5. Summaries of Studies and Data Collection

5.1. Water Quality Monitoring

Water quality sampling of the Huron Creek watershed has been completed in effort to characterize the overall water quality of the watershed, as well as to identify which parameters, if any, exceed existing standards. In this way, pollutants are identified and a platform is created from which further investigations and water-quality based improvement projects are launched.

5.1.1. Results from Previous Studies

The Michigan Department of Environmental Quality has conducted several water quality campaigns on Huron Creek since 2000, primarily in connection with water quality issues associated with the City of Houghton landfill. The results of these efforts are discussed in Chapter 6. Huron Creek has been monitored for water quality by several local educational institutions, including Houghton Middle School and Michigan Technological University over the last decade. The majority of these water quality sampling and analysis efforts has followed informal protocols and are not listed in this document. However, they have been compiled by the MTU Center for Water & Society (CWS) and can be examined by contacting the CWS Director (asmayer@mtu.edu).

5.1.2. Results from Quarterly Monitoring 2006-2008

Quarterly water quality monitoring of Huron Creek was completed by the MTU Center for Water & Society between November 2006 and May 2008. For each monitoring event, sampling was completed at five different locations, each chosen to reflect the water quality of a specific portion of the creek. These locations are indicated in Figure 5.1 and are described as follows, listed from upstream to downstream:

- Green Acres (GA) – This site is farthest upstream and is assumed to characterize water quality that has not been affected by development and disturbance.
- Downstream of Wetland (DWL) – This sampling site is downstream of the former Huron Lake, which is now a wetland mitigation site. This site is also downstream of residential areas that use septic systems and is the last location upstream of commercial development.
- Frog Pool (FP) – This site is the first downstream of commercial areas but is upstream of the former City of Houghton landfill.
- Landfill (LF) – This sampling location is immediately downstream of the former landfill that is located adjacent to Huron Creek. The placement of this site is intended to detect impacts the landfill may have on water quality.
- Houghton Waterfront Park (HWP) – This site is located near the mouth of Huron Creek in the Houghton Waterfront Park. This sampling location is utilized to characterize the aggregate water quality impacts of the entire watershed.

Figure 5.1 Water quality monitoring locations

At each of these locations, field data collection was completed as well as sample collection for laboratory analysis. A photo was also taken of the creek at each location to provide a record of flow conditions at that time. All details of sampling including parameters, analysis methods, sampling methods, equipment used and quality control are described in the Huron Creek Quality Assurance Project Plan (QAPP) for Water Quality Sampling that is provided as Appendix B. This QAPP was reviewed and approved by MDEQ to ensure that appropriate methods for sampling and data collection were utilized. All laboratory analysis was completed by White Water Associates, Inc. of Amasa, Michigan.

Water quality parameters were chosen to provide basic hydro-geochemical data and to detect potential impacts associated with the development activities that have taken place in the watershed including mining, residential development, and commercial development. These parameters are listed in Table 5.1.

Table 5.1 Water Quality Parameters Analyzed During Quarterly Sampling

Field-Analyzed Parameters
Air Temperature
Conductivity
Dissolved Oxygen
pH
Turbidity
Water Temperature
Laboratory-Analyzed Parameters
Alkalinity
Ammonia-N
Arsenic (total) [1]
Barium (total) [1]
Cadmium (total) [1]
Chromium (total) [1]
Copper (total) [a]
Hardness
Iron (total)
Lead (total) [1]
Manganese (total)
Mercury (total) [1]
Nitrate/Nitrite-N
Selenium (total) [1]
Silver (total) [1]
Total Kjeldahl Nitrogen
Total Phosphorus
Zinc (total) [1]

[1] These compounds are referred to the "Michigan 10 Metals"

The results of water quality sampling are provided in

Table 5.2. Samples labeled “FL” were duplicate samples collected at the landfill (LF) site for quality control purposes. Graphs of results for parameters yielding a significant number of data points (few to zero “no detects”) are provided in Figure 5.2 through Figure 5.15. Calculations related to quality assurance are provided as Appendix C. All water quality data has been supplied to MDEQ for inclusion into the U.S. Environmental Protection Agency’s Storage and Retrieval (STORET) Database. The Michigan Final Chronic Value (FCV), Aquatic Maximum Value (AMV) and Final Acute Value (FAV) are water quality standards based on the chronic (long-term) exposure threshold, maximum recommended threshold and acute (one-time) exposure threshold for aquatic life such as fish and macro-invertebrates, respectively. These standards are used for comparison to the collected data because Huron Creek’s parameter concentrations generally fall below or near them, and Huron Creek is not utilized as a drinking water source. The recommended parameter standards listed by MDEQ as Human Non-Cancer Values (HNVs) for drinking water or human body contact are generally significantly higher than those designated for protection of aquatic life. For example, the HNVs for copper are 0.47 mg/L (drinking water) and 38 mg/L (human body contact) compared to the aquatic thresholds which range from 0.009 to 0.027 mg/L[12].

[12] Based on an average hardness of 100 mg/L.

Table 5.2 Water Quality Monitoring Results for Huron Creek (11/16/06 – 5/9/08)

Event	Location	Alkalinity	Ammonia-N	Hardness	Iron (t)	Manganese (t)	Arsenic (t)	Barium (t)	Cadmium (t)	Chromium (t)	Copper (t)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
11/1/06	GA	69	0.05 J-	79.2	--	--	ND	0.0205	ND	0.0010 J-	ND
	DWL	63	ND	88.5	--	--	ND	0.0095	ND	0.0007 J-	0.010 J-
	FP	82	ND	111	--	--	ND	0.0101	ND	0.0010 J-	0.015 J-
	LF	127	0.15	174	--	--	ND	0.0264	ND	0.0017 J-	0.065
	HWP	139	0.09 J-	193.6	--	--	ND	0.0252	ND	0.0011 J-	0.048
2/7/07	GA	63	0.1	71.3	1.04	0.228	ND	0.026	ND	0.0027	0.0064
	DWL	84	0.1	106	0.35	0.0682	ND	0.0106	ND	ND	0.0066
	FP	99	0.11	127	0.33	0.205	ND	0.0132	ND	0.0014	0.018
	LF	124	0.14	163	1.7	0.388	ND	0.022	ND	0.0012	0.0315
	HWP	130	0.16	175	1.05	0.318	ND	0.0232	ND	0.0018	0.0369
5/7/07	GA	60	0.1	65.3	0.15	0.0256	ND	0.0152	ND	ND	ND
	DWL	54	0.08	68	0.32	0.0307	ND	0.0068	ND	ND	0.008
	FP	43	0.08	82.1	0.2	0.0587	ND	0.008	ND	ND	0.022
	LF	75	0.11	124	0.99	0.212	ND	0.0163	ND	ND	0.034
	FL	76	ND	106	0.89	0.196	ND	0.0153	ND	ND	0.031
	HWP	71	0.09	141	0.77	0.164	ND	0.0183	ND	ND	0.04
8/7/07	GA	94	0.08	89	0.62	0.166	ND	0.045	ND	0.001	0.0034
	DWL	191	0.32	188	1.76	1.24	ND	0.036	ND	ND	0.0518
	FP	218	0.07	232	0.43	0.97	ND	0.0268	0.001	ND	0.074
	LF	181	0.34	279	3.28	1.04	ND	0.0543	ND	ND	0.0523
	FL	186	0.32	277	3.22	0.997	ND	0.0519	ND	ND	0.0516
	HWP	180	0.06	250	0.31	0.108	ND	0.0296	ND	ND	0.0261
12/5/07	GA	54	0.1	57.9	0.34	0.0628	ND	0.0155	ND	0.0012	0.004
	DWL	68	ND	76.5	0.23	0.0902	0.01	0.0083	ND	ND	0.0089
	FP	86	ND	91	0.19	0.0924	0.01	0.009	ND	0.0007	0.0185
	LF	100	0.07	116	0.71	0.203	ND	0.0146	ND	ND	0.0357
	FL	99	0.08	124	0.68	0.201	ND	0.0138	ND	0.0006	0.0322
	HWP	106	0.05	129	0.49	0.18	ND	0.0157	ND	ND	0.0354
2/27/08	GA	54	0.06 J-	63.6	0.48	0.087	ND	0.0179	ND	0.002	0.006
	DWL	80	ND	93.3	0.11	0.013	ND	0.0078	ND	0.001	0.014
	FP	88	ND	97.6	0.16	0.061	ND	0.0093	ND	0.001	0.017
	LF	104	0.09 J-	132	0.70	0.201	ND	0.016	ND	0.001	0.032
	FL	102	0.09 J-	125	0.68	0.201	ND	0.0155	ND	0.001	0.03
	HWP	110	0.08 J-	147	0.54	0.181	ND	0.0168	ND	0.002	0.035
5/9/08	GA	40	ND	45.4	0.129	0.017	ND	0.0129	ND	0.0007	0.003
	DWL	48	0.08	53.2	0.175	0.041	ND	0.0065	ND	ND	0.01
	FP	56	0.07	62.8	0.164	0.036	ND	0.0069	ND	0.0006	0.019
	LF	66	0.06	84.9	0.309	0.076	ND	0.0099	ND	0.0016	0.031
	FL	68	0.08	66.6	0.283	0.075	ND	0.0098	ND	0.0004	0.03
	HWP	71	0.07	101	0.277	0.064	ND	0.0114	ND	0.0008	0.034

MI Standard (mg/L)											
	FCV	N/A	0.029	N/A	N/A	1.258	0.15	0.472	0.003	0.074	0.009
	AMV	N/A	0.16	N/A	N/A	2.471	0.34	1.438	0.005	0.570	0.013
	FAV	N/A	0.32	N/A	N/A	4.543	0.68	3.004	0.005	1.140	0.027

Event	Location	Lead (t) mg/L	Mercury (t) mg/L	Selenium (t) mg/L	Silver (t) mg/L	Zinc (t) mg/L	Nitrate/Nitrite-N mg/L	Total Kjeldahl Nitrogen mg/L-N
11/1/06	GA	0.0006 J-	ND	0.002 J-	ND	0.005 J-	0.17	0.48
	DWL	0.0007 J-	ND	ND	ND	0.004 J-	ND	0.88
	FP	0.0006 J-	ND	ND	ND	0.006 J-	0.03 J-	0.92
	LF	0.0011 J-	ND	0.001 J-	ND	0.008 J-	0.25	0.47
	HWP	0.0010 J-	ND	0.001 J-	ND	0.012	0.08 J-	ND
2/7/07	GA	ND	ND	ND	ND	0.006	0.21	0.7
	DWL	ND	ND	ND	ND	ND	0.26	0.26
	FP	ND	ND	0.001 J-	ND	0.006	ND	0.32
	LF	ND	ND	ND	ND	ND	ND	0.31
	HWP	ND	ND	ND	ND	0.01	0.3	0.47
5/7/07	GA	ND	ND	ND	ND	ND	ND	ND
	DWL	0.006	ND	ND	ND	ND	ND	ND
	FP	ND	ND	ND	ND	ND	ND	ND
	LF	ND	ND	ND	ND	ND	0.14	ND
	FL	ND	ND	ND	ND	ND	0.09	ND
	HWP	ND	ND	ND	ND	ND	0.40	ND
8/7/07	GA	ND	ND	ND	ND	0.009	0.08	0.37
	DWL	ND	ND	ND	ND	0.006	17.0	2.4
	FP	ND	ND	ND	ND	0.008	0.07	0.41
	LF	ND	ND	ND	ND	0.007	0.67	0.55
	FL	ND	ND	ND	ND	0.007	0.16	0.55
	HWP	ND	ND	0.02 J-	ND	ND	0.87	0.31
12/5/07	GA	ND	ND	ND	ND	0.01 J-	0.25	0.71
	DWL	ND	ND	ND	ND	0.01 J-	0.24	0.61
	FP	ND	ND	ND	ND	0.01 J-	ND	0.62
	LF	ND	ND	ND	ND	0.01 J-	0.07 J-	0.38
	FL	ND	ND	0.02 J-	ND	0.02 J-	0.10 J-	0.62
	HWP	ND	ND	0.02 J-	0.0013 J-	0.02 J-	0.36	0.31
2/27/08	GA	ND	ND	ND	ND	ND	0.54 M+	1.3
	DWL	ND	ND	ND	ND	ND	ND M+	0.42
	FP	ND	ND	ND	ND	ND	0.06 J-	ND
	LF	ND	ND	ND	ND	0.01 J-	0.1 J-	0.34
	FL	ND	ND	ND	ND	0.01 J-	0.17	0.25
	HWP	ND	ND	ND	ND	0.01 J-	0.35	0.3
5/9/08	GA	ND	ND	ND	ND	ND	ND	0.89
	DWL	ND	ND	0.011	ND	0.006	ND	ND
	FP	ND	ND	0.018	ND	0.008	0.04	0.22
	LF	ND	ND	ND	ND	0.007	0.08	0.2
	FL	ND	ND	ND	ND	0.008	0.08	0.2
	HWP	ND	ND	ND	ND	0.01	0.07	ND
MI Standard (mg/L)	FCV	**0.004**	0.00077	0.005	0.00006	**0.118**	N/A	N/A
	AMV	**0.068**	0.0014	0.062	0.00054	**0.117**	N/A	N/A
	FAV	**0.135**	0.0028	0.12	0.0011	**0.234**	N/A	N/A

Event	Location	Total Phosphorus mg/L	Fecal Coliform 10 - 10,000 Count cfu/100ml	Conductivity µS/cm	Turbidity NTU	pH --	Dissolved Oxygen mg/L	Temperature ºC
11/1/06	GA	ND	--	93.5	0.65	8.03	10.50	4.0
	DWL	ND	--	135.9	2.2	7.83	10.07	4.0
	FP	ND	--	170.6	2.75	7.87	11.92	4.1
	LF	ND	--	292	3.45	7.43	10.21	5.1
	HWP	0.04 J-	--	332	3.7	8.61	12.00	4.8
2/7/07	GA	0.08	10	158	4.75	6.84	11.30	1.1
	DWL	ND	<10	142.6	2.25	6.28	8.10	0.1
	FP	ND	<10	193.4	3	6.54	13.8	0.2
	LF	0.04	<10	257	2.2	6.56	13.5	1.2
	HWP	ND	10	361	4.2	6.86	15.1	0.0
5/7/07	GA	ND	<10	104	1	6.52	14.99	10.3
	DWL	0.06	40	152.9	1.1	6.63	15.52	15.2
	FP	0.05	<10	202.47	1	6.66	15.50	14.0
	LF	0.05	<10	280.67	1.4	6.69	14.76	13.5
	FL	ND	<10	280.67	1.4	6.69	14.76	13.5
	HWP	ND	<10	344.73	1.5	6.63	16.86	12.3
8/7/07	GA	ND	200	174	1	7.87	8.75	13.6
	DWL	0.38	30	491	1	6.55	7.06	18
	FP	ND	440	649	3.5	6.6	6.6	16
	LF	0.09	20	799	30	7.28	6.03	16.4
	FL	0.06	20	799	30	7.28	6.03	16.4
	HWP	ND	50	814	3.5	7.05	8.88	15.4
12/5/07	GA	0.06 M-	<10	112	1.6	7.49	10.4	0.1
	DWL	0.06 M-	10	144	3	7.39	7.87	0.1
	FP	0.06 M-	<10	166	1.2	7.34	10.71	0.1
	LF	ND	<10	262	1.4	7.1	10.2	0.1
	FL	0.06 M-	<10	262	1.4	7.1	10.2	0.1
	HWP	0.06 M-	<10	300	1.6	8.22	11.54	0.1
2/27/08	GA	ND	<10	101.5	4.09	6.69	13.48	0.2
	DWL	ND	<10	218	0.92	6.72	12.58	0.1
	FP	ND	<10	159	1.2	7.19	13.5	0.1
	LF	ND	<10	222	1.14	6.72	12.91	0.1
	FL	ND	<10	222	1.14	6.72	12.91	0.1
	HWP	ND	<10	269	1.97	6.88	14.13	0.1
5/9/08	GA	0.1	<10	71	6	6.62	10.66	8.1
	DWL	ND	<10	116.5	2	6.7	9.25	10.4
	FP	ND	<10	149	2	6.72	10.31	11.4
	LF	ND	<10	211	2	7.08	10.36	11.1
	FL	ND	<10	211	2	7.08	10.36	11.1
	HWP	ND	<10	266	2	6.86	10.8	10.1

MI Standard (mg/L)	FCV	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	AMV	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	FAV	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	MI Col. HBC		300					
	MI Col. F&B		1000					

Notes for

Table 5.2:

1. “MI Standard” values represent the Michigan Rule 57 Water Quality Standards for Aquatic Life Protection for each parameter.
2. “FCV” = Final Chronic Value, “AMV” = Aquatic Maximum Value and “FAV” = Final Acute Value. Additional information can be found at: http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html.
3. Michigan water quality standards indicated in **bold** are calculated based on an average hardness of 100 mg/L.
4. “MI Col. HBC” = Michigan Coliform Human Body Contact Standard. “MI Col. F&B” = Michigan Coliform Fishing and Boating Standard. More information at: http://www.deq.state.mi.us/documents/deq-wb-swas-rules-part4.pdf.
5. “N/A” = Not Applicable. Either there are no Michigan standards for this parameter or, a standard is site-specific and requires a Total Maximum Daily Load calculation, such as with nutrients (nitrate/nitrite, phosphorus, TKN).
6. “ND” = None Detected.
7. “(t)” = Total (i.e. Total Iron vs. only Fe^{3+} or Fe^{2+})
8. White Water & Associates Results Flags: “J-“ = The quantitation is an estimated value because the result is less than the sample quantitation limit, but greater than the detection limit; “M+” = A matrix effect was present with a high bias; “M-“ a matrix effect was present with a low bias.
9. cfu = colony forming unit

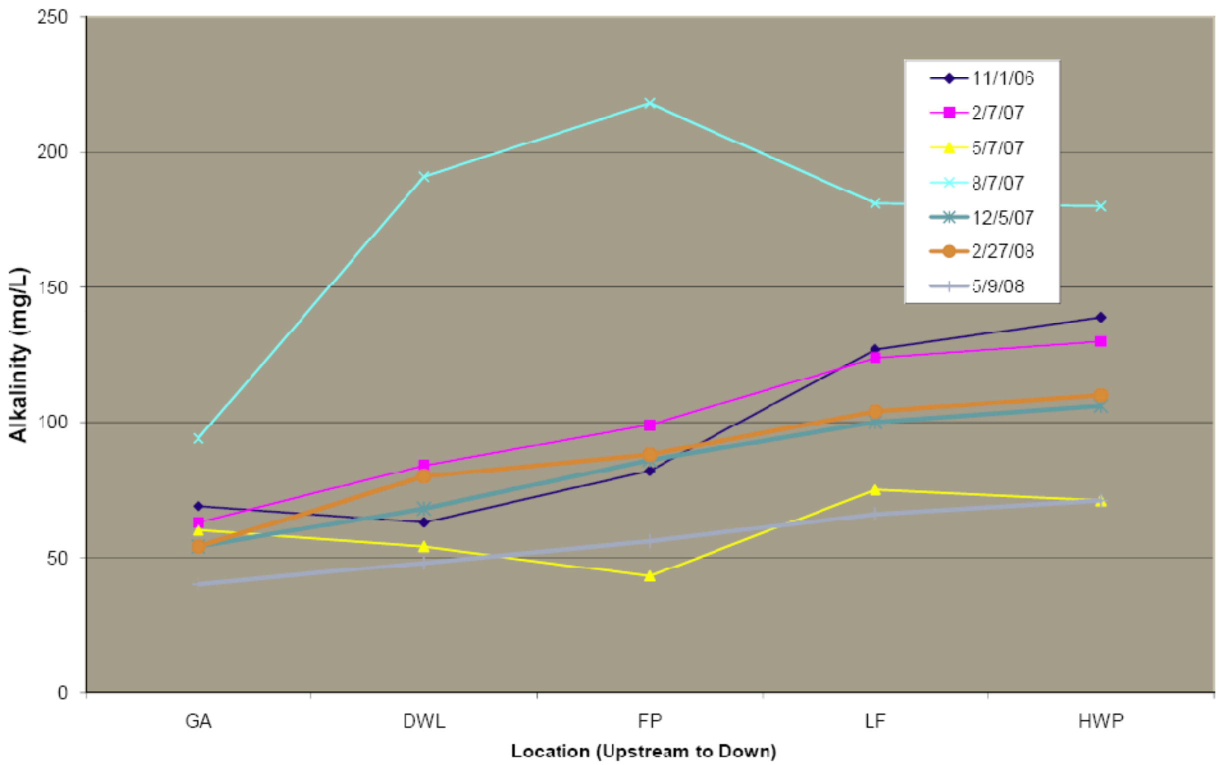

Figure 5.2 Alkalinity concentrations as a function of sample location and date.

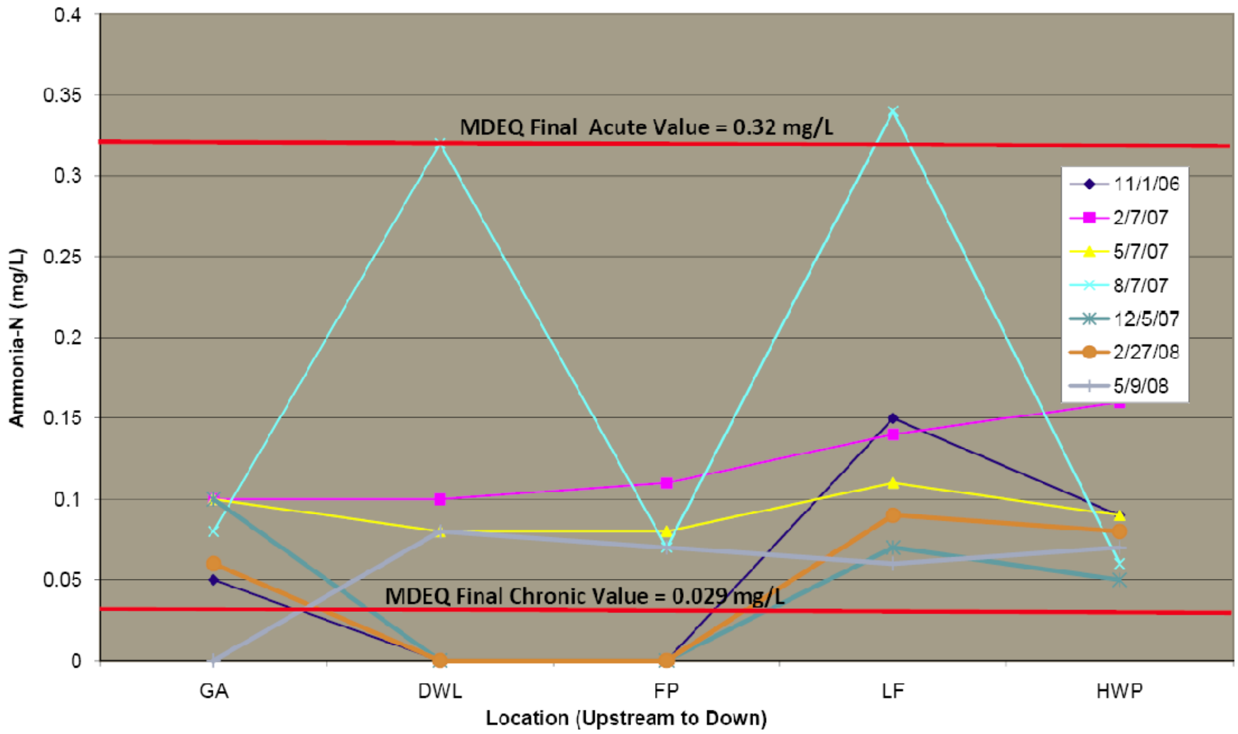

Figure 5.3 Ammonia (as mg N/L) concentrations as a function of sample location and date.

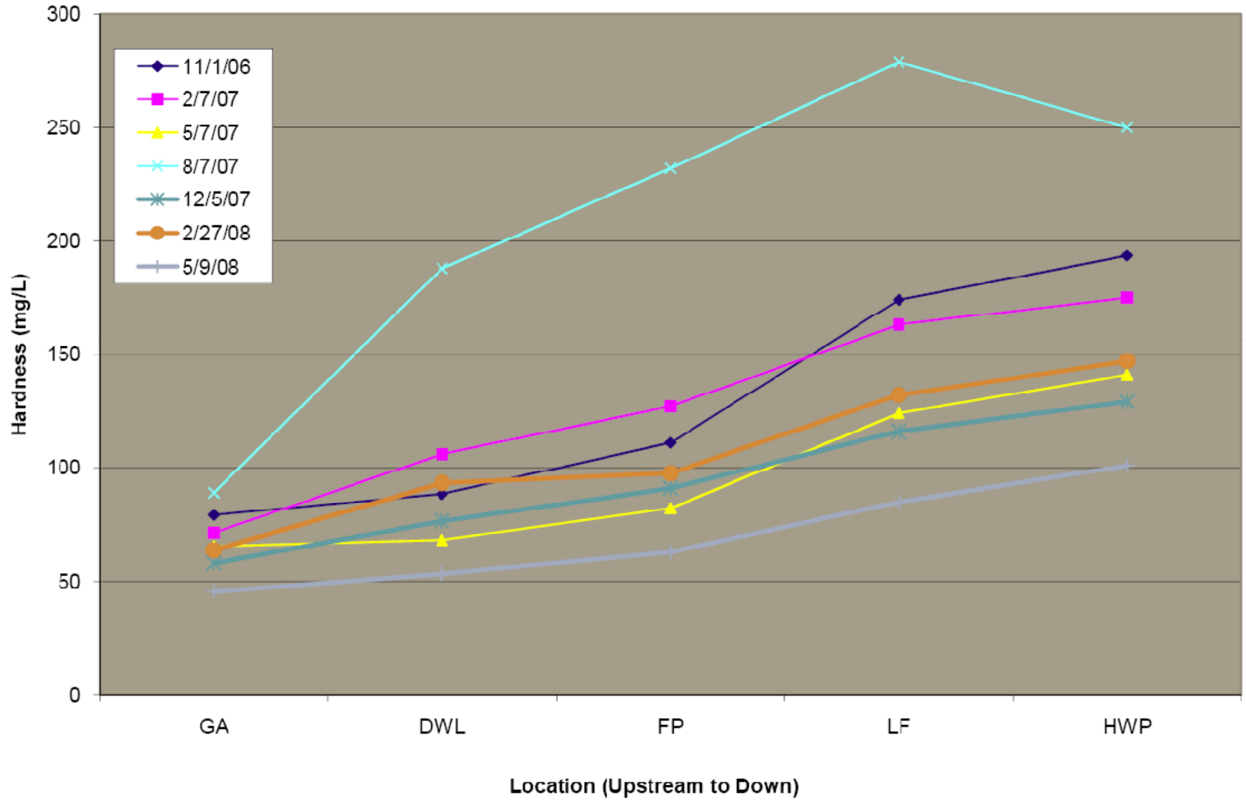

Figure 5.4 Hardness as a function of sample location and date.

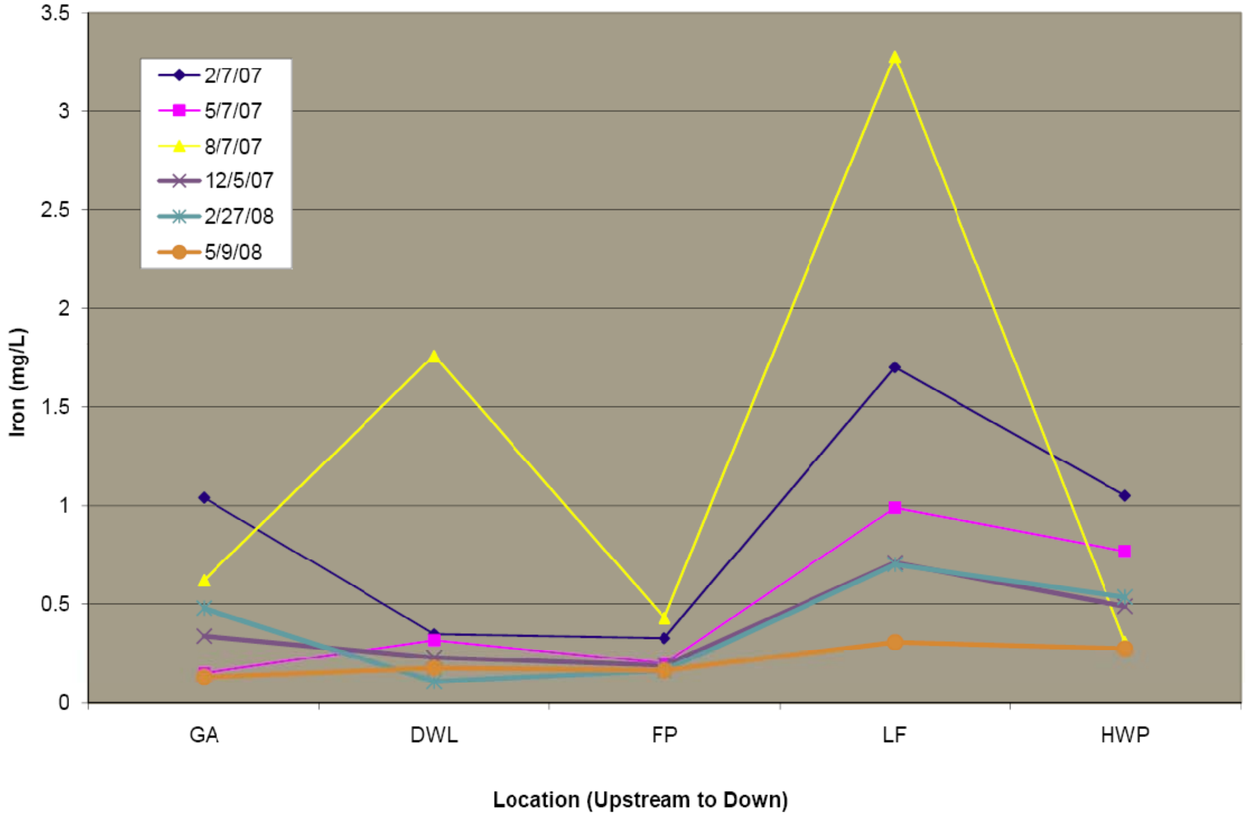

Figure 5.5 Total iron concentrations as a function of sample location and date.

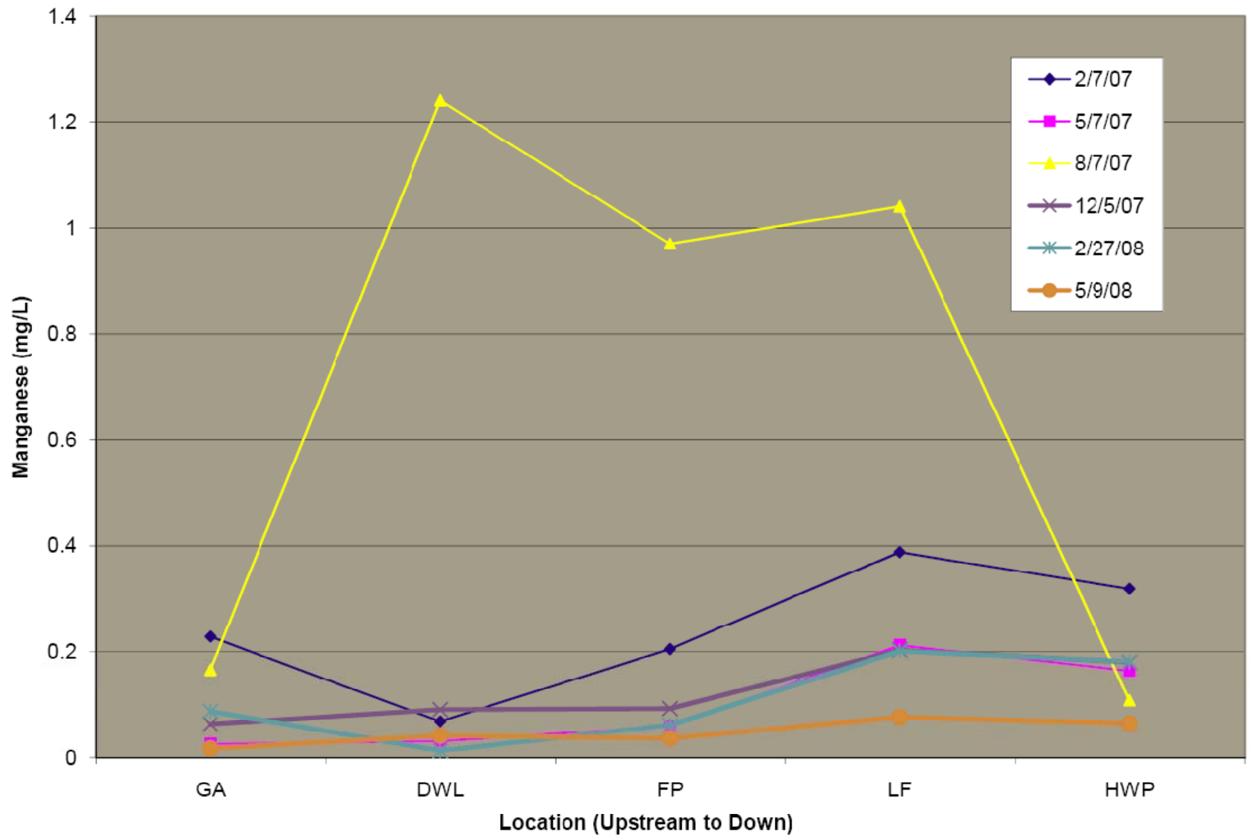

Figure 5.6 Total manganese concentrations as a function of sample location and date.

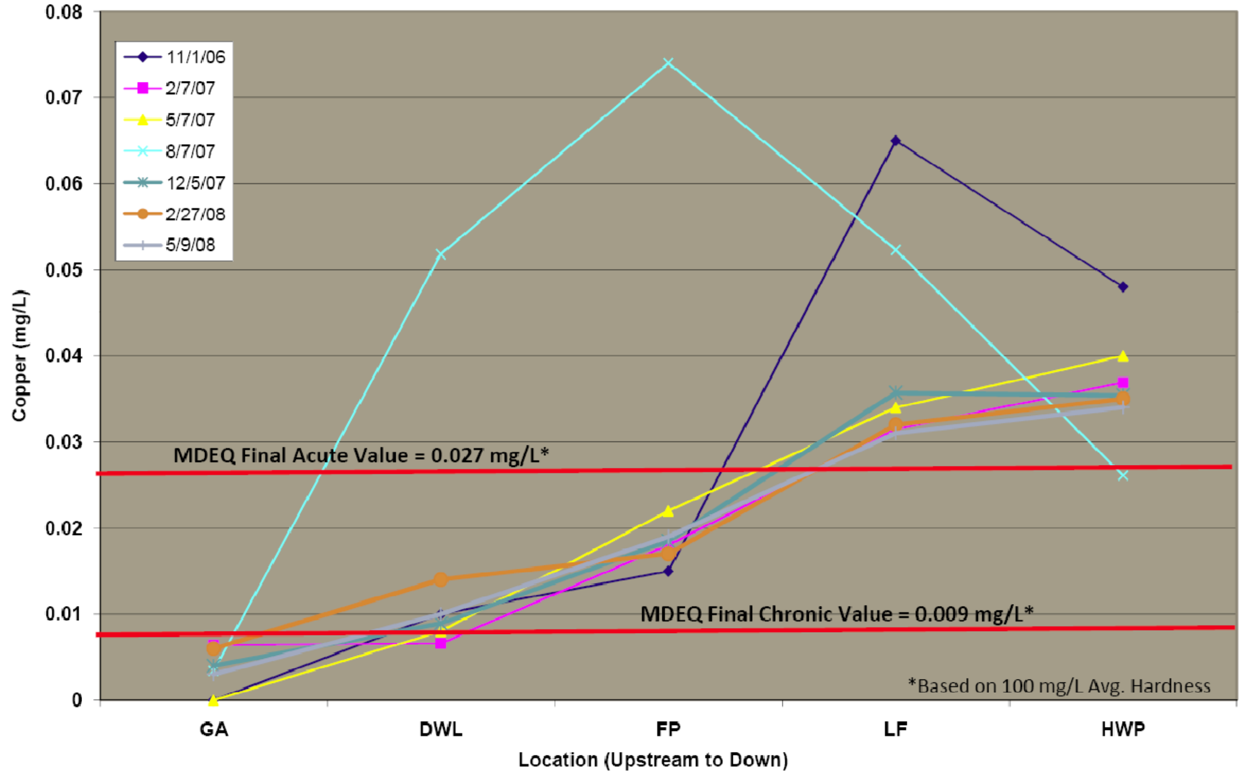

Figure 5.7 Total copper concentrations as a function of sample location and date.

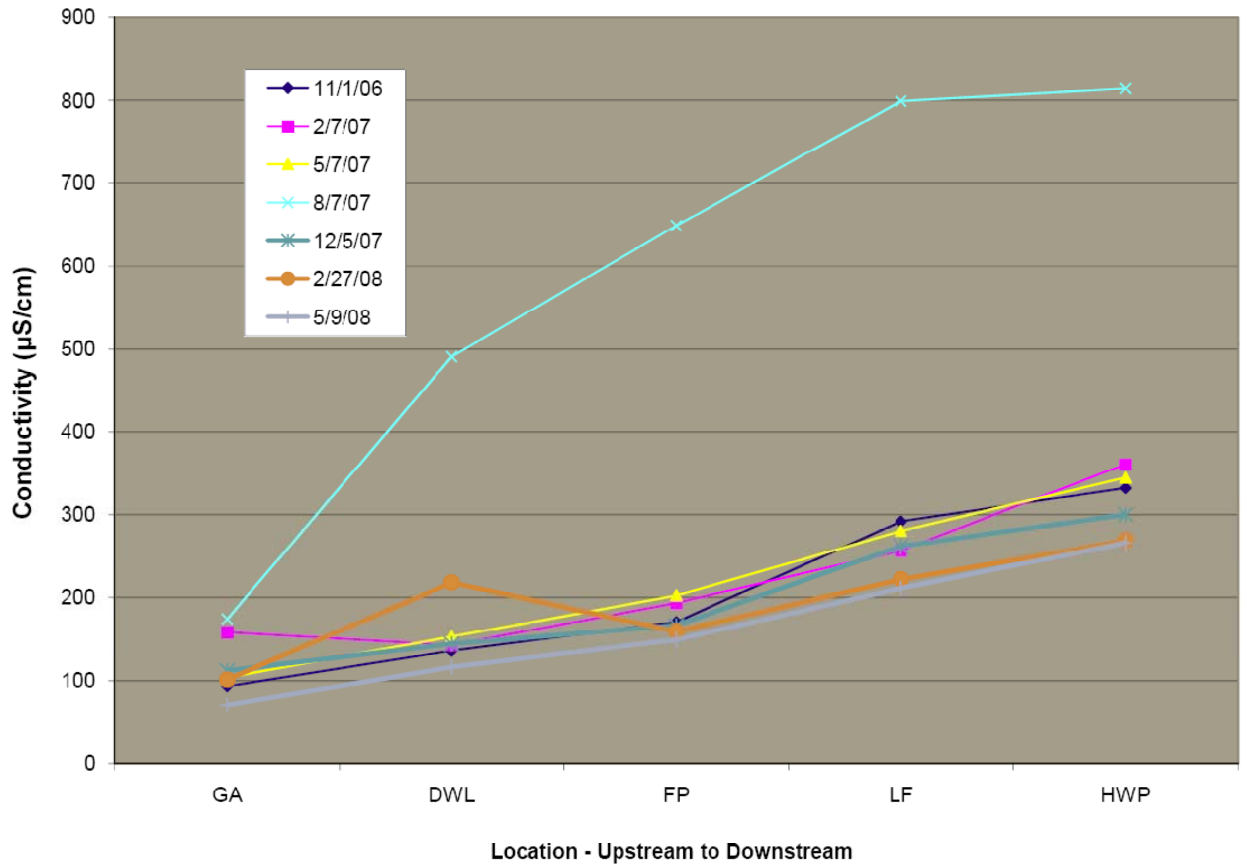

Figure 5.8 Conductivity as a function of sample location and date.

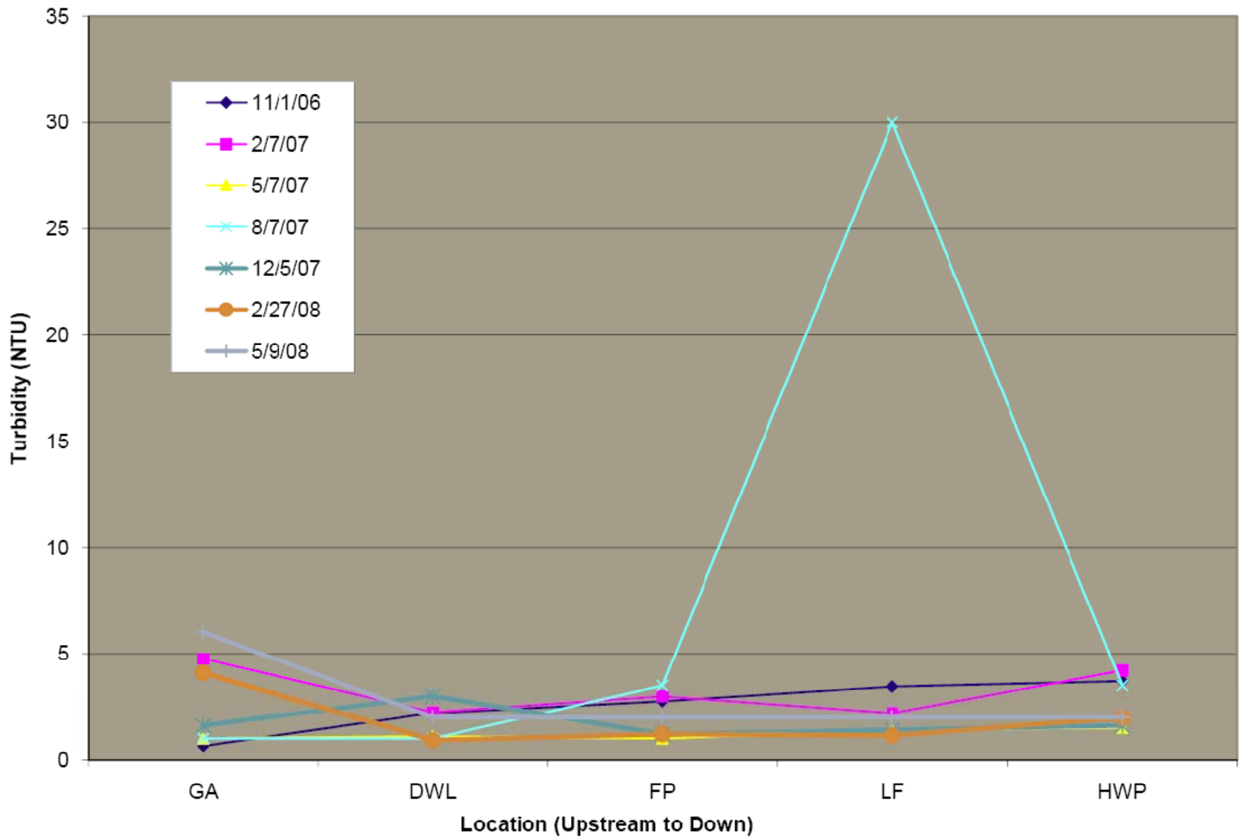

Figure 5.9 Turbidity as a function of sample location and date.

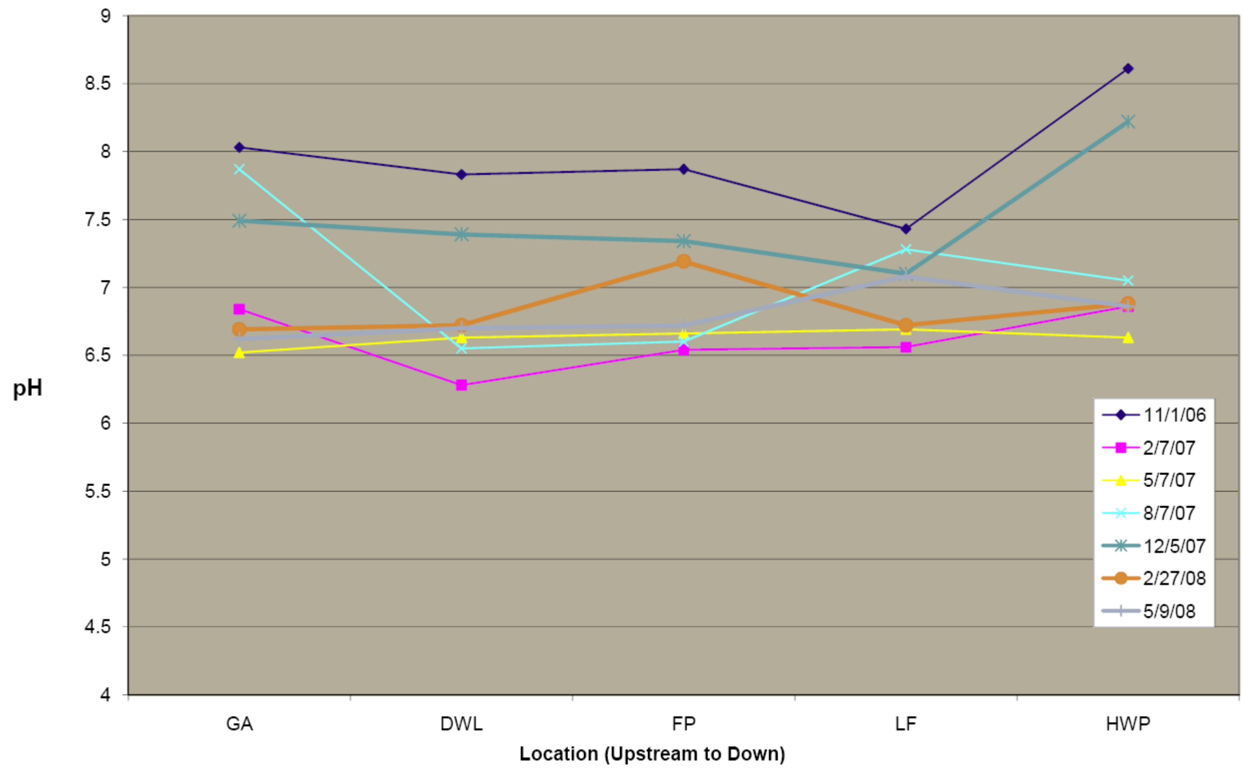

Figure 5.10 pH as a function of sample location and date.

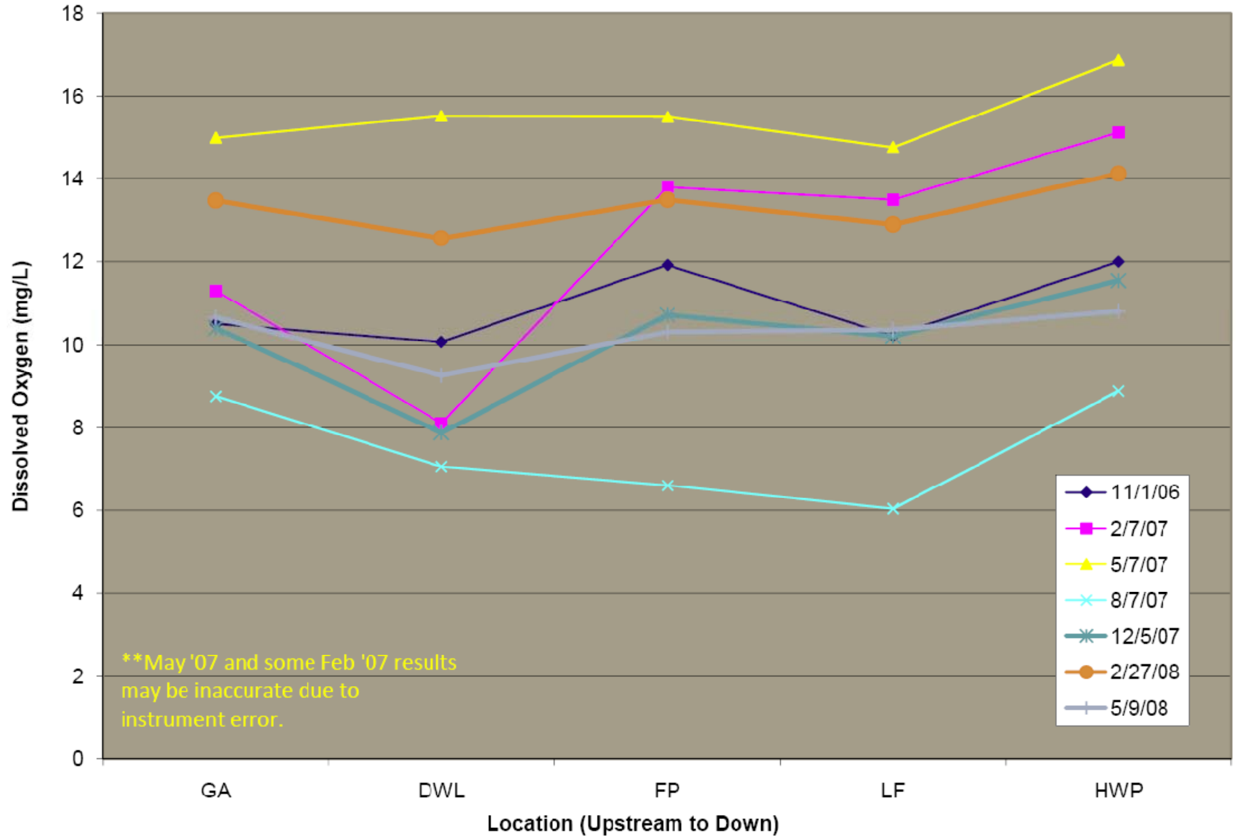

Figure 5.11 Dissolved oxygen concentrations as a function of sample location and date.

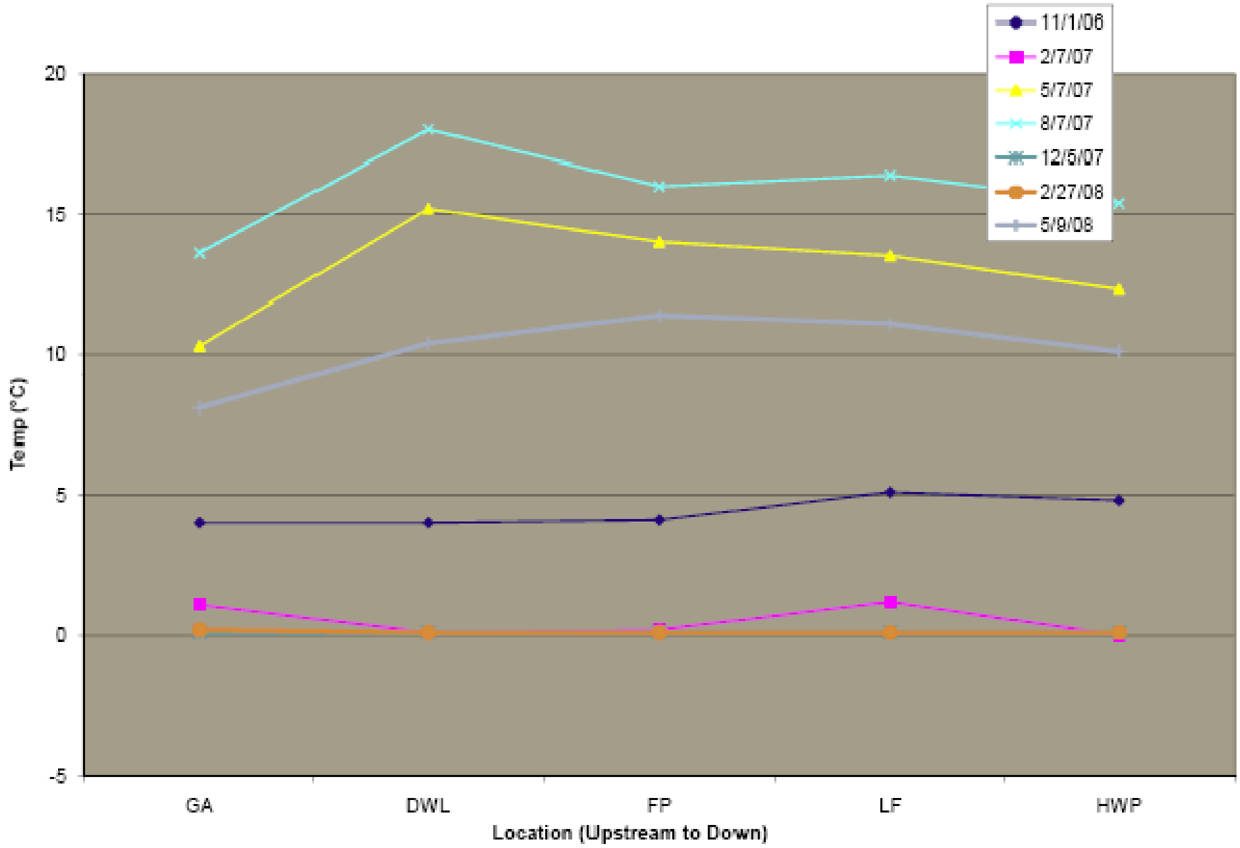

Figure 5.12 Temperature as a function of sample location and date.

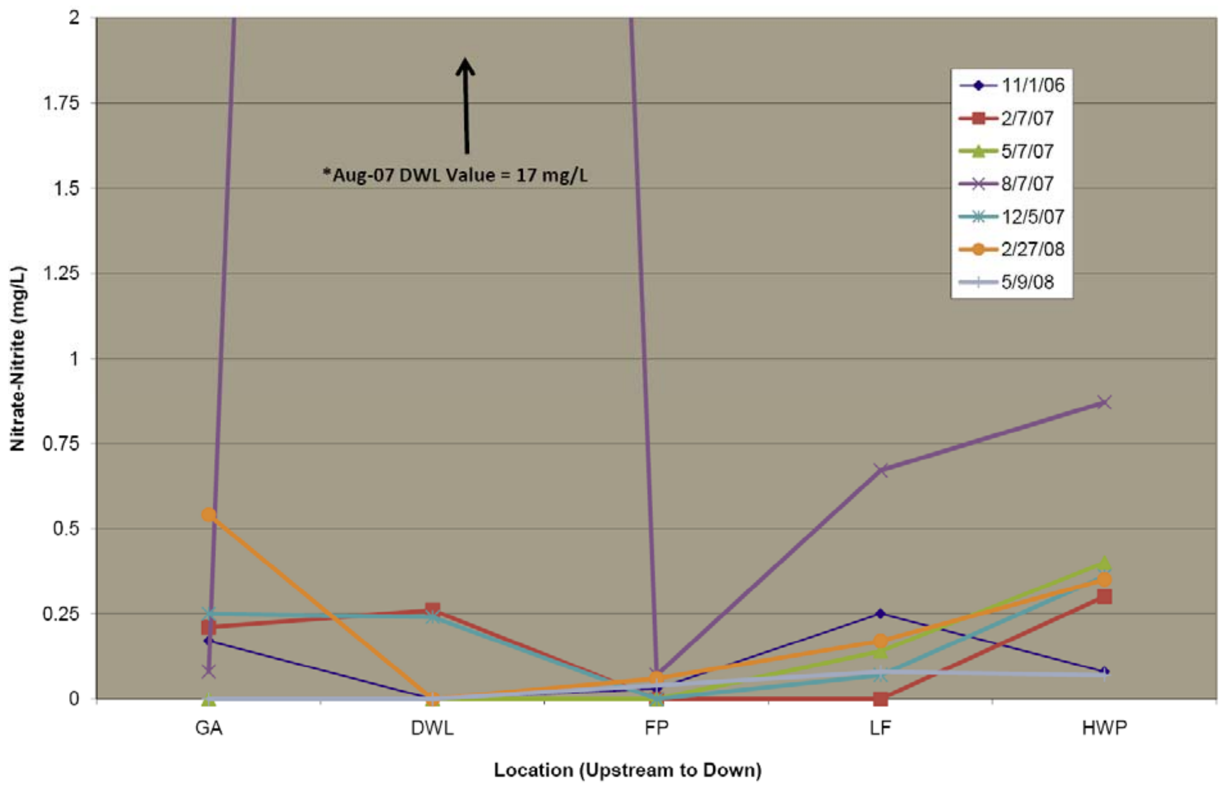

Figure 5.13 Nitrate-nitrite concentrations as a function of sample location and date.

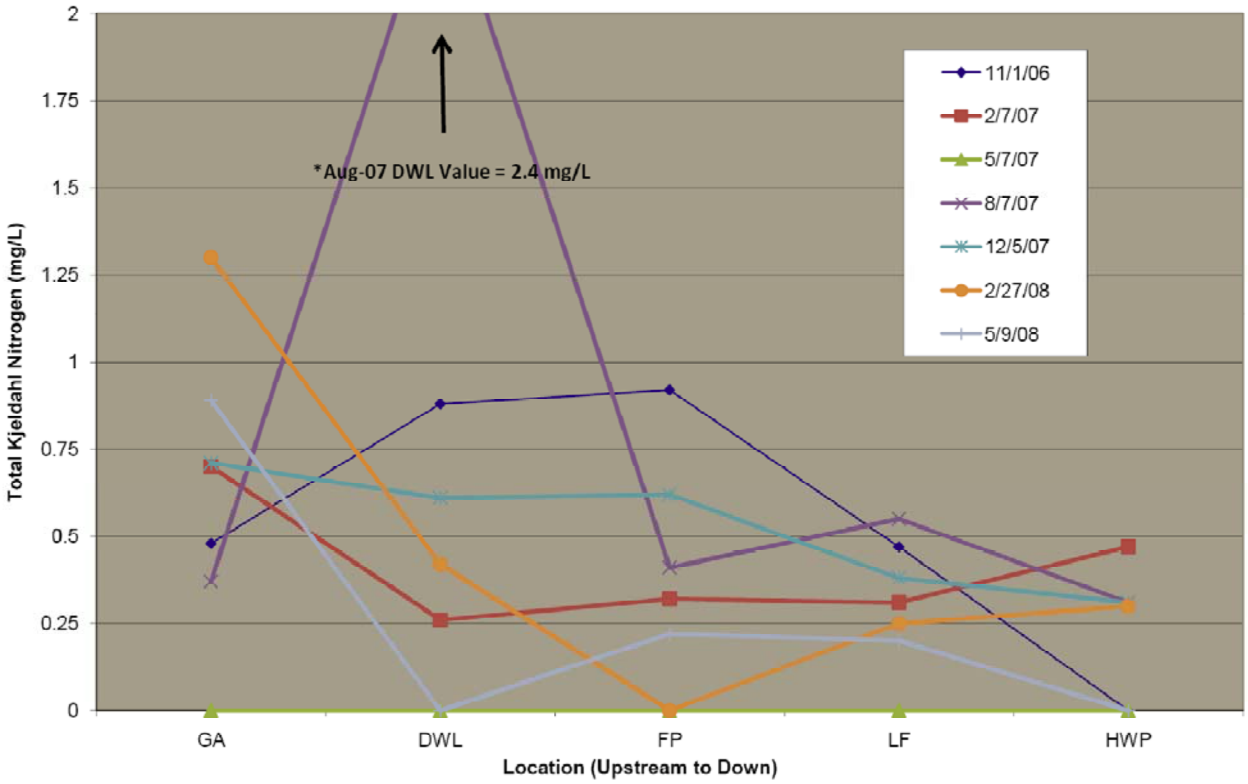

Figure 5.14 Total Kjeldahl nitrogen concentrations as a function of sample location and date.

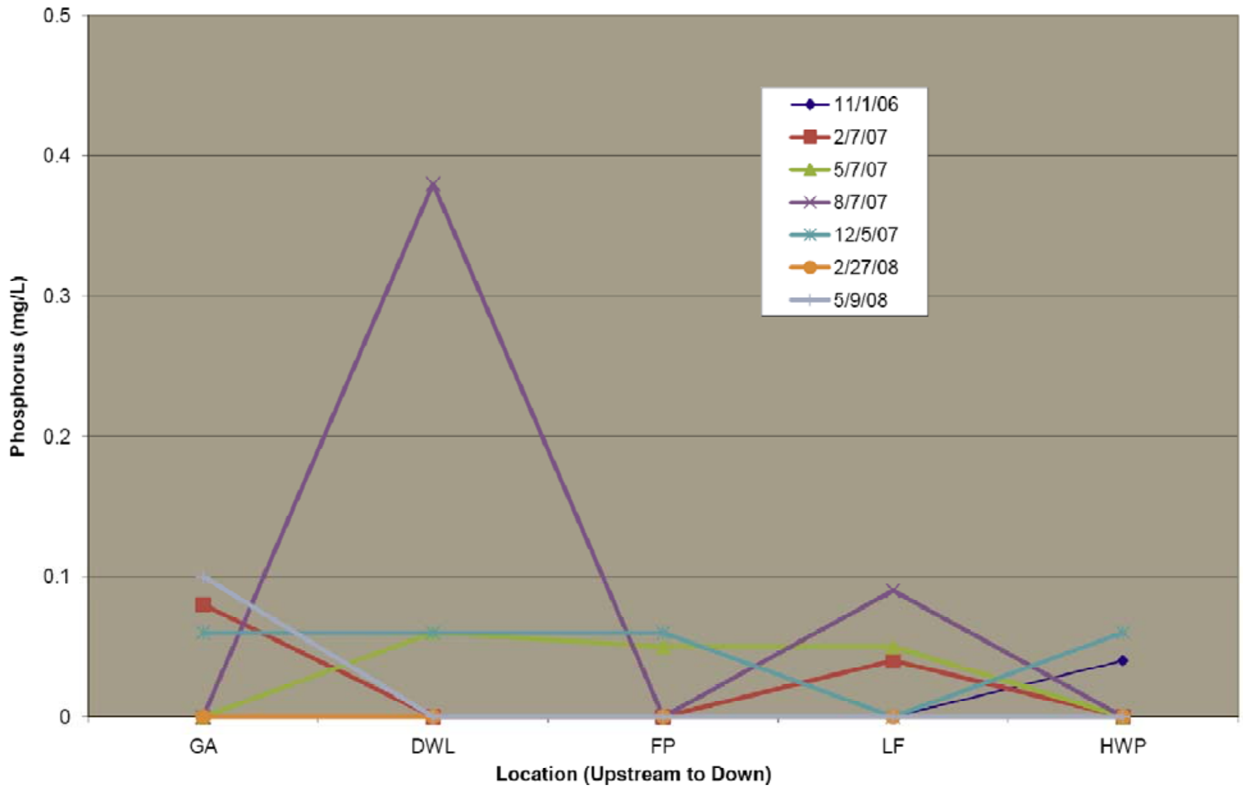

Figure 5.15 Total phosphorus concentrations as a function of sample location and date.

5.1.3. Identified Standards Exceedances in Quarterly Monitoring 2006-2008

Ammonia (NH_3) concentrations commonly exceeded the FCV, with a few occasions of the AMV and FAV being exceeded. Exceedances of the FCV in this case, may be considered "potential exceedances" as many of these values are flagged with a "J-" by the analytical laboratory. This means that they fall below the level at which the laboratory can accurately quantify the concentration, but they are above the level at which they can detect any concentration. Ammonia concentrations in Huron Creek exceeded the FAV at three locations in August 2007. This result may have been attributable to the extremely low amount of flow at that time, as several other parameter concentrations were elevated compared to other sampling events.

Total copper (Cu) concentrations regularly exceeded the AMV and FAV at all sampling locations except for the most upstream sampling site, Green Acres (GA). These results are not surprising considering the history of copper mining within the watershed and the presence of several stamp sand deposits. As mentioned in Chapter 4, this exceedance of the water quality standards qualifies the designated use of "Habitat for Aquatic Life and Wildlife" as "impaired."

Ammonia and total copper were the only measured parameters that consistently exceeded MDEQ aquatic protection standards. A few of the other metals including total lead (Pb), total selenium (Se) and total silver (Ag) occasionally exceeded the FCV (including silver exceeding the FAV once), however all but one of these results were flagged with a "J-" by the analytical laboratory, and may be inaccurate.

The August 2007 sampling event also identified levels of coliform bacteria in excess of the Michigan Human Body Contact (HBC) standard. This result occurred at only one sampling locations out of five, and only for the August 2007 sampling event. For all other locations and sampling events, lead, silver, selenium and coliform testing generally has resulted in a "no detect" (ND) or "< 10 CFU" for coliforms.

5.1.4. General Parameter Trends in Quarterly Monitoring 2006-2008

- Alkalinity – Alkalinity is the measure of the water's ability to buffer the addition of acids such as acidic rainfall. Typical streams have alkalinities of less than 200 mg/L. Studies have determined that streams with alkalinities from 100-200 mg/L support the highest diversity (Brooks, K.N., P.F. Folliot, H.M. Gregersen, and L.F. DeBano., 1997). The alkalinity of Huron Creek has generally measured between 50 and 150 mg/L, with concentrations increasing downstream.

- Hardness - Hardness is the measurement of the amount of certain minerals in water such as calcium and magnesium. Hardness is often expressed as a total amount of minerals equivalent to mg/L of calcium carbonate ($CaCO_3$) (as they are presented in Table 5.1). Concentrations of magnesium greater than 100-400 mg/L can be toxic to some fish. Total hardness in Huron Creek has generally varied between 50 and 200 mg/L, with concentrations increasing downstream.

- Iron and Manganese – Iron (Fe) and manganese (Mn) are commonly found in igneous rocks and are leached through soils. Iron is a specific concern in Huron Creek near an old landfill where "iron bacteria" blooms are present that create an orange slime of ferrous iron precipitate. Iron concentrations in the creek generally range between 0 and 1.5 mg/L, with a few sampling events yielding higher average concentrations. A consistent “spike” in iron concentration is evident in Figure 5.5 at the landfill (LF) sampling location. A similar increase is also evident in the graph of manganese concentrations (Figure 5.6) which generally indicates concentrations between 0 and 0.4 mg/L. According to Brooks, et. al., natural stream concentrations of manganese are generally less than 1.0 mg/L.

- Michigan 10 Metals – A set of ten dissolved metals known as the “Michigan 10 Metals” were sampled for and analyzed, for all sampling events. The Michigan 10 Metals are often monitored in surface waters of the state as they can be toxic or have negative health effects. These metals include arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), selenium (Se), silver (Ag) and zinc (Zn). Of these metals, analysis of arsenic, cadmium, lead, mercury, selenium and silver typically resulted in a no detect. Low levels of barium were detected at each sampling point and during each sampling event, but never exceeded standards. Measurements of chromium and zinc also yielded low levels (often below the quantitation limit) mixed with “no detect” results. As mentioned above, copper regularly exceeded at least one of the water quality standard thresholds, and generally increased in concentration further downstream.

- Nutrients – The term “nutrients” when referring to water quality generally includes phosphorus (P) and nitrogen (N). Organic nitrogen, nitrates (NO_3^-), nitrites (NO_2^-), ammonia and ammonium (NH_4^+) are different forms in which nitrogen is present in the environment. Total Kjeldahl nitrogen (TKN) is the measure of the sum of organic nitrogen, ammonia and ammonium. High concentrations of nitrate-N in surface waters can stimulate growth of algae and other aquatic plants, but if phosphorus is present, only about 0.3 mg/L of nitrate-N is needed for algal blooms (Brooks, K.N., P.F. Folliot, H.M. Gregersen, and L.F. DeBano., 1997). Some fish life can be affected when nitrate-N exceeds 4.2 mg/L (Brooks, K.N., P.F. Folliot, H.M. Gregersen, and L.F. DeBano., 1997).

  As mentioned above, ammonia consistently exceeds the FCV, AMV or FAV through all sampling events. A notable “spike” in ammonia concentration was repeatedly observed at the landfill (LF) sampling site. Nitrate/nitrite concentrations typically ranged between 0 and 0.5 mg/L, while the range of TKN values was typically 0 to 1.0 mg/L. Higher concentrations of TKN may be attributable to the elevated concentrations of ammonia and/or organic nitrogen. Phosphorus concentrations generally varied between 0 and 0.1 mg/L, with approximately 50 percent of measurements resulting in a “no detect.” Another concentration “spike” of note is that levels of ammonia, nitrate-nitrite, TKN and phosphorus all were elevated at the DWL (downstream of wetland) sampling location during the August 2007 sampling event. This occurrence can be attributed to the flow of Huron Creek being extremely low during that sampling event, and possibly to nitrogen fixation (changing gaseous N_2 into NO_3^- and NH_4^+) and export by wetland plants.

- Dissolved Oxygen (DO) – Most fish require 4.0 to 5.0 mg/L DO minimum (California Water Quality Resources Board, 1963). DO levels in Huron Creek ranged between 6.0 mg/L and 14 mg/L, with levels around 14 mg/L occurring during the winter months. There are no apparent trends in pH or DO levels along the length of the creek.

- pH – Most fish can tolerate pH values between 5.0 and 9.0 (California Water Quality Resources Board, 1963). The pH levels in Huron Creek varied between 6.0 and 9.0.

- Conductivity – Conductivity in Huron Creek typically ranged between 100 µS/cm and 400 µS/cm, which repeatedly increased in the downstream direction. Conductivity is the measure of the amount of dissolved ions in water (salts, metals, etc.), and commonly increases further downstream in a watershed. It is considered natural for stream water if the average conductivity measured at a site is 800 microSiemens (µS/cm) or less (The Watershed Center, 2005).

- Turbidity – Turbidity is a measure of the amount of suspended solids (clarity) of the water. Measurements of Huron Creek consistently yielded levels between 0 and 5 NTU (Nephelometric Turbidity Units), with no apparent trends in the upstream/downstream directions. The American Public Health Association turbidity standard for drinking water is 0.5 NTU or less (California Water Quality Resources Board, 1963).

- Temperature – The temperature of Huron Creek varies from 0° to 5.0° C in the winter months and 10° to 20° C in summer months. Rainbow trout, a fish requiring generally pristine water quality, lives in an optimum water temperature of 13° C. Warm-water species of fish such as carp however, can tolerate temperatures up to 32°C.

- Coliform Bbacteria – Coliform bacteria are bacteria that live in the digestive systems of mammals, including humans. Fecal coliform assays are intended to be an indicator of fecal contamination, or more specifically *E. coli* which is an indicator microorganism for other pathogens that may be present in feces. Fecal coliform can be associated with waste from mammals and birds, from agricultural and storm runoff, and from untreated human sewage. Coliform testing is often included in water quality monitoring as a method of detecting if sewage is reaching the water body (such as might occur with a leaking septic system).

  Most sampling events and locations have yielded results of <10 colony forming units (cfu), with 10 being the laboratory detection limit. However, as stated above, the August 2007 sampling event resulted in the Frogpool (FP) site having coliform levels higher than the Michigan standard for human body contact. Again, the flow rate of Huron Creek was low during this sampling event, which most likely caused elevated concentrations for many measured parameters (versus having high concentrations during high or average-flows).

5.2. Climate Data Study

Climate data was downloaded from the National Climatic Data Center (NCDC)[13] website for weather stations nearest Houghton, MI. Downloaded data included daily total precipitation, rainfall, snowfall, and temperature data between July 1887 and April 2007. Data from July 1887 to July 1952 was recorded at a weather station that was located near the Portage Canal (Co-op ID # 210213). In August 1952, the weather station was moved to the current location of the Houghton County airport, which is where the weather station is located today (Co-op ID# 203908).

[13] http://www.ncdc.noaa.gov/oa/ncdc.html

A graph of annual total precipitation, rainfall and snowfall for 1890 to 2007 is shown in Figure 2.12. The nearly 120 years of data indicates that total precipitation has regularly fluctuated, but has been steadily decreasing since the late 1970's. Historically, rainfall has contributed most to the total precipitation amount. However, the amount of snowfall (measured in inches of melted snow) became nearly equal to or exceeded the amount of rainfall from the late 1970's to the late 1990's. Figure 2.13 provides monthly average total precipitation data for the Houghton area for 1890 to 2007[14]. Historically, the months with the highest amounts of total precipitation have been January and September, with 3.33 and 3.26 inches of precipitation, respectively.

As mentioned in Chapter 10, the Houghton area has experienced some relatively intense rain storms in recent years that have caused flooding and severe erosion of bank areas along Huron Creek. The most recent intense storm occurred on September 4, 2007, and produced 3.66 inches of rain in less than 10 hours. Another intense storm occurred on July 16, 2006 which produced 2.99 inches of rain in less than 10 hours. This storm produced approximately the same amount of precipitation as the average 5-year, 24 hour storm (Menerey, 1999), in less than half the time. Figure 5.16 shows a graph of hourly precipitation for the 2006 and 2007 storms mentioned here.

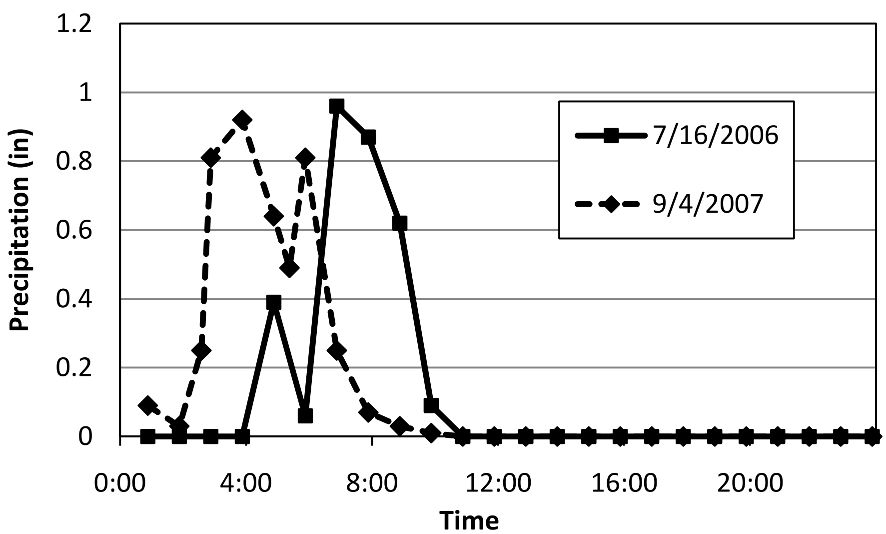

Figure 5.16 Recent Intense Rainstorms of the Houghton, MI Area

Figure 5.17 and Figure 5.18 present average annual and average monthly temperature data for the Houghton area from 1887 to 2006. As can be seen in Figure 5.17, the annual average temperature has generally ranged between 38°F and 42°F with some extreme years dropping near 36°F and increasing up to 46°F. No major trend in average temperature increase or decrease is event from this graph. However, further investigation might be completed to identify trends on a finer level. According to the data presented in Figure 5.18, the average monthly temperature of the Houghton, Michigan area varies from approximately 15°F in January to approximately 65°F in July. The raw data associated with graphs

[14] Snowfall precipitation contributing to the total is measured in inches of melted snow.

presented in this chapter is available on the NCDC website or by contacting Alex Mayer at the MTU Center for Water & Society (e-mail: asmayer@mtu.edu).

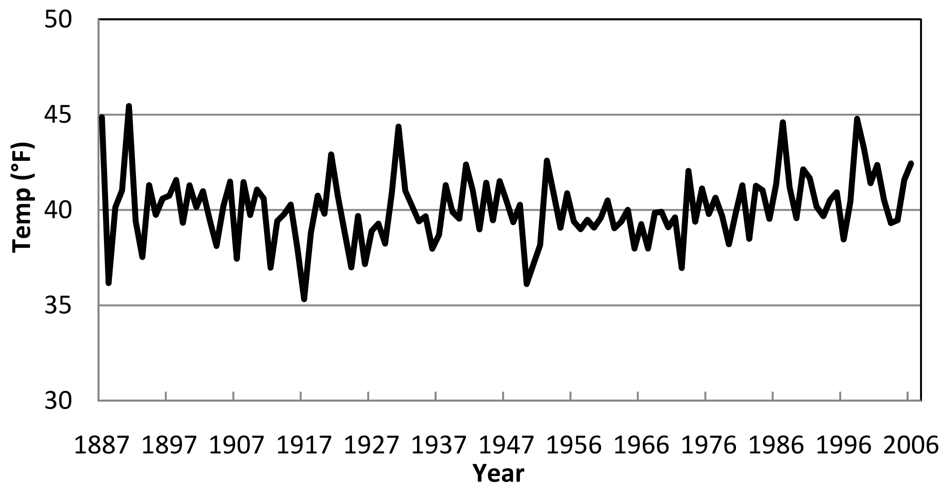

Figure 5.17 Average Annual Temperature for Houghton, MI, 1887-2006

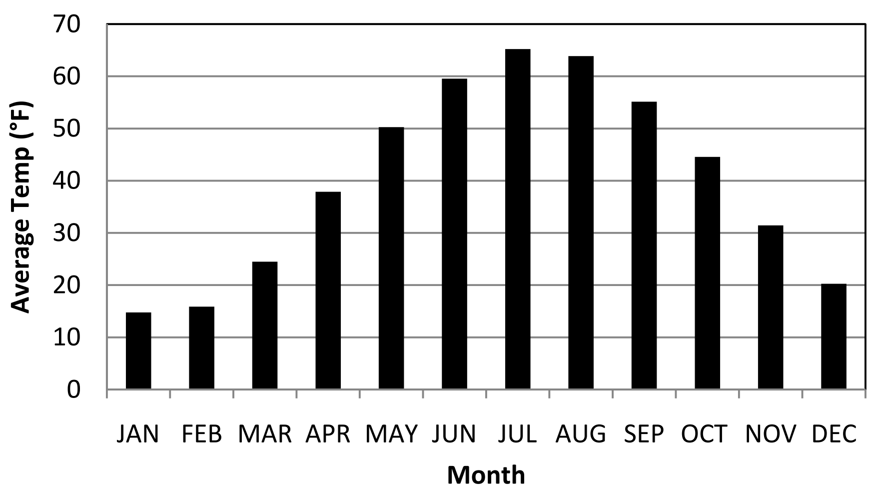

Figure 5.18 Average Monthly Temperatures for Houghton, MI, 1887-2006

5.3. Land Use Study

In fall 2006, a land use study of the Huron Creek watershed was completed using a geographical information system (GIS). The study resulted in the production of a land use map based on the most recently available aerial photo of the watershed (2005 NAIP[15] aerial photo), as well as analysis of

[15] National Agriculture Imagery Program

changes in land use between 1978 and 2005. These results are included in this report as Figure 2.4(2005 Land Use Map), Figure 2.5 (2005 Huron Creek Watershed Land Use Distribution) and Figure 2.6 (Percent Change in Land Use, 1978-2005). The data presented in these figures is discussed in Section 2.3. The complete land use study is attached to this report as Appendix D. The report describes data sources and methods, as well as provides further discussion of results and recommendations for future investigation.

5.4. Hydrologic Modeling

Two different approaches were used to estimate runoff in Huron Creek. First, a water balance approach as used to estimate average monthly and average annual flows. Second, a rainfall-runoff model was used to estimate runoff in response to discrete storm events.

5.4.1. Average Annual Streamflow

The Thornthwaite water balance equation (e.g., (Dingman, 2002)) provides a means for accounting for the amount of water stored in each component of the hydrological cycle. Local meteorological data for temperature, precipitation, daylength, humidity, etc. are input into simple empirical formulae that estimate the values in this form of the Thornthwaite-type water balance model. The model consists of several subcomponents that are combined to simulate values of watershed or regional water inputs, including precipitation (as rain and snow) and output via evapotranspiration. Water can be stored as soil moisture and snowpack. All hydrological quantities are expressed as depth of water over an assumed area (region or drainage basin). Monthly climatic averages of temperature and precipitation are used as inputs to the model. The model divides precipitation inputs into rain or snow depending on a surface air temperature melt factor. This factor is also used to determine the monthly melt component of the snow pack. From these quantities, the resulting monthly water runoff can be determined.

Calculations using the Thornthwaite water balance equation were made using a spreadsheet (see Appendix N). The results of the calculations are given in Figure 5.19. If it is assumed that all recharge reaches the stream, integration under the Runoff and Recharge curve in Figure 5.19 gives an annual total streamflow of or 357 mm or 14.1 inches. Multiplying by the area of the watershed (3.4 square miles) gives an annual volumetric streamflow of 3.5 cubic feet per second (cfs) or 0.01 in cubic meters per second.

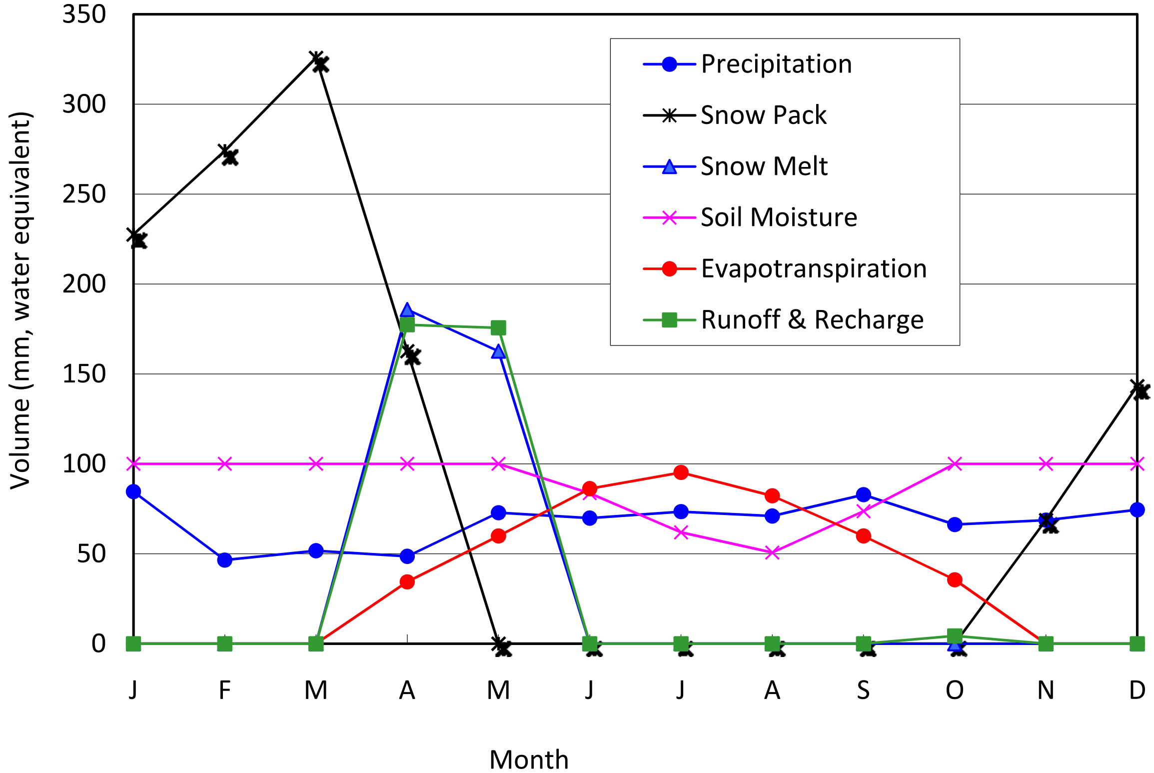

Figure 5.19 Monthly water balance calculations using the Thornthwaite water balance equation.

5.4.2. Peak Streamflow

A hydrologic model of the Huron Creek watershed was developed using rainfall-runoff modeling software (HydroCAD®) in order to estimate runoff in response to discrete storm events. HydroCAD® uses the Natural Resource Conservation Service (NRCS) TR-20 method to calculate rainfall-runoff. Spatial data used as input to the software included land use/land cover, ground surface slopes, soil types, catchment areas and reach lengths. This information was determined from GIS coverages and entered into HydroCAD® for the following three development scenarios:

- Pre-Development –approximates conditions before any disturbance or development of the Huron Creek watershed.
- Current Development – represents conditions of today's Huron Creek watershed. The main difference between this model and the pre-development model are the increases in less permeable land cover (currently existing residential and commercial areas, roads, quarries, etc.).
- Future Development – represents potential future increases in commercial and residential development (see Figure 2.8).

For purposes of modeling rainfall-runoff responses, the watershed was divided into 12 sub-watersheds and five stream reaches, as shown in Figure 5.20. The sub-watersheds are further divided into areas with different land cover and soil types. The land cover-soil type combinations are assigned curve numbers (CN). The CN is an empirical parameter used to estimate runoff resulting from rainfall excess (rainfall that exceeds the capacity of the land area to infiltrate the rainfall). A higher CN indicates higher amounts of runoff, with a CN = 100 indicating a completely impervious surface. For example, CN = 90 would correspond to commercial and business developments in urban areas, indicating significant amounts of rooftops and paved area, and CN = 30 to 80 would be indicative of vegetated cover.

The output for each modeling scenario is a hydrograph, which depicts flow rate of the creek as a function of time, in response to a model storm event. Two model storm events were considered: a 2-year, 24-hour storm event with a total rainfall of 2.39 inches and a 25-year, 24-hour storm event of with a total rainfall of 4.17 inches (Sorrell, 2008). These storms represent events that are likely to occur in the Houghton area, on average, once every 2 or 25 years, respectively. Three antecedent moisture conditions (AMC) were considered. AMC refers to the state of saturation of the soils in a watershed before a modeled storm event occurs. AMC-I has the lowest runoff potential and the watershed soils are dry. AMC-II represents normal soil moisture conditions. AMC-III has the highest runoff potential as the watershed is practically saturated from antecedent rainfall or snowmelt. The purpose of using three difference AMCs is to represent the envelope of possible soil moisture conditions and resulting runoff behavior.

Figure 5.21 and Figure 5.22 show the hydrographs for the 2-year and 25-year storms, respectively, and represent the flow at the outlet of the watershed. The results show that runoff and consequent flow rates at the outlet of the watershed apparently have increased from prior development to current development conditions and will further increase with future development. The degree of increase is sensitive to the magnitude of the storm (2-year vs. 25-year) and the AMC. Table 5.3 shows the peak discharges for all of the combinations of development scenarios, storm recurrence probabilities, and antecedent moisture conditions. The results in Figure 5.21, Figure 5.22, and Table 5.3 show that the increase in flows from prior to current development is lower for the larger storm and higher AMC since these conditions generally produce more excess runoff, no matter what the land cover conditions are.

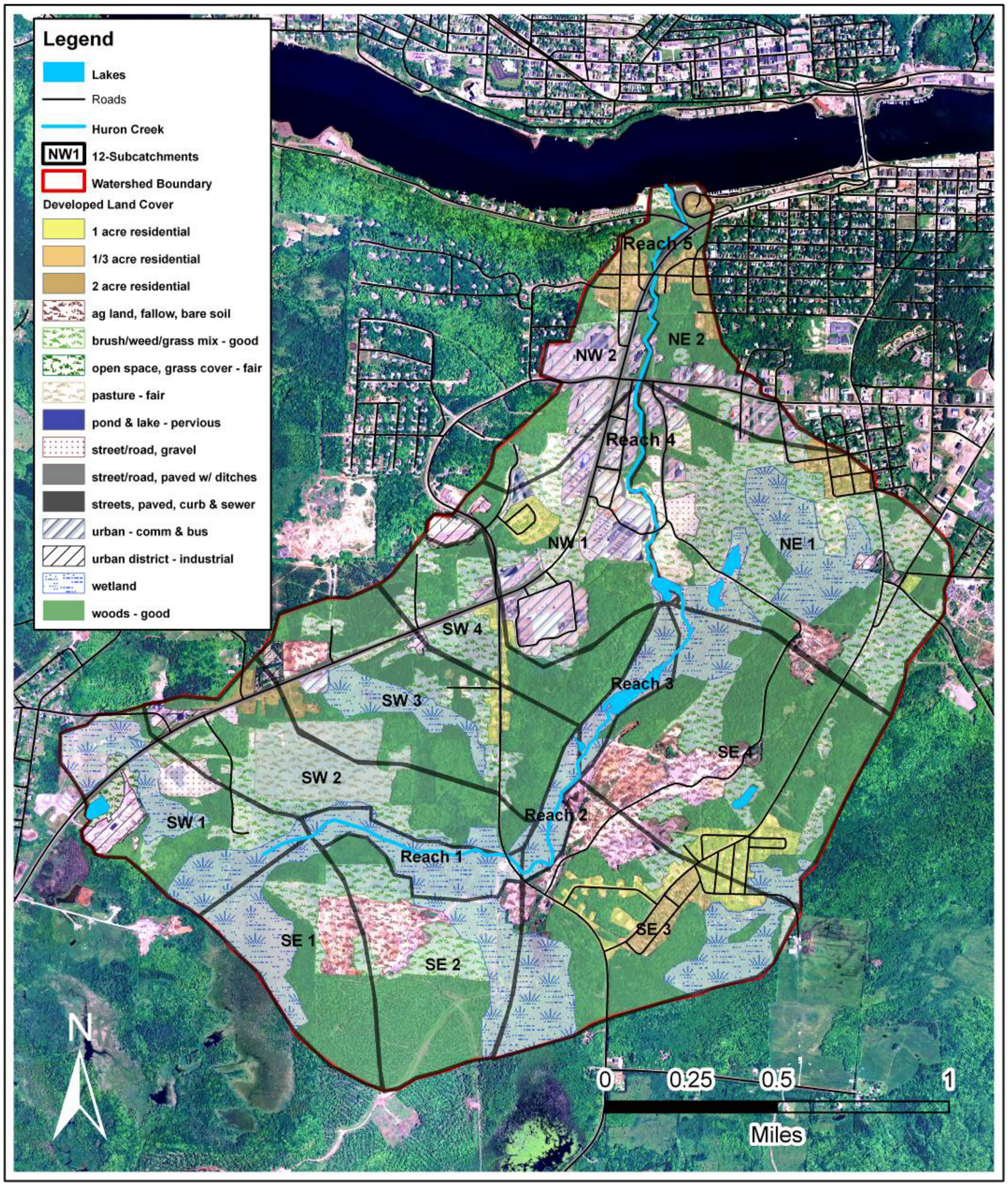

Figure 5.20 Division of watershed into sub-watersheds and reaches Created by Linda Kersten, 4/10/08. Map projection: NAD 1983 UTM Zone 16N.

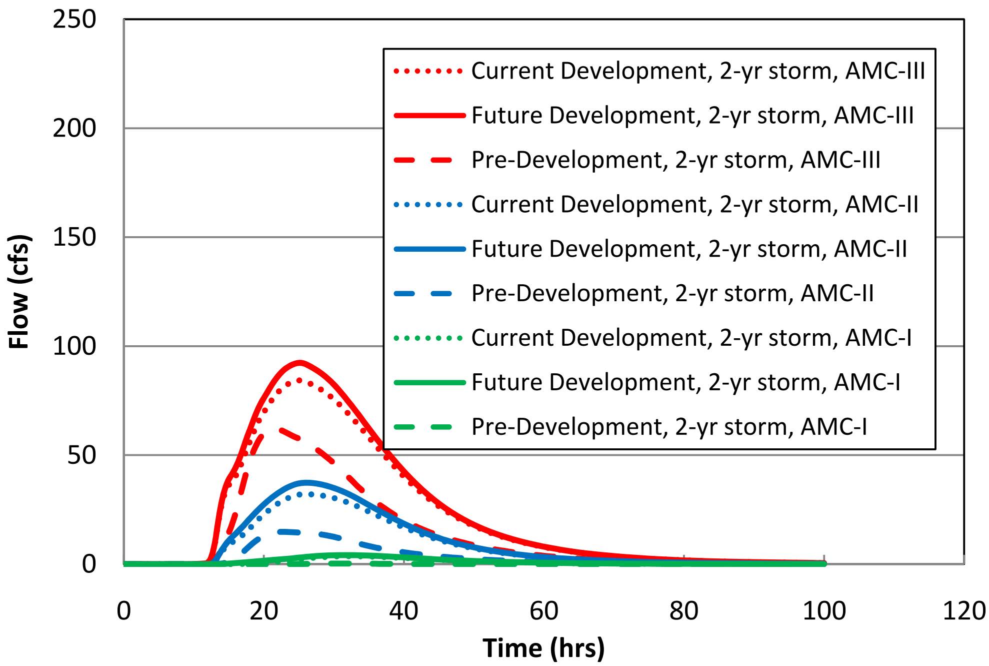

Figure 5.21 2-year storm hydrograph comparison of pre-development, current development and future development models for various antecedent moisture conditions.

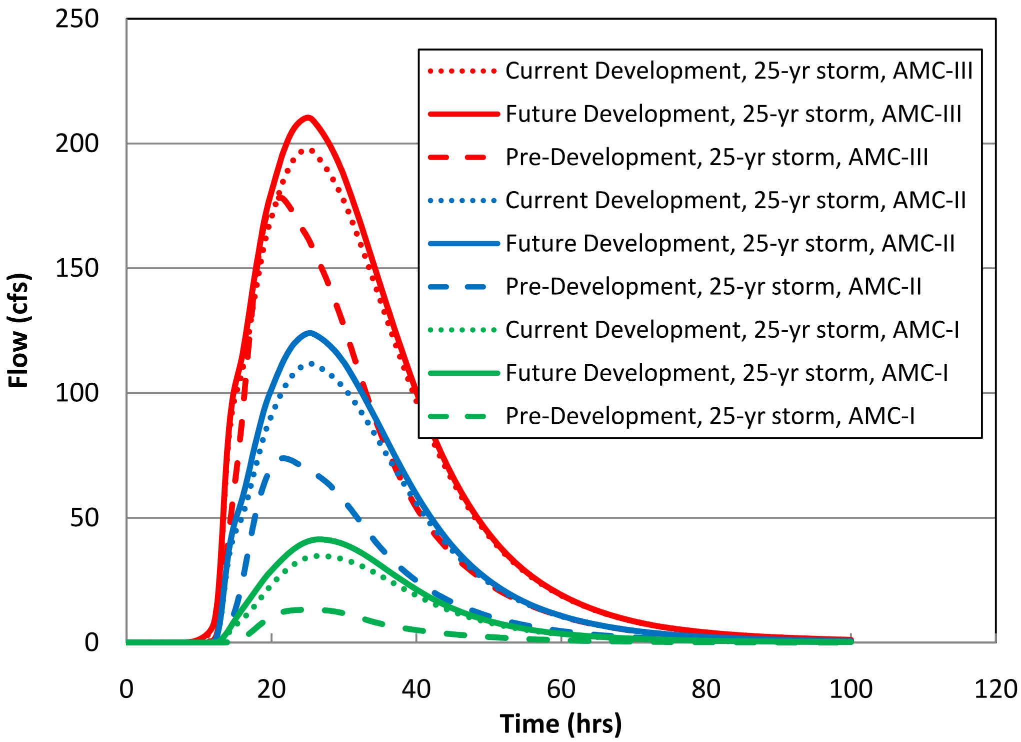

Figure 5.22 25-year storm hydrograph comparison of pre-development, current development and future development models for various antecedent moisture conditions.

Table 5.3 Peak flows for combinations of development scenarios, storm recurrence probabilities, and antecedent moisture conditions

	Peak Flow (cfs)		
	Pre-Development	Current Development	Future Development
2-yr Storm, AMC-I	<1	4	4
2-yr Storm, AMC-II	15	32	37
2-yr Storm, AMC-III	62	84	92
25-yr Storm, AMC-I	13	35	41
25-yr Storm, AMC-II	74	112	124

In Table 5.4, the fractions of the watershed corresponding to surface cover with curve numbers (CN) greater than 80 and 90 are given for each development scenario, using the 2-year storm and AMC=II as example conditions. A CN = 90 is indicative of commercial and business developments in urban areas, indicating significant amounts of rooftops and paved area, and a CN = 80 is indicative of high-density residential areas (average lot sizes of 1/8 of an acre or less). The results in Table 5.4 indicate that the significant increase of in area with CN > 80 and CN > 90 from pre-development to current development explains the large increase in the amount of simulated peak flow.

Table 5.4 Hydrologic characteristics for 2-year storm event and antecedent moisture characteristic II

Scenario	Peak Flow (cfs)	Runoff Volume (acre-feet)	Fraction of Watershed Area Corresponding to Given Curve Number (CN) *		% Increase in Peak Flow Over Pre-Development
			CN > 80	CN > 90	
Pre-Development	15	29	13%	13%	--
Current Development	32	67	35%	25%	113%
Future Development	37	78	39%	31%	134%

Several important assumptions used in the rainfall-runoff modeling need to be considered when interpreting the results in Figure 5.21 and Figure 5.22 and Table 5.3 and Table 5.4, described as follows.

- Much of the stormwater in the commercial and residential areas of the watershed is routed through storm sewers. The stormwater runoff in the Copper Country Mall, Wal-Mart, Shopko and Econo Foods areas is routed to detention ponds. More sophisticated modeling is needed to account for these stormwater management measures, but the overall impact of these measures is likely to result in even higher peak flows.

- The storm events modeled here are used to model runoff associated with conventional rain storm events. However, since a significant snowpack typically develop in the watershed over the winter, rain-on-snow events can occur, where rain and snowmelt simultaneously contribute to runoff and can produce high flows. The runoff from the rain and snowmelt also is likely to occur with saturated or frozen soil conditions, where the ground can absorb or store less water, resulting in even higher flows than those simulated here.

5.5. Storm Drain, Ditch and Road Crossing Surveys

In fall 2006, a road crossing survey and storm drain survey was completed. The road crossing survey included taking photos of road crossings and visually assessing their condition using MDEQ's Watershed Survey Data Sheet for single site stream crossings and corresponding procedures. The purpose of this survey is to identify problematic sites and those that may be appropriate for biological surveys. Data collected to evaluate the crossings included substrate material, the presence or abundance of aquatic plants, algae, turbidity, foam, oil, trash and bacterial sheen/slime. Other information recorded included width of riparian vegetation, important stream habitat, percentage of stream shading, adjacent land uses and potential sources of pollution. Eight road crossings along the stream were identified to be in generally good shape. The most common problems noted were excessive turbidity, the presence of trash and lack of aquatic vegetation. Data collection locations, completed data sheets and photos from this survey are included in Appendix F.

The storm drain survey identified and documented locations of approximately 94 storm drain inlets, outlets and culverts. Their construction, condition and size were also documented, with locations of each identified on an aerial photo of the watershed. Observations were also made of culvert and storm drain flow paths and routing, which was also documented on an aerial photo. Spreadsheets containing collected data and maps showing locations and routing are provided in Appendix G.

Another survey was completed in September 2007, this time documenting conditions of specific culverts and ditches during rain events. The purpose of this survey was to identify which culverts and ditches were contributing significant amounts of flow during a storm. Locations, descriptions and comments on the relative amount of flow were recorded in a spreadsheet. Photos were also taken and are referenced by location within the spreadsheet. Data and photos compiled from this survey can be found in Appendix G.

5.6. Property Ownership Survey

Property ownership along Huron Creek was investigated in fall 2006. This information was gathered so that the possibility of adding public access sites and/or a nature trail along the creek could be better addressed by the watershed advisory committee.

Property line information was overlain on aerial photos and labeled so that each parcel's owner could be listed in a separate spreadsheet according to the parcel label. Sources of parcel and property data included the 2006 Houghton County plat book and the City of Houghton and Portage Township. The information pertaining to Portage Township may not be up to date as it predates the addition of M-26 and the associated changes in property lines.

The figures and spreadsheet provided in Appendix H summarize riparian property owner information along Huron Creek from its source north to the Keweenaw Foot Care Clinic on M-26. This data may not be completely accurate due to the methods used to create the maps and the publishing date of the information.

5.7. Geomorphology Survey

In fall 2007, a multi-part geomorphology and stream habitat survey was completed. The primary goals of the survey included:

- Provide a baseline of geomorphologic conditions for future comparison.
- Provide data for use in relating geomorphology with land use, hydrology and condition of stream re-route areas.
- Provide data for use in recommending BMPs for the Huron Creek watershed management plan.
- Provide preliminary recommendations for stream improvements as they relate to stream stability.

These goals were achieved by completing the following components of the overall geomorphology survey:

- Modified BEHI (Bank Erosion Hazard Index) – This is a method for assessing stream bank condition and erosion potential. This includes observing physical characteristics of the stream banks, assigning individual scores, and calculating an overall score that indicates risk of bank erosion.
- Stream Habitat Survey – This is a survey that identifies channel bottom materials, streamside vegetation and channel characteristics and uses them to calculate an overall stream habitat score.
- Sediment Monitoring – This survey characterizes sediment size distributions (<1” in diameter) and establishes sediment monitoring locations in the bed of the creek. These locations have been designed for monitoring aggradation and degradation of the creek bed.
- Cross Section and Slope Measurement – Physical cross-section and slope measurements have been completed at designated locations along Huron Creek.
- Other Erosion Monitoring – This is a visual survey that documents erosion within 200 feet of the stream banks. Locations have been recorded along with a photo.
- Photos – Photos have been taken at designated locations for comparative purposes. Photo locations correspond with specific survey locations indicated in the geomorphology survey report.

These survey types were selected based on discussions with Joe Rathbun of the MDEQ’s Water Bureau (Rathbun, 2007). The geomorphology survey methods, locations, data forms and quality assurance procedures are summarized in the Huron Creek Geomorphology Survey QAPP that is provided in Appendix I. This QAPP was reviewed and approved by MDEQ prior to beginning the survey[16].

Results of the individual surveys are as follows:

[16] Changes were made to the approved QAPP that are included in Appendix I. These changes were also approved by MDEQ.

- Modified BEHI – For the nine survey locations:
  - 1 location has a “very low” hazard index
  - 4 locations have a “low” hazard index
  - 1 location has a “low to moderate” hazard index
  - 2 locations have a “moderate” hazard index
  - 1 location has a “very high” hazard index

- Stream Habitat Survey – For the nine survey locations:
  - 4 locations rated “fair”
  - 4 locations rated “good”
  - 1 location rated “excellent”

- Sediment Monitoring – A rebar pin was driven into the creek bed at 3 locations where sediment deposition had previously been observed. A measurement from the top of the stream bed substrate to the top of the pin was collected at each location. These measurements will be compared with future measurements to identify if sediment is collecting at (aggrading) or being transported away from (degrading) that location. At the sediment pin locations and one additional location, grab samples of bed sediment were also collected for use in a sieve analysis. It was determined that each sample classified as a poorly graded sand (SP) per the Unified Soil Classification System.

- Cross-Section and Slope Monitoring – Cross-section and longitudinal creek bed slopes were measured using surveying techniques at each of the locations designated in the QAPP. The generated results included figures depicting the physical shape of each cross-section, and a table providing slope data for each location.

- Other Erosion Monitoring – Locations of concern were identified, photographed and incorporated into the future monitoring recommendations as needed.

The Huron Creek Geomorphology Survey final report is attached as Appendix J. The report includes a map of survey locations, detailed explanations of results, cross-section and grain size graphs, slope data and photos.

Recommendations for stormwater management, stream bank stabilization and future monitoring can also be found in the report. The specifics of these include:

- A design for a stormwater detention pond, recommendations for bank stabilization, and future monitoring of a head cut in order to solve severe erosion problems in “Shopping Cart Creek,” a man-made tributary to Huron Creek. (The stormwater detention pond was designed by modeling flows with HydroCAD®).
- Recommendations for repair of damaged creek banks in the Houghton Waterfront Park (Ray Kestner Park).
- A schedule for future monitoring that includes completion of the surveys mentioned above.

Portions of the geomorphology survey were not completed in 2007 due to weather and time constraints. The remaining data collection was then completed in spring 2008, and is supplied as an addendum to the geomorphology report in Appendix J.

5.8. Vegetation and Buffer Survey

In September 2007, a buffer and vegetation survey of riparian zones along Huron Creek was completed. The overall goals of the surveys were to:

- Provide a baseline of vegetation data for future comparison.
- Provide data for use in relating vegetative conditions with other characteristics such as geomorphology, land use, or water quality.
- Provide data for use in recommending BMPs for the Huron Creek watershed management plan.
- Identify locations of invasive plant species, if any.

Survey locations, methods and quality assurance standards are provided in the Huron Creek Vegetation Survey QAPP, attached as Appendix K. This QAPP was reviewed and approved by MDEQ prior to initiation of the survey.

The buffer survey of Huron Creek was completed using GIS and the most recent (2005) aerial photo of the watershed. The riparian buffer used in the survey was created by delineating all areas within 200 feet perpendicular to the creek, creating a 400-foot wide zone (see Figure 2, Appendix K). Each side of the creek within this zone was then categorized based on the amount of contiguous vegetation extending in an outward direction. Next, the total area that each categorized buffer distance covered was calculated. This resulted in the determination of how much of the total buffer zone each vegetated buffer category covered. The categories and results are provided in Table 5.5, as well as in Figure 5.23.

Table 5.5 Fraction of Total Buffer Area Corresponding to Different Buffer Widths

Buffer Width Category (*BW*)	Fraction of Total Buffer Area Corresponding to Category
BW > 400 ft	53%
200 ft < *BW* < 400 ft	15%
100 ft < *BW* < 200 ft	8%
0 ft < *BW* < 100 ft	<1%
No buffer	23%

The second survey completed was a physical, on-the-ground survey of vegetation types within the buffer zone, and is referred to in the QAPP as the "Vegetation Transect Survey." Nine separate transect location were selected along Huron Creek based on having consistent vegetation and habitat characteristics (see Figure 3, Appendix K). Vegetation species and percent cover information was collected at anywhere between 1 and 3 "data plot" locations along each transect. A spreadsheet is provided in Appendix L that describes the location of each plot (GPS coordinates), a photo of each plot location, common and scientific names of identified species, and percent cover based on stratum (herbaceous, shrub, tree). Invasive species locations are indicated on Figure 5.24 and highlighted in the spreadsheet for easy identification. No general conclusions are easily made from the collected data as habitat type (therefore vegetation type) and percent cover vary randomly along Huron Creek. This information will be used in combination with other survey results to identify Areas of Concern that are described in Chapter 6. The vegetation species data will also be used as a reference for native plant species and a baseline for invasive species management.

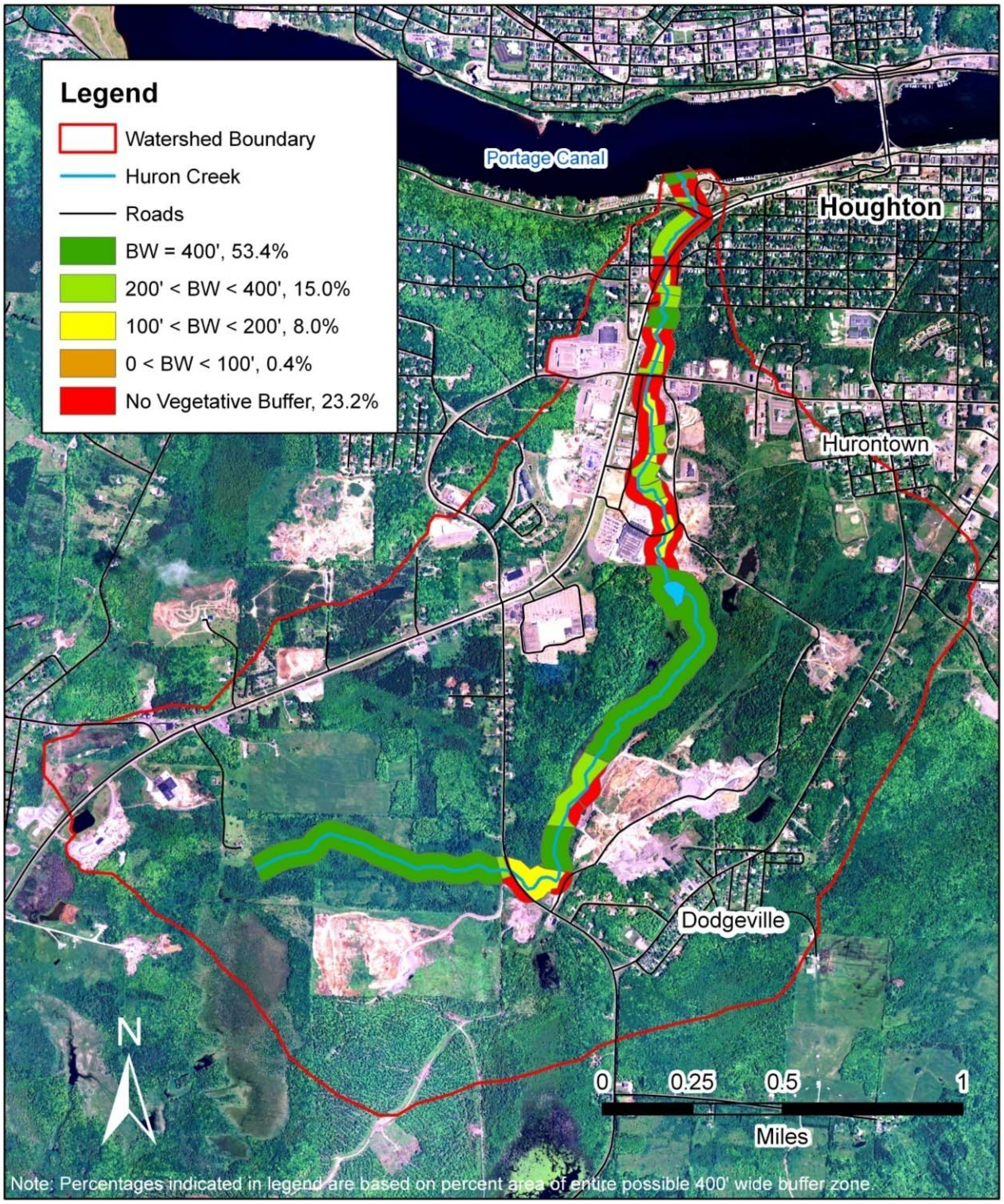

Figure 5.23 Vegetative buffer zones of Huron Creek categorized by buffer width (BW). Created by: Linda Kersten, 12/20/06. Map projection: NAD 1927 UTM Zone 16N. Data source: 2005 NAIP 1-meter digital orthophoto.

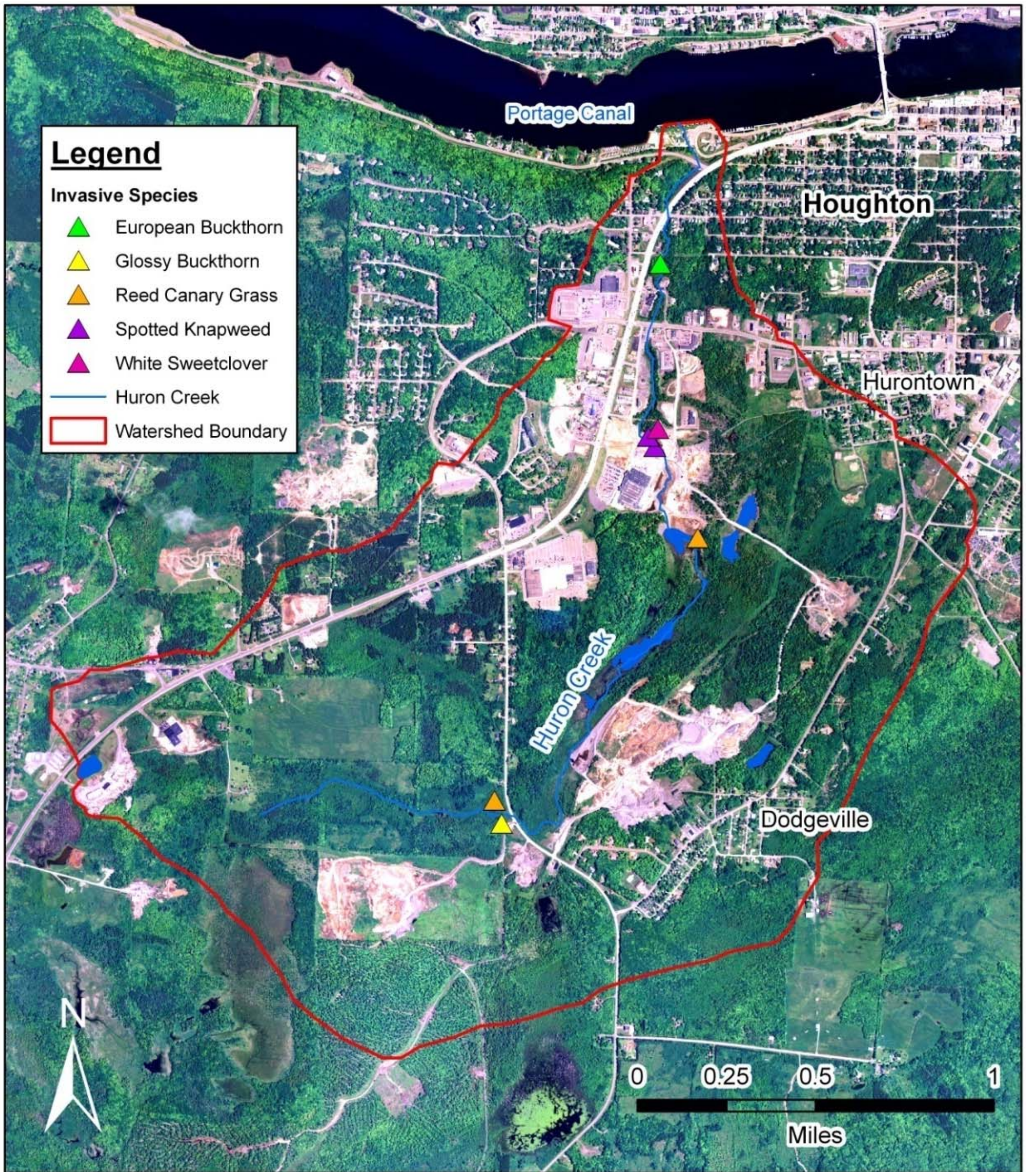

Figure 5.24 Locations and types of invasive plant species found on transects. Created by: Linda Kersten, 12/20/06. Map projection: NAD 1927 UTM Zone 16N. Data source: 2005 NAIP 1-meter digital orthophoto.

5.9. Wetland Restoration Analysis

A simple analysis of potential wetland restoration areas was conducted for the Huron Creek Watershed through the use of a publicly available GIS data layer. This layer is simply referred to as a "potential wetland restoration layer," and is available for most of the state of Michigan on the Michigan

Geographic Data Library website[17]. The information the layer provides to the user is probable locations of former wetland areas that are prioritized by the likelihood they could be restored. In order to give some insight into the interpretation of this data, it is best to first understand how it was created:

- A layer showing historical wetlands data from the 1800's is overlain on today's wetland locations that are from the National Wetland Inventory (NWI) or other similar sources. The current wetland locations are then "erased" from the 1800's data, leaving only locations of where wetlands "used to be" due to changes in land use.

- Next, a layer showing today's locations of hydric soils (soils associated with wetlands) is overlain on top of the same NWI (or similar) layer. The current wetland locations are again "erased" from the hydric soils layer leaving only locations where there are currently hydric soils, but no wetlands.

- Next, the resulting layers from #1 and #2 are overlapped resulting in a layer indicating areas where there used to be wetlands (but currently are not), yet currently have hydric soils. An example of this might be a wetland that was drained for agricultural use.

- Finally, information from #1, #2 and #3 are compiled into one final data layer, with each type of layer categorized by restoration potential according to the following (Chad Kotke MDEQ, 2008):
    - Areas that used to be wetlands (in the 1800's), but currently are not (#1) = *Low Restoration Potential*
    - Areas that currently have hydric soils but are not wetlands (#2) = *Moderate Restoration Potential*
    - Areas that used to be wetlands and currently have hydric soils (#3) = *High Restoration Potential*

Prioritized areas of wetland restoration potential for the Huron Creek watershed are indicated in Figure 5.25, along with areas of existing wetlands. As can be seen on Figure 5.25, the majority of potential restoration areas are of moderate potential, meaning they have been documented as having hydric soils. The largest high potential area, located in the southwestern part of the watershed, is currently a pond. The rest of the high potential areas are relatively small "slivers" that are adjacent to other moderate or low potential areas. It should be noted that the layers used to create the results have not all been verified on the ground, and so field confirmation of existing conditions may be necessary prior to carrying out any action based on this data.

[17] http://www.mcgi.state.mi.us/mgdl/

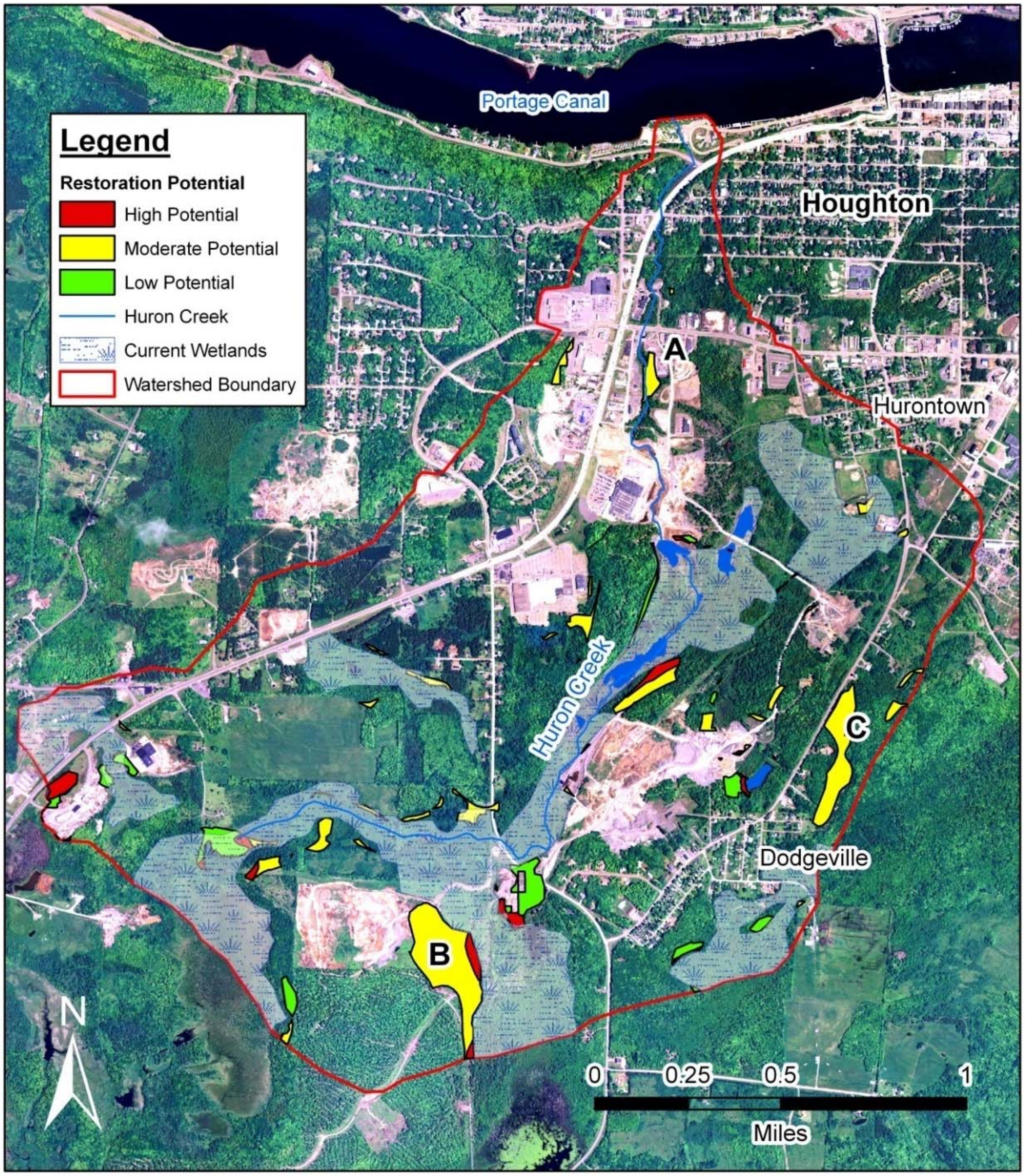

Figure 5.25 Potential wetland restoration areas and current wetland areas. Created by: Linda Kersten, 12/20/06. Map projection: NAD 1927 UTM Zone 16N. Data source: 2005 NAIP 1-meter digital orthophoto.

Three areas of moderate potential in particular stand out as feasible sites for wetland restoration, and are labeled as areas A, B and C on Figure 5.25:

- Area A is located on the east side of Huron Creek immediately south of Sharon Avenue between Razorback Drive and Ridge Road). This area currently exhibits some wetland characteristics such as hydrophytic vegetation and generally saturated soils. In recent years the area has been disturbed due to construction and could be improved through soil stabilization and re-establishment of vegetation.

- Area B is the largest area of moderate potential located near the southern watershed boundary, immediately southeast of the western gravel pit. This area is located between a high, sandy area and a large area of existing wetland. Evidence of excavated drainage ditches is apparent in the aerial photo (Figure 5.25) which may have been created to drain water away from the gravel pit area. If that is the case, then restoration may only rely on returning natural hydrologic conditions to this area (plugging the ditches). However, the benefits of restoration would have to be weighed against the impact it would have on the operation of the gravel pit. Restoration might best be attempted once operations in the southeast portion of the pit cease or in combination with land reclamation performed once all operations cease.

- Area C is the restoration area to northeast of Dodgeville off the east side of Superior Road Based on "drive-by" observation and review of the aerial photo, the majority of this area appears to be existing wetland that has had trails cut through it. (The area is not included in the "current wetlands" most likely because the NWI is not field verified and is not always inclusive of every wetland present.) If this area is confirmed as wetland in the future, it may be a good site for restoration involving either removal or consolidation of trails using proper trail construction techniques so as not to alter hydrology and minimize erosion. These actions, combined with re-vegetation, may be the best first steps at restoration.

5.10. Threatened and Endangered Species Investigation

The Michigan Natural Features Inventory (MNFI) is an organization operated by Michigan State University Extension that maintains databases of the numbers and locations of endangered species, threatened species, species of concern and some natural communities in the state of Michigan[18]. MNFI provides this data to the public in the form of GIS layers that are often used for land use planning. The data is supplied in the form of models that are geared to provide adequate information on rare and endangered species locations, while maintaining the sensitive nature of this data so the resource can remain protected.

An MNFI probability model of sensitive species information was obtained for the Huron Creek watershed. This model indicates the likelihood of finding a rare (threatened or endangered) species or natural community in a given area, in this case, by Public Land Survey System (PLSS) quarter section. Despite its name, the model is not probabilistic in the sense that it provides a statistical probability of an occurrence. The underlying assumption is that the more recent an occurrence has been observed, the more likely it is to still exist. Factors considered in the model are the spatial extent of the occurrences, the presence of potential habitat within the known spatial extent of the occurrence, and the last observed date of the occurrence. The age of each record is then used to determine the likelihood of the species still being present, with recent sightings given a higher likelihood of still existing (Ed Schools,

[18] http://web4.msue.msu.edu/mnfi/

Helen Enander, and John Paskus). Specifically, records prior to 1970 are given a “low” probability of still existing, records between 1970 and 1982 are given a “moderate” probability of still existing, and records after 1982 are given a “high” likelihood of still existing.

The results of this investigation are provided in Figure 5.26. Seventeen sections in the Huron Creek watershed were ranked as having a “low” probability of having a rare species or natural community. All other areas are listed as “no status,” meaning that no rare species or communities have been documented there. Again, the “low” or “no status” designations given do not eliminate those areas from the possibility of having rare species. It only provides an indication of the likelihood a species might be encountered.

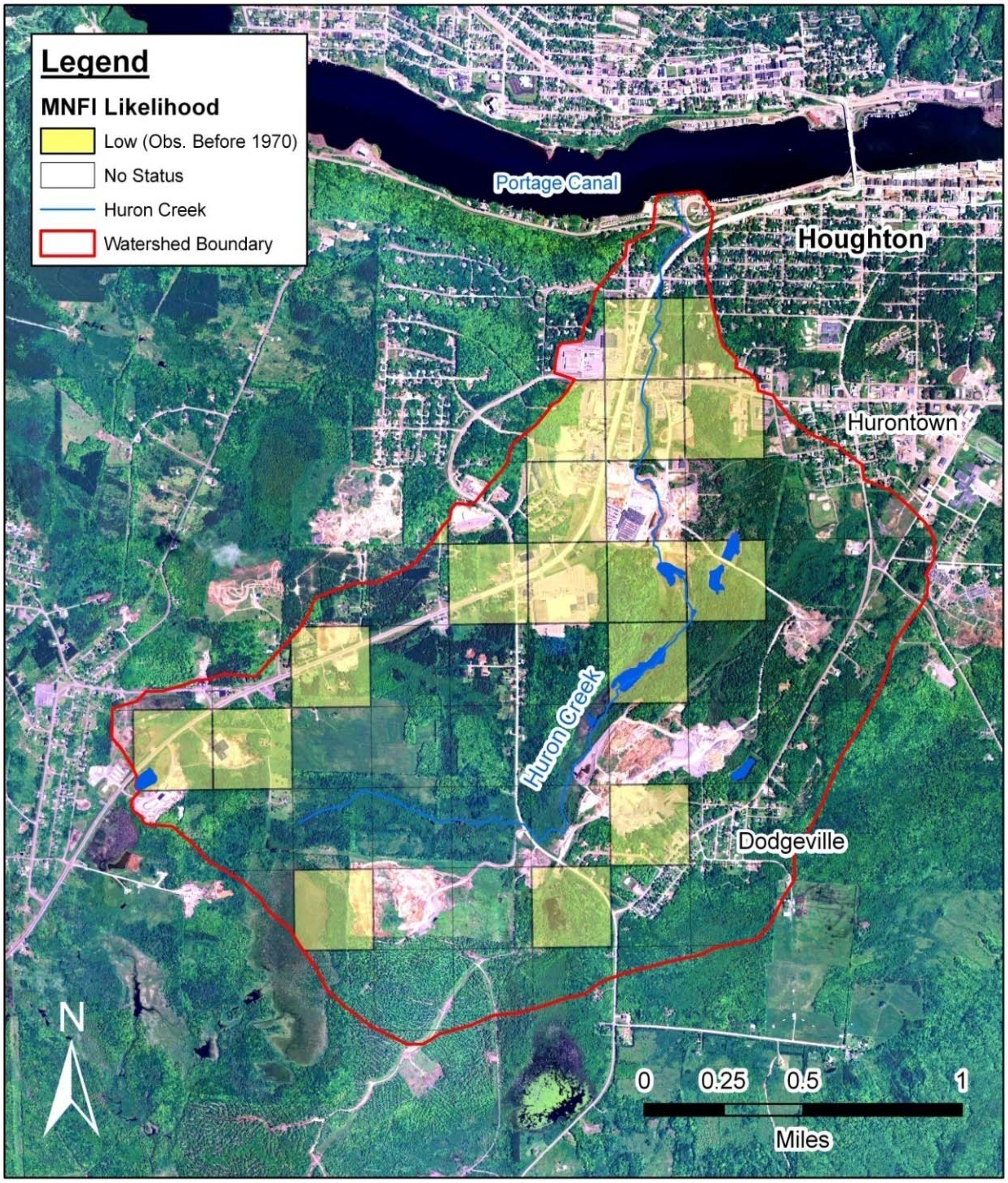

Figure 5.26 MNFI Rare species or natural feature occurrence likelihood. Created by: Linda Kersten, 12/20/06. Map projection: NAD 1927 UTM Zone 16N. Data sources: 2005 NAIP 1-meter digital orthophoto; MNFI Biological Rarity Index and Probability Value.