Beneficial Use Impairment Investigation for Eighteenmile Creek Niagara County, New York

April 2009

Prepared for:
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List of Abbreviations and Acronyms

AOC	area of concern
BUI	Beneficial Use Impairment
CPUE	catch per unit effort
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GIS	Geographic Information System
GLNPO	Great Lakes National Program Office
HQ	hazard quotient
IJC	International Joint Commission
LOAEL	lowest observed adverse effect level
µg/kg	micrograms per kilogram
mg/kg	milligrams per kilogram
MMP	Marsh Monitoring Program
NCSWCD	Niagara County Soil and Water Conservation District
ng/kg	nanograms per kilogram
NOAEL	no observed adverse effect level
NYSDEC	New York State Department of Environmental Conservation
PCBs	polychlorinated biphenyls
PMA	pigmented macrophage aggregate
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAC	Remedial Action Committee
RAP	Remedial Action Plan
RI	remedial investigation
ROD	Record of Decision

List of Abbreviations and Acronyms (cont.)

SPDES	State Pollutant Elimination System
SRI	supplemental remedial investigation
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF	toxic equivalence factor
TEQ	toxic equivalent
TOC	total organic carbon
USACE	U.S. Army Corps of Engineers

Executive Summary

Three potential Beneficial Use Impairments (BUIs) at Eighteenmile Creek, a Great Lakes Area of Concern (AOC), were evaluated as part of the current investigation:

1. Existence of fish tumors and other deformities;

2. Status of fish and wildlife populations; and

3. Status of bird or mammal deformities or reproductive impairment.

To determine whether Eighteenmile Creek is impaired in regard to these BUIs, a wide range of data was collected from Eighteenmile Creek and a similar background stream, Oak Orchard Creek, and the data from the two creeks were compared. Both creeks are tributaries of Lake Ontario, are of similar size and surrounding geography, and are subject to water level fluctuations due to changes in lake water levels . In addition, each creek has a hydro-electric dam located some distance from their confluences with the lake. Oak Orchard Creek is not listed as an AOC and was recommended as a suitable reference location by the New York State Department of Environmental Conservation.

Between May and September 2007, the following types of data were collected from both creeks for the BUI evaluation: (1) fish diversity, abundance, and condition; (2) wildlife (birds, mammals, amphibians) diversity and abundance; (3) concentrations of polychlorinated biphenyl (PCB) and dioxins/furans in brown bullheads; and (4) prevalence of external, internal, and liver tumors in brown bullheads.

The status of the first BUI was previously listed as unknown. It has been recently recommended that the delisting criteria for this BUI should be based on bullhead liver tumors because they are reliably associated with contaminant exposure, principally polycyclic aromatic hydrocarbons (PAH) exposure. No impairment was evident at Eighteenmile Creek compared with Oak Orchard Creek with regard to liver tumors in the brown bullhead. This result suggests that Eighteenmile Creek may be delisted for the fish tumor and other deformities BUI.. This result is not surprising given that the principal contaminants in Eighteenmile Creek are polychlorinated biphenyls (PCBs), not PAHs.

The status of the second BUI also was previously listed as unknown. The data collected for this investigation suggest that bird and amphibian populations at Eighteenmile Creek are not impaired, but that fish and mammal populations likely are. The possible impairment of fish and mammal populations results from high levels of PCBs in fish. Whole-body concentrations of PCBs in brown bullheads collected from Eighteenmile Creek were: (1) 10 times greater than in bullheads collected from Oak Orchard Creek; (2) often exceeded critical PCB tissue concentrations for effects on fish; and (3) great enough to possibly affect reproduction of fish-eating mammals. Impaired reproduction can affect population size.

The principal Aroclor detected in the bullhead samples collected for this investigation was 1248, which was also the principal Aroclor found in sediment in lower Eighteenmile Creek by USACE (2004) and one of the principal Aroclors found in sediment in upper Eighteenmile Creek near Lockport (Ecology and Environment 2007). Although sediments need to be investigated more completely within the system, this information suggests that fish in Eighteenmile Creek are accumulating the principal Aroclor present in the system.

The status of the third BUI was previously considered to be likely. The present evaluation confirms this suspicion. Specifically, the present evaluation found that PCB levels in fish from Eighteenmile Creek may be great enough to adversely affect reproduction of fish-eating mammals. Fish-eating birds do not appear to be at risk due largely to their lower sensitivity to PCBs compared with mammals.

Lastly, although it was not a stated objective to evaluate the fish consumption BUI currently in force for the Eighteenmile Creek AOC, the bullhead PCB data collected for this investigation can be used to address this issue. Of note, total PCB levels in bullheads from Eighteenmile Creek greatly exceed EPA risk-based concentrations for fish consumption for both cancer and non-cancer health effects.

Overall, the Eighteenmile Creek BUIs investigated in this study are linked to PCB contamination, as evidenced by the high PCB levels found in fish in this study and in sediment samples collected for other investigations. The reduction or elimination of BUIs at Eighteenmile Creek hinges upon the identification and control of the sources of this contamination. There are known PCB source areas in Lockport, New York. Secondary source areas may exist in areas downstream from Lockport, such as in sediment behind Burt Dam. Other primary and secondary source areas may exist. It is recommended that future resources be devoted to understanding the sources, transport, and fate of PCBs in the Eighteenmile Creek watershed and how these factors affect PCB levels in sediment and fish in the lower reaches of the creek. This information will allow remedial actions to focus in those locations that will provide the greatest benefit to the Eighteenmile Creek watershed in general and the Eighteenmile Creek AOC in particular.

1 Introduction

This report was prepared by Ecology and Environment, Inc. (E & E) for the Niagara County Soil and Water Conservation District (NCSWCD) in support of the Beneficial Use Impairment (BUI) Assessment for Eighteenmile Creek, located in Niagara County, New York. Funding for this study was provided by the U.S. Environmental Protection Agency (EPA) Region 2.

A project-specific QAPP was prepared in accordance with *United States Environmental Protection Agency (EPA) Requirements for Quality Assurance Project Plans* (EPA 2001) and EPA Region 2 *Guidance for the Development of QAPPs for Environmental Monitoring Projects* (EPA 2004). The QAPP also incorporates New York State Department of Environmental Conservation (NYSDEC) requirements. The draft QAPP was submitted to EPA Region 2 for review in February 2007 and was finalized in May 2007. The QAPP summarizes the policies, organization, objectives, functional activities, and specific quality assurance/quality control (QA/QC) procedures employed by E & E to ensure that all technical data generated for the Eighteenmile Creek BUI Assessment are accurate, representative, and ultimately capable of withstanding judicial scrutiny. A complete copy of the final QAPP is presented as Appendix A.

The Eighteenmile Creek Remedial Action Plan (RAP) was prepared by NYSDEC and the Eighteenmile Creek Remedial Action Committee (RAC) in 1997. The RAP was prepared in response to a recommendation by the Water Quality Board of the International Joint Commission (IJC) that RAPs be prepared for the 43 Areas of Concern (AOCs) identified within the Great Lakes basin, including the Eighteenmile Creek AOC.

The NCSWCD acts as the Eighteenmile Creek RAP Coordinator, having assumed management of the RAP in 2005 with funding support from the EPA's Great Lakes National Program Office (GLNPO). The NCSWCD has been involved in re-invigorating investigative and remedial activities and public education/outreach activities within communities affected by the Eighteenmile Creek AOC.

The NCSWCD has developed this project to assist in determining the status of one "likely" and two "unknown" beneficial uses and to continue progress towards the delisting of Eighteenmile Creek as an AOC.

The three BUIs included in this investigation are:

- Existence of fish tumors and other deformities (status unknown);
- Status of fish and wildlife populations (status unknown); and
- Status of bird or mammal deformities or reproductive impairment (status likely).

1.1 Background: Designation of Eighteenmile Creek as a Great Lakes Area of Concern and Contamination Profile

Persistent environmental contamination in the Great Lakes basin resulted from 19th and 20th century industrial development combined with inadequate environmental regulations and enforcement into the latter part of the 20th century. However, as the importance of biological, social, and economic benefits of functioning and healthy ecosystems became more apparent, the contamination in the Great Lakes basin raised concerns regarding human health and the sustainability and integrity of ecosystems and wildlife populations within the basin. As a result, in 1987 the IJC identified 43 AOCs in the Great Lakes basin where the beneficial uses of the water were considered impaired. A portion of Eighteenmile Creek basin was identified as one of the 29 AOCs wholly within the United States.

Eighteenmile Creek flows generally north through central Niagara County and discharges via Olcott Harbor into Lake Ontario, approximately 18 miles east of the mouth of the Niagara River. The AOC includes Olcott Harbor and extends upstream to the farthest point at which backwater conditions exist during Lake Ontario's highest monthly average lake level (see Figure 1-1). This point is located just downstream of Burt Dam, approximately 2 miles south of Olcott Harbor. This portion of the watershed, a unique gorge habitat created during the last glaciation of the region, attracts recreational boaters, anglers, birders, and waterfowl hunters.

As originally identified, only a small portion of the Eighteenmile Creek basin was designated an AOC by the IJC. However, sediment contamination in areas upstream of the AOC has impacted residential properties adjacent to the creek. Eighteenmile Creek is surrounded by six residential townships, and many citizens own property along the creek, from its headwaters in the town of Lockport downstream to its discharge to Lake Ontario.

The NCSWCD, with assistance from the U.S. Army Corps of Engineers (USACE), Buffalo District, recently completed the *Eighteenmile Creek State of the Basin Report* (E & E 2007). That document provides information to initiate an assessment of the basin's ecological resources in a context that quantifies biological, social, and economic benefits. The *State of the Basin Report* also identifies AOC priority projects as provided by the RAP Coordinator and the RAC, including sediment investigations for the entire length of the creek above the AOC.

Industrial and municipal discharge practices, pesticides, and waste disposal resulted in poor water quality and sediment contamination in Eighteenmile Creek (NYSDEC 1997). Five substances or classes of substances were identified as occurring in creek sediments that could have detrimental and disruptive effects on the natural systems within the AOC and Lake Ontario and are the causes of the listed BUIs (see below). These contaminants include but are not limited to:

- Polychlorinated biphenyls (PCBs)
- Mercury
- Dioxins and furans
- Dieldrin
- Mirex
- dichloro-diphenyl-trichloroethane (DDT)
- Lead
- Copper

Sediments contaminated with these substances have contributed to restrictions on fish and wildlife consumption, degradation of benthic organisms, and restrictions on dredging activities in the AOC. It also is suspected that the contaminated sediments may adversely affect fish and wildlife populations, increase the frequency of fish tumors, and increase the prevalence of deformities and reproductive problems in birds and animals.

Since the Eighteenmile Creek RAP process began , the AOC has been considered the impact area and the upper watershed as the source area (NYSDEC 1997). With the exception of potential impacts from agricultural operations (e.g., agricultural runoff containing pesticides or fertilizers, sedimentation, etc.) adjacent to the current AOC boundary, there are no documented sources or source areas of contamination within the AOC. Recent investigations conducted by E & E (2008) and NYSDEC (2006) suggest that contaminants may be entering the AOC from upstream areas. Both investigations found elevated levels of PCBs, copper, lead, and other metals in creek sediment and bank fill in Lockport, New York, indicating that contaminant sources exist in this upstream area. Other source areas along the creek between Lockport and the AOC may exist. The upstream portion of the Eighteenmile Creek watershed may be investigated in the near future with funding from GLNPO and/or other sources.

For this investigation, fish from Eighteenmile and Oak Orchard creeks were analyzed for PCBs and dioxins/furans, not all eight contaminants listed above. Only these two chemical groups were evaluated for the following reasons:

- Findings of a USACE bioaccumulation study indicated that there is ongoing transfer of PCBs from the sediments through the food web , higher-than-normal bioavailability of PCBs in certain areas of the creek, and dioxin/furan contamination in creek sediments, suggesting a bioaccumulation risk (see summary below for USACE 2008);

- A fish consumption advisory for Eighteenmile Creek has been imposed due to PCB contamination; and

- Funding limited the number of constituents that could be analyzed.

1.2 Extent and Sources of Contamination

Ongoing and recently completed investigations by NCSWCD and NYSDEC continue to evaluate source identification issues and the extent of sediment contamination in Eighteenmile Creek. These investigations have determined that PCBs contaminate the sediments of Eighteenmile Creek from its upper reaches in the Lockport area downstream to the portion of the creek identified as the AOC. Significant findings of these investigations include the following:

- A surface sediment sample collected in the 1994 Olcott Harbor Sediment Sampling from the AOC contained PCBs at a concentration greater than the NYSDEC guidance for screening of contaminated sediments (NYSDEC 1999);

- Ten of 15 fish flesh samples obtained from the creek contained PCBs at levels above the Food and Drug Administration's action level of 2.0 milligrams per kilogram (mg/kg); and

- A surface sediment sample collected by NYSDEC in 2005 in Lockport (at the Flintkote site) contained PCBs at a concentration of 49 mg/kg (NYSDEC 2006).

The presence of contaminated sediments in the creek's upper portions in Lockport and below Burt Dam in Olcott suggests that contaminated sediments are continuing to migrate downstream. Contaminated sediments in the upper portions of the creek will continue to move downstream and negatively impact areas within lower reaches of the stream. Consequently, it is suspected that there are pockets of contaminated sediment between Lockport and the Burt Dam.

Questions regarding the specific sources of continuing contamination and their locations persist. The sources and potential sources of PCBs in Eighteenmile Creek have been identified as industrial and municipal wastewater discharges, combined sewer overflows, inactive hazardous waste sites, the New York Barge Canal discharge, contaminated sediments already present in the creek, and an unknown source between Olcott Street and North Transit Road in Lockport. These sources are contributing to the occurrence and persistence of contaminants (listed

above) in the environment. It is suspected that DDT, dieldrin, PCBs, and dioxins likely contribute to bird and animal deformities and reproductive problems; PCBs and dioxins contribute to restrictions on fish and wildlife consumption; PCBs and metals contribute to degradation of benthos; and dioxin and metals contribute to dredging restrictions. Recent sampling investigations indicated that sediment contamination occurs well above Burt Dam in Lockport (EEEPC 2007a; E & E 2007b; NYSDEC 2006). Additional studies will be needed to locate the point and non-point sources of contamination and the extent of contamination below Lockport to Burt Dam and below. The USACE, Buffalo District, has prepared a Draft Sediment Investigation Upstream of the Eighteenmile Creek AOC (this plan is unpublished but shown as a draft in the Eighteenmile Creek State of the Basin Report, Appendix A; E & E 2007). Given the ongoing investigations by NYSDEC and NYSDOH near the Flintkote Plant, the USACE draft plan focuses on an approach for sampling sediments at various locations upstream of Burt Dam.

Extensive progress has been made for reducing the inflows of contaminants into the creek by monitoring discharges and updating State Pollutant Elimination System (SPDES) permits for industrial and municipal wastewater dischargers and delisting inactive hazardous waste sites.

Recent Sediment Investigations within the Watershed

NCSWCD conducted a study in 2006 to further evaluate the extent of PCB contamination in sediments in Eighteenmile Creek. Surface grab and core samples were collected between Harwood Street and Stone Road, covering approximately 8,000 feet of creek (approximately 2,000 feet of creek where it flows down through the Niagara Escarpment was not sampled due to high gradients, high flow velocities, and absence of sediments). First, grab samples were collected throughout the study area for the purposes of PCB screening. A total of 80 samples and three duplicates were collected. Concentrations ranged from 59 µg/kg to 4,300 µg/kg; the concentrations in 29 samples were non-detect. A comparison of PCB screening results to PCB confirmation samples at other sites indicate the screening results need to be corrected by a factor of 6.5 to be comparable to the confirmation results. Twelve cores were then collected in areas for PCB confirmation. Three samples were collected at various depths. The concentrations in the core samples ranged from 12 µg/kg to 6,900 µg/kg; the concentrations in six samples were non-detect.

The PCB results strongly suggest that PCBs are present in all areas of Eighteenmile Creek. The core sample results show a general decrease in concentration with depth; however, they also indicate that the sediment profile is entirely contaminated with PCBs and only the native material in the creek bed is free of PCB contamination. The positive PCB results were corrected for an average total organic carbon (TOC) concentration and compared to NYSDEC criteria; most of the positive PCB results exceeded the PCB screening criteria. The results show a relatively uniform concentration of PCBs except at areas close to the Flintkote property and in the area near the intersection of Old Niagara and Plank Road. The

results indicate the potential for an additional source of PCBs in an area north of the Lockport wastewater treatment plant.

The surface samples from all 12 cores were also analyzed for selected metals, and the results were compared to NYSDEC TAGM 4046 standards. All metal concentrations were near or exceeded TAGM criteria and were relatively uniform throughout the study area. The results indicate that metals continue to be a source of concern in the creek and that work should be conducted to evaluate Eighteenmile Creek results relative to background concentrations in other areas.

In addition to the NCSWCD investigation, NYSDEC has been evaluating contamination and source issues in the Eighteenmile Creek Corridor (Site No. 932121), located between the New York State Barge Canal and Harwood Street in the City of Lockport, Niagara County, New York. A remedial investigation (RI) of the Eighteenmile Creek Corridor Site was completed in the fall of 2005 (NYSDEC 2006). During the RI, elevated concentrations of PCBs and metals (i.e., arsenic, chromium, copper, lead, and zinc) were found in sediment samples from Eighteenmile Creek and the millrace adjacent to the former Flintkote plant site. In addition, contaminated sediment was found in the New York State Barge Canal upstream of Eighteenmile Creek. PCBs, arsenic, chromium, copper, lead, and zinc levels detected in the fill at Upson Park, the White Transportation property, the former United Paperboard Company property, and the former Flintkote plant site may potentially adversely impact Eighteenmile Creek. A Record of Decision (ROD) for the former Flintkote plant site was issued in March 2006 (NYSDEC 2006). However, the other potential source areas were not fully investigated, and a supplemental remedial investigation (SRI)/feasibility study (FS) was begun in the spring of 2007. Additional sediment, surface and subsurface soil, and groundwater samples were collected from Eighteenmile Creek, the New York State Barge Canal, and other potential source areas, including Upson Park, located at 100 Clinton Street; United Paperboard Company, located at 62-70 Mill Street; and White Transportation, located at 30-40 Mill Street.

The SRI activities included analysis of sediment, surface soil, subsurface soil, and groundwater for a wide range of contaminants. PCBs, lead, copper, and other metals were found in the sediment and soil samples at concentrations much greater than risk-based screening levels. Elevated PCB concentrations appeared to coincide with the presence of historic fills. Based on the preliminary conceptual site model and evaluation of possible exposure pathways , further evaluation of potential risks to human and ecological receptors was deemed necessary. In addition, a field investigation was conducted in fall 2008 to estimate the contribution, if any, of PCBs and lead from the New York State Barge Canal to the creek. The results for these investigations will be provided in the final SRI report, which is expected in 2009.

Bioaccumulation Study within the AOC

The USACE, Buffalo District, analyzed sediment samples collected from Eighteenmile Creek in the reach that extends from Burt Dam to just upstream of the

creek mouth. Surface sediment samples were analyzed for heavy metals, chlorinated pesticides, PCBs, and dioxins/furans. In addition, composited sediment samples were exposed to the aquatic oligochaete *Lumbriculus variegates* for 28 days to quantify the bioaccumulation of chlorinated pesticides, PCBs, and heavy metals (USACE 2008). A report interpreting the results of this investigation indicated that there is an ongoing transfer of PCBs and DDE (a metabolite of DDT) from the sediments through the food web, between benthic invertebrates and their predators (USACE 2008). The bioaccumulation experiments also evidenced a higher than normal bioavailability of DDE and PCBs in certain areas of the creek. In addition, dioxin/furan contamination in the creek sediments suggested a bioaccumulation risk, and various heavy metal concentrations in the sediment appeared to exert chronic toxicity. PCB levels in the Eighteenmile Creek sediment samples were significantly higher than the concentrations in any other tributaries to Lake Ontario, including the Black River, Salmon River, Oswego River, and Genesee River.

1.3 Project Purpose

The purpose of this investigation is to initiate evaluation of contamination within portions of the Eighteenmile Creek AOC ecosystem by examining the status of three BUIs, for which little information has been previously developed. Similar field investigations and sampling have occurred within specific reaches of Oak Orchard Creek, in Orleans County, New York. Oak Orchard Creek was recommended by NYSDEC as a suitable control creek for the comparison of fish and wildlife survey results. In brief, both creeks are tributaries of Lake Ontario, are of similar size and surrounding geography, are subject to water level fluctuations due to changes in lake water levels, and contain hydro-electric dams some distance from the confluences of the creeks with the lake. Oak Orchard Creek is not listed as an AOC and is not known to have contamination issues similar to Eighteenmile Creek.

The overall goal is to evaluate the status of three BUIs and to make progress in understanding the degree of impairment for these beneficial uses. Accomplishing this will add to the information base regarding the watershed and will ultimately contribute to the de-listing of Eighteenmile Creek.

Specific project objectives include the following:

- Determine the prevalence of tumors or other deformities in fish inhabiting the AOC.

- Determine the status of fish and wildlife populations in the AOC by conducting seasonal fish and wildlife population surveys within the AOC and Oak Orchard Creek.

- Determine the status of bird or animal deformities and/or reproductive impairment in wildlife populations in the AOC.

The primary components of this investigation include collection of field data, sample collection and analysis, and histological/pathological examinations. Field data collection involved:

- Conducting fish community surveys during two periods—early spring (May) and summer (late August);
- Targeted sampling of brown bullhead for gross external and internal observations, excision of livers for pathological/histological examination, and preparing selected specimens for whole-body tissue chemical analyses (for PCBs and dioxin) (late August); and
- Periodic bird, amphibian, and mammal surveys from May through September.

The data generated by the field activities are being used in a weight-of-evidence approach to determine the status of these three BUIs. For each type of data collected, the results for lower Eighteenmile Creek have been compared with background data to determine whether there is impairment.

2 Methods

Field sampling and laboratory methodologies were described in detail in Section 2 of the QAPP prepared by E & E in the spring of 2007 (see Appendix A). The following sections summarize the actual field and laboratory procedures and indicate any deviations from the planned methodologies. Detailed field sampling and laboratory reports are provided in the following appendices:

- Appendix B: Fish Community Survey Data
- Appendix C: Wildlife Survey Data
- Appendix D: Bullhead Analytical Data for PCBs and Dioxins/Furans
- Appendix E: Bullhead Liver Pathology Report
- Appendix F: Bullhead Sampling Field Data Sheets

2.1 Fish Community Surveys and Brown Bullhead Collection

2.1.1 Fish Community Survey Methodology

Fish surveys were conducted to document fish species composition at selected sampling locations within Eighteenmile Creek and Oak Orchard Creek. The surveys were conducted during two seasons (late spring and late summer) in 2007. The first round of sampling was conducted from May 21-23, 2007; the second round was conducted from August 27-31, 2007. The bullhead collection effort for the analysis of fish tumors and other deformities was conducted during the August sampling effort and is discussed in Section 2.1.2.

The fish community surveys involved electrofishing three separate reaches in both Eighteenmile Creek and Oak Orchard Creek (see Figures 2-1 and 2-2). Survey locations were selected in order to sample different geographic areas and a variety of habitats. In each creek, two sampling locations were chosen in deepwater habitat (> 4 feet) (Reaches 1 and 2), and one location was chosen in shallow-water habitat (< 4 feet) (Reach 3) (see Figures 2-1 and 2-2). The deepwater reaches

were approximately 1,000 feet in length, and the shallow water areas were approximately 350 feet in length.

Deepwater habitats were sampled from boats using electrofishing equipment. The majority of the boat electrofishing was conducted at night, except for the August sampling of Oak Orchard Creek, which was conducted during daylight hours as a result of the intensity of effort expended toward capturing brown bullheads for the analyses of fish tumors and deformities and chemistry analyses of whole fish. When electrofishing from a boat, the entire reach was sampled in one pass. During each pass, the boat was maneuvered on both sides of the channel to sample the range of habitats present (primarily fringing wetland/shoreline, open water midchannel, and steep bank/exposed bedrock). Sampling durations of 900 to 1,200 seconds were needed to electrofish an entire reach. Variation in sampling durations resulted from variable accessibility of habitats within the various reaches and the time required to completely and adequately cover each survey reach. Boat electrofishing crews consisted of three biologists; two persons netted fish and one person drove the boat.

Shallow-water habitats were sampled near the shoreline using electrofishing equipment carried in a backpack. This effort was conducted during the daytime. Working upstream, one person carried the backpack electrofishing unit, one person behind netted fish, and a third person along the shoreline carried the stunned fish in a bucket. Similar to boat electrofishing, a range of habitats were sampled (e.g., riffles, runs, macrophytes, boulders, large woody debris). Because of high flows in both creeks, only one shoreline area was sampled along the reach, as water depths and velocities inhibited wading access in some areas. Sampling durations of 1,250 to 1,900 seconds were needed to electrofish an entire reach. The reason for variation in sampling durations is as described above.

In addition to the electrofishing effort, hoop nets and fyke nets (August only) were set in both creeks in an attempt to capture benthic fish in deeper-water habitats. Nets were set in depths greater than 8 feet and were baited with chicken livers and cat food. Two nets were set in both creeks during the May sampling effort and were checked after approximately 12 to 14 hours. Brown bullheads were never collected from the nets from either creek. During August, a total of ten nets were set (two fyke nets and eight hoop nets). Only one yellow perch was collected, and there were technical difficulties with the fyke nets as the cod-ends were broken when the nets were pulled. Based on the lack of success, no additional nets were set in Eighteenmile Creek or Oak Orchard Creek, and further sampling efforts were limited to electrofishing.

Population estimates were not computed as outlined in the QAPP. The intention was to use block nets to enclose a specific reach of stream and use a Zippin removal method to estimate numbers of fish. Due to the variation in channel depths and lengths of wetted channel, field teams were unable to enclose a given reach of stream within the limits of the project budget. Consequently, catch per unit effort (CPUE) data is presented to indicate abundance of fish. Since population

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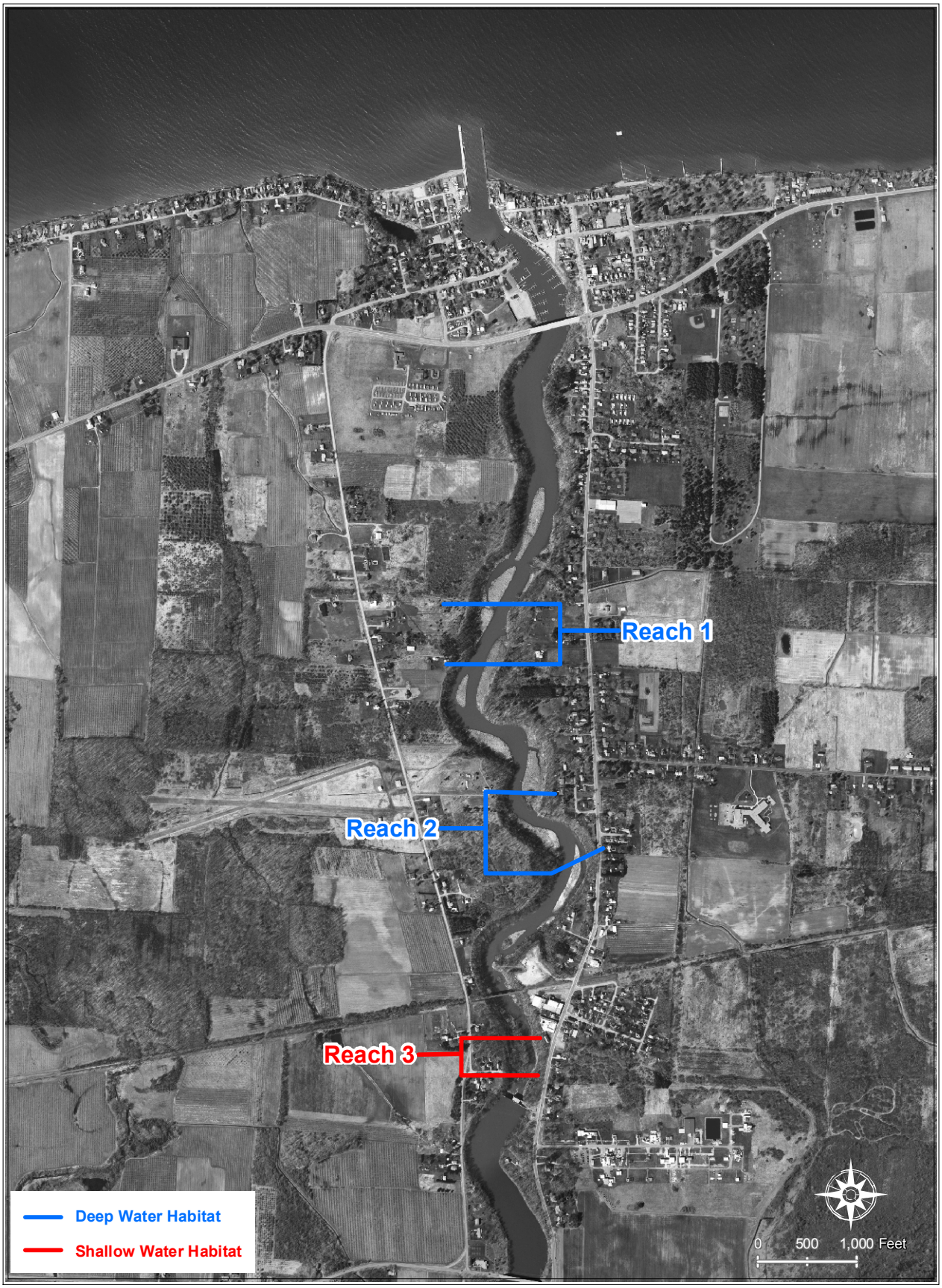

Source: New York State 2002; Ecology and Environment 2007

Figure 2-1
Fish Community Sampling Reaches for May and August 2007 Surveys - Eighteenmile Creek

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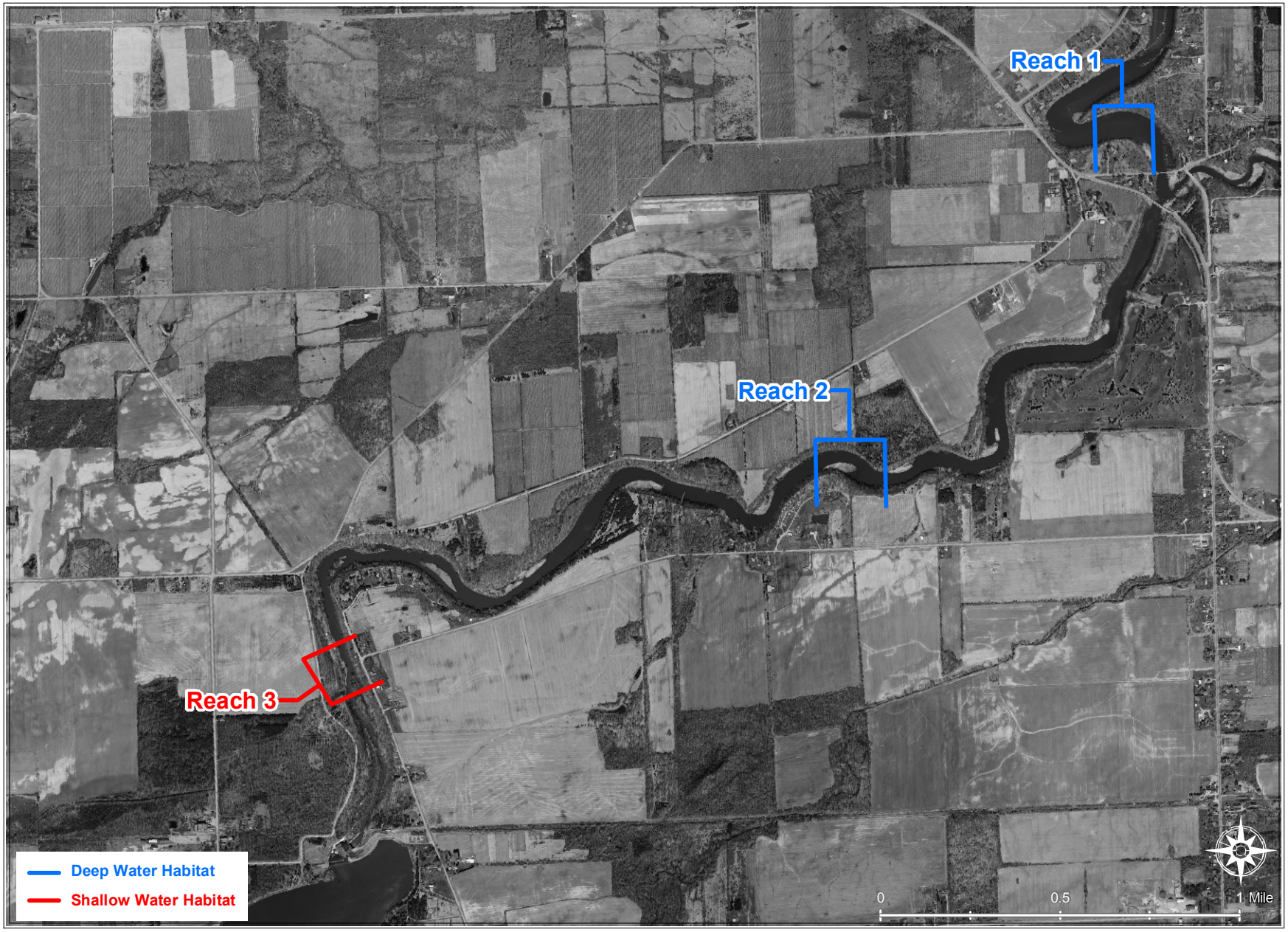

Source: New York State 2002; Ecology and Environment 2007

Figure 2-2
Fish Community Sampling Reaches for May and August 2007 Survey - Oak Orchard Creek

estimates were not obtained, biomass estimates for each creek also were not computed.

Data were summarized by sampling period for each creek. Since electrofishing was the only effective sampling technique, no data are presented for net sampling. Additional effort regarding targeted bullhead sampling is discussed in Section 2.1.2. For the CPUE data, catch rates for each creek were computed for each time period by multiplying the number of fish captured by the corresponding electrofishing time intervals. The lengths and weights of all fish collected were recorded on field data sheets (see Appendix B). Fish condition also was computed to determine community-level differences in length and weight relationships in fish. Fish condition was computed by the standard equation (Carlander 1977):

$K = 100{,}000 * (\text{weight})/\text{length}^3$.

The brown bullheads captured for the pathology work also were subjected to gross external and internal visual examinations to determine the incidences of deformities or physical aberrations. This was done to assess the condition of the fish from Eighteenmile Creek relative to those from Oak Orchard Creek.

2.1.2 Collection and Processing of Brown Bullheads for Gross Visual and Pathological Analyses

2.1.2.1 Bullhead Collection Methods

The equipment and general approach to the sampling of brown bullhead (*Ameiurus nebulosus*) are as presented in Section 2.1.1. Targeted collection of brown bullhead occurred in addition to the fish community surveys during the August sampling event. Bullhead collected during the community surveys were kept alive for inclusion in the gross visual and pathological analyses; however, the majority of the bullhead collected were obtained after the community surveys were completed. The targeted sampling for bullhead was performed only in August to maximize the probability of collecting fish that either reside in the creek year-round or spend most of the year in the creek. Boat electrofishing was determined to be the most effective technique for collecting adult bullhead. The fish were found on the bottom in 4 to 6 feet of water in stands of aquatic vegetation. The bullhead were captured by slowly maneuvering upstream through these habitats.

2.1.2.2 External/Internal Gross Visual Examination and Liver Dissection

The fish tumors or other deformities BUI has been identified in 14 of the 31 AOCs located within or partially within the U.S. In U.S. AOCs, this BUI is most often associated with the brown bullhead (*Ameiurus nebulosus*) (Rafferty and Grazio 2006). Therefore, the ability to accurately and consistently identify tumors or other deformities in brown bullhead is critical for proper assessment and monitoring of the status of this BUI.

To determine the prevalence of tumors, gross visual external and internal observations and histo-pathological examinations were conducted to identify potential

lesions and neoplasms. The histo-pathological work involved the examination of the fish livers. This type of examination is a reliable tool for evaluating tissue damage resulting from contaminated sediments and environmental pollution. Samples of the target species, brown bullhead, were collected as described in Sections 2.1.1 and 2.1.2.1 from the Eighteenmile Creek AOC and Oak Orchard Creek. As identified in the QAPP, the goal was to collect approximately 60 adult brown bullheads from each creek. Sampling efforts resulted in the collection of 50 live individuals from both creeks (for a total collection of 100 individuals), with all individuals collected from electrofishing; hoop and fyke nets proved to be ineffective for reasons that remain undetermined.

According to Rafferty and Grazio (2006), the literature indicates that fish that die prior to being visually assessed or necropsied may develop post-mortem lesions. Only live individuals (freshly euthanized) were used for the gross external and internal visual observations and for the collection of liver and fish tissue samples. Once collected, the bullhead were kept alive by changing the water in the collection tubs and using aerator pumps to maintain adequate oxygen levels.

Gross internal and external visual observations followed the procedures outlined in Section 5.3 of the *Field Manual for Assessing Internal and External Anomalies in Brown Bullhead (Ameiurus nebulosus)* (Rafferty and Grazio 2006). Fish were euthanized prior to visual observation and necropsy procedures using a mixture of clove oil and water. A datasheet, which followed the Fish Health Data Sheet in Rafferty and Grazio, was completed for all fish to record the visual necropsy observations (see Appendix F). Photographs were taken of many of the fish processed, including both fish exhibiting and not exhibiting tumors, lesions, or other deformities. The lower incidence rates of visible abnormalities lead to a reduction in photo-documentation.

Liver tissue samples were stored in sample containers with preservative until all samples had been collected. The preserved liver tissue samples were then shipped under chain-of-custody to Experimental Pathology Laboratories, Inc. (EPL) for evaluation.

2.2 Wildlife Surveys

Wildlife surveys were conducted at Eighteenmile Creek and Oak Orchard Creek from May to September 2007. Six point locations were established at each creek, and field biologists attempted to sample similar habitats along both creeks (e.g., survey locations closest to the dams on each creek were both located in forested habitat). Moving downstream, point locations were labeled A through F at Eighteenmile Creek and 1 through 6 at Oak Orchard Creek (see Figures 2-3 and 2-4). Point locations A and 1 were located near the dams in deciduous forested habitat; point locations B, C, D, 2, 3, and 4 were located near cattail marshes; point locations E, F, 5 and 6 were located near open water. All survey areas were characterized by deciduous forested habitat adjacent and upslope of the creeks.

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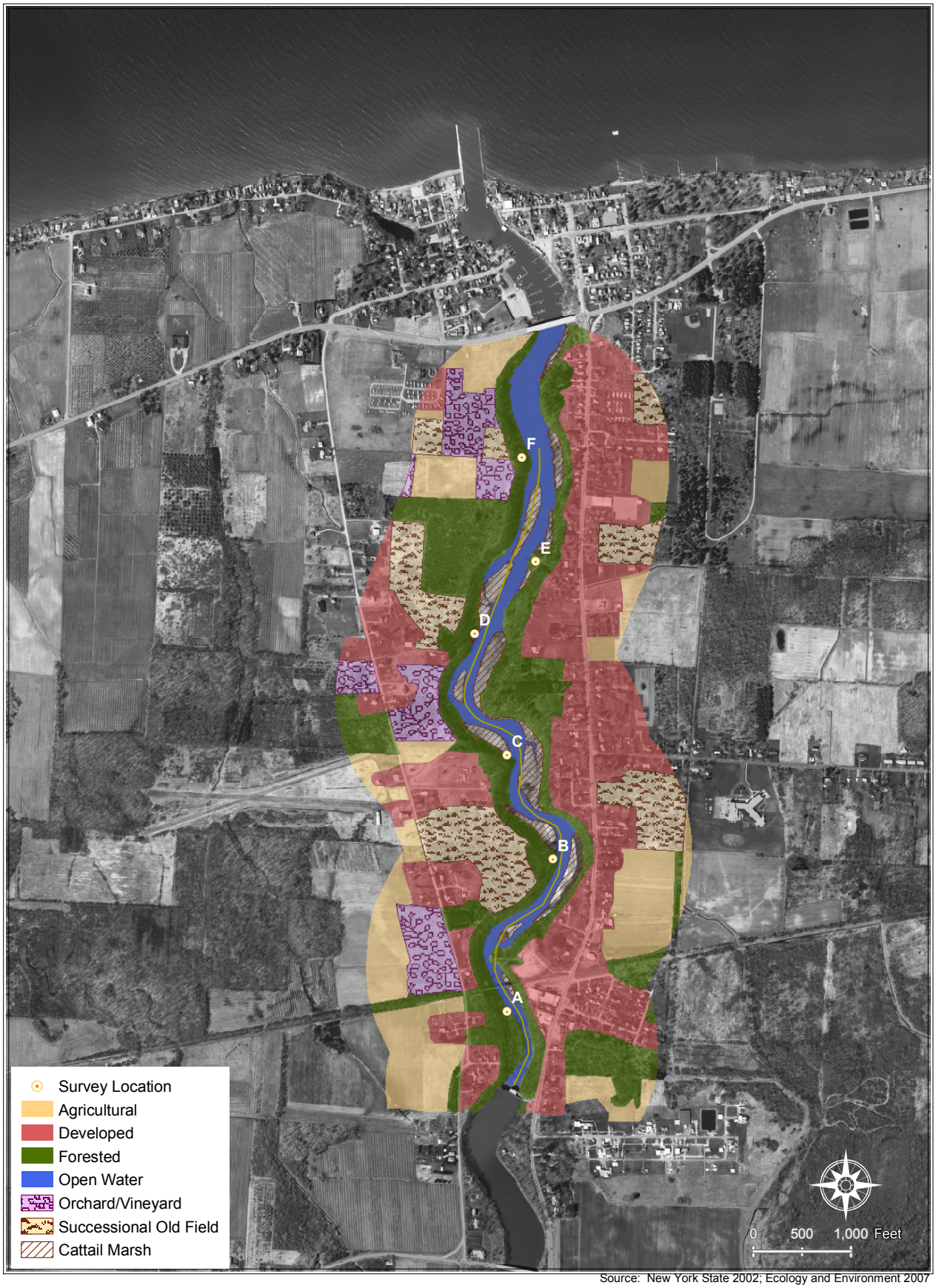

Source: New York State 2002; Ecology and Environment 2007

Figure 2-3
Wildlife Survey Locations and Surrounding Cover Types - Eighteenmile Creek

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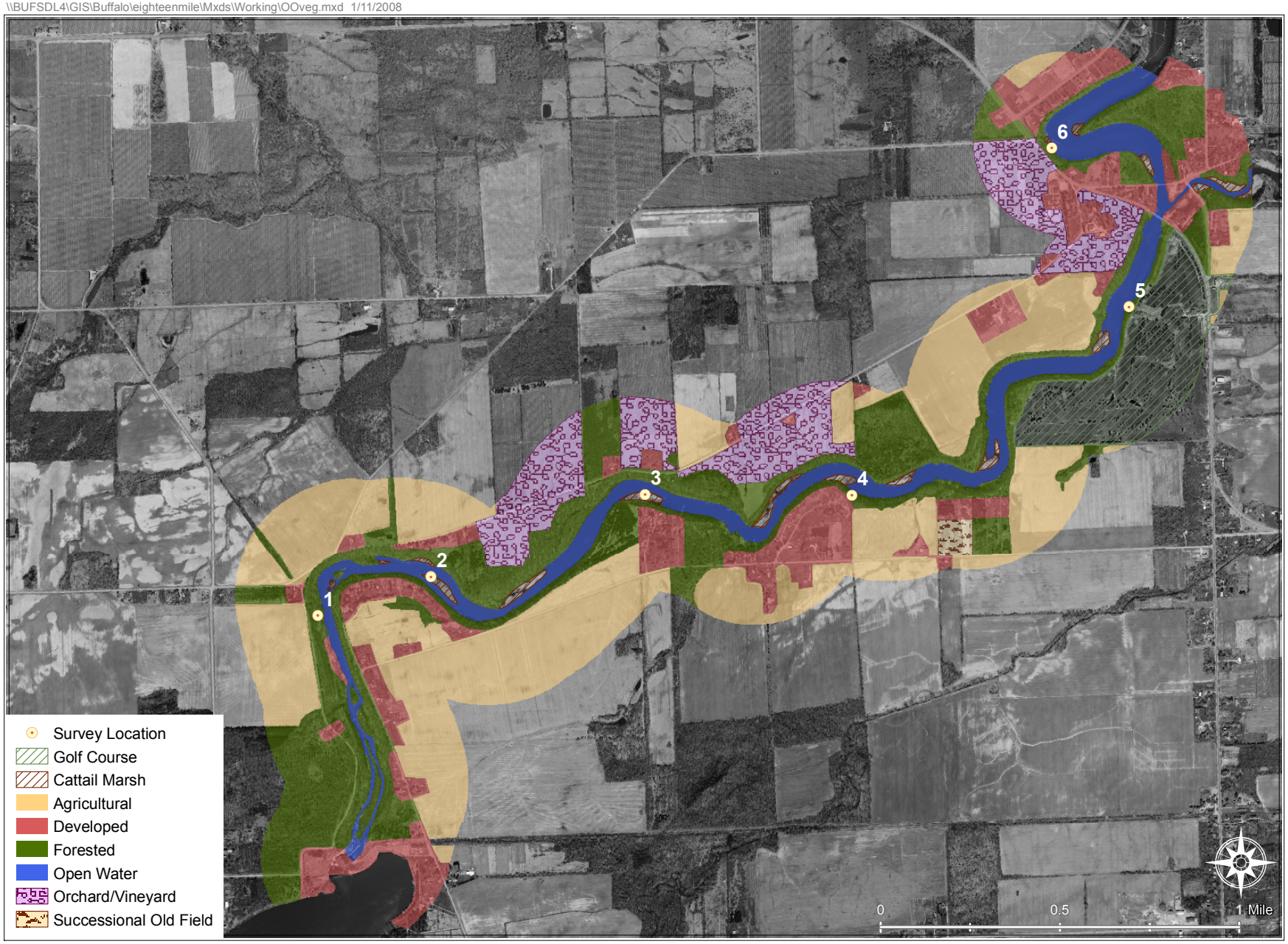


Source: New York State 2002; Ecology and Environment 2007

Figure 2-4
Wildlife Survey Locations and Surrounding CoverTypes - Oak Orchard Creek

In addition to species identified during surveys, species observed incidentally within the creeks at other times of day outside of the survey periods also were recorded. Data from the actual surveys as well as from incidental observations were used to document the occurrence and distribution of wildlife species at the two creeks. The sample locations were accessed from a canoe for all of the surveys.

Field biologists logged a total of 56 hours at Eighteenmile Creek and 59 hours at Oak Orchard Creek periodically over six months for the completion of the bird, amphibian, and qualitative mammal surveys. These hours included night-time surveys during those periods when the Marsh Monitoring Programs methods were employed (see Sections 2.2.1 and 2.2.3). The somewhat greater number of hours expended along Oak Orchard Creek was due to the longer distances between survey points at Oak Orchard Creek compared with Eighteenmile Creek. The survey points were located within a stream length of 3.8 miles along Oak Orchard Creek versus 1.3 miles along Eighteenmile Creek. Hence, more time was needed to travel between survey points at Oak Orchard Creek.

Habitat is important for describing the distribution of species; therefore, habitat was assessed at each creek by interpreting aerial photographs from Eighteenmile Creek (2002) and Oak Orchard Creek (2005). A 0.25-mile buffer was added to the centerline of each creek to identify the habitats used by birds, mammals, amphibians, and reptiles in the riparian corridor. A 0.25-mile buffer was chosen because it is the distance used by the USGS for the detection of birds during the Breeding Bird Survey (Sauer et al. 1997). Where major natural habitats (e.g., cattail marsh, forested, open water, and early successional communities) and developed/managed habitats (agricultural, developed, orchard/vineyard, and golf course) were identified, information from the aerial photographs was digitized using a geographic information system (GIS), and a coarse-level analysis was conducted to determine the relative prevalence of habitat types in the immediate vicinity of the two survey areas. The total acreages were calculated for each habitat type. Acknowledging that habitat may have changed since the aerial photographs were taken, some effort was made in the field to determine whether the habitat cover types in the aerials were similar to those observed on the ground. No prominent differences were noted, although a detailed, rigorous ground-truthing effort was not performed.

2.2.1 Birds

Point Count Surveys

Point count surveys were conducted at each point location along Eighteenmile Creek and Oak Orchard Creek, twice a month in May and once a month from June to September. Point count surveys generally followed procedures described in Rottenborn (1999); however, the point counts were 10 minutes in duration, rather than 5 minutes as suggested in Rottenborn. During each point count, all species seen or heard were recorded on data sheets (see Appendix C). Observations of birds flying over the creeks were recorded separately on data sheets as it was difficult to determine whether observed individuals actually used the creek

(e.g., for nesting, roosting, foraging). Because bird activity is greatest in the morning, the surveys were conducted between sunrise and 11:00 A.M. Surveys were not conducted on days with heavy precipitation, fog, or high wind speeds, because these weather conditions make seeing or hearing birds more difficult.

Marsh Monitoring Program Surveys

The Marsh Monitoring Program (MMP) protocol for avian surveys (MMP 2003) was followed to document marsh-dwelling birds that are typically nocturnal and somewhat secretive. The MMP protocol involves broadcasting audio recordings of marsh bird calls and listening for a response. The MMP protocol has been an established protocol to survey for marsh birds (and amphibians) in the Great Lakes Basin since 1994 and is sponsored by Bird Studies Canada in association with the U.S. Environmental Protection Agency (EPA) and Environment Canada.

Surveys involved playing a broadcast from an audio tape for 10 minutes and recording all birds heard or observed within the 10-minute period. These surveys were conducted at each point location along both Eighteenmile Creek and Oak Orchard Creek beginning after 6:00 P.M. The broadcast tape was provided by the MMP and included the calls of the Virginia rail, sora, least bittern, common moorhen/American coot, and pied-billed grebe. The common moorhen and American coot have similar calls and habitat requirements and were played during the same minute. Each call was played for one minute followed by one minute of silence so the observer could listen for responses for a survey duration of ten minutes. All adult birds heard or observed within 50 meters of the observer were mapped on a data sheet. Aerial flyovers were indicated separately on the data sheet.

2.2.2 Mammals

Observations of mammals were recorded coincident with the bird and amphibian surveys. Direct observations of mammals were noted, as were tracks, dens, scat, and other signs of mammal presence (e.g., tree damage, hair). Species such as the eastern chipmunk were often heard rather than observed; these detections also were noted. Field observations recorded species presence, type of observation or sign, and the location of the observation. The purpose of these surveys was to collect qualitative information regarding mammal species occurrences and some sense of species richness within the creek corridors. This study was not designed to collect quantitative count data on mammals.

2.2.3 Amphibians and Reptiles

Pitfall and Minnow Traps

Reptile and amphibian sampling was accomplished using 5-gallon plastic buckets as pitfall traps. Six arrays were established along each creek at the bird survey point locations (see Figures 2-3 and 2-4). Each array consisted of two buckets that were buried flush with the ground surface connected by a 12- to 15-foot-long drift fence erected between the two buckets. The arrays were installed on April

20, 2007, and the traps were closed using the covers to the buckets. A minnow trap was placed near each array to capture tadpoles and water-dwelling species.

The evening before the morning bird surveys, the covers were removed from the buckets and the minnow traps were placed in the water. The minnow traps were baited with dog or cat food to attract tadpoles (Conant and Collins 1998). All traps were checked the following morning when the bird surveys were conducted. For each capture, the species, number of individuals, and trap type (e.g., pitfall or minnow) were recorded, and the captured individuals were released alive.

Marsh Monitoring Program Surveys

Point count surveys to detect calling frogs and toads also were conducted using the MMP protocol. Each frog/toad survey was conducted at the bird survey point locations and was 3 minutes in duration. The surveys were conducted starting approximately 30 minutes after sunset and were completed before midnight. Surveys were timed to occur during peak breeding (and calling) periods for the species found in the Great Lakes region (MMP 2003). Peak calling periods are dependent on nighttime air temperatures. For species such as the chorus frog, wood frog, and spring peeper, nighttime air temperatures should be greater than 41°F; for American toad, northern leopard frog, and pickerel frog, nighttime air temperatures should be greater than 50°F; and for gray tree frog, mink frog, green frog, and bullfrog, nighttime air temperatures should be greater than 63°F (MMP 2003). Three amphibian surveys were originally planned, but nighttime temperatures were not high enough during one of the survey nights, so an additional survey was conducted.

All species heard during surveys were recorded, as were the number of individuals heard. In addition, a call level code (1, 2, or 3) was assigned for each species. The code is intended to provide a measure of the intensity and number of individuals calling (MMP 2003). Code 1 indicates that individuals could be counted and that calls were not simultaneous; code 2 indicates that calls were distinguishable, but some of the calls were simultaneous; and code 3 indicates a full chorus where calls were continuous and overlapping.

2.3 Collection and Analysis of Brown Bullheads for PCBs and Dioxins/Furans

2.3.1 Bullhead Collection and Analysis

In August 2007, eight brown bullheads (9 to 12 inches in length) were collected by electrofishing from both Eighteenmile Creek and Oak Orchard Creeks. The fish were sent to Pace Analytical Services for analysis of PCBs (EPA Method 3540C) and percent lipids (Pace Lipid Method). Two specimens from each creek also were analyzed for dioxins/furans (EPA Method 1613B). The bullheads submitted for chemical analysis were a subset of those used for the liver pathology work and thus had their livers removed. In accordance with the QAPP, each specimen for chemical analysis was double wrapped in aluminum foil, sealed in a plastic bag, given a unique sample identification number, packed in a cooler with ice, and shipped under chain-of-custody by overnight courier to the analytical

laboratory. Whole-body homogenates for chemical analysis were prepared at the analytical laboratory.

2.3.2 Dioxin/Furan Summation Approach

EPA Method 1613B yields results for 17 different dioxin/furan compounds (see Appendix D for a complete listing). The various dioxin/furan compounds differ in toxicity. The most toxic member of the group is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Dioxins/furans usually are evaluated collectively by multiplying the concentration of each individual compound by its toxic equivalence factor (TEF), which is a measure of its toxicity relative to TCDD, and summing the resulting products (Van den Berg et al. 1998). This sum is referred to as the TCDD toxic equivalent (TEQ). TEQs were calculated using both mammalian TEFs from Van den Berg et al. (2006) and avian and fish REFs from Van den Berg et al. (1998). Therefore, three TEQs—mammalian, avian, and fish—were calculated for each bullhead sample. Undetected dioxins/furans were set equal to one-half of the reported detection limit when calculating TEQs.

2.3.3 Statistical Methods

The Mann-Whitney U-test was used to test for differences in chemical concentrations between bullheads from Eighteenmile Creek and Oak Orchard Creek. This test is a non-parametric procedure that is used in situations where the *t*-test cannot be applied because of sample variance heterogeneity, non-normal data distribution, or both (Sokal and Rohlf 1981).

2.4 Bullhead Liver Pathology

2.4.1 Histopathology Methods

The methods for preparing the livers for histopathological examination followed the procedures outlined in the QAPP in Section 2.2.1.2 (See Appendix A, pages 2-11 and 2-12). The histo-pathological procedures were performed and subsequently reported by EPL following EPL® Standard Operating Procedures (see pages 2-11 and 2-12 of the final QAPP, Appendix A).
Additionally, the complete report (*Eighteenmile Creek Beneficial Use Impairment Assessment Niagara County, New York: Targeted Fish Collection for Analysis of Fish Tumors and Deformities*) prepared by EPL is included in Appendix E of this report.

2.4.2 Statistical Methods

During review of the draft version of this report, EPA requested a statistical evaluation of the bullhead external abnormality and liver pathology results. In November 2008, E & E prepared a technical memorandum for EPA summarizing the statistical methods used and results of the evaluation. A copy of the memo is provided in Appendix G. The evaluation was expanded and integrated into this revised report. A description of the statistical methods used is provided below.

The Mann-Whitney U-test was used to test for differences in the number and severity of external abnormalities between creeks. The data used in the evaluation

are summarized in Table 3-26. Each deformity was tested separately between creeks using the severity scores (0, 1, 2, or 3) for all 50 fish from each creek.

The Mann-Whitney U-test also was used to test for differences in the number and severity of two types of liver abnormalities—pigmented macrophage aggregates and hepatocellular vacuolation—in bullheads from the two creeks. These two types of liver abnormalities are assigned scores or grades indicating the level of severity. The data used in the evaluation are provided in Table 3 of Appendix E.

The chi-square test was used to test for differences in the prevalence of six types of liver abnormalities—hyperplasia, neoplasia, altered foci, inflammation, necrosis, and endoparasitism—in bullheads from the two creeks. The data used in the evaluation are summarized in Tables 2 and 4 of Appendix E. The data for these abnormalities indicate only their presence or absence in the examined livers, not the level of severity. This type of presence/absence data for two sites is best evaluated using the chi-square test for a 2x2 table.

3 Results

The results of this investigation are presented in this section in four primary sections: (1) Fish Community Surveys, (2) Wildlife Surveys, (3) Bullhead Chemical Residue Data and Risk Evaluation, and (4) Bullhead Deformities and Liver Pathology.

3.1 Results

Eighteenmile Creek and the reference creek (Oak Orchard Creek) had similar water quality parameters (see Table3-1). Water temperatures, dissolved oxygen, and conductivity were slightly higher in Oak Orchard Creek in May, but all parameters were within concentrations suitable for fish survival and propagation. While flows are not gauged in either stream, their flows appeared similar during sampling events in each stream. During the May 2007 sampling events, no rainfall had occurred in either watershed for several days prior to and during the sampling events. During the August period, the region experienced drought conditions and both streams were in low flow conditions, influenced by controlled flow releases from the New York State Barge Canal.

Table 3-1 Water Quality Parameters[1] for Eighteenmile Creek (EMC) and Oak Orchard Creek (OOC) during the Fish Community Sampling Collection Periods in 2007.

Sampling Period	Creek	Water Temp (°F)	Air Temp (°F)	DO (mg/L)	pH	Conductivity (µS/cm)
May	EMC	58	55	8.49	9.19	585
May	OOC	65	68	11.05	8.69	698
August	EMC	72	79	7.03	ND	ND
August	OOC	76	82	8.41	ND	ND

Note:
[1] Measured with field meter calibrated as per the manufacturers instructions.

Key:

DO = dissolved oxygen.
ND = No data due to equipment malfunction.

Species Composition and Relative Abundance

Both creeks had similar species composition, with totals of 25 and 24 species being caught in Eighteenmile Creek and Oak Orchard Creek, respectively (see Table 3-2). Twenty-nine species were captured between both creeks, 20 of which were

sampled from both creeks. Species unique to Eighteenmile Creek included golden shiner, green sunfish, hybrid bluegill, silver redhorse, and steelhead. The steelhead, an adult, was captured in shallow water (approximately 1 foot depth) while backpack electro-fishing a riffle in Reach 3. Species unique to Oak Orchard Creek included banded killifish, brook silverside, gizzard shad, and tesselated darter. Several small coho salmon were captured in both creeks, and discussions with local fishermen and the DEC indicated that salmon had been stocked in the creeks several days prior to the sampling trips and that the captures were likely hatchery fingerlings (see Appendix B for fish community survey datasheets).

Table 3-2 Species Captured in Eighteenmile Creek and Oak Orchard Creek

Eighteenmile Creek	Oak Orchard Creek
Alewife*	Alewife*
Black crappie*	Banded killifish
Bluegill*	Black crappie*
Bluntnose minnow*	Bluegill*
Bowfin*	Bluntnose minnow*
Brown bullhead*	Bowfin*
Coho salmon*	Brook silverside
Common carp*	Brown bullhead*
Common shiner*	Coho salmon*
Emerald shiner*	Common carp*
Golden redhorse*	Common shiner*
Golden shiner	Emerald shiner*
Green sunfish	Gizzard shad
Hybrid Bluegill	Golden redhorse*
Largemouth bass*	Largemouth bass*
Logperch*	Logperch*
Longnose gar*	Longnose gar*
Pumpkinseed*	Pumpkinseed*
Rock bass*	Rock bass*
Shortnose redhorse*	Shorthead redhorse*
Silver redhorse	Slimy sculpin*
Slimy sculpin*	Smallmouth bass*
Smallmouth bass*	Tesselated darter
Steelhead	Yellow perch*
Yellow perch*	

Note:
* = Indicates species found in both creeks.

The most common species captured in the creeks differed. During the May sampling, the top three species captured in Eighteenmile Creek were emerald shiner (115), alewife (110), and rock bass (28). In Oak Orchard Creek, the top three species captured in May were bluegill (45), rock bass (28), and golden redhorse (27). During the May sampling events, many cyprinids and clupeids (e.g., emer-

ald shiners and alewives) were concentrated in the sampling reaches of Eighteenmile Creek. Many alewives were visible on the surface engaged in mating frenzies. While alewives were observed in Oak Orchard Creek engaged in the same behavior, large concentrations of fish were not observed within the sampling reaches.

During the August sampling, the top three species captured in Eighteenmile Creek were bluegill (61), largemouth bass (25), and slimy sculpin (23). In Oak Orchard Creek, the top three species captured were rock bass (21), bluegill (17), and brown bullhead and largemouth bass (13 each) (see Table 3-3). There are two likely reasons why fewer fish were captured during the Oak Orchard Creek sampling event in August. Foremost, only one netter was used; the remaining crew was assisting the brown bullhead processing team as part of the fish analysis. The warm weather and numbers of bullhead captured necessitated as many staff as possible processing fish.

Table 3-3 Totals for Fish Species Captured during Electro-fishing Sampling

Species	May		August	
	Eighteenmile Creek	Oak Orchard Creek	Eighteenmile Creek	Oak Orchard Creek
Alewife	110	1		
Banded killifish				1
Black crappie	3	2	1	
Bluegill	24	45	61	17
Bluntnose minnow	1	11	7	1
Bowfin	3	1	5	3
Brook silverside		1		
Brown bullhead	5	6	6	13
Coho salmon	1	1		
Common carp	1			2
Common shiner	1	19		3
Emerald shiner	115	15		
Gizzard shad		1		
Golden redhorse	3	27		
Golden shiner	2		3	
Green sunfish	3		10	
Hybrid Bluegill	1			
Largemouth bass	5	17	25	13
Logperch	2	1	5	4
Longnose gar		6	1	
Pumpkinseed	25	20	21	10
Rock bass	28	28	30	21
Shortnose redhorse		4	1	
Silver redhorse	1			
Slimy sculpin	15	2	23	12
Smallmouth bass	6	10	5	

Table 3-3 Totals for Fish Species Captured during Electro-fishing Sampling

Species	May		August	
	Eighteenmile Creek	Oak Orchard Creek	Eighteenmile Creek	Oak Orchard Creek
Steelhead	1			
Tesselated darter				1
Yellow perch	13	4	1	2

Catch Per Unit Effort

Eighteenmile Creek had a higher catch per unit effort (CPUE) for both sampling periods (see Table 3-4). These higher catch rates were observed in each of the three reaches during the May sampling period. The average CPUEs for Eighteenmile Creek (6.8 fish/minute) and Oak Orchard Creek (4.8 fish/minute) during the May sampling events were higher than those observed in August for both creeks (3.5 fish/minute and 1.3 fish/minute, respectively). Similarities in the CPUE data indicated that the lowermost reaches (i.e., closest to Lake Ontario) contained the highest abundance of fish during the spring sampling period. This pattern was observed in both creeks. Eighteenmile Creek had a slightly higher abundance of fish, primarily based on the high numbers of cyprinids and clupeids captured during the sampling events. For May, the data suggest that Oak Orchard Creek had a higher abundance of top predator fish (see Table 3-3). During May, Oak Orchard had 17 largemouth bass, compared to 5 largemouth bass in Eighteenmile Creek. In addition, six longnose gar were captured in Oak Orchard Creek, whereas none were captured in Eighteenmile Creek.

Table 3-4 Catch per Unit Effort (CPUE) Data for Community Fish Sampling in Eighteenmile Creek and Oak Orchard Creek

Area	E Time (sec)	Total No. of Fish	CPUE (fish/min)
May			
Eighteenmile Creek			
Reach 1	900	144	9.6
Reach 2	900	109	7.3
Reach 3	1,920	116	3.6
Average	**1,240**	**123**	**6.8**
Oak Orchard Creek			
Reach 1	900	106	7.1
Reach 2	900	89	5.9
Reach 3	1,269	27	1.3
Average	**1,023**	**74**	**4.8**
August			
Eighteenmile Creek			
Reach 1	1,176	58	3.0
Reach 2	1,045	108	6.2
Reach 3	1,760	39	1.3
Average	**1,327**	**68**	**3.5**

Table 3-4 Catch per Unit Effort (CPUE) Data for Community Fish Sampling in Eighteenmile Creek and Oak Orchard Creek

Area	E Time (sec)	Total No. of Fish	CPUE (fish/min)
Oak Orchard Creek			
Reach 1	1,431	32	1.3
Reach 2	1,517	27	1.1
Reach 3	1,680	44	1.6
Average	**1,542**	**34**	**1.3**

Key:
CPUE = total number of fish captured per electrofishing minute.
E Time = Electrofishing time.

During the summer sampling period, opposite patterns were observed. Eighteenmile Creek had a higher abundance of dominant predators, including largemouth bass (almost twice as many), smallmouth bass (five compared to zero), bluegill (more than three times as many), bowfin, rock bass, and pumpkinseed (see Table 3-3). This pattern is likely a result of the focus on targeted bullhead sampling for the pathology and analytical work during the summer sampling period. The fish community sampling effort on Oak Orchard Creek was conducted during the daytime and with only one netter, whereas the sampling effort on Eighteenmile Creek involved more than one netter and was conducted at night.

Fish Condition

Fish condition also was computed to determine community-level differences in the length and weight relationships. Typically, smaller ratios indicate a healthy, prolific fish community. Due to small sample sizes, only 3 of the top five species caught during all sampling events are presented in this report. Tables 3-5 and 3-6 show the average weights, lengths, and associated condition factors for bluegill, pumpkinseed, and rock bass for Eighteenmile Creek and Oak Orchard Creek, respectively. For these three species in Eighteenmile Creek, fish condition was fairly similar during the May and August sampling events. For bluegill and pumpkinseed, the average condition factor was slightly higher during the May sampling event, whereas rock bass had a higher condition factor in August. In Oak Orchard Creek, condition factors for these three species were lower in August. Bluegill were most similar in Oak Orchard Creek, and rock bass had the largest variation between the two sampling events.

Condition factors closest to 1.0 indicate a healthy fish population. All of the condition factors were higher than one, which may suggest various influences in these waterbodies on the health of the fish community. Factors that influence fish condition include available food sources, environmental changes, and disease.

However, the scope of the fish sampling effort was limited to three sampling events in each creek per season. This small sample size may have influenced the results. Based on the sensitivity of condition factor to age and length of fish, the brown bullhead collected for tumor analysis were used to examine the age-specific condition of fish between the two creeks.

Table 3-5 Length, Weight, and Condition Factor Comparisons of Spring and Summer Sampling Results for Eighteenmile Creek1

May 2007				August 2007			
Species	Average Length (mm)	Average Weight (g)	Average Fulton Condition Factor	Species	Average Length (mm)	Average Weight (g)	Average Fulton Condition Factor
Bluegill	129.50	49.10	1.90	Bluegill	108.31	33.56	1.70
Pumpkinseed	117.28	38.99	2.19	Pumpkinseed	110.33	31.95	2.08
Rock bass	128.21	66.05	2.04	Rock bass	90.64	40.23	2.52

Table 3-6 Length, Weight, and Condition Factor Comparisons of Spring and Summer Sampling Results at Oak Orchard Creek[1]

May 2007				August 2007			
Species	Average Length (mm)	Average Weight (g)	Average Fulton Condition Factor	Species	Average Length (mm)	Average Weight (g)	Average Fulton Condition Factor
Bluegill	120.9	42.1	1.99	Bluegill	97.47	22.86	1.85
Pumpkinseed	146.6	73.7	2.08	Pumpkinseed	118.90	35.40	1.87
Rock bass	140.5	92.2	2.68	Rock bass	106.95	30.97	1.86

Note:
[1] Blanks indicate species was not captured

To classify the various size classes of bullheads, length-frequency histograms were developed to determine size categories of fish. Figures 3-1 and 3-2 present the length frequency distribution for bullhead captured in Eighteenmile Creek and Oak Orchard Creek, respectively. Based on these size frequency distributions, the following size categories were established: 250-280 mm, 281-320 mm, 321-350 mm, 351-360 mm, and 361-390 mm. Table 3-7 summarizes the average lengths, weights, and condition factors for bullhead captured in the two creeks. Condition factors in both creeks were similar, ranging from 1.2 to 1.4. Overall, there was no consistent difference in the average weight or condition factor for the various size classes between creeks that would suggest that fish in Eighteenmile Creek were less healthy or fit than those in Oak Orchard Creek. Indeed, for the size class with the greater number of individuals (281 to 320 mm), the average weight and condition factor were greater for Eighteenmile Creek (see Table 3-7).

Table 3-7 Brown Bullhead Lengths and Weights for Various Size Categories in Eighteenmile Creek and Oak Orchard Creek

Length Category	Average Length (mm)	Average Weight (g)	Condition Factor	N
Eighteenmile Creek				
250-280	266.5	240	1.26	6
281-320	302	379	1.38	28
321-350	335	518	1.38	10
351-360	355	582	1.29	3
361-390	380	809	1.48	2
Oak Orchard Creek				
250-280	274	278	1.35	8
281-320	299	344	1.28	30
321-350	331	503	1.39	11
351-360	-	-	-	0
361-390	365	682	1.4	1

3.2 Wildlife Surveys

Wildlife surveys were conducted along Eighteenmile Creek within a stream length of approximately 1.3 miles and along Oak Orchard Creek within a stream length of approximately 3.8 miles. The percent cover was calculated for habitat types parallel to those stream lengths to determine their relative availability (see Table 3-8).

Eighteenmile Creek had more cattail marsh, developed (residential), and early successional habitat than Oak Orchard Creek, whereas Oak Orchard Creek had more agricultural land, open water, and there was a large golf course nearby. Both creeks had a similar relative percentage of surrounding forestland and orchard/vineyard habitat.

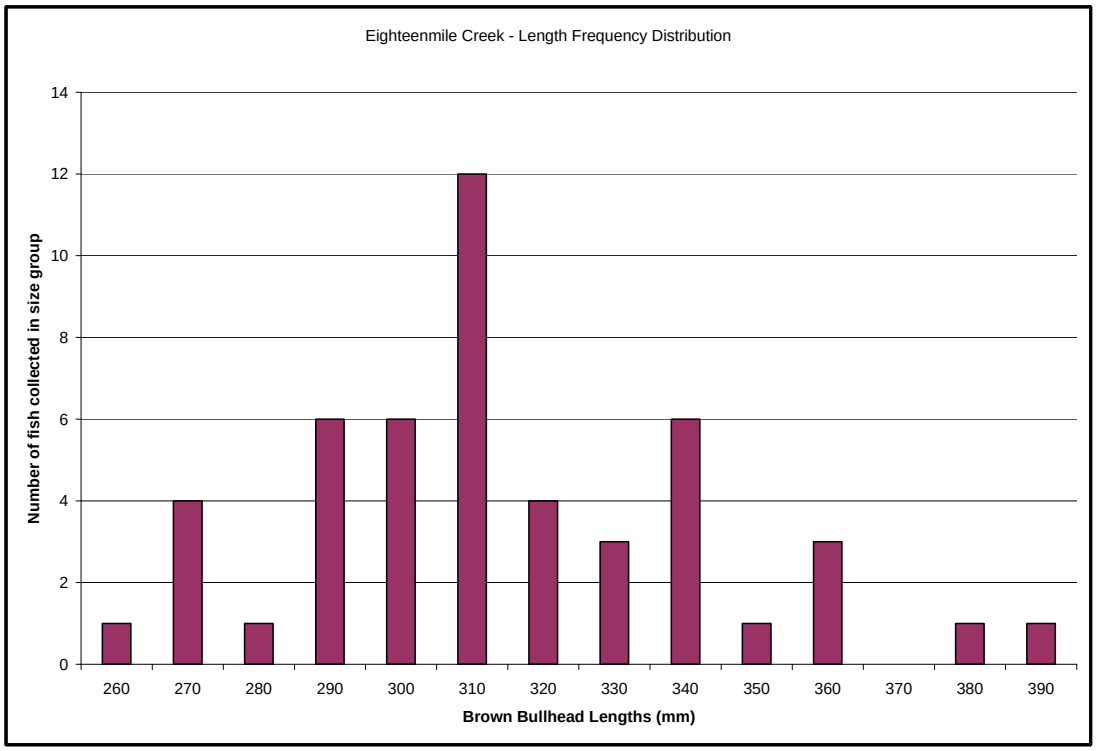


Figure 3-1 Length Frequency Distribution for Brown Bullhead in Eighteenmile Creek, August 2007

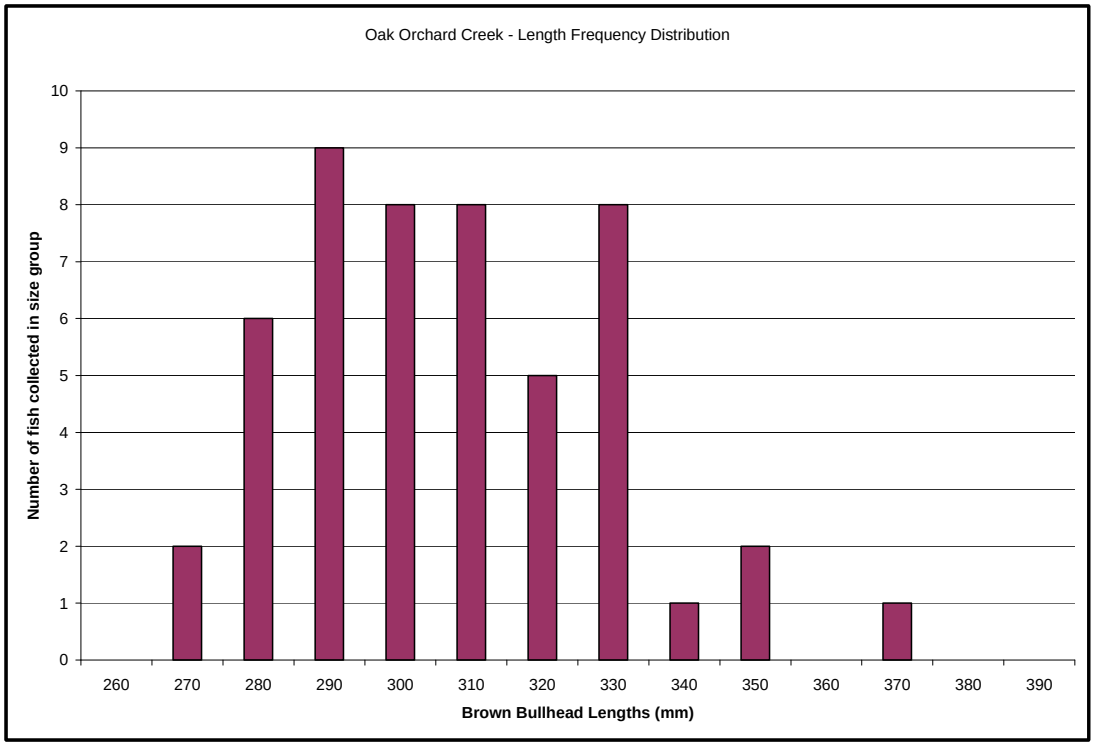


Figure 3-2 Length Frequency Distribution for Brown Bullhead in Oak Orchard Creek, August 2007

Table 3-8 Habitat Types along Eighteenmile Creek and Oak Orchard Creek[1]

Habitat	Eighteenmile		Oak Orchard	
	Acres	%	Acres	%
Agricultural	147.70	20.46	464.40	31.71
Cattail Marsh	19.21	2.66	14.58	1.00
Developed	237.84	32.94	235.02	16.05
Forested	169.58	23.49	374.32	25.56
Open Water	34.30	4.75	127.94	8.74
Early Successional	62.22	8.62	6.17	0.42
Orchard/Vineyard	51.14	7.08	144.51	9.87
Golf Course	0.00	0.00	97.58	6.66
Total	**721.98**	**100.00**	**1464.52**	**100.00**

Note:
[1] Based on analysis of aerial photography.

3.2.1 Birds

Point Count Surveys – Eighteenmile Creek

Point counts were conducted at each of the six point locations along Eighteenmile Creek on May 5, May 19, June 29, July 23, August 19, and September 17, 2007 (see Appendix C for wildlife survey data). In total, 1,309 birds representing 66 species were identified during the six morning bird surveys at Eighteenmile Creek (see Tables 3-9 and C-1). Of the 1,309 birds observed, 431 birds were flyovers. Because the species observed were generally observed throughout the study area, they were believed to be local birds traveling through (versus migrants) and were included in the analyses that follow. The total number of birds observed per survey, defined as the sum of birds from the six point locations on a given survey day, ranged from 134 to 261 birds, with an average of 218 birds. The total number of species identified per survey ranged from 29 to 36, with an average of 32. The most numerous species recorded at Eighteenmile Creek were Red-winged Blackbird (198 birds), Mallard (116 birds), Common Grackle (95 birds), and Canada Goose (92 birds) (see Table C-1). There were no observations of deformed or obviously sick or diseased birds at either of the creeks.

By point location, the total number of birds ranged from eight birds at point B on September 17 to 77 birds at point F on July 23, with an overall average per point location of 36.4 birds at Eighteenmile Creek (see Table 3-9 and Figure 2-3). Total species per survey point location ranged from four species at point B on September 17 to 20 species at point A on June 29, with an overall average of 13.0 species. Point F consistently had higher numbers of birds and species, whereas points B and E usually had lower numbers of birds and species.

Point counts were conducted at each point location along Oak Orchard Creek on May 7, May 18, June 28, July 22, August 18, and September 16, 2007. At Oak Orchard Creek, a total of 1,309 birds representing 71 species were identified during the six morning surveys (see Table 3-9 and Appendix C). Of the 1,309 birds observed, 441 birds were flyovers. Because the species observed were generally

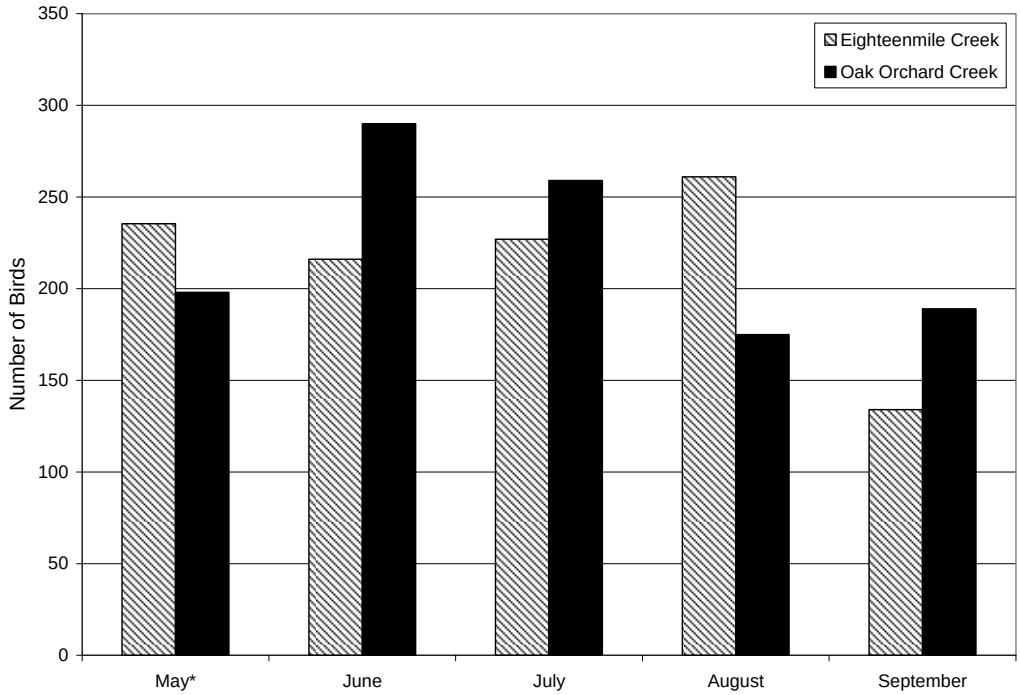
observed throughout the study area, they were believed to be local birds traveling through (versus migrants) and were included in the analyses that follow. The total number of birds ranged from 175 to 290 (see Figure 3-3), with an average of 218, and the total number of species per survey point ranged from 28 to 46 (see Figure 3-4), with an average of 35 species. The most numerous species recorded were Red-winged Blackbird (135 birds), American Goldfinch (114 birds), and Canada Goose (108 birds) (see Table C-1).

By point location at Oak Orchard Creek, the total number of birds ranged from nine at point 4 on August 18 to 79 birds at point 6 on June 28, with an overall average per point location of 36.4 birds (see Table 3-9). The total species per survey point location ranged from six at point 3 on September 16 to 21 at point 1 on June 28, with an overall average of 13.9 species. Point 6 consistently had higher numbers of birds and species, whereas point 2 consistently had lower numbers of birds and species.

The species composition at both creeks were generally consistent with what was anticipated for the habitat and location and was generally consistent with those species typically found in or near Niagara and Orleans counties (E & E 2007). No federally or state-listed threatened or endangered species were identified during the point count surveys; however, two state-listed species of concern (Osprey and Cooper's Hawk) were observed (see Table B-1). Osprey were observed at Eighteenmile Creek on August 19 and at Oak Orchard Creek on September 16. One Cooper's Hawk was observed at Eighteenmile Creek on August 19.

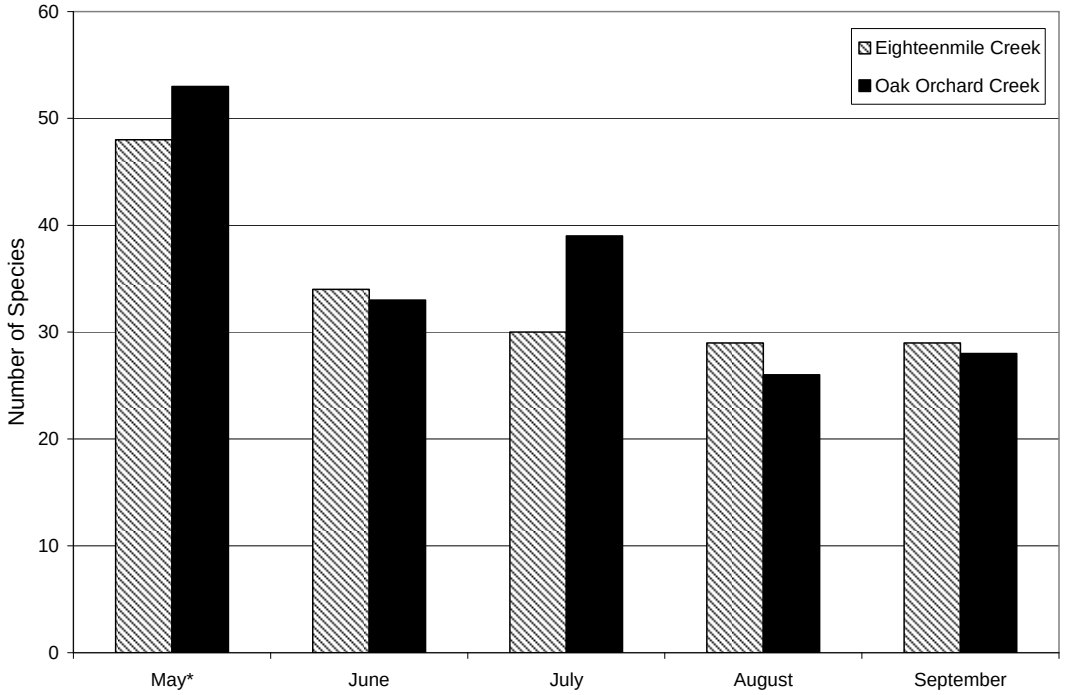
Marsh Monitoring Program Surveys

Marsh Monitoring Program (MMP) surveys were conducted at Eighteenmile Creek on June 14 and 28, 2007. A total of 278 birds representing 28 species were identified during the two surveys at the six Eighteenmile Creek point locations (see Table 3-10). Two hundred and fifty-six of the 278 birds observed were fly-overs; these birds were included in the analyses that follow. The most numerous species recorded were Red-winged Blackbird (85 birds) and Common Grackle (42 birds) (see Table C-2). By point location, the total number of birds on June 14 ranged from 21 to 30, with an average per point location of 26.3, and the total number of birds on June 28 ranged from nine to 29, with an average per point location of 20.0. On June 14, the total species per survey point location ranged from seven to 14, with an average of 11.0, and on June 28 the total species per survey point location ranged from four to nine, with an average per point location of 7.3. There were no observations of deformed or obviously sick or diseased birds at either of the creeks.



*The number of birds from the two May surveys were averaged.

Figure 3-3 The Total Number of Birds Observed during the Monthly Surveys at Eighteenmile Creek and Oak Orchard Creek



* The number of species from the two May surveys were combined so that additional species observed during the second survey were added to the species list.

Figure 3-4 The Total Number of Species of Birds Observed during the Monthly Surveys at Eighteenmile and Oak Orchard Creeks

Table 3-9 Summary of Morning Point Count Surveys for Birds by Date and by Point Location along Eighteenmile Creek and Oak Orchard Creek (2007)

	Location	5/5	5/19	6/29	7/23	8/19	9/17	Overall
Eighteenmile Creek								
Total Birds	A	35	47	43	27	33	18	**203**
	B	38	35	22	35	51	8	**189**
	C	43	33	31	26	76	15	**224**
	D	44	30	27	29	37	17	**184**
	E	38	34	20	33	22	23	**170**
	F	35	59	73	77	42	53	**339**
	Total	**233**	**238**	**216**	**227**	**261**	**134**	**1,309**
Species Count	A	17	15	20	15	10	11	**38**
	B	14	14	12	12	11	4	**33**
	C	11	14	12	11	16	5	**30**
	D	12	16	11	14	13	10	**40**
	E	14	15	10	16	10	13	**33**
	F	14	16	19	17	12	13	**40**
	Overall	**36**	**35**	**34**	**30**	**29**	**29**	**66**
Oak Orchard Creek								
Total Birds	1	27	28	37	46	18	51	**207**
	2	38	41	36	65	41	32	**253**
	3	47	44	51	39	37	13	**231**
	4	27	30	39	36	9	24	**165**
	5	32	30	48	32	33	42	**217**
	6	28	24	79	41	37	27	**236**
	Total	**199**	**197**	**290**	**259**	**175**	**189**	**1,309**
Species Count	1	14	15	21	15	9	16	**38**
	2	17	18	17	14	14	11	**35**
	3	17	15	18	18	12	6	**34**
	4	10	16	15	15	7	6	**38**
	5	15	19	14	14	9	9	**40**
	6	17	17	16	16	9	10	**44**
	Overall	**37**	**46**	**33**	**39**	**26**	**28**	**71**

MMP surveys were conducted at Oak Orchard Creek on June 12 and 27, 2007. A total of 263 birds representing 38 species were identified during the two surveys at the six Oak Orchard Creek point locations (see Table 3-10). Two hundred and twenty-one of the 263 birds observed were flyovers; these birds were included in the analyses that follow. The most numerous species recorded were Red-winged Blackbird (68 birds), Cedar Waxwing (20 birds), and American Robin (18 birds) (see Table C-2). By point location, the total number of birds on June 12 ranged from 17 to 37, with an average per point location of 25.0, and on June 27 the total number of birds ranged from nine to 37, with an average per point location of 18.8. On June 12, the total number of species per survey point location ranged from nine to 17, with an average of 11.7, and on June 27, the total number of species ranged from three to 13, with an average per point location of 8.5.

Species detected during the evening surveys that were not detected during the morning surveys include Common Yellowthroat at Eighteenmile Creek and Least Flycatcher, Eastern Kingbird, and Eastern Bluebird at Oak Orchard Creek.

Bird Species List and Threatened/Endangered Species

During the surveys and other activities (e.g., installation of traps, paddling between point locations) in the Project Area, E & E identified a total of 79 species at Eighteenmile Creek and 94 species at Oak Orchard Creek throughout the study period (see Table 3-11). Sixty-four of the species were detected at both creeks, 15 were detected only at Eighteenmile Creek, and 30 were detected only at Oak Orchard Creek (see Table 3-12). Canada Goose, Mute Swan, Wood Duck, and Mallard were observed throughout the study; other species of waterfowl were observed only in early spring and late summer. Migrants were detected primarily in May and early June. Species observed from late June to mid-August were believed to be breeding birds. Observations of Osprey were limited to August and September. The species identified during the study period were generally consistent with those species expected for the geographic area (E & E 2007). Table C-3 identifies species presence by survey point location.

Some of the differences in species present at each creek can be attributed to differences in habitat availability. Species such as the Virginia Rail, Sora, Common Moorhen, Marsh Wren, and Swamp Sparrow that are often associated with cattail marsh were observed only at Eighteenmile Creek (see Table 3-11). Although there was only approximately 1.5% more of the area in cattail marsh at Eighteenmile Creek compared to Oak Orchard Creek (see Table 3-1), the expanses of cattail marshes along Eighteenmile were much larger than those at Oak Orchard Creek and may provide more suitable habitat for these marsh-dwelling species. More neotropical migrants (Tennessee Warbler, Nashville Warbler, Northern Parula, Magnolia Warbler, Black-throated Blue Warbler, Bay-breasted Warbler, American Redstart, Hooded Warbler, Scarlet Tanager, and Indigo Bunting) were observed at Oak Orchard Creek than at Eighteenmile Creek, possibly due to the lack of residential development along the forested riparian corridor.

Six state-listed species were identified, and no federally listed species were identified (see Table 3-11). At Eighteenmile Creek, Osprey (special concern) and Cooper's Hawk (special concern) were observed. At Oak Orchard Creek, American Bittern (special concern), Osprey (special concern), Bald Eagle (threatened), Northern Harrier (threatened), and Red-shouldered Hawk (special concern) were observed.

Table 3-10 Summary of MMP Surveys for Birds by Date and by Point Location at Eighteenmile Creek and Oak Orchard Creek (2007)

	Point	6/14	6/28	Overall
Eighteenmile Creek				
Total Birds	A	30	16	**46**
	B	27	29	**56**
	C	28	28	**56**
	D	22	19	**41**
	E	21	19	**40**
	F	30	9	**39**
	Total	**158**	**120**	**278**
Species Total	A	12	8	**14**
	B	13	9	**14**
	C	8	9	**12**
	D	14	7	**16**
	E	7	7	**11**
	F	12	4	**13**
	Overall	**26**	**24**	**28**
Oak Orchard Creek				
Total Birds	1	19	9	**28**
	2	27	12	**39**
	3	37	37	**74**
	4	17	12	**29**
	5	21	23	**44**
	6	29	20	**49**
	Total	**150**	**113**	**263**
Species Total	1	9	3	**10**
	2	9	8	**13**
	3	12	13	**17**
	4	10	6	**13**
	5	13	10	**18**
	6	17	11	**21**
	Overall	**33**	**25**	**38**

Table 3-11 Summary of Bird Species Detected at Eighteenmile Creek and Oak Orchard Creek (2007)

Common Name	Eighteenmile Creek	Oak Orchard Creek
Canada Goose	X	X
Mute Swan	X	X
Wood Duck	X	X
Gadwall	-	X
American Wigeon	-	X
American Black Duck	X	X
Mallard	X	X
Blue-winged Teal	X	X
Greater Scaup	X	-
Lesser Scaup	-	X
Bufflehead	X	X
Common Goldeneye	X	X
Hooded Merganser	-	X
Common Merganser	-	X
Red-breasted Merganser	X	-
American Bittern (SC)	-	X
Great Blue Heron	X	X
Green Heron	X	X
Black-crowned Night Heron	X	-
Turkey Vulture	X	X
Osprey (SC)	X	X
Bald Eagle (T)	-	X
Northern Harrier (T)	-	X
Cooper's Hawk (SC)	X	-
Red-shouldered Hawk (SC)	-	X
Red-tailed Hawk	X	X
American Kestrel	-	X
Virginia Rail	X	-
Sora	X	-
Common Moorhen	X	-
American Coot	-	X
Killdeer	X	X
Greater Yellowlegs	-	X
Spotted Sandpiper	X	X
American Woodcock	X	-
Ring-billed Gull	X	X
Caspian Tern	X	-
Rock Pigeon	X	X
Mourning Dove	X	X
Great Horned Owl	-	X

Table 3-11 Summary of Bird Species Detected at Eighteenmile Creek and Oak Orchard Creek (2007)

Common Name	Eighteenmile Creek	Oak Orchard Creek
Chimney Swift	X	X
Ruby-throated Hummingbird	X	X
Belted Kingfisher	X	X
Red-bellied Woodpecker	X	X
Yellow-bellied Sapsucker	-	X
Downy Woodpecker	X	X
Hairy Woodpecker	-	X
Northern Flicker	X	X
Eastern Wood-Pewee	X	X
Least Flycatcher	X	X
Eastern Phoebe	X	X
Great Crested Flycatcher	X	X
Eastern Kingbird	X	-
Blue-headed Vireo	X	X
Warbling Vireo	X	X
Red-eyed Vireo	X	X
Blue Jay	X	X
American Crow	X	X
Purple Martin	X	X
Tree Swallow	X	X
Northern Rough-winged Swallow	X	X
Barn Swallow	X	X
Black-capped Chickadee	X	X
White-breasted Nuthatch	X	X
Brown Creeper	X	X
Carolina Wren	X	-
House Wren	X	X
Marsh Wren	X	-
Golden-crowned Kinglet	X	X
Ruby-crowned Kinglet	-	X
Eastern Bluebird	-	X
Swainson's Thrush	X	X
Wood Thrush	X	X
American Robin	X	X
Gray Catbird	X	X
European Starling	X	X
Cedar Waxwing	X	X
Tennessee Warbler	-	X
Nashville Warbler	-	X
Northern Parula	-	X

Table 3-11 Summary of Bird Species Detected at Eighteenmile Creek and Oak Orchard Creek (2007)

Common Name	Eighteenmile Creek	Oak Orchard Creek
Yellow Warbler	X	X
Chestnut-sided Warbler	X	X
Magnolia Warbler	-	X
Black-throated Blue Warbler	-	X
Yellow-rumped Warbler	X	X
Black-throated Green Warbler	X	X
Blackburnian Warbler	X	X
Pine Warbler	X	-
Bay-breasted Warbler	-	X
American Redstart	-	X
Ovenbird	X	X
Common Yellowthroat	X	X
Hooded Warbler	-	X
Scarlet Tanager	-	X
Chipping Sparrow	X	X
Song Sparrow	X	X
Swamp Sparrow	X	-
Dark-eyed Junco	-	X
Northern Cardinal	X	X
Rose-breasted Grosbeak	X	X
Indigo Bunting	-	X
Bobolink	X	-
Red-winged Blackbird	X	X
Eastern Meadowlark	-	X
Common Grackle	X	X
Brown-headed Cowbird	X	X
Baltimore Oriole	X	X
American Goldfinch	X	X
House Sparrow	-	X
Species Count	**79**	**94**

Key:
E = State-listed as endangered
T = Threatened
SC = Special concern

Table 3-12 Species Observed Only at Eighteenmile Creek or Oak Orchard Creek (2007)

Species Detected Only at Eighteenmile Creek	Species Detected Only at Oak Orchard Creek	
Greater Scaup	Gadwall	Ruby-crowned Kinglet
Red-breasted Merganser	American Wigeon	Eastern Bluebird
Black-crowned Night Heron	Lesser Scaup	Tennessee Warbler
Cooper's Hawk	Hooded Merganser	Nashville Warbler
Virginia Rail	Common Merganser	Northern Parula
Sora	American Bittern	Magnolia Warbler
Common Moorhen	Bald Eagle	Black-throated Blue Warbler
American Woodcock	Northern Harrier	Bay-breasted Warbler
Caspian Tern	Red-shouldered Hawk	American Redstart
Eastern Kingbird	American Kestrel	Hooded Warbler
Carolina Wren	American Coot	Scarlet Tanager
Marsh Wren	Greater Yellowlegs	Dark-eyed Junco
Pine Warbler	Great Horned Owl	Indigo Bunting
Swamp Sparrow	Yellow-bellied Sapsucker	Eastern Meadowlark
Bobolink	Hairy Woodpecker	House Sparrow

3.2.2 Mammals

As indicated in Section 2.2.2, observations of mammals within the subject creeks were recorded coincident with the bird and amphibian surveys. Nine mammal species were identified at Eighteenmile Creek, and 13 species were identified at Oak Orchard Creek (see Table 3-13). Nine species were identified at both creeks, and four species were identified only at Oak Orchard Creek. No threatened or endangered species were observed. There were no observations of deformed or obviously sick or diseased individuals at either of the creeks.

Table 3-13 Mammal Species Observations at Eighteenmile Creek and Oak Orchard Creek (2007)

Common Name	Eighteenmile Creek	Oak Orchard Creek
Bat Species	X	X
Beaver	X	X
Eastern Chipmunk	X	X
Gray Squirrel	X	X
Meadow Vole	-	X
Mouse (*Peromyscus* sp.)	-	X
Muskrat	X	X
Raccoon	X	X
Red Squirrel	X	X
Shrew Species	X	X
White-tailed Deer	X	X
Woodchuck	-	X
Unknown Small Mammal	-	X
Species Count	**9**	**13**

Species diversity appeared to be greater nearer to the dams at both creeks (see Table C-3). The species most frequently observed or heard along the entire length of both creeks was the eastern chipmunk. Commonly observed species within both stream corridors included beaver, gray squirrel, and red squirrel. Other species were observed at only a few locations along the creeks. For example, bats were primarily observed near the wooded areas in the vicinities of the dams at both creeks, and meadow voles were only found in the pitfall traps at Oak Orchard Creek at points 2 and 3, which were located on islands in the creek (see Section 3.2.3).

Generally, the diversity and overall numbers of wildlife species occurring within a given area are directly related to the number, size, and quality of the existing habitat types, and the degree to which land has been developed. Wildlife habitat contains a combination of resources (e.g., water, forage, cover) and environmental conditions (climate, temperature, predators, competitors) that promote the presence of certain species and allow for the relatively successful survival and reproduction of species over time (Morrison, Marcot, and Mannan 1998). An in-depth analysis of habitat structure, functions, and values were beyond the scope of this investigation. However, the slightly greater number of species observed along Oak Orchard Creek may be related to the larger overall area within which observations were made compared to the Eighteenmile Creek survey area. Additionally, there were minor differences in overall habitat structure and availability between the two study areas. Eighteenmile Creek is more characterized by a canyon or ravine environment where the walls are steep and rocky, which provides less habitat area for burrowing animals such as small mammals and woodchucks compared to Oak Orchard Creek.

3.2.3 Amphibians and Reptiles

Pitfall and Minnow Traps

Traps were open for a total of six nights at each creek (see Table 3-14). Individual traps were considered closed if a minnow trap was lost (i.e., vegetation occasionally made minnow traps difficult to find between surveys) or in the case of one trap, when the bucket popped out due to flooding and the hole collapsed.

Very few amphibians or reptiles were captured in the pitfall traps. One painted turtle was captured at Eighteenmile Creek (see Table 3-15). In addition, one shrew was captured in a pitfall trap at Eighteenmile Creek, but species identification could not be confirmed. At Oak Orchard Creek, two Eastern American toads were captured. Six meadow voles and two shrews (unknown species) also were found in the pitfall traps.

Table 3-14 Nights on Which Individual Traps Were Open (2007)

Eighteenmile Creek							
Location	**Trap Type**	**5/4-5/5**	**5/18-5/19**	**6/28-6/29**	**7/22-7/23**	**8/18-8/19**	**9/16-9/17**
A	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
B	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	C	X	X	X
C	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
D	Pitfall	X	C	C	C	C	C
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
E	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
F	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
Oak Orchard Creek							
Location	**Type**	**5/6-5/7**	**5/17-5/18**	**6/27-6/28**	**7/21-7/22**	**8/17-8/18**	**9/15-9/16**
1	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
2	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	C	R	X	X
3	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
4	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X
5	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	C	C	C	C
6	Pitfall	X	X	X	X	X	X
	Pitfall	X	X	X	X	X	X
	Minnow	X	X	X	X	X	X

Key:
C = Closed trap.
R = Replaced trap.
X = Trap was open.

A number of small fish of a variety of species, including bass, brown bullhead, crappie, round goby, minnows, red-ear sunfish, and other sunfish species, were found in the minnow traps (see Table 3-15). One crayfish and one snail were also found in the minnow traps at Eighteenmile Creek. At Oak Orchard Creek, one crayfish and one snail were captured. Five tadpoles of two species (leopard frog and green frog) were captured at Oak Orchard Creek, but only one bullfrog tadpole was captured at Eighteenmile Creek.

Overall, 26 animals of ten species were captured at Eighteenmile Creek, and 44 animals of 14 species were captured at Oak Orchard Creek (see Table 3-15). Seven species were captured at both creeks, four species were captured only at Eighteenmile Creek, and eight species were captured only at Oak Orchard Creek. No threatened or endangered species were captured.

Marsh Monitoring Program Surveys

Four frog and toad surveys were conducted at Eighteenmile Creek on May 4 and 18 and June 14 and 28, 2007, and four frog and toad surveys were conducted at Oak Orchard Creek on May 6 and 17 and June 12 and 27, 2007 (see Table C-4). During MMP surveys, 63 individuals of six species were identified at Eighteenmile Creek and 66 individuals of six species were identified at Oak Orchard Creek (see Table 3-16). More frogs and toads were identified in the middle portions of both creeks (survey point locations B, C, D, 2, 3, and 4) than elsewhere. Few or individual frogs or toads were heard more often than larger groups of frogs or toads during surveys, and very few full choruses were detected (see Table 3-17). The most common species at both creeks were spring peeper, green frog, and bullfrog.

Amphibian and Reptile Species List and Threatened/Endangered Species

During trapping, surveys, and other activities in the Project Area (e.g., installation of traps, paddling between point locations), a total of 11 amphibian or reptile species were observed or heard at Eighteenmile Creek and 12 amphibian or reptile species were observed or heard at Oak Orchard Creek (see Table 3-18). No federally or state-listed species were identified.

Table 3-15 Summary of Species Captured in Pitfall and Minnow Traps at Eighteenmile Creek and Oak Orchard Creek in 2007

Eighteenmile Creek													
	5/5		5/19		6/29		7/23		8/19		9/17		
Common Name[1]	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Total
Bass	-	-	-	-	-	-	-	-	-	2	-	-	**2**
Bullfrog	-	-	-	-	-	1	-	-	-	-	-	-	**1**
Crappie	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Crayfish	-	-	-	-	-	-	-	-	-	3	-	-	**3**
Goby	-	-	-	1	-	-	-	1	-	7	-	1	**10**
Minnow	-	1	-	-	-	-	-	-	-	2	-	-	**3**
Painted Turtle	-	-	-	-	-	-	-	-	-	-	1	-	**1**
Shrew	-	-	-	-	-	-	1	-	-	-	1	-	**2**
Snail	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Sunfish	-	-	-	-	-	-	-	-	-	-	-	2	**2**
Grand Total	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**0**	**16**	**2**	**3**	**26**
Species Count	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**0**	**6**	**2**	**2**	**10**

Table 3-15 Summary of Species Captured in Pitfall and Minnow Traps at Eighteenmile Creek and Oak Orchard Creek in 2007

Oak Orchard Creek													
	5/7		5/18		6/28		7/22		8/18		9/16		
Common Name[1]	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Pitfall	Minnow	Total
American Toad	-	-	-	-	2	-	-	-	-	-	-	-	**2**
Bass	-	-	-	-	-	-	-	1	-	1	-	1	**3**
Bass/sunfish?	-	2	-	-	-	-	-	-	-	-	-	-	**2**
Brown Bullhead	-	-	-	2	-	-	-	5	-	-	-	1	**8**
Crappie	-	-	-	-	-	-	-	-	-	-	-	1	**1**
Crayfish	-	-	-	-	-	1	-	-	-	-	-	-	**1**
Goby	-	-	-	1	-	-	-	-	-	-	-	1	**2**
Green Frog	-	2	-	-	-	-	-	2	-	-	-	-	**4**
Leopard Frog	-	-	-	-	-	-	-	1	-	-	-	-	**1**
Meadow Vole	-	-	1	-	1	-	2	-	1	-	1	-	**6**
Minnow	-	2	-	5	-	-	-	-	-	-	-	-	**8**
Redear Sunfish	-	-	-	-	-	-	-	-	-	-	-	1	**1**
Shrew	-	-	-	-	2	-	-	-	-	-	-	-	**2**
Sunfish	-	-	-	-	-	-	-	-	-	-	-	2	**2**
Waterbug	-	1	-	-	-	-	-	-	-	-	-	-	**1**
Grand Total	**0**	**7**	**1**	**8**	**5**	**1**	**2**	**9**	**1**	**1**	**1**	**7**	**44**
Species Count	**0**	**4**	**1**	**3**	**3**	**1**	**1**	**4**	**1**	**1**	**1**	**6**	**14**

[1] Species in bold were observed in only one creek.

Table 3-16 Summary of MMP Surveys for Frogs and Toads by Date and by Point Location at Eighteenmile Creek and Oak Orchard Creek (2007)

Eighteenmile Creek						
	Point	**5/4**	**5/18**	**6/14**	**6/28**	**Overall**
Total Frogs/ Toads	A	0	0	1	1	2
	B	4	5	3	1	13
	C	7	3	3	5	18
	D	6	4	3	4	17
	E	1	1	3	4	9
	F	1	0	0	3	4
	Total	**19**	**13**	**13**	**18**	**63**
Species	A	0	0	1	1	2
	B	1	2	3	1	4
	C	3	1	3	2	5
	D	3	2	3	2	5
	E	1	1	3	2	4
	F	1	0	0	2	3
	Overall	**3**	**3**	**4**	**2**	**6**
Oak Orchard Creek						
Point	**Point**	**5/6**	**5/17**	**6/12**	**6/27**	**Overall**
Total Frogs/ Toads	1	0	0	3	4	7
	2	0	6	3	2	11
	3	0	4	2	7	13
	4	6	3	2	9	20
	5	1	2	3	3	9
	6	3	0	3	0	6
	Total	**10**	**15**	**16**	**25**	**66**
Species	1	0	0	1	1	1
	2	0	2	3	2	6
	3	1	1	2	3	4
	4	2	1	2	3	4
	5	1	1	3	2	4
	6	1	0	3	0	4
	Overall	**2**	**2**	**3**	**3**	**6**

Table 3-17 Species, Number of Individuals, and Call Level Code for Frogs Detected at Eighteenmile Creek and Oak Orchard Creek (2007)

Common Name	Eighteenmile Creek				Oak Orchard Creek			
	Code				Code			
	1	2	3	Total	1	2	3	Total
American Toad	4	-	-	**4**	1	-	-	**1**
Gray Tree Frog	1	1	-	**2**	1	2	-	**3**
Green Frog	14	3	-	**17**	17	3	1	**21**
Spring Peeper	3	22	-	**25**	6	17	0	**23**
Bullfrog	10	1	1	**12**	7	-	4	**11**
Pickerel Frog	1	2	-	**3**	-	-	-	**0**
Leopard Frog	-	-	-	**0**	7	-	-	**7**
Grand Total	**33**	**29**	**1**	**63**	**39**	**22**	**5**	**66**

Key:
Code 1 = Individuals can be counted; calls not simultaneous.
Code 2 = Calls distinguishable; some simultaneous calling.
Code 3 = Full chorus; calls continuous and overlapping.

Table 3-18 Summary of Reptile and Amphibian Species Identified at Eighteenmile Creek and Oak Orchard Creek (2007)

Common Name	Eighteenmile Creek	Oak Orchard Creek
Amphibians		
Bullfrog	X	X
Eastern American Toad	X	X
Gray Treefrog	X	X
Green Frog	X	X
Northern Leopard Frog	X	X
Northern Redback Salamander	X	-
Northern Spring Peeper	X	X
Pickerel Frog	X	X
Wood Frog	X	X
Reptiles		
Common Snapping Turtle	-	X
Diamondback Terrapin	-	X
Northern Watersnake	X	X
Painted Turtle	X	X
Species Count	**11**	**12**

3.2.4 Summary of Similarities and Differences Between Study Areas

The wildlife survey results suggest that the species assemblages at the two creeks are similar, implying that both creeks are equally capable of providing the ecological services (e.g., food, shelter, nesting sites) needed by the bird and mammal species typically found in this part of New York State. The number of species observed at the two creeks throughout the season was similar, but a greater diversity of species was observed at Oak Orchard Creek (i.e., 15 more bird species, four more mammal species, and one more amphibian/reptile species) than at Eighteenmile Creek. In addition, greater numbers of tadpoles were observed at Oak Orchard Creek, possibly indicating better water quality; however, very few amphibians were observed overall, and this apparent difference between creeks may simply be an artifact of sampling. The species assemblages were also similar at the two creeks. A slightly greater diversity of waterfowl, raptors, and neotropical migrants were observed at Oak Orchard Creek.

The differences observed in species assemblages can mostly be attributed to differences in habitat availability. Overall, the two study areas were found to be comprised of similar cover types, with a few minor exceptions. The area evaluated immediately adjacent to Eighteenmile Creek is characterized by more areas of cattail marsh, developed (residential), and early successional habitat compared to Oak Orchard Creek, whereas Oak Orchard is characterized by areas containing agricultural land, open water, and a large golf course. Both creeks have similar amounts of surrounding forested land and orchard/vineyard habitat.

Amphibian values from 2007 may not be typical. The spring and summer of 2007 were particularly dry, which may have limited frog/toad calling rates and breeding. Further, very little immigration or emigration was detected, as indicated by the limited number of amphibians caught in the pitfalls traps, which also may be a result of the dry weather. In terms of the numbers of frogs detected, the instability of nighttime temperatures in the spring may have affected when frogs and toads were calling. In spite of the dry and unstable weather conditions, most of the species expected for this area of New York State were identified.

The similarity of wildlife, in terms of numbers and species, detected at both creeks and the relatively high diversity of species indicates that Eighteenmile Creek likely offers habitat of similar quality as Oak Orchard Creek.

3.3 Bullhead Chemical Residue Data and Ecological Risk Evaluation

In August 2007, eight brown bullheads were collected from both Eighteenmile and Oak Orchard creeks and analyzed for PCBs. Two bullheads from each creek also were analyzed for dioxins/furans. The data were collected to: (1) determine whether levels of PCBs and dioxins/furans in bullheads from Eighteenmile Creek are elevated compared with the levels in bullheads from Oak Orchard Creek; (2) determine whether these chemicals pose a potential risk to bullheads in these creeks; and (3) determine whether these chemicals pose a potential risk to fish-

eating birds and mammals at these creeks. These three topics are discussed in turn below.

3.3.1 Chemical Residues in Bullhead

Whole-body concentrations of Aroclors 1248, 1254, and 1260 and total PCBs were an order of magnitude greater in brown bullheads from Eighteenmile Creek compared with the levels in brown bullheads from Oak Orchard Creek (see Table 3-19). The less-chlorinated PCB Aroclors (1016, 1221, 1232, and 1242) were not detected in bullheads from either creek (see Appendix D). Whole-body concentrations of dioxins/furans (expressed as the TCDD toxic equivalent [TEQ]) in bullheads from Eighteenmile Creek were approximately five times greater than in bullheads from Oak Orchard Creek (see Table 3-20).

Elevated levels of PCBs and dioxins/furans in bullheads from Eighteenmile Creek probably are the result of historic industrial activities in the upstream reaches of the creek near Lockport, New York (NYSDEC 2006; EEEPC 2007a). These historic activities have resulted in elevated sediment concentrations of PCBs and dioxins in the lower reaches of Eighteenmile Creek, and these contaminants have been shown to be bioavailable in laboratory bioaccumulation studies (USACE 2004). The bullhead data collected for this study also indicate that sediment contaminants in the lower reaches of Eighteenmile Creek are bioavailable.

The principal Aroclor detected in the bullhead samples collected for this investigation was 1248 (see Table 3-19). Interestingly, Aroclor 1248 was the principal Aroclor found in sediment in lower Eighteenmile Creek by USACE (2008) and one of the principal Aroclors found in sediment in upper Eighteenmile Creek near Lockport (EEPC 2007a). Hence, it appears that the fish in Eighteenmile Creek are accumulating the principal Aroclor present in the system.

3.3.2 Risk Evaluation for the Brown Bullhead

Potential risks to bullheads from PCBs and dioxins/furans were assessed by comparing the measured whole-body concentrations of these chemicals with critical tissue concentrations from the literature. The following critical tissue concentrations were used:

- PCBs (all Aroclors): 440 micrograms per kilogram (µg/kg) wet weight (Dyer et al. 2000); and

- 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD): 72 nanograms per kilogram (ng/kg) wet weight (Windward 2004).

Whole-body concentrations of Aroclors 1248 and 1254 and total PCBs in bullheads from Eighteenmile Creek often exceeded the PCB critical tissue concentration (see shaded values in Table 3-19). No sample from Oak Orchard Creek exceeded the PCB critical tissue concentration. In both Eighteenmile Creek and

Table 3-19 Whole-Body PCB Concentrations in Brown Bullheads from Eighteenmile and Oak Orchard Creeks

Location	Sample1	Aroclor 1248		Aroclor 1254		Aroclor 1260		Total PCBs		Percent Lipids
		ug/kg wet	ug/g lipid	ug/kg wet	ug/g lipid	ug/kg wet	ug/g lipid	ug/kg wet	ug/g lipid	
Eighteenmile Creek	EMC-01-BB-LP	2000	50	960	24	230	5.8	3200	80	3.98
	EMC-05-BB-LP	1200	46	440	17	120	4.6	1800	69	2.6
	EMC-07-BB-LP	650	50	230	18	57	4.4	890	69	1.29
	EMC-18-BB-LP	2300	87	1400	53	380	14	3700	140	2.65
	EMC-19-BB-LP	4100	74	2000	36	570	10	6100	111	5.52
	EMC-25-BB-LP	3200	67	1500	31	380	7.9	4700	98	4.79
	EMC-31-BB-LP	1000	57	350	20	95	5.4	1400	80	1.76
	EMC-34-BB-LP	2700	82	1400	43	380	12	4100	125	3.29
	Minimum	650	46	230	17	57	4.4	890	69	1.29
	Maximum	4100	87	2000	53	570	14	6100	140	5.52
	Average	**2144**	**64**	**1035**	**30**	**277**	**8.0**	**3236**	**96**	**3.24**
Oak Orchard Creek	OOC-07-BB-LP	23	0.76	62	2.0	37	1.2	120	3.9	3.04
	OOC-08-BB-LP	19	0.59	35	1.1	28	0.88	63	2.0	3.2
	OOC-09-BB-LP	33	0.92	73	2.0	64	1.8	170	4.7	3.58
	OOC-16-BB-LP	30	0.77	50	1.3	31	0.79	110	2.8	3.91
	OOC-19-BB-LP	26	0.92	84	3.0	61	2.1	170	6.0	2.84
	OOC-28-BB-LP	43	0.74	100	1.7	66	1.1	210	3.6	5.84
	OOC-31-BB-LP	35	0.90	97	2.5	59	1.5	190	4.9	3.88
	OOC-38-BB-LP	71	1.18	230	3.8	160	2.6	460	7.6	6.04
	Minimum	19	0.59	35	1.1	28	0.79	63	2.0	2.84
	Maximum	71	1.18	230	3.8	160	2.6	460	7.6	6.04
	Average	**35**	**0.85**	**91**	**2.2**	**63**	**1.5**	**187**	**4.4**	**4.04**
EMC versus OOC	Mann-Whitney U Statistic	64	64	63.5	64	57	64	64	64	21
	Probability	0.001	0.001	0.001	0.001	0.008	0.001	0.001	0.001	0.248
	Significantly Different?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**

Key:
EMC = Eighteenmile Creek
OOC = Oak Orchard Creek
PCB = Polychloroinated biphenyl
ug/kg wet = microgram per kilogram wet weight
ug/g lipid = microgram per gram lipid

Notes:
1. Aroclors 1016, 1221, 1232, and 1242 were undetected in all bullhead samples from both creeks (see Appendix D [Analytical Data]).
2. Shading = Sample concentration equals or exceeds critical tissue concentration (440 ug/kg for all aroclors; Dyer et al. 2000) for effects on fish.

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Table 3-19.xls-2/14/2008

Table 3-20 Whole-Body Dioxin/Furan Concentrations in Brown Bullheads from Eighteenmile and Oak Orchard Creeks

Location	Sample[1]	TCDD TEQ (Fish)[2]		TCDD TEQ (Mammalian)[2]		TCDD TEQ (Avian)[2]		Percent Lipids
		ng/kg wet[3]	ng/kg lipid	ng/kg wet	ng/kg lipid	ng/kg wet	ng/kg lipid	
Eighteenmile Creek	EMC-01-BB-LP	-	-	-	-	-	-	3.98
	EMC-05-BB-LP	-	-	-	-	-	-	2.6
	EMC-07-BB-LP	-	-	-	-	-	-	1.29
	EMC-18-BB-LP	-	-	-	-	-	-	2.65
	EMC-19-BB-LP	7.5	136	6.3	114	16.9	306	5.52
	EMC-25-BB-LP	5.2	109	4.8	100	10.8	224	4.79
	EMC-31-BB-LP	-	-	-	-	-	-	1.76
	EMC-34-BB-LP	-	-	-	-	-	-	3.29
Oak Orchard Creek	OOC-07-BB-LP	-	-	-	-	-	-	3.04
	OOC-08-BB-LP	-	-	-	-	-	-	3.2
	OOC-09-BB-LP	1.0	27.9	0.95	26.5	1.76	49.2	3.58
	OOC-16-BB-LP	-	-	-	-	-	-	3.91
	OOC-19-BB-LP	-	-	-	-	-	-	2.84
	OOC-28-BB-LP	0.74	12.7	0.69	11.8	1.59	27.2	5.84
	OOC-31-BB-LP	-	-	-	-	-	-	3.88
	OOC-38-BB-LP	-	-	-	-	-	-	6.04

Key:
- (dash) = not analyzed
EMC = Eighteenmile Creek
ng/kg wet = nanogram per kilogram wet weight
ng/kg lipid = nanogram per kilogram lipid
NOAEL = no observed adverse effect level
OOC = Oak Orchard Creek
TCDD = 2,3,7,8-tetrachlorodibenzo-p-dioxin
TEQ = toxic equivalent
TEF = toxic equivalency factor

Notes:
[1] Only two fish from each creek were analyzed for dioxins/furans. See Appendix D for congener-specific concentrations.
[2] Fish and avian TEFs were taken from Van den Berg (1998). Mammalian TEFs were taken from Van den Berg (2006). See text for further explanation.
[3] No samples exceeded the TCDD, NOAEL-based, critical tissue concentration (72 ng/kg, Windward 2004) for effects on fish.

Oak Orchard Creek, whole-body concentrations of dioxins/furans in bullheads were well below the critical tissue concentration (see Table 3-20). Overall, these results suggest that bullheads from Eighteenmile Creek may be at risk from elevated tissue residues of PCBs but not from dioxins/furans. These chemicals pose no risks to fish in Oak Orchard Creek.

3.3.3 Risk Evaluation for Fish-Eating Wildlife

Potential ecological risks to fish-eating wildlife from PCBs and dioxins/furans were assessed in accordance with accepted ecological risk assessment guidance (EPA 1993; Sample and Suter 1996). In brief, the bullhead data for total PCBs and dioxins/furans collected for this study were used to estimate exposure and risk for the great blue heron (*Ardea herodias*) and mink (*Mustela vison*), two wildlife species known to use lower Eighteenmile Creek and Oak Orchard Creek.

3.3.3.1 Heron and Mink Exposure to PCBs and Dioxins/Furans

Dietary exposure for the heron and mink was estimated separately for Eighteenmile Creek and Oak Orchard Creek using the following equation:

$$EE_{diet} = (C_f \times IR/BW) \times SUF \times ED$$

where:

EE_{diet} = estimated exposure from diet (mg/kg-day);
C_f = chemical concentration in fish (mg/kg wet weight);
IR = ingestion rate of receptor (kg/day wet weight);
BW = body weight of receptor (kg);
SUF = site use factor (unit-less); and
ED = exposure duration (unit-less), equal to fraction of year spent at site.

The SUF is the portion of a receptor's home range represented by the site. For this analysis, it was assumed that mink and heron at Eighteenmile Creek use only Eighteenmile Creek to satisfy their food and habitat needs, and those at Oak Orchard Creek use only Oak Orchard Creek. Hence, the SUF was set equal to 1 for the mink and heron at both creeks. Exposure duration (ED) is the percentage of the year spent at the site by the receptor species. A value of 1 (year-round resident) was assumed for the mink and 0.5 was assumed for the heron to account for the migratory nature of this species. The exposure parameters and estimated dietary exposure for the heron and mink for total PCBs are presented in Tables 3-21 and 3-22, respectively. Tables 3-23 and 3-24 present analogous information for dioxin/furans for the heron and mink, respectively.

Wildlife also may be exposed to chemicals through drinking contaminated surface water and by incidental ingestion of contaminated sediment. These exposure routes were not quantitatively evaluated in this assessment because they typically account for only a negligible portion of total chemical exposure for piscivorous wildlife, especially for highly bioaccumulative contaminants (Sample et al. 1998).

Table 3-21 Risk Analysis for Total PCBs for Great Blue Heron at Eighteenmile and Oak Orchard Creeks

Parameter	Units	Value	References and Notes
Heron Exposure Factors			
Body Weight (BW)	kg	2.23	USEPA (1993) for herons in eastern North America.
Food Ingestion Rate (FIR)	kg/d (wet wt.)	0.31	Calculated from body weight using allometric equation for all birds USEPA (1993) assuming 68% food moisture content.
Site Use Factor (SUF)	unitless	1	Assumed value of 1 implies that herons at EMC forage only at EMC and that herons at OOC forage only at OOC.
Exposure Duration (ED)	unitless	0.5	Assumed based on migratory nature of this species.
Avian Toxicity Reference Values			
Chronic NOAEL	mg/kg-day	0.18	Dahlgren et al. (1972) as cited in Sample et al. (1996); based on reproductive-effects study with ring-necked pheasants with Aroclor 1254.
Chronic LOAEL	mg/kg-day	1.8	Dahlgren et al. (1972) as cited in Sample et al. (1996); based on reproductive-effects study with ring-necked pheasants with Aroclor 1254.
Heron Exposure and Risk - Eighteenmile Creek			
Diet	Percent	100	Fish from Eighteenmile Creek assumed to be sole food source.
Fish PCB Concentration	mg/kg (wet wt.)	4.43	95 percent upper confidence limit on the arithmetic average concentration for eight samples listed in Table 3.3.1 as calculated by ProUCL verision 4 from USEPA .
Estimated Exposure from Diet	mg/kg-day	0.30	((Fish PBC Concentration) x FIR / BW) x SUF x ED
HQ-NOAEL	unitless	1.7	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.17	Estimated Exposure from Diet / LOAEL
Heron Exposure and Risk - Oak Orchard Creek			
Diet	Percent	100	Fish from Oak Orchard Creek assumed to be sole food source.
Fish PCB Concentration	mg/kg (wet wt.)	0.29	95 percent upper confidence limit on the arithmetic average concentration for eight samples listed in Table 3.3.1 as calculated by ProUCL verision 4 from USEPA.
Estimated Exposure from Diet	mg/kg-day	0.020	((Fish PBC Concentration x FIR) / BW) x SUF X ED
HQ-NOAEL	unitless	0.11	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.01	Estimated Exposure from Diet / LOAEL

Key:
BW = body weight
EMC = Eighteenmile Creek
FIR = food ingestion rate
HQ = hazard quotient
LOAEL = lowest observed adverese effect level
NOAEL = no observed adverse effect level
OOC = Oak Orchard Creek
PCBs = polychlorinated biphenyls
shading = HQ exceeds 1.0 (see Section 3.3.3.2 for further explanation).

Table 3-22 Risk Analysis for Total PCBs for Mink at Eighteenmile and Oak Orchard Creeks

Parameter	Units	Value	References and Notes
Mink Exposure Factors			
Body Weight (BW)	kg	0.974	USEPA (1999).
Food Ingestion Rate (FIR)	kg/d (wet wt.)	0.21	Calculated from body weight using allometric equation for all mammals USEPA (1993) assuming 68% food moisture content.
Site Use Factor (SUF)	unitless	1	Assumed value of 1 implies that mink at EMC forage only at EMC and that mink at OOC forage only at OOC.
Exposure Duration (ED)	unitless	1	Year-round resident.
Mammlian Toxicity Reference Values			
Chronic NOAEL	mg/kg-day	0.14	Aulerich and Ringer (1977) as cited in Sample et al. (1996); based on reproductive-effects study with mink with Aroclor 1254.
Chronic LOAEL	mg/kg-day	0.69	Aulerich and Ringer (1977) as cited in Sample et al. (1996); based on reproductive-effects study with mink with Aroclor 1254.
Mink Exposure and Risk - Eighteenmile Creek			
Diet	Percent	100	Fish from Eighteenmile Creek assumed to be sole food source.
Fish PCB Concentration	mg/kg (wet wt.)	4.43	95 percent upper confidence limit on the arithmetic average concentration for eight samples listed in Table 3.3.1 as calculated by ProUCL verision 4 from USEPA.
Estimated Exposure from Diet	mg/kg-day	0.95	((Fish PBC Concentration x FIR) / BW) x SUF x ED
HQ-NOAEL	unitless	6.8	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	1.4	Estimated Exposure from Diet / LOAEL
Mink Exposure and Risk - Oak Orchard Creek			
Diet	Percent	100	Fish from Oak Orchard Creek assumed to be sole food source.
Fish PCB Concentration	mg/kg (wet wt.)	0.29	eight samples listed in Table 3.3.1 as calculated by ProUCL verision 4 from USEPA.
Estimated Exposure from Diet	mg/kg-day	0.062	((Fish PBC Concentration x FIR) / BW) x SUF x ED
HQ-NOAEL	unitless	0.44	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.09	Estimated Exposure from Diet / LOAEL

Key:
BW = body weight
EMC = Eighteenmile Creek
FIR = food ingestion rate
HQ = hazard quotient
LOAEL = lowest observed adverese effect level
NOAEL = no observed adverse effect level
OOC = Oak Orchard Creek
PCB = polychlorinated biphenyl
shading = HQ exceeds 1.0 (see Section 3.3.3.2 for further explanation)

Table 3-23 Risk Analysis for Dioxins/Furans for Great Blue Heron at Eighteenmile and Oak Orchard Creeks

Parameter	Units	Value	References and Notes
Heron Exposure Factors			
Body Weight (BW)	kg	2.23	USEPA (1993) for herons in eastern North America.
Food Ingestion Rate (FIR)	kg/d (wet wt.)	0.31	Calculated from body weight using allometric equation for all birds USEPA (1993) assuming 68% food moisture content.
Site Use Factor (SUF)	unitless	1	Assumed value of 1 implies that herons at EMC forage only at EMC and that herons at OOC forage only at OOC.
Exposure Duration (ED)	unitless	0.5	Assumed based on migratory nature of this species.
Avian Toxicity Reference Values			
Chronic NOAEL	mg/kg-day	0.000014	Nosek et al. (1992) as cited in Sample et al. (1996); based on reproductive-effects study with ring-necked pheasants with 2,3,7,8-TCDD.
Chronic LOAEL	mg/kg-day	0.00014	Nosek et al. (1992) as cited in Sample et al. (1996); based on reproductive-effects study with ring-necked pheasants with 2,3,7,8-TCDD.
Heron Exposure and Risk - Eighteenmile Creek			
Diet	Percent	100	Fish from Eighteenmile Creek assumed to be sole food source.
Fish Dioxin/Furan Concentration	mg/kg (wet wt.)	0.0000169	Maximum TCDD TEQ (avian) for bullhead from Eighteenmile Creek (Table 3.3.2)
Estimated Exposure from Diet	mg/kg-day	0.0000012	((Fish dioxin/furan concentration x FIR) / BW) x SUF x ED
HQ-NOAEL	unitless	0.08	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.01	Estimated Exposure from Diet / LOAEL
Heron Exposure and Risk - Oak Orchard Creek			
Diet	Percent	100	Fish from Oak Orchard Creek assumed to be sole food source.
Fish Dioxin/Furan Concentration	mg/kg (wet wt.)	0.0000018	Maximum TCDD TEQ (avian) for bullhead from Oak Orchard Creek (Table 3.3.2)
Estimated Exposure from Diet	mg/kg-day	0.00000012	((Fish dioxin/furan concentration x FIR) / BW) x SUF x ED
HQ-NOAEL	unitless	0.009	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.001	Estimated Exposure from Diet / LOAEL

Key:
BW = body weight
EMC = Eighteenmile Creek
FIR = food ingestion rate
HQ = hazard quotient
LOAEL = lowest observed adverese effect level
NOAEL = no observed adverse effect level
OOC = Oak Orchard Creek
TCDD TEQ (avian) = 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalent concentration (based on avian TEFs)
TEF = toxic equivalency factor

Table 3-24 Risk Analysis for Dioxins/Furans for Mink at Eighteenmile and Oak Orchard Creeks

Parameter	Units	Value	References and Notes
Mink Exposure Factors			
Body Weight (BW)	kg	0.974	USEPA (1999).
Food Ingestion Rate (FIR)	kg/d (wet wt.)	0.21	Calculated from body weight using allometric equation for all mammals USEPA (1993) assuming 68% food moisture content.
Site Use Factor (SUF)	unitless	1	Assumed value of 1 implies that mink at EMC forage only at EMC and that mink at OOC forage only at OOC.
Exposure Duration (ED)	unitless	1	Year-round resident.
Mammlian Toxicity Reference Values			
Chronic NOAEL	mg/kg-day	0.000001	Murray et al. (1979) as cited in Sample et al. (1996); based on reproductive-effects study with rats with 2,3,7,8-TCDD.
Chronic LOAEL	mg/kg-day	0.00001	Murray et al. (1979) as cited in Sample et al. (1996); based on reproductive-effects study with rats with 2,3,7,8-TCDD.
Mink Exposure and Risk - Eighteenmile Creek			
Diet	Percent	100	Fish from Eighteenmile Creek assumed to be sole food source.
Fish PCB Concentration	mg/kg (wet wt.)	0.0000063	Maximum TCDD TEQ (mammalian) for bullhead from Eighteenmile Creek (Table 3.3.2)
Estimated Exposure from Diet	mg/kg-day	0.0000014	((Fish dioxin/furan concentration x FIR) / BW) x SUF x ED
HQ-NOAEL	unitless	1.4	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.14	Estimated Exposure from Diet / LOAEL
Mink Exposure and Risk - Oak Orchard Creek			
Diet	Percent	100	Fish from Oak Orchard Creek assumed to be sole food source.
Fish PCB Concentration	mg/kg (wet wt.)	0.0000010	Maximum TCDD TEQ (mammalian) for bullhead from Oak Orchard Creek (Table 3.3.2)
Estimated Exposure from Diet	mg/kg-day	0.0000002	((Fish dioxin/furan concentration x FIR) / BW) x SUF x ED
HQ-NOAEL	unitless	0.20	Estimated Exposure from Diet / NOAEL
HQ-LOAEL	unitless	0.02	Estimated Exposure from Diet / LOAEL

Key:
BW = body weight
EMC = Eighteenmile Creek
FIR = food ingestion rate
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
OOC = Oak Orchard Creek
shading = HQ exceeds 1.0 (see Section 3.3.3.2 for further explanation)
TCDD TEQ (mammalian) = 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalent (based on mammalian TEFs)
TEF = toxic equivalency factor.

3.3.3.2 Heron and Mink Risks from PCBs and Dioxins/Furans

The potential risks posed by PCBs and dioxins/furans were estimated by calculating a hazard quotient (HQ) for each receptor and chemical group. The HQ was calculated by dividing dietary exposure (EE_{diet}) by a no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL), as shown in the following equations:

$$HQ_{NOAEL} = EE_{diet}/NOAEL$$

$$HQ_{LOAEL} = EE_{diet}/LOAEL$$

For a given receptor and chemical, an HQ_{NOAEL} greater than 1 indicates that the estimated exposure exceeds the highest dose at which no adverse effect was observed. Such a result does not imply that the receptor is at risk, especially if the HQ_{NOAEL} is only marginally above 1. An HQ_{LOAEL} greater than 1 suggests that a chronic adverse affect is possible to an individual receptor, assuming that the estimated exposure for that receptor is accurate. For both the heron and mink, the NOAEL and LOAEL used in this assessment are based on a reproductive-effects study (see Tables 3-21 to 3-24 under mammalian and avian toxicity reference values). Hence, the resulting HQs for the heron and mink relate directly to the potential for reproductive impairment, or lack thereof, in the study areas.

Table 3-25 lists the HQs for the heron and mink at Eighteenmile Creek and Oak Orchard Creek. At Oak Orchard Creek, neither PCBs nor dioxins/furans pose a risk to the heron or mink, as all HQs are less than 1. Mink and heron exposure to total PCBs and dioxins/furans at Eighteenmile Creek is greater than at Oak Orchard Creek (see exposure estimate in Tables 3-21 to 3-24), and this difference is reflected in the magnitude of the HQs in Table 3-25, many of which exceed 1 at Eighteenmile Creek. Most importantly, the HQ_{LOAEL} for the mink for total PCBs exceeds 1 at Eighteenmile Creek, suggesting that mink reproduction at Eighteenmile Creek may be adversely impacted by PCBs. The heron at Eighteenmile Creek does not appear to be at risk from either total PCBs or dioxins/furans. Although the heron HQ_{NOAEL} for PCBs marginally exceeds 1 (see Table 3-25), this results does not necessarily indicate that the heron is at risk, for the reason noted above.

Table 3-25 Summary of Heron and Mink Hazard Quotients for Total PCBs and Dioxins/Furans at Eighteenmile and Oak Orchard Creeks

Receptor	Chemical	HQ_{NOAEL}	HQ_{LOAEL}
Eighteenmile Creek			
Heron	Total PCBs	1.7	0.17
	Dioxins/Furans	0.08	0.01
Mink	Total PCBs	6.8	1.4
	Dioxins/Furans	1.4	0.14
Oak Orchard Creek			
Heron	Total PCBs	0.11	0.01
	Dioxins/Furans	0.009	0.001
Mink	Total PCBs	0.44	0.09
	Dioxins/Furans	0.20	0.02

Key:
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
PCBs = polychlorinated biphenyls

Note:
[1] HQ_{NOAEL} and HQ_{LOAEL} are from Tables 3-21 to 3-24.
[2] Shading = HQ exceeds 1. See Section 3.3.3.2 for further explanation.

3.3.3.3 Uncertainty Evaluation

It is common in risk assessments to indicate the main uncertainties affecting the exposure and risk estimates and indicate whether they would tend to under- or over-estimate exposure and risk. The main uncertainties associated with the risk evaluation presented in this section are described below:

- **Chemical Concentrations in Prey.** Measured concentration of total PCBs and dioxins/furans in brown bullheads were used to estimate dietary exposure to the heron and mink. Using these data in the risk evaluation eliminated the uncertainty associated with using modeling approaches to predict chemical concentrations in the prey of these receptors. However, the bullheads analyzed for this study were 9 to 12 inches in length and, therefore, would be considered large prey, particularly for the heron. In reality, the heron and other piscivorous birds in the study areas probably consume smaller fish from various species. Using only data for 9- to 12-inch bullheads in the risk evaluation likely overestimates exposure and risk for the heron because smaller forage fish typically contain lower levels of bioaccumulative contaminants.

- **Diet Composition.** The diet of the heron and mink were conservatively assumed to consist entirely of fish. For the heron, this assumption seems reasonable. However, mink consume other prey, including meadow voles, muskrats, and ducklings (EPA 1993), all of which would be expected to contain lower levels of sediment contaminants than bullheads. Therefore, assuming that mink consume only bullheads likely overestimates their exposure and risk in the study areas.

- **Site Use.** Both the heron and mink were assumed to acquire all of their prey from either Eighteenmile Creek or Oak Orchard Creek, depending on which creek they were assumed to reside at. For the mink, this assumption seems reasonable given the length of the creeks compared with the average home range size of the mink—about 2 kilometers (km) of stream length (EPA 1993). However, the heron is known to forage over a wider area (up to 20 km from colony sites; EPA 1993) and in reality probably forages at various aquatic habitats in the general vicinity of the study creeks. These other foraging areas could contain prey with either lower or higher levels of bioaccumulative contaminants compared with the study areas. Hence, assuming a site use factor of 1.0 for the heron (see Section 3.3.3.1) may lead to either an under- or overestimation of exposure and risk for this receptor.

3.4 Bullhead Deformities and Liver Pathology

This section describes the results of the external and internal examination of brown bullheads for tumors and other deformities (Section 3.4.1) and summarizes the liver pathology evaluation (Section 3.4.2).

3.4.1 External and Internal Examination Results

One hundred brown bullheads, 50 from Eighteenmile Creek and 50 from Oak Orchard Creek, were collected during the August sampling event. The majority of the specimens collected resulted from the targeted sampling efforts; a small number of specimens were incidentally collected during the fish community surveys. The external and internal condition of each fish from both creeks was visually evaluated and recorded according to the procedures outlined in Section 5.3 of the *Field Manual for Assessing Internal and External Anomalies in Brown Bullhead* (*Ameiurus nebulosus*) (Rafferty and Grazio, 2006; see Appendix A of the QAPP). The datasheets used were similar to the Fish Health Data Sheet in Rafferty and Grazio (2006) and are presented in Appendix F. Digital photography was used to provide further documentation of the external conditions of fish and of the livers (see Appendix F).

Differences were noted between the two creeks regarding the number of types of morphological aberrations (missing/truncated barbels, raised skin lesions, black/yellow pigmentation, ulcers, etc.) and their severity. Fish in Eighteenmile Creek exhibited a broader range of external aberrations and greater frequency of severity scores of 2 and 3 (on a scale of 0 to 3, with 3 being the most severe) compared with Oak Orchard Creek fish. In addition, while just less than half of the fish examined (21) from Oak Orchard Creek exhibited no morphological aberrations at all (score of 0 for each type of aberration), only three fish from Eighteenmile Creek scored 0 for all types of aberrations.

Table 3-26 compares the number and severity of four common types of aberrations observed in fish from the two creeks—raised mouth lesions, raised skin lesions, ulcers, and barbel deformities. The incidence (i.e., rate of occurrence) and severity of raised mouth lesions and barbell deformities was significantly greater

in fish from Eighteenmile Creek than in fish from Oak Orchard Creek. Overall, there was a very low incidence (2) of the most severe type (severity score 3) of ulcers, raised skin/mouth lesions, or barbel deformities. Only one fish from Eighteenmile Creek (EMC-27-BB-LP; see datasheets and photographs in Appendix F) exhibited the most severe rating of 3 for raised mouth and skin lesions (and black pigmentation). No fish from Oak Orchard Creek displayed such severe aberrations.

Table 3-26 Number and Severity of Raised Mouth Lesions, Raised Skin Lesions, Ulcers, and Barbel Deformities in Brown Bullheads from Eighteenmile and Oak Orchard Creeks

External Aberration Categories	Number[1] and Severity[2] of Aberrations		
	Eighteenmile Creek	Oak Orchard Creek	Probability
Raised Mouth Lesions	6 fish with score of 1 2 fish with score of 2 1 fish with score of 3 **9 total**	1 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **2 total**	0.027
Raised Skin Lesions	1 fish with score of 1 1 fish with score of 2 1 fish with score of 3 **3 total**	1 fish with score of 1 0 fish with score of 2 0 fish with score of 3 **1 total**	0.300
Ulcers	8 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **9 total**	2 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **3 total**	0.072
Barbels	19 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **20 total**	6 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **7 total**	0.004

Notes:
[1] Out of 50 fish per creek.
[2] On a scale of 0 to 3 (0=normal, 1=mild, 2=moderate, 3=severe).
[3] Two-tailed probability based on Mann Whitney U test (see Section 2.3.3).

According to Baumann and Dabrowski (2006), external aberrations such as those described in this section should not be used to determine the status of the *Fish Tumors and Other Deformities* BUI, but are relevant to the *Degraded Fish and Wildlife Populations* BUI. The greater incidence of raised mouth lesions and barbel deformities in fish from Eighteenmile Creek compared with Oak Orchard Creek suggests that bottom-dwelling fish in the AOC are experiencing some level of impairment.

Lesion: An area of abnormal tissue.

Parasite: An organism that lives on or in another from which it draws its nourishment. Flatworms are common fish liver parasites

Neoplasm: An abnormal mass of tissue that results when cells divide more than they should or do not die when they should. Neoplasms may be benign (not cancerous), or malignant (cancerous); also called tumor.

Hyperplasia: A general term referring to the proliferation of cells within an organ or tissue beyond that which is ordinarily seen. Hyperplasia may result in the gross enlargement of an organ, the formation of a benign tumor, or may be visible only under a microscope. Hyperplasia is considered to be a physiological response to a specific stimulus, and the cells of a hyperplastic growth remain subject to normal regulatory control mechanisms. This stands in contrast to neoplasia (the process underlying cancer and some benign tumors), in which genetically abnormal cells proliferate in a non-physiological manner which is unresponsive to normal stimuli

A**lter focus:** A pre-neoplasitic lesion.

Internal visual observations of the fish from Eighteenmile Creek indicated that there appeared to be a relatively high incidence of discoloration and/or granular appearance to the livers (40 fish had some degree of pale discoloration, and many of those exhibited a granular texture [see photos in Appendix F]). However, the results for the Oak Orchard Creek specimens were similarly high, with 43 fish exhibiting the same or similar characteristics. Observations of parasites and lesions on the livers also were similar (and in low numbers) for specimens from both creeks. Overall, the incidence of visual liver abnormalities in fish from the two creeks was comparable.

3.4.2 Bullhead Liver Pathology

The objective of the liver pathology evaluation was to determine the prevalence of tumors and other abnormalities in the livers of brown bullheads collected from Eighteenmile Creek and Oak Orchard Creek. The work was done to provide data needed to assess the first BUI to be evaluated as part of the current investigation—existence of fish tumors and other deformities (status unknown). The liver histopathology was conducted by Dr. Jeffrey Wolf of Experimental Pathology Laboratories, Inc., in Sterling, Virginia, using 50 bullhead livers each from Eighteenmile Creek and Oak Orchard Creek. The livers were harvested in the field by personnel from Ecology and Environment, Inc. (E & E), preserved, and shipped to Experimental Pathology Laboratories as described in Section 2.1.2.2. Appendix E describes the laboratory methods used to process and examine the livers. The livers were examined for three primary categories of abnormalities: (1) proliferative epithelial lesions such as altered foci, hyperplasia, and neoplasia; (2) pigmented macrophage aggregates and hepatocellular vacuolation; and (3) other non-neoplastic lesions such as inflammation, necrosis, and endoparasitism. Definitions and examples of these abnormalities are provided in Blazer et al. (2006). A summary of the results for each of these categories of abnormalities is provided in Table 3-27 and discussed below. Appendix E provides a complete discussion of the results.

3.4.2.1 Proliferative Epithelial Lesions

A variety of proliferative epithelial lesions, including a low number of benign hepatocellular and bile duct neoplasms, various foci of hepatocellular alteration, and bile duct hyperplasia, were observed in the livers of fish collected from Eighteenmile Creek and Oak Orchard Creek. Proliferative bile duct lesions (bile duct hyperplasia and cholangiomas) were observed only in fish from Eighteenmile Creek; however, the incidences of these two findings were low, and the overall incidences of tumors and altered foci were not significantly different between sites (see Table 3-27).

Table 3-27 Summary of Statistical Comparison of Bullhead Liver Pathology Data from Eighteenmile and Oak Orchard Creeks

Parameter	Count: Eighteenmile Creek (EMC)	Count: Oak Orchard Creek (OOC)	Probability[1]	Remarks
Proliferative Epithelial Lesions				
Altered foci	10 total	13 total	0.635	No difference between creeks.
Hyperplasia	4 total	0 total	0.117	No difference between creeks.
Neoplasia (benign)	5 total	2 total	0.436	No difference between creeks.
Pigmented Macrophage Aggregates and Hepatocellular Vacuolation[2]				
Pigmented Macrophage Aggregates	34 (grade 1) 13 (grade 2) 3 (grade 3) 0 (grade 4)	44 (grade 1) 5 (grade 2) 1 (grade 3) 0 (grade 4)	0.017	EMC had fewer grade 1 and more grade 2 than OOC.
Hepatocellular Vacuolation	16 (grade 1) 16 (grade 2) 18 (grade 3) 0 (grade 4)	24 (grade 1) 22 (grade 2) 4 (grade 3) 0 (grade 4)	0.007	EMC had more grade 3 than OOC.
Selected Non-Neoplastic Lesions				
Inflammation	62 total	41 total	0.002	Greater in EMC.
Necrosis	15 total	16 total	0.829	No difference between creeks.
Endoparasitism	28 total	17 total	0.027	Greater in EMC.

Key:
- (dash) = no remarks
Shading = significant difference ($p < 0.05$).

Notes:
1. See Section 2.3.3 for description of statistical methods used.
2. Grade 1 is least severe and grade 4 is most severe.

3.4.2.2 Pigmented Macrophage Aggregates and Hepatocellular Vacuolation

Pigmented macrophage aggregate (PMA) and hepatocellular vacuolation (HV) scores were significantly higher ($p < 0.05$) in fish from Eighteenmile Creek than in fish from Oak Orchard Creek (see Table 3-27). Because these are nonspecific indicators of stress and condition, and because the differences were not dramatic, the biological importance of these results is uncertain.

3.4.2.3 Selected Non-Neoplastic Lesions

The incidences of inflammation and endoparasitism also were significantly higher ($p < 0.05$) in Eighteenmile Creek fish than in Oak Orchard Creek fish (see Table 3-27). Although inflammatory and parasitic lesions were common in the livers of fish from both creeks, the severity of the lesions was often minimal and never

greater than mild. The levels of inflammation and endoparasitism that were evident in the livers of brown bullheads in this study are considered typical for wild caught fish.

3.4.2.4 Relevance to BUI Assessment

Only some of the bullhead liver pathology data collected for this investigation are relevant to understanding the status of the *Fish Tumors and Other Deformities* BUI. Baumann and Dabrowski (2006) recommend that the delisting criteria for this BUI be based on bullhead liver neoplasia (i.e., tumors) because they are reliably associated with contaminant (principally PAH) exposure. Three results from the current study suggest that Eighteenmile Creek may be delisted regarding fish tumor impairments:

- No malignant tumors were observed in the livers of brown bullheads from Eighteenmile Creek;
- There was no significant difference in the number of benign liver tumors in brown bullheads from Eighteenmile and Oak Orchard Creeks; and
- There was no significant difference in the incidence of altered foci in the livers of brown bullheads from either creek. Altered foci are potential preneoplastic lesions (i.e., lesions that could lead to liver tumor formation) and therefore are also relevant to evaluating this BUI.

The finding of no fish tumor impairments at the Eighteenmile Creek AOC is not surprising given that the principal contaminant in the AOC are PCBs, not PAHs.

The other types of liver abnormalities evaluated in this study (e.g., vacuolation, inflammation, endoparasitism, etc.) are not considered relevant to determining the status of the fish tumor impairment BUI. These other types of liver abnormalities may provide some overall indication of fish health, but no specific guidance is available regarding the use of these data for assessing BUIs in Great Lakes AOCs.
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4 Eighteenmile Creek BUI Evaluation

As described in the QAPP (see Appendix A) and Section 1, three BUIs are being evaluated as part of the current investigation:

- Existence of fish tumors and other deformities (status unknown),
- Status of fish and wildlife populations (status unknown), and
- Status of bird or mammal deformities or reproductive impairment (status likely).

The data collected for this study (see Section 3) were used in a weight-of-evidence approach to determine the status of these three BUIs. When appropriate, the available data were used to address more than one BUI, as described in the QAPP. For each type of data, the results for the Eighteenmile Creek AOC were compared with data obtained from the lower reaches of Oak Orchard Creek to identify impairment, or the lack thereof. A beneficial use was considered impaired at Eighteenmile Creek if at least one line of evidence indicated impairment.

4.1 Existence of Fish Tumors and Other Deformities

Baumann and Dabrowski (2006) recommend that the delisting criteria for this BUI be based on bullhead liver neoplasia (i.e., tumors) because they are reliably associated with contaminant (principally PAH) exposure. Hence, only one line of evidence was used to evaluate the status of this BUI. As described in Section 3.4.2.4, no fish tumor impairment is evident at the Eighteenmile Creek AOC.

Table 4-1 Existence of Fish Tumors and Other Deformities BUI Evaluation, Eighteenmile Creek versus Oak Orchard Creek

Line of Evidence	Result	Interpretation
Prevalence and severity of liver tumors in brown bullheads.	No difference between creeks (see Section 3.4.2).	No impairment at Eighteenmile Creek.

Key:
BUI = Beneficial Use Impairment
PCBs = polychlorinated biphenyls.

4.2 Evaluation of Fish and Wildlife Populations

The status of fish, bird, mammal, and amphibian populations in the Eighteenmile Creek AOC was evaluated as described in the following subsections.

4.2.1 Fish Populations

Four lines of evidence were examined to evaluate the potential impairment of fish populations in Eighteenmile Creek: (1) diversity, abundance, and condition of fish; (2) concentrations of PCBs and dioxins/furans in bullheads; (3) the prevalence and severity of external abnormalities in bullheads; and (4) the prevalence and severity of liver tumors in bullheads (see Table 4-2). Two lines of evidence (1 and 4) showed no impairment at Eighteenmile Creek. Impairment was noted at Eighteenmile Creek regarding the second and third lines of evidence. Specifically, whole-body concentrations of PCBs in bullheads from Eighteenmile Creek were highly elevated compared with levels found in fish from Oak Orchard Creek. And, the prevalence and severity of raised mouth lesions and barbell deformities was greater in bullheads from Eighteenmile Creek compared with Oak Orchard Creek. Based on these results, it appears that fish populations in Eighteenmile Creek are experiencing some level of impairment.

Table 4-2 Status of Fish Populations BUI Evaluation, Eighteenmile Creek versus Oak Orchard Creek

Line of Evidence	Result	Interpretation
Diversity, abundance, and condition of fish	Fish diversity and condition between creeks was highly similar. A minor difference between creeks was observed in catch per unit effort, but this difference is likely due to a difference in sampling efforts between creeks in August 2007 (see Section 3.1).	No impairment at Eighteenmile Creek.
Concentrations of PCBs and dioxins/furans in bullheads.	Whole-body PCB concentrations in bullheads were ten times greater in fish from Eighteenmile Creek compared with fish from Oak Orchard Creek and exceeded the critical PCB tissue concentration for effects on fish. Dioxins/furans also were elevated in fish from Eighteenmile Creek compared with fish from Oak Orchard Creek, but the critical tissue concentration for dioxins/furans was not exceeded (see Section 3.3.1)	Eighteenmile Creek impaired (based on PCBs).
Prevalence and severity of external tumors and other deformities in brown bullheads.	Barbel deformities in brown bullheads were three times greater in Eighteenmile Creek than in Eighteenmile Creek; however, the severity of barbel deformities typically was mild (see Section 3.4.1).	Mild impairment at Eighteenmile Creek (based on barbel deformities).
Prevalence and severity of liver tumors in brown bullheads.	No difference between creeks (see Section 3.4.2).	No impairment at Eighteenmile Creek.

Key:
BUI = Beneficial Use Impairment
PCBs = polychlorinated biphenyls.

4.2.2 Bird Populations

Two lines of evidence were examined to evaluate the potential impairment of bird populations at Eighteenmile Creek: (1) the diversity and abundance of birds, and (2) the risk of reproductive impairment for fish-eating birds (see Table 4-3). No impairment was found.

Table 4-3 Status of Bird Populations BUI Evaluation, Eighteenmile Creek versus Oak Orchard Creek

Line of Evidence	Result	Interpretation
Diversity and abundance of birds	Bird diversity and abundance between creeks were very similar. Some minor differences in species between creeks were observed, but these differences likely are the result of minor differences in the riparian habitats provided by the creeks (see Section 3.2.1).	No impairment at Eighteenmile Creek.
Risk of reproductive impairment for fish-eating birds from PCBs and dioxins/furans in fish.	The estimated exposure of a representative fish-eating bird (great blue heron) to total PCBs and dioxins/furans at Eighteenmile Creek was greater than at Oak Orchard Creek but did not exceed the lowest observed adverse effect level for effects on bird reproduction at Eighteenmile Creek (see Section 3.3.3)	No impairment at Eighteenmile Creek.

Key:
BUI = Beneficial Use Impairment
PCBs = polychlorinated biphenyls.

4.2.3 Mammal Populations

Two lines of evidence were examined to evaluate the potential impairment of mammal populations at Eighteenmile Creek: (1) the diversity and abundance of mammals, and (2) the risk of reproductive impairment for fish-eating mammals (see Table 4-4). Although limited, the available qualitative data on mammal diversity and abundance does not suggest impairment at Eighteenmile Creek. Reproductive impairment potentially exists at Eighteenmile Creek for fish-eating mammals such as the mink due to the high levels of PCBs in fish.

4.2.4 Amphibian Populations

Only a single line of evidence was examined to evaluate potential impairment of amphibian populations at Eighteenmile Creek—the diversity and abundance of amphibians (see Table 4-5). No impairment was noted.

Table 4-4 Status of Mammal Populations BUI Evaluation, Eighteenmile Creek versus Oak Orchard Creek

Line of Evidence	Result	Interpretation
Diversity and abundance of mammals	A lower number of mammal species was observed at Eighteenmile Creek (9) compared with Oak Orchard Creek (13), but this may be in part an artifact of sampling (see Section 3.2.2). Overall, far fewer observations were made for mammals compared with birds due to the more secretive habits of many mammal species.	The available data, although limited and qualitative, do not suggest impairment at Eighteenmile Creek.
Risk of reproductive impairment for fish-eating mammals from PCBs and dioxins/furans in fish.	The estimated exposure of a representative fish-eating mammal (mink) to total PCBs and dioxins/furans at Eighteenmile Creek was greater than at Oak Orchard Creek. For PCBs, the estimated exposure exceeded the lowest observed adverse effect level for effects on mammal reproduction at Eighteenmile Creek (see Section 3.3.3). Impaired reproduction could affect population size.	Possible impairment from PCBs at Eighteenmile Creek.

Key:
BUI = Beneficial Use Impairment
PCBs = polychlorinated biphenyls.

Table 4-5 Status of Amphibian Populations BUI Evaluation, Eighteenmile Creek versus Oak Orchard Creek

Line of Evidence	Result	Interpretation
Diversity and abundance of amphibians	A similar number of amphibian species was observed at Eighteenmile Creek (9 species) and Oak Orchard Creek (8 species). The relative abundances of these species were similar between creeks.	No impairment at Eighteenmile Creek.

Key:
BUI = Beneficial Use Impairment
PCBs = polychlorinated biphenyls.

4.3 Evaluation of Bird and Mammal Deformities or Reproductive Impairment

Two lines of evidence were examined to evaluate this BUI: (1) the risk of reproductive impairment for fish-eating birds and mammals, and (2) the prevalence of bird and mammal deformities (see Table 4-6). Potential reproductive impairment may exist at Eighteenmile Creek for fish-eating mammals, but not fish-eating birds, due to high levels of PCBs in fish. The available survey data for mammals does not suggest impairment for this BUI at Eighteenmile Creek; however, given that the available survey data are limited, they are not conclusive proof. Nonetheless, it should be noted that over the course of the surveys (over 50 hours of sur-

vey time over the course of three seasons within each creek corridor), no dead or deformed birds or mammals were observed. In addition, discussions with NYSDEC biologists who have spent a substantial amount of time in and near the Eighteenmile Creek AOC indicate that they have never seen any diseased, deformed, or dead birds or mammals.

Table 4-6 Status of Bird and Mammal Deformities or Reproductive Impairment BUI Evaluation, Eighteenmile Creek versus Oak Orchard Creek

Line of Evidence	Result	Interpretation
Risk of reproductive impairment for fish-eating birds and mammals from PCBs and dioxins/furans in fish.	Birds: The estimated exposure of a representative fish-eating bird (great blue heron) to total PCBs and dioxins/furans at Eighteenmile Creek was greater than at Oak Orchard Creek but did not exceed the lowest observed adverse effect level for effects on bird reproduction at Eighteenmile Creek (see Section 3.3.3). Mammals: The estimated exposure of a representative fish-eating mammal (mink) to total PCBs and dioxins/furans at Eighteenmile Creek was greater than at Oak Orchard Creek. For PCBs, the estimated exposure exceeded the lowest observed adverse effect level for effects on mammal reproduction at Eighteenmile Creek (see Section 3.3.3).	Birds: No impairment at Eighteenmile Creek. Mammals: Possible reproductive impairment from PCBs at Eighteenmile Creek.
Examination of dead or disabled birds and mammals for deformities.	No dead or disabled birds or mammals were observed during field activities in 2007 or by NYSDEC biologists in previous studies.	Although limited, the available observational data do not suggest impairment at Eighteenmile Creek.

Key:
BUI = Beneficial Use Impairment
PCBs = polychlorinated biphenyls.

4.4 Observations Relevant to Fish Consumption BUI

Currently, a fish consumption BUI exists for the Eighteenmile Creek AOC. In addition, the New York State Department of Health recommends eating no fish of any species from Eighteenmile Creek due to PCB contamination (NYSDOH 2007). It was not the original intent of this investigation to evaluate this particular impairment. Nonetheless, the bullhead PCB data collected for this investigation can be used to address this issue.

EPA (2000) recommends consuming no fish from a water body when their total PCB levels exceed the following risk-based concentrations:

- 380 µg/kg wet weight (non-cancer effects)
- 190 µg/kg wet weight (cancer effects)

Total PCB levels in bullheads collected from Eighteenmile Creek for this investigation (see Table 3-19) exceed these risk-based concentrations by an order of magnitude. Hence, the results from this investigation support the fish consumption BUI for the Eighteenmile Creek AOC.

5 Summary, Conclusions, and Recommendations

5.1 Summary and Conclusions

Table 5-1 summarizes the evaluation of the three BUIs that were the subject of the present investigation:

- Existence of fish tumors and other deformities,
- Status of fish and wildlife populations, and
- Status of bird or mammal deformities or reproductive impairment.

The status of the first BUI was previously unknown. Data collected for this investigation suggest that Eighteenmile Creek is not impaired in this regard (see Table 5-1). The status of the second BUI also was previously unknown. The data collected for this investigation suggest that bird and amphibian populations at Eighteenmile Creek are not impaired, but that fish and mammal populations are likely impaired (see Table 5-1). The possible impairment of fish and mammal populations at Eighteenmile Creek is the result of high levels of PCBs in fish. Whole-body concentrations of PCBs in brown bullheads collected from Eighteenmile Creek were: (1) 10 times greater than in bullheads collected from Oak Orchard Creek, (2) often exceeded the critical PCB tissue concentration for effects on fish, and (3) great enough to possibly affect reproduction of fish-eating mammals. Impaired reproduction can affect population size (http://www.foxriver-watch.com/wildlife_reproductive_pcbs.html).

Regarding fish populations, an additional line of evidence that suggests impairment is the significantly greater prevalence of raised mouth lesions and barbell deformities in bullheads from Eighteenmile Creek compared with Oak Orchard Creek.

Table 5-1 Summary of Eighteenmile Creek BUI Evaluation

BUI	Prior Status	Status Based on This Investigation[1]	Rationale
Existence of fish tumors and other deformities.	Unknown.	**Not impaired.**	No differences were observed between Eighteenmile Creek (EMC) and Oak Orchard Creek (OOC) regarding liver tumors in brown bullheads (see Section 3.4.2.4 and Table 4-1).
Status of fish and wildlife populations.	Unknown.	**Fish: Impaired.**	Fish: PCB levels in brown bullheads from EMC were 10 times greater than in fish from OOC and exceeded the critical PCB tissue concentration for effects on fish (see Table 4-2). Also, mouth lesions and barbell deformities were significantly ($p < 0.05$) more prevalent in bullheads from EMC compared with OOC. In contrast, two lines of evidence (fish diversity and abundance; bullhead liver tumor prevalence) did not indicate impairment at EMC.
		Birds: Not impaired.	Birds: Diversity and abundance of birds were similar between EMC and OOC. Risk of reproductive impairment due to PCB exposure was negligible at EMC (see Table 4-3).
		Mammals: Impaired.	Mammals: Reproductive impairment likely for fish-eating mammals due to high levels of PCBs in fish (see Table 4-4). Impaired reproduction could affect population size. Mammal diversity and abundance did not appear to differ between creeks, but the mammal survey data were qualitative and limited.
		Amphibians: Not impaired.	Amphibians: Diversity and abundance very similar between EMC and OOC (see Table 4-5).

Table 5-1 Summary of Eighteenmile Creek BUI Evaluation

BUI	Prior Status	Status Based on This Investigation[1]	Rationale
Status of bird or mammal deformities or reproductive impairment.	Likely.	Birds: Not impaired.	Birds: Risk of reproductive impairment from PCB exposure negligible at EMC (see Table 4-3). No deformed, disabled, or dead birds were observed at EMC in over 50 hours of survey time over many months.
		Mammals: Impaired.	Mammals: Reproductive impairment likely for fish-eating mammals at EMC due to high levels of PCBs in fish (see Table 4-4). No deformed, disabled, or dead mammals were observed at EMC in over 50 hours of survey time over many months.

Note: 1. **Bold** text indicates impairment. If at least one line of evidence indicated impairment, the BUI status was considered impaired.

Key:

BUI = Beneficial Use Impairment
EMC = Eighteenmile Creek
OOC = Oak Orchard Creek
PCBs = polychlorinated biphenyls.

The status of the third BUI was previously considered to be likely. The present evaluation confirms this suspicion (see Table 5-1). Specifically, the present evaluation found that PCB levels in fish from Eighteenmile Creek may be great enough to adversely affect reproduction of fish-eating mammals. Fish-eating birds do not appear to be at risk due largely to their lower sensitivity to PCBs compared with mammals (Sample and Suter. 1996).

Finally, although it was not an objective of the current investigation to evaluate the fish consumption BUI that currently is recognized for the Eighteenmile Creek AOC, the bullhead PCB data collected for this investigation can be used to address this issue. Of note, total PCB levels in bullheads from Eighteenmile Creek greatly exceed EPA risk-based concentrations for fish consumption for both cancer and non-cancer health effects.

5.2 Recommendations

Beneficial use impairment at Eighteenmile Creek is largely due to PCB contamination. The USACE (2008) found high levels of PCBs in sediment from Eighteenmile Creek that were highly bioavailable in laboratory uptake studies. Not surprisingly, this investigation found high levels of PCBs in brown bullheads from Eighteenmile Creek. The reduction or elimination of BUIs at Eighteenmile Creek hinges upon the identification and control of the sources of this contamination. There are known PCB source areas in Lockport, New York (NYSDEC

2006; EEEPC 2007a). Secondary source areas may exist downstream from Lockport, such as in the sediments behind Burt Dam. Other primary and secondary source areas also may exist. As a result of this investigation, and given the results of recent sediment investigations, it is recommended that future resources be devoted to understanding the sources, transport, and fate of PCBs in the Eighteenmile Creek watershed and how these factors affect PCB levels in sediment and fish in the lower reaches of the creek. This information will allow remedial actions to be focused in those locations that will provide the greatest benefit to the Eighteenmile Creek watershed in general and the Eighteenmile Creek AOC in particular. Continuing investigations will allow for the implementation of a watershed approach to remediation and restoration, and ultimately a delisting of Eighteenmile Creek as an AOC.

6 References

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A

Quality Assurance Project Plan

See attached CD.

B Fish Community Survey Data

See attached CD

C Wildlife Survey Data

See attached CD.

D Bullhead Analytical Data for PCBs and Dioxins/Furans

See attached CD.

E

Bullhead Liver Pathology Report

See attached CD.

F Bullhead Sampling Field Data Sheets

See attached CD.

G Statistical Analysis Memorandum and Program Output

Technical Memorandum

From: Carl Mach and Kris Erickson (E&E)

To: Barbara Belasco (USEPA - Region 2, Project Officer) and Victor DiGiacomo (NCSWCD, Eighteenmile Creek RAP Coordinator)

CC: M. Ritter (GRIPA), M. Galloway (E & E)

Date: November 26, 2008

Subject: Statistical Analyses to Support Explanation of Brown Bullhead External and Internal Data from Eighteenmile and Oak Orchard Creeks for Determining Status of Existence of Fish Tumors and Other Deformities Beneficial Use Impairment

As requested by U.S Environmental Protection Agency (EPA) Region 2, Ecology and Environment, Inc. (E & E) used statistical analyses to compare the bullhead abnormality and liver pathology data from Eighteenmile Creek (EMC) and Oak Orchard Creek (OOC) to determine how the statistics could support an explanation of the status of the *Fish Tumors and Other Deformities* beneficial use impairment (BUI) at EMC. Our evaluation focused on the four external abnormalities discussed in our draft report (*Draft Beneficial Use Impairment Investigation for Eighteenmile Creek Niagara County, New York*, February 2008) —raised mouth lesions, raised skin lesions, ulcers, and barbel deformities—and on a group of liver abnormalities known as altered foci. Of the types of liver abnormalities that we examined, altered foci are the best examples of potential pre-neoplastic lesions (i.e., lesions that could lead to liver tumor formation) and therefore are particularly relevant to the BUI being assessed.

Statistical Methods

The Mann-Whitney U-test was used to test for differences in the number and severity of external abnormalities between creeks. The data used in the evaluation are summarized in Table 3-26 (inserted below) in our draft report (E & E 2008). Each deformity was tested separately between creeks using the severity scores (0, 1, 2, or 3) for all 50 fish from each creek. The chi-square test was used to test for differences in the prevalence of altered foci in bullhead livers between the two creeks. The data used in the evaluation are summarized in Table 2 of Appendix E (inserted below) in our draft report (E & E 2008). The data for altered foci indicate only the presence or absence of this abnormality in the examined livers, not the level of severity. This type of presence/absence data for two sites is best evaluated using the chi-square test for a 2x2 table.

Table 3-26 Number and Severity of Raised Mouth Lesions, Raised Skin Lesions, Ulcers, and Barbel Deformities in Brown Bullheads from Eighteenmile and Oak Orchard Creeks

External Aberration Categories	Number[1] and Severity[2] of Aberrations	
	Eighteenmile Creek	Oak Orchard Creek
Raised Mouth Lesions	6 fish with score of 1 2 fish with score of 2 1 fish with score of 3	1 fish with score of 1 1 fish with score of 2 0 fish with score of 3
	9 total	**2 total**

Table 3-26 Number and Severity of Raised Mouth Lesions, Raised Skin Lesions, Ulcers, and Barbel Deformities in Brown Bullheads from Eighteenmile and Oak Orchard Creeks

External Aberration Categories	Number[1] and Severity[2] of Aberrations	
	Eighteenmile Creek	Oak Orchard Creek
Raised Skin Lesions	1 fish with score of 1 1 fish with score of 2 1 fish with score of 3 **3 total**	1 fish with score of 1 0 fish with score of 2 0 fish with score of 3 **1 total**
Ulcers	8 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **9 total**	2 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **3 total**
Barbels	19 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **20 total**	6 fish with score of 1 1 fish with score of 2 0 fish with score of 3 **7 total**

Notes:
[1] Out of 50 fish per creek.
[2] On a scale of 0 to 3 (0=normal, 1=mild, 2=moderate, 3=severe).

Table 2 Numbers of Epithelial Proliferative Lesion Diagnoses in the Livers of Brown Bullheads*

Collection Site	OOC				EMC			
Sex**	M	F	U	T	M	F	U	T
Number Examined	19	27	4	50	23	25	2	50
Altered Foci								
Focus, Basophilic, Multiple	0	0	0	0	0	1	0	1
Focus, Clear Cell	0	2	2	4	1	0	0	1
Focus, Clear Cell, Multiple	4	1	0	5	0	2	0	2
Focus, Eosinophilic	2	1	0	3	1	1	0	2
Focus, Eosinophilic, Multiple	0	1	0	1	0	3	0	3
Focus, Vacuolated	0	0	0	0	0	1	0	1
Altered Foci, Total	6	5	2	13	2	8	0	10
Hyperplasia								
Bile Duct Hyperplasia	0	0	0	0	1	3	0	4
Neoplasia								
Hepatocellular Adenoma	2	0	0	2	0	1	0	1
Hepatocellular Adenoma, Multiple	0	0	0	0	0	1	0	1
Cholangioma	0	0	0	0	2	1	0	3
Neoplasms, Total	2	0	0	2	2	3	0	5

*It was not unusual for a fish to have more than one type of diagnosis

**M = male, F = female, U = unknown, T = total

Results

There is a significant ($p < 0.05$) difference in raised mouth lesions and barbel deformities in EMC bullheads compared with OOC bullheads. The number of raised skin lesions and ulcers did not differ significantly between creeks. There is no difference between creeks in the prevalence of altered liver foci. Probability values for these comparisons are provided in the table below. Statistical program output is included in Attachment A.

Summary of Statistical Comparison of Bullhead Abnormality and Liver Pathology Data from Eighteenmile and Oak Orchard Creeks

Parameter	Count		Probability
	Eighteenmile Creek	Oak Orchard Creek	
Raised mouth lesions	9 total	2 total	0.027
Raised skin lesions	3 total	1 total	0.300
Ulcers	9 total	3 total	0.072
Barbell deformities	20 total	7 total	0.004
Altered foci	10 total	13 total	0.635

Discussion

Earlier this year, E & E reviewed the workshop report by Baumann and Dabrowski (2007) on the *Fish Tumors and Other Deformities* BUI. These authors recommend that deformities, eroded fins, lesions, and tumors (DELT anomalies) not be used as a delisting criterion for this BUI. Instead, they recommend that the delisting criterion for this BUI be based on liver neoplasms because liver neoplasms are a reliable indicator of chemical exposure in fish and are not caused by other factors. E & E understands that this issue is currently under discussion and that the science is developing relative to the direct cause-and-effect question. However, based on the Baumann and Dabrowski recommendation and the statistical evaluation presented above, E & E recommends that EMC be considered not impaired with regard to the *Fish Tumors and Other Deformities* BUI. This recommendation is based on the finding that there is no significant difference in altered foci in bullhead livers between EMC and OOC, which supports our earlier assertion that there were no observed differences between the creeks regarding liver tumors in brown bullheads.

This recommendation represents a revision to the Draft BUI Report (E & E 2008) where we had originally combined the results of the external data with the liver pathology information to recommend the status be considered "mildly impaired". In our draft report, barbel deformities were the driver for this recommendation. Although raised mouth lesions and barbel deformities are more prevalent in bullheads from EMC compared with OOC, these types of external deformities should not be used to determine the status of the *Fish Tumor and Other Deformities* BUI according to Baumann and Dabrowski (2007).

References

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Attachment A – Statistical Output

Mann-Whitney Test for External Abnormalities in Bullheads (EMC versus OOC)

Ranks

	Creek_no	N	Mean Rank	Sum of Ranks
Raised Mouth Lesions	EMC	50	53.98	2699.00
	OOC	50	47.02	2351.00
	Total	100		
Raised Skin Lesions	EMC	50	51.52	2576.00
	OOC	50	49.48	2474.00
	Total	100		
Ulcers	EMC	50	53.44	2672.00
	OOC	50	47.56	2378.00
	Total	100		
Barbells	EMC	50	56.87	2843.50
	OOC	50	44.13	2206.50
	Total	100		

Test Statistics[a]

	Raised Mouth Lesions	Raised Skin Lesions	Ulcers	Barbells
Mann-Whitney U	1076.000	1199.000	1103.000	931.500
Wilcoxon W	2351.000	2474.000	2378.000	2206.500
Z	-2.210	-1.036	-1.798	-2.846
Asymp. Sig. (2-tailed)	.027	.300	.072	.004

[a] Grouping Variable: creek_no

Crosstabs – Altered Foci in Bullhead Livers (EMC versus OOC)

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Creek * Status	100	100.0%	0	.0%	100	100.0%

Creek Status Crosstabulation

			Status		
			Absent	Present	Total
Creek	EMC	Count	40	10	50
		% within creek	80.0%	20.0%	100.0%
		% within status	51.9%	43.5%	50.0%
		Std. Residual	.2%	-.4%	
	OOC	Count	37	13	50
		% within creek	74.0%	26.0%	100.0%
		% within status	48.1%	56.5%	50.0%
		Std. Residual	-.2%	.4	
Total		Count	77	23	100
		% within creek	77.0%	23.0%	100.0%
		% within status	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymo. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.508[b]	1	.476		
Continuity Correction[a]	.226	1	.635		
Likelihood Ratio	.509	1	.475		
Fisher's Exact Test				.635	.318
N of Valid Cases	100				

[a] Computed only for a 2x2 table
[b] 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.50

2-25-09, Merrilee Ritter, M.S., Eighteen Mile Creek Study, Second Analysis

Carl, here are your stats for your 2x2 tables and Mann-Whitney U tests.

For the chi-square tables, I adjusted inflammation for EMC to be 50, so that I could run the chi-square analysis, since it wouldn't run with a total count of 62 incidences on 50 animals. For this analysis, the number of incidences must be at or below the total number examined. A full row by column chi-square analysis runs into the same problem as the 2x2 table. I also looked at it from a Mann-Whitney U but we have no scores for the various categories.

The significant tests are highlighted in yellow. The non-significant tests are turquoise.

For the Mann-Whitney U test, you want to use the p value associated with the test that is adjusted for ties. It is more appropriate than the unadjusted test.

The software used for this analysis is Minitab 11.21, 1996, www.minitab.com.
Please let me know if you need additional info for the reference. I used Minitab because the license for SPSS that I have at home has expired and I am not sure I will renew it. So, for now, when you need me to do some stats, and Minitab is not adequate, I will need to come into the office to do the work.

Thanks, Merrilee

Tabulated Statistics - Necrosis

Rows: creek Columns: status

	present	absent	All
OOC	16	34	50
	32.00	68.00	100.00
	51.61	49.28	50.00
	16	34	50
	15.50	34.50	50.00
	0.13	-0.09	--
EMC	15	35	50
	30.00	70.00	100.00
	48.39	50.72	50.00
	15	35	50
	15.50	34.50	50.00
	-0.13	0.09	--
All	31	69	100
	31.00	69.00	100.00
	100.00	100.00	100.00
	31	69	100
	31.00	69.00	100.00
	--	--	--

Chi-Square = 0.047, DF = 1, P-Value = **0.829**

Cell Contents -- Necrosis
Count
% of Row
% of Col
Count
Exp Freq
St Resid

Tabulated Statistics - Endoparasitism

Rows: creek Columns: status

	present	absent	All
OOC	17	33	50

	34.00	66.00	100.00
	37.78	60.00	50.00
	17	33	50
	22.50	27.50	50.00
	-1.16	1.05	--
EMC	28	22	50
	56.00	44.00	100.00
	62.22	40.00	50.00
	28	22	50
	22.50	27.50	50.00
	1.16	-1.05	--
All	45	55	100
	45.00	55.00	100.00
	100.00	100.00	100.00
	45	55	100
	45.00	55.00	100.00
	--	--	--

Chi-Square = 4.889, DF = 1, P-Value = **0.027**

Cell Contents -- Endoparasitism
Count
% of Row
% of Col
Count
Exp Freq
St Resid

Tabulated Statistics - Inflammation

```
 Rows: creek     Columns: status

     present   absent      All

 OOC   82.00    18.00   100.00
       45.05   100.00    50.00
          41        9       50
       45.50     4.50    50.00
       -0.67     2.12      --

 EMC  100.00      --    100.00
       54.95      --     50.00
          50        0       50
       45.50     4.50    50.00
        0.67    -2.12      --

 All   91.00     9.00   100.00
      100.00   100.00   100.00
          91        9      100
       91.00     9.00   100.00
         --        --       --
```

Chi-Square = 9.890, DF = 1, P-Value = **0.002**
2 cells with expected counts less than 5.0

```
  Cell Contents --
                  % of Row
                  % of Col
                  Count
                  Exp Freq
                  St Resid
```

Mann-Whitney Confidence Interval and Test - PMA

```
EMC_PMA    N = 50     Median =      1.0000
OOC_PMA    N = 50     Median =      1.0000
Point estimate for ETA1-ETA2 is     -0.0000
95.0 Percent CI for ETA1-ETA2 is (0.0000, 0.0001)
W = 2776.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0842
The test is significant at 0.0166 (adjusted for ties)
```

Mann-Whitney Confidence Interval and Test - HVG

```
EMC_HVG    N = 50     Median =      2.0000
OOC_HVG    N = 50     Median =      2.0000
Point estimate for ETA1-ETA2 is      0.0000
95.0 Percent CI for ETA1-ETA2 is (-0.0001, 1.0000)
W = 2891.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0117
The test is significant at 0.0069 (adjusted for ties)
```