Biological and Water Quality Study of Walhonding and Muskingum River Tributaries, 2010

Includes Walhonding River, 2007

Coshocton and Muskingum Counties

OHIO EPA Technical Report EAS/2012-6-8

Biological and Water Quality Study of Walhonding and Muskingum River Tributaries

2010

Includes Walhonding River, 2007

Coshocton and Muskingum Counties, Ohio

October 31, 2012
OHIO EPA Technical Report EAS/2012-6-8

Prepared by:
Ohio Environmental Protection Agency
Division of Surface Water
Lazarus Government Center
50 W. Town Street, Suite 700
Columbus, Ohio 43215

Ohio Environmental Protection Agency
Division of Surface Water
Groveport Field Office
4675 Homer Ohio Lane
Groveport, Ohio 43125

and

Ohio Environmental Protection Agency
Southeast District Office
2195 Front Street
Logan, Ohio 43138

Mail to:
P.O. Box 1049, Columbus, Ohio 43216-1049

John R. Kasich, Governor, State of Ohio
Scott J. Nally, Director, Ohio Environmental Protection Agency

TABLE OF CONTENTS

List of Figures

List of Tables

EXECUTIVE SUMMARY

Rivers and streams in Ohio support a variety of uses such as recreation, water supply, and aquatic life. Ohio EPA evaluates each stream to determine the appropriate use designation and to also determine if the use is meeting the goals of the federal Clean Water Act. Twenty-two streams in the Walhonding and Muskingum River tributaries watershed, located in Coshocton and Muskingum counties, were evaluated for aquatic life and recreation use potential in 2010 (Table 1, Figure 1). The Walhonding River mainstem, located in Coshocton County, was assessed in 2007.

Of the 35 biological samples collected and assessed, 22 (63%) were fully meeting the designated or recommended aquatic life use, 8 (23%) were in partial attainment, and 5 (14%) were in non-attainment (Table 2). Sources of impairment are categorically mapped in Figure 2. While natural sources of impairment (flow or habitat) were common, agricultural activities had the most influence on biological resource quality where impaired communities were encountered. Row crops, livestock, or a combination of the two impaired biological communities in the Mill Creek subwatershed and in the lower reach of Beaver Run. The effects of acid mine drainage from abandoned mine lands resulted in non-attainment in both Robinson Run and Mill Run in the upper Muskingum River watershed. The Walhonding River main stem, sampled in 2007, was in full attainment of the Exceptional Warmwater Habitat (EWH) aquatic life use except for the site at river mile (RM) 8.81 near Warsaw, which is impounded by the Six Mile Dam. Removal of this dam would allow for the Walhonding River to become free-flowing throughout its length, thus increasing the likelihood of full attainment of EWH criteria in the future.

In general, biological resource quality for the Walhonding and Muskingum River tributaries study area can be described as good to very good. Exceptional fish and macroinvertebrate communities were collected in Mohawk Creek and its unnamed tributary at RM 2.93, warranting the recommendation of the EWH aquatic life use for both of these streams. Cold water biological communities were collected in Dutch Run, Honey Run, the Beaver Run headwaters, Turkey Run, and Blunt Run. As a result, the Coldwater Habitat (CWH) aquatic life use is recommended for these streams or stream segments.

Twenty-two locations in the Walhonding and Muskingum River tributaries watershed were tested for bacteria indicators (*Escherichia coli*) to determine recreation use attainment status. Evaluation of *E. coli* results revealed that eight locations attained the applicable geometric mean criterion, and thus were in full attainment of the designated recreation use. Among these were the five locations sampled on the Walhonding River main stem in 2007, thus the entire length of the river was in full attainment of the recreation use criteria. Widespread bacterial contamination elsewhere in the watershed was attributed mostly to agricultural sources; namely unrestricted livestock access to streams. Horses and cattle were either physically observed in many of the streams, or their fecal deposits were noted within stream channels. In addition to livestock, failing on-lot septic systems are also suspected to have contributed excessive bacterial loads to the streams.

Water chemistry in the Walhonding and Muskingum tributaries watershed was generally good, with only a few exceedances of Ohio Water Quality Standards (WQS) for dissolved oxygen and sulfate. Low dissolved oxygen was attributed primarily to either late summer stream flows or to the effects of nutrient and organic enrichment from agricultural activities. Sulfate exceedances were confined mostly to Muskingum River tributaries and were the result of historical mining activities in the basin.

The 2010 survey was the first comprehensive biological and water quality study of the Walhonding and Muskingum River tributaries. The Walhonding River, however, has been sampled for both fish and macroinvertebrates since the 1980s. With the exception of the area impounded by Six Mile Dam, biological index scores have continually improved through time and have been fully meeting EWH criteria since 1994.

Table 1. Walhonding and Muskingum River tributaries watershed sampling locations, 2010. Walhonding River main stem was sampled in 2007.

Site Number*	Stream	Location	RM	Drain. Area	Latitude	Longitude
1	Mohawk Creek	TR 409	4.10	9.47	40.290820	-82.086286
2	Mohawk Creek	CR 82	1.48	22.60	40.320576	-82.074001
3	UT to Mohawk @ RM 2.93	TR 373	0.60	6.38	40.308870	-82.094327
4	Dutch Run	TR 344/TR 338	0.15	4.29	40.366860	-82.096240
5	Honey Run	TR 359	0.60	1.86	40.364621	-82.115316
6	Beaver Run	CR 22	2.60	8.36	40.354395	-82.022752
7	Beaver Run	SR 36 @ Warsaw	0.17	14.10	40.333241	-82.001720
8	Simmons Run	TR 78	2.97	9.29	40.297333	-82.006045
9	Simmons Run	TR 41B	0.60	16.30	40.326325	-82.008951
10	Flint Run	SR 60	0.40	2.25	40.323260	-82.016509
11	Darling Run	TR 340 at Nellie Cemetery	0.10	3.82	40.343730	-82.049205
12	Mill Creek	TR 215	12.50	8.84	40.411979	-81.833722
13	Mill Creek	TR 206	8.50	18.50	40.367468	-81.855589
14	Mill Creek	At GAGE - farm lane off CR 12	7.90	27.20	40.362738	-81.862685
15	Mill Creek	TR 322	3.54	39.90	40.324026	-81.857908
16	Mill Creek	CR 24	0.40	51.10	40.296901	-81.872277
17	Little Mill Creek	Driveway off TR 206	0.10	8.40	40.366702	-81.854767
18	Beards Run	CR 12	0.03	2.72	40.394744	-81.845742
19	Turkey Run	CR 12	0.19	5.50	40.360910	-81.870900
20	Crooked Run	CR 23	0.98	8.03	40.296996	-81.908822
21	Crooked Run	End of TR 495	0.06	8.97	40.299699	-81.895220
22	Robinson Run	CR 271	1.35	3.81	40.213551	-81.857998
23	Monroe Basin Creek	SR 16	1.80	5.84	40.152998	-81.979272
24	North Branch Symmes Creek	Steel Hill Road	4.25	8.16	40.105381	-81.915960
25	North Branch Symmes Creek	Madison Hall Road	0.10	15.00	40.083749	-81.953617
26	Symmes Creek	Steel Hill Road @ oil rig	5.65	8.30	40.077523	-81.920167
27	Symmes Creek	Mutton Ridge Road	4.35	15.30	40.069945	-81.933584
28	Symmes Creek	Mollies Rock Road	2.35	31.50	40.083272	-81.953805
29	South Branch Symmes Creek	Sheck Road	0.15	4.33	40.066307	-81.924647
30	Blount Run	SR 666	0.31	7.70	40.021977	-81.976587
31	Blunt Run	CR 418	0.10	2.80	40.029141	-81.995868
32	Mill Run	Coal Run Road	0.45	3.38	39.952870	-81.989500
33	Spoon Creek	SR 193	0.60	7.85	40.327162	-81.846075
34	Walhonding River (2007)	Near Walhonding @ SR 715	21.80	1490.00	40.358448	-82.138142
35	Walhonding River (2007)	at Nellie @ US 36	15.73	1505.00	40.341241	-82.064818
36	Walhonding River (2007)	ust Sixmile Dam	8.81	1572.00	40.326002	-81.967280

Site Number*	Stream	Location	RM	Drain. Area	Latitude	Longitude
37	Walhonding River (2007)	ust Killbuck Creek @ US 36	7.54	1575.00	40.324834	-81.943746
38	Walhonding River (2007)	at Coshocton @ US 36	0.76	2255.00	40.283659	-81.870724

*The color of the site number corresponds to the narrative biological score (blue is exceptional to very good (meets EWH goals), green is good to marginally good (meets WWH goals) yellow is fair, orange is poor and red is very poor (fair, poor and very poor do not meet the goals of WWH). Purple indicates sites where chemical parameters only were sampled (i.e., no biology).

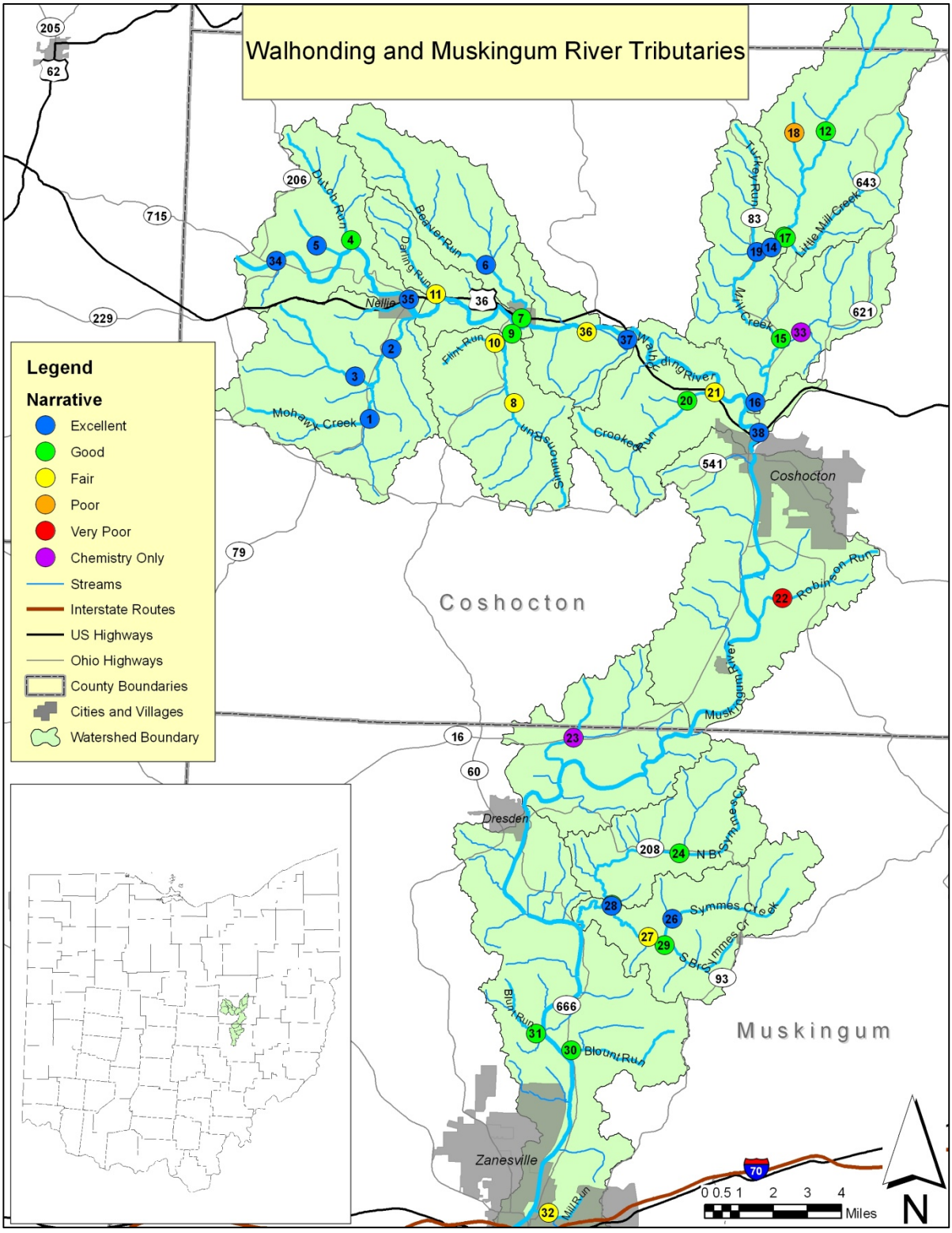


Figure 1. Map of the Walhonding and Muskingum River tributaries watershed and sampling locations from the Ohio EPA 2007 and 2010 surveys.

Table 2. Aquatic life use attainment status for stations sampled in the Walhonding and Muskingum tributaries basin based on data collected July-October 2010, and in the Walhonding River based on data collected July-October 2007. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community. All sampled streams lie within the Western Allegheny Plateau (WAP) ecoregion.

Location	River Mile (STORET)	Drain. (mi²)	IBI	MIwb[a]	ICI[b]	QHEI	Status[c]	Causes	Sources
Mohawk Creek – Trib. to Walhonding River at RM 15.21 – WWH existing/EWH recommended									
Mohawk Creek @ TR 409	4.10 [H] (301011)	9.47	52	n/a	VG[ns]	66.3	FULL		
Mohawk Creek @ CR 82	1.48 [W] (300887)	22.60	51	9.5	50	57.8	FULL		
Unnamed Trib. to Mohawk Creek at RM 2.93 – Undesignated – EWH recommended									
UT to Mohawk Creek at RM 2.93 @ TR 373	0.60 [H] (301012)	6.38	52	n/a	E	74.3	FULL		
Dutch Run – Trib. to Walhonding River at RM 18.40 – WWH existing/CWH recommended									
Dutch Run @ TR 144/TR 338	0.15 [H] (301013)	5.44	42	n/a	E	63.3	FULL		
Honey Run – Trib. to Walhonding River at RM 18.86 – WWH existing/CWH recommended									
Honey Run @ TR 359	0.60 (301014)	1.86	--	--	VG	50.5	FULL		
Beaver Run – Trib. to Walhonding River at RM 11.8 – EWH existing/CWH recommended - headwaters to RM 2.53									
Beaver Run @ CR 22	2.60 [H] (301015)	8.36	46	n/a	VG	53.5	FULL		
Beaver Run – Trib. to Walhonding River at RM 11.8 – EWH existing									
Beaver Run @ SR 36 at Warsaw	0.17 [H] (200633)	14.10	54	n/a	G*	60.3	**PARTIAL**	Sedimentation/siltation Particle distribution (embeddedness)	Crop production (crop land or dry land)
Simmons Run – Trib to Walhonding River at RM 10.66 – WWH existing									
Simmons Run @ TR 78	2.97 [H] (301016)	9.29	52	n/a	F*	64.5	**PARTIAL**	Sedimentation/siltation	Channelization Stream bank destabilization/modification
Simmons Run @ TR 41B	0.60 [H] (301017)	16.30	52	n/a	G	78.0	FULL		
Flint Run – Trib to Simmons Run at RM 1.2 – WWH existing									

Location	River Mile (STORET)	Drain. (mi²)	IBI	MIwb[a]	ICI[b]	QHEI	Status[c]	Causes	Sources
Flint Run @ SR 60	0.40 H (301018)	2.25	50	n/a	F*	56.5	**PARTIAL**	Natural conditions (flow or habitat)	Natural Sources
Darling Run – Trib to Walhonding River at RM 14.24 – WWH existing									
Darling Run @ TR 340 at Nellie Cemetery	0.10 H (301019)	3.82	44	n/a	F*	59.8	**PARTIAL**	Natural conditions (flow or habitat)	Natural Sources
Mill Creek – Trib. to Walhonding River at RM 1.9 – EWH existing									
Mill Creek @ TR 215	12.50 H (301020)	8.84	52	n/a	G*	68.0	**PARTIAL**	Nutrient/eutrophication biological indicators	Livestock (Grazing or feeding operation)
Mill Creek @ TR 206	8.50 H (R04S29)	18.50	44*	n/a	VG[ns]	64.3	**PARTIAL**	Sedimentation/siltation Organic enrichment (sewage) biological indicators	Unrestricted cattle access
Mill Creek @ gage	7.9 W (300978)	27.20	47[NS]	9.2 [NS]	VG[ns]	58.0	FULL		
Mill Creek @ TR 322	3.54 W (300888)	39.90	44*	8.7*	36*	59.8	**NON**	Sedimentation/Siltation Organic enrichment (sewage) biological indicators	Crop production (crop land or dry land) Livestock (grazing or feeding operation) Sediment resuspension (contaminated sediment) Onsite treatment systems (septic systems)
Mill Creek @ CR 24	0.40 W (R04S28)	51.10	46[NS]	9.3[NS]	44[ns]	59.8	FULL		
Little Mill Creek – Trib. To Mill Creek at RM 8.45 – EWH existing									
Little Mill Creek @ driveway off TR 206	0.10 H (200632)	8.40	54	n/a	G*	63.8	**PARTIAL**	Sedimentation/siltation	Livestock (Grazing or feeding operation) Streambank destabilation/modification
Beards Run – Trib. To Mill Creek at RM 10.88 – WWH existing									
Beards Run @ CR 12	0.03 (300888)	2.72	--	--	P*	47.0	N/A	Livestock access to stream; macroinvertebrate fauna almost entirely comprised of flatworms.	

Location	River Mile (STORET)	Drain. (mi²)	IBI	MIwb[a]	ICI[b]	QHEI	Status[c]	Causes	Sources
Turkey Run – Trib. to Mill Creek at RM 7.29 – EWH existing – EWH/CWH recommended									
Turkey Run @ CR 12	0.19[W] (R04S31)	5.50	58	n/a	E	70.5	FULL		
Crooked Run – Trib. to Walhonding River @ RM 3.22 – WWH existing									
Crooked Run @ CR 23, ust WWTP	0.98[H] (301024)	8.03	44	n/a	MG[ns]	53.3	FULL		
Crooked Run @ TR 495	0.06[H] (301023)	8.97	36*	n/a	F*	42.8	**NON**	Natural conditions (flow or habitat)	Natural Sources
Robinson Run – Trib. to Muskingum River at RM 105.21 – WWH existing									
Robinson Run @ CR 271	1.35[H] (300289)	3.81	20*	n/a	VP*	79.5	**NON**	Sedimentation/siltation Particle distribution (embeddedness) Bottom Deposits Total Dissolved Solids	Acid Mine Drainage Impacts from abandoned mine lands (inactive)
North Branch Symmes Creek – Trib. to Symmes Creek at RM 2.35 – WWH existing									
North Branch Symmes Creek @ Steel Hill Road	4.25[H] (301031)	8.16	44	n/a	G	73.0	FULL		
North Branch Symmes Creek @ Madison Hall Road	0.10[H] (301030)	15.00	56	n/a	G	78.5	FULL		
Symmes Creek – Trib. to Muskingum River at RM 87.14 – WWH existing									
Symmes Creek @ Steel Hill Road at oil rig	5.65[H] (301034)	8.30	46	n/a	VG	62.8	FULL		
Symmes Creek @ Mutton Ridge Road	4.35[H] (301033)	15.30	34*	n/a	VG	58.0	**PARTIAL**	Natural conditions (flow or habitat)	Natural Sources
Symmes Creek @ Mollie's Rock Road	2.35[W] (300889)	31.50	51	9.1	50	76.8	FULL		
South Branch Symmes Creek – Trib. to Symmes Creek at RM 4.81 – WWH existing									
South Branch Symmes Creek @ Sheck Road/TR 156	0.15[H] (301032)	4.33	48	n/a	G	66.8	FULL		
Blount Run – Trib. to Muskingum River at RM 82.38 – WWH existing									

Location	River Mile (STORET)	Drain. (mi²)	IBI	MIwb[a]	ICI[b]	QHEI	Status[c]	Causes	Sources
Blount Run @ SR 666	0.31 [H] (300890)	7.70	52	n/a	G	68.3	FULL		
Blunt Run – Trib. to Muskingum River at RM 83.38 – WWH existing/CWH recommended									
Blunt Run @ CR 418	0.10 [H] (301035)	2.80	48	n/a	G	69.3	FULL		
Mill Run – Trib. to Muskingum River at RM 77.50 – WWH existing									
Mill Run @ Coal Run Rd	0.45 [H] (301036)	3.38	36*	n/a	F*	52.5	**NON**	Sedimentation/siltation Particle distribution (embeddedness) Bottom Deposits Total Dissolved Solids	Acid Mine Drainage Impacts from abandoned mine lands (inactive)
Walhonding River (2007) – EWH existing									
Walhonding River near Walhonding @ SR 715	21.8[B] (300321)	1490.0	56	10.64	52	81.5	FULL		
Walhonding River at Nellie @ US 36	15.73[B] (601910)	1505.0	55	10.88	E	83.0	FULL		
Walhonding River ust Sixmile Dam	8.81[B] (300288)	1572.0	45*	8.53*	F*	64.0	**NON**	Direct Habitat Alterations Other flow regime alterations	Dam or impoundment
Walhonding River ust Killbuck Creek @ US 36	7.54[B] (R04S35)	1575.0	54	11.54	48	92.0	FULL		
Walhonding River at Coshocton @ US 36	0.76[B] (R04W27)	2255.0	52	10.66	52	94.0	FULL		

a - MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates. VP=Very Poor, P=Poor, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment is given for the proposed status when a change is recommended.

ns - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Biological Criteria: Western Allegheny Plateau

Index – Site Type	EWH	WWH	MWH
IBI – Headwaters	50	44	24
IBI – Wading	50	44	24
IBI – Boat	48	40	24
MIwb – Wading	9.4	8.4	6.2
MIwb – Boat	9.6	8.6	5.8
ICI	46	36	22

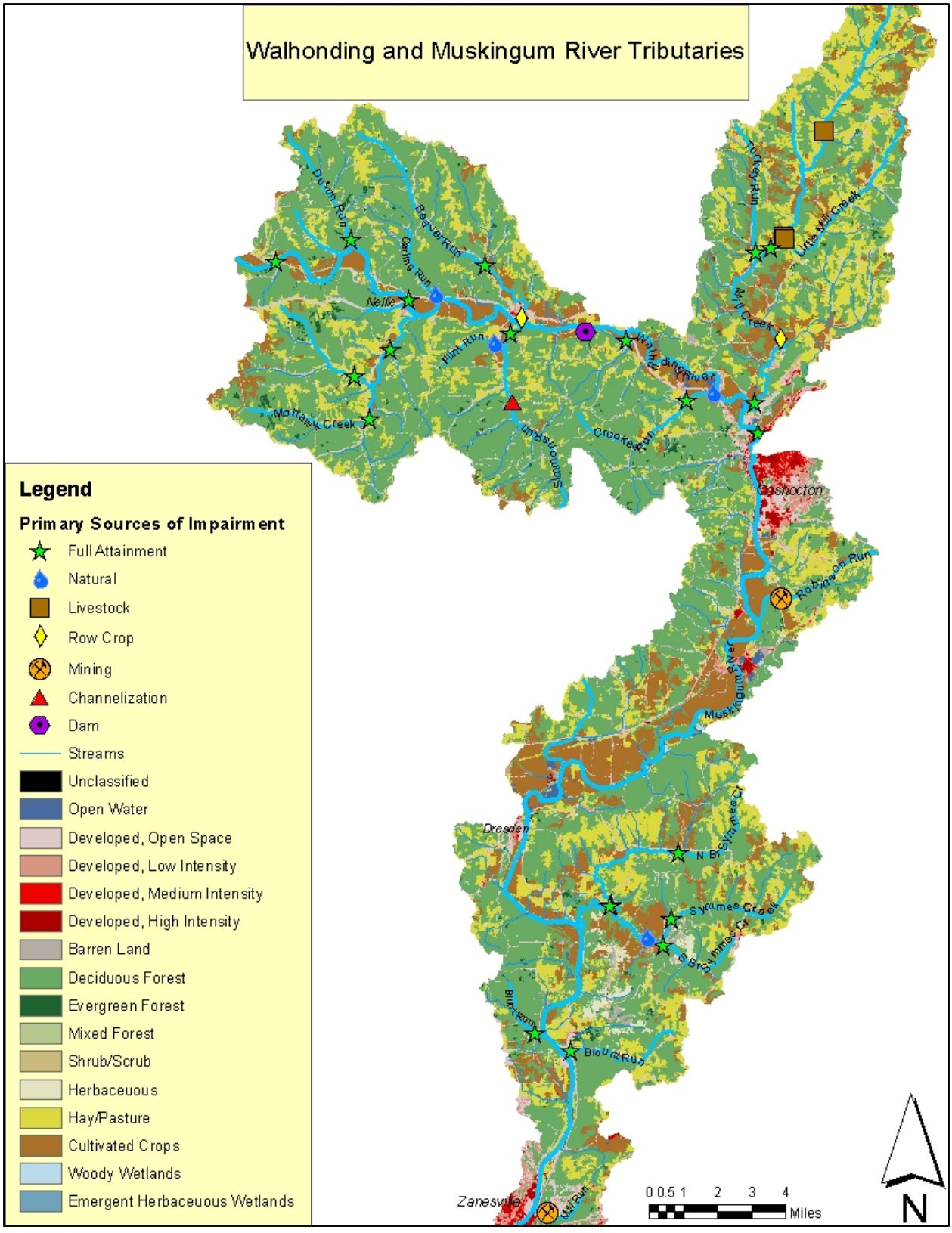


Figure 2. Primary sources of aquatic life use impairment vs. land cover (NLCD 2006) in the Walhonding and Muskingum River tributaries watershed.

RECOMMENDATIONS

The streams in the Walhonding and Muskingum River tributaries study area currently listed in the Ohio Water Quality Standards (WQS) are assigned either the Warmwater Habitat (WWH) or Exceptional Warmwater Habitat (EWH) aquatic life use. The unnamed tributary to Mohawk Creek at RM 2.93 is not listed in the WQS. The aquatic life use designations for the Walhonding River, Mill Creek, Turkey Run, Little Mill Creek, and Beaver Run have been previously verified. All other streams in the survey were originally designated for aquatic life uses in the 1978 WQS. The techniques used then did not include the standardized approaches to the collection of instream biological data or numerical biocriteria. This study used biological data to evaluate and establish aquatic life uses for streams in the Walhonding and Muskingum River tributaries study area.

Twenty streams in the Walhonding and Muskingum River tributaries study area were evaluated for aquatic life and recreation use potential in 2010 (Table 3). The Walhonding River main stem was evaluated in 2007. Significant findings include the following:

- Five streams have an existing, verified EWH aquatic life use that should be maintained. Biological monitoring on the Walhonding River, Mill Creek, Turkey Run, Little Mill Creek, and Beaver Run confirmed the appropriateness of the EWH aquatic life use.

- In addition to maintaining the EWH aquatic life use, it is recommended that Turkey Run also be assigned the Coldwater Habitat (CWH) aquatic life use. Biological sampling revealed large populations of three cold water fish species and the presence of three cold water macroinvertebrate taxa. This biological community composition satisfies the minimum two cold water fish and two cold water macroinvertebrate taxa that are required to recommend the CWH aquatic life use in the draft OAC 3745-1-07. Turkey Run should maintain the dual EWH/CWH aquatic life use throughout its entire length.

- Biological sampling on Beaver Run at County Road 22 north of Warsaw (RM 2.60) indicated the presence of three cold water fish species and two cold water macroinvertebrate taxa. Like Turkey Run, this community composition satisfies the requisite fish and macroinvertebrate taxa to recommend the CWH aquatic life use. Sampling downstream at RM 0.17 revealed only one fish and one macroinvertebrate cold water taxa. Beaver Run is currently designated EWH throughout its length. Based upon these findings, it is recommended that Beaver Run be assigned the CWH aquatic life use from its headwaters downstream to the confluence with the unnamed tributary at RM 2.53. The currently assigned EWH aquatic life use should be maintained on all other segments.

- Dutch Run, Honey Run, and Blunt Run have unverified WWH aquatic life uses in the WQS. Biological sampling results indicate that the CWH aquatic life use would be more appropriate for these streams. Four fish and ten macroinvertebrate cold water taxa were collected from Dutch Run, nine macroinvertebrate cold water taxa were collected from Honey Run, and four macroinvertebrate cold water taxa were collected from Blunt Run. These collections satisfy the minimum taxa necessary to recommend the CWH aquatic life use, and as such, CWH is recommended for these three streams.

- Mohawk Creek has an unverified WWH aquatic life use in the WQS. Biological sampling results revealed exceptional fish and macroinvertebrate communities in this stream. As a result, Mohawk Creek should be assigned the EWH aquatic life use.

- The unnamed tributary to Mohawk Creek at RM 2.93 is not listed in the Ohio WQS. Biological sampling on this stream indicated exceptional fish and macroinvertebrate communities in this stream. Therefore, the EWH aquatic life use should be assigned for the entire length of the unnamed tributary to Mohawk Creek at RM 2.93.

- Beards Run was originally designated Warmwater Habitat-Limited (WWH-*L aka Limited Warmwater Habitat [LWH]) due to acid mine drainage in the 1978 WQS. Based on sampling results from this survey, while impairment was determined, the causes and sources were not of acid mine origin. The appropriate aquatic life use designation is WWH.

- The remaining nine streams from the 2010 study – Mill Run, Blount Run, Symmes Creek, North and South branches of Symmes Creek, Robinson, Crooked, Simmons, Flint, and Darling runs – all have unverified WWH aquatic life uses in the WQS. Biological sampling conducted on these streams verified that the WWH aquatic life use is indeed appropriate.

The Walhonding River should be assigned the Primary Contact Recreation Class A use for its entire length. All remaining streams or stream segments in the study area should retain or be assigned the Primary Contact Recreation Class B use. All streams in the study area should retain or be assigned the Agricultural Water Supply and Industrial Water Supply uses.

Six Mile Dam impounds the Walhonding River at RM 8.80 and resulted in non-attainment of EWH biocriteria for both fish and macroinvertebrates within the impounded portion. Six Mile Dam will likely be a continued source of impairment within the Walhonding River, as the monotypic habitat throughout the impounded reach cannot support the diverse communities found within the free-flowing portions of the Walhonding River. Removing Six Mile Dam would improve diversity and likely bring biological index scores into full attainment of EWH criteria. Therefore, it is recommended that a feasibility study be conducted to examine the dam's removal potential.

Six Mile Dam of the Walhonding River.

Cattle in Spoon Creek.

Livestock was frequently observed in many streams throughout the study area. Unrestricted livestock access to streams results in sedimentation from trampled banks, nutrient and organic enrichment from urine and fecal deposits, as well as high fecal bacteria levels. Fencing out horses and cattle from streams would serve to abate much of the biological and recreation use impairment observed in the watershed.

Table 3. Beneficial use designations for water bodies in the Walhonding and Muskingum River tributaries study area. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). A plus sign (+) indicates a confirmation of an existing use and a triangle (▲) denotes a new recommended use based on the findings of this report.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Mill run		*/+							*/+	*/+		*/+		
Blount run		*/+							*/+	*/+		*/+		
Blunt run						▲			*/+	*/+		*/+		
Shawnee run		*							*	*		*		
Beech run		*							*	*		*		
Symmes creek		*/+							*/+	*/+		*/+		
North branch		*/+							*/+	*/+		*/+		
South branch		*/+							*/+	*/+		*/+		
Robinson run		*/+							*/+	*/+		*/+		
North creek							+		+	+			+	Small drainageway maintenance
West creek							+		+	+			+	Small drainageway maintenance
Walhonding river			+						+	+		+		
Mill creek			+						+	+		+		
Spoon creek		+							+	+		+		
Turkey run			+			▲			+	+		+		
Little Mill creek			+						+	+		+		
Beards run		*/+							*/+	*/+		*/+		
Crooked run		*/+							*/+	*/+		*/+		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Simmons run		*/+							*/+	*/+		*/+		
Flint run		*/+							*/+	*/+		*/+		
Beaver run														
-Headwaters to RM 2.53						▲			+	+		+		
-All other segments			+						+	+		+		
Darling run		*/+							*/+	*/+		*/+		
Mohawk creek			▲						*/+	*/+		*/+		
Unnamed tributary to Mohawk Creek at RM 2.93			▲						▲	▲		▲		
Dutch run						▲			*/+	*/+		*/+		
Honey run						▲			*/+	*/+		*/+		

SRW=State Resource Water; WWH=Warmwater Habitat; EWH=Exceptional Warmwater Habitat; MWH=Modified Warmwater Habitat; SSH=Seasonal Salmonid Habitat; CWH=Coldwater Habitat; LRW=Limited Resource Water; PWS=Public Water Supply; AWS=Agricultural water Supply; IWS=Industrial Water Supply; BW=Bathing Waters; PCR=Primary Contact Recreation; SCR=Secondary Contact Recreation

INTRODUCTION

Thirty-eight stream sampling locations were evaluated in the Walhonding and Muskingum River tributaries watershed in Coshocton and Muskingum counties. Five sites were sampled on the main stem of the Walhonding River, while 33 sites were sampled on direct and indirect tributaries to both the Walhonding and Muskingum rivers. Tributaries to the Walhonding River that were sampled include Mohawk Creek, Beaver Run, Simmons Run, Mill Creek, and Crooked Run. Tributaries to the Muskingum River that were sampled include Robinson Run, Symmes Creek (including North and South branches), Blount Run, Blunt Run, and Mill Run. A total of seven National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the Walhonding and Muskingum River Tributaries study area.

Location of Walhonding and Muskingum River Tributaries watershed in Ohio.

Ohio EPA conducted resource assessments of the Walhonding River main stem in 2007 and 22 Walhonding and Muskingum River tributaries in 2010 using standard Ohio EPA protocols as described in Appendix A. Included in this study were assessments of the biological, surface water, sediment, and recreation (bacterial) condition. A total of 36 biological, 38 surface water, 3 fish tissue, 6 sediment, and 17 bacterial stations were sampled in the Walhonding and Muskingum River Tributaries watershed. All of the biological, chemical and bacteria results can be downloaded from the Ohio EPA GIS interactive maps at the following link: http://www.epa.state.oh.us/dsw/gis/index.aspx.

Specific objectives of this evaluation were to:

- Establish the present biological conditions in the Walhonding and Muskingum River Tributaries watershed by evaluating fish and macroinvertebrate communities,
- Identify the relative levels of organic, inorganic, and nutrient parameters in the sediments and surface water,
- Evaluate influences from NPDES outfall discharges,
- Assess physical habitat influences on stream biotic integrity,
- Determine recreation water quality,
- Compare present results with historical conditions, and
- Determine beneficial use attainment status and recommend changes if appropriate.

STUDY AREA DESCRIPTION

The Walhonding and Muskingum River tributaries watershed is located in the Western Allegheny Plateau (WAP) ecoregion and is comprised mostly of deciduous forest in the west, with increasing areas of pasture land and cultivated crops in the eastern and southern reaches of the catchment (Figure 2). The watershed is largely undeveloped, although the city of Coshocton occupies the area where the Walhonding and Tucarawas rivers join to form the Muskingum River, and the city of Zanesville encroaches on the southern boundary of the watershed. The underlying bedrock geology consists of mostly Pennsylvanian strata, with a mix of Allegheny and Pottsville groups covering most of the study area, and the Conemaugh group occupying the southeastern fringe of the Muskingum River tributaries. These coal-producing strata have resulted in the presence of both active and abandoned coal mines, particularly in the central and southern portion of the watershed (Figure 3).

The Walhonding River main stem, sampled in 2007, is 23.5 miles long, drains 2256 mi^2, and is the largest stream contained wholly within the study area. Most of the Walhonding and Muskingum River tributaries that were sampled in 2010 are smaller streams that drain less than 20 square miles. Exceptions are the Walhonding River tributaries Mohawk Creek (25.6 mi^2) and Mill Creek (51.2 mi^2), and Symmes Creek (32.2 mi^2) in the Muskingum River basin. The Walhonding River, Mill Creek, Turkey Run, and Little Mill Creek are listed as EWH in the Ohio WQS. All other streams are assigned the WWH aquatic life use except for the unnamed tributary to Mohawk Creek at RM 2.93, which is not listed in the WQS and therefore is undesignated. These WWH streams, with the exception of Spoon Creek, were originally assigned aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical

biological criteria. This study used biological data to evaluate and establish aquatic life uses for these streams. All designated streams in the Walhonding and Muskingum River Tributaries study area are currently assigned as Primary Contact Recreation (PCR) (Class A for Walhonding River and Class B for all other stream segments), Agricultural Water Supply (AWS) and Industrial Water Supply (IWS). There are no Public Water Supplies (PWS) in the study area.

The findings of this evaluation may factor into regulatory actions taken by the Ohio EPA (e.g. NPDES permits, Director's Orders, or the Ohio Water Quality Standards [OAC 3745-1], and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, Total Maximum Daily Loads (TMDLs) and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

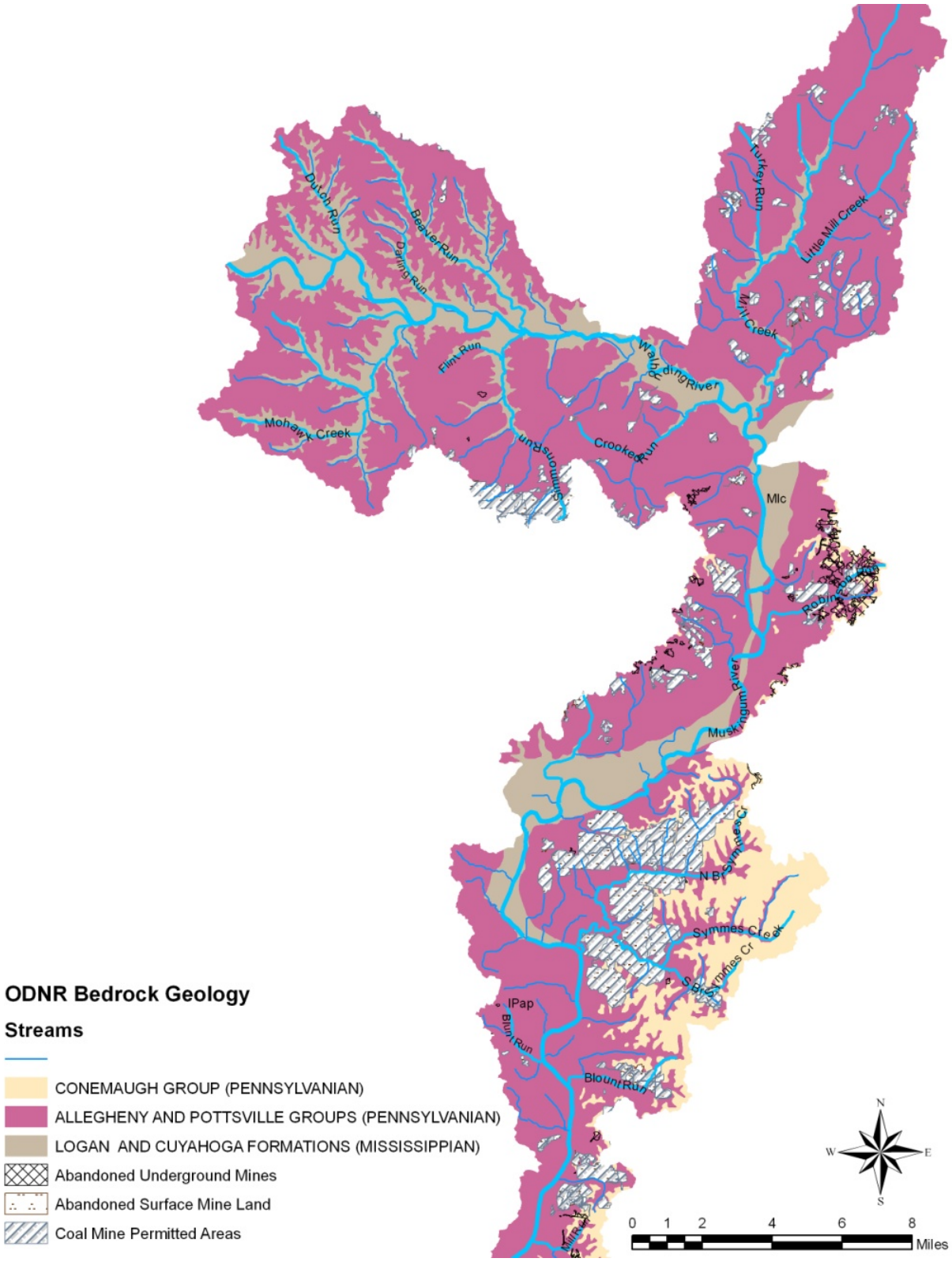


Figure 3. Bedrock geology of the Walhonding and Muskingum River tributaries study area, showing both active and abandoned coal mines.

RESULTS AND DISCUSSION

NPDES-Regulated Facilities

A total of seven National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge wastewater and storm water into tributaries of the Walhonding and Muskingum rivers in Muskingum and Coshocton counties (Table 4). One municipal facility discharges directly to the Walhonding River.

Table 4. NPDES permitted facilities in the Walhonding and Muskingum River tributaries watershed.

Facility Name	Ohio EPA Permit No.	Location of Discharge	River Mile	Design Flow	Type
Smurfit Stone Container-Mill Creek Landfill	0IN 00128	Unnamed trib. to Turkey Run @ RM 0.4	2.00	--	Industrial
Coshocton Landfill	0IN00216	Robinson Run	3.53	--	Industrial
Coshocton Ethanol	0IN00260	Robinson Run	0.74	0.3482	Industrial
Edgewood Terrace MHP	0PV00022	Crooked Run	0.8	0.01	Municipal
Luburgh Shale Pit	0IJ00043	Mill Run	0.17	--	Industrial
James Brother Sand and Gravel	0IJ00044	Mill Run	1.9	--	Industrial
Echoing Hills	0PR00154	Unnamed trib to Mohawk Creek @ RM 4.27	1.9	0.01	Municipal
Warsaw WWTP	0PB00084	Walhonding River	11.1	0.170	Municipal

Smurfit Stone Container-Mill Creek Landfill: This facility is located on CR 38, Mill Creek Township, Coshocton County. The facility has two permitted outfalls, one for discharge from a sedimentation pond, and the other from a pump station bypass to a wetland area. Both discharges go to an unnamed tributary to Turkey Run and enter Turkey Run at RM 0.4.

Coshocton Landfill: This facility is located at 19469 CR 7 in Coshocton and discharges to Robinson Run at RM 3.53, about 1.2 miles upstream from the sampling location on Robinson Run. This is a municipal solid waste landfill, constructed on a site that has been deep and surfaced-mined for coal. Acid mine drainage seeps from an underground mine voids on the site. The treatment system was built in 1998 and consists of directing flow over soda ash and briquettes to raise pH. It then flows through a ditch to two settling ponds built in series. Once the pH is at a satisfactory level, a valve is opened at the end of the last pond to release the water to Robinson Run.

Coshocton Ethanol: This facility is located at 18137 CR 271, in Coshocton and discharges to Robinson Run at RM 0.74. The plant was designed as an anhydrous ethanol fuel production facility. The Permit to Install for the construction of the treatment system was approved in August 2007. It was designed to handle three waste streams: cooling tower blowdown, boiler blowdown, and reverse osmosis concentrate. This water would enter the cooling pond and discharge from there to Robinson Run. The process water and sanitary waste were planned to be treated at the city of Coshocton's wastewater treatment plant, for which facilities were constructed on that site under a separate Permit to Install. Coshocton Ethanol has an NPDES permit to discharge cooling pond overflow into Robinson Run. There are also six other outfalls in their NPDES permit for

site run-off resulting from storm water. The facility hasn't operated since late 2008, less than a year from starting production, and there have been discussions regarding potential use and sale of the property. At the present time, the facility is not operating.

Edgewood Terrace MHP: This mobile home park is located at 46115 US Route 36 in Coshocton and has an extended aeration plant, built in the late 1960s to treat sanitary wastewater generated at the mobile home park. It discharges to Crooked Run at RM 0.8. During the summer of 2010, there were only a few mobile homes located in the park. The property was sold in September 2010, and use of the park has increased. The plant is an extended aeration plant consisting of aeration, settling, dosing to sand filters, chlorination and de-chlorination. Sludge holding tanks were added in 1999.

Luburgh Shale Pit: This facility is located at the intersection of Hall and Gattrell Streets in Zanesville, Ohio and discharges to Mill Run at RM 0.17, below our sampling point on Mill Run. The facility is permitted to discharge effluent from two sedimentation ponds, and has no process water.

James Brother Sand and Gravel: This facility is located at the intersection of Old Adamsville Road and Coal Run Road, in Zanesville. The discharge is to Mill Run at RM 1.9, upstream from the sampling point on Mill Run. The facility is permitted to discharge from two sedimentation ponds, and has no process water.

Echoing Hills: This camp is located at 36272 CR 79 in Warsaw, Ohio (Coshocton county) and discharges to the headwaters of Mohawk Creek. Echoing Hills has an extended aeration plant, approved in 1972, to treat sanitary wastewater generated at the camp. The plant is an extended aeration plant consisting of trash trap, extended aeration, settling, sand filters, and chlorination. An expansion of the sand filters was made in 1976.

Warsaw WWTP: This municipal wastewater treatment plant is located at 40232 TR 41 in Warsaw, and discharges to the Walhonding River at RM 11.1. The plant has a design flow of 0.170 MGD. Treatment of the village's wastewater is an aerated lagoon, chlorination and de-chlorination.

Water Chemistry

Surface water chemistry samples were collected from the Walhonding and Muskingum River tributaries study area from June through October 2010 at thirty-three locations (Table 1, Figure 1). Among these were six sentinel stations that were sampled from April 2010 to February 2011. Stations were established in free-flowing sections of the stream and were primarily collected from bridge crossings. Surface water samples were collected directly into appropriate containers, preserved and delivered to Ohio EPA's Environmental Services laboratory. Collected water was preserved using appropriate methods, as outlined in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2009). Interactive maps of surface water chemical data, downloadable to Excel files, are available at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx .

USGS gage data from Mill Creek near Coshocton was used to show flow trends in the Walhonding and Muskingum River tributaries study in 2010 (Figure 4). Dates when water samples and bacteria samples were collected in the study are noted on the graph. This graph also indicates that flow conditions during the summer field season were significantly higher during the month of June than the recorded median flow. Extremely low flow conditions were recorded from late August through October. Water samples captured a variety of flow conditions in the study area during the field season. Bacteria was collected during the recreation use season (May 1 through October 31) and was typically collected during low flows.

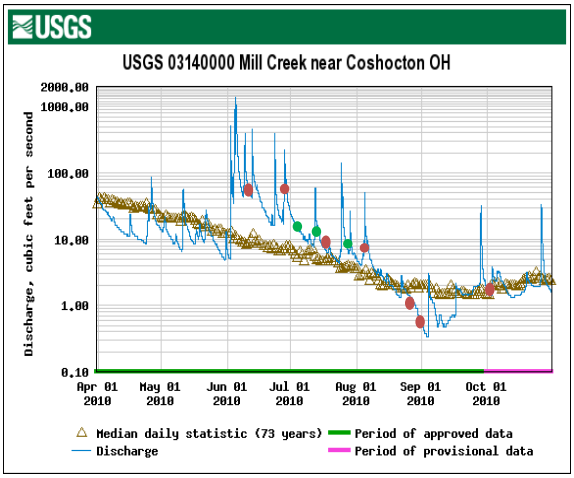


Figure 4. Flow conditions in Mill Creek during 2010 field season. Red dots indicate water chemistry and bacteria sampling events. Green dots represent bacteria only sampling.

Surface water samples were analyzed for metals, nutrients, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O. saturation, and suspended and dissolved solids (Appendix B). Parameters which were in exceedence of the Ohio Water Quality Standards (WQS) criteria are reported in *Table 5*. Bacteriological samples were collected from seventeen locations in 2010, and the results are reported in the Recreation Use section. Datasonde™ water quality recorders were placed at thirty locations to monitor hourly levels of D.O., pH, temperature, and conductivity (Appendix C).

Metals were measured at all thirty-three locations with seventeen parameters tested (Appendix B). While there were no WQS exceedances, several metals and other parameters that are associated with mining activities were found to be elevated above reference conditions for the Western Allegheny Plateau (WAP) ecoregion (Table 6). Historical mining is noted in the study area, particularly within the Simmons Creek headwaters and in the western Muskingum River tributaries (Figure 3). Although iron, aluminum and sodium were not above reference values, sulfate, manganese, and conductivity were elevated at several locations. Affected streams included Simmons Run, Robinson Run, North Branch Symmes Creek, Symmes Creek, and Mill Run. In addition to being elevated above reference conditions, several individual WQS criterion exceedances for sulfate were also recorded for these streams. Sulfate is a by-product of the oxidation of iron-bearing minerals and in the production of acid mine drainage (AMD). Elevated sulfate concentrations can also create nuisance conditions to recreational waters because of noxious odors. While sulfate exceedances could indicate the presence of AMD, alkalinity was present throughout the watershed at levels high enough to provide a buffering capacity to the streams, and thus kept pH levels within a neutral range of 7 to 8.

Nutrients were measured at each water sampling location, and included ammonia-N, nitrate+nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). Summary statistics for select nutrients measured in the Walhonding and Muskingum River tributaries watershed are detailed in Table 7. Nutrient levels were measured below statewide reference conditions throughout most the watershed. Nitrates were elevated throughout the length of Mill Creek and also in Beards Run and South Branch Symmes Creek due to agricultural land use practices.

DataSonde© hourly monitoring results for dissolved oxygen, temperature, pH, and conductivity at thirty locations are listed in Appendix E and F. Temperature, conductivity, and pH measurements were well within acceptable

environmental levels. Dissolved oxygen levels occasionally dipped below WQS criteria at a few sampling locations; however, two streams had D.O. concentrations remain chronically low for long periods during the sonde deployment (Table 5). Low flows, possibly combined with agricultural influences, likely contributed to depressed D.O. levels recorded at Mohawk Creek RM 4.10. Organic enrichment from unrestricted livestock access was likely responsible for the extremely low D.O. at Monroe Basin Creek RM 1.80. All other values were typically above the EWH average (6.0 mg/l) water quality criterion. The sonde deployed at Beaver Run at Co.Rd. 22 became covered with sand during a rain event, and the data was discredited from further evaluation. Pronounced D.O. swings in excess of 4 mg/l were recorded at Mill Creek RM 3.54 and in Spoon Creek RM 0.60, indicating potential nutrient over-enrichment from agricultural activities.

Table 5. Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical/physical parameters measured in the Walhonding River 2007 and Walhonding and Muskingum River tributaries study area, 2010. Bacteria exceedances are presented in the Recreational Use Section.

Stream/Location	River Mile	Parameter (value in ug/l unless noted)
Mohawk Creek-Trib to Walhonding River at RM 15.21 – EWH Recommended		
Mohawk Creek @ TR 409	4.10	D.O. (5.56)b; D.O. sonde (ranged 4.84-4.99 over 6 hrs)a; D.O. sonde (ranged from 5.01-5.9 over 22 hrs)b
Mohawk Creek @ CR 82	1.48	D.O. (5.70)b
Unnamed trib to Mohawk Creek at RM 2.93 – EWH Recommended		
Unnamed trib. To Mohawk Creek @ TR 373	0.60	D.O. sonde (5.95)b
Simmons Run – Trib to Walhonding River at RM 10.66 – WWH Recommended		
Simmons Run @ TR 78	2.97	D.O. (2.19)a,b Sulfates (367, 488, 753)c
Simons Run @ TR 41B	0.60	Sulfates (377, 527)c
Mill Creek – Trib. To Walhonding River at RM 1.9– EWH Existing		
Mill Creek @ CR 24	0.40	D.O. sonde (5.98, 5.77, 5.77, 5.89)b
Little Mill Creek – Trib. To Mill Creek at RM 8.45 – EWH Existing		
Little Mill Creek @ driveway off TR 206	0.10	D.O. sonde (5.95, 5.96)b
Spoon Creek-Trib. to Mill Creek at RM 3.25 – WWH Existing		
Spoon Creek	0.60	D.O. sonde (4.54)b
Robinson Run – Trib. to Muskingum River at RM 105.21 – WWH Recommended		
Robinson Run @ CR 271	1.35	Sulfates (251,464, 390, 538, 560,471)c
Monroe Basin Creek-Trib. to Muskingum River – not assigned		
Monroe Basin Creek @ SR 16	1.80	D.O. (4.27)b ;D.O. sonde (ranged 3.27-4.7 for 37 hrs)a,b
North Branch Symmes Creek – Trib. to Symmes Creek at RM 2.35 – WWH Recommended		
North Branch Symmes Creek @ Madison Hall Rd.	0.10	Sulfates (457, 377, 779)c
Symmes Creek – Trib. to Muskingum River at RM 87.14 – WWH Recommended		
Symmes Creek @ Mollie's Rock Rd.	2.35	Sulfates (307, 396, 370, 573, 690, 490, 664, 619, 746)c
Blount Run – Trib. to Muskingum River at RM 82.38 – WWH Recommended		
Blount Run @ SR 666	0.31	Sulfates (277, 267, 274, 254)c
Mill Run – Trib. to Muskingum River at RM 77.50 – WWH Recommended		
Mill Run @ Coal Run Rd.	0.45	Sulfate (301, 264, 327)c

a Exceedance of aquatic life Outside Mixing Zone Maximum water quality criterion (below minimum for D.O.)
b Exceedance of aquatic life Outside Mixing Zone Average water quality criterion (below 24 hour average for D.O.)
c Exceedance of human health intakes/elsewhere criterion (Table 34-1 of OAC 3745-1-34)

Table 6. Summary statistics for select mine drainage inorganic water quality parameters sampled in the Walhonding and Muskingum River tributaries watershed, 2010. The 90th percentile value from reference sites for the Western Allegheny Plateau ecoregion is shown for comparison. Values above reference conditions are shaded.

		Iron	Manganese	Conductivity	Sodium	Sulfate	Aluminum
Units		µg/l	µg/l	umhos/cm	mg/l	mg/l	µg/l
Stream	River Mile	Mean	Mean	Mean	Mean	Mean	Mean
Mohawk Creek	4.10[H]	691	208	317	12	24	135
Mohawk Creek	1.48[W]	819	129	294	11	22	189
Unnamed trib. to Mohawk Creek	0.60[H]	299	124	274	2.5	23	100
Dutch Run	0.15[H]	253	27	189	-	16	100
Honey Run	0.60[H]	272	19	253	-	22	100
Beaver Run	2.60[H]	602	88	191	-	24	100
Beaver Run	0.17[H]	983	91	210	2.5	26	364
Simmons Run	2.97[H]	811	1102	936	15	368	174
Simmons Run	0.60[H]	573	195	789	14	292	153
Flint Run	0.40[H]	214	101	240	2.5	21	208
Darling Run	0.10[H]	967	147	169	2.5	18	144
Mill Creek	12.50[H]	751	177	340	17	31	158
Mill Creek	8.5[H]	1113	219	334	14	30	228
Mill Creek	7.9[W]	1199	192	362	14	37.2	267
Mill Creek	3.54[W]	1227	273	412	15	78	226
Mill Creek	0.40[W]	1139	218	395	14	79	318
Little Mill Creek	0.10[H]	847	206	361	14	46	185
Spoon Creek	0.60[H]	956	364	546	13	129	304
Beards Run	0.03[H]	382	84	314	-	34	100
Turkey Run	0.19[H]	407	183	602	21	161	130
Crooked Run	0.98[H]	1260	341	415	11	106	197
Crooked Run	0.06[H]	1626	291	428	11	110	388
Robinson Run	1.35[H]	1760	1885	951	34	446	141
Monroe Basin Creek	1.80[H]	653	310	403	-	63	155
North Branch Symmes Ck	4.25[H]	1207	387	586	12	165	333
North Branch Symmes Ck	0.10[H]	891	200	1009	14	435	362
Symmes Creek	5.65[H]	1030	219	383	11	76	223
Symmes Creek	4.35[H]	868	256	577	14	167	216
Symmes Creek	2.35[W]	911	205	884	16.5	426	335
South Branch Symmes Ck	0.15[H]	899	385	19	15	167	402
Blount Run	0.31[H]	730	226	632	12	215	266
Blunt Run[b]	0.10[H]	259	59	438	-	141	100
Mill Run	0.45[H]	1084	464	907	41	253	208
Reference Values: headwater[H]/ wading[W]		1266/ 1820	379/ 610	1019/ 791	86/ 45	259/ 242	750[a]

a – U.S. EPA maximum criteria.
b-based on only one sample, and not a mean

Table 7. Summary statistics for select nutrient water quality parameters sampled in the Walhonding and Muskingum River tributaries, 2010. The 90th percentile value for reference sites statewide is shown for comparison for ammonia and the proposed statewide criteria are used to evaluate nitrate-nitrite and phosphorus. Values above reference conditions are shaded yellow. All values are in mg/l.

		Ammonia—N	Nitrate+Nitrite-N	Phosphorus-T
Stream	River Mile	Mean	Mean	Mean
*Mohawk Creek**	4.10[H]	0.034	0.23	0.02
*Mohawk Creek**	1.48[W]	0.036	0.34	0.03
Unnamed trib. To Mohawk Creek8	0.60[H]	0.025	0.38	0.01
Dutch Run	0.15[H]	0.025	0.21	0.01
Honey Run	0.60[H]	0.025	0.31	0.02
Beaver Run	2.60[H]	0.025	0.25	0.02
*Beaver Run**	0.17[H]	0.033	0.72	0.03
Simmons Run	2.97[H]	0.025	0.09	0.03
Simons Run	0.60[H]	0.036	0.15	0.02
Flint Run	0.40[H]	0.044	0.38	0.01
Darling Run	0.10[H]	0.025	0.18	0.02
*Mill Creek**	12.50[H]	0.063	1.42	0.05
*Mill Creek**	8.5[H]	0.059	1.06	0.04
*Mill Creek**	7.9[W]	0.051	0.89	0.04
*Mill Creek**	3.54[W]	0.051	0.83	0.03
*Mill Creek**	0.40[W]	0.048	0.88	0.04
*Little Mill Creek**	0.10[H]	0.063	0.50	0.02
Spoon Creek	0.60[H]	0.055	0.88	0.03
Beards Run	0.03[H]	0.030	1.59	0.04
*Turkey Run**	0.19[H]	0.025	0.37	0.02
Crooked Run	0.98[H]	0.048	0.21	0.03
Crooked Run	0.06[H]	0.050	0.40	0.05
Robinson Run	1.35[H]	0.090	0.33	0.01
Monroe Basin Creek	1.80[H]	0.064	1.01	0.02
North Branch Symmes Creek	4.25[H]	0.041	0.23	0.03
North Branch Symmes Creek	0.10[H]	0.031	0.32	0.10
Symmes Creek	5.65[H]	0.038	0.60	0.01
Symmes Creek	4.35[H]	0.025	0.62	0.01
Symmes Creek	2.35[W]	0.032	0.32	0.03
South Branch Symmes Creek	0.15[H]	0.025	0.93	0.04
Blount Run	0.31[H]	0.033	0.33	0.08
Blunt Run	0.10[H]	0.025	0.20	0.01
Mill Run	0.45[H]	0.064	0.46	0.01
Statewide Reference Value (headwater[H]/wading[W])		0.110/0.100	1.0/0.5 WWH 1.0/0.5 EWH	0.08/0.10 WWH 0.05/0.05 EWH

*EWH aquatic life use values; all others use WWH values

Walhonding River

Surface water samples were collected from five sites on the Walhonding River during the summer of 2007 (June-August). Surface water samples were collected at bridges, and appropriate methods of collection and preservation were also used in accordance to the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (2006). Bacteria samples were also collected at the time chemistry was collected, with an additional three bacteria sites collected separate from the chemistry.

USGS gage data from the Muskingum River near Coshocton was used to show flow trends in the Walhonding River in 2007 (Figure 5). Dates when water samples and bacteria samples were collected in the study are noted on the graph. This graph also indicates that flow conditions were below recorded median flows for most of the sampling period, with higher flow events occurring in late summer. Water samples captured a variety of flow conditions in the study area during the field season. Bacteria was collected during the recreation use season (May 1 through October 31) and was typically collected during low flows.

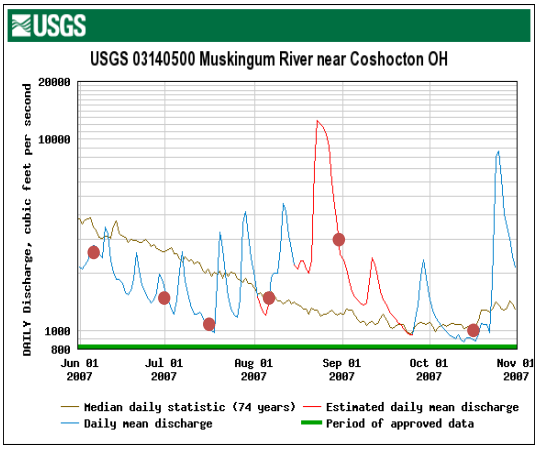


Figure 5. Flow conditions in the Muskingum River near Coshocton during 2007 field season. Red dots indicate water chemistry and bacteria sampling events.

Surface water samples were analyzed for metals, nutrients, pH, temperature, conductivity, dissolved oxygen, and suspended and dissolved solids. No parameters exceeded WQS criteria. Nutrient parameters were below statewide reference values (Table 8).

All five sites on the Walhonding River main stem had DataSondes© deployed during the summer of 2007. All temperature and dissolved oxygen levels were within acceptable levels.

Table 8. Summary statistics for select nutrient water quality parameters sampled in the Walhonding River, 2007. The 90th percentile value for reference sites statewide for ammonia and the proposed statewide criteria is shown for comparison. Values above reference conditions are shaded yellow. All values are in mg/l.

		Ammonia—N	Nitrate+Nitrite-N	Phosphorus-T
Stream	River Mile	Mean	Mean	Mean
Walhonding River @ SR 715	20.47	<0.05	1.394	0.111
Walhonding River @ US 36, Nellie	15.73	<0.05	1.326	0.101
Walhonding River upstream Six Mile Dam	8.81	<0.05	1.268	0.097
Walhonding River upstream Killbuck Creek	7.54	<0.05	1.30	0.094
Walhonding River @ SR 36 in Coshocton	0.76	<0.05	1.252	0.082
Statewide Reference Value (large river)		0.200	1.500 EWH	0.150 EWH

Recreation Use

Water quality criteria for determining attainment of recreation uses are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) based upon the presence or absence of bacteria indicators (*Escherichia coli*) in the water column.

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour, 1977), but there is currently no simple way to differentiate between human and animal sources of coliform bacteria in surface waters, although methodologies for this type of analysis are becoming more practicable. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

Pathogenic (disease-causing) organisms are typically present in the environment in such small amounts that it is impractical to monitor them directly. Fecal indicator bacteria by themselves, including *E. coli*, are usually not pathogenic. However, some strains of *E. coli* can be pathogenic, capable of causing serious illness. Although not necessarily agents of disease, fecal indicator bacteria such as *E. coli* may indicate the potential presence of pathogenic organisms that enter the environment through the same pathways. When *E. coli* are present in high numbers in a water sample, it invariably means that the water has received fecal matter from one source or another. Swimming or other recreational-based contact with water having a high fecal coliform or *E. coli* count may result in ear, nose, and throat infections, as well as stomach upsets, skin rashes, and diarrhea. Young children, the elderly, and those with depressed immune systems are most susceptible to infection.

The streams of the Walhonding and Muskingum River tributaries watershed evaluated in this survey are designated the Primary Contact Recreation (PCR) use in OAC Rule 3745-1-24. Water bodies with a designated recreational use of PCR "...are waters that, during the recreation season, are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking and SCUBA diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of the PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR Class A typically have identified public access points and support primary contact recreation. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. All streams assessed during this survey are designated Class B PCR waters, with the exception of the Walhonding River main stem, which is designated Class A PCR. The *E. coli* criteria that apply to PCR Class A and B streams include a geometric mean of 126 and 161 cfu/100 ml, and a maximum value of 298 and 523 cfu/100 ml, respectively. The geometric mean is based on two or more samples and is used as the basis for determining attainment status when more than one sample is collected (*Table 9*).

Summarized bacteria results are listed in Table 9, and the complete dataset is reported in Appendix C. Downloadable bacteria results are also available from the Ohio EPA GIS interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx. Twenty-two locations in the Walhonding and Muskingum River tributaries watershed were tested for *E. coli*) to determine recreation use attainment status. Evaluation of *E. coli* results revealed that eight locations attained the applicable geometric mean criterion, and thus were in full attainment of the designated recreation use. Among these were the five locations sampled on the Walhonding River main stem in 2007, thus making the entire length of the river in full attainment of PCR Class A recreation use criteria. The Walhonding River has considerable recreational use during the summer months, including canoeing and kayaking.

The fourteen locations not meeting the use designation were mostly impaired by agricultural sources of bacteria caused by unrestricted livestock access to streams. Horses and cattle were either physically observed in many of the streams, or their fecal deposits were noted within stream channels. An extremely elevated maximum value of 24,000 cfu/100ml was found in Monroe Basin Creek at RM 1.8. This area is downstream from Graham Farms, which had cattle in the pasture upstream from the site. In addition to livestock, failing on-lot septic systems in some of the smaller towns and villages in the watershed are also suspected to have contributed excessive bacterial loads to the streams.

Table 9. A summary of E.coli data for locations sampled in the Walhonding and Muskingum River tributaries watershed, May-October 2010. Recreation use attainment is based on comparing the geometric mean to the PCR class B geometric mean water quality criterion of 161 cfu/100 mL (Ohio Administrative Code 3745-1-07). All values are expressed in Colony Forming Units (cfu) per 100 ml of water. Walhonding River main stem sites were sampled in 2007 and attainment is based on PCR class A geometric mean criterion of 126 cfu/100mL. Gray shaded areas exceed the applicable PCR geometric mean criterion.

Location	River Mile	Recreation Use	# of Samples	Geometric Mean†	Attainment Status	Probable Source(s) of Bacteria
Mohawk Creek @ CR 82	1.48	PCR Class B	14	340	NON	Livestock/agriculture
Dutch Run @ TR 344/TR 338	0.15	PCR Class B	4	389	NON	Livestock/agriculture
Beaver Run @ US 36 Warsaw	0.17	PCR Class B	14	475	NON	On-lot sewage systems
Simmons Run @ TR 41B	0.60	PCR Class B	4	447	NON	Livestock/agriculture
Darling Run @ TR 340	0.10	PCR Class B	5	499	NON	Livestock/agriculture
Mill Creek @ TR 206	8.5	PCR Class B	10	556	NON	Livestock/agriculture
Mill Creek at USGS gage	7.9	PCR Class B	14	746	NON	Livestock/agriculture
Mill Creek @ TR 322	3.54	PCR Class B	7	718	NON	Livestock/agriculture
Little Mill Creek adj TR 206	0.1	PCR Class B	5	104	FULL	
Crooked Run upst. Edgewood MHP @ lane off CR 23	0.98	PCR Class B	5	869	NON	On-lot sewage systems
Crooked Run @ TR 495	0.06	PCR Class B	4	985	NON	On-lot sewage systems
Robinson Run ust Coshocton Ethanol @ CR 271	1.35	PCR Class B	4	121	FULL	
Monroe Basin Creek @ SR 16	1.80	PCR Class B	5	1095	NON	Livestock/agriculture
North Branch Symmes Creek @ Madison Hall Road	0.10	PCR Class B	10	409	NON	Livestock/agriculture
Symmes Creek @ Mutton Ridge Road	4.35	PCR Class B	5	98	FULL	
Symmes Creek @ Mollies Rock Road	2.35	PCR Class B	14	313	NON	Livestock/agriculture
Blount Run @ SR 666	0.31	PCR Class B	13	269	NON	Unknown
Walhonding River @ SR 715	20.47	PCR Class A	8	56	FULL	
Walhonding River @ US 36	15.73	PCR Class A	8	73	FULL	
Walhonding River ust Six Mile Dam	8.81	PCR Class A	8	70	FULL	
Walhonding River @ US 36 ust Killbuck Creek	7.54	PCR Class A	8	60	FULL	
Walhonding River @ US 36 @ Coshocton	0.76	PCR Class A	8	95	FULL	

† Attainment status is determined based on the seasonal geometric mean. The status cannot be determined at locations where fewer than two samples were collected during the recreation season.

Sediment

Sediment samples were collected at six locations in Walhonding and Muskingum River tributaries by Ohio EPA on September 15, 2010. Sampling locations were co-located with biological sampling sites. Samples were analyzed for total metals, total phosphorus, ammonia and particle size. Specific chemical parameters tested and results are listed in Appendix D. Sediment data were evaluated using Ohio Specific Sediment Reference Values (SRVs) for metals (Ohio EPA 2008), along with guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et.al*. 2000). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed.

Sediment samples were conservatively sampled by focusing on depositional areas of fine grain material (silts and clays). These near-bank areas typically are represented by higher contaminant levels when compared to coarse sands and gravels. Fine-grained depositional areas were not a predominant substrate type at all six sites; however, fine substrates were common along the stream margins.

Metals which were above screening benchmarks are presented in Table 10. Sediments collected from all six locations were not considered likely to be harmful to sediment-dwelling organisms (MacDonald *et.a*l. 2000). A value exceeding the TEC, but below the PEC and SRV, for arsenic was noted at Mohawk Creek at CR 82. Arsenic can be naturally-occurring in rock and groundwater. It was formerly used in a compound for pressure treated wood until 2003 when its use was discontinued. To a lesser degree, it has been used in pyrotechnics and in lead alloys for bullets and lead shot. All other parameters tested were within the established guidelines.

Sediment samples were also collected at three sites on the Walhonding River during the fall of 2007 (Table 11). Arsenic exceeded the TEC at all three locations but was below the PEC level. Zinc was also exceeded at the Walhonding RM 15.73. 3 & 4-Methylphenol was detected at the SR 36 site in Coshocton at a level of 1.39 mg/kg. Fluoranthene was detected upstream from the Six Mile Dam at just above the detection limit of 0.76 at 0.95 mg/kg. No semi-volatile organics or PCBs/pesticides were detected at the Nellie site.

Table 10. Results of sediment chemistry from select Walhonding and Muskingum River tributaries, collected September 15, 2010. All units are in mg/kg except for % solids.

Parameter/Site	Beaver Run at Warsaw	Mohawk Creek @ CR 82	Mill Creek @ TR 322	Symmes Creek @ Mollies Rock	Blount Run @ SR 666	Mill Creek @ gage
Arsenic	8.0	15.5	5.4	5.1	4.1	4.7
Barium	84.8	96.8	72.4	68.3	120.0	62.0
Cadmium	0.4	0.4	0.4	0.4	0.3	0.4
Chromium	9.6	8.7	7.6	8.5	6.1	8.6
Copper	12.5	13.6	10.6	10.8	8.2	10.9
Iron	23100.0	29300.0	22900.0	22800.0	16300.0	26400.0
Lead	11.7	10.4	9.5	9.8	9.4	8.9
Manganese	1060.0	511.0	1100.0	1850.0	688.0	594.0
Nickel	15.6	17.2	15.3	16.4	12.6	15.1
Strontium	<25	<22	<21	29.0	<20	<18
Zinc	84.7	83.7	74.2	72.6	60.6	72.2
Aluminum	7620.0	4680.0	5360.0	6430.0	4420.0	5220.0
Selenium	<1.69	<1.45	<1.38	<1.43	<1.3	<1.18
Ammonia	56.0	33.0	31.0	75.0	43.0	84.0
Total Phosphorus	504.0	379.0	373.0	355.0	334.0	438.0
% Solids	44.7	54.2	57.9	51.9	58.0	64.2
Mercury	<0.049	<0.035	<0.036	<0.043	<0.029	0.0
Calcium	2210.0	2520.0	<1380	8850.0	1660.0	1250.0
Magnesium	1900.0	1380.0	1250.0	2460.0	1280.0	1140.0
Sodium	<4220	<3620	<3450	<3570	<3250	<2940
Potassium	<1690	<1450	<1380	<1430	<1300	<1180

Exceeds the TEC (TEC for arsenic is 9.79)

Table 11 . Results of sediment chemistry from the Walhonding River, collected October 10, 2007. All units are in mg/kg except for % solids.

Parameter/Site	Walhonding River at Nellie	Walhonding River upst. Six Mile Dam	Walhonding @ SR 36, Coshocton
Arsenic	10.6	11.5	14.4
Barium	78.4	95.3	116
Cadmium	0.308	0.363	0.289
Chromium	19	23	20
Copper	16.5	17.7	15.6
Iron	20400	22700	24500
Lead	18.9	21.2	19.1
Manganese	471	618	1580
Nickel	<25	<30	<26
Strontium	20	27	31
Zinc	134	102	98.9
Aluminum	7080	8920	8580
Selenium	<1.24	<1.52	<1.3
Ammonia	98	160	220
Total Phosphorus	713	716	743
% Solids	52.1	45.4	39.4
Mercury	0.059	0.046	0.048
Calcium	8990	10800	17300
Magnesium	3970	4200	5220
Sodium	<3100	<3800	<3250
Potassium	<1240	<1520	<1300
TOC	2	2.1	1.6

Exceeds TEC (TEC for arsenic is 9.79; TEC for Zinc is 121)

Stream Physical Habitat

Stream habitat was evaluated at 36 locations in the Walhonding and Muskingum River tributaries study area between 2007 and 2010 (Table 12, Appendix G). In 2007, five of these stations were located on the Walhonding River, where habitat quality was excellent at all locations except for the impounded reach upstream from Six Mile Dam (RM 8.81). All of the remaining sites in the study area were evaluated in 2010 and were tributary streams with Qualitative Habitat Evaluation Index (QHEI) scores averaging 63.1, which was consistent with good overall habitat quality.

Twenty-three (74%) of the thirty-one tributary sites had good to excellent habitat indicating an ability to support WWH communities. Moderate to extensive amounts of instream cover along with diverse substrates and good channel development were common characteristics among these sites. The fish communities within these areas generally reflected the quality habitat available with good to excellent narrative scores, with the exception of Robinson Run RM 1.35 and Symmes Creek RM 4.35. Coal mining activities upstream of Robinson Run RM 1.35 have negatively impacted the water quality, overriding the good to excellent channel development and extensive instream cover provided to the fish community. The orange AMD precipitate was present in moderate amounts and embedded much of the substrates present. While the habitat present at Symmes Creek RM 4.35 was good (QHEI=58.0), the primarily bedrock substrate and sparse amounts of instream cover limited the ability of the stream to support a WWH fish community in this reach.

Seven of the remaining eight tributary sites had fair habitat quality, with a range of QHEI scores from 47.0 - 58.0. Only Beaver Run RM 2.6 had 6 WWH attributes, with the remaining sites having 2 to 4 WWH attributes and ≥4 moderate influence MWH attributes (Table 2). Row crop agriculture and livestock access to the streams appeared to contribute to the heavy siltation, embedded substrates and various stages of recovery from channelization activities commonly associated with these sites. However, the fair habitat present at Mill Creek RM 0.45 was attributed to siltation and embedded substrates associated with historical coal mining. The only site noted as having poor habitat quality, Crooked Run RM 0.06, was dominated by sand with occasional silt, muck and gravel. The nearly absent instream cover and poor channel development contributed to the low QHEI score of 42.8.

Table 12. Stream physical habitat (QHEI) summarized results for the Walhonding and Muskingum River tributaries study area, 2010, and the Walhonding River main stem, 2007.

STREAM	RIVER MILE	Drain. area (mi^2)	LOCATION	QHEI	COMMENTS
Walhonding River	21.8	1490.0	SR 715	81.5	
Walhonding River	15.73	1505.0	US 36	83.0	
Walhonding River	8.81	1572.0	Upstream Sixmile Dam	64.0	Impounded by dam
Walhonding River	7.54	1575.0	Upstream Killbuck Creek at US 36	92.0	
Walhonding River	0.76	2255.0	Coshocton at US 36	94.0	
Mohawk Creek	4.10	9.47	TR 409	66.3	
Mohawk Creek	1.48	22.6	CR 82	57.8	Heavy siltation and extensively embedded substrates
Unnamed Tributary to Mohawk Creek at RM 2.93	0.6	6.38	TR 373	74.3	
Dutch Run	0.15	5.44	TR 144 / TR 338	63.3	
Honey Run	0.6	1.86	TR 359	50.5	Sparse amounts of instream cover
Beaver Run	2.6	8.36	CR 22	53.5	Recovering from past channelization
Beaver Run	0.17	14.1	SR 36 at Warsaw	60.3	
Simmons Run	2.97	9.29	TR 78	64.5	
Simmons Run	0.6	16.3	TR 41B	78.0	
Flint Run	0.4	2.25	SR 60	56.5	

STREAM	RIVER MILE	Drain. area (mi^2)	LOCATION	QHEI	COMMENTS
Mill Creek	12.5	8.84	TR 215	68.0	
Mill Creek	8.5	18.50	TR 206	64.3	
Mill Creek	7.9	27.20	Gage	58.0	Extensively embedded riffle
Mill Creek	3.54	39.90	TR 322	59.8	Extensively embedded substrates
Mill Creek	0.4	51.10	CR 24	59.8	Extensively embedded substrates
Little Mill Creek	0.10	8.4	Driveway off TR 206	63.8	
Beards Run	0.03	2.72	CR 12	47.0	Poor instream cover
Turkey Run	0.19	5.50	CR 12	70.5	
Crooked Run	0.98	8.03	CR 23, upstream WWTP	53.3	Extensively embedded substrates
Crooked Run	0.06	8.97	TR 495	42.8	Sparse amounts of instream cover
Robinson Run	1.35	3.81	CR 271	79.5	
North Branch Symmes Creek	4.25	8.16	Steel Hill Road	73.0	
North Branch Symmes Creek	0.1	15.00	Madison Hill Road	78.5	
Symmes Creek	5.65	8.3	Steel Hill Road at oil rig	62.8	
Symmes Creek	4.35	15.3	Mutton Ridge Road	58.0	
Symmes Creek	2.35	31.5	Mollie's Rock Road	76.8	
South Branch Symmes Creek	0.15	4.33	Sheck Road/TR 156	66.8	
Blount Run	0.31	7.70	SR 666	68.3	
Blunt Run	0.1	2.80	CR 418	69.3	
Mill Run	0.45	3.38	CR 418	52.5	Siltation and embedded substrates

General narrative ranges assigned to QHEI scores.			
Narrative Rating		QHEI Range	
		Headwaters ($\leq$20 mi^2)	Larger Streams
Excellent		$\geq$70	$\geq$75
Good		55 to 69	60 to 74
Fair		43 to 54	45 to 59
Poor		30 to 42	30 to 44
Very Poor		< 30	< 30

Fish Community

A total of 34,803 fish representing 79 species were collected from the Walhonding and Muskingum River tributaries study area between June and September, 2010 with the exception of the five sites on the Walhonding River which were sampled in 2007. Relative numbers and species collected per location are presented in Appendix I and IBI and MIwb scores are presented in Appendix H. Sampling locations were evaluated using WWH or EWH biocriteria. A summary of the fish data are presented in Table 15. The study area's biological and habitat data are available on Ohio EPA interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx .

The Walhonding River main stem sites sampled during 2007 achieved the EWH fish biocriterion at four of the five sampling locations. The only site which scored below EWH expectations was Walhonding River RM 8.81 (IBI=45 and MIwb=8.5) which is impounded by Six Mile Dam. The free-flowing sites on the Walhonding River had an average IBI of 54 and MIwb of 10.9, reflecting the high overall integrity of the system. The exceptional fish community included the state endangered northern and mountain madtoms, state threatened bluebreast darter, and state species of concern river redhorse and eastern sand darter.

Twenty-nine sites on eighteen tributary streams in the Walhonding and Muskingum River tributaries study area had fish community assessments completed in 2010. Thirteen of the eighteen streams were fully achieving the existing or recommended aquatic life use biocriteria for fish including Mohawk Creek, tributary to Mohawk Creek at RM 2.93, Dutch Run, Beaver Run, Simmons Run, Flint Run, Darling Run, Little Mill Creek, Turkey Run, North Branch Symmes Creek, South Branch Symmes Creek, Blount Run, and Blunt Run. The fish communities of these sites had an average IBI of 49.6 (n=23) and MIwb of 9.3 (n=3), indicating the overall very good integrity of these streams.

Two of the five streams with fish communities not meeting the WWH fish biocriterion were Mill Run and Robinson Run. These two streams each have historical coal mining within their watersheds that contribute to poor water quality and thereby negatively affect the fish community. The relative numbers of the fish community of Mill Run were predominated by tolerant fish (blacknose dace 37% and creek chub 53%). Only four species total were collected from Robinson Run, with the pollution-tolerant creek chub comprising 92.4% of the relative number of fish present.

One of the two sites on Crooked Run, RM 0.06 near TR 495 did not meet WWH expectations as a result of natural habitat limitations (QHEI=42.8), including very shallow riffle and pool areas, which contributed to the lower quality fish community. Only 11 species were found at this location, while the upstream site (RM 0.98) had 21 species. Symmes Creek RM 4.35 also did not meet WWH expectations as a result of limited quality habitat, including sparse instream cover and bedrock-dominated substrates. The relative number of fish collected at RM 4.35 was nearly one-third of the relative number collected upstream at RM 5.7 (374 compared to 948, respectively). Omnivores also comprised a greater percentage of the community at RM 4.35 (45%) than at either of the other two sampling locations on Symmes Creek (RM 5.7=18% and RM 2.35=28%). Three of five sites on Mill Creek did not meet EWH fish biocriteria as a result of the prevalent livestock access to the stream and row crop agriculture noted throughout the Mill Creek watershed.

An interesting characteristic of the fish communities of numerous tributary streams in the study area is the presence of cold water fish species. For Ohio, native cold water species are those "…species of aquatic life adapted to cool (19-22ºC) or cold (15-18ºC) thermal regimes and other special stream habitat conditions found in perennial flowing water associated with the outflowing of shallow or deep water aquifers, perched springs or natural seeps." (Draft OAC 3745-1-2). Fish species which are considered cold water species in Ohio are listed in Table 13.

Table 13. Ohio cold water fish species (Adapted from draft OAC 3745-1-07)

American brook lamprey (*Lampetra appendix*)
Brook stickleback (*Culaea inconstans*)
Brook trout (*Salvelinus fontinalis*)
Central bigmouth shiner (*Notropis dorsalis dorsalis*)
Central mottled sculpin (*Cottus bairdi bairdi*)
Central mudminnow (*Umbra limi*)
Longnose dace (*Rhinichthys cataractae*)
Northern brook lamprey (*Ichthyomyzon fossor*)
Redside dace (*Clinostomus elongatus*)
Southern redbelly dace (*Phoxinus erythrogaster*)
Western tonguetied minnow (*Exoglossum laurae hubbsi*)

Fourteen of the twenty-nine sampling locations had at least two cold water fish species. The proposed coldwater habitat (CWH) rule (draft OAC 3745-1-07) requires the presence of at least two cold water macroinvertebrate taxa in addition to the presence of two cold water fish species. Interestingly, only five streams - Dutch Run, Honey Run (not sampled for fish), Beaver Run, Turkey Run, and Blunt Run - had the requisite number of cold water macroinvertebrate taxa to recommend the CWH designation.

Two of the CWH designated streams, Turkey Run and Dutch Run, had cold water fish species present in large numbers. Turkey Run had three coldwater species - redside dace (28.38%), southern redbelly dace (8.09%) and mottled sculpin (2.47%) - which combined comprised 38.94% of the relative number of fish collected, which was the largest cold water species percentage of all of the sites. Dutch Run had four cold water species - redside dace (2.87%), southern redbelly dace (0.19%), mottled sculpin (19.89%) and brook stickleback (1.15%) - which combined comprised 24.1% of the relative number of fish collected. The two sites on Beaver Run each had cold water species present, though the upstream site at RM 2.6 had redside dace (3.61%), mottled sculpin (5.54%) and brook stickleback (0.24%) while the downstream site at RM 0.2 had only mottled sculpin (1.75%) present. Blunt Run had one of the weakest cold water fish representations, with just one southern redbelly dace collected. However, in the absence of cold water fish, the presence of four cold water macroinvertebrate taxa may be used to recommend or confirm the CWH aquatic life use designation. Four cold water macroinvertebrate species were collected in Blunt Run.

Several additional sampling locations were noted as having strong cold water fish populations, though few, if any, corresponding cold water macroinvertebrate species were found. All six fish sampling locations within the Mill Creek subwatershed had cold water fish species present (Figure 6 and Table 16). Mill Creek RM 12.5 had redside dace (8.21%) and mottled sculpin (3.35%), which when combined, was the second largest percentage (11.56%) of cold water fish in the Mill Creek subwatershed next to Turkey Run (38.94%). Little Mill Creek RM 0.1 had redside dace (8.18%), southern redbelly dace (0.14%), and mottled sculpin (1.0%) which combined comprised 9.32% of the fish community present. If the livestock and related sources of water quality impairment are addressed, the presence and abundance of pollution sensitive, cold water species may increase over time. Specifically, the presence of cold water macroinvertebrate taxa in Turkey Run may be a potential source of cold water macroinvertebrate recruitment in the future.

Though generally comprising a smaller percentage of the total fish collected at each site, cold water fish species comprised up to 13.81% of the fish communities sampled within the Symmes Creek subwatershed (Figure 7 and Table 16). Redside dace were collected at five of the six sampling locations, though it was the only cold water fish species collected at Symmes Creek RMs 4.4 and 2.3, and North Branch Symmes Creek RM 4.3. The only site with cold water macroinvertebrate taxa was South Branch Symmes Creek RM 0.15, which had two secondary indicator cold water macroinvertebrate taxa present. All of the sampling locations within the Symmes Creek subwatershed were within Late Wisconsinan geology described as “lacustrine silt, deposited in low velocity water of glacial and slackwater lakes, may contain fine sand or clay; well laminated in distal portions of deltas,

poorly laminated elsewhere" (Pavey, et al., 1999). Throughout the study area, fewer cold water macroinvertebrates were noted in streams underlain by lacustrine silt.

In conclusion, the fish communities of the tributaries within the study area generally ranged from good to excellent. Addressing the agricultural sources of impairment noted in Mill Creek, and historical coal mining issues in Robinson Run and Mill Run would benefit the fish communities of each of these streams. The extensive presence of cold water fish species throughout these streams indicates the potential of strong connectivity to groundwater, which may enhance the speed of recovery if water quality impairments are addressed.

Fish Trends

The fish community of the Walhonding River has been sampled four times since 1983 (Figure 8). Each year of sampling, fish community scores improved both upstream and downstream from Six Mile Dam. Six Mile Dam will likely be a continued source of impairment within the Walhonding River, as the monotypic habitat throughout the impounded reach cannot support the diverse communities found within the free-flowing portions of the Walhonding River.

Few tributaries within the study area were sampled previous to 2010 (Table 14). The high quality fish communities of Little Mill Creek and Turkey Run have consistently performed at EWH expectations over time. The eight-point increase in IBI for Turkey Run is directly related to a smaller proportion of the community being comprised of pollution tolerant fish (1994=46%, 2010=22%), pioneering fish (1994=55%, 2010=22%) and omnivorous fish (1994=22%, 2010=12%), and an increase in the proportion of insectivorous fish (1994=34%, 2010=54%). In 1994, bluntnose minnow (19.04%) and creek chub (17.87%) comprised over 36% of the fish community, while in 2010 redside dace alone comprised 28.38% of the fish community.

The fish community scores of Mill Creek have decreased slightly over time. The fish community in the headwaters near RM 8.5 had a reduction in the number of sensitive species from eight in 1994 to five in 2010. This may be related to an increase in siltation and sedimentation from unrestricted livestock access to the stream as indicated in 2010, while in 1994 the surrounding land use was indicated as a mixture of fenced pasture, row crop agriculture and residential use. Further downstream, sampling was conducted at RM 0.7 in 1994 and RM 0.4 in 2010. An overall decrease in the IBI score was also noted in this stretch, resulting from an increase in omnivorous fish (1994=5%, 2010=30%) and a decrease in top carnivores (1994=5.3%, 2010=.75%). The shift in fish community feeding guild is likely attributable to the large amount of livestock access to streams throughout the Mill Creek subwatershed.

Table 14. Fish and habitat scores for streams within the Walhonding and Muskingum River tributaries study area, 1994-2010.

Stream	1994 IBI	1994 QHEI	2010 IBI	2010 QHEI
Mill Creek				
RM 0.4	--	--	46 (9.3)*	59.8
RM 0.7	58 (9.3)*	61	--	--
RM 8.5	50	56.5	44	64.3
Little Mill Creek				
RM 0.1	56	61	54	63.8
Turkey Run				
RM 0.1	--	--	58	70.5
RM 0.2	50	65	--	--

* - MIwb for streams > 20mi^2.

Table 15. Fish community attributes based on pulsed D.C. electrofishing sampling conducted by Ohio EPA in the Walhonding River (2007) and the Walhonding and Muskingum River tributaries study area during 2010. Relative numbers and weight are per 0.3 km.

Location	River Mile	Drain. (mi²)	IBI	MIwb[a]	QHEI	Total Fish Species	Relative Number	Relative Weights	Narrative Fish Evaluation
Walhonding River near Walhonding @ SR 715	21.8[B]	1490.0	56	10.64	81.5	32	975	267.33	Exceptional
Walhonding River at Nellie @ US 36	15.73[B]	1505.0	55	10.88	83.0	35	1,043	173.70	Exceptional
Walhonding River ust Sixmile Dam	8.81[B]	1572.0	45*	8.53*	64.0	21	275	64.76	Good
Walhonding River ust Killbuck Creek @ US 36	7.54[B]	1575.0	54	11.54	92.0	48	1,055	375.40	Exceptional
Walhonding River at Coshocton @ US 36	0.76[B]	2255.0	52	10.66	94.0	41	1,484	428.28	Exceptional
Mohawk Creek @ TR 409	4.10[H]	9.47	52	n/a	66.3	23	976	N/A	Exceptional
Mohawk Creek @ CR 82	1.48[W]	22.60	51	9.5	57.8	29	1,097.33	10.81	Exceptional
UT to Mohawk Creek at RM 2.93 @ TR 373	0.60[H]	6.38	52	n/a	74.3	21	3,052	N/A	Exceptional
Dutch Run @ TR 144/TR 338	0.15[H]	5.44	42[ns]	n/a	63.3	13	1,046	N/A	Marginally Good
Beaver Run @ CR 22	2.60[H]	8.36	46[ns]	n/a	53.5	19	830	N/A	Very Good
Beaver Run @ SR 36 at Warsaw	0.17[H]	14.10	54	n/a	60.3	23	2,634	N/A	Exceptional
Simmons Run @ TR 78	2.97[H]	9.29	52	n/a	64.5	21	2,030	N/A	Exceptional
Simmons Run @ TR 41B	0.60[H]	16.30	52	n/a	78.0	26	1,054.5	N/A	Exceptional
Flint Run @ SR 60	0.40[H]	2.25	50	n/a	56.5	15	1,602.86	N/A	Exceptional
Darling Run @ TR 340 at Nellie Cemetery	0.10[H]	3.82	44	n/a	59.8	15	988	N/A	Good
Mill Creek @ TR 215	12.50[H]	8.84	52	n/a	68.0	21	1,730	N/A	Exceptional
Mill Creek @ TR 206	8.50[H]	18.50	44*	n/a	64.3	22	948.75	N/A	Good
Mill Creek @ gage	7.9[W]	27.20	47[ns]	9.2*	58.0	30	1,953	N/A	Very Good
Mill Creek @ TR 322	3.54[W]	39.90	44*	8.7*	59.8	29	937.5	4.03	Good
Mill Creek @ CR 24	0.40[W]	51.10	46[ns]	9.3[ns]	59.8	37	1,872	11.38	Very Good
Little Mill Creek @ driveway off TR 206	0.10[H]	8.40	54	n/a	63.8	23	4,400	N/A	Exceptional
Turkey Run @ CR 12	0.19[W]	5.50	58	n/a	70.5	20	4,130	N/A	Exceptional

Location	River Mile	Drain. (mi²)	IBI	MIwb[a]	QHEI	Total Fish Species	Relative Number	Relative Weights	Narrative Fish Evaluation
Crooked Run @ CR 23, ust WWTP	0.98 H	8.03	44	n/a	53.3	21	1,923.33	N/A	Good
Crooked Run @ TR 495	0.06 H	8.97	36*	n/a	42.8	11	914	N/A	Fair
Robinson Run @ CR 271	1.35 H	3.81	20*	n/a	79.5	4	392	N/A	Poor
North Branch Symmes Creek @ Steel Hill Road	4.25 H	8.16	44	n/a	73.0	22	2,134	N/A	Good
North Branch Symmes Creek @ Madison Hall Road	0.10 H	15.00	56	n/a	78.5	22	1,268	12.34	Exceptional
Symmes Creek @ Steel Hill Road at oil rig	5.65 H	8.30	46	n/a	62.8	16	3,258	N/A	Very Good
Symmes Creek @ Mutton Ridge Road	4.35 H	15.30	34*	n/a	58.0	15	1,396	N/A	Fair
Symmes Creek @ Mollie's Rock Road	2.35W	31.50	51	9.1	76.8	34	1,335.75	11.42	Very Good
South Branch Symmes Creek @ Sheck Road/TR 156	0.15 H	4.33	48	n/a	66.8	15	1,492	N/A	Very Good
Blount Run @ SR 666	0.31 H	7.70	52	n/a	68.3	26	1,996	N/A	Exceptional
Blunt Run @ CR 418	0.10 H	2.80	48	n/a	69.3	15	1,436	N/A	Very Good
Mill Run @ CR 418	0.45 H	3.38	36*	n/a	52.5	**8**	1,144	N/A	Fair

BIOCRITERIA		
INDEX - Site Type	WWH	EWH
IBI: Headwater/Wading/ Boat	44/ 44/ 40	50/ 50/ 48
MIwb: Wading/ Boat	8.4/ 8.6	9.4/ 9.6

ns Nonsignificant departure from biocriterion (≤4 IBI units; ≤0.5 MIwb units).

* Significant departure from biocriterion (>4 IBI units; >0.5 MIwb units). Poor and very poor results are underlined.

Table 16. Cold water fish species present at sampling locations in the Walhonding and Muskingum River tributaries study area, 2010. Shaded sites are located on streams or stream reaches that are being recommended for the CWH aquatic life use.

Location	RM (mi^2)	Redside Dace[A]	Southern Redbelly Dace[A]	Mottled Sculpin[A]	Brook Stickleback[A]	American Brook Lamprey[A]	Total CWH Species[B]
Mohawk Creek	4.1 (9.5)	14 (2.87%)	--	--	--	--	1 (2.87%)
Trib. to Mohawk Creek (2.93)	0.6 (6.4)	28 (1.83%)	39 (2.56%)	--	--	--	2 (4.39%)
Dutch Run	0.1 (5.2)	15 (2.87%)	1 (0.19%)	104 (19.89%)	6 (1.15%)	--	4 (24.1%)
Beaver Run	2.6 (8.4)	15 (3.61%)	--	23 (5.54%)	1 (0.24%)	--	3 (9.39%)
Beaver Run	0.2 (14.1)	--	--	23 (1.75%)	--	--	1 (1.75%)
Simmons Run	3.0 (6.9)	31 (3.05%)	--	--	--	--	1 (3.05%)
Flint Run	0.4 (2.3)	22 (2.94%)	42 (5.61%)	4 (0.53%)	--	--	3 (9.08%)
Darling Run	0.1 (3.3)	1 (0.2%)	--	12 (2.43%)	--	--	2 (2.63%)
Mill Creek	12.5 (8.8)	71 (8.21%)	--	29 (3.35%)	--	--	2 (11.56%)
Mill Creek	8.5 (18.50	11 (2.17%)	--	1 (0.2%)	--	--	2 (2.37%)
Mill Creek	7.9 (27.1)	23 (0.88%)	--	5 (0.19%)	--	2 (0.08%)	3 (1.15%)
Mill Creek	3.5 (39.9)	6 (0.48%)	--	1 (0.08%)	--	42 (3.36%)	3 (3.92%)
Mill Creek	0.4 (51.1)	--	--	--	--	3 (0.12%)	1 (0.12%)
Little Mill Creek	0.1 (8.4)	180 (8.18%)	3 (0.14%)	22 (1.0%)	--	--	3 (9.32%)
Turkey Run	0.1 (5.5)	586 (28.38%)	167 (8.09%)	51 (2.47%)	--	--	3 (38.94%)
North Branch Symmes Creek	4.3 (8.2)	40 (3.75%)	--	--	--	--	1 (3.75%)
North Branch Symmes Creek	0.1 (15.0)	--	1 (0.16%)	--	--	--	1 (0.16%)
Symmes Creek	5.7 (8.3)	88 (5.4%)	16 (0.98%)	--	--	--	2
Symmes Creek	4.4 (15.3)	24 (3.44%)	--	--	--	--	1 (3.44%)
Symmes Creek	2.3 (31.4)	1 (0.06%)	--	--	--	1 (0.06%)	2 (0.12%)
South Branch Symmes Creek	0.2 (4.3)	98 (13.14%)	5 (0.67%)	--	--	--	2 (13.81%)
Blunt Run	0.1 (2.8)	--	1 (0.14%)	--	--	--	1 (0.14%)
Mill Run	0.4 (3.1)	--	2 (0.35%)	--	--	--	1 (0.35%)

A - Total number of fish collected with the percent of total sample in parentheses.
B - Total number of cold water fish species collected with percent of sample in parentheses.

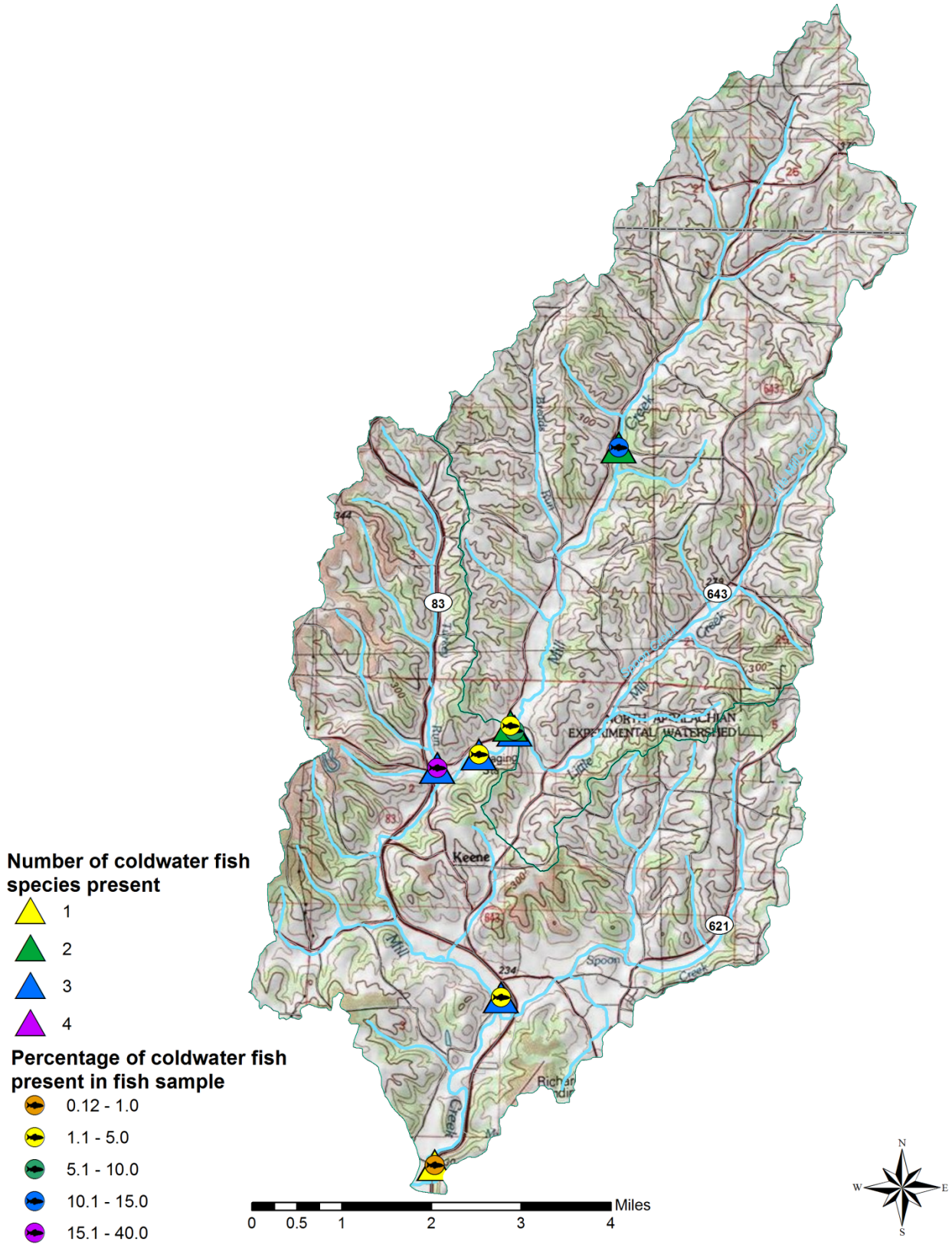


Figure 6. Number of cold water fish species and percent of total sample comprised of cold water fish for sampling locations within the Mill Creek subwatershed, 2010.

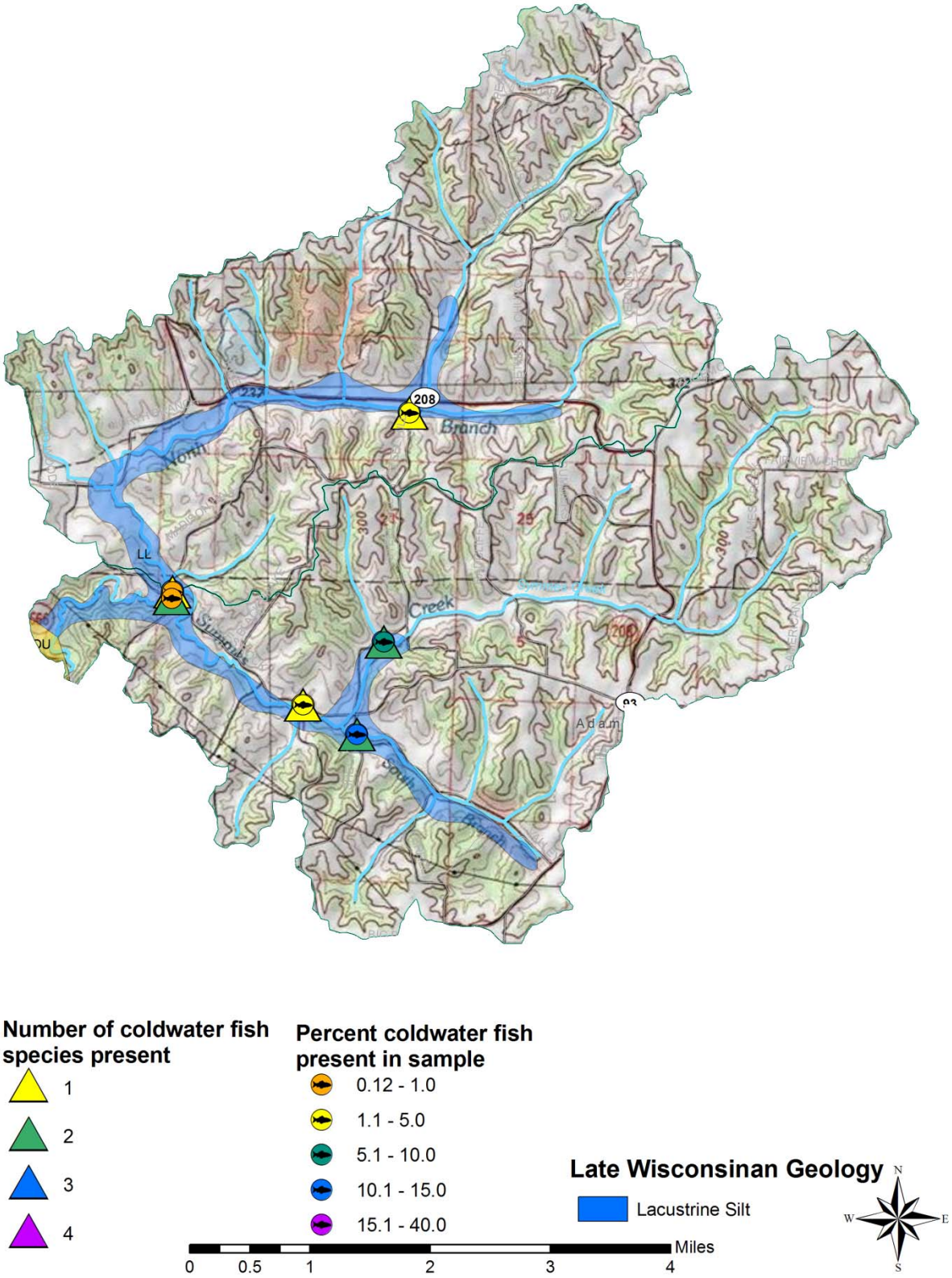
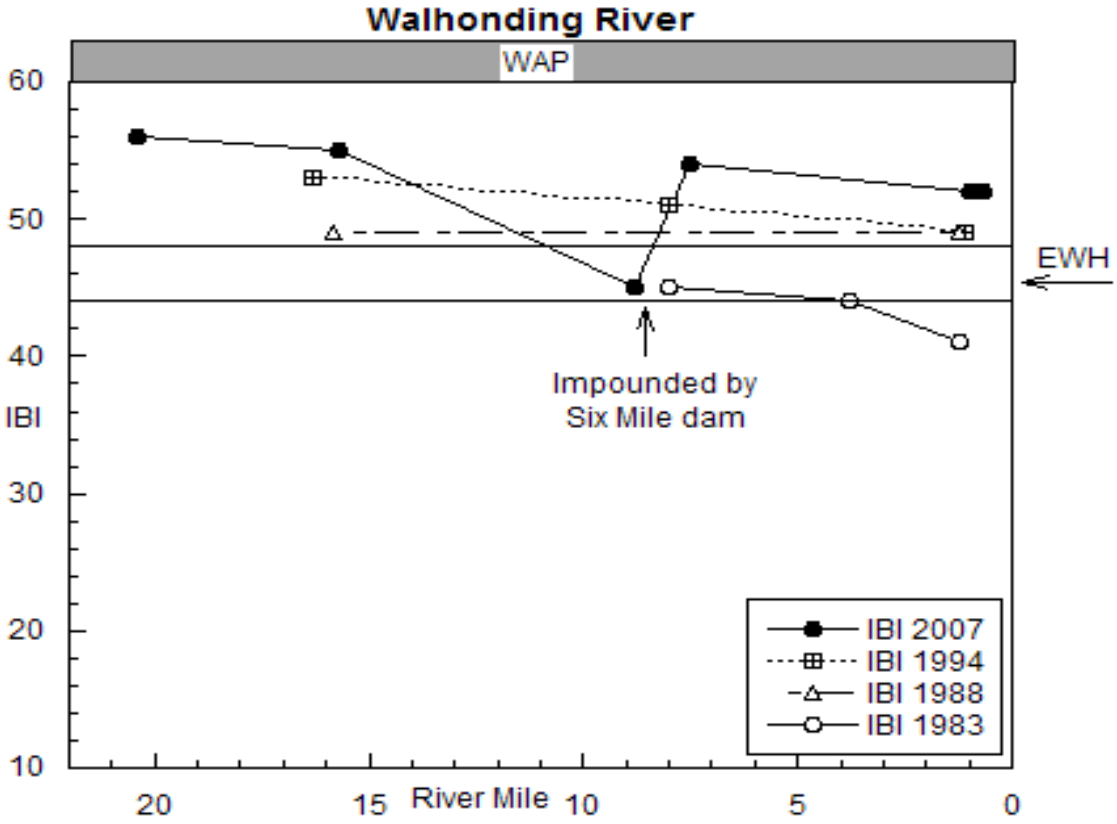


Figure 7. Number of cold water fish species and percent of total sample comprised of cold water fish for sampling locations within the Symmes Creek subwatershed, 2010.



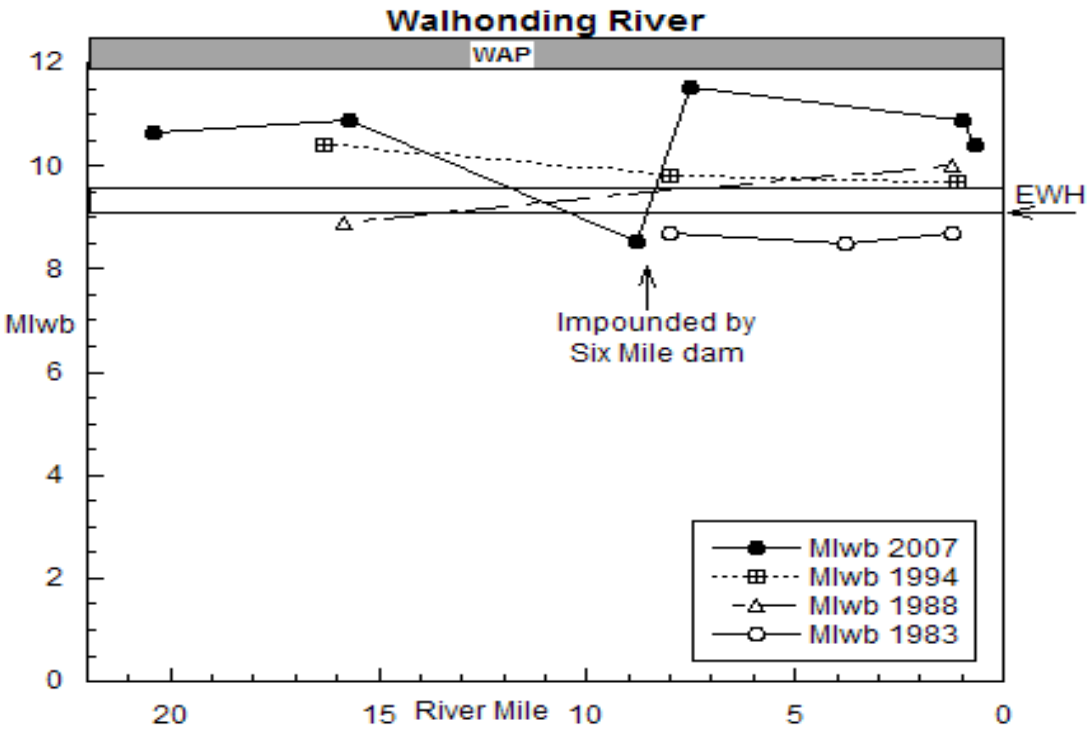
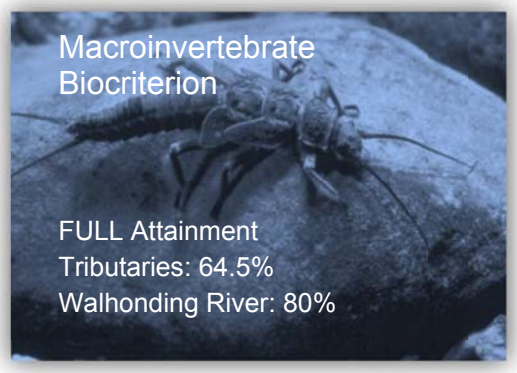


Figure 8. Fish community IBI and MIwb trends for the Walhonding River; including data from 1983, 1988, 1994, and 2007.



Macroinvertebrate Community

The macroinvertebrate communities from 31 locations in 20 direct or indirect tributaries to the Walhonding and Muskingum rivers were sampled in 2010. Qualitative multi-habitat composite samples were collected from all sampling locations. Quantitative Hester-Dendy artificial substrate samples were collected from five sites with drainage areas that were larger than 20 square miles. A summary of the macroinvertebrate data are presented in Table 18. The macroinvertebrate raw data are presented in Appendix J, K and L. Sampling locations were evaluated using Warmwater Habitat (WWH) or Exceptional Warmwater Habitat (EWH) biocriteria based on current or recommended aquatic life uses, as well as Coldwater Habitat (CWH) narrative benchmarks where applicable. Overall, 20 sites were meeting the applicable biocriterion (64.5%). Impaired communities were primarily attributed to natural conditions, sedimentation/siltation, acid mine drainage, or nutrient and organic enrichment. High resource quality was abundant in the tributaries to the Walhonding River in the western portion of the study area, where both exceptional and cold water communities were frequently encountered. The survey in 2010 marks the first time macroinvertebrate communities have been sampled from these tributaries by Ohio EPA.

Natural conditions impacted sites on Flint, Darling, and Crooked runs. Flint Run was a sluggish, hardpan substrate stream that contained no functional riffles, while the rise and fall of the Walhonding River frequently scoured the mouths of Darling and Crooked runs. These natural phenomena reduced EPT[1] and sensitive taxa numbers such that the WWH biocriterion was not achieved for Flint Run RM 0.4, Darling Run RM 0.10, and Crooked Run RM 0.06.

Sedimentation affected macroinvertebrate communities in Beaver Run, Simmons Run, Little Mill Creek, Mill Creek, Robinson Run and Mill Run. At Beaver Run RM 0.30, caddisfly abundance and diversity was low due to riffle substrates that were embedded with sand and silt. The resultant evaluation of *good* did not meet the EWH criterion at this location. Crop production activities in the headwaters of Beaver Run were likely responsible for the excess sediment load. Eroding stream banks and the recent channelization of an upstream tributary affected the biological integrity of Simmons Run RM 2.97. This resulted in a mud-bottom stream with little margin habitat available for colonization. The evaluation of *fair* did not meet WWH expectations. Taxa richness at this site was considerably lower than downstream at RM 0.60, where the habitat was more intact. At Little Mill Creek RM 0.30, unrestricted livestock access resulted in slumped, unstable stream banks. EPT and sensitive taxa richness were both low for an EWH stream and resulted in an evaluation of *good*, which did not meet the EWH biocriterion. At Mill Creek RM 3.54, sedimentation prevented inadequate colonization by filter-feeding caddisflies on the artificial substrates, resulting in an Invertebrate Community Index (ICI) score of 36, which was below EWH expectations. Agricultural activities in the watershed (livestock, row crop) were the likely source of excess sediment at this location.

In addition to sedimentation, acid mine drainage (AMD) was responsible for impaired communities in Robinson Run and Mill Run. Orange silt coated and bound the substrates in Robinson Run, rendering macroinvertebrate colonization difficult. Only six total taxa were collected from the stream. Although Mill Run fared better with 30 total taxa, no sensitive taxa were collected. The orange silt was less profound than in Robinson Run, but the overall sediment load was very high and encumbered the bottom substrates. Abandoned coal mines were determined to be the source of the sediment and AMD in both Robinson and Mill runs.

[1] EPT stands for Ephemeroptera-Plecoptera-Trichoptera, the orders of invertebrates commonly known as mayflies, stoneflies, and caddisflies, respectively. Their collective presence and abundance in the benthos is generally considered an indicator of high resource quality.

The headwaters of Mill Creek are surrounded largely by pasture land, thereby rendering its streams vulnerable to the effects of nutrient and organic over-enrichment. In the headwaters of Mill Creek at RM 12.5, only seven sensitive taxa were collected, and the midge genus *Rheotanytarsus* was predominant on the natural substrates, indicating potential nutrient enrichment. The evaluation of *good* for this site was not meeting the EWH biocriterion. The land upstream from RM 12.5 is almost entirely pastured, and the elevated nutrients in this reach are likely sourced from manure-laden runoff or from unrestricted livestock access to the stream. Beards Run, a small tributary to Mill Creek at RM 10.88, was highly degraded by both nutrient and organic enrichment. The natural substrates were coated with flatworms, and no EPT or sensitive taxa were among the 21 total taxa collected. Algae choked the stream channel, indicating the presence of excess nutrients. As with Mill Creek RM 12.5, the land surrounding Beards Run is mostly pasture, so it is likely that the source of excess nutrients is from livestock operations.

Exceptional and cold water-adapted macroinvertebrate communities were most frequently encountered in the tributaries to the Walhonding River in the western portion of the study area. These streams – Mohawk Creek, the unnamed tributary to Mohawk Creek at RM 2.93, Dutch Run. Honey Run, and Beaver Run – supported an average of 18 EPT and 18 sensitive taxa, and collectively were considered to be of *very good* resource quality. The Mohawk Creek subwatershed, with an average of 20 EPT and 20 sensitive taxa among the three sites sampled, consistently supported EWH communities and was considered to have the highest resource quality in the 2010 survey. Dutch Run and Honey Run, smaller (<5 mi^2) direct tributaries to the Walhonding River, both supported a large number of cold water adapted macroinvertebrates (10 and 9 taxa, respectively). The draft Cold Water Habitat (CWH) rule (OAC 3745-01-07) requires the presence of at least four cold water macroinvertebrate taxa in order to recommend the CWH aquatic life use. As such, these two streams are recommended to receive the CWH aquatic life use designation. In addition to Dutch Run and Honey Run, Blunt Run, a tributary to the Muskingum River in the southern portion of the study area, also had a macroinvertebrate community with the requisite number of cold water taxa and should also be recommended the CWH aquatic life use. Table 17 lists the cold water macroinvertebrate fauna collected in the study area by site.

Walhonding River, 2007

Walhonding River main stem sampling, conducted in 2007, revealed that four of five samples achieved the EWH biocriterion. The EWH-attaining sites had an average ICI of 50, which corresponds to exceptional resource quality. Only RM 8.81 did not meet EWH expectations. The fair community that was collected reflected the impounded conditions created by the Six Mile Dam. The Walhonding River was previously sampled by Ohio EPA in 1987, 1988, and 1994. Macroinvertebrate communities collected in those years consistently met EWH expectations (Figure 9).

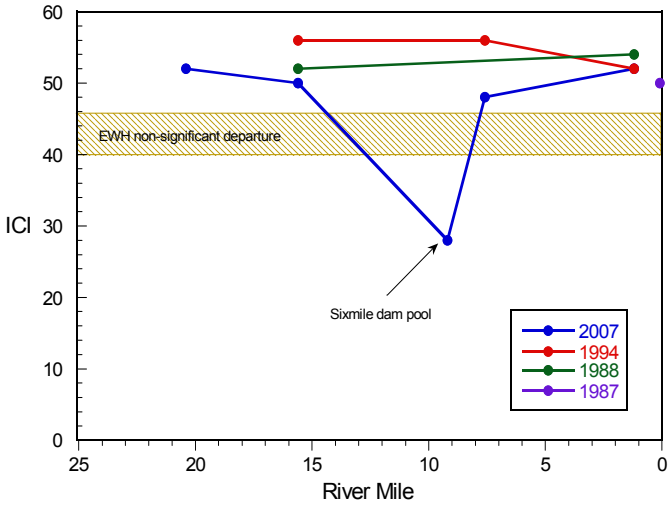


Figure 9. Longitudinal plots of Walhonding River ICIs, 1987-2007.

Table 17. Cold water macroinvertebrate fauna collected by site in the Walhonding and Muskingum River tributaries study area, 2010. Shaded areas represent sites located in streams or stream segments that are recommended for the CWH aquatic life use.

Stream	RM	Taxa
Mohawk Creek	4.1	*Leuctra sp., Polypedilum aviceps*
UT to Mohawk Creek at RM 2.93	0.60	*Leuctra sp.*
Dutch Run	0.15	*Gammarus minus, Baetis tricaudatis, Leuctra sp., Dolophilodes distinctus, Ceratopsyche slossonae, Lepidostoma sp., Oligostomis pardalis, Dicranota sp., Trissopelopia ogemawi, Parametriocnemus sp.*
Honey Run	0.60	*Ceratopsyche slossonae, Oligostomis pardalis, Glossosoma sp., Trissopelopia ogemawi, Parametriocnemus sp., Heterotrissocladius marcidus, Polypedilum albicorne, Polypedilum aviceps, Paratanytarsus longistylus*
Beaver Run	2.60	*Baetis tricaudatis, Diplectrona modesta*
Beaver Run	0.17	*Goera stylata*
Simmons Run	2.97	*Dicranota sp.*
Darling Run	0.10	*Paratanytarsus longistylus*
Mill Creek	12.50	*Leuctra sp.*
Mill Creek	3.54	*Leuctra sp.*
Little Mill Creek	0.10	*Parametriocnemus sp.*
Turkey Run*	0.19	*Leuctra sp., Ceratopsyche slossonae, Parametriocnemus sp.*
North Branch Symmes Creek	0.10	*Leuctra sp.*
Symmes Creek	4.35	*Leuctra sp., Dicranota sp.*
South Branch Symmes Creek	0.15	*Leuctra sp., Parametriocnemus sp.*
Blount Run	0.31	*Gammarus minus, Leuctra sp.*
Blunt Run	0.10	*Leuctra sp., Dolophilodes distinctus, Lepidostoma sp., Parametriocnemus sp.*
Mill Run	0.45	*Diplectrona modesta, Parametriocnemus sp.*

*CWH recommendation based on the presence of at least two cold water fish and two cold water macroinvertebrate taxa.

Table 18. Summary of macroinvertebrate data collected from artificial substrates (quantitative data) and natural substrates (qualitative data) in the Walhonding and Muskingum River tributaries basin, July-September, 2010, and in the Walhonding River, July-September 2007.

Location	River Mile	Drain. (mi^2)	Total Taxa	Qual EPT	Total Sens.	Total Tol.	CW Taxa	Substrate Density[a]	ICI[b]	Narrative Evaluation	Observations[c]
Mohawk Creek @ TR 409	4.1	9.47	47	19	15	9	2	Moderate	n/a	Very Good	Hydropsychid and philopotamid caddisflies, riffle beetles, heptageniid mayflies, and fingernail clams predominant.
Mohawk Creek @ CR 82	1.48	22.60	84	21	24	7	0	Low	50	Exceptional	Riffle beetles and fingernail clams predominant. *Baetisca sp* mayflies collected.
UT to Mohawk Creek at RM 2.93 @ TR 373	0.60	6.38	52	22	21	5	1	Moderate	n/a	Exceptional	*Leuctra sp* stoneflies, polycentropid and hydropsychid caddisflies, and *MacCaffertium vicarium* mayflies predominant.
Dutch Run @ TR 144/TR 338	0.15	5.44	46	20	20	3	10	Moderate	n/a	Exceptional	Baetid and heptageniid mayflies, hydropsychid caddisflies, and *Rheotanytarsus sp* midges predominant.
Honey Run @ TR 359	0.60	1.86	49	15	16	9	9	High	n/a	Very Good	Sowbugs predominant.
Beaver Run @ CR 22	2.60	8.36	55	17	17	10	2	Moderate	n/a	Very Good	Hydropsychid caddisflies, water mites, and midges predominant.
Beaver Run @ SR 36 at Warsaw	0.17	14.10	47	15	11	10	1	Moderate	n/a	Good	Hydropsychid caddisflies and baetid mayflies predominant.
Simmons Run @ TR 78	2.97	9.29	36	7	6	6	1	Low	n/a	Fair	Midges predominant.
Simmons Run @ TR 41B	0.60	16.30	52	13	10	6	0	Moderate	n/a	Good	Hydropsychid and philopotamid caddisflies, midges, heptageniid and caenid mayflies predominant.
Flint Run @ SR 60	0.40	2.25	37	8	7	7	0	Low	n/a	Fair	Midges predominant.
Darling Run @ TR 340 at Nellie Cemetery	0.10	3.82	24	6	6	2	1	Low	n/a	Fair	Midges predominant.
Mill Creek @ TR 215	12.50	8.84	51	12	7	12	1	Moderate	n/a	Good	*Rheotanytarsus sp* midges and *Stenacron sp* mayflies predominant.
Mill Creek @ TR 206	8.50	18.50	48	16	14	4	0	Moderate	n/a	Very Good	Hydropsychid caddisflies, midges predominant.
Mill Creek @ gage	7.90	27.20	66	15	16	9	0	High	n/a	Very Good	Midges and riffle beetles predominant.
Mill Creek @ TR 322	3.54	39.90	49	18	16	3	1	Moderate	36	Good	Philopotamid caddisflies, *Isonychia sp* mayflies, and heptageniid mayflies.

Location	River Mile	Drain. (mi^2)	Total Taxa	Qual EPT	Total Sens.	Total Tol.	CW Taxa	Substrate Density[a]	ICI[b]	Narrative Evaluation	Observations[c]
Mill Creek @ CR 24	0.40	51.10	81	23	25	12	0	High	44	Very Good	*Rheotanytarsus sp* midges, *Stenacron sp* mayflies, and Asian clams predominant.
Little Mill Creek @ driveway off TR 206	0.10	8.40	50	13	13	8	1	Low	n/a	Good	Baetid mayflies and midges predominant.
Beards Run @ CR 126	1.30	1.70	21	0	0	11	0	High	n/a	Poor	Flatworms predominant.
Turkey Run @ CR 12	0.19	5.50	60	20	17	7	3	Moderate	n/a	Exceptional	Hydropsychid and philopotamid caddisflies, *Leuctra sp* stoneflies and caenid mayflies predominant.
Crooked Run @ CR 23, ust WWTP	0.98	8.03	45	10	8	7	0	Low	n/a	Marginally Good	Hydropsychid caddisflies, *Rheotanytarsus sp* midges, and other midges predominant.
Crooked Run @ TR 495	0.06	8.97	30	8	5	6	0	Low	n/a	Fair	Hydropsychid maddisflies, and heptageniid mayflies predominant.
Robinson Run @ CR 271	1.35	3.81	6	1	0	1	0	Very low	n/a	Very Poor	A few hydropsychd caddisflies and crane flies present.
North Branch Symmes Creek @ Steel Hill Rd	4.25	8.16	47	15	11	8	0	Low	n/a	Good	Hydropsychid caddisflies and rifle beetles predominant.
North Branch Symmes Creek @ Madison Hall Rd	0.10	15.00	47	13	11	4	1	Moderate	n/a	Good	Hydropsychid caddisflies and riffle beetles predominant.
South Branch Symmes Creek @ Sheck Rd/TR 156	0.15	4.33	36	12	9	5	2	Moderate	n/a	Good	*MacCaffertium vicarium* mayfly and hydropsychid caddisflies predominant.
Symmes Creek @ Steel Hill Rd	5.65	8.30	44	17	14	5	0	Low	n/a	Very Good	Hydropsychid caddisflies, caenid mayflies predominant.
Symmes Creek @ Mutton Ridge Rd	4.35	15.30	51	15	12	8	2	Moderate	n/a	Very Good	Hydrosychid, philopotamid, and polycentropid caddisflies; alderflies predominant.
Symmes Creek @ Mollie's Rock Rd	2.35	31.50	79	14	14	11	0	Moderate	50	Exceptional	Riffle beetles and caenid mayflies predominant.
Blount Run @ SR 666	0.31	7.70	46	13	11	12	2	Moderate	n/a	Good	Heptageniid and caenid mayflies predominant.
Blunt Run @ CR 418	0.10	2080	30	11	9	4	4	Moderate	n/a	Good	*Leuctra sp* stoneflies predominant.
Mill Run @ Coal Run Rd	0.45	3.38	31	5	0	8	2	Low	n/a	Low Fair	Hydropsychid caddisflies and riffle beetles predominant.

Location	River Mile	Drain. (mi^2)	Total Taxa	Qual EPT	Total Sens.	Total Tol.	CW Taxa	Substrate Density[a]	ICI[b]	Narrative Evaluation	Observations[c]
Walhonding River near Walhonding @ SR 715	21.8	1490.0	75	28	40	7	1	Moderate	52	**Exceptional**	Hydropsychid and hydroptilid caddisflies, Asian clams,and *Rheotanytarsus sp* midges predominant.
Walhonding River at Nellie @ US 36	15.73	1505.0	69	27	39	9	0	Moderate	n/a	**Exceptional**	*Isonychia sp* and burrowing mayflies, hydropsychid and psychomyiid caddisflies predominant.
Walhonding River ust Sixmile Dam	8.81	1572.0	38	9	11	12	0	Low	n/a	**Fair**	Hydroptilid caddisflies, *Elimia sp*. snails and *Stenacron sp*. mayflies predominant.
Walhonding River ust Killbuck Creek @ US 36	7.54	1575.0	79	28	41	13	0	High	48	**Exceptional**	Hydropsychid caddisflies and baetid mayflies predominant.
Walhonding River at Coshocton @ US 36	0.76	2255.0	47	19	28	2	0	Moderate	50	**Exceptional**	Hydropsychid caddisflies, baetid mayflies, and *Rheotanytarsus sp* midges predominant.

a – Observed relative density of benthos on natural substrates. Please refer to Appendix L for relative densities on artificial substrates (where available).
b – Invertebrate Community Index. ICI not available for sampling locations with drainage area <20mi^2 (excluding reference sites), and are indicated by n/a. Dashed lines (--) indicate sites where quantitative data were not available due to vandalism, dessication, or some other disturbance of Hester Dendy artificial substrates.
c – Predominant taxa are those observed on natural substrates. Please refer to Appendix L for predominant taxa on artificial substrates.

Fish Tissue Contamination

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. Other contaminants are sometimes analyzed if indicated by site-specific current or historic sources. For more information about the chemicals analyzed, how fish are collected, or the history of the fish contaminant program, see State Of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, OhioEPA,January2010(http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure10.pdf).

Fish contaminant data are primarily used for three purposes: 1) to determine fish advisories; 2) to determine attainment with the Ohio Water Quality Standards; and 3) to examine trends in fish contaminants over time.

Fish advisories

Fish contaminant data are used to determine a meal frequency that is safe for people to consume (e.g., two meals a week, one meal a month, do not eat), and a fish advisory is issued for applicable species and locations. Because mercury mostly comes from nonpoint sources, primarily aerial deposition, Ohio has had a statewide one meal a week advisory for most fish since 2001. Most fish are assumed to be safe to eat once a week unless specified otherwise in the fish advisory, which can be viewed at http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

The minimum data requirement for issuing a fish advisory is 3 samples of a single species from within the past 10 years. For the Walhonding River, channel catfish, common carp, and freshwater drum met this requirement with data collected in 2008. Common carp were in the one meal a week advisory category for both mercury and PCB contamination. Channel catfish were in the one meal a month advisory category for PCB contamination. Freshwater drum were in the one meal a month advisory category due to mercury contamination. For all other species, the statewide advisories apply, which are: two meals a week for sunfish (e.g., bluegill) and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish 23” and over and northern pike 23” and over.

For a listing of 2008 fish tissue data collected from the Walhonding River in support of the advisory program, and how the data compare to advisory thresholds, see Table 20.

Fish tissue/human health use attainment

In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health water quality criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health water quality criteria are presented in water column concentrations of µg/Liter, and are then translated into fish tissue concentrations in mg/kg. [See Ohio’s 2010 Integrated Report, Section E (http://www.epa.state.oh.us/portals/35/tmdl/2010IntReport/Section%20E.pdf) for further details of this conversion.]

In order to be considered in attainment of the Ohio WQS, the sport fish caught within a USGS 12-digit Hydrologic Unit Code (HUC-12) must have a weighted average concentration of the geometric means for all species below 1.0 mg/kg for mercury, and below 0.054 mg/kg for PCBs.

Fish tissue data were adequate to determine attainment status. At least 2 samples from each trophic level, 3 and 4, are needed, and the Walhonding River met that data requirement. Concentrations of mercury and PCBs and the associated attainment status are listed in Table 19.

Table 19. Attainment status of Walhonding River HUC-12s for fish tissue/human health use.

HUC-12	Mercury (mg/kg)	PCBs (mg/kg)	Attainment
0504000309 02	0.150	0.251	NON
0504000309 08	0.130	0.156	NON

Both HUC-12s for which the human health attainment status was determined were in non-attainment of the human health use due to PCB contamination in excess of the WQS-based threshold of 0.054 mg/kg PCBs in fish tissue.

Fish contaminant trends

Fish contaminant levels can be used as an indicator of pollution in the water column at levels lower than laboratory reporting limits for water concentrations but high enough to pose a threat to human health from eating fish. Most bioaccumulative contaminant concentrations are decreasing in the environment because of bans on certain types of chemicals like PCBs, and because of stricter permitting limits on dischargers for other chemicals. However, data show that PCBs continue to pose a risk to humans who consume fish, and mercury concentrations have been increasing in some locations because of increases in certain types of industries for which mercury is a byproduct that is released to air and/or surface water.

For this reason, it is useful to compare the results from the survey presented in this document with the results of the previous survey(s) done in the study area. Recent data can be compared against historical data to determine whether contaminant concentrations in fish tissue appear to be increasing, decreasing, or staying the same in a water body or watershed.

Fish tissue had previously been collected from the Walhonding River in 1995. Those data covered the same study area as the 2008 data, from downstream from the Mohawk Dam at river mile 17.2 to near the mouth in Coshocton at river mile 1.0. The weighted average concentration of PCBs in Walhonding River fish appears to have decreased between the two study periods, from 0.231 mg/kg in 1995 to 0.176 mg/kg in 2008. The weighted average concentration of mercury in fish from the Walhonding River appears to have increased between 1995 and 2008, from 0.119 mg/kg to 0.151 mg/kg. That increase is likely attributable to an increase in the size of fish caught, from an average of 338 mm in 1995 to 517 mm in 2008.

Table 20. Select Fish Tissue data from 2008 Walhonding River sampling (mg/kg).

Year Collected	Location	River Mile	Species	Mercury	PCBs
2008	Walhonding River downstream Mohawk Dam	17.2	Channel Catfish	0.121	0.204
2008	Walhonding River downstream Mohawk Dam	17.2	Channel Catfish	0.187	0.431
2008	Walhonding River upstream U.S. Route 36	1.0	Channel Catfish	0.11	0.273
2008	Walhonding River upstream U.S. Route 36	1.0	Channel Catfish	0.062	0.082
	Averages			0.120	0.248
2008	Walhonding River downstream Mohawk Dam	17.2	Common Carp	0.111	0.201
2008	Walhonding River upstream Route 60	11.9	Common Carp	0.122	0.235
2008	Walhonding River upstream U.S. Route 36	1.0	Common Carp	0.09	0.187
	Averages			0.108	0.208
2008	Walhonding River downstream Mohawk Dam	17.2	Freshwater Drum	0.156	0.193
2008	Walhonding River upstream Route 60	11.9	Freshwater Drum	0.704	0.296
2008	Walhonding River upstream Route 60	11.9	Freshwater Drum	0.107	0.098
2008	Walhonding River upstream U.S. Route 36	1.0	Freshwater Drum	0.283	0.075
	Averages			0.313	0.166
2008	Walhonding River downstream Mohawk Dam	17.2	Northern Pike	0.176	<0.05
2008	Walhonding River upstream Route 60	11.9	Smallmouth Bass	0.424	<0.05
2008	Walhonding River upstream U.S. Route 36	1.0	Smallmouth Bass	0.161	0.174
	Averages			0.293	0.112

The shading indicates the advisory category that would apply, though as discussed in the text, the data are not sufficient for issuing additional advisories beyond the statewide advisory. Green = two meals per week, yellow = one meal per week, orange = one meal per month.

ACKNOWLEDGEMENTS

The following Ohio EPA staff provided technical expertise for this project:

Report preparation and analysis:	Angela Dripps, Joann Montgomery, Holly Tucker, Mylynda Shaskus
Data support:	Dennis Mishne
Reviewers:	Jeff DeShon, Holly Tucker
Stream sampling:	Full-time staff: Brian Alsdorf, Mohammed Asasi, Kelly Capuzzi, Angela Dripps, Dan Imhoff, Joann Montgomery, Ed Moore, Randy Spencer, Holly Tucker Interns: Sarah Boley, Jeff Calhoun, Andy Claus, Ellina Dovgopolaya, Brittany Dripps, Mike Ernst, Clarence David Fullard, Amelia Hettinger, Max Pettit, Audra Sabo, Nick Schell, Nicole Smith

The Ohio EPA appreciates the cooperation of the property owners who allowed Ohio EPA personnel access to the project area.

REFERENCES

Dufour, A.P. (1977). *Escherichia coli*: The fecal coliform. Am. Soc. Test. Mater. Spec.Publ. 635: 45-58.

Karr, J. R. 1991. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1(1): 66-84.

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Ill. Nat. Hist. Surv. Spec. Publ. 5. 28 pp.

MacDonald, D., C. Ingersoll, T. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxical.: Vol.39, 20-31.

Miner R. and D. Borton. 1991. Considerations in the development and implementation of biocriteria, Water Quality Standards for the 21st Century, U.S. EPA, Offc. Science and Technology, Washington, D.C., 115 pp.

Ohio Department of Natural Resources (ODNR). 2001. Gazetteer of Ohio Streams. Ohio Water Inventory Report No. 29. Ohio DNR Div. of Water, Columbus, Ohio.

Ohio Environmental Protection Agency (OEPA). 2009. Ohio EPA manual of surveillance methods and quality assurance practices, updated edition. Division of Environmental Services, Columbus, Ohio.

Ohio Environmental Protection Agency. 2008a. 2008 updates to Biological Criteria for the Protection of Aquatic Life: Volume II and Volume II Addendum. Users manual for biological field assessment of Ohio surface waters. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2008b. 2008 updates to Biological Criteria for the Protection of Aquatic Life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2008c. Sediment Reference Values. Division of Emergency and Remedial Response. Columbus, Ohio.

Ohio Environmental Protection Agency. 2006. Methods for assessing habitat in flowing waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Tech. Bull. EAS/2006-06-1. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1999. Association Between Nutrients, Habitat, and Aquatic Biota in Ohio Rivers and Streams. Ohio EPA Tech. Bull. EAS/2006-06-1. Division of Surface Water, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989a. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Pavey, Richard R., Richard P. Goldthwait, C. Scott Brockman, Dennis N. Hull, E. Mac Swinford, and Robert G. Van Horn. 1999. Quaternary Geology of Ohio: Map SG-1. ODNR Division of Geological Survey, Columbus, Ohio.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Suter, G.W., II. 1993. A critique of ecosystem health concepts and indexes. Environmental Toxicology and Chemistry, 12: 1533-1539.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C. O. 1991**.** Answering some concerns about biological criteria based on experiences in Ohio, *in* G. H. Flock (ed.) Water quality standards for the 21st century. Proceedings of a National Conference, U. S. EPA, Office of Water, Washington, D.C.

Yoder, C.O. 1989. The development and use of biological criteria for Ohio surface waters. U.S. EPA, Criteria and Standards Div., Water Quality Stds. 21st Century, 1989: 139-146.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

*Some of the references not in the report can be found in the Appendix A which includes Methods, Biosurvey Background Information, and Notice to Users.