Aquatic Biota Survey Report For the PolyMet Project

Prepared for
PolyMet Mining Company

August 2011

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Executive Summary

As part of the baseline studies for United States Forest Service Region 9 (USFS R9) and PolyMet Mining, Inc. (PolyMet) land exchange, two Partridge River sites was were evaluated to assess their biotic integrity. Physical stream habitats were assessed at each site using the QHEI with similar scores at each site. Surrounding land use, riparian zone characteristics, and in-stream substrates were similar for the two sites. Pools and runs were the common habitats with overhanging vegetation, emergent vegetation and woody debris habitats with o riffle habitat present. The sinuosity, flow rate and gradient were similar at both sites, which are characterized by flow through expansive wetland areas.

Nine unique fish species were collected from the two sites, with 3 species at the west site and 9 species at the east site. The Shannon-Wiener Diversity Index (H´) scores for the species were similar (west – 0.81; east – 0.79). The H´ score is primarily affected by richness and the distribution of individuals among the taxa present at the site. There were only 19 fish (not including young-of-year) collected at the west site; therefore the score does not provide additional information about the fish communities. At the east site, the northern redbelly dace composed 80 percent of the total fish catch; resulting in a low evenness score (0.36).

Over 80 percent of the macroinvertebrates identified at the two sites were midges, collected from sediment substrate. The H´, evenness and HBI scores for species at the two sites were similar. The HBI is generally a measure of organic or nutrient pollution which affects organisms resulting from low DO or fluctuating DO levels. Evaluation of streams in this region based on the HBI may actually underestimate biologic integrity because these streams have naturally low DO levels since they generally flow through wetland complexes. However, even with these limitations, the HBI values were presented in this report as a method for comparison with other streams in the area.

Fish and macroinvertebrate community compositions are similar to data reported at downstream sites on the Partridge River (Breneman, 2005). Fish species identified at the west and east sites were also identified at downstream sites. Macroinvertebrates at downstream sites were also dominated by true flies. Just as Breneman (2005) concluded for the downstream sites, the west and east sites discussed in this report are also characteristic of other aquatic habitats in the region.

1.0 Project Description

The United States Forest Service Region 9 (USFS R9) and PolyMet Mining, Inc. (PolyMet) are in the process of completing an environmental impact statement (EIS) for a land exchange which includes lands within and around the proposed PolyMet mine site. The USFS owns the surface rights in the land exchange area. As part of the land exchange, an evaluation of the species in the Partridge River within the Land Exchange parcel is required because the USFS is responsible for assuring the protection of sensitive and other animal species. Based on discussion with the USFS (Ken Gebhardt, Personal communication), the purpose of this report is to summarize the habitat characteristics of the existing aquatic habitat associated with water bodies and water courses residing within the Land Exchange area that have not been previously field surveyed as part of the PolyMet NorthMet Project EIS.

As part of the baseline studies, macroinvertebrates and fish were surveyed at two sites on the Partridge River. This Aquatic Biota Survey Report is intended to provide the baseline characterization for fish and macroinvertebrates along with their associated habitats for this portion of the Partridge River. This report summarizes collection methodology and fieldwork conducted on September 15 and 21, 2009.

2.0 Survey Methods

Methods for the aquatic biota survey followed Minnesota Pollution Control Agency (MPCA) protocols as outlined in Appendix A. The reaches were selected by the U.S. Forest Service to obtain more information about the biota in the Partridge River within the potential land exchange area.

2.1 Site Selection

Biological monitoring required an assessment of the status of the fish and macroinvertebrate population in terms of the physical, chemical, and biological conditions at two sites on the Partridge River. The general location of the two sites was selected by the U.S. Forest Service (Ken Gebhardt, Personal communication). The locations of the aquatic biota assessment sites are shown in Figure 2 and included the west site and the east site. The two sites were co-located with the stream geomorphology monitoring and mussel survey sites. The final reach selection at each site was chosen after field reconnaissance and prior to the collection of aquatic biota.

2.2 Aquatic Biota Surveys

2.2.1 Stream Measurements

The two sites were sampled for fish on September 15, 2009 and for macroinvertebrates on September 21, 2009. The upstream and downstream coordinates of the sample sites were collected using a Global Positioning System (GPS) with submeter accuracy (Table 1). Each sample site was approximately 100-150 feet in length within the reach. Field measurements collected at the two sampling locations included dissolved oxygen (DO), temperature, pH, conductivity and flow (Table 2). Flow measurements were collected with a Marsh McBirney Flo-Mate 2000 flowmeter. All other field measurements were taken using YSI 556 MPS multi-parameter probe. Photographs taken at each site on the day of the macroinvertebrate sampling are provided in Appendix A.

The streams were below bankfull conditions during fish and macroinvertebrate sampling. Precipitation was normal in August and below the normal in April, May and June (Table 3). Prior to sampling, there was 0.13 of precipitation from September 1-21, with 0.10 inches and 0.03 inches of rainfall on September 9 and 12, respectively. Precipitation data was

downloaded (http://climate.umn.edu/HIDradius/radius.asp) from the State climatologist network for Station 210390 Babbitt 2SE.

A habitat evaluation was completed for each stream using the MPCA Stream Habitat Assessment worksheet, revised 03-07 (Appendix B). The worksheet was used to provide a general overall physical assessment of each stream, as well as features in the general area that may influence the quality of the site. These field worksheets provided information about the substrates, channel characteristics, riparian characteristics, and general area information. The quantitative habitat evaluation index (QHEI) scores for the MPCA Stream Habitat Assessment worksheet are based on a scale from -5 to 100 with higher numbers representing better quality habitat.

Ten-foot topographic contours, obtained from the United States Geological Survey quadrangle maps (DRGs), were overlain on the 2003 Farm Services Association (FSA) aerial imagery using ArcMap 9.3, in order to calculate the gradient and sinuosity of each stream. The results were used in the worksheets to assess the similarities and differences between the physical habitats of the sites.

2.2.2 Fish Sampling and Identification

Fish were sampled and data was provided by from the Natural Resources Research Institute (NRRI), University of Minnesota. A Minnesota Department of Natural Resources (MnDNR) collection permit was obtained prior to fish sampling. Fish were sampled during the summer index period of mid-June through mid-September when the stream was within baseflow conditions.

Fish were sampled using a seine net with a block net (1/4-inch mesh size). All sampling was conducted while walking in an upstream direction and weaving between habitat types. Table 1 provides the proportion of the channel type found in each reach. All in-stream cover types were sampled in the proportion that they existed in the stream reach.

Fish less than 25 mm in total length are excluded from the sampling effort. Fish over 25 mm were either collected as a voucher specimen or counted and returned to the stream. All fish collected as voucher specimens were preserved in 10 percent formalin. All individual fish recovered were identified to species, divided into age classes when necessary (e.g., adult, juvenile, young of the year) and enumerated.

2.2.3 Macroinvertebrate Sampling and Identification

Macroinvertebrates were collected using a modified version of the Minnesota Pollution Control Agency (MPCA) multi-habitat invertebrate sampling procedure (Protocol EMAP-SOP4). Qualitative samples were collected from emergent vegetation, undercut banks and woody debris using a D-frame net (mesh size 500 µm). The sampling effort lasted for 30 seconds per sample, with three samples composited per substrate. Emergent vegetation and undercut banks were swept while woody debris was scrubbed with a brush and washed. Quantitative samples were collected for sediment from the run and pool habitats using a petite ponar dredge ($0.023 m^2$). Information was collected at the sample sites including stream width (ft), water temperature (ºF), discharge (cfs), dissolved oxygen, conductivity and pH. Other general information was recorded at the sites to describe each site (Table 1). Representative photographs were taken at each site (Appendix A).

The streams were wadeable, however with the mucky sediment present throughout most of the reach, it was nearly impossible to walk through the stream. Therefore, samples were collected while either floating on the stream while using an inflatable U-boat or floating and locating solid footing where possible (see Appendix A).

For each habitat type at a sample site, three sampling efforts were completed using a D-frame dip net. The debris (large twigs, leaves, plants, rocks, etc.) were washed with stream water, visually inspected and discarded. Collected macroinvertebrates were composited in a sieve bucket, transferred into 500-ml plastic bottles, and preserved in 85 percent reagent alcohol. All containers were labeled with information including site identification, habitat type and collection date.

Macroinvertbrates were sorted using the MPCA *Invertebrate Multi-habitat Dip-net Sample Sorting* and *Invertebrate Identification and Enumeration* procedures (Appendix A). Macroinvertebrates were identified by Dr. Dean Hansen, and the MPCA procedures were provided to Dr. Hansen. Subsampling was not performed if the total abundance was less than 300 organisms at each site. Macroinvertebrates were identified to the genus level as possible for all organisms. Large macroinvertebrates were picked and identified for the entire sample.

2.3 Biotic Indices

The Shannon-Wiener Diversity Index (H') was used in conjunction with abundance and richness to evaluate the diversity of the macroinvertebrate and fish communities that were

sampled at each site. In addition, the macroinvertebrate data was also evaluated using the Hilsenhoff Biotic Index (HBI), percent Ephemeroptera, Plecoptera, and Tricoptera (% EPT), percent Ephemeroptera, Plecoptera, Tricoptera, and Odonata (% EPTO), and percent insects versus percent non-insects.

3.0 Survey Results

3.1 Physical and Chemical Measurements

The physical and chemical measurements that were taken in the field are presented in Tables 1 and 2. In September 2009, at the Babbitt NWS stations, there was 0.13 inches of rainfall in the week prior to fish sampling and in the two weeks prior to macroinvertebrate sampling. The water level in the streams in September appeared to be normal based on observations of vegetation along the bank. At both sites and for both sampling efforts, the water level was within the banks of the streams when the fish and macroinvertebrate samples were collected.

Available habitat types at the stream reaches included woody debris, overhanging vegetation, undercut banks, emergent vegetation and sediment (Table 1). The riparian zone at all sites was characterized by shrubs and wetland herbaceous vegetation. Maximum water depth was 3.5 feet at the east site and 3.9 feet at the west site. Water levels were within bankfull. The flow measurement was 3.1 cfs at the west site and 2.5 cfs at the east site (Table 2).

The water temperature, pH, conductivity and dissolved oxygen values were generally similar at the two sites in September (Table 2). The west site had a water temperature of 15.2 $^{\circ}$C, ph value of 7.9, dissolved oxygen value of 4.9 ppm and conductivity of 284 µmhos. The east site had a water temperature of 16.0 $^{\circ}$C, ph value of 7.9, dissolved oxygen value of 6.3 ppm and conductivity of 292 µmhos.

3.2 Habitat Analysis

The habitat condition of the two sites was determined on September 21, 2009 using the MPCA Stream Habitat Assessment worksheet (Appendix C). The QHEI Scores for the MPCA worksheet were similar at the west site (40) and the east site (41). Generally, the surrounding land use, riparian zone characteristics, and in-stream substrates were similar for the two sites. The riparian zone at all sites was characterized by thick vegetative growth. The substrate at the two sites was generally peaty muck with some areas of sand. The gradient was lower at the west site (0.5 ft/mile) compared to east site (1.1 ft/mile). The streams generally had low sinuosity ranging from 1.3 to 1.6 (Table 1). Pools and runs were the dominant channel types for both sites, with no riffle habitat present. At these sites, the Partridge River is characterized by flow through expansive wetland areas. The QHEI scores are similar for both sites.

3.3 Biological Diversity – Fish

A total of 9 species representing four families were collected at the two sites (Tables 4 and 5). The families included suckers (Catostomidae), minnows (Cyprinidae), stickleback (Gasterosteidae) and perch (Percidae).

3.3.1 Abundance and Richness

The abundance for the west site and east site were 19 and 1,847 individuals, respectively (Table 4). One type of gear was used for both sites – a 1/4-inch seine and block net.

There were a total of 9 unique species collected from the two sites (Tables 4 and 5). The west site and east site had 3 and 9 species, respectively. Common fish that were collected from the two sites included the white sucker, northern redbelly dace and brook stickleback. White suckers are omnivores that are tolerant of a wide range of environmental conditions and are typically found in Minnesota streams. Northern redbelly dace are common in northern Minnesota and typically inhabit small streams or bog lakes that contain beds of emergent or vegetation which are commonly found at both sites (MnDNR 2002). Over 80 percent of the fish collected at the east site were identified as northern redbelly dace. Brook sticklebacks, while listed as sensitive to environmental conditions, are very tolerant of low oxygen and low flow conditions that were typical of both sites.

3.3.2 Shannon-Wiener Diversity Index

Generally, a higher H´ score is indicative of a higher quality stream. The H´ values may be influenced by several factors such as in-stream cover, shading, erosion and sedimentation problems, riparian cover, water quality and stream size (watershed area).

The west site score was 0,81 which was higher than the east site score of 0.79 (Table 6). The H´ score is primarily affected by richness and the distribution of individuals among the taxa. There were few fish collected at the west site; therefore the score does not provide additional information about the fish communities. At the east site, the northern redbelly dace composed 80 percent of the total fish; therefore the evenness score was lower at 0.36. Higher evenness scores occur when species are nearly equal in abundance and lower scores result when a community is dominated by only a few species that have high abundance, like at the east site.

3.4 Biological Diversity – Macroinvertebrates

Taxa collected at the four sites represented 37 families, 12 orders, 8 classes and 4 phyla (Tables 7 and 8). The taxa included: insects (class: Insecta) – beetles (order: Coleoptera), true

flies (order: Diptera), mayflies (order: Ephemeroptera), true bugs (order: Hemiptera), dragonflies (order: Odonata), alderflies and dobsonflies (order: Megaloptera), and caddisflies (order: Trichoptera); crustaceans (class: Crustacea) – scuds (order: Amphipoda); segmented worms (phylum: Annelida) – leeches (subclass: Hirudinea) and aquatic worms (subclass: Oligochaeta); goblet worms (phylum: Entoprocta); and horsehair worms (phylum: Nematomorpha); and mollusks (phylum: Mollusca) – snails (class: Gastropoda) and clams (class: Bivalvia).

3.4.1 Abundance and Richness

There were 710 organisms collected at the west site and 912 organisms collected at the east site. Insects were the dominant class at both sites, comprising over 82 percent and 87 percent of the population at the west and east sites, respectively (Table 9). The dominate orders at both sites were true flies and caddisflies (Table 10). The midges or blood worms (family: Chironomidae) comprised over 80 percent of all macroinvertebrates and over 97 percent of the insects at the sites. Midges were collected from the mucky substrate in the Partridge River. These taxa are generally tolerant of variable stream conditions and are typically found in low gradient streams.

3.4.2 Shannon-Wiener Diversity Index

The Shannon-Wiener Diversity Index (H´) score for the species present was 2.81 at the west site and 2.98 at the east site (Table 11). The evenness score was 0.73 and 0.78 at the west and east sites, respectively. At west and east sites, the macroinvertebrates were dominated by 2 to 4 species, each with 78 to 178 individuals, respectively. Lower evenness scores result when the majority of macroinvertebrates are unevenly distributed among only a few species.

3.4.3 Hilsenhoff Biotic Index

The Hilsenhoff Biotic Index (HBI) provides a method to assess water quality based on taxa pollution-tolerance (Hilsenhoff 1987). The HBI was developed based on data from more than 1,000 small streams in Wisconsin. Small streams typically have a natural low biological diversity, which is unrelated to their water quality. Streams in this area are also generally naturally low in DO without the introduction of nutrient or organic pollutants. Other water quality indices attribute biological diversity to stream condition and water quality. However, research indicates the HBI does an excellent job of ranking small streams in this region according to their stream condition.

The HBI was developed using macroinvertebrate populations in streams with a range of organic

and nutrient levels, and hence DO levels. The HBI is typically used to measure biodiversity in streams that may be affected by nutrient or organic pollution that causes excessive plant growth which reduces the DO and may affect the growth of other aquatic biota, e.g. macroinvertebrates. In general, species living in streams with high organic levels and low DO levels were assigned high tolerance values and those species absent from these types of streams were given lower tolerance values. Using the tolerance values developed by Hilsenhoff (1997), every species or genus identified at the three monitoring sites has been assigned an index value from 0 to 10; with 1 assigned to the most tolerant species. Intermediate values were assigned to species intermediate in their tolerance of organic pollution (Table 12).

When evaluating water quality conditions at a site, the HBI is an average of tolerance values for all individuals collected from a site. The calculations result in an HBI value that is tolerant score for the sample weighted by the number of individuals in each contributing taxon. The calculated HBI scores can range from 0 to 10. A score at the low end of the scale (0) indicates the macroinvertebrate community is dominated by organisms intolerant of organic pollution and implies that the water quality is good (Table 12). An HBI at the high end of the scale (10) indicates the macroinvertebrate community is dominated by pollution-tolerant taxa and the site has dome amount of organic pollution. The HBI scores were “Fair” at the west and east sites (Table 11).

The stream evaluations based on the HBI may underestimate the biologic integrity of the streams discussed in this report. The HBI is generally a measure of organic or nutrient pollution which affects organisms resulting from low DO or fluctuating DO levels. These streams have naturally low DO levels since they generally flow through wetland complexes. However, even with these limitations, the HBI values were presented as a method for comparison with other streams in the area. The ranking “fair” needs to be reviewed in the context of the streams discussed in this study.

3.4.4 Other Measures of Biotic Integrity

Richness, the percentage composition of Ephemeroptera, Plecoptera and Trichoptera (% EPT), and the percentage of Ephemeroptera, Plecoptera, Trichoptera and Odonata (% EPTO) are other methods used to evaluate macroinvertebrate data. Richness is generally higher and the EPT/EPTO species are generally considered to be more environmentally sensitive Orders so are better indicators of the stream quality.

Richness was defined as the number of Families identified at each site. There were 11 and 10 families collected from the west and east sites, respectively (Table 11). Throughout the taxonomic levels, the numbers were also very similar. The %EPT and %EPTO were low at the west (19 percent) and east (22 percent) sites, which was expected in a low gradient wetland dominated stream system like the upper portion of the Partridge River. The majority of the macroinvertebrates at the sites were collected in the sediment samples. In addition, the lack of canopy and shading in these reaches may contribute to low richness and diversity.

4.0 Conclusions

The physical stream habitats were assessed at each site using the QHEI with similar scores at each site. The surrounding land use, riparian zone characteristics, and in-stream substrates were similar for the two sites. Walking in the streams was difficult at both sites because of the soft mucky substrate with isolated areas of firmer substrate. Pools and runs were the common habitats with overhanging vegetation, emergent vegetation and woody debris found at each site. No riffle habitat was present. The sinuosity, flow rate and gradient were similar at both sites, which are characterized by flow through expansive wetland areas.

There were a total of 9 unique fish species collected from the two sites. There were 3 and 9 species collected at the west and east sites, respectively. The Shannon-Wiener Diversity Index (H´) scores for the species at the west and east sites were 0.81 and 0.79, respectively. The H´ score is primarily affected by richness and the distribution of individuals among the taxa present at the site. There were few fish (19) collected at the west site; therefore the score does not provide additional information about the fish communities. At the east site, the northern redbelly dace composed 80 percent of the total fish catch; therefore the evenness score was low (0.36).

Over 80 percent of the macroinvertebrates identified at the two sites were midges, which were collected from sediment substrate. The Shannon-Wiener Diversity Index (H´) and evenness scores for the species present at the two sites was similar. In addition, the HBI Scores were "Fair" at both sites. The stream evaluations based on the HBI may underestimate the biologic integrity of the streams discussed in this report. The HBI is generally a measure of organic or nutrient pollution which affects organisms resulting from low DO or fluctuating DO levels. These streams have naturally low DO levels since they generally flow through wetland complexes. However, even with these limitations, the HBI values were presented as a method for comparison with other streams in the area. The ranking "fair" needs to be reviewed in the context of the streams discussed in this study.

Fish and macroinvertebrate community compositions are similar to data reported at site further downstream on the Partridge River (Breneman, 2005). The fish species identified at the west and east sites were also identified at downstream sites. The macroinvertebrates at the downstream sites were also dominated by true flies as were the west and east sites. Just as

Breneman (2005) concluded for the downstream sites, the west and east sites are also characteristic of other aquatic habitats in the region.

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Tables

Table 1. Stream parameters for QHEI.

Parameter	West Site	East Site
Length of Station (ft)	300	300
Channel Types (%)	run (100%)	run (100%)
Gradient (ft/mi)	0.5	1.1
Sinuosity	1.3	1.6
Discharge (cfs)	3.14	2.54
Width Average (ft)	16.0	13.0
Depth Average (ft)	2.6	2.9
Depth Maximum (ft)	3.9	3.5
Stream Stage	normal	normal
Substrate Type (in order of abundance)	sediment detritus/silt	sediment detritus/silt
In-stream Cover Types	overhanging vegetation emergent vegetation woody debris	overhanging vegetation emergent vegetation woody debris
Buffer Cover Types	shrubs wetland	shrubs wetland
QHEI score	40	41

Table 2. Field analysis of stream water chemistry.

Parameter	West Site	East Site
Water Temp (ºC)	15.2	16.0
Dissolved Oxygen (ppm)	4.9	6.3
Conductivity (µmhos)	284	292
pH	7.6	7.9
Flow (cfs)	3.14	2.54

Table 3
Precipitation Summary Compared to WETS[1] Data
1999-2008
PolyMet Mining Company
Hoyt Lakes, Minnesota

	30% chance			Babbitt										
	Average	more than	less than	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Inches													
January	0.88	0.52	1.07	0.73	0.55	**1.21**	*0.12*	*0.19*	**1.23**	**2.15**	*0.42*	**1.56**	**0.69**	**1.09**
February	0.70	0.36	0.86	0.60	0.71	**1.77**	*0.26*	0.44	*0.23*	0.50	**0.88**	*0.34*	*0.17*	**1.13**
March	1.10	0.63	1.34	1.01	1.11	*0.22*	0.96	0.82	0.64	0.95	**1.69**	**2.39**	*0.33*	**2.81**
April	1.96	1.27	2.35	1.70	*0.94*	**5.07**	*0.47*	1.56	1.63	1.91	1.82	**3.56**	**4.46**	**3.36**
May	3.01	1.89	3.63	**5.13**	**3.65**	**6.69**	*1.72*	2.16	**4.53**	**9.01**	3.35	**4.31**	2.77	*1.54*
June	4.29	3.26	5.00	3.96	**5.89**	3.79	4.28	3.36	*1.45*	**5.78**	*1.71*	4.88	**5.58**	*2.30*
July	3.37	2.44	3.96	**13.51**	**4.08**	**4.91**	**5.13**	**5.51**	3.23	*1.42*	**4.92**	*1.22*	*1.31*	*2.38*
August	3.94	2.73	4.70	**4.91**	**5.14**	**9.59**	**4.90**	*1.90*	3.01	*1.77*	*2.10*	*1.05*	*1.07*	3.56
September	3.65	2.44	4.36	**5.33**	*2.23*	*1.41*	3.74	**5.42**	4.04	2.79	*2.13*	**12.75**	**4.87**	*1.17*
October	2.88	1.77	3.48	*1.48*	2.34	**4.07**	2.16	*1.50*	3.08	2.78	1.98	**6.43**	2.28	3.08
November	1.75	1.00	2.13	*0.09*	1.33	2.02	*0.29*	1.49	*0.34*	**3.44**	*0.82*	*0.77*	*0.75*	NA
December	1.07	0.74	1.27	*0.19*	0.81	*0.67*	*0.50*	0.88	**1.96**	0.90	1.03	**2.21**	**1.52**	NA
Annual	28.60	*25.96*	**30.86**	**38.64**	28.78	**41.42**	*24.53*	*25.23*	*25.37*	**33.40**	*22.85*	**41.47**	*25.80*	*22.42*
Water Year					26.06	**39.14**	28.34	*24.31*	*23.86*	**31.66**	26.14	**35.89**	30.66	23.89

The only normal period available for Babbitt is 1961-1985, which is the basis of the data above.
All data is from Babbitt weather station except box shaded gray, which is from Embarrass weather station.
Bold = above the normal range
Italics = below the normal range
NA = not available on date of report

Table 4. Total fish catch[1].

Family	Genus	Species	Common Name	West Site				East Site			
				Total Catch	Minimum Total Length (mm)	Maximum Total Length (mm)	Average Total Weight (g)	Total Catch	Minimum Total Length (mm)	Maximum Total Length (mm)	Average Total Weight (g)
Catostomidae (sucker)	*Catostomus*	*commersonii*	white sucker	1	145	145	28.0	45	28	42	0.5
Cyprinidae (minnow)	*Hybognathus*	*hankinsoni*	brassy minnow	0	---	---	---	4	50	75	2.3
	Luxilus	*cornutus*	common shiner	0	30	30	0.5	185	27	100	0.5
	Phoxinus	*eos*	northern redbelly dace	6	30	49	0.3	1,478	33	59	0.9
	Pimephales	*promelas*	fathead minnow	0	---	---	---	14	50	74	3.1
	Rhinichthys	*atratulus*	blacknose dace	0	---	---	---	86	26	83	0.6
	Semotilus	*margarita*	pearl dace	0	---	---	---	18	51	80	2.9
Gasterosteidae (stickleback)	*Culaea*	*inconstans*	brook stickleback	12	25	38	0.3	12	26	40	0.3
Percidae (perch)	*Etheostoma*	*nigrum*	johnny darter	0	---	---	---	5	29	35	0.2
Total Individuals (abundance)[2]				19	---	---	---	1,847	---	---	---

[1]The fish were caught using a 1/4-inch seine and block net.

[2]The young of year was not included in the total abundance or indice calculations.

Table 5. Classification of the collected fish species.

Family	Genus	Species	Common Name	Classification[1]			
				Taxa	Trophic Level	Tolerance	Spawning Method
Catostomidae (sucker)	*Catostomus*	*commersonii*	white sucker	N	O	T	SL
Cyprinidae (minnow)	*Hybognathus*	*hankinsoni*	brassy minnow	N	---	---	---
	Luxilus	*cornutus*	common shiner	N	O	I	SL
	Phoxinus	*eos*	northern redbelly dace	N	H	T	SL
	Pimephales	*promelas*	fathead minnow	N	O	T	---
	Rhinichthys	*atratulus*	blacknose dace	N	G	I	SL
	Semotilus	*margarita*	pearl dace	N	I	---	SL
Gasterosteidae (stickleback)	*Culaea*	*inconstans*	brook stickleback	N	I	I	C
Percidae (perch)	*Etheostoma*	*nigrum*	johnny darter	N	I	I	C

[1]Taxa: (N) native or (E) exotic; Trophic Level: Generalist (G), Herbivore (H), Insectivore (I), Omnivore (O), Piscivore (P) or Top Carnivore (TC); Tolerance: Intolerant (I), Moderately Intolerant (M) or Tolerant (T); Spawning Method: Parental Care (C), Simple Miscellaneous (M) or Simple Lithophil (SL).

Table 6. Fish diversity measures.

Parameter	West Site	East Site
Abundance	19	1847
Richness	3	9
Shannon-Wiener Diversity Index (H´)	0.81	0.79
Evenness (E)	0.74	0.36

Table 7. Summary of macroinvertebrate data.

Taxa Phylum	Class	Order	Family	Genus/species	Site Equipment Substrate	West Ponar[1] Sediment	West D-net Emergent vegetation	West D-net Undercut banks	West D-net Woody debris	West TOTAL	East Ponar[1] Sediment	East D-net Emergent vegetation	East D-net Undercut banks	East D-net Woody debris	East TOTAL
Arthropoda	Insecta	Coleoptera	Elmidae	Dubiraphia							8			2	10
			Gyrinidae	Gyrinus (adults)								4	4		8
			Haliplidae	Haliplus			2			2				2	2
			Hydrophilidae	Tropisternus (adults)				1		1		8	16		24
		Diptera	Chironomidae												
			Subfamily: Chironominae	Chironomus		4				4	76				76
			Tribe: Chironomini	Cladopelma		56				56					
				Cryptochironomus							4				4
				Dicrotendipes		8	26	20	124	178	4			2	6
				Einfeldia		16				16					
				Endochironomus								4			4
				Glyptotendipes					2	2					
				Microtendipes		8		8	32	48	84		32	42	158
				Stenochironomus					20	20				26	26
				Tribelos		1			4	5	40				40
				Undetermined Chironomini							4				4
			Subfamily: Chironominae	Micropsectra				2	2	4					
			Tribe: Tanytarsini	Tanytarsus		8	2		2	12		4		4	8
				Undetermined Tanytarsini		4				4					
			Subfamily: Tanypodinae	Krenopelopia							4				4
			Tribe: Pentaneurini	Thienemannimyia group			28		8	36		12	52	14	78
				Paramerina undetermined		48				48			8		8
			Subfamily: Orthocladiinae	Brillia								4			4
				Cricotopus			6		8	14		12			12
				Nanocladius								4			4
				Orthocladius					4	4				12	12
				Parametriocnemus				2		2					
				Psectrocladius			2			2				2	2
				Thienemanniella					2	2					
				Xylotopus										8	8
				Undetermined Orthocladiinae				2		2					
			Dixidae	Dixella				8		8					
			Ceratopogonidae	Bezzia/Palpomyia					2	2					
				Undetermined										2	2
		Ephemeroptera	Baetidae	Baetis			2			2				2	2
			Caenidae	Caenis					4	4	16			10	26
			Leptophlebiidae	Leptophlebia			4	4	4	12			12		12
				Paraleptophlebia										4	4
		Hemiptera	Belostomatidae	Belostoma								2	5		7
			Corixidae	Hesperocorixa				2		2					
				Sigara			2			2		32			32
			Nepidae	Ranatra			4	2		6					
		Odonata	Aeshnidae	Undetermined			2			2					
			Coenagrionidae	Undetermined immatures				2		2					
				Ishnura			2			2					
			Corduliidae	Somatochlora											
				Epitheca							1				1

Taxa Phylum	Class	Order	Family	Genus/species	Site Equipment Substrate	West Ponar[1] Sediment	West D-net Emergent vegetation	West D-net Undercut banks	West D-net Woody debris	West TOTAL	East Ponar[1] Sediment	East D-net Emergent vegetation	East D-net Undercut banks	East D-net Woody debris	East TOTAL
		Megaloptera	Sialidae	Sialis							8				8
		Trichoptera	Undetermined Trichoptera Larvae					2		2					
			Hydropsychidae	Cheumatopsyche (larvae)					2	2				2	2
			Hydroptilidae	Hydroptila										12	12
				Undetermined pupae										2	2
			Leptoceridae	Undetermined larvae										2	2
			Limnephilidae	Limnephilus			22	66		88		8	20		28
				Nemotaulius			16	6	1	23			4		4
				Hydatophylax								24	32		56
			Molannidae	Molanna (empty case only)										1	1
			Phryganeidae	Ptilostomis			2			2				1	1
			Polycentropodidae	Nyctiophylax								4		36	40
				Polycentropus									4		4
				Undetermined							2				2
			Psychomyiidae	Lype										2	2
	Crustacea	Amphipoda	Talitridae	Hyalella			10	24	10	44		20	108	4	132
Annelida	**Subclass**: Hirudinaea	Undetermined Hirudinea												3	3
		Rhynchobdellida	Glossiphoniidae	Glossiphonia			1			1					
				Placobdella				1		1					
	Subclass: Oligochaeta	Undetermined oligochaeta									4	8	8	2	22
Entoprocta	----	Urnatellida	Urnatellidae	Urnatella gracilis					masses						
Nematomorpha	Undetermined							2		2					
Mollusca	Gastropoda	Undetermined Gastropoda					1			1					
		Basommatophora	Ancylidae	Ferrissia			2		10	12					
			Planorbidae	Gyraulus					2	2					
				Helisoma			14	1		15		1		2	3
			Physidae	Physa			1	2		3					
			Lymnaeidae	Bulimnaea			2			2					
				Stagnicola				2		2					
	Bivalvia	Veneroida	Psidiidae	Pisidium				2		2					
Total Specimens										710					912

[1]Two samples were collected and composited using a petite ponar dredge (0.023 m^2).

Table 8. Number of macroinvertebrate classes, orders and families at each site.

Taxa	West	East
Class	5	3
Order	7	5
Family	11	10
Genus	27	26
Total Organisms	710	912

Table 9. Percentage of macroinvertebrate classes collected at each site.

Class	West	East
Insecta	87.7%	82.5%
Crustacea	6.2%	14.5%
Annelida	0.3%	2.7%
Entoprocta	n/a	0.0%
Nematomorpha	0.3%	0.0%
Mollusca	5.5%	0.3%

Table 10. Percentage of macroinvertebrate orders collected at each site.

Order	West	East
Coleoptera	0.4%	4.8%
Diptera	66.1%	50.4%
Ephemeroptera	2.5%	4.8%
Hemiptera	1.4%	4.3%
Odonata	0.8%	0.1%
Megaloptera	0.0%	0.9%
Trichoptera	16.5%	17.1%
Amphipoda	6.2%	14.5%
Subclass: Hirudinaea	0.3%	0.3%
Subclass: Oligochaeta	0.0%	2.4%
Urnatellida	masses	0.0%
Phylum Nematomorpha	0.3%	0.0%
unknown Gastropoda	0.1%	0.0%
Basommatophora	5.1%	0.3%
Veneroida	0.3%	0.0%

Table 11. Macroinvertebrate diversity measures.

Diversity Measure	West	East
% Ephemeroptera, Plecoptera and Trichoptera (%EPT)	19.0%	21.9%
% EPT and Odonata (%EPTO)	19.9%	22.0%
% Insects	87.7%	82.5%
% Non-insects	12.3%	17.5%
Shannon-Wiener Diversity Index (H´)	2.81	2.98
Evenness (E)	0.73	0.78
HBI Score	6.43	6.02
HBI Value[1]	Fair	Fair

[1]The value was determined using Table 11 in this report.

Table 12. HBI values for streams.

HBI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Possible slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

Table 13. HBI values for each strean site.

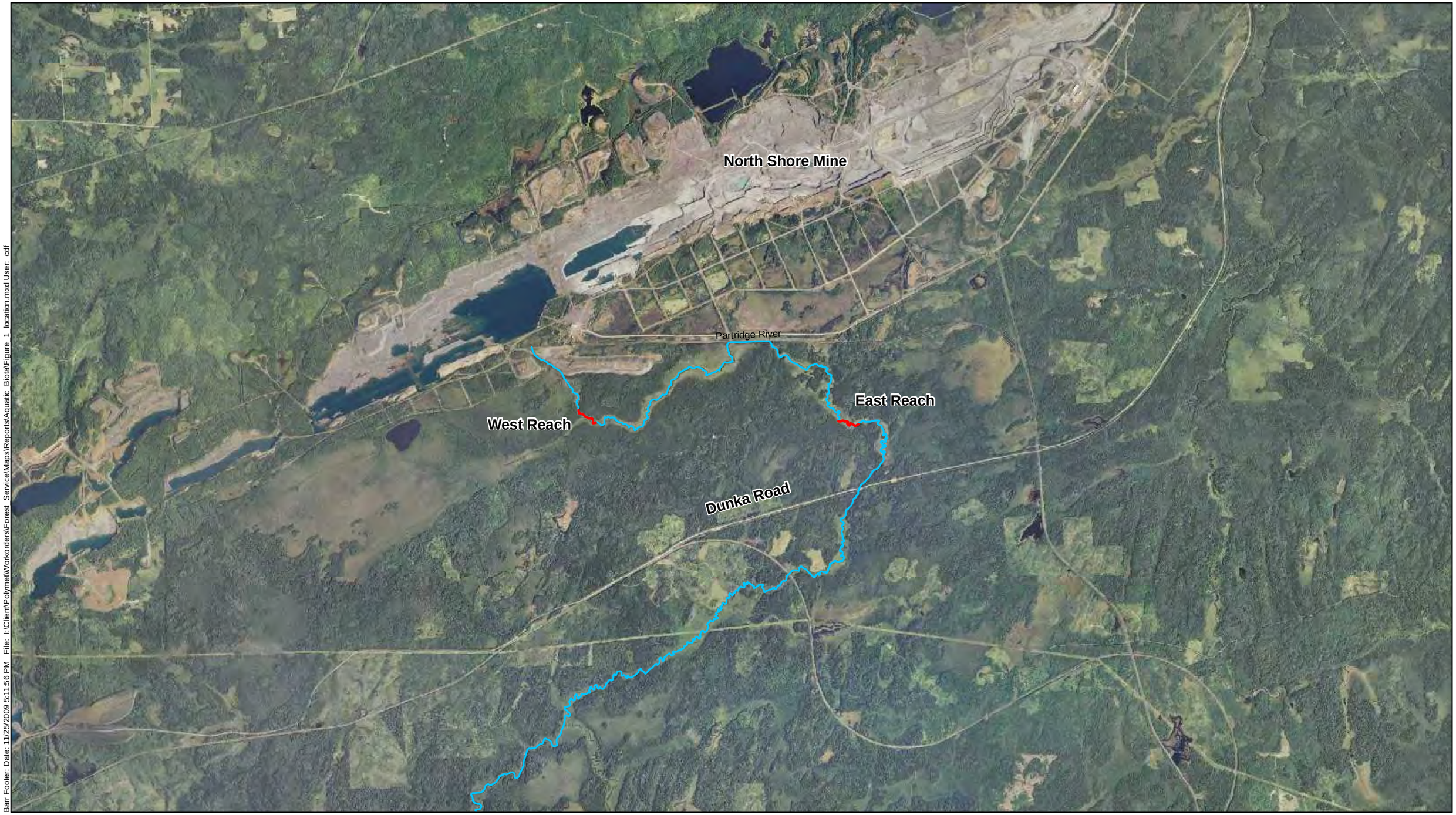
				YEAR	West Sit			East Site		
				Tolerance Values	September 2009			September 2009		
Taxa				HBI (10-0)	# Specimens	# Specimens w/ HBI Tolerance Values	HBI Sum	# Specimens	# Specimens with HBI Tolerance Values	HBI Sum
INSECTA										
	Coleoptera									
		Elmidae		4						
			Dubiraphia	6				10	10	60
		Gyrinidae								
			Gyrinus	4				8	8	32
		Haliplidae		5						
			Haliplus	5	2	2	10	2	2	10
		Scirtidae								
			Scirtes							
		Hydrophilidae		5						
			Tropisternus	5	1	1	5	24	24	120
	Diptera									
		Subfamily: Chironominae Tribe: Chironomini	undetermined	6				4	4	24
			Cryptochironomus	8				4	4	32
			Chironomus	10	4	4	40	76	76	760
			Cladopelma	9	56	56	504			
			Glyptotendipes	10	2	2	20			
			Dicrotendipes	8	178	178	1424	6	6	48
			Einfeldia	9	16	16	144			
			Microtendipes	6	48	48	288	158	158	948
			Stenochironomus	5	20	20	100	26	26	130
			Endochironomus	10				4	4	40
			Tribelos	5	5	5	25	40	40	200
		Subfamily: Chironominae Tribe: Tanytarsini	Undetermined	na	4					
			Micropsectra	7	4	4	28			
			Tanytarsus	6	12	12	72	8	8	48
		Subfamily: Orthocladiinae	Undetermined	6	2	2	12			
			Brillia	5				4	4	20
			Orthocladius	6	4	4	24	12	12	72
			Cricotopus	7	14	14	98	12	12	84
			Nanocladius	3				4	4	12
			Parametriocnemus	5	2	2	10			
			Psectrocladius	8	2	2	16	2	2	16
			Thienemanniella	6	2	2	12			
			Xylotopus	2				8	8	16

				YEAR	West Sit			East Site		
				Tolerance Values	September 2009			September 2009		
Taxa				HBI (10-0)	# Specimens	# Specimens w/ HBI Tolerance Values	HBI Sum	# Specimens	# Specimens with HBI Tolerance Values	HBI Sum
		Subfamily: Tanypodinae Tribe: Tanypodiinae								
			Paramerina	6	48	48	288	8	8	48
			Krenopelopia	4				4	4	16
			Thienemannimyia group	6	36	36	216	78	78	468
		Dixidae								
			Dixella	1	8	8	8			
		Ceratopogonidae								
			Undetermined	na				2		
			Bezzia	6	2	2	12			
	Ephemeroptera									
		Baetidae								
			Baetis	4	2	2	8	2	2	8
		Caenidae								
			Caenis (larvae)	7	4	4	28	26	26	182
		Leptophlebiidae								
			Leptophlebia	4	12	12	48	12	12	48
			Paraleptophlebia	1				4	4	4
	Hemiptera			8						
		Belostomatidae								
			Belostoma (adults)	8				7	7	56
		Corixidae								
			Sigara (adults)	3	2	2	6	32	32	96
			Hesperocorixa	5	2	2	10			
		Nepidia								
			Ranatra (adults)	na	6					
	Odonata									
		Aeshnidae	undetermined	3	2	2	6			
		Coenagrionidae	undetermined	9	2	2	18			
			Ischnura	9	2	2	18			
		Corduliidae								
			Somatochlora (nymph)	1						
			Epitheca	7				1	1	7
		Gomphidae	Gomphus	6						
	Megaloptera									
		Sialidae	Sialis	4				8	8	32
	Trichoptera		undetermined	na	2					
		Hydropsychidae								
			Cheumatopsyche (larvae)	5	2	2	10	2	2	10
		Hydroptilidae		4						

				YEAR	West Sit			East Site		
				Tolerance Values	September 2009			September 2009		
Taxa				HBI (10-0)	# Specimens	# Specimens w/ HBI Tolerance Values	HBI Sum	# Specimens	# Specimens with HBI Tolerance Values	HBI Sum
			Hydroptila	6				12	12	72
			Undetermined pupa	4				2	2	8
		Leptoceridae	undetermined	na				2		
		Limnephilidae								
			Limnephilus	3	88	88	264	28	28	84
			Nemotaulius	3	23	23	69	4	4	12
			Hydratophylax	2				56	56	112
		Molannidae	Molanna (empty case)	6				1	1	6
		Phryganeidae								
			Ptilostomis	5	2	2	10	1	1	5
		Polycentropodidae		6						
			Nyctiophylax	5				40	40	200
			Polycentropus	6				4	4	24
			Undetermined	6				2	2	12
		Psychomyiidae		2						
			Lype	2				2	2	4
CRUSTACEA										
		Talitridae		8						
			Hyalella	8	44	44	352	132	132	1056
ANNELIDA										
Subclass: Hirudinaea	**Rhynchobdellida**		undetermined leech	10				3	3	30
		Glossiphoniidae	Placobdella	10	1	1	10			
			Glossiphonia	10	1	1	10			
Subclass: Oligochaeta	**Oligochaeta**									
			Undetermined aquatic earthworm	8				22	22	176
MOLLUSCA	**Basommatophora**		undetermined	na	1					
		Ancylidae								
			Ferrisia	7	12	12	84			
			Lymnaea	7						
		Lymnaeidae								
			Bulimnaea	6	2	2	12			
			Stagnicola	6	2	2	12			
		Physidae		7						
			Physa	7	3	3	21			
		Planorbidae		6						
			Gyraulus	8	2	2	16			
			Helisoma	6	15	15	90	3	3	18
	Veneroida									
		Psidiidae		8						
			Pisidium	6	2	2	12			
Entoprocta										

				YEAR	West Sit			East Site		
				Tolerance Values	September 2009			September 2009		
Taxa				**HBI (10-0)**	**# Specimens**	**# Specimens w/ HBI Tolerance Values**	**HBI Sum**	**# Specimens**	**# Specimens with HBI Tolerance Values**	**HBI Sum**
	Urnatellida	Urnatellidae								
			Urnatella gracilis	na	2					
			Total Specimens		710	695		912	908	
			Index Value				**6.43**			**6.02**
			Water Quality				**Fair**			**Fair**

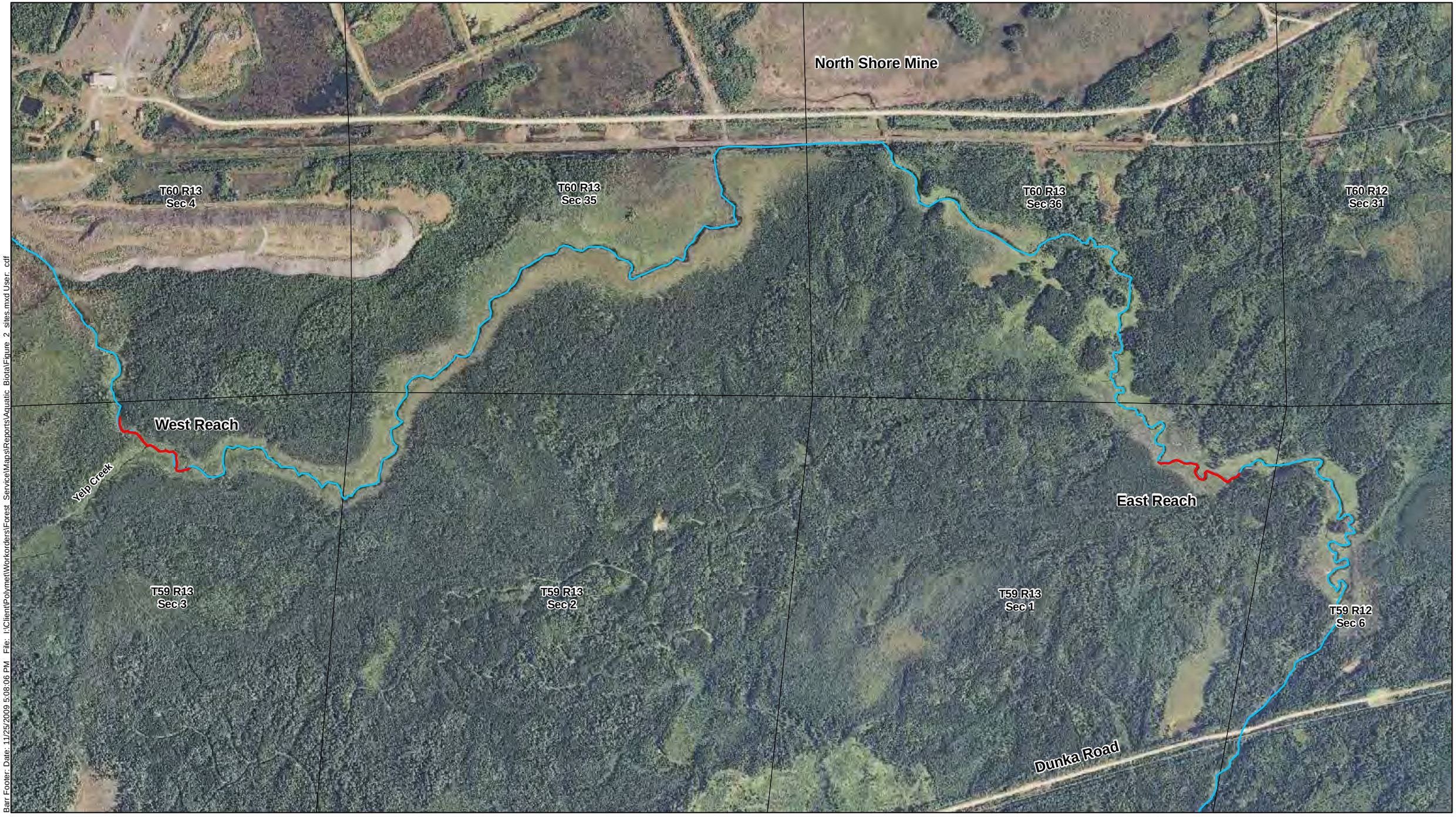
Figures



Partridge River
Reach Location

0 0.5 1 2 Miles

FIGURE 1
REACH LOCATIONS
Partridge River
St. Louis County, Minnesota



Partridge River
Reach Location

0 500 1,000 2,000 3,000
Feet

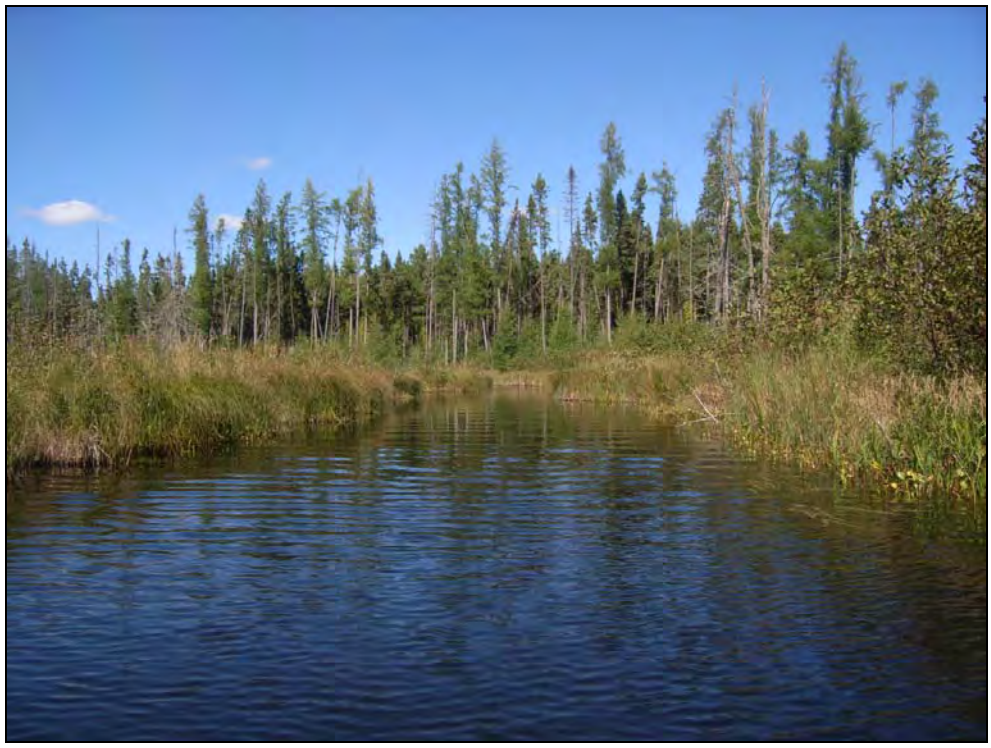
FIGURE 1
AQUATIC BIOTA SAMPLING SITES
Partridge River
St. Louis County, Minnesota

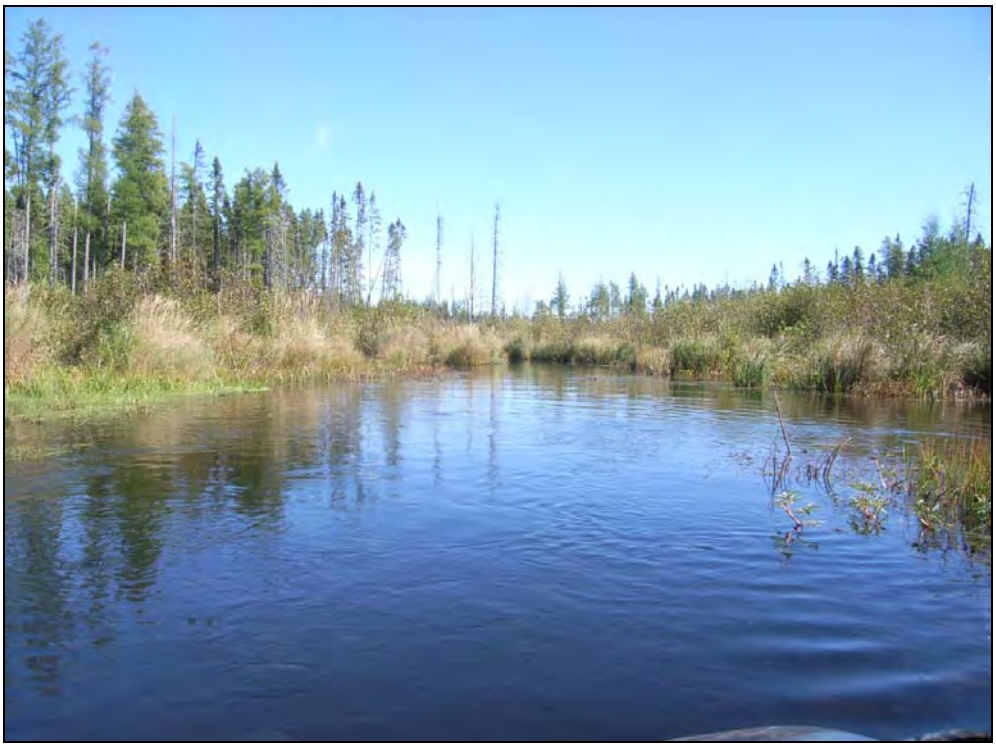
Barr Footer: Date: 11/25/2009 5:08:06 PM File: I:\Client\Polymet\Workorders\Forest Service\Maps\Reports\Aquatic Biota\Figure 2 sites.mxd User: cdf

Appendices

Appendix A

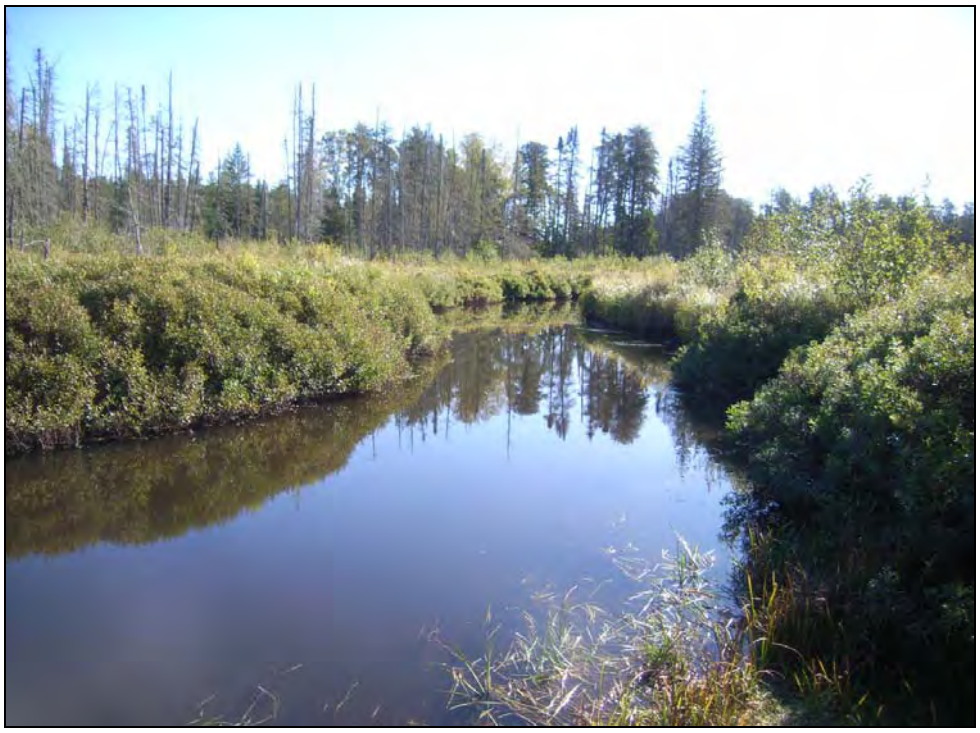
Photographs

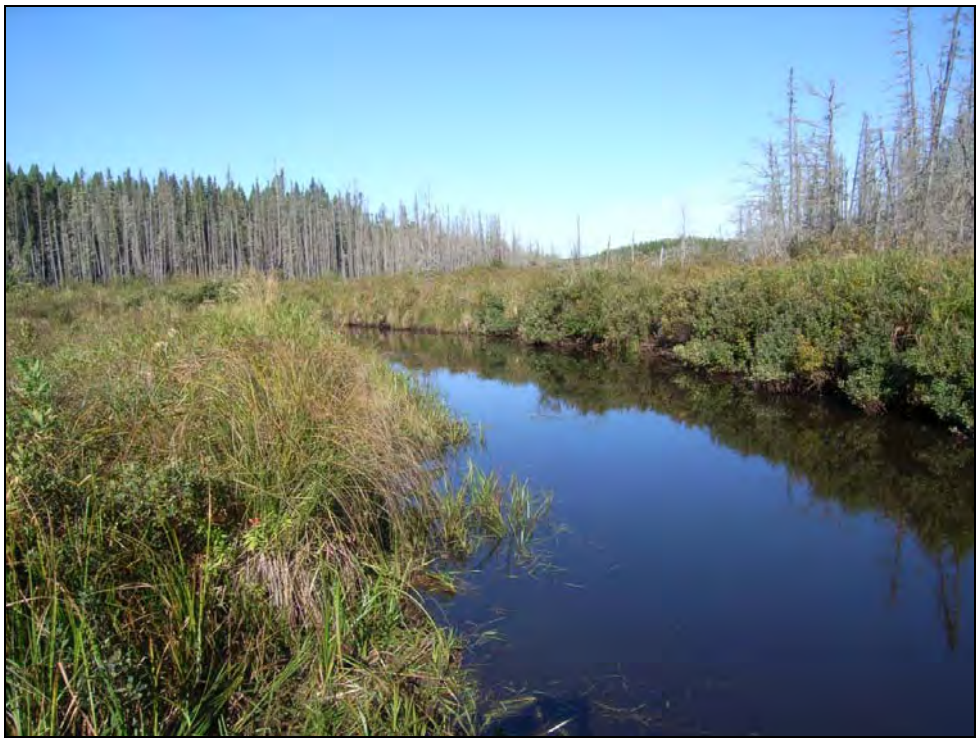




Top Photograph: Looking east
Bottom Photograph: Looking west

Figure A1
Partridge River – West Site
September 21, 2009
Aquatic Biota Survey
PolyMet Mining
St. Louis County, MN





Top Photograph: Looking east
Bottom Photograph: Looking west

Figure A2
Partridge River – East Site
September 21, 2009
Aquatic Biota Survey
PolyMet Mining
St. Louis County, MN

Appendix B

QHEI Habitat Assessment Worksheets

West Site

L/R looking downstream

9/21/2009

MPCA HABITAT ASSESSMENT WORKSHEET

Stream Partridge River Major watershed _____ Ecoregion _____ QHEI SCORE 40

County _____ Quad maps _____ Drainage area _____

Station ID _____ River mile _____ Lat/Long _____ Sec. _____ Twp. _____ Rng. _____

Reach # _____ Site location _____

Field crew PJH2 Date 9/19/05

70/30 more SS than EM

1. Surrounding Land Use (check the most predominant)

L = left bank R = right bank facing downstream

L	R			L	R		
X	X	Forest, Wetland, Prairie, Shrub	[5]	☐	☐	Residential/Park	[2]
☐	☐	Old Field	[3]	☐	☐	Urban/Industrial	[0]
☐	☐	Fenced Pasture	[2]	☐	☐	Open Pasture	[0]
☐	☐	Conservation Tillage, No Till	[2]	☐	☐	Row Crop	[0]

Land Use 5

2. Riparian Zone (check the most predominant)

A. Riparian Width

L	R			
X	X	Extensive	> 300'	[5]
☐	☐	Wide	150'-300'	[4]
☐	☐	Moderate	30'-150'	[3]
☐	☐	Narrow	15'-30'	[2]
☐	☐	Very Narrow	3'-15'	[1]
☐	☐	None		[0]

C. Bank Erosion

L	R			
X	X	None	0 - 5%	[5]
☐	☐	Little	5-25%	[4]
☐	☐	Moderate	25-50%	[3]
☐	☐	Heavy	50-75%	[1]
☐	☐	Severe	75-100%	[0]

E. Shade

☐	Heavy	>75%	[5]
☐	Substantial	50-75%	[4]
☐	Moderate	25-50%	[3]
X	Light	5-25%	[1]
☐	None		[0]

B. Riparian Cover (rank)

L	R		
1	☐	Trees	
2	X	Shrubs	1
3	X	Grasses/Forbs	2
☐	☐	Bare Soil	
☐	☐	Rock	

grasses on edge from Shrubs (alder) from blackspur swamp

D. Bank Cover (rank)

L	R		
2	X	Trees	2
1	X	Shrubs	1
☐	☐	Grasses/Forbs	
☐	☐	Bare Soil	
☐	☐	Rock	

F. Average Bank Height

L _____ ft.

R _____ ft.

Riparian 11

3. Instream Zone

A. Substrate (check two for each channel type)

	Boulder [10]	Cobble [9]	Gravel [8]	Sand [7]	Clay [5]	Bedrock [5]	Silt [2]	Muck [1]	Detritus [1]	Sludge [0]	Channel Type %
Pool	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Riffle	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Run	☐	☐	☐	☐	☐	☐	☐	X	X	☐	100%
Glide	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

B. Embeddedness

☐	None	[5]	
X	Light	[3]	
☐	Moderate	[1]	(1)
☐	Severe	[-1]	

D. Water Color

☐ Clear ☒ Stained

Turbid: ☒ Brown ☐ Green ☐ Other (specify)

C. Substrate Types

X	>4	[2]	
X	<=4	[0]	(0)

E. Clarity _____ ft.

☐ check if CTB

Substrate 3

F. Cover Type (check all that apply)

X	Undercut Banks	[1]	(1)
X	Overhanging Vegetation	[1]	
X	Deep Pools	[1]	
X	Logs or Woody Debris	[1]	
☐	Boulders	[1]	
☐	Rootwads	[1]	

X	Macrophtyes:	[1]	(1)
X	Emergent		
X	Floating Leaf		
☐	Submergent		

G. Cover Amount (check one)

☐	Extensive	>50%	[10]
☐	Moderate	25-50%	[7]
X	Sparse	5-25%	(3)
☐	Nearly Absent		[0]
☐	Choking Vegetation only		[-1]

Cover 7

4. Channel Morphology

A. Average Maximum Pool Depth

☐	> 4 feet	[6]
☐	2-4 feet	[4]
☐	1-2 feet	[1]
☐	< 1 ft. or no pool	[0]

NA

B. ~~Riffle~~/Run Depth

nonriffles NA

X	> 0.3 ft. max. >1.5 ft.	[6]
☐	> 0.3 ft. max. <1.5 ft.	[3]
☐	0.15 - 0.30 ft.	[1]
☐	< 0.15 ft.	[0]

C. Pool Width / Riffle Width

NA

☐	Pool Width > Riffle Width	[2]
☐	Pool Width = Riffle Width	[1]
☐	Pool Width < Riffle Width	[0]

D. Channel Stability

X	High	[6]
☐	Moderate	[3]
☐	Low	[0]

E. Sinuosity

☐	Excellent	>=4	[6]
☐	Good	2.6-3.9	[3]
X	Fair	1.4-2.5	(2)
☐	Poor	<=1.3	[0]

F. Channel Development

X	Good	[6]
☐	Fair	[3]
☐	Poor	[-1]

G. Velocity Types (check all that apply)

☐	Torrential	[-1]
☐	Fast	[-1]
☐	Moderate	[-1]
X	Slow	[-1]
X	Eddies	[-1]
☐	Interstitial	[-2]
☐	Intermittent	[-2]

H. Present Water Level

☐	Flood
X	High
X	Normal
☐	Low
☐	Interstitial

I. Reach Gradient

_____ ft./mi.

Channel Morphology 14

East Site

L/R - looking downstream

70

9/21/2009

MPCA HABITAT ASSESSMENT WORKSHEET

Stream Partridge River Major watershed _____ Ecoregion _____ QHEI SCORE 41

County _____ Quad maps _____ Drainage area _____

Station ID _____ River mile _____ Lat/Long _____ Sec _____ Twp _____ Rng _____

Reach # _____ Site location _____

Field crew PJH2 GDK KDM Date 9/19/05

1. Surrounding Land Use (check the most predominant) L = left bank R = right bank facing downstream

L	R			L	R		
X	X	Forest, Wetland, Prairie, Shrub	[5]	☐	☐	Residential/Park	[2]
☐	☐	Old Field	[3]	☐	☐	Urban/Industrial	[0]
☐	☐	Fenced Pasture	[2]	☐	☐	Open Pasture	[0]
☐	☐	Conservation Tillage, No Till	[2]	☐	☐	Row Crop	[0]

Land Use 5

2. Riparian Zone (check the most predominant)

A. Riparian Width

L	R			
☐	X	Extensive	> 300'	[5]
☐	☐	Wide	150'-300'	[4]
☐	☐	Moderate	30'-150'	[3]
☐	☐	Narrow	15'-30'	[2]
☐	☐	Very Narrow	3'-15'	[1]
☐	☐	None		[0]

C. Bank Erosion

L	R			
X	X	None	0 - 5%	[5]
☐	☐	Little	5-25%	[4]
☐	☐	Moderate	25-50%	[3]
☐	☐	Heavy	50-75%	[1]
☐	☐	Severe	75-100%	[0]

E. Shade

☐	Heavy	>75%	[5]
☐	Substantial	50-75%	[4]
☐	Moderate	25-50%	[3]
X	Light	5-25%	[2]
☐	None		[0]

on clay soils

B. Riparian Cover (rank)

L	R	
☐	☐	Trees
2 X	2 X	Shrubs
1 X	1 X	Grasses/Forbs

D. Bank Cover (rank)

L	R	
☐	☐	Trees
2 X	2 X	Shrubs
1 X	1 X	Grasses/Forbs
☐	☐	Bare Soil
☐	☐	Rock

F. Average Bank Height

L 5 ft.

R 0.3 ft.

Riparian 11

3. Instream Zone

A. Substrate (check two for each channel type)

	Boulder [10]	Cobble [9]	Gravel [8]	Sand [7]	Clay [5]	Bedrock [5]	Silt [2]	Muck [11]	Detritus [11]	Sludge [0]	Channel Type %
Pool	☐	☐	☐	☐	☐	☐	☐	X	☐	☐	0
Riffle	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Run	☐	☐	☐	☐	☐	☐	☐	X	X	☐	100
Glide	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

some fine sand in sample

B. Embeddedness

☐	None	[5]
X	Light	[3]
☐	Moderate	[1]
☐	Severe	[-1]

D. Water Color

☐ Clear X Stained → Turbid: X Brown, ☐ Green, ☐ Other (specify)

C. Substrate Types

☐	>4	[2]
X	<=4	[0]

E. Clarity _____ ft.

☐ check if CTB

Substrate 5

F. Cover Type (check all that apply)

X	Undercut Banks	[1]
X	Overhanging Vegetation	[1]
☐	Deep Pools	[1]
X	Logs or Woody Debris	[1]
☐	Boulders	[1]
☐	Rootwads	[1]

X Macrophtyes: [11]

X	Emergent	
☐	Floating Leaf	
☐	Submergent	

G. Cover Amount (check one)

☐	Extensive	>50%	[10]
☐	Moderate	25-50%	[7]
X	Sparse	5-25%	[3]
☐	Nearly Absent		[0]
☐	Choking Vegetation only		[-1]

Cover 7

4. Channel Morphology

A. Average Maximum Pool Depth

☐	> 4 feet	[6]
☐	2-4 feet	[4]
☐	1-2 feet	[1]
☐	< 1 ft. or no pool	[0]

NA no pools

B. ~~Riffle~~/Run Depth — no riffles

X	> 0.3 ft. max. >1.5 ft.	[3]
☐	> 0.3 ft. max. <1.5 ft.	[1]
☐	0.15 - 0.30 ft.	[1]
☐	< 0.15 ft.	[0]

C. Pool Width / Riffle Width NA

☐	Pool Width > Riffle Width	[2]
☐	Pool Width = Riffle Width	[1]
☐	Pool Width < Riffle Width	[0]

D. Channel Stability

X	High	[6]
☐	Moderate	[3]
☐	Low	[0]

E. Sinuosity straight

☐	Excellent	>=4	[6]
☐	Good	2.6-3.9	[3]
X	Fair	1.4-2.5	[2]
☐	Poor	<=1.3	[0]

F. Channel Development

X	Good	[6]
☐	Fair	[3]
☐	Poor	[-1]

G. Velocity Types (check all that apply)

☐	Torrential	[-1]
☐	Fast	[1]
☐	Moderate	[1]
X	Slow	[1]
☐	Eddies	[1]
☐	Interstitial	[-1]
☐	Intermittent	[-2]

H. Present Water Level

☐	Flood	
☐	High	
X	Normal	
☐	Low	
☐	Interstitial	

I. Reach Gradient _____ ft./mi.

Channel Morphology 13