approximately 483 acres of the land area within the community are of recreational use. This comprises 7% of the watershed's recreational land. The City surrounds its namesake, Orchard Lake, but also includes a portion of Upper Straits Lake and borders, along its northern limits, the waters of Cass Lake. All residents are connected to the sanitary sewer.

The City of Orchard Lake Village has instituted wetland, tree and environmental protection ordinances in order to protect and preserve the City's natural resources. In addition, the City has started an invasive species removal requirement. The City has also completed improvement projects along Orchard Lake Road, in which biologs were installed in order to help support the road and surrounding lakeshore slopes. More areas of natural preservation have been installed within 35' of the lake or wetlands and a natural rock seawall has been constructed along Old Orchard Trail (southwest side of Orchard Lake).

Improved water quality through the construction of storm water detention at Orchard Lake St. Mary's (on Seminary Street) has been achieved. The impervious areas on the campus formerly drained directly to Orchard Lake. A native wildflower buffer is planned around the storm water detention basin. Catch basin filter inlets have been utilized along Indian Trail (adjacent to Orchard Lake). Drainage improvements, including ditch renovations and pumps along Shady Beach Boulevard (adjacent to Orchard Lake), have been completed that help improve drainage and water quality to Orchard Lake.

Priorities additionally communicated by municipal representatives and City officials include direct storm water drainage to Orchard Lake along Indian Trail (along the east side of Orchard Lake) and along Orchard Lake Road. In addition, there are continued discussions with West Bloomfield Township (WBT) with regard to storm water culvert maintenance and flow capacities (specifically with regard to Pine Lake water levels). High-elevation natural banks along Commerce Road (north side of Orchard Lake) are areas of special concern for

Entrance Sign

erosion potential. The Orchard Lake Nature Sanctuary provides beautiful recreational opportunities and opportunities for public education activities. Table 3.11 and Map 9 show the sites visited with community representatives and also highlights many of the concerns described previously.

Table 3.11 City of Orchard Lake Village Community Tour Sites

Site Number*	Community	Location	Description
OLV01	Orchard Lake Village	Indian Trail and Orchard Lake Road	Connection of Pine Lake and Orchard Lake
OLV02	Orchard Lake Village	Orchard Lake (N. side)	Control structure for Orchard Lake
OLV03	Orchard Lake Village	Seminary Street (Orchard Lake St. Mary's)	Area of stormwater retention
OLV04	Orchard Lake Village	Shady Beach Boulevard	Drainage/ditch improvement areas
OLV05	Orchard Lake Village	Orchard Lake Nature Sanctuary	Native prairie planting

*Site Number corresponds to locations identified on Map 9

Pontiac

The City has, by far, the largest quantity of land contained within the subwatershed (11,757 acres). Almost all of the 12,900 acres of the City are located within the subwatershed, and are occupied by a wide variety of land uses. The most prevalent land use is single-family residential, with high-density residential being the most common type of residential development. Recreational land use holds 1,415 acres, approximately 21% of the subwatershed share. Priorities of community representatives include the following:

- locating illicit discharges;
- minimizing areas of flooding within residential areas;
- reducing bank erosion and sedimentation;
- eliminating encroachments along the river corridor; and
- improving public understanding about available recreational opportunities.

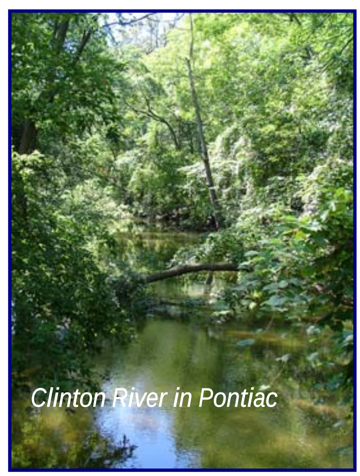

Clinton River in Pontiac

Table 3.12 and Map 9 show the sites visited with community representatives and also highlight many of the concerns described previously.

Table 3.12 City of Pontiac Community Tour Sites

Site Number*	Community	Location	Description
PON01	Pontiac	Featherstone and Northeast Blvd.	Waste water treatment plant
PON02	Pontiac	S. of Auburn Road	High quality stream corridor
PON03	Pontiac	Rails-to-Trails Pathway	High quality stream corridor

Site Number*	Community	Location	Description
		Bridge	
PON04	Pontiac	Skandia Corp. site	High quality wetland area; possible future public access
PON05	Pontiac	Beaudette Dam	Water-level control structure
PON06	Pontiac	Galloway Drain (at Giddings Road)	Area of residential flooding concern
SYL01	Pontiac	Sylvan Lake Estates	Sylvan Lake outlet
SYL02	Pontiac	Telegraph Road (Sylvan Lake Estates)	Potential location of illicit discharge

*Site Number corresponds to locations identified on Map 9

City of Sylvan Lake


Sylvan Lake Boat Docks


Sylvan Lake to Clinton River under Telegraph Road

The City of Sylvan Lake is located just northeast of Keego Harbor and is bordered by Sylvan Lake to the northwest. The City is located on the southwest side (upstream end) of the Clinton Main subwatershed. In land area, Sylvan Lake is the second smallest community in the subwatershed with all of its 516 acres within the subwatershed.

Water is the largest land use in Sylvan Lake, representing 38% of the community. Residential development is similar, in that it covers 33% of the community. Specific issues and areas of concern communicated by City officials include direct storm water drainage to Sylvan Lake from Orchard Lake Road and the control of fertilizer use within the City.

The City of Sylvan Lake is planning to renovate its community center (located on Pontiac Drive; adjacent to Sylvan Lake) in 2005-2006. The construction will likely incorporate several storm water best management practices within the newly constructed parking areas. An additional City project planned for 2005 includes storm sewer repair/renovation on Garland Avenue adjacent to Sylvan Lake. These improvements will help improve storm water quality by decreasing the amount of floatable debris that reaches the lake from the surrounding City streets. Table 3.13 and Map 9 show the sites visited with community representatives and also highlight many of the concerns described previously.

Table 3.13 Sylvan Lake Community Tour Sites

*Site Number**	*Community*	*Location*	*Description*
SYL03	Sylvan Lake	Ferndale Street	City-leased dock spaces (street drainage directly to Sylvan Lake)
SYL04	Sylvan Lake	Pontiac Drive	Location of Community Center (proposed storm water BMPs)
SYL05	Sylvan Lake	Lakeview Drive	Location of proposed

Site Number*	Community	Location	Description
			stormsewer improvement

*Site Number corresponds to locations identified on Map 9

3.2 Landscape Characteristics

This analysis looks at the components that make up the landscape characteristics found within the subwatershed, including topography, ecoregions, hydrologic soil groups, flora and fauna, wetlands, woodlands, riparian corridors and channel morphology. These geological and ecological conditions are unique component that helps guide the watershed planning goals, objectives and actions within the subwatershed. It is important to understand how they are affected by activities and development within the subwatershed in order to minimize those impacts. Many of these landscape characteristics are further described in the Clinton Main Riparian Analysis contained in Appendix B.

3.2.1 Topography

Topography in the Clinton Main subwatershed is quite varied. The high elevation located in the headwaters is approximately 1,273 feet while the low elevation in the downstream end is approximately 564 feet. The Clinton River watershed has two distinct topographical regions including the upper portion that has more relief and steeper channels while the lower portion is predominately flat with very low channel slopes. The entire Clinton River is approximately 80 miles with a change in elevation of about 465 feet or an average gradient of 6 feet per mile.

3.2.2 Ecoregions and Soil Characteristics

Glaciers once covered all of Michigan. When a glacier moves down a drainage pathway or a valley, it pushes ahead of itself a large burden of debris, known as glacial till. This debris consists of unstratified mixtures of clay, sand, gravel and boulders. A terminal moraine marks the maximum advance of a glacier, while end moraines mark later stages in the recession of the glacier. As glaciers melted, large quantities of water flowing from the ice deposited various kinds of materials, most of which consisted of glacial outwash. These outwash deposits are characteristically flat and consist of layers of sand and other fine sediments.

The Michigan Department of Natural Resources Fisheries Division DRAFT Clinton River Assessment describes four main ecoregions within the Clinton River Watershed. Ecoregions are classifications of land areas based on climate, physiography, soil and vegetation. Within the Clinton River Watershed, there are four (4) distinct ecoregions of which the Clinton Main subwatershed contains two. The four ecoregions include the Maumee Lake Plan, the Sandusky Lake Plan, the Ann Arbor Moraines and the Jackson Interlobate. The Clinton Main subwatershed is located within both the Ann Arbor Moraines and the Jackson Interlobate. Map 10 Defined Ecoregions shows these two ecoregions within the Clinton Main subwatershed.

The Ann Arbor Moraines encompasses approximately 21% of the entire watershed with an average elevation of 897 feet. This area is primarily located within the western portion of the Middle segment of the Clinton River. Topography consists of primarily low, rounded hills with some more rolling areas near the end moraines. These glacial deposits are approximately 200 feet thick consisting of fine and medium textured material. This area has primarily good drainage with various pockets of poorly drained soils on the lower slopes of the ground moraines. The glacial deposits in this area have a high conductivity thus providing high groundwater input to the river and lakes. Historic vegetation included oak-hickory and swamp forests in areas supporting loam. Galloway Creek is also contained within this defined ecoregion.

The Jackson Interlobate is the most upstream ecoregion and occupies approximately 24% of the watershed. Elevations range from 984 feet to 1276 above mean sea level with an average elevation of 1,018 feet. Glacial deposits are approximately 300 feet thick above bedrock and Albert (1995) described the area as consisting of outwash sands with sandy/gravelly end moraines and ground moraines. The appearance of moraines are like hills surrounded by flat outwash areas. Kettle lakes and ponds were formed from the outwash and end moraines, of which a number are directly connected to the Clinton River. The glacial deposits in this area have a high conductivity thus providing high groundwater input to the river and lakes.

Within Oakland County, soil infiltration characteristics range from well-drained to poorly-drained. The southeastern part of Oakland County soils are generally poorly to moderately well drained and consist of sandy, loamy or clayey materials. In the remaining portions of Oakland County, including the Clinton Main subwatershed, soils are loamy or loamy/sandy and some areas are underlain by gravelly sand.

There are two primary soil texture terms for the surface layer of the major soils in the Clinton Main subwatershed, including the ***Urban Land-Marlette-Capac*** and the ***Urban Land-Spinks-Oshtemo***. Urban Land refers to areas that were fairly developed at the time of the soil survey and include land that is nearly level, but in some places it has gentle slopes. It is covered by impervious surfaces that have obscured the soils so that identification of the soils is not possible.

The soils in these categories are described in three distinct layers, including the *surface layer* that is 8 inches thick, the *subsoil* with a thickness of 24 inches and a *substratum* approximately 60 inches thick. Marlette soils are on plains, ridges and side slopes that are generally level to hilly. They are well-drained with a surface layer of dark grayish brown sandy loam, subsoil consisting of a brown to grayish brown mottled clay loam and a substratum made up of brown, mottled, calcareous loam. Capac soils are located in areas that are nearly level or have gentle rolling slopes. These soils are more poorly-drained than the Marlette group and have a surface layer consisting of dark grayish-brown sandy loam, a subsoil consisting of brown and grayish/brown mottled clay loam, followed by a brown, mottled calcareous loam.

The Spinks and Oshtemo soils are well drained and are located in areas of level terrain. These areas are generally located on broad plains, ridges and along the side slopes of streams, lakes and wetlands. The surface layer of Spinks soils includes dark brown loamy sand, the subsoil consists of pale brown sand and the substratum is made up of brown, loose sand. Oshtemo soils are also well drained with a surface layer of dark brown loamy sand, subsoil of yellowish brown loamy sand and substratum of both reddish-brown and yellowish-brown sandy soil. Other groups of minor extent include poorly drained Granby, Gilford and Houghton soils. These soils are generally located in depressions and waterways.

The soils within the Clinton Main subwatershed were further categorized into hydrologic soil groups, which is a description of their runoff-producing or infiltration characteristics. Topography along with vegetative cover is not considered in the classification of hydrologic soil groupings. Group A soils are well-drained sandy or gravelly materials with a high infiltration rate and low runoff potential. Group D soils, on the other hand, are soils having a very slow infiltration rate and thus a high runoff potential and are generally characterized as having a clay pan or clay later near the surface. High water tables are also characteristic of these types of soils. Soils classified as Group B or C have characteristics intermediate of those soils in Groups A and D. Soils classified in two (2) hydrologic soil groups indicate an upper layer of more permeable material underlain by a less permeable layer.

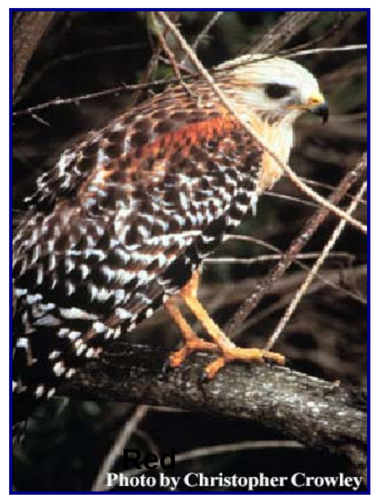
Map 11 shows the Hydrologic Soil Groups for soils located in the Clinton Main subwatershed. Table 3.14 provides a breakdown of Hydrologic Soil Groups by percentage within the subwatershed.

Table 3.14: Hydrologic Soil Groups

Hydrologic Soil Group	Percentage of Subwatershed
Group A	12%
Group A/D	5%
Group B	43%
Group B/D	6%
Group C	1%
Urban Land	24%
Water	9%

Priorities for subwatershed activities based solely on these types of soil include potential erosion concerns as well as carefully identifying infiltration opportunities. Low permeability soils are located throughout the subwatershed and infiltration best management practices should be limited to Groups A and B soils.

3.2.3 Unique Flora & Fauna



Red

Threatened Species and Species of Special Concern

The protection of threatened and endangered species and species of Special Concern status in Michigan is an important component of protecting natural habitat areas and corridors in the subwatershed. Endangered (E), Threatened (T), and Probably Extirpated (X) plant and animal species of Michigan, are protected under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act).


Red Fox Tracks

The Endangered Species Program of the Michigan Department of Natural Resources and the Michigan Natural Features Inventory (MNFI) produced lists of these species. The Michigan Natural Features Inventory maintains databases of all known occurrences of these types of species (plant and animal), as well as high quality natural communities, occurring within Michigan. These lists are based on known and verified sightings of threatened, endangered, and special concern species and represent the most complete data set available. The current list became effective on March 20, 1999, after extensive review by technical advisors to the Michigan Department of Natural Resources and the citizenry of the state.

The MNFI information is collected by teams of scientists with expertise in botany, zoology, aquatic ecology, and ecology. MNFI has conducted surveys by foot, kayak, canoe, and air, from interior forests and grasslands, Great Lakes shores to remote islands in search of information about Michigan's special plants, animals and plant communities. Information is also gathered by studying museum and herbaria records, communicating with other scientists in the Great Lakes area, and reading published works. It should not be considered a

Great Blue

comprehensive listing of every potential species found within the subwatershed. Because of the inherent difficulties in surveying and inconsistencies of inventory effort across the state, species may be present in a watershed and not appear on this list.

The mission of the MNFI is to actively contribute to decisions that impact the conservation of biological and ecological diversity by collecting, analyzing, and communicating information about rare and declining plants and animals, and the array of natural communities and ecosystems native to Michigan.

Unique flora and fauna thrive in the Clinton Main subwatershed. Red fox, mink and muskrat have been observed along portions of the subwatershed. Great blue herons and other waterfowl, freshwater clams, native fish, and a multitude of native wildflowers populate the stream and riparian corridor. A variety of threatened, endangered, and special concern species, high-quality natural communities, and champion trees have been identified in the Clinton Main subwatershed. Table 3.15 lists Threatened, Endangered and Special Concern Plants and Table 3.16 lists Threatened, Endangered and Special Concern Animals in the Clinton Main Subwatershed. English names in common usage or from published sources have been incorporated, when possible, to facilitate public understanding of and participation in the Endangered Species Program.

Also included in the lists are plant and animal species of Special Concern (SC). While not afforded legal protection under the Act, many of these species are of concern because of declining or relict populations in the state. Should these species continue to decline, they would be recommended for Threatened or Endangered status. Protection of Special Concern species now, before they reach dangerously low population levels, would prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare species are listed as Special Concern pending more precise information on their status in the state; when such information becomes available, they could be moved to threatened or endangered status or deleted from the list (MNFI, 2005).

Blanchard's Cricket Frog
Photo by Thomas R. Johnson

Photo by Steven P. Grund

Table 3.15. Threatened, Endangered & Special Concern Plants

Scientific Name	Common Name	State Status
Agalinis gattingeri	Gattinger's Gerardia	E
Amorpha canescens	Leadplant	SC
Angelica venenosa	Hairy Angelica	SC
Arabis missouriensis var. deamii	Missouri Rock-cress	SC

Scientific Name	Common Name	State Status
Astragalus Canadensis	Canadian Milk-vetch	T
Bouteloua curtipendula	Side-oats Grama Grass	T
Carex lupuliformis	False Hop Sedge	T
Carex richardsonii	Richardson's Sedge	SC
Cirsium hillii	Hill's Thistle	SC
Cyperus acuminatus	Nut-grass	X
Epioblasma triquetra	Snuffbox	E
Galearis spectabilis	Showy Orchis	T
Gentiana puberulenta	Downy Gentian	E
Gentianella quinquefolia	Stiff Gentian	T
Gymnocladus dioicus	Kentucky Coffee-tree	SC
Hieracium paniculatum	Panicled Hawkweed	SC
Hydrastis Canadensis	Goldenseal	T
Linum virginianum	Virginia Flax	T
Scirpus clintonii	Clinton's Bulrush	SC
Trichostema dichotomum	Bastard Pennyroyal	T
Valeriana edulis var. ciliate	Edible Valerian	T

E = State Endangered; T = State Threatened; SC = State Special Concern; T = Probably Extirpated

Table 3.16. Threatened, Endangered & Special Concern Animals

Scientific Name	Common Name	State Status
Acris crepitans blanchardi	Blanchard's Cricket Frog	SC
Buteo lineatus	Red-shouldered Hawk	T
Clemmys guttata	Spotted Turtle	T
Erynnis baptisiae	Wild Indigo Duskywing	SC
Lampsilis fasciola	Wavy-rayed Lampmussel	T
Microtus pinetorum	Woodland Vole	SC
Nicrophorus americanus	American Burying Beetle	E
Notropis anogenus	Pugnose Shiner	SC
Pleurobema coccineum	Round Pigtoe	SC
Sistrurus catenatus catenatus	Eastern Massasauga	SC
Pyrgulopsis letsoni	Gravel Pyrg	SC
Toxolasma lividus	Purple Lilliput	T
Vilosa iris	Rainbow	SC

E = State Endangered; T = State Threatened; SC = State Special Concern

3.2.4 Wetlands, Woodlands & Riparian Corridor

Wetlands

Since pre-settlement, many acres of wetland have been lost in the Clinton Main Subwatershed, either by natural processes or to make way for agriculture and development. Most of the subwatershed's wetlands have been drained and lost due to farming and development since the 1800's. According to state law, only wetland over five acres in size, or that are contiguous to or within 500 feet of a waterbody, are protected by the State. Smaller wetlands, and those further away from or not connected to waterbodies are not given state protection. These wetlands can be filled according to state law, unless there is a local ordinance protecting these wetland areas.

Wetlands provide a number of functions that are beneficial to humans. Six benefits provided by wetlands, which are of interest to stakeholders, have been identified as: 1. floral and wildlife habitat, 2. fish and herptile habitat, 3. flood water storage, 4. nonpoint source pollution abatement, 5. shoreline and stream bank protection, and 6. aesthetic and recreational opportunities.

Map 12 is a Potential Wetland Map for the Clinton River Watershed. The GIS data sets used in Clinton Main Watershed Potential Wetland Map were Michigan Resource Inventory System (MIRIS) Land Use/Land Cover data, National Wetland Inventory (NWI) data and Oakland County Planning Department Soil Data. MIRIS Land Use/Land Cover data was acquired through the Michigan Department of Natural Resources online Michigan Geographic Data Library, where it is maintained for public use. NWI data was prepared by the U.S. Geological Survey (USGS) and the U.S Fish and Wildlife Service, and is also accessible through the MDNR online Geographic Data Library. Oakland County Soil Data was acquired through Oakland County in cooperation with the Clinton Main subwatershed planning activities.

The Potential Wetland Map was created to depict areas with a moderate to high likelihood of containing wetlands. To synthesize the Clinton Main subwatershed Potential Wetland Map, NWI, MIRIS Land Use/Land Cover and hydric soil themes were superimposed in the ArcView Geographical Information System (GIS) software. The areas where two or more of these themes intersected were identified as potential wetland areas.

The Potential Wetland Map gives an overall generalization of wetland areas within the watershed. Wetland area utilizes approximately 3% of the subwatershed. A quick glance of the data shows that the areas along the river corridor are primarily the areas of concentration for wetland potential. This is not to say that these are the only locations of wetland within the subwatershed but it demonstrates the likelihood of these natural wetland areas along the river corridor and in the headwaters.

Woodlands in Orchard Lake Village

Woodlands

Woodlands, forests and heavily treed areas provide many benefits to water quality, water quantity and wildlife habitat. Wooded areas provide nesting, perching, feeding and cover for birds and mammals. Wooded areas also provide water quality and quantity benefits by cooling and shading storm water, intercepting storm water as it falls with leaf and trunk surface area and leaf litter, and increasing infiltration of storm water with root systems and often more permeable soils.

Wooded areas also benefit humans, providing natural area aesthetics, and passive and active recreation. According to 1995 MIRIS Land Use Data, there are approximately 1,500 acres of woodlands in the Clinton Main subwatershed and make up less than 5% of the subwatershed's land use. For the purpose of comparison, the World Wildlife Fund has recommended that 25% of a watershed should be covered with woodlands in order to support a diversity and abundance of wildlife.

Riparian Corridor


Clinton River in Auburn Hills

The Clinton Main subwatershed encompasses approximately 60 miles of river and creeks with 22 miles of Clinton Main and the remaining 38 miles consisting of creeks and tributaries. The state of the land area adjacent to the river and creeks is critical to the health of the water that flows through it. A vegetated riparian corridor, or all the land adjacent to the river and creeks, can provide shading and cooling for water; organic debris to feed aquatic organisms; bank stabilization with it's root structure; cover, perching and nesting areas for aquatic organisms; and a buffer for pollutants and sediments from surface runoff. In addition to providing habitat for aquatic organisms, the corridor is used by many birds and mammals. Currently, the riparian corridor in the Clinton Main Subwatershed is in good condition in many areas along the river with woodlands and wetlands lining the banks, but has become mowed lawn in many of the urban areas. Local natural feature setback ordinances in some communities are serving to protect these important systems, yet with pending development, some parts of the corridor are at risk.

A complete detailed Riparian Analysis was conducted by Oakland County Planning and Economic Development Services Environmental Stewardship Group and is included as Appendix B of this plan.

3.2.5 Channel Morphology

The Michigan Department of Natural Resources draft Clinton River Assessment provides a description of morphology throughout the Clinton River Watershed. As discussed in the Introduction, this assessment defined five (5) main river segments, while the Clinton Main Subwatershed is encompassed within two (2) of these segments, including the Upper and Middle segments. See Figure 2.2. The Upper segment includes the western portion of the Clinton Main to just east of I-75. The Middle segment includes the eastern half of the Clinton Main subwatershed.

The Upper segment of the Clinton River runs through glacial outwash sand and gravel, post glacial alluvium, and end moraines of medium textured till. The outwash deposits provided numerous kettle lakes, a number of which are directly connected to the Clinton River. The MDNR Fisheries Division evaluated 233 channel locations using aerial photography and the river width averaged 54 feet with the beginning elevation at 993 feet and ending elevation at 854 feet. With an approximate length of 30 miles, the average gradient was determined to be 4.6 feet per mile, which is considered low and provides only modest potential for sport fisheries habitat. Sinuosity, which provides an indication of the amount of meanders in the river, was calculated to be 1.36. Rivers with no meanders have a Sinuosity Index of 1.0. Rosgen (1994) classified Sinuosity Index as described in Table 3.17.

Table 3.17 Rosgen (1994) Sinuosity Index

Classification	Sinuosity Index
Low	< 1.2
Moderate	1.2 – 1.5
High	> 1.5

The upper half of the Middle segment is located primarily in the Clinton Main subwatershed and consists of glacial outwash sand and gravel between end moraines of medium textured till. Of the 377 channel measurements, the MDNR estimated an average channel width of 56 feet. The elevation at the upper end is about 854 feet above mean sea level and about 617 at the lower end in Utica. With a length of approximately 19 miles, the average gradient was calculated to be 12.4 feet per mile, which is the highest gradient in the entire Clinton River watershed. This area, thus has a high potential for sports fisheries habitat. The sinuosity index was 1.46 and ranked high as compared to other segments. Similar to the Upper segment, the glacial deposits in this area have a high conductivity thus providing high groundwater input to the river and lakes. The high gradient, good potential for groundwater input and opportunities for public access make this segment most opportune for fisheries management.

3.3 Flow Characteristics

Water quantity, or how much and at what rate water travels through a surface water system, is one of the measurements used to study the Clinton River. Certain hydrologic characteristics can indicate the ecological state of a surface water system and provide a good analysis of how the land, developed or undeveloped, is interacting with the nature of the surface water system. In a natural river system, storm water is intercepted by vegetation, stored temporarily on the land in wetlands or infiltrates into groundwater, and then is slowly released into the surface water system, with only a small fraction of water entering the river via surface runoff. This hydrologic scenario will create a stable stream system. In an urban setting, a large percentage of storm water falls onto impervious surfaces and travels directly to the river through storm drains. In this urban setting, a storm event will cause the rate of surface water to increase quickly and dramatically and is referred to as “flashy”. A flashy creek or river will provide unstable habitat - low base flows and high peak flow rates - for fish and aquatic organisms. These urban creeks and rivers become degraded with high sediment loads and scoured stream banks.

3.3.1 Historic Changes in River Flow

Within the Clinton River watershed, there are a total of 61 USGS gage sites. Of these, sixteen gages contain enough historical data to enable drawing significant statistical trends. Two of these sixteen locations are located directly within the Clinton Main Subwatershed (see Map 13 USGS Gages). These gages are within the Clinton River in Auburn Hills (gage 04161000) and within the Galloway Creek in Auburn Hills (gage 04161100).

As a part of the Clinton River Hydrologic and Geomorphic Analysis of the Clinton River Watershed, detailed flow trend analyses have been conducted deploying the data collected from these USGS gages within the Clinton River watershed, including the following:

- Peak Flow Trends – Calculate the trends in the yearly maximum flow for the period of record at the USGS gage;
- Annual Mean Stream Flow Trends – Calculate the trends in the yearly average flowrate for the period of flow record; and

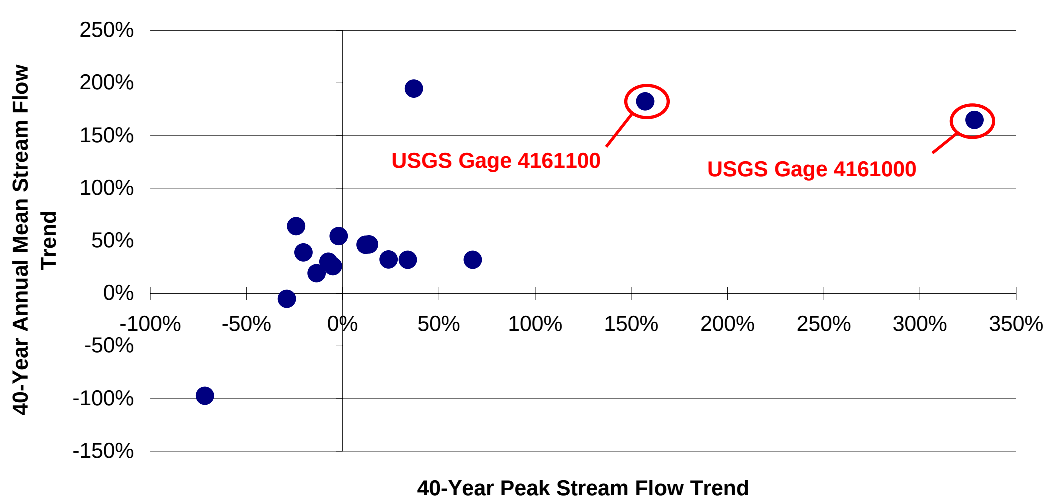
❖ Bankfull Flow Trends – Calculate the trends in the 1.5-year flow (or "channel-forming flow") over the period of record.

Table 3.18 summarizes the results of the flow trend analysis conducted on each USGS gage within the entire Clinton River watershed. In this table, gages within the Clinton Main subwatershed are highlighted in grey. Figure 3.1 shows the relationship between the peak stream flows and the annual mean stream flows for these sixteen USGS gages.

Table 3.18: Changes in flows over a 40-year time period at these sixteen USGS gages within the Clinton River Watershed.

USGS Gage	Peak Flow Trend	Annual Mean Trend	Bankfull Flow Trend
4160800	12.00%	46.20%	0.00%
4160900	23.90%	32.20%	0.00%
4161000	328.30%	164.90%	96.60%
4161100	157.30%	182.50%	50.00%
4161500	-24.10%	63.70%	100.00%
4161540	67.70%	32.00%	0.00%
4161580	-29.00%	-5.20%	-27.30%
4161800	-5.00%	25.90%	0.00%
4162900	-71.60%	-97.30%	-91.60%
4163400	13.70%	46.60%	0.00%
4164000	33.90%	31.80%	11.60%
4164100	-7.30%	30.20%	0.00%
4164300	-2.00%	54.30%	0.00%
4164500	-13.50%	19.20%	0.00%
4164800	37.00%	194.70%	126.80%
4165500	-20.40%	38.90%	0.00%

Figure 3.1: Peak Stream Flow vs. Annual Mean Stream Flow Trends

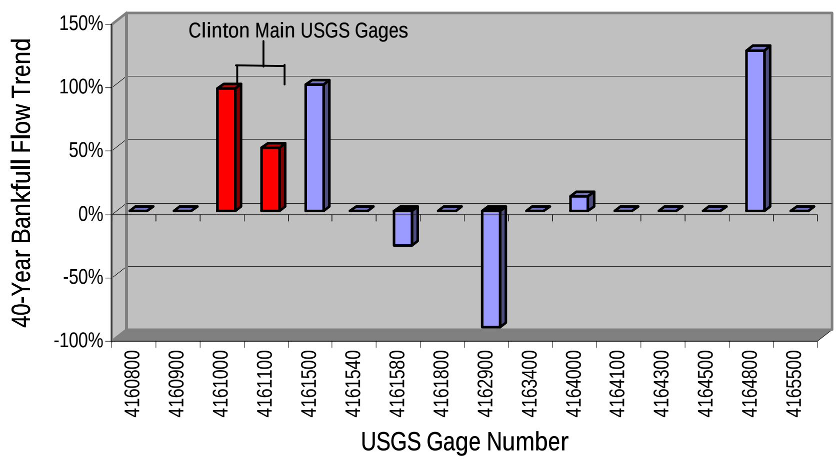


The following conclusions may be drawn from Figure 3.1:

- ❖ Most gages indicate drastic increases in Annual Mean Stream Flow and Peak Stream Flows;
- ❖ More gages have larger increases in Annual Mean Stream Flow than Peak Stream Flow; and
- ❖ The two USGS gages located within the Clinton Main Subwatershed show the largest increases in both annual mean stream flow and peak stream flow.

The bankfull flows, or 1.5-year flows, are significant to analyze for a watershed because these flows are "channel forming flow" due to their frequent occurrence. Therefore, significant increases in the bankfull flows often indicate a stream's instability leading to high amounts of bank erosion. The methodology used for the analysis of the bankfull flows consists of investigating a plot of the cumulative volume curve for each gage. Any noticeable changes in the slope of this plot points towards a change in the average flows over that time period. Secondly, the bankfull flow was calculated based on the general rule that the bankfull flow occurs every 1.5 years. See Figure 3.2 for the relative bankfull flow changes within the Clinton River watershed.

Figure 3.2: 40 – Year Bankfull Trends



In many USGS gages within the Clinton River watershed and especially within the Main Subwatershed, this bankfull flow increased from the values early in the record when compared to the bankfull late in the record. See Figures 3.3 through 3.6 for the plots of this analysis for the Clinton Main Subwatershed locations. It is evident that increased imperviousness has had a drastic effect on the bankfull discharge within the Clinton Main subwatershed.

Figure 3.3: Cumulative Volume for Clinton Main USGS Gage 04161000

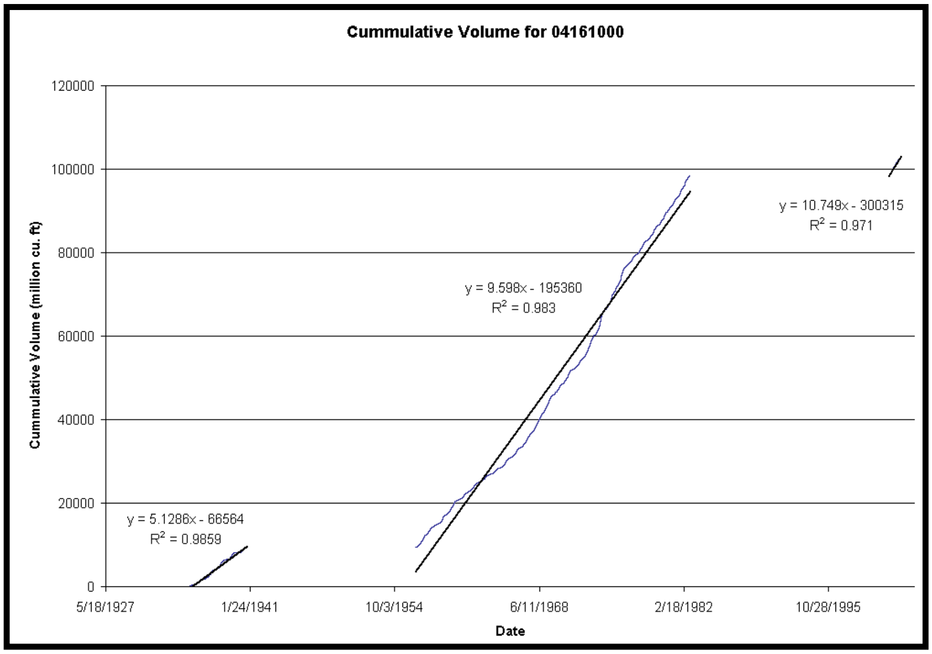


Figure 3.4: Mean Daily Flow for USGS Gage 04161000[1]

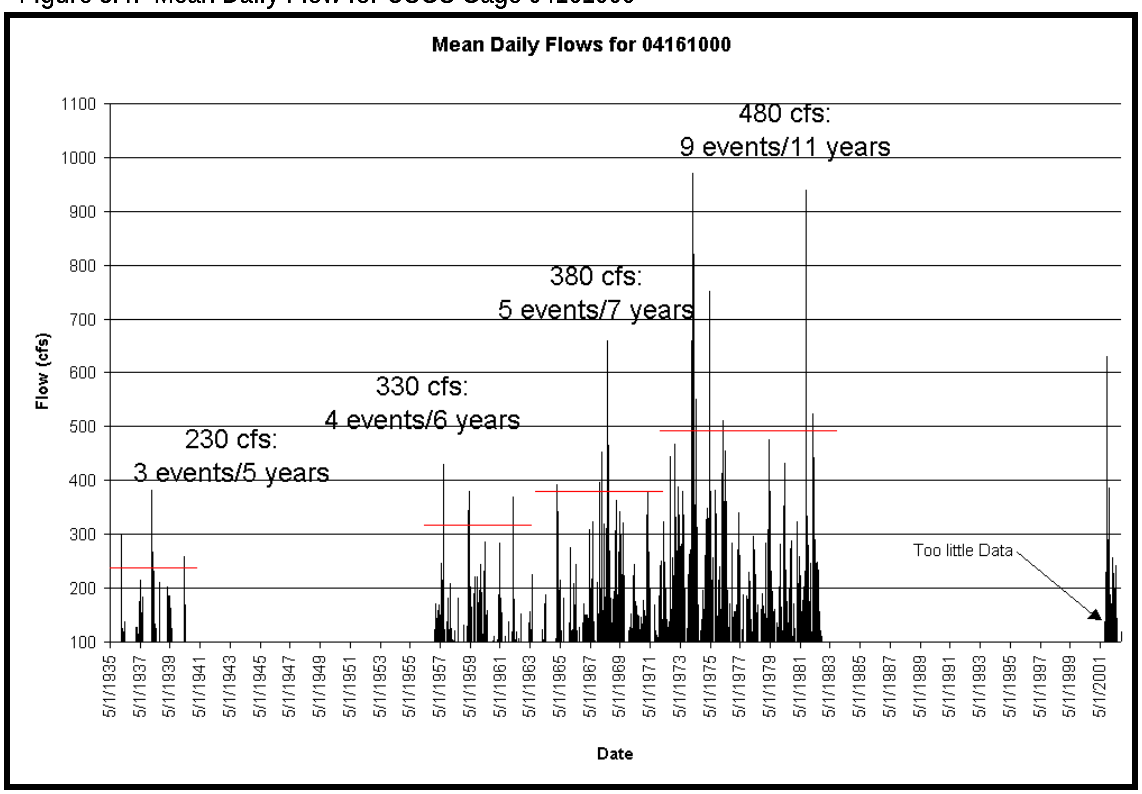


Figure 3.5: Cumulative Volume for Galloway Creek USGS Gage 04161100

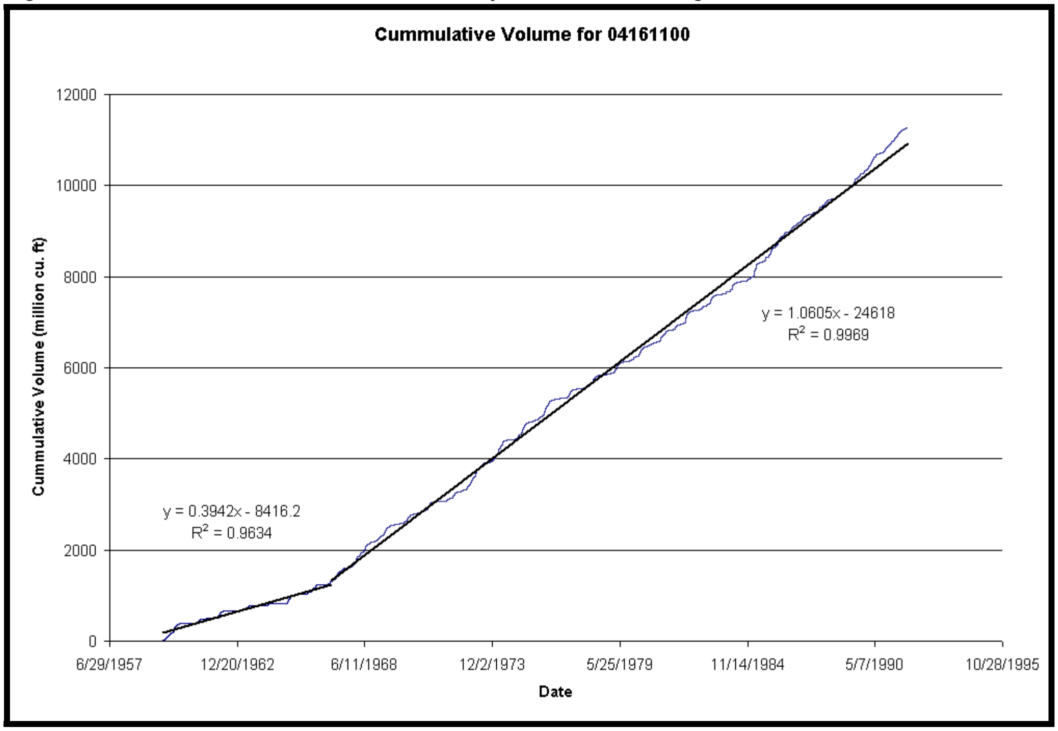
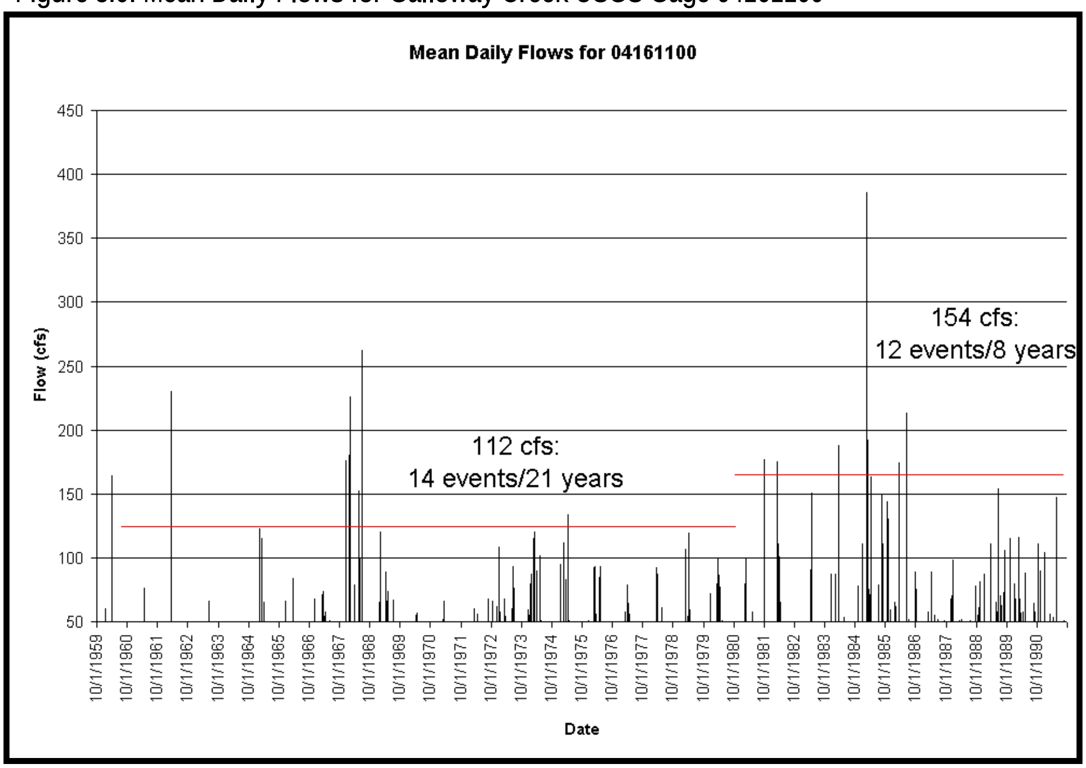


Figure 3.6: Mean Daily Flows for Galloway Creek USGS Gage 04161100



3.3.2 Water Level Control Structures

Water level control structures or dams, as they are commonly called, are located throughout the Clinton River Watershed. In all, the MDNR Fisheries Division identified 79 dams in the Clinton River Watershed, of which there are six known dams in the Clinton Main subwatershed. These water level control structures are located on most of the lakes within the Clinton Main subwatershed and are set at a legal level and maintained by the Oakland County Drain Commission.

Although dams have been historically constructed for specific watershed, recreational, and private benefits, there are disadvantages to their presence including blocking fish passage, modifying downstream river flows, increasing water temperature and impacting habitat opportunities. Each dam within the watershed was historically constructed for unique specific benefits. Conversely, each dam also has associated environmental impacts. The purpose of this section report is to provide a historical summary of the existing dams within the Clinton Main subwatershed.

The Clinton Main subwatershed has six dams and Table 3.19 describes the name, location and legally set elevation for each. Refer to Map 14 Water Level Control Structures for Dam (i.e. Water Level Control Structure) locations within the watershed.

Table 3.19 Control Structure Location and Set Elevation

Lake/Structure Name	City/Township	Summer Level (feet amsl)	Winter Level (feet amsl)
Orchard Lake Dam ID# 2570	City of Orchard Lake Village	930.50	929.50
Watkins Lake Dam ID# 918	Waterford Township	950.00	949.50
Cass Lake (Structure #1) Dam ID# 1664	Waterford Township	929.22	927.87
Cass Lake (Structure #2) Dam ID# 1664	Waterford Township	929.22	927.87
Crystal Lake (Walter Moore Dam) Dam ID# N/A	City of Pontiac	917.50	917.00
Otter and Sylvan Lakes (Price Dam) Dam ID#718	City of Pontiac	928.60	927.25

Strictly from a river restoration perspective, dam removal is a topic of concern, as there are potential long-term benefits; however, there is also documented information regarding ecological impacts of dam removal. Any discussion of these structures should certainly consider all relevant factors including environmental, historical, hydrological, biological and political.

Each of the structures listed in Table 3.19 inspected and maintained by the Oakland County Drain Commission. The following information contains a description of each structure as described in the Oakland County Drain Commission Dam Inspection Reports.

Orchard Lake Dam ID# 2570: (Refer to Figure 3.7)

Description of the structure as per the Oakland County Drain Commissioner Dam Inspection Report is as follows: "The Orchard Lake Level Control System is located on the northern shore of Orchard Lake off of Commerce Road. The control system consists of the following:

1. An 18-inch x 29-inch corrugated metal pipe (CMP) inlet from Orchard Lake.
2. An on-shore 11-foot diameter control structure containing a stop log weir.

3. A pump station
4. A 24-inch diameter reinforced concrete transmission pipe.
5. A 24-inch diameter CMP outlet pipe to Cass Lake. The same pipe acts as the inlet when augmentation pump is on.

The system has two different modes of operation – Overflow to Cass Lake and Pump Augmentation Flow From Cass Lake to Orchard Lake. Each mode is described below.

Overflow to Cass Lake
Water from Orchard Lake drains by gravity through the 18-inch x 29-inch CMP into the control structure manhole. The control structure houses a concrete weir at elevation 929.5 equipped with stop logs that allow the elevation to be adjusted to elevation 930.46. Water flows over the weir and out of the control structure into the pump station wet well the out of the pump station through the 24-inch diameter transmission pipe to Cass Lake. The distance from the pump station to Cass Lake is approximately 620 feet, and there are four manholes along the alignment of the transmission pipe.

Pump Augmentation Flow From Cass Lake to Orchard Lake
Water is pumped from Cass Lake into Orchard Lake as needed if the level of Cass Lake is above legal. There is a rock crib surrounding the Cass Lake inlet/outlet. The pump station consists of a wet well, a 4000 gallon-per-minute axial-flow-type pump, discharging piping, and associated controls. The pump station wet well is connected directly to Cass Lake via the 24-inch transmission pipe, so the water elevation inside the wet well is essentially the same as Cass Lake. The pump discharges into Orchard Lake through a 14-inch steel pipe at an invert elevation of 931.50 feet. A gabion mattress was constructed at the discharge location to protect the lake bed against erosion. The pump is operated by the Oakland County Drain Commissioner's personnel."

Watkins Lake Dam ID# 918:
Description of the structure as per the Oakland County Drain Commissioner Dam Inspection Report is as follows:

"The structure is located on the west shore of the lake on horseshoe canal. It is a concrete structure with a trash rack and a removable aluminum stop log weir. Flow enters the structure and outlets into a 30-inch diameter rcp that is 300 lf long. The reinforced concrete pipe outlets to another concrete structure with a three-sided removable stop log weir. Flow ultimately discharges overland to existing wetlands located within the Drayton Plains Nature Center. The existing force main for the Clinton River augmentation pump is connected to the outlet pipe with a duck bill valve. The pump will be reserved for back-up use."

Cass Lake(Structure #1) Dam ID# 1664: (Refer to Figure 3.7)
Description of the structure as per the Oakland County Drain Commissioner Dam Inspection Report is as follows:

"Cass Lake Control Structure No. 1 is one of two control structures for Cass Lake. It is located on a canal just west of Cass Lake Road between Rosedale and Otter about one mile north of Orchard Lake Road with a portion of the structure lying in Waterford Township and a portion lying in the City of Keego Harbor. The water level of Cass Lake is controlled by the operation of four wooden gates set in a reinforced concrete structure. The gates have manual controls and a bar screen set in concrete upstream of each gate. When the gates are in a closed position the top of each gate is at the summer legal level. The gates are raised as needed with SCADA that electronically monitors the lake level."

Cass Lake(Structure #2) Dam ID# 1664: (Refer to Figure 3.7)
Description of the structure as per the Oakland County Drain Commissioner Dam Inspection Report is as follows:

"Cass Lake Control Structure No. 2 is one of two control structures for Cass Lake. It is located on a canal just east of Cass Lake Road north of Bangor Road about one quarter mile south of Cass-Elizabeth Lake Road in Waterford Township. Control Structure No. 2 has no movable parts and consists of a 20-foot wide by 10-foot long weir box constructed of sheet piling with two, eight-inch diameter outlet pipes through its east or downstream wall. A 22-inch wide concrete cap covers the east wall and angle iron covers the north and south walls of the structure. The top elevation of the structure or weir elevation is 931.0 feet. A 10-foot wide concrete box culvert beneath Cass Lake Road serves as an inlet to the control structure. Water flows from the Dolphine Canal through the box culvert, into the weir box then out of the weir box through the two outlet pipes then back into the canal and into Otter Lake. The function of Control Structure No. 2 compliments Control Structure No. 1, which has gates to regulate the flow from Cass Lake. Control Structure No. 2 holds water in the canal system, provides dry weather flow downstream and provides emergency overflow capacity into the Clinton River."

Crystal Lake(Walter Moore Dam): (Refer to Figure 3.7)
Description of the structure as per the Oakland County Drain Commissioner Dam Inspection Report is as follows:

"The dam consists of a concrete control structure and steel sheet piling weir. The shorelines of the upstream pond leading to the control structures are protected with steel sheet oiling. Flow is regulated through the dam by two methods. The first method is by the operation of two 66" x 66" sluice gates which are enclosed within a concrete structure. The flow through the sluice gates discharges into an 11' x 10' enclosed box culvert known as the Pontiac-Clinton River Drain No. 3, which eventually discharges into the Clinton River. The second means of regulating the flow is by the operation of an adjustable overflow weir, which consists of removable stop logs and an adjustable mechanical weir. Flow from the overflow weir discharges into the downstream Oaks Drain open channel (a.k.a. former Clinton River channel) and then into the Pontiac-Clinton River Drain No. 3 enclosure, which eventually flows into the Clinton River. Dry weather flow is conveyed through a sluice gate to the Oaks (County) Park."

Otter and Sylvan Lakes(Price Dam) Dam ID# 718: (Refer to Figure 3.7)
Description of the structure as per the Oakland County Drain Commissioner Dam Inspection Report is as follows:

" The dam consists of an earth embankment, protected on the upstream side with steel sheet piling. Flow in conveyed through the dam by opening four sluice gates that are attached to the stream side of the sheet piling. Flow from the gates is conveyed through the embankment by four 4'-0" x 4'-0" concrete box culverts which outlet through a common concrete headwall into an outlet pond. Flow then leaves the outlet pond, through a bridge culvert under Orchard Lake Road, continuing downstream, in the Clinton River, to Crystal Lake. The dam structure is equipped with an emergency overflow spillway and also has a provision to convey dry weather flow through the embankment via a 12" diameter sluice gate."

3.4 River and Stream Water Quality

Table 3.25: Pollutant Loading Results of PLOAD Model Runs (mg/L)

BASIN	BOD	TSS	TP	DP	TKN	NO23	PB	CU	ZN	CD
Clinton Main	44	158	0.7	0.3	4.2	2.9	0.10	0.065	0.46	0.006
Red Run	63	245	0.9	0.4	5.4	3.7	0.14	0.10	0.73	0.009
North Branch	5	50	0.2	0.1	1.0	1.4	0.01	0.003	0.02	0.000
Clinton Overall	30	112	0.5	0.2	3.0	2.2	0.06	0.04	0.27	0.004

Overall, the delineated basins within the Main Branch of the Clinton River are somewhere between a rural and an urban watershed. However, most of the values of the pollutant loadings more closely resemble the loadings produced from a highly urban basin. Map 18 shows individual parameter results for phosphorus, nitrate and nitrites, biochemical oxygen demand and total suspended solids. The total loading of the Clinton Main subwatershed can also be compared to the total loading from the entire Clinton River watershed. This comparison can show the relative loading generated from the Clinton Main subwatershed. See Table 3.26 and Figure 3.11 for these results.

Table 3.26: Total Pollutant Loading from the Clinton Main Subwatershed

	Entire Clinton River Watershed	Clinton Main	Percent of Total Loading
BOD	13,668,722	2,044,139	15.0%
TSS	50,630,319	7,353,249	14.5%
TP	218,453	31,000	14.2%
DP	103,300	14,848	14.4%
TKN	1,378,958	195,892	14.2%
NO23	1,007,742	136,314	13.5%
PB	28,290	4,478	15.8%
CU	18,374	3,033	16.5%
ZN	123,465	21,314	17.3%
CD	1,740	274	15.8%
Area, Square Miles	760	73	9.6%

All Pollutant Units are in lbs/year

NH_3 is converted to NO_3^- and NO_2 by the process of nitrification. When present as organic nitrogen or ammonia, nitrogen exerts an oxygen demand, meaning that oxygen levels are decreasing in the water. Total Kjeldahl Nitrogen (TKN) is a measurement of organic nitrogen plus ammonia nitrogen.

Nitrates and nitrites are commonly measured in river systems. Acceptable levels of nitrate are below 4 mg/L and when the concentration exceeds this level, accelerated plant growth occurs. The EPA ecoregional criteria for total nitrogen in rivers and streams of ecoregion VII is 0.54 mg/L (US EPA 2000). Nitrate less than 90 mg/L has not demonstrated adverse impacts on warm water fish. Nitrite levels less than 5 mg/L have not demonstrated adverse impacts on warm water fish (US EPA 1986). Sources of nitrates come from decomposition of dead plants and animals, fertilizers, animal waste and sewage.

Ammonia (NH_3-N) toxicity is pH and temperature dependent. Chronic and acute toxicity increases as pH decreases and acute toxicity increases as temperature decreases. Freshwater phytoplankton and vascular plants are more tolerant to NH3-N than invertebrates or fish. At a pH of 8.0 and a temperature of 24 degrees centigrade the chronic criterion for fish protective of early life stages is 1.32 mg nitrogen per liter (mg N/L) (USEPA 1999). It is important to note, however, that the USEPA is currently reevaluating the aquatic life ambient water quality criteria for ammonia (Federal Register: July 8, 2004 (Volume 69, number 130). Further, the State of Michigan Rule 57 final chronic value for the protection of aquatic life for unionized ammonia in warm water is much lower than the EPA value at 0.053 mg/L.

Total Suspended Solids (TSS)

Total suspended solids measure the sediment in the water column. Wet weather loadings are often much higher than dry weather loadings, indicating storm water runoff as the conveyance medium for sediments as opposed to wind or other vehicles. Sediments from streets, stream bank erosion due to high river velocities and lack of vegetation, sediments from agricultural runoff and dust, and construction sedimentation are some of the suspected sources of TSS in the creeks and river.

High TSS in the water column reduces dissolved oxygen concentrations, decreases light penetration for aquatic plants, clogs gills of aquatic organisms and fish, and impairs the aesthetic and recreational uses of the river. TSS may have direct impacts on fish either as fish kills, reduced growth rates or resistance to disease. According to the Neoponset River Basin Survey[1], which used indicators of aesthetic quality to judge TSS concentrations, TSS below 25 mg/l is good, between 25-80 mg/l is fair and above 80 mg/l is poor.

E. coli Bacteria

Elevated numbers of *E. coli* bacteria, a species of fecal coliform, suggest the presence of microorganisms that threaten public health from untreated human and/or animal waste. Dry weather bacteria loading can suggest an illicit sanitary sewer connection to a storm sewer or other constant source, whereas wet weather bacteria loading can suggest that bacteria is being carried by storm water from sources on the landscape such as pet waste, large animal waste, or failing septic systems. Typical standards for bacterial coliforms are as follows:

- 0 total coliforms per 100 milliter (ml) for drinking water;
- 300 E. coli per 100 ml (daily geometric mean) or 130 E. coli/100 ml (30-day geometric mean for total body contact (swimming);

[1] The Neoponset River Basin study regarding aesthetic quality of water (clarity) is used by the Rouge Program Office as a general guideline for assessing levels of Total Suspended Solids in baseline data reports.

- 1000 E. coli per 100 ml (daily geometric mean) for partial body contact (boating, etc.);
- 200 fecal coliforms per100 ml (30-day geometric mean) or 400 fecal coliforms/100 ml (discharge) for treated or untreated sewage effluent.

Elevated levels of bacterial coliforms can prevent total body contact recreation, such as swimming, and often preclude partial body contact recreation, such as wading, fishing or boating, in the surface water systems.

Organic Chemicals and Heavy Metals

Organic chemicals and heavy metals (lead, copper, zinc, chromium, cadmium, etc.) are two classes of chemicals that are frequently cited as causing adverse environmental impacts in river ecosystems. The chemicals can disrupt physiology of aquatic organisms and some chemicals have been noted as accumulating in the fatty tissues of fish and other aquatic organisms. Organic chemicals such as polycyclic aromatic hydrocarbons (PAH) are by-products of manufacturing processes and combustion of fossil fuels. A common source of organic chemicals is automobile fluids such as gasoline and lubricating oils. Heavy metals, such as lead, zinc, copper, and mercury are also common by-products of manufacturing, but these contaminants are also common in agricultural and road surface runoff.

Temperature

Water temperature is a critical indicator of and directly affects many physical, biological, and chemical characteristics of a river. Temperature affects the amount of oxygen that can be dissolved in water; the rate of photosynthesis by algae and larger aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases. Table 3.20 shows examples of life supported at various temperatures. Thermal pollution, which is the discharge of heated water from industrial operations or runoff from impervious surfaces such as roads and parking lots, increases water temperature. Changes in water temperature affect the rate of photosynthesis by aquatic plants (higher temperatures = higher rates of photosynthesis) until temperatures become so high that tissue damage or death of the plant occurs. Temperature also affects the sensitivity of organisms to pollutants, parasites, and disease.

In order to support brown trout, the maximum water temperature should not rise above 20° C, or 68° F, in the summer months. When water temperature rises, dissolved oxygen decreases and fish populations are threatened. Measures should be taken to reduce the impact of impervious surfaces and to increase native stream bank vegetation and shading along the Clinton River and its tributaries. For warm water fisheries, a maximum summer temperature of 29.4° C, 85° F, should be maintained in order to maintain the many warm water fish species.

Table 3.20: Temperature Sensitivity of Aquatic Life

Temperature	Life Supported
>20°C	Much plant life, warm water fish: bass, crappie, bluegill, carp, catfish
13 – 20 °C	Some plant life, cold water fish: salmon, trout, aquatic insects; stone fly nymphs
<13°C	Mayfly nymphs, caddisfly larvae, water beetles, and water striders; cold water fish such as trout

(CRWC Stony Creek Subwatershed Management Plan, 2003)

Dissolved Oxygen (DO)

A certain concentration of DO is essential for the survival of fish and aquatic organisms. A stable flow regime with riffles and cool water temperatures lead to increased DO concentrations. DO is essential for fish and is an important component in the respiration of aerobic plants and animals, photosynthesis, oxidation-reduction processes, solubility of minerals, and decomposition of organic matter. The accumulation of organic wastes and accompanying aerobic respiration by microorganisms as they consume the wastes depletes dissolved oxygen in rivers. DO is reported in milligrams of dissolved oxygen per liter of water – also reported as parts per million or ppm. The amount of oxygen an organism requires varies according to species and stage of life. DO levels below 1 or 2 ppm will not support fish. DO levels below 3 ppm are stressful to most aquatic organisms. DO levels of 5 to 6 ppm are usually required for growth and activity. Low DO levels encourage the growth of anaerobic organisms and nuisance algae causing poor odors and low food supply for aquatic organisms.

High levels of bacteria from sewage pollution and high levels of organic matter in the water can lead to low DO levels. Aquatic plants, algae and phytoplankton produce oxygen as a by-product of photosynthesis. Oxygen diffuses very slowly in water and distribution depends on the movement of the aerated water. DO levels naturally fluctuate throughout the day and in bodies of water with extensive plant growth. DO levels rise from morning through late afternoon as a result of photosynthesis, reaching a peak in late afternoon. Photosynthesis stops at night, but plants and animals continue to respire and consume oxygen, therefore causing DO levels to fall to a low point just before dawn (CRWC, 2003).

pH

pH is a measure of the hydrogen ion concentration in a solution and is important in determining the chemical speciation and solubility of various substances as well as regulating biological processes in rivers. pH is measured on a scale of 0 – 14, with zero indicating acidic, 7 as neutral and 14 as highly basic. Most organisms have adapted to life in water with a specific pH and may not survive if the pH changes even slightly. At extremely high or low pH values (>9.6 or <4.5) the water becomes unsuitable for most organisms. A pH range of 6.5 to 8.2 is optimal for most organisms. Most natural waters will have pH values ranging from 5.0 to 8.5. Seawater has a pH value close to 8.0. Rapidly growing algae and vegetation can remove carbon dioxide (CO2) from the water during photosynthesis, which can result in a significant increase in pH levels. Low pH can cause heavy metals to become more mobile and be released into the water. Acid rain, industrial wastes, agricultural runoff and dredging can cause fluctuations in pH levels.

Biochemical Oxygen Demand (BOD)

Aerobic bacteria placed in contact with organic material will use this organic material as a food source. The end products are CO2 and water. The amount of dissolved oxygen used in this process is the biochemical oxygen demand. It is considered to be a measure of the organic content of the waste. The difference between the DO result and the BOD result is the oxygen available to other aquatic organisms. In slow moving and polluted rivers, bacteria consume much of the available dissolved oxygen. High levels of BOD indicate increased levels of nutrients, which can result from both natural and human-induced activities. BOD is reported as milligrams of oxygen used per liter (mg/L) (US EPA, 2000).

3.4.1 Clinton Main River Water Quality Data Summary

The Clinton River Main Branch is located in Oakland County and flows to Lake St. Clair, near the city of Mt. Clemens. The river consists of many branches that cover 70 square miles of agricultural, urban, suburban, and industrial land. Many parties have collected water quality data in the Clinton River including

Environmental Consulting & Technology, Inc., (ECT), Clinton River Watershed Council (CRWC) volunteers as part of the Global Rivers Environmental Education Network (GREEN) and United States Geological Survey (USGS). This section summarizes data from these sources.

ECT collected water quality data at two locations within the Clinton Main subwatershed as part of the Lake St. Clair Regional Monitoring program conducted for the Macomb County Health Department (MCHD). The two monitoring locations were located at the Clinton River at Auburn Road (CR09) and the Clinton River at M-59 (CR-11) (see Map 15). ECT collected water samples from these locations during dry and wet weather conditions. From September 2004 through October 2005, 16 dry weather events were sampled along with ten wet weather events. Water samples were analyzed for the following parameters: aluminum, biochemical oxygen demand (BOD), chloride, chemical oxygen demand (COD), *E. coli*, hardness, ammonia-N (NH3), nitrate-N (NO3), oil & grease (O/G), orthophosphate, total phosphorus (P), total dissolved solids (TDS), total Kjeldahl nitrogen (TKN), total organic carbon (TOC) and total suspended solids (TSS). However, only BOD, chloride, O/G, P, TSS, and *E. coli* are discussed below. These are the constituents that are used as relative indicators for water quality in this system.

The CRWC GREEN volunteers collect data for various water quality parameters, including dissolved oxygen concentrations, BOD, pH, nitrate, phosphate, temperature, turbidity and fecal coliform. They also document recent rain events during their data collection. Data collected by the CRWC GREEN volunteers is generally qualitative in nature. Depending upon the measured concentration, analytical results are classified into one of four categories (excellent, good, fair, and poor) and assigned a numerical ranking (4 through 1). These results are then pooled to calculate an overall qualitative water quality index and classify the water generally in one of the four categories.

Tables 3.21 and 3.22 present the summary data for ECT sample locations CR09 and CR11, respectively. These tables summarize the dry and wet weather monitoring data and compare the values to the average concentration measured at the mouth of the Clinton River (Shoemaker et al., 2002) and “critical values” as defined in Shoemaker et al., (2002). It is important to note that the following text summarizes a limited number of samples and any exceedances of criteria or identified differences may not be statistically significant. In general, there were 16 sets of dry weather data and 10 sets of wet weather data for each site. Four *E. coli* samples were collected during each wet weather event. The geometric mean values for each event were calculated from the individual sample results. These calculated values were used in Tables 3.21 and 3.22.

CR09 (South side of Auburn Road; West of Squirrel Road)

CR09 is located downstream from the City of Pontiac in Auburn Hills at the Auburn Road crossing, west of Squirrel Road. This location is directly across the street and upstream from Riverside Park. This site also corresponds to site #CM03 in these subwatershed planning activities. In general, water quality data at Clinton River at Auburn Road is higher than critical values presented in Shoemaker et al. (2002) for *E. coli,* BOD and total phosphorus. All three of these constituents have the potential to deplete oxygen either directly or indirectly. In addition, measurements collected during the wet-weather monitoring events were significantly higher than the dry weather measurements for *E. coli,* and TSS. This suggests that storm water runoff may be considered a source for these parameters at this location. This is consistent with expectations associated with wet weather monitoring. Four of the 16 dry weather samples for BOD; 12 of the 16 dry weather samples for *E. coli;* and, 16 of the 16 dry weather samples for total phosphorus were above the critical value presented in Shoemaker et al (2002). Further, average concentrations of BOD, chloride and total phosphorus were higher at the Clinton River at Auburn Road location than the mouth of the Clinton River.

In addition, data from the continuous monitoring station installed by the USGS at the Auburn Road crossing were also evaluated for the non-winter months from September 2004 to November 2005. These data indicate that dissolved oxygen concentrations fluctuate seasonally, as expected, and are generally above 6 mg/L. This indicates that dissolved oxygen concentrations are generally adequate at this location.

CR11 (Clinton River at M-59; West of Crescent Lake Road)

CR11 was located on the Clinton River at M-59 west of Crescent Lake Road, upstream of the City of Pontiac and the Clinton Main boundary. Based on the data collected by ECT in 2004 and 2005, water quality appears to be slightly better than that at CR09. The average dry weather measurements were not in excess of the critical values presented in Shoemaker et al (2002). However, all ten *E. coli* measurements collected during wet weather events were higher than the critical values. Of the six parameters, chloride was the only one that did not increase during wet weather conditions. Total phosphorus levels breached the critical values in 3 of the 16 dry weather samples and 2 of the 10 wet weather samples. This is significantly less than those for CR09, and suggests that nutrients may not be elevated at the M-59 location.

As with the data evaluated from the Auburn Road crossing, data from the continuous monitoring station installed by the USGS at the M-59 Road crossing were also evaluated for the non-winter months from September 2004 to November 2005. These data also indicate that the dissolved oxygen concentrations fluctuate seasonally, and are generally above 7 mg/L. This indicates that dissolved oxygen concentrations are generally adequate at this location.

Table 3.21 CR09: Clinton River at Auburn Road

	SampleID	BOD (mg/L)	Chloride (mg/L)	*E. coli**** (cfu/100 mL)	O&G (mg/L)	P (mg/L)	TSS (mg/L)
Dry Weather	Maximum	28	300	340	30	0.69	6
	Minimum	< *2*	130	20	< *1*	0.065	< *1*
	Average	5.0	234	130	4.2	0.349	2.0
	Number of non-detect Samples	8	0	0	5	0	10
	Number of exceedences	4		12		16	
	Number of Samples	16	16	16	16	16	16
Wet Weather	Maximum	7	280	71571	8.7	0.67	680
	Minimum	< *2*	110	329	< *1*	0.096	16
	Average	3	167	4971	2.5	0.321	132
	Number of non-detect Samples	2	0	0	3	0	0
	Number of exceedences	3		9		11	
	Number of Samples	9	11	10	10	11	11
Other	Clinton Mouth (average)**	1.55	63			0.045	
	Critical Value**	4		130		0.05	

* Italics value represents a non-detect. Half the detection limit was used to calculate the average.

** From: Shoemaker et al., 2002

*** Wet weather *E. coli* results reported as the geometric mean values for the 4 samples collected in a single event.

Table 3.22 CR11: Clinton River at M-59

	SampleID	BOD (mg/L)	Chloride (mg/L)	*E. coli**** (cfu/100 mL)	O&G (mg/L)	P (mg/L)	TSS (mg/L)
Dry Weather	Maximum	7	190	410	12	0.170	9
	Minimum	< *2*	110	< *10*	< *1*	< *0.01*	< *1*
	Average	2	144	101	2.6	0.037	3
	Number of non-detect Samples	10	0	1	7.0	3	8
	Number of exceedences	2		9		3	
	Number of Samples	16	16	16	16	16	16
Wet Weather	Maximum	8	150	33888	13	2.2	67
	Minimum	< *2*	110	137	< *1*	< *0.01*	3
	Average	3	129	1171	2.9	0.241	22
	Number of non-detect Samples	5	0	0	7	1	0
	Number of exceedences	2		10		2	
	Number of Samples	9	10	10	9	10	9
Other	Clinton Mouth (average)**	1.55	63			0.045	
	Critical Value**	4		130		0.05	

* Italics value represents a non-detect. Half the detection limit was used to calculate the average.

** From: Shoemaker et al., 2002

*** Wet weather *E. coli* results reported as the geometric mean values for the 4 samples collected in a single event.

3.4.2 Nonpoint Source Pollutant Loading in the Clinton Main Subwatershed

PLOAD Model Background

The GIS Pollutant Loading Application (PLOAD), developed by CH2M HILL is a simplified, GIS-based model used to calculate pollutant loads for watersheds. PLOAD is an extension of the EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) software package.

This model is a useful tool that provides an overall perspective of a watershed's pollutant loadings from storm water runoff. The PLOAD model output is useful in identifying a pollutant's potential origin within a watershed and can also show the relative impact to the watershed based on specific land use changes or implementation of Best Management Practices (BMPs). The PLOAD model does not show the impact of development on a site-specific scale, but rather on a watershed wide scale. Additionally, the model should not be used as a final calculation of exact loadings, but rather should be used to show which sub-basins within a watershed are likely to have relatively higher or lower concentrations of storm water pollutants.

PLOAD Model Assumptions

The PLOAD model was used to estimate nonpoint source pollutant loadings of typical storm water quality parameters for the Clinton Main Subwatershed. The Clinton Main subwatershed was delineated into sixteen (16) sub-basins as identified in Map 16 for purposes of the evaluation. The Total Pollutant Loadings are based upon nonpoint pollution loading factors that vary by land use and the percent imperviousness associated with each land use type. Refer to Map 17. The land use types and pollutants are linked via an *Event Mean Concentration* value, which defines the concentrations of specific pollutants within each land use type. Nationally, these values vary significantly so regional values were used in the PLOAD model. Table 3.23 outlines the Event Mean Concentrations for the pollutants analyzed in the Clinton Main subwatershed.

Table 3.23: Summary of Event Mean Concentrations for the Clinton Main Subwatershed (mg/L)

Name	BOD	TSS	TP	DP	TKN	NO23	Pb	Cu	Zn	Cd
Agricultural	3	145	0.37	0.09	1.92	4.06	0	0	0	0
Commercial	21	77	0.33	0.17	1.74	1.23	0.05	0.04	0.16	0.003
Forest/Rural Open	3	51	0.11	0.027	0.94	0.8	0	0	0	0
High Density Residential	14	97	0.24	0.08	1.17	2.12	0.04	0.03	0.22	0.003
Highways	24	141	0.43	0.22	1.82	0.83	0.05	0.04	0.16	0.003
Industrial	24	149	0.32	0.11	2.08	1.89	0.07	0.06	0.67	0.005
Low Density Residential	38	70	0.52	0.27	3.32	1.83	0.06	0.03	0.16	0.004
Medium Density Residential	38	70	0.52	0.27	3.32	1.83	0.06	0.03	0.16	0.004
Urban Open	3	51	0.11	0.03	0.94	0.8	0.01	0	0.04	0.001
Water/Wetlands	4	6	0.08	0.04	0.79	0.59	0.01	0.01	0.03	0.001

(The Rouge River National Wet Weather Demonstration Project, 1998)

Definition of Terms

BOD:	Biochemical Oxygen Demand	NO23:	Nitrate + Nitrite
TSS:	Total Suspended Solids	Pb:	Lead
TP:	Total Phosphorus	Cu:	Copper
DP:	Dissolved Phosphorus	Zn:	Zinc
TKN:	Total Kjeldahl Nitrogen	Cd:	Cadmium

Storm water runoff volume is another important parameter in the PLOAD model and is based on the average yearly precipitation and imperviousness associated with each land use type. The average yearly precipitation value for the Clinton Main subwatershed in the PLOAD model is 32 inches. Table 3.24 provides the corresponding percent impervious value associated with each land use type.

Table 3.24: Percent Impervious Based on Land Use Type

Land Use Type	Percent Impervious
High Density Residential	50
Medium Density Residential	30
Low Density Residential	10
Urban Open	10
Commercial	90
Industrial	80
Highways	90
Forest/Rural Open	0.5
Agricultural	0.5
Water/Wetlands	100

The PLOAD model allows both point source loadings as well as the implementation of BMP . Neither of these inputs was added to the PLOAD model of the Clinton Main Branch Basin due to lack of data available for both of these data inputs.

Results

The Clinton Main subwatershed is urbanized and comprised mainly of single-family residential, low-density residential and industrial land use types. Surface waters and lakes also account for a significant portion of the subwatershed. Map 17 outlines the land use information used in the PLOAD model. Because the subwatershed is significantly urbanized, variability in the storm water runoff pollutant loadings between sub-basins is minimal.

Results of the normalized pollutant loading analysis are shown in Table 3.25: Pollutant Loading Results of PLOAD Model Runs. Map 16 also depicts the delineated sub-basins with the associated annual loading rates. In order to provide a frame of reference for the results, a comparison to both urban and rural subwatersheds has been included . A catchment within the Red Run subwatershed was selected as the nearby urban subwatershed while the North Branch subwatershed was selected as the rural subwatershed.

Table 3.25: Pollutant Loading Results of PLOAD Model Runs

BASIN	*BOD*	*TSS*	*TP*	*DP*	*TKN*	*NO23*	*PB*	*CU*	*ZN*	CD
Clinton Main	44	158	0.7	0.3	4.2	2.9	0.10	0.065	0.46	0.006
Red Run	63	245	0.9	0.4	5.4	3.7	0.14	0.10	0.73	0.009
North Branch	5	50	0.2	0.1	1.0	1.4	0.01	0.003	0.02	0.000
Clinton Overall	30	112	0.5	0.2	3.0	2.2	0.06	0.04	0.27	0.004

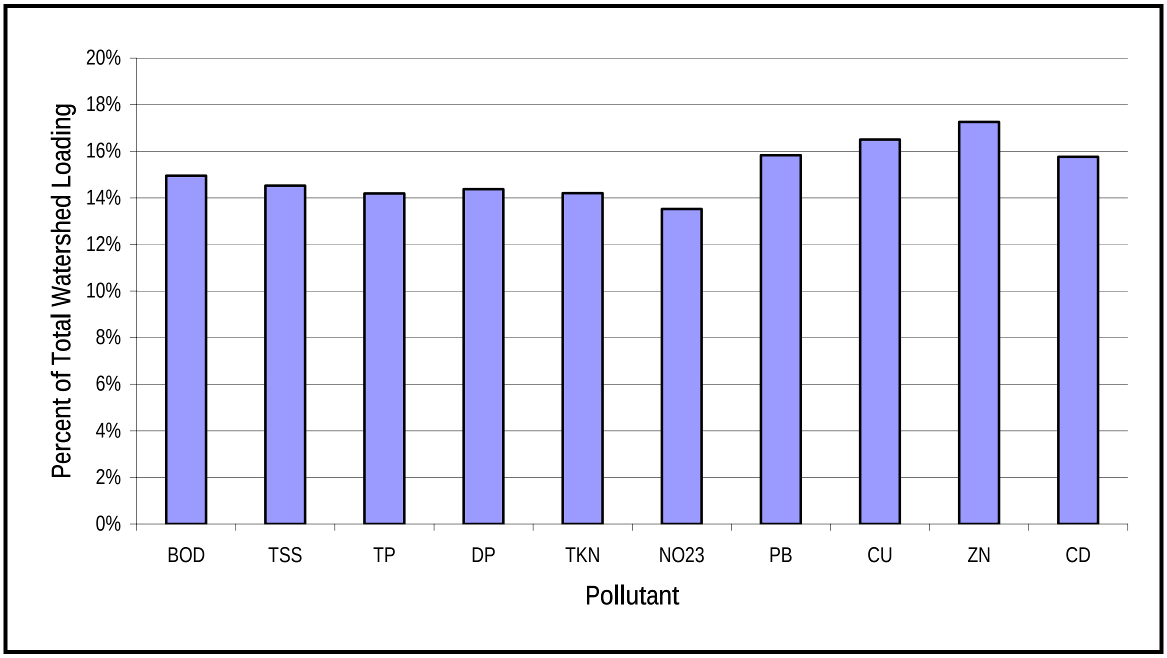
Overall, the delineated basins within the Main Branch of the Clinton River are somewhere between a rural and an urban watershed. However, most of the values of the pollutant loadings more closely resemble the loadings produced from a highly urban basin. Map 18 shows individual parameter results for phosphorus, nitrate and nitrites, biochemical oxygen demand and total suspended solids. The total loading of the Clinton Main subwatershed can also be compared to the total loading from the entire Clinton River watershed. This comparison can show the relative loading generated from the Clinton Main subwatershed. See Table 3.26 and Figure 3.11 for these results.

Table 3.26: Total Pollutant Loading from the Clinton Main Subwatershed

	Entire Clinton River Watershed	Clinton Main	Percent of Total Loading
BOD	13,668,722	2,044,139	15.0%
TSS	50,630,319	7,353,249	14.5%
TP	218,453	31,000	14.2%
DP	103,300	14,848	14.4%
TKN	1,378,958	195,892	14.2%
NO23	1,007,742	136,314	13.5%
PB	28,290	4,478	15.8%
CU	18,374	3,033	16.5%
ZN	123,465	21,314	17.3%
CD	1,740	274	15.8%
Area, Square Miles	760	73	9.6%

All Pollutant Units are in lbs/year

Figure 3.11: Percent of Total Clinton River Watershed Loading from the Clinton Main Subwatershed



Therefore, although the Clinton Main subwatershed comprises roughly 10% of the overall area of the Clinton River watershed, this subwatershed contributes from 13.5% to over 17% of the pollutant loading.

3.4.3 Point Source Discharges

The Michigan Department of Natural Resources Fisheries Division Draft Clinton River Assessment (December 2004) also describes point source pollution within the Clinton River Watershed. The Michigan Department of Environmental Quality has permitted 521 point source (storm sewer outfall discharges) discharges into the Clinton River and its tributaries. These permits have been issued through the National Pollution Discharge Elimination System (NPDES) Clean Water Act program. These permitted discharges emanate from wastewater treatment plants, water treatment facilities, industrial discharges, process water and storm water runoff. These permits also contain limits for various effluent parameters including metals, organics, nutrients, oil and grease, biochemical oxygen demand, temperature, dissolved oxygen and chorine.

3.4.4 Clinton Main Subwatershed Waters Listed Under the Clean Water Act Section 303(d)

The 1972 Clean Water Act (CWA) Section 303 (d) provides special authority for restoring polluted waters, calling on states to work with interested parties to develop Total Maximum Daily Loads (TMDLs) for polluted waters. A TMDL is essentially a "pollution budget" designed to restore the health of the polluted body of water, specifying the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. It also allocates pollutant loadings among point and non-point sources. If a body of water is "listed" for CWA Section 303 (d) in Michigan, the MDEQ is charged with the task of setting dates to determine the pollution budget for the listed waterbody, as well as setting dates by which the waterbody will meet the designated budget. It is important to recognize TMDL listed waters in the subwatershed so that the appropriate actions can be considered in this plan to address the various water quality or biological problems in these specified waterbodies.

Recent federal court decisions regarding Total Maximum Daily Loads (TMDLs) and subsequent changes in United States Environmental Protection Agency (USEPA) direction on the listing process have prompted the need for developing TMDLs for impaired waterbodies. In response, the USEPA has developed new rules regarding TMDLs that were implemented in 2002. Until that time, Michigan is proceeding with the TMDL process under the old rules. The MDEQ uses a rotating watershed cycle for surface water quality monitoring and National Pollutant Discharge Elimination System (NPDES) permit reissuance. Each of the 58 major watersheds in the State is scheduled for monitoring and discharge permit reissuance at least once every five years. This approach allows nonpoint source water quality-related issues and all the NPDES permits within a watershed to be addressed at the same time. Monitoring used to enhance permit issuance reviews is conducted in the targeted watersheds two years prior to NPDES permit reissuance. Michigan's Section 303(d) list is compiled by evaluating the most current, available site-specific data using the following decision process:

- The waterbody is not attaining Water Quality Standards (WQS), and the waterbody will not attain WQS with the application of technology-based controls, Best Available Technologies, or Best Management Practices.
- The waterbody is presently attaining WQS, but is expected to not meet WQS by April 2004 (Threatened Waterbodies).

Waterbodies that fall under these definitions are where the State needs to develop and implement either TMDLs or other suitable corrective actions to achieve WQS. The CWA Section 303 (d) list for the Middle One Subwatershed in the year 2004 includes the following waterbodies:

- Cass Lake located in the vicinity of Keego Harbor and West Bloomfield for PCBs and mercury. The schedule for TMDL development is 2010 & 2011, respectively.
- Clinton River from Yates Dam upstream to Pontiac WWTP outfall for poor fish communities. The schedule for TMDL development is 2006.
- Orchard Lake for mercury. The schedule for TMDL development is 2011.
- Osmun Lake upstream of Terry Lake in Pontiac for FCA-PCBs. The schedule for TMDL development is 2010.
- Terry Lake in Pontiac for FCA-PCBs. The schedule for TMDL development is 2010.

The complete report can be found on the MDEQ homepage, Surface Water Quality Division, GLEAS section. As the subwatershed communities and agencies develop their Storm Water Pollution Prevention Initiatives (SWPPIs), these waterbodies and their impairments should be given special consideration.

3.4.5 Clinton River Sediment Transport and Bank Erosion Hazard Index

US Army Corps of Engineers Clinton River Sediment Transport Modeling Study

The U.S. Army Corps of Engineers (ACOE) developed a series of sediment transport models for the Clinton River Area of Concern. The goal in these and other related studies is to support State and local reductions in sediment loading to navigation channels, and thereby reduce the costs for navigation maintenance and sediment remediation (ACOE 2005).

The ACOE used a set of computational tools to evaluate watershed hydrology, soil erosion, sediment delivery, river channel hydrodynamics and sediment transport to evaluate best management practices (BMPs) within the watershed. Three models were used (Watershed Characterization System [WCS], Soil and Water Assessment Tool [SWAT], and Gridded Surface Subsurface Hydrologic Analysis [GSSHA]). These tools allow a broad understanding of the hydrologic and geomorphic factors in the watershed, which in turn can be used to predict relative effects of changing land use on soil erosion and sediment yield. Each tool is a necessary component of the watershed evaluation, as no individual model can assess the entirety of the system.

This study compared catchment baseline conditions (such as effective precipitation and drainage area) with empirical relationships established in other studies. Using this method, net erosion is estimated on the order of 200 to 600 tons per square kilometer per year ($t/km^2/yr$) and sediment delivery to the outlet of the Clinton River (Lake St. Clair) of around 40,000 – 120,000 tons per year (t/yr) (ACOE 2005).

The Galloway Creek, a tributary to the main branch of the Clinton River , was considered separately in the ACOE investigation. This watershed covers approximately 17 square miles (mi^2). It is classified as 44 percent (%) urban/developed, 24% agriculture, 27% forested and 8% water and wetlands. The model calculated that the amount of sediment in urban runoff to this tributary delivered to the channels is on the order of hundreds to several thousand cubic meters of which, approximately 93 percent leaves the system and enters the lower reach of the Clinton Main watershed.

In general, the models determined that land use and land use change are key factors contributing to soil erosion and sediment yield in this watershed. Cultivated and grazed land is the greatest nonpoint source of sediment, while developed land leads to flashy river flow (ACOE 2005). The models determined that sediment yields are not strongly correlated to population or new housing developments. Instead, sediment yield is strongly controlled by the occurrence of peak flows. As a result, increased flashiness due to urban development appears to trigger river channel instability and therefore increased channel erosion (ACOE 2005). This offsets the anticipated reduction in the amount of sediment available for transport once an area undergoes urbanization. The ACOE evaluated several best management practices to determine the effectiveness of various remedial measures. The impact of buffer strips on sediment load was evaluated the most thoroughly. It was determined that buffer width had the most influence on sediment load, rather than the vegetation type within the buffer. Other BMPs that were evaluated included sedimentation basins, wetlands, and construction control measures.

Streambank erosion is a natural process that occurs in every watershed; however excessive erosion has serious consequences for the physical and biological functions of any river system. Eroding streambanks can be a major source of pollutant loading to streams and it is often difficult to quantify streambanks eroding at natural rates as opposed to streambank erosion due to changes in watershed hydrology or sediment loads.

Bank Erosion Hazard Index

The Bank Erosion Hazard Index is a procedure developed by Dave Rosgen of Wildland Hydrology for assessing streambank erosion condition and potential. It assigns point values to several aspects of bank condition and provides a scoring mechanism for inventorying streambank conditions over large areas and prioritizing eroding banks for restoration (Rosgen, 2001).

The Michigan Department of Environmental Quality developed a Standard Operating Procedure for Assessing Bank Erosion Potential using Rosgen's Bank Erosion Hazard Index (BEHI). This method was utilized at each of the road stream crossings within the Clinton Main subwatershed. Results of the field surveys are provided on Table 3.28 and shown on Map 19. These results are compared with the other field surveys and data in order to categorize critical areas for the subwatershed. The following information highlights the information collected during the survey:

The Modified Bank Erosion Hazard Index (BEHI) is a subjective survey of existing stream bank conditions. It is used to determine the probable likelihood of streambank erosion. Both banks of the watercourse are subject to the survey. In both the upstream and downstream directions there are 4 observational categories that are evaluated during this survey that include the following:

- Root Depth to Bank Height- This represents the average root depth to the bank height.
- Root Density – This represents the proportion of the streambank surface covered and protected by plant roots.
- Bank Angle – This is the angle of the streambank from the waterline to the top of bank.
- Surface Protection – Similar to root density, but higher ranking if stone is present.

The Total Score relative to the BEHI Category described in Table 3.27 below describes the potential for bank erosion to occur on one streambank. Four streambanks were assessed at each Survey Site, the right and left bank looking both upstream and downstream. Subsequent to determining the Total Score as shown in Table 3.27, a point system of five (5) points per streambank was assigned in order to further characterize the entire Survey Site.

Table 3.27: Bank Erosion Hazard Index Score

BEHI Category	Total Score	Points Assigned at for each bank (4 at each site)
Very Low	<=5.8	5
Low	5.8-11.8	4
Moderate	11.9-19.8	3
High	19.9-27.8	2
Very High	27.827.9-34.0	1
Extreme	34.1-40	0

From these scores, an overall ranking was applied to the survey area. A total of 20 points was possible for each survey site, with 20 points representing the best possible score and minimal erosion potential. Table 3.28 depicts the overall Survey Site score based on this point system.

Table 3.28: Bank Erosion Hazard Index Scoring Results

Survey Site	CM01	CM02	CM03	CM04	CM05	CM06	G01	G02	G03	G04	G05	PC01	PC02	T01	T02	T03
Total Points	14	15	14	13	13	16	14	13	12	16	15	20	12	15	16	16

Map 19 illustrates the ranking for each of the survey sites within the subwatershed. "Poor" sites show signs of extensive erosion conditions. A "Fair" site displays some erosion but has a good foundation that will limit future erosion. This foundation may consist of vegetation growth on the banks or slight slope angles on the bank. Finally, a "Good" site will have minimal erosion. These sites have a good vegetation buffer and root cover. As the ACOE study demonstrated, increased imperviousness has had an impact on the flashiness in the river, which in turn impacts the direct channel bank erosion.

3.5 Physical Watershed Environment Characteristics

Michigan Department of Environmental Quality Road Stream Crossing

Field surveys were conducted at road stream crossings within the Clinton Main subwatershed in order to gain an overall picture of the physical conditions of the subwatershed. The Michigan Department of Environmental Quality, Surface Water Quality Division, developed the Stream Crossing Watershed Survey Procedure. This procedure is generally used as a screening tool to increase the amount of information available on the water quality of streams and rivers. It provides a standardized assessment with data recording procedures for use by experienced watershed professionals as well as trained volunteers for long-term watershed monitoring programs.

Field surveys within the Clinton Main subwatershed consisted of evaluating various parameters at road stream crossings in the subwatershed. Table 3.29 identifies the community and road crossing location with the corresponding site identification number. Physical conditions were documented on the MDEQ's Single Site Watershed Survey Data Sheet and compiled into a database for comparison with other watershed data.

Table 3.29 Survey Site Location

Site Number	Road Crossing	Community
CM01	Avon/Dequindre	Rochester Hills
CM02	Livernois south of Avon	Rochester Hills
CM03	Auburn	Auburn Hills
CM04	Martin Luther King	Pontiac
CM05	Orchard Lake Road	Pontiac
CM06	Cooley Lake	Waterford
G01	Butler	Rochester Hills
G02	Pavilion	Oakland University
G03	Squirrel	Auburn Hills
G04	Perry	Pontiac
G05	Giddings	Pontiac
PC01	Sanderson & Norton	Pontiac
PC02	Oakland County	Pontiac
T01	Elizabeth Lake Road	Waterford
T02	Coomer Road	Waterford/W. Bloomfield
T03	Orchard & Pine Lake	Orchard Lake Village

The data was tabulated and points were assigned to various categories in the survey. A total score was achieved for the Physical Characteristics. Points were awarded depending on width of the stream riparian vegetation buffer and type of vegetation, such as lawn, wetland or forest, along with the diversity of instream cover and substrate. Points were deducted for negative appearance factors such as turbidity or floating algae and if the adjacent land uses consisted of impervious or disturbed ground. Points were also deducted for any potential pollution source recorded based on low, moderate or high severity. Potential sources included but were not limited to urban runoff, site development construction activities and road runoff. The following information describes the data that were collected during the Road Stream Crossing Survey along with the associated points that were allocated based on these data:

Stream Width and Depth and Highest H_2O Mark: Stream depth indicates the average depth over the area observed while the highest watermark is determined from the bridge/culvert crossings. This gives a relative indication of flow variability within the stream. These data were reviewed from an overall relative perspective and not included in the total scoring of this category due to the fact that more detailed information have been studied and are described in Section 3.4 River Flow Characteristics.

Stream Flow Type: This describes the general volume of flow in relation to an overall annual average. The various types include Dry, Stagnant, Low, Medium, or High. Dry refers to no standing or flowing water and bottom sediments may be wet. Stagnant refers to water present, but not flowing. Low, Medium and High categories reflect the flow in relation to the average for the stream.

Substrate: This is the material that makes up the bottom of the stream and is a general indication of potential aquatic habitat. This information was compared to the macroinvertebrate results for consistency. This category was included in the overall ranking of the Physical Characteristics. Table 3.30 describes the categories and the ranking methodology are described as follows:

Table 3.30 Road Stream Crossing Substrate Points

Substrate Type	Points Assigned
>50% Boulders	3
>50% Cobble/Gravel	2
>50% Sand	1
>50% Artificial/Clay/Fine Grain	0

River Morphology: This describes the presence of pools and riffles and which gives an indication of potential aquatic habitat. Table 3.31 describes the points were assigned as follows:

Table 3.31 Road Stream Crossing Morphology Points

Morphology Type	Present/Abundant	Points Assigned
Pools	Present	1
	Abundant	2
Riffles	Present	1
	Abundant	2

Instream Cover: This describes the type of cover available for various aquatic habitat species. One point was assigned to each of the following categories if it was observed to be present during the survey:

- Undercut banks, overhanging vegetation, deep pools, boulders, aquatic plants and logs or woody debris.

Stream Corridor: This describes the condition, buffer widths, vegetation types and stream canopy of the riparian corridor. Table 3.32 describes the points, which were assigned to each characteristic in this category:

Table 3.32 Road Stream Crossing Stream Corridor Points

Stream Corridor Characteristic	Points Assigned
Riparian Vegetation Width Left	
<10 feet	1
10-30 feet	2
30-100 feet	3
>100 feet	4
Riparian Vegetation Width Right	
<10 feet	1
10-30 feet	2
30-100 feet	3
>100 feet	4
Bank Erosion	
No Erosion	3
Low Relative Erosion	2
Moderate Relative Bank Erosion	1
High Relative Bank Erosion	0
Streamside Land Cover	
Bare	0
Grass	1
Shrubs	2
Trees	3
Stream Canopy (%)	
<25%	1
25-50%	2
>50%	3

Physical Appearance: This category identifies various characteristics observed in the stream, a list of which is provided in Table 3.33. One point was deducted if the characteristic was obviously "*present*" while 2 points were deducted from the total score if the characteristic was "*abundant*".

Table 3.33: Road Stream Crossing Physical Appearance Categories

Aquatic Plants	plants roots/stems/leaves
Floating Algae	suspended algae or floating algae (not observed in fall timeframe)
Filamentous Algae	algae that appear in stringy/ropy strands
Bacterial Sheen/Slimes	Oily sheens from bacterial decomposition; distinguished from petroleum products by

	breaking into distinct platelets when disturbed.
Turbidity	Water appears cloudy
Oil Sheen	Caused by petroleum products; thin sheen has rainbow of hues
Foam	Natural foam typical in streams when water flows thru rapids or past surface obstructions; distinguished from soapsuds by rubbing it between fingers. If it disintegrates and leaves wet or gritty residue, then it is naturally occurring. If it is slippery/soapy, then it is not natural foam.
Trash	General litter.

Potential Pollution Sources: Adjacent land use types are also noted at each of the selected sites. This observation provides a relative understanding of the types and extent of pollutant loadings entering the river near the site. Finally, points were deducted for the presence of various Potential Pollutant Sources. Pollutant Potential was scored on a Slight, Moderate or High scale. To convert to a point system a Slight score received 1 point, a Moderate score received 2 points and a High score received 3 points. Table 3.34 provides the list of Potential Sources to select from.

Table 3.34 Potential Pollution Source List

POTENTIAL SOURCES	
Crop Related Sources	Land Disposal
Grazing Related Sources	On-site Wastewater Systems
Intensive Animal Feeding Operations	Silviculture (Forestry NPS)
Highway/Road/Bridge Maintenance and Runoff	Resource Extraction (Mining NPS)
Channelization	Recreational/Tourism Activities
Dredging	• Golf Course
Removal of Riparian Vegetation	• Marinas/Recr. Boating (water releases)
Bank and Shoreline Erosion/Modification/Destruction	• Marinas/Recr. Boating (bank or shoreline erosion)
Upstream Impoundment	Debris in Water
Construction: Highway/Road/Bridge/Culvert	Industrial Point Source
Construction: Land Development	Municipal Point Source
Urban Runoff (Residential/Urban NPS)	Natural Sources
	Source(s) Unknown

Clinton River Cold Water Conservation Project (CRCCP)

The Clinton River watershed includes three DNR designated trout streams and several more tributaries that are known to harbor trout year-round. A steelhead run is located within the lower main branch of the Clinton River. The Clinton Valley Chapter of Trout Unlimited (TU) has worked on long-term habitat restoration for trout streams in the watershed.

The Clinton River Cold Water Conservation Project consisted of a first phase, which included an evaluation of 25 miles of river and tributary from Squirrel Road downstream to Yates Dam. An assessment of the cold water potential and public access opportunities in lower Galloway Creek and the middle mainstream section of the Clinton River was completed in order to determine potential designation of a trout stream. Stream inventory work consisted of an evaluation of physical conditions including riparian corridor, woody debris and aquatic plants. Stream temperature, morphology and macroinvertebrate surveys were also conducted. Data collected from this study was also incorporated into the physical data collected in the during the road stream crossing.

The maximum number of points possible was 92 with sites ranging from 1 to 40 points. The highest quality sites were G02 and G03 while the lowest quality sites were CM02 and T01 strictly based on this physical characteristic data. These data were further used with the macroinvertebrate survey data, the bank erosion hazard index and the nonpoint source pollutant loading estimates to qualitatively describe initial critical areas within the subwatershed. Further discussion is presented in Section 3.10 Description of Critical Areas.

3.6 Biological Conditions

Macroinvertebrates

Aquatic macroinvertebrate communities (aquatic insects and invertebrate animals) are useful long-term indicators of water quality. Aquatic macroinvertebrates live in or on the bottom of streams, and include species of insects, clams`, snails, worms, scuds, sow bugs, and crayfish, among others. Since macroinvertebrates are relatively immobile and short lived, the presence/absence, abundance, and diversity of certain taxanomic groups (taxa or family of macroinvertebrates) can indicate long-term changes in water quality.


Site G03 – Galloway Creek, Oakland University Katke-Cousins Golf Course

Different groups of macroinvertebrates respond differently to changes in water quality and physical habitat characteristics. Generally, a natural, unpolluted stream supports a diversity of macroinvertebrates. Examples of sensitive aquatic insect groups include the stonefly, mayfly, and caddisfly orders. These insect orders are almost always present in healthy stream environments, and usually represent a significant portion of the overall macroinvertebrate numbers. In degraded streams, such “pollution-intolerant” macroinvertebrate groups are less abundant or absent, while more “pollution-tolerant” groups become more abundant. Examples of such pollution-tolerant macroinvertebrate groups include aquatic worms, midges, leeches, and true bugs. Many of the pollution-tolerant aquatic insect groups have the ability to survive low dissolved oxygen conditions by using atmospheric oxygen.

Macroinvertebrate communities have been assessed at twelve main branch sites and nine tributary sites throughout the Clinton River main subwatershed (Map 21). Multiple assessments have been conducted at some sites between 1991 and fall of 2004. Environmental Consulting & Technology, Inc. (ECT) conducted assessments at fourteen sites in November 2004 to provide recent macroinvertebrate community assessment data for the entire Clinton River main subwatershed, including tributaries. All of the assessment data was collected and evaluated using the Michigan Department of Environmental Quality “Stream Crossing Watershed Survey Procedure, April 27, 2000” (Procedure). The Procedure outlines macroinvertebrate sampling methodology and provides a data form for scoring the assessment sites

(Appendix D). The Procedure results in a "Stream Quality Score" (SQS) and ranking. Table 3.36 presents summary statistics for individual main branch sites with three or more data points and all main branch sites combined (includes assessment data collected between 1999 and fall 2004).

Mayfly– Ephemeroptera,
Heptagenidae family

Mayfly adult

Table 3.36: Macroinvertebrate Summary Stream Quality Scores.

	Stream Quality Score (SQS)			
Site	Count	Mean	Min	Max
CM03	9	33	16	45
CM05	3	31	21	39
CM01	3	49	36	59
ALL	24	31	13	59

*Summary statistics of assessment data collected between 1999 and fall 2004

Interestingly, the furthest downstream site, CM01 (23 Mile Road/Yates Park), had the highest SQS, was the only main branch site to receive an Excellent ranking in two out of three assessments, and had the highest mean SQS. The lowest main branch SQS score was 13 and occurred at Auburn Road.

The location and ranking of sites assessed by ECT in November 2004 are shown on Map 22 in Appendix A. Figure 3.12 shows the results of ECT's November 2004 macroinvertebrate assessments. Although three sites ranked as Good, the scores for those sites (36, 37, 39) only slightly exceeded the lowest possible score for the Good ranking of 34, range 34 to 48. The highest scoring site scored 39 out of a possible 74 points. Generally, as diversity of macroinvertebrates decreases, the SQS and ranking decrease.

Net-spinning caddisfly – Trichoptera, Hydrosychidae family

The mean number of taxa seemed to be the best predictor of community rank. Figure 3.13 shows that the mean number of taxa was highest for Good sites and lowest for Poor sites. The mean number of common taxa also shows a similar trend. However, the mean number of taxa seemed to be a stronger indicator of macroinvertebrate community health. The low influence of common taxa is probably suggestive of general low abundance across all sampling stations, and is reinforced by observation during field sampling.

Figure 3.14 shows the contribution of the three pollution tolerance groups to the total SQS. The sensitive group score is an important aspect of higher total SQS scores. The sensitive taxa group accounted for fifty-three percent (53%) of the mean score for the Good sites, but only accounted for thirty-percent (30%) of the mean score for Fair and Poor sites. Furthermore, the mean tolerant taxa group score of Fair and Poor sites was double that of Good sites (24% versus 12%). In addition, the sensitive taxa group was dominant at Good sites, while the moderately sensitive taxa group was dominant at Fair and Poor sites. The primary difference between Good sites and Fair or Poor sites was the number of sensitive taxa. The main difference between Fair and Poor sites was the total number of taxa rather than the community composition.

Typical macroinvertebrates present at the sites included the following:

- ❖ Good: Beetle adults, Caddisfly larvae, Mayfly, Stonefly
- ❖ Fair: Clams, Cranefly, Damselfly, Scuds
- ❖ Poor: Aquatic worms, Midge larvae, Sowbugs, Water snipe flies, Pouch snails

Caddis flies were present, and typically common, at all but three sites (G04, PC02, and T01). Either scuds or sow bugs (crustaceans), sometimes both, were present at all but one site (PC02). One or the other were typically common if present. When both were present, only one was typically common. The most variable taxa were the mayflies, stoneflies, and adult beetles. Other surprising observations include the absence of blackflies at many sites, and low abundance at sites where they were present.

Comparing 2003 and 2004 data, including ECT's fall 2004 data, with data collected prior to 2003 yields some interesting information about macroinvertebrate communities in the Clinton River main subwatershed area (comparisons were not made with tributary data due to the low number of samples available). Due to the low number of assessments in any given year, the assessment data were pooled for the years 1999 through 2001 for comparison to more recent data (2003 and 2004, no 2002 data are available).

This comparison was drawn two ways. First, all of the 2003 and 2004 assessment sites were used to calculate a mean SQS. Second, only the 1999-2001 assessment sites (CM01 and CM03) were used to calculate the mean SQS for 2003 and 2004 (only CM03 was assessed in 2003, yielding two data points). In 2004, twelve different sites were assessed including, CM01 and CM03. Those twelve sites covered the entire Clinton River main branch within the main sub-watershed area, although nine of the twelve are located east of the I-75 corridor. Table 3.37 summarizes the results of macorinvertebrate assessments in the Clinton River main subwatershed area over time.

Table. 3.37: Summary Stream Quality Scores for Clinton Main Sites by Year.

	Stream Quality Score (SQS)			
Period	Count	Mean	Min	Max
99-01 All Sites	5	41	22	59
2003 All Sites	4	35	24	45
2004 All Sites	15	26	13	42

	Stream Quality Score (SQS)			
2003 CM03 Only	2	35	24	45
2004 CM01/CM03 Only	5	35	16	42

Figure 3.15 shows the apparent trend in stream quality score resulting from this comparison between the 1999-2001 period and 2003/2004. The trend using all 2003/2004 assessment sites shows a decrease in the mean SQS from 41 during the 1999-2001 period to 26 in 2004. When only the 1999-2001 period assessment sites are used to calculate the 2004 mean, the difference is less, but still shows a declining trend from 41 to 35. Similar declines can be seen in the maximum and minimum SQS values. The differences in the mean SQS in 2004 for all assessed main branch sites and CM01/CM03 only suggests that spatial variability plays some role in defining the trend. However, even the CM01/CM03 mean for 2004 shows a decline in the mean SQS from the 1991-2001 period. It is worth noting that the differences in the means between the 1991-2001 period and 2004 (including all 2004 sites) is not statistically significant (t=1.66, a=0.5). However, the t-test used is not very robust due to the low number of samples obtained during the 1991-2001 period (n=5). It is plausible that the declining trend may have been significant had the 1999-2001 period assessments been more extensive.

Despite the results presented above, it is difficult to conclude at this time whether the macroinvertebrate community health is changing in the Clinton River main sub-watershed area. Biological populations and communities can fluctuate substantially. It is possible that the 1999-2001 data represent a high point, while the 2004 data represent a low point. Such swings in populations can be caused by various environmental factors, both natural and human-induced. Figure 3.16 illustrates this point very well. Figure 3.16 shows the results of assessments conducted at CM03 between 1999 and fall 2004. This is the only site with a long enough sampling history to make this illustration possible. The CM03 data show substantial variation with no clear trend. Future volunteer monitoring efforts will be important to determining whether macroinvertebrate community health in the Clinton Main subwatershed area is stable, declining, or improving.

The Michigan Department of Natural Resource recently released its Final Draft of the Clinton River Assessment. In the assessment, the MDNR presents the results of watershed-wide sampling in the 1970's and early 1980's (35 sites) and recent, but more spatially limited, sampling. The assessment does not provide information about sampling site locations, but does reference a 1988 MDNR report (MDNR 1988). The MDNR assessment summarizes macroinvertebrate assessment results in the executive summary:

Riffle beetle adult

Riffle beetle larvae

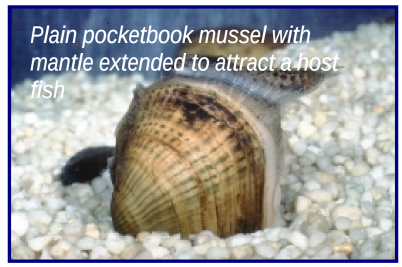
> "The headwaters area and some of the major tributaries, such as Paint Creek and North Branch of the Clinton River have good species diversity, including sensitive species that are indicators of good water quality. However, abundance of sensitive species have declined in recent samples, indicating reduced water quality. But other severely degraded sections, such as downstream of Pontiac, have shown a recovery."

The results presented in the MDNR assessment are briefly summarized below.

Upper Segment (Middle Lake to I-75)
During the 1970's and early 1980's, pollution tolerant species dominated the macroinvertebrate community upstream of Pontiac, although mayflies and caddisflies were present in reduced numbers. Only one site was sampled in 1999. The 1999 sampling found no mayflies or caddisflies.

Middle Segment (I-75 to M-59 at Utica)
Sixteen sites were sampled in the Middle Segment during the 1970's and early 1980's. Macroinvertebrate assessment results during the early 1970's were indicative of heavy industrial pollution and poor waste water treatment, especially downstream of the Pontiac and Rochester waste water treatment plants. Macroinvertebrate communities improved downstream of the WWTPs. Later assessments in 1982 showed that macroinvetebrate communities were improving due to advancing waster water treatment technologies, tighter regulatory controls, and increasing awareness of environmental concerns. More recent assessments in 1994 and 1999 had similar results to the 1982 assessments.

Mussels


Plain pocketbook mussel with mantle extended to attract a host fish

Typical macroinvertebrate assessment methods like those described and used herein and by volunteer groups, generally are not designed to assess mussel populations. The macroinvertebrate assessments described above do not provide information about past or current mussel populations. The MDNR assessment (MDNR 2004) provides results from mussel-specific surveys conducted primarily in the late 1970's. The results presented in the MDNR assessment are summarized in the assessment's executive summary:

> "A comprehensive mussel survey was conducted throughout the watershed in 1977 and 1978. Species richness in the Clinton River was excellent (31 species). A colony of purple lilliput is the only known colony in the state and the largest colony reported anywhere since around 1900 and the upper Clinton also supports what is likely the only population or rayed bean living in Michigan's streams. The North Branch of the Clinton River contains the finest remaining example of a large river mussel community in eastern Michigan, because it has many species that have been extirpated from their range in eastern Michigan. More recent sampling of mussels in the upper Clinton River in the mid-1990s found similar species present as earlier samples, although relative abundance varied." (MDNR 2004)

An effort should be made to assess the current status of mussel populations in the main sub-watershed area, especially populations of threatened, endangered, and special concern species.

Fisheries


Longear sunfish (Lepomis megalotis)

The most comprehensive source of information about the fisheries of the Clinton River main sub-watershed area is the MDNR 2004 Final Draft of the Clinton River Assessment. The assessment thoroughly summarizes past and current fish populations, management practices, and fisheries status in the executive summary:

> "There is little information on the Clinton River's original fish community, although fisheries surveys show 100 species of fishes recently occurring in the Clinton River drainage. Most species are native, although 3 species have colonized and 17 species were introduced

(some intentional and others accidental). Four introduced species (coho and kokanee salmon, cutthroat trout, and lake whitefish) are no longer present because their stocking programs have stopped. Nine species have been identified as status unknown because they have not been captured during recent fisheries surveys. Although present fish species richness in the Clinton River watershed remains high, certain species have declined. Watershed development has favored tolerant species with broad habitat requirements. Agricultural and urban development activities have reduced flow stability and increased sediment load in streams throughout the watershed. The abundance of silt-tolerant fish species have increased in the watershed, whereas fishes requiring clean gravel substrate or clean water with aquatic vegetation at some point in their life cycles have declined." (MDNR 2004)

"Fish sampling was conducted by Fisheries Division at 38 sites throughout the watershed during the summer of 2001 and 2002. Sixty one species of fish were caught, with white suckers, creek chubs, bluegills, green sunfish, largemouth bass, and Johnny darters being the most frequently seen species among sites." (MDNR 2004)

"Fishery management of the Clinton River ranges from low in the headwaters and upper segment to high in the middle and lower segments and Paint Creek. Past management practices have included fish stocking, habitat improvements, fishing regulations, and chemical reclamation to reduce competitors. A number of species of fish have been stocked at various times and locations throughout the watershed. Current significant sport fisheries include a brown trout fishery on Paint Creek, and a seasonal steelhead and walleye fishery on the lower portion of the Clinton River. There are also ongoing stocking efforts at various lakes within the watershed." (MDNR 2004)

The MDNR used Michigan's Procedure 51 protocol to evaluate the well-being of the fish community at sampling sites. Procedure 51 provides a means of scoring and ranking fish communities using a set of ten metrics such as "Total Number of Taxa" and "Number of Darter Taxa." The results presented in the MDNR assessment are briefly summarized below.

<u>Headwaters Segment</u> (origin in north-central Oakland County to Middle Lake)

One site was surveyed in 2001. Survey results indicated water quality is good. Darter species, a sensitive species, made up 35% of the total number captured. The procedure 51 rating was excellent.

<u>Upper Segment</u> (Middle Lake to I-75)

Two main branch sites were sampled in 2001. Site 2 received an acceptable ranking, while site 3 received an excellent ranking. Several sites throughout Upper Segment were surveyed in the 1970's and early 1980's. The 2001 survey results were similar to previous survey results.

<u>Middle Segment</u> (I-75 to M-59 at Utica)

Three sites were sampled in the Middle Segment in 2001 and 2002. One of the sites, site 7, was downstream of the main sub-watershed area. Application of Procedure 51 resulted in site rankings of acceptable for sites 5 and 6. Site 7 received an excellent ranking. The assessment compared recent fisheries survey results in the Middle Segment to results of surveys conducted in 1973:

"Even given these constraints, there have been enough data collected to note clear changes in the fish community in the past three decades. In 1973, twelve stations were sampled along this [Middle] segment.

> Catch rates improved from 14.1 fish/100 foot sampled in 1973 to 58.5 fish /100 foot sampled in 2001 and 2002. Not only are more fish present in recent samples, but species richness has also improved. Pollution intolerant species were not found until the late 1980's. These results are not surprising given the history of pollution problems on the Clinton River downstream of Pontiac." (MDNR 2004)

Galloway Creek is the only major tributary of the MDNR's "Middle Segment" that is also within the main sub-watershed area. The MDNR surveyed the fishery of Galloway Creek at one site in 2001. The site was located between Galloway Lake and the confluence with the Clinton River. The fish population was dominated by pollution tolerant species, although a few rainbow trout and brown trout were captured. Results were similar to a survey conducted in 1986 with the exception of trout captured in 2001.

Figure 3.12: Clinton Main Subwatershed Macroinvertebrate Community Ratings

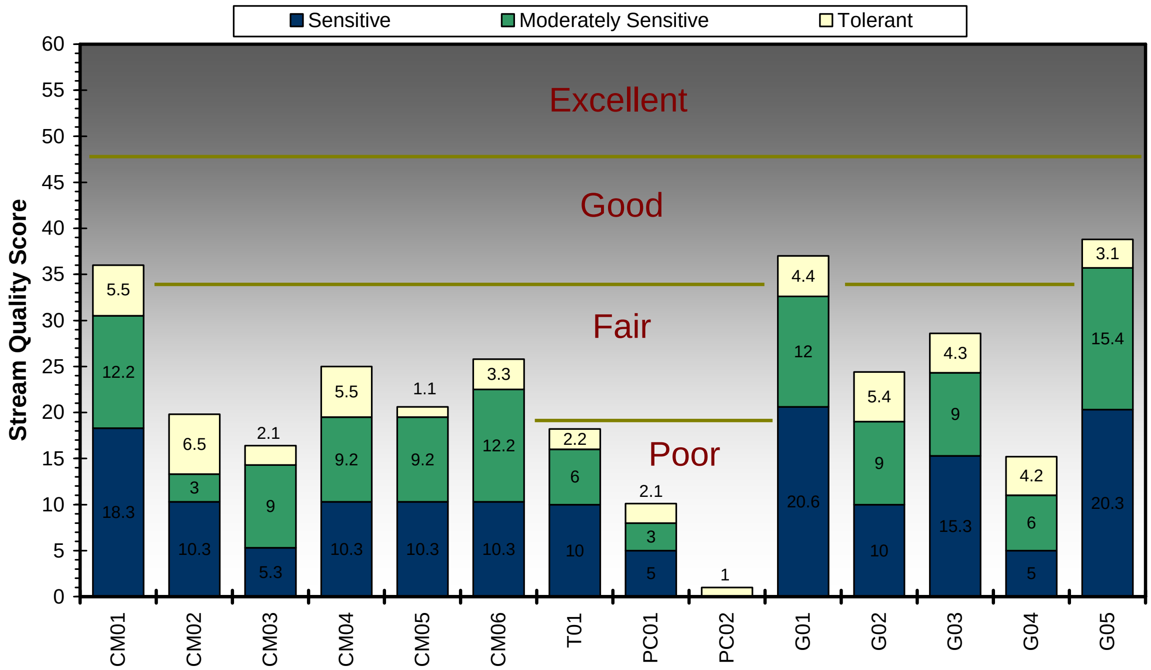


Figure 3.13: Number of Taxa by Rank (Measure of Diversity)

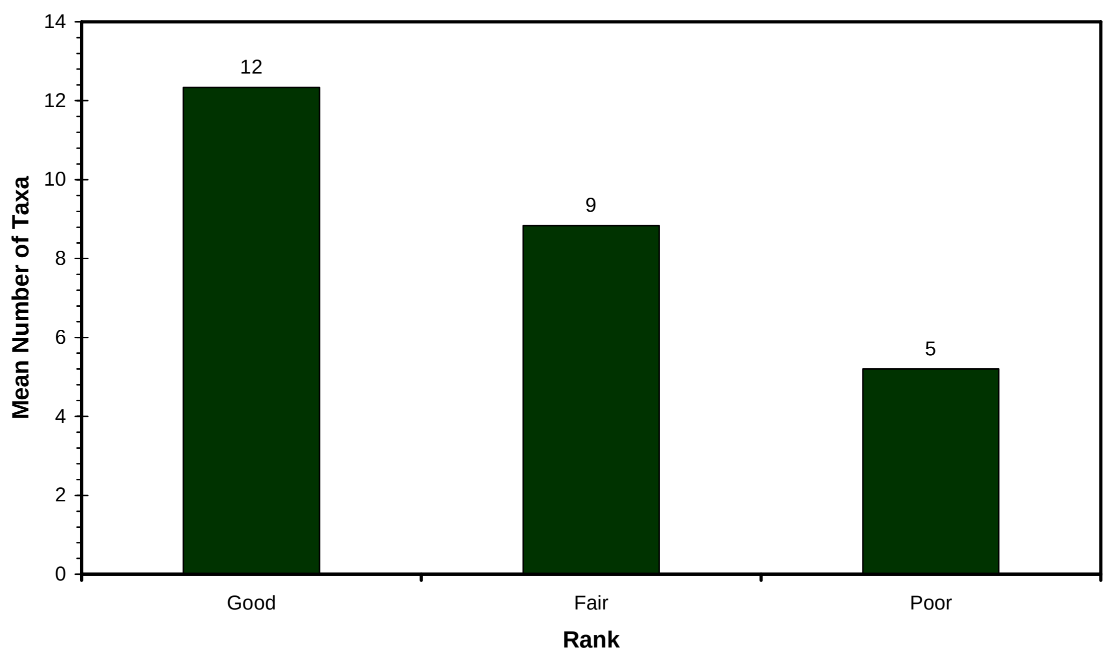


Figure 3.14: Taxa Group Scores by Site Ranking

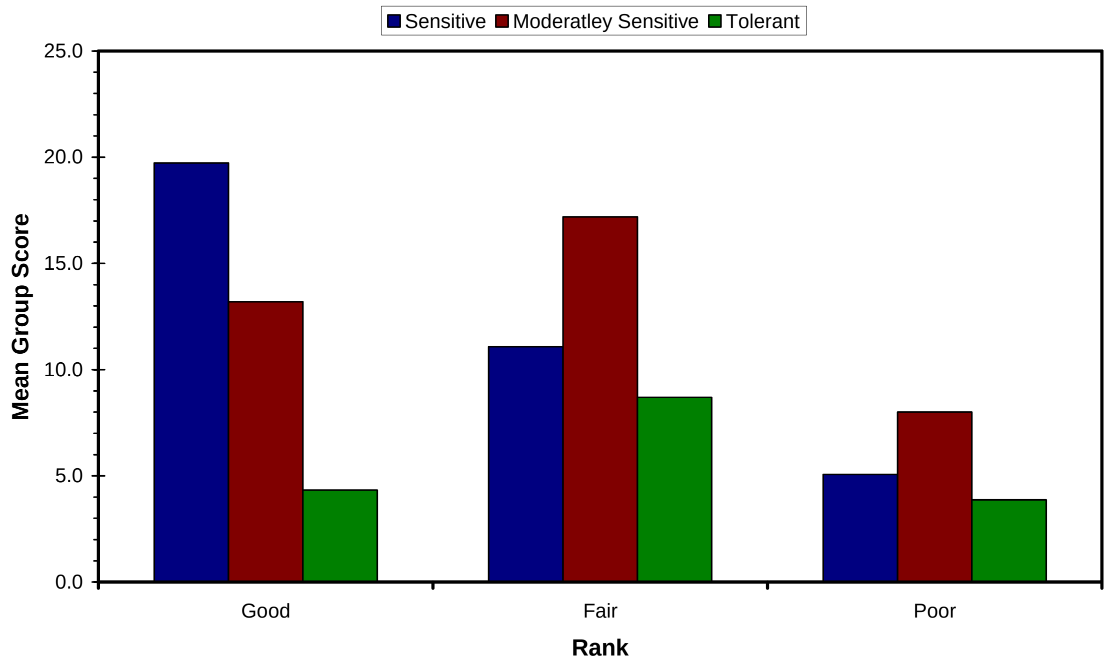


Figure 3.15: Time Trend Plot – Comparison of Stream Quality Scores

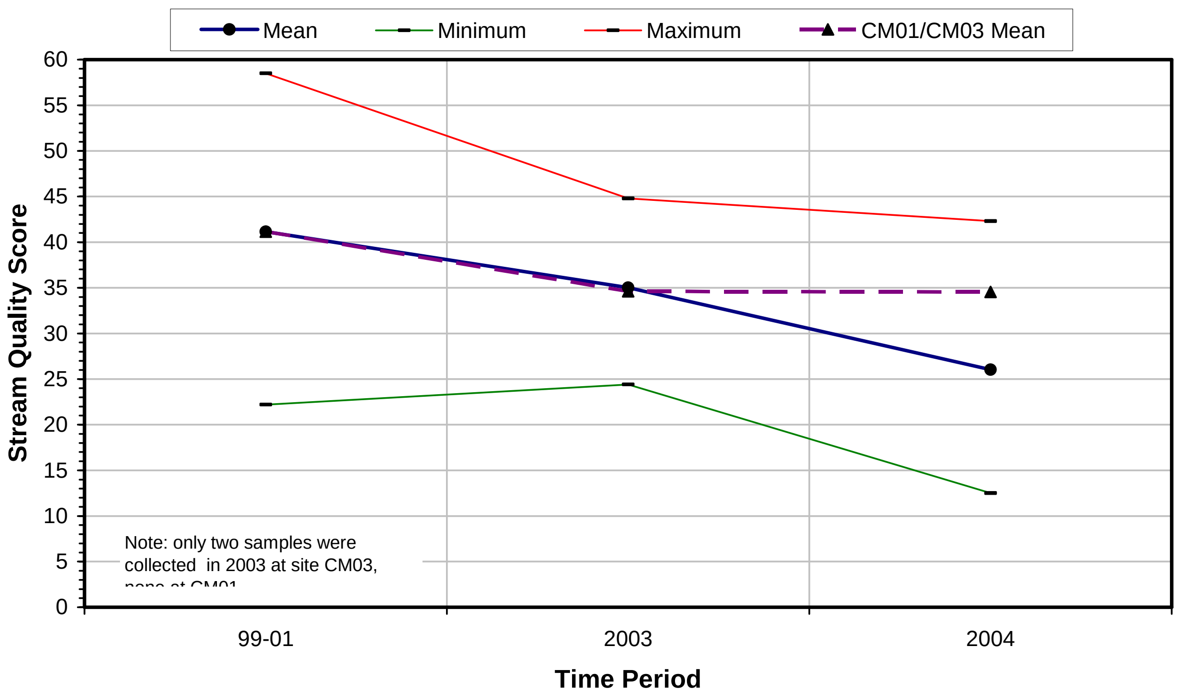
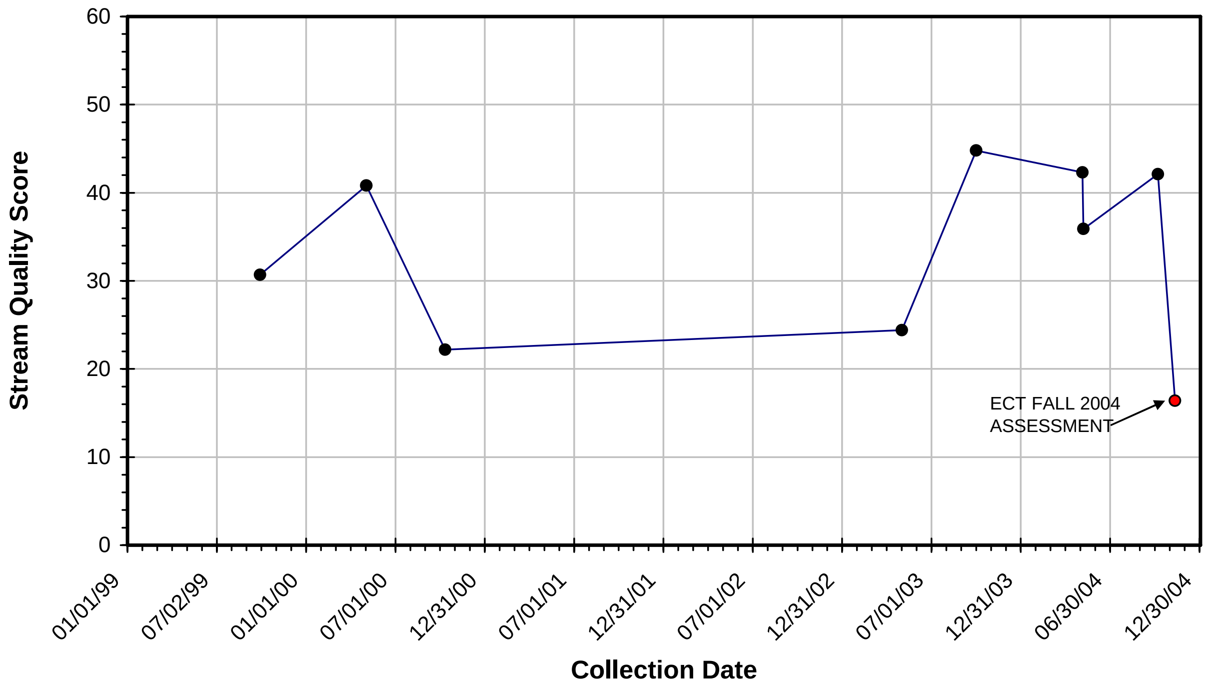


Figure 3.16: CM03 Time Trend – Stream Quality Scores



3.7 Quality of Lakes in the Subwatershed

There are a total of 172 lakes in the Clinton River Watershed that are at least 10 acres in size. The Upper segment of the Clinton River begins at Middle Lake and continues approximately 30 miles to just east of I-75 in Auburn Hills. Both the Upper and Main Clinton River subwatersheds encompass this area. The character of the river is influenced by the lakes that it passes through. Lakes traversed by the Clinton River following Middle Lake in the Upper Clinton subwatershed, include Dollar Lake, Greens Lake, Lotus Lake, Lester Lake, Van Norman Lake, Woodhull Lake, Lake Oakland, Loon Lake, Cass Lake, Otter Lake, Sylvan Lake, Dawsons Mill Pond and Crystal Lake. Of these lakes, Cass Lake, Otter Lake, Sylvan Lake, Dawsons Mill Pond and Crystal Lake are located within the Clinton Main subwatershed.

Within the Clinton Main subwatershed, the Clinton River is a connector between many of the lakes. It enters the west side of Cass Lake, flows to Otter Lake, then thru Sylvan Lake and exits Sylvan Lake at Telegraph Road. It then flows into Dawsons Mill Pond and finally Crystal Lake in Pontiac. All of these lakes have an impact on the flows in the Clinton River.

The overall quality of lakes is dependent on many factors, including water quality, recreational use and development around the shoreline of the lake. Phosphorus is a nutrient that is a major factor influencing the productivity or trophic state of a lake. Trophic state refers to a lake's ability to support plant/animal life. Oligotrophic lakes have little plant/animal life and are generally deep, clear and have little aquatic plant growth. Eutrophic lakes are shallower, turbid and have a high amount of plant and animal life. Mesotrophic lakes are classified in a stage between oligotrophic and eutrophic. Lakes with nuisance algae and weed growth are classified as hypereutrophic. Generally dissolved oxygen concentrations are highest in oligotrophic lakes and these lakes support cold water fish such as trout and whitefish. On the other hand, eutrophic lakes have lower dissolved oxygen concentrations and support warm water fish such as pike, bass and sunfish.

Various parameters are commonly measured to gage the level of eutrophication in a lake. These parameters include phosphorus concentrations in the water, *chlorophyll a*, transparency, dissolved oxygen, temperature and suspended solids. Temperatures in a lake indicate if the mixing process is occurring. This process occurs as nutrients move from the bottom of the lake into the surface waters and is apparent by the presence of algae blooms. Dissolved oxygen gives an indication of fish populations that may be supported in the lake. The transparency of the water is measured using a Secchi disk and the lower the value the higher the indication of a nutrient rich lake. Chlorophyll a provides an indication of the presence of plants and algae in the lake while phosphorus also is a primary indication of eutrophication.

Phosphorus is a plant nutrient and also a component of commercial products such as detergents and fertilizers. Phosphorus in surface water bodies may contribute to overgrowth of aquatic plants, which in turn can cause low dissolved oxygen levels. Dissolved oxygen is a measurement of the amount of oxygen held in the water and it is critical for survival of fish. Dissolved oxygen levels in the deeper parts of the Lake can be quite low in late summer months (WBTPE 2001). Other parameters, which are routinely measured in lake water, include conductivity, alkalinity and pH. Conductivity is a measurement of the amount of electrical current that can pass through the water. The more ions that are present, the higher the conductivity value. Alkalinity is the capacity of water to neutralize acids. Alkalinity measures components in water such as carbonates and bicarbonates (baking soda is a type of bicarbonate) in the water. The converse of this measurement is acidity (which is a measure of the water's ability to neutralize bases). pH gives an indication of the intensity of the water's acidic or basic character (American Public Health Association [APHA] 1989). Finally, water clarity in lakes is measured by a device known as a secchi disk, which measures the water clarity by depth in feet.

Various water quality and sediment data has been collected throughout a number of the lakes in the Clinton Main subwatershed. Data further described in this section includes water quality data for Orchard Lake, Cass Lake and Pine Lake. Sediment data has been collected in Sylvan Lake and is also summarized in this section. Maps 23 through 28 in Appendix A provided through the Michigan Department of Natural Resources website are survey maps of the following lakes within the Clinton Main subwatershed:

- Cass Lake; Map 23
- Crystal Lake; Map 24
- Elizabeth Lake; Map 25
- Pine Lake; Map 26
- Orchard Lake; Map 27 and
- Sylvan and Otter Lakes Map 28

3.7.1 Cass Lake Water Quality

Cass Lake occupies parts of Bloomfield and Waterford Townships, Orchard Lake Village and Keego Harbor in southeast Michigan. Its main tributary is the Clinton River. According to West Bloomfield Township Planning and Environment Department (WBTPE) (1997) Cass Lake flows to Sylvan Lake. It is approximately 1280 acres in size with a perimeter of 26.1 miles and maximum depth of 120 feet. The shoreline of Cass Lake is mostly developed for residential use, with manicured lawns commonly extending to the water's edge. During initial development, small seasonal summer cottages were constructed on the lakeshore. These summer cottages are being replaced with larger year-round homes. This increases the impervious surface associated with the perimeter of the Lake and may increase direct runoff to the Lake