Detailed Human Health Risk Assessment: Lyon's Creek East

Submitted to:

Niagara Peninsula Conservation Authority

Dillon Project No. 04-2907

Submitted by

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EXECUTIVE SUMMARY

The human health risk assessment (HHRA) for the Lyon's Creek East study area (Figure 1) builds on the conclusions and recommendations of the human health screening level risk assessment (HHSLRA) completed for the area in 2005 (Dillon, 2005). The HHSLRA concluded that *polychlorinated biphenyls* (PCB) were the only contaminants that may represent a potential concern for human health. Therefore, the HHRA focused on potential exposures to PCB in the Lyon's Creek East study area. In addition, *dioxin-like polychlorinated biphenyls* (DL-PCB) were added to the assessment where data were available.

The HHSLRA considered exposures to PCB based on an *Upper Concentration Limit* (UCL) of 9 mg/kg calculated for the entire sediment quality data set. As noted in the HHSLRA, this approach overestimated potential exposures to PCB for residents in the Cooks Mills area. To provide exposure estimates that better reflect potential exposures for residents in the Cooks Mills area and in the homes adjacent to Lyon's Creek in the vicinity of Highway 140, the Lyon's Creek East site was divided into Upper and Lower Lyon's Creek East study areas (Figure 2). A review of the sediment quality data indicates that PCB concentrations in sediments are highest in the section between the Welland Canal Bypass and Highway 140 and that PCB concentrations decrease with distance downstream of the CN railway crossing that lies east of Highway 140. Therefore the site division was set at the CN railway crossing. The section between the Welland Canal Bypass and the CN railway crossing was designated as the Upper Lyon's Creek East study area and the section from the CN railway crossing downstream to Montrose Road was designated as the Lower Lyon's Creek East study area. The sediment quality data collected by the Ministry of Environment between 1991 and 2003 were used to estimate PCB UCL concentrations of 21.98 and 1.99 mg/kg in the Upper and Lower Lyon's Creek Study areas respectively. The maximum DL-PCB *dioxin toxic equivalent* (TEQ) of 0.034 ng/g TEQ was used in the assessment of DL-PCB in Upper Lyon's Creek East.

In the Upper Lyon's Creek East area, the UCL concentration of 21.98 mg/kg PCB is above the MOE Table 2 standard of 5.0 mg/kg PCB for residential/parkland soil. Therefore potential exposures to PCB in sediments were assessed for the Upper Lyon's Creek East study area. The potential presence of dioxins and furans were investigated with focused core sampling, but these compounds were found to be at low concentrations and did not screen on as COCs. In the Lower Lyon's Creek East study area, the PCB UCL concentration of 1.99 mg/kg is below the MOE Table 2 standard. Therefore, exposure to PCB in sediments in the Lower Lyon's Creek East study area would not be considered a potential concern for human health and exposures to PCB in sediments in this area were not assessed in the HHRA.

A Community Survey was conducted with the participation of residents in the Upper and Lower Lyon's Creek East study areas to establish the number of people in the community who catch and eat fish and game taken from Lyon's Creek East and the recreational uses of Lyon's Creek East that exist in the community. A total of 365 surveys were hand-delivered to homes in the Upper and Lower Lyon's Creek East areas. A total of 167 responses were received, including those that were mailed back and those that were filled out over the telephone. The results of the survey indicate:

- The consumption of fish from Lyon's Creek East is limited (3 of 167 responses);
- The highest reported rate of fish consumption was once per year;

- Fish that were consumed were taken either from the Cooks Mills area or downstream from Cooks Mills;
- Fish from the Highway 140 area were not consumed by any survey respondents;
- Deer and waterfowl taken from the Lower Lyon's Creek East area were consumed by members of the community (5 of 167 responses);
- Game or waterfowl were not taken from the Upper Lyon's Creek East study area;
- Recreational use of Upper and Lower Lyon's Creek East is common (44 of 167 responses) with hiking and boating (canoeing) being the most frequently reported activities; and
- Use of water from Lyon's Creek East for watering lawns and vegetable gardens and washing cars also occurs (8 of 167 responses).

The results of the survey were used to refine many of the activity pattern assumptions used in the HHSLRA to provide exposure estimates that reflect conditions in the community. These refinements include:

- Fish consumption is not a concern in the Upper Lyon's Creek East study area;
- Recreational activities occur over the summer months with the highest reported frequency being for boating at 2 – 3 times per week. This estimate was used to assess exposures to PCB and DL-PCB in sediments;
- Watering activities occur and were addressed; and
- Consumption of game and waterfowl from the Lower Lyon's Creek East study area occurs and has been addressed.

Detailed consideration of activity patterns and the potential for PCB movements in environmental media resulted in the identification of potentially complete exposure pathways for the Upper and Lower Lyon's Creek East study area. The pathways considered for each study area were:

- Upper Lyon's Creek East: Dermal contact with sediments; and
- Lower Lyon's Creek East: Consumption of sport fish.

Assessment of dermal exposure to PCB in the Upper Lyon's Creek East area showed that exposures to PCB were below the toxicity reference value for PCB. Hazard quotient (HQ) values ranged between 0.15 for the toddler and 0.033 for the adult. Both are below the hazard acceptability benchmark of 0.2 established by the Ontario Ministry of the Environment.

Assessment of dermal exposure to DL-PCB in the Upper Lyon's Creek East area yielded much lower HQs, ranging from 0.00051 for the adult receptor to 0.0022 for the toddler. In all cases, HQs related to DL-PCB in Upper Lyon's Creek East are below the hazard acceptability benchmark of 0.2.

Assessment of exposure to PCB through the consumption of sport fish taken from Lower Lyon's Creek East showed that exposures for all receptor age groups (infants, toddlers, children, teens and adults) are below the toxicity reference value for PCB. Hazard quotient values ranged between 0.13 for the infant to 0.067 for the toddler, child and teen receptors. Based on these results it can be concluded that:

- Exposure to PCB in sediments in Upper Lyon's Creek East would not be expected to result in adverse human health effects;
- Exposure to DL-PCB in sediments in Upper Lyon's Creek East would not be expected to result in adverse human health effects;
- Exposure to PCB through the consumption of sport fish taken from Lower Lyon's Creek East would not be expected to result in adverse human health effects; and
- PCB concentrations in sediments in Lower Lyon's Creek East are below the MOE Table 2 Standard for PCB in residential soil and therefore would not be considered to pose a potential hazard to human health.

As results of the community survey and field observations made during the course of this study did not reveal fish consumption from Upper Lyons Creek, the associated risk was not calculated as part of this study. However, there remains the possibility that some people could, now or in the future, catch and eat fish from the portion of the creek upstream of Highway 140. Anyone who wishes to consume fish from that area should consult the Guide to Eating Ontario Sport Fish, which is available on the Ministry of the Environment web site at www.ene.gov.on.ca and through the Public Information Centre, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5. The current version of the Guide at the time of drafting of this report was 2005-2006 Twenty-third Edition, Revised. Page 65 of that Edition provides consumption advice for a range of lengths of nine species of fish from "Lyons Creek at Highway 140". Users of the Guide should also read the text of the Guide before referring to the advisory tables. The Guide is published every other year. In alternate years, major changes in fish consumption advice are made public by the Ministry through its Public Information Centre, the Ministry web site and media notification. The public can also contact the Sport Fish Contaminant Monitoring Program at (416) 327-6816 or 1-800-820-2716 or e-mail sportfish@ene.gov.on.ca with questions on the status of specific advisories.

Based on the exposure estimates used in this assessment, the results of the detailed human health risk assessment suggest that remediation of either the Upper or Lower Lyon's Creek East areas to address potential human health concerns is not warranted.

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1. INTRODUCTION

1.1 Background

The governments of Canada and the United States have identified the Niagara River Watershed as an *Area of Concern* (AOC). Tributaries of the Niagara River, such as Lyon's Creek are considered part of this AOC. Since 1991, several studies of sediment quality have been undertaken and tissue from fish and other biota have been collected from within the Lyon's Creek East study area. These studies have identified the presence of *polychlorinated biphenyls* (PCB), metals and other contaminants in the sediments in Lyon's Creek East. Fish and other biota have also been found to contain PCB. The presence of these contaminants in sediments and biota from Lyon's Creek East represents a potential route of exposure for people who live adjacent to the creek and for people from the City of Welland and others who may use the creek for recreational purposes. A *Human Health Risk Assessment* (HHRA) was undertaken to determine the potential health risks for people who may come into contact with contaminants that originate from within the Lyon's Creek East study area. The results of the HHRA will form part of a larger review and will be an important component in support of the development of a remedial action plan for the Lyon's Creek East study area.

The Lyon's Creek East human health risk assessment has been planned as a two-stage process. The initial stage included a *Human Health Screening Level Risk Assessment* (HHSLRA). The second stage includes a detailed human health risk assessment. The initial HHSLRA (Phase I) involved the use of very conservative exposure assumptions to ensure that exposures were not underestimated. Following on the results of the HHSLRA, only those contaminants that are deemed to be potential human health concerns are evaluated in the detailed HHRA. The detailed HHRA (Phase II) builds on the results of the HHSLRA and incorporates community-specific data to provide exposure and risk estimates that are representative of conditions in the community. This report provides the results of the HHRA (Phase II).

Phase I, the HHSLRA, focused on potential exposures for people of all ages who live in the Cooks Mills area (residential receptors). A number of potentially complete exposure pathways were identified including;

- Incidental ingestion of sediment;
- Dermal contact with sediment;
- Consumption of Sport Fish;
- Consumption of other biota (snapping turtles);
- Incidental ingestion of soil;
- Dermal contact with soil;
- Incidental ingestion of surface water; and,
- Dermal contact with surface water.

Although a number of potentially complete exposure pathways were identified, insufficient data were available to evaluate exposures through all pathways. Of the pathways listed above, the ones listed in italics could not be evaluated due to a lack of data. Based on the results of the analysis, the HHSLRA concluded that:

- Iron and PCB were the initial contaminants of concern;
- The concentrations of other contaminants (metals, *polycyclic aromatic hydrocarbons* (PAH) and *organochlorine pesticides* (OCP)) are below their respective human health based screening guidelines and are not a concern for human exposure in the Lyon's Creek East study area;
- For all receptor age groups, exposure to iron is below the tolerable daily exposure limit. Therefore, although iron is present in the sediment at levels that exceed its screening guideline, iron does not pose a potential human health hazard and iron does not need to be carried through to the detailed human health risk assessment (Phase II);
- Based on the results of the HHSLRA, exposures to PCB exceed the hazard acceptability benchmark of 0.2; and,
- The HHSLRA was based on a number of conservative assumptions that were designed to over estimate exposures and risks. Therefore, the results of HHSLRA should not be used to conclude that the presence of PCB in the sediments in Lyon's Creek East poses an unacceptable risk to residents in Cooks Mills or the surrounding community of Welland. Rather, the results should be viewed as an indication that a more detailed human health risk assessment should be undertaken to properly characterize both exposures and risks in the community.

The HHRA for the Lyon's Creek East study area builds on the conclusions and recommendations of the HHSLRA (Dillon, 2005) and examines potential exposures to PCB from sediments and biota in the Lyon's Creek East area using community-specific information.

1.2 Scope and Objectives

The objective of the HHRA is to identify the potential human health risks associated with exposure to PCB in the sediments and biota in the Lyon's Creek East study area. The study area has been defined as the section of Lyon's Creek East that is bounded by the Welland Canal Bypass at the western end, and extends downstream and eastward as far as Montrose Road. The HHRA incorporates the results of a Community Survey, undertaken to collect information on the consumption of fish, game and waterfowl from Lyon's Creek East and the recreational use of Lyon's Creek East in the community. This information is used to refine many of the receptor activity pattern assumptions used in the HHSLRA to provide exposure estimates that better reflect conditions in the community. The results of the HHRA will be incorporated into the larger review for the development of a RAP for Lyon's Creek East.

This report represents the HHRA phase of the assessment. Data from the following reports have been used in the current assessment.

- **MOE, 1992:**
  Lyon's Creek Sediment Survey, Water Resources Unit, Ministry of the Environment (Draft, June 25th, 1992);
- **MOE, 1993:**
  Lyon's Creek –East Section: Report on Sediment and Biological Studies; Ministry of the Environment, (Draft, October, 1993);

- **MOE, 1996a:**
  A Sediment/Biological Assessment of Lyons Creek East, Ministry of the Environment (Draft, 1996)
- **MOE, 1996b:**
  Laboratory Sediment and Bioassay Report, 1992 and 1996, Ministry of the Environment (Draft, 1996)
- **MOE, 2004:**
  An Overview of the PCB Sediment Concentrations and Biological Characteristics of Lyon's Creek East (2002 data, MOE, 2004) (Includes electronic data provided by Dr. Rachael Fletcher MOE, EMRB)
- **EC, 2003:**
  Working Statement: Snapping Turtles in Lyon's Creek, 2002, (Preliminary Results, (Environment Canada, November, 2003)
- **Dillon, 2005:**
  Human Health Screening Level Risk Assessment for Lyon's Creek East. Prepared for the Niagara Peninsula Conservation Authority, March 2005

The first objective of the HHRA is to identify activity patterns in the community that can be used to better estimate potential exposures to PCB in Lyon's Creek East.

The second objective of the HHRA is to identify the relevant exposure pathways for members of the Cooks Mills and surrounding communities.

The third objective is to estimate potential hazards associated with exposure to PCB in Lyon's Creek East for the people who live in the vicinity of Lyon's Creek East.

The final objective is to make recommendations for necessary remedial action if the results of the HHRA suggest that exposures to PCB in Lyon's Creek East may pose unacceptable hazards to human health.

1.3 Organization of the Report

This report is organized in 9 sections and 2 appendices, of which this introduction is Section 1. Section 2 provides a summary of the environmental and biological monitoring data available for the Lyon's Creek East study area. Section 3 presents the Problem Formulation that identifies the contaminants of concern, the potential receptors and the active or complete exposure pathways. Section 4 presents the results of the Exposure Assessment. Section 5, the Toxicity Assessment, provides a listing of the toxicological reference values used to assess the potential hazards/risks associated with exposure to the chemicals of concern on the site. Section 6 characterizes the risks associated with exposure to chemicals in the soil/sediments for all identified receptors. Section 7 provides a discussion of the uncertainties associated with the hazard and risk estimates from the HHRA. Section 8 provides a summary of the recommendations and conclusions stemming from the HHRA. Section 9 lists the citations for the reference materials used in the development of the HHRA. Appendix A provides a listing of the sediment, surface water and biota monitoring data that have

been used to calculated PCB concentrations for use in the HHRA. Appendix B provides a copy of the Community Survey, a summary of the survey results and a detailed listing of the responses.

1.4 Limitations

Risk assessments, by their nature, have inherent limitations and uncertainties. It is believed that these uncertainties have been addressed through the conservative interpretation of site-specific data and parameter selection, and in the conservatism inherent in existing toxicity information. The quantitative estimates of risk provided by this process are valid only for the assumptions and exposure scenarios outlined in this report. However, should knowledge of the site conditions or toxicity information change, the risk posed by the site may differ from that presented in this report.

This report was prepared exclusively for the purposes, project, and site location outlined in the report. The report is based on information provided to or obtained by Dillon as indicated in the report, and applies solely to site conditions existing at the time of the site investigation. Where the risk assessment has relied on information provided to Dillon by the other parties, Dillon has, within the scope and expectations of the risk assessment process, reviewed this data but Dillon does not warrant the accuracy, completeness and representativeness of this information. Dillon's report represents a reasonable review of available information within an established work scope, work schedule, and budget.

This report was prepared by Dillon for the sole benefit and use of the Niagara Peninsula Conservation Authority and the Ontario Ministry of the Environment. The material in it reflects Dillon's best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decision made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

2. SITE CHARACTERIZATION

2.1 Site Description

2.1.1 Site Location and Land Use

Lyon's Creek is a tributary of the Welland River that flows in an easterly direction from the Welland Canal Bypass in the west to the Welland River in the east (east of the QEW) (Figure 1). Flow within Lyons Creek East is maintained by a pump station on the east bank of the canal that draws canal water and releases it to the creek upstream of Ridge Road. Lyons Creek East in the vicinity of Cooks Mills is comprised of a series of broad marshy ponds, intersected by a number of road and rail crossings and includes areas that have been designated as Provincially Significant Wetland (PSW) . In addition to the pumped flow input to the creek, Lyon's Creek East also receives intermittent drainage from the lands and roads that are adjacent to the creek east of the Welland Canal and south of the Welland River.

The Lyon's Creek East HHRA study area includes the section of Lyon's Creek that lies between the Welland Canal Bypass in the west and Montrose Road in the east. The study area is shown in Figure 1 as a dark blue line bounded by red bars that indicate the upper and lower limits of the study area. Lyon's Creek East and the lands that border the creek, including the wetlands, would be considered as recreational parkland. The lands adjacent to the creek include a mixture of agricultural, strip residential and industrial lands. Industrial activity is located predominantly on the southern side of the creek at the western end of the study area between the Welland Canal and Highway 140. The lands on the south side of the creek, immediately downstream of Highway 140, are zoned for commercial development. Further downstream, and on the north side of the creek, the lands are predominantly rural agricultural and strip residential, including the village of Cooks Mills.

2.1.2 Defining Upper and Lower Lyon's Creek East

The screening level risk assessment completed as Phase 1 of the study, considered the entire study area as a single site. The potential risks associated with exposure to PCB and other contaminants were assessed over the entire length of the creek from the Welland Canal Bypass to Montrose Road. As noted in the introduction, the HHSLRA concluded that exposures to PCB may represent a potential human health hazard. The HHSLRA recommended additional work to better characterize potential exposures in the Cooks Mills community. A review of PCB concentrations in sediments showed that PCB concentrations are highest between the Welland Canal Bypass and the Canadian National Railway (CN) crossing immediately east of Highway 140 and that there is a marked decline in PCB concentrations downstream of the CN crossing. The Cooks Mills community is located downstream of Highway 140 and the CN crossing. Therefore to better characterize potential exposures in the Cooks Mills area, the Lyon's Creek East site has been divided into two areas, referred to in the remainder of this report as Upper and Lower Lyon's Creek East, corresponding to the reaches upstream and downstream of the CN crossing, respectively.

- Upper Lyon's Creek East;
  Upper Lyon's Creek East has been defined as the area that lies between the Welland Canal Bypass and the CN railway crossing (see Figure 2)

- Lower Lyon's Creek East
  Lower Lyon's Creek East has been defined as the area that lies between the CN railway crossing and Montrose Road (see Figure 2).

It should be noted that there is an additional rail crossing of Lyons Creek within the study area. Similar to the CN line, the Canadian Pacific Railway (CPR) crosses Lyons Creek in a north-south direction, but this location is within the Lower Lyon's Creek East area and is east and downstream of Cooks Mills, between McKenney Road and Crowland Avenue.

2.2 Summary of Environmental Data Used in the Risk Assessment

The HHSLRA reviewed information from a number of available reports (MOE, 1992, MOE, 1993, MOE, 1996a, MOE, 1996b, MOE, 2004, E.C., 2003, Dillon, 2005). Although contaminant concentrations have been measured in a number of media, those determined for sediment, sport fish, snapping turtles and soil were considered the most relevant for inclusion in a human health risk assessment. The HHSLRA concluded that:

- Data are sufficient to characterize PCB concentrations in sediments;
- Data are insufficient to properly characterize PCB levels in fish tissue from fish caught in the Cooks Mills area of Lyon's Creek;
- Data are insufficient to characterize PCB levels in surface water, groundwater, soil and backyard garden produce.

The data gaps identified in the HHSLRA were addressed through the collection of additional data as part of the HHRA. Surface water samples were collected from Lyons Creek in the Cooks Mills and Highway 140 areas to characterize PCB concentrations in surface water. Fish were collected from Lyons Creek at three locations in the Cooks Mills area. In addition, a fish and wildlife consumption survey was undertaken to determine if people in the area consume fish and wildlife from Lyon's Creek East. The survey was also used to identify recreational use patterns of Lyon's Creek in the local community. Summaries of the sediment and surface water data and the results of the community survey are discussed in the following sections.

2.2.1 Sediment Data

Although monitoring data provides information on the concentrations of numerous contaminants in the sediments in Lyon's Creek East, the HHRA focuses on PCB. As noted in the HHSLRA report (Dillon, March 2005), sediment data are provided in MOE (1992), MOE (1993), MOE (1996a), MOE (1996b) and MOE (2004). A large number of PCB samples are available from MOE (1992), MOE (1996a) and MOE (2004), representing approximately 140 data points for PCB.

The upper portion of Lyon's Creek East (between the Welland Canal Bypass and Highway 140) was the focus of the early studies. The initial 1991 study (MOE, 1992) collected samples from five transect locations between the Welland Canal and Highway 140 (Figure 3a). Samples were collected at three depth intervals within the sediments (0 – 25 cm, 25 – 50 cm and >50 cm), and from four locations on each of the 5 transects (i.e., a total of 12 samples per transect). In addition, 5 surface sediment grab samples were collected from locations between the transect locations. The data from

this study were incorporated into the sediment data set. The sediment quality data provided in MOE (1992) included the laboratory descriptor fields that provided an indication of the detection limits for the analyses. The MOE commonly uses two descriptor field notations;

- <T: a measurable trace amount was detected
- <W: no measurable amount was detected.

In incorporating the data, the values identified as <T or <W were assumed to be present at the concentration stated in the report. The PCB sediment data from this study have been included in the Upper Lyon's Creek East Study Area, and are summarized in Appendix A.

The data presented in MOE (1996a) replicates the data from the MOE (1992) report and adds an additional 6 transect locations between the Welland Canal Bypass and Montrose Road (Figure 3b). Each transect was sampled at three locations: south bank, mid-channel and north bank. Sediment cores were divided into two depth horizons (0 – 25 cm and 25 – 50 cm). The results were presented for each transect sample at the two sampling depths for Transect 6 through Transect 11. Two additional transect locations (Transect 9a and Transect 10a) were identified in the report but analytical data for these locations are not listed in the tables provided in the report. In the absence of information identifying these latter transects, it has been assumed that the data listed in Appendix A of this report refer to Transect 9 and Transect 10 and not Transect 9a and Transect 10a. Transect sample locations T6, T7 and T12 lie upstream of the CN railway crossing and have therefore been included in the Upper Lyon's Creek East data set. Transect sample locations, T8, T9, T10 and T11 lie downstream of the CN railway crossing and have been included in the Lower Lyon's Creek East data set (see Appendix A).

MOE (1996b) provides a very limited amount of sediment data for metals and PCB related to 4 Lyons Creek samples collected for sediment bioassay purposes. This report does not provide the level of sampling detail contained in the other reports. Those sediment samples were not collected for monitoring or delineation purposes, but for use in sediment bioassay studies and have been assessed for a limited number of metals. Further, the PCB data associated with the sediments collected for bioassay do not differ from the data already contained in the earlier MOE reports (MOE 1992; MOE 1993; MOE 1996a). Therefore, to avoid the potential of incorporating inappropriate and/or incomplete data, the data from MOE (1996b) has not been included in the sediment data set. The four samples represent approximately two percent (2%) of the total data available. Therefore, eliminating these data from the study will not alter the estimation of contaminants concentrations in the study.

The most recent data from the MOE (MOE, 2004) provides a number of surface sediment grab samples collected at 36 sample locations between the Welland Canal Bypass and Montrose Road (Figure 3c). It also includes sediment core samples representing three depths (<10cm, 10 – 25 cm and >25cm) from five transect locations within the study area (Figure 3c). Samples from each of the three horizons were collected at three points on each transect corresponding to the south bank, mid-channel and north bank of the creek. The three samples from each depth horizon (south bank, mid-channel and north bank) were composited to provide a single sample for each depth for each of the five transect locations. Data are available for the each of the 36 surface grab samples and for the core samples. Sample locations LC01 through LC18 lie between the Welland Canal Bypass and the CN railway crossing and have been included in the Upper Lyon's Creek East data set. Sample locations

LC19 through LC36 lie between the CN railway crossing and Montrose Road and have therefore been included in the Lower Lyon's Creek East data set. In addition to total PCBs, PCB congener analysis was undertaken and supported the calculation of DL-PCB TEQs for sediments in Upper Lyons Creek (see Appendix A).

For both the Upper Lyon's Creek East and Lower Lyon's Creek East data sets, data from the various sampling horizons have been combined to provide data sets that cover all sediment depths (0 – 50 cm). This provides approximately 100 data points for the Upper Lyon's Creek East area and approximately 40 data points for the Lower Lyon's Creek East area.

The early reports (MOE 1992; MOE 1996a) report PCB concentrations as µg/g, while the more recent data are provided in ng/g units. These values have been converted to mg/kg units to be consistent with MOE soil standards released in October 2004 (see Appendix A).

Minimum, and maximum values and the *Upper Confidence Limit* (UCL) PCB concentrations in the Upper and Lower Lyon's Creek East areas were calculated using ProUCL® (Version 3) software available from the US EPA. ProUCL tests datasets for several potential distributions including; normality; log-normality; and gamma distributions, and calculates a conservative 95% UCL of the mean (ProULC, 2004). A detailed summary of ProUCL and the various statistical approaches it applies to the calculation of UCL can be found in the ProUCL User Guidance Manual (Singh et al. 2004) available through the US EPA. ProUCL provides a statistical summary for each chemical constituent and based on the analysis recommends the most stable UCL for use as the *Exposure Point Concentration* (EPC) for use as input to the risk assessment. A summary of the recommended UCL and the statistical basis for the value for PCB in the Upper and Lower Lyon's Creek East study areas are provided in Table 2-1. In cases where the ProUCL software recommends more than one possible UCL, the highest recommended value has been selected. The statistical summary outputs from the ProUCL software for PCB concentrations in Upper and Lower Lyon's Creek East are provided in Appendix A.

In addition to evaluating exposures to total PCB, the risk assessment considered the potential hazards associated with exposures to dioxin-like PCB (DLPCB) in Upper Lyon's Creek East. This group of PCB isomers and congeners has similar biological mechanisms of action to polychlorinated Dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF). Where PCB congener analysis data was available, the concentration of DLPCB was calculated. These concentrations were expressed as ng Toxicity Equivalent (TEQ) DLPCB/g soil.

The various isomers and congeners of PCDD, PCDFs and DLPCBs all have the same biological mechanism of action (*ie.* they all work on the body in the same way). However, they differ in their levels of toxicity. In assessing PCDD/PCDF and DLPCB concentrations in soil, the concentrations of the individual isomers and congeners are converted to a *Toxicity Equivalent* (TEQ) concentration which effectively expresses the concentration of individual isomers and congeners as function of its effective concentration relative to the most biologically active congener (2,3,7,8-TCDD) which is assigned an *Toxicity Equivalency Factor* (TEF) of 1.0. The concentrations of the individual PCDD and PCDF isomers and congeners are multiplied by their respective TEF to provide a toxic equivalent concentration or TEQ. For example if the soil concentration of octachlorodibenzo-p-dioxin (OCDD) is reported as 500ng/g, this is converted to a TEQ concentration by multiplying the reported

concentration by the TEF for OCDD (500 ng/g x 0.0001 = 0.5 ng TEQ/g). Similar calculations are completed for each PCDD, PCDF and DLPCB and the TEQ concentrations are summed to provide a total or overall TEQ for the sample. This approach has been used to calculate the TEQ concentration of DLPCB in sediments of the Upper Lyon's Creek East area, as summarized in tabular format in Appendix A. The TEQ concentrations range from 0.003887 ng/g TEQ to 0.034006 ng/g TEQ in the wetland sediments. The maximum TEQ concentration of 0.034 ng/g TEQ in sediment in Upper Lyon's Creek East is reported in Table 2-1.

Table 2-1: Upper Confidence Limit Concentration for PCB and DL-PCB in Sediments

Study Area	Recommended UCL for PCB and DL-PCB in Sediments	
	Statistical Basis	Value (mg/kg)
PCB		
Upper Lyon's Creek East	95% H-UCL	21.98
Lower Lyon's Creek East	Approximate Gamma UCL	1.99
DL-PCB		
Upper Lyon's Creek East	Maximum Value	0.034 ng/g TEQ

2.2.2 Soil Data

Information regarding PCB concentrations in soil is limited to samples collected in the Upper Lyon's Creek East study area. MOE (1996a) included PCB data for soil samples that were collected 1m, 5m and 25m from the edge of Lyon's Creek in the upper portion of the creek (between the Welland Canal Bypass and Highway 140). The data in Table 2-2 have been reproduced from the data as presented in Table 13 of MOE (1996a), but have been converted from μg/g, as reported by MOE, to mg/g for the purposes of the HHRA. Data were not provided for Transect 1 in Table 13 of the MOE report (MOE, 1996a). PCB concentrations were reported in only 7 soil samples. The remainder of the samples are reported as "DL". The report does not define DL, but it has been assumed that this is intended to refer to *Detection Limit*. Because the detection limits are not provided, it is not possible to incorporate the DL data into the risk assessment. The 7 samples for which PCB concentrations are reported are insufficient to properly establish a UCL value for use in the risk assessment. Therefore, the maximum concentration reported in the soil (1.48 mg/g) has been used to screen for chemicals of concern in the soil.

Table 2-2: PCB Concentrations in Soil (from MOE, 1996a)

Transect	PCB Concentration (mg/kg)[1] (at specified distance inland from creek bank)		
	1m	5m	25m
1	-	-	-
2	**0.50**	**0.30**	DL
3	**0.28**	**0.62**	DL
4	DL	**0.160**	DL
5	DL	DL	**1.48**

Transect	PCB Concentration (mg/kg)[1] (at specified distance inland from creek bank)		
	1m	5m	25m
6	DL	DL	DL
7	**0.11**	DL	DL
8	DL	DL	DL
9	DL	DL	DL
Control	DL	DL	DL
	Distance from the creek bank ..... →		

1: adjusted from µg/g (MOE 1996a)

2.2.3 Surface Water and Groundwater

The lack of information related to PCB concentrations in surface water and groundwater was identified as a data gap in the HHSLRA. As part of the HHRA, Dillon collected surface water samples from ten (10) locations in Lower Lyon's Creek East in the vicinity of Cooks Mills (see Figure 4). PCB levels were below the method detection limit of 0.000025 mg/L in all samples tested. The data are provided in Table 2-3.

Table 2-3: PCB Concentrations in Surface Water

Sample Location	Concentration	EQL[1]
	mg/L	mg/L
SW1	N.D.	0.000025
SW2	N.D.	0.000025
SW3	N.D.	0.000025
SW4	N.D.	0.000025
SW5	N.D.	0.000025
SW6	N.D.	0.000025
SW6 (repeat)	N.D.	0.000025
SW7	N.D.	0.000025
SW8	N.D.	0.000025
SW9	N.D.	0.000025
SW10	N.D.	0.000025

1. Estimated Quantitation Limit

The data in Table 2-3 show that PCB are not present in surface water in Lyon's Creek East. PCB are highly insoluble in water and are not likely to dissolve from sediment particles into the water column, or to migrate through sediments to groundwater in the area. The data further suggest that PCBs are not being released in measurable concentrations from the sediments by the resuspension and entrainment of sediment into the water column. In addition, recent investigations of sediment and geological conditions in Lyon's Creek East suggest that a confining layer of clay underlies the organics-rich sediments in Lyon's Creek (Golder, 2005). This clay layer would prevent migration of contaminants from sediments to any groundwater that may underlie the clay layer. Based on this

information it is unlikely that PCB have had an impact on local groundwater and testing groundwater was therefore not deemed to be necessary.

2.2.4 Sport Fish Data

The consumption of sport fish that are caught in areas where contaminants are present in surface water or sediments represents a potential route of exposure for people who eat sport fish. Contaminant concentrations in sport fish from Lyon's Creek East have been measured by the MOE on several occasions over the past decade. As part of the 2002 Lyon's Creek East sampling program, sport fish were collected from the vicinity of Highway 140 (MOE, 2004). Sport fish were also collected from two locations downstream of the HHRA study area, at sites downstream of the QEW and at the mouth of Lyon's Creek, respectively. As these data fall outside the current study area, they have not been included. The fish collected in the vicinity of Highway 140 included:

- Bowfin (6)
- White Sucker (4)
- Carp (10)
- Brown Bullhead (2)
- Pumpkinseed (8)
- Bluegill (5)
- Largemouth Bass (8)
- Black Crappie (6)

The numbers in brackets indicate the number of fish for which PCB concentrations were reported. The data were provided by the MOE in electronic format. A total of 49 samples were available for inclusion in the Upper Lyon's Creek East study area. The data provided by the MOE represent dorsal fillet samples. Dillon collected an additional 21 fish from three locations of Lower Lyon's Creek East within the Cooks Mills area, corresponding to the road crossings at Doan's Ridge Road, Pearson Road and McKenney Road (Figure 4). These Lower Lyons Creek East sites are readily accessible to Cooks Mills residents and possess depths and relatively weed-free conditions in limited areas near the road crossings that can be effectively fished by anglers. Consistent with the sampling procedures used by the MOE, dorsal boneless, skinless fillets from these fish were collected and submitted for total PCB analysis as part of the HHRA. The results are summarized in Appendix A. Fish species collected and retained for PCB analysis in the Lower Lyons Creek East study area include:

- Pumpkinseed (16);
- Bluegill (1);
- Green sunfish (3); and
- Yellow perch (1).

Many small/immature fish were captured, however the 21 fish retained for analysis were the largest of those captured and were within a size range that might be consumed. The species and lengths of the sampled fish are listed along with the PCB analysis in Appendix A. It should be noted that fish habitat in the Lower Lyons Creek East study area differs from the Upper Lyon's Creek East study area in that the channel is narrower, shallower and more heavily vegetated. As a result, it provides habitat for smaller panfish, particularly the pumpkinseed, but is not as suitable for larger predators

such as largemouth bass and bowfin, or for large adult carp. There are no barriers to fish migration within the creek, so it is possible that individuals or small numbers of these larger fish may be periodically encountered in Lower Lyons Creek East, however panfish would appear to comprise the major proportion of the Lower Lyon's Creek East fishery, in keeping with the habitat conditions.

Information relating to consumption patterns for individual sport fish was not available for the HHSLRA. The results of the HHSLRA suggested that sport fish consumption could make a significant contribution to PCB exposures in the community (Dillon, March 2005). A fish consumption survey was conducted in the Upper and Lower Lyon's Creek East study areas to determine local fish consumption patterns in the community. The results of the survey showed that, in the local community, the consumption of fish from Lyon's Creek is very limited. Only three (3) of the 167 respondents indicated that they consumed fish either from the Cooks Mills area or areas east of Cooks Mills. None of these respondents indicated consumption of fish from the Upper Lyons Creek East study area. The respondents reported eating pumpkinseed, catfish and smallmouth and largemouth bass from the Lower Lyons Creek study area only. The results of the survey are presented in detail in Appendix B.

Not all species identified by the respondents are represented in the data collected by the MOE. Therefore, to ensure that exposures would not be underestimated, all sport fish data collected by the MOE were combined into a single data set for sport fish for the Upper Lyon's Creek East study area. The sport fish data collected as part of the current HHRA were used to establish PCB tissue residues in fish from the Lower Lyon's Creek East area. The data sets for the Upper and Lower Lyons Creek areas were used to calculate UCLs for PCB residues in fish tissues. The recommended UCLs, and the statistical basis for the values for the Upper and Lower Lyon's Creek East study areas, are provided in Table 2-4. The statistical summary outputs from the ProUCL software for PCB concentrations in Upper and Lower Lyon's Creek East are provided in Appendix A.

Table2-4: Upper Confidence Limit Concentration for PCB in Fish Tissue

Study Area	Recommended UCL for PCB in Fish Tissue	
	Statistical Basis	Value (mg/kg)
Upper Lyon's Creek East	95% Chebyshev (Mean, Sd) UCL	0.83
Lower Lyon's Creek East	95% Chebyshev (Mean, Sd) UCL	0.15

2.2.5 Snapping Turtles and Wild Game

Although the consumption of snapping turtles was addressed as a potential concern in the HHSLRA, the results of the Community Survey indicated that consumption of snapping turtles was not an issue in the community. While snapping turtles may be taken under the authority of a valid Ontario sport or conservation fishing licence, none of the 167 survey respondents indicated that they currently consumed snapping turtles from Lyon's Creek. One respondent indicated past consumption of snapping turtles, but stated that none had been consumed since eight years prior to the survey. Snapping turtle seems to have been popular with some members of earlier generations of Southern Ontarians, who lived closer to the land and more frequently consumed wild game. However, it does not seem to be a target of most sportsmen today. Commercial harvest of snapping turtles is not

permitted in Ontario, as it is widely understood that the species' low rate of recruitment and slow growth to adulthood cannot support any substantial harvest without deleterious effects on local populations. It is notable, therefore, that large snapping turtles were visually observed in Lyons Creek during site visits and were also captured in the fyke nets set for short periods to collect fish at the road crossings in Cooks Mills. It seems unlikely that adult snapping turtles would be so readily observed and captured at access points if the species were being exploited as a food source.

As there is no evidence of current or ongoing snapping turtle consumption occurring within the study area, it is considered that the data gap has been filled by the results of the community survey and observations of an apparently abundant turtle population that is inconsistent with turtle exploitation. Therefore, snapping turtle consumption has not been considered in the HHRA.

Several survey respondents indicated that they consume deer or waterfowl taken from the Lyon's Creek East area. PCB concentrations in deer or waterfowl from the Lyon's Creek East area are not known, and data related to these wildlife species has not been collected as part of the present study. However, the absence of this data is not considered to have an impact on the assessment of potential human exposure to PCB in the Upper or Lower Lyon's Creek East study areas, based on the low level of exposure and subsequent accumulation of PCBs considered to be associated with these species.

Deer and waterfowl are considered further in the report, based on the concentrations of PCB to which they would likely be exposed in Lower Lyons Creek East. The effects that the data gaps concerning PCB concentrations in game species could have on the conclusions of the risk assessment are discussed in Section 7 of the report.

2.2.6 Backyard Garden Produce

The lack of data relating to PCB concentrations in soil and backyard garden vegetables was identified as a data gap in the HHSLRA. As noted in Section 2.2.2, PCB concentrations decline rapidly as distance from the creek bank increases. Based on this it is unlikely that residential soils would contain PCB as a result of migration from Lyon's Creek East. The HHSLRA also identified the potential for PCB to be moved from the creek to residential gardens through watering activities that take water directly from Lyon's Creek East. Three survey respondents indicated that they used water from Lyon's Creek to water vegetable gardens two to three times per season. In addition, 5 respondents reported using water from Lyon's Creek East to water lawns. Thus, the potential movement of PCB from Lyon's Creek to backyard garden vegetables could represent a potential exposure pathway if PCB were present in the water in Lyon's Creek East. However, as noted in Section 2.2.3, sampling of surface waters has shown that measurable concentrations of PCB are not present in the surface water in Lyon's Creek East. Therefore, using water from Lyon's Creek East to water vegetable gardens would not be expected to introduce PCB to gardens, and thus the consumption of backyard garden vegetables would not be a potential route of human exposure. Based on this, the absence of data related to PCB concentrations in backyard garden vegetable was no longer considered to be a data gap for the HHRA and sampling backyard garden vegetables was not deemed necessary.

2.3 Community Survey Summary

The HHSLRA phase of the human health risk assessment was designed to provide very conservative estimates of potential exposures in the community. It relied on the use of a number of assumptions relating to fish and game consumption and the use of Lyon's Creek East for recreational purposes in the community. The HHSLRA identified a number of data gaps that could best be addressed through a Community Survey. A Community Survey designed to gather the information necessary to support the HHRA was circulated in the Cooks Mills area in the winter and spring of 2005. The Survey package was hand-delivered to 365 households extending from Ridge Road in the west to Pearson Road in the east on the south side of Lyon's Creek East and also along Silverthorne and Lyon's Creek Roads on the north side of the creek. The area covered by the survey is shown in Figure B1 in Appendix B. The survey consisted of 21 questions divided into four sections related to:

- The consumption of fish caught from Lyon's Creek East;
- The consumption of wild game caught from Lyon's Creek East;
- Recreational use of Lyon's Creek East by community members; and,
- The use of water from Lyon's Creek East for domestic purposes.

A summary of the overall responses related to these four categories is provided below. The survey, the compiled results and a detailed summary of the individual survey responses are provided in Appendix B. The results of the survey show:

- Consumption of fish caught from Lyon's Creek East in the community is very limited.
  Of the 167 responses received, 3 respondents indicated that they caught and ate fish from Lyon's Creek. The responses indicated that:
  - Fish were caught in the Cooks Mills area or east of Cooks Mills;
  - No fish were caught upstream of the Cooks Mills area.;
  - Fish consumption rates ranged from once per year to once every 3 or 4 years;
  - Fish species consumed included pumpkinseed, catfish and largemouth and smallmouth bass.

- Consumption of wild game caught from Lyon's Creek East is very limited;
  Of the 167 responses received, 5 respondents indicated that they caught and ate game and/or waterfowl from the Lyon's Creek east area. The responses indicate:
  - 2 respondents take deer annually from Highway 140 to Cooks Mills and Cooks Mills areas on a yearly basis;
  - 3 respondents take waterfowl from east of the Cooks Mills area;
  - Consumption of waterfowl ranged from once per year to 10 times per year; and
  - One respondent indicated that snapping turtles were consumed up to eight years prior to the survey, but had not been eaten since.

- The Lyon's Creek East area is used for recreational purposes by the community;
  Of the 167 responses received, 44 respondents from across the Upper and Lower Lyon's Creek East areas indicated using Lyon's Creek East for recreational activities. The most common recreational activity was boating (generally identified as canoeing).

Hiking and fishing were also relatively commonly reported activities. A breakdown of the identified activities, their relative frequencies and durations, is provided below.

- Boating, 25 respondents, frequency weekly to yearly, duration 1 to 2 hours;
- Hiking, 17 respondents, frequency weekly to monthly, duration ½ to 2 hours;
- Fishing; 14 respondents, 3 of which consume fish on a yearly basis, 11 of which practice catch and release on a frequency ranging from daily to yearly, duration ½ hour to 2 hours;
- Wading; 2 respondents, frequency 2 – 3 times per year, duration 1 to 2 hours;
- Winter activities were reported by 11 respondents; and
- Unspecified activities; 4 respondents, frequency twice per year, 1 to 2 hours.

Although survey respondents have included winter activities in their responses, exposures to sediments would not be likely during the winter months due to ice cover. Winter activities observed on Lyons Creek East during the course of this study included snowmobiling, ice-skating and hockey. A few respondents indicated ice fishing, but fish consumption was limited to 3 respondents in total. In each case, winter activities were enjoyed during periods of thick ice cover. No evidence of ice-fishing was observed by Dillon staff during winter sediment collection activities, and the winter sediment collections undertaken in 2005 revealed too little depth of water beneath the ice for effective ice-fishing in most of Lyons Creek East. Therefore, as a whole, winter activities have not been considered in the current HHRA, as the potential exposure to sediments and fish are unlikely.

- Surface water from Lyon's Creek East is used for domestic purposes.
  Of the 167 responses received, 8 respondents indicated using water from Lyon's Creek East for domestic purposes. The uses include:
  - Watering Lawns, 4 respondents;
  - Watering vegetable gardens; 3 respondents; and
  - Car washing and watering ornamental plantings; 4 respondents

Appendix B provides the results of the 167 completed survey forms.

The information from the Community Survey has been used to refine the assumptions related to potential exposures to PCB contaminated sediments in the Upper and Lower Lyon's Creek East areas in the development of the *Site Conceptual Model* for receptors in the Upper and Lower Lyon's Creek East areas (Section 3.3).

3. PROBLEM FORMULATION

3.1 Identification of Contaminants of Potential Concern

The objective of the contaminants screening process is to determine which contaminants are present in the environment at levels that may pose a potential risk to human health or the environment. The identification of contaminants of concern is based on a comparison of contaminant concentrations and applicable screening guidelines. Guidelines have been established for several environmental media including soil, groundwater, surface water and ambient air. These guidelines are established using very conservative assumptions that overestimate exposures. As a result the guidelines represent contaminant concentrations that do not pose a risk to human health or the environment. Contaminants that are present at concentrations that are lower than their respective guideline concentration are not considered to pose a risk to humans or the environment. If the concentration of a contaminant exceeds the guideline value, it does not mean that the contaminant poses a risk to humans or the environment. An exceedance of a guideline is an indication that additional work must be undertaken to determine if site-specific exposures to contaminants pose a potential risk. This additional work is usually undertaken as a risk assessment. Thus, contaminants that are present at concentrations that exceed their respective guidelines are identified as contaminants of concern and are carried through to a quantitative risk assessment.

As noted in Section 1, the screening for contaminants of potential concern in the HHSLRA identified iron and PCB. The results of the HHSLRA showed that exposure to iron in the sediments of Lyon's Creek East would not pose a potential hazard for human health. Therefore, iron has not been addressed in the detailed human health risk assessment.

The HHSLRA concluded that exposures to PCB in sediment in Lyon's Creek East could pose an unacceptable hazard for human health. Given the presence of PCB, there was a concern that dioxins and furans could also be present in sediments of Lyons Creek East in concentrations that could pose risks to human health and the environment. A sediment core was collected in the spring of 2005 from a site within the reach of Upper Lyons Creek East, a short distance upstream of Highway 140. As PCB concentrations in Upper Lyons Creek East are higher than in the lower reaches of the creek, it was felt that if co-occurring dioxins and furans were present, these compounds would also be present at higher concentrations. This approach was therefore considered to be conservative in addressing the decision whether to include these compounds as part of the HHRA. Results of this investigation are presented in Appendix A, but are summarized here. Dioxins and furans within the core sample ranged from 43.0 pg/g TEQ at the top of the core (0-10 cm), through 121 pg/g TEQ in the middle of the core (25-35 cm), to 37.1 pg/g TEQ at the bottom of the core (35-45 cm). This pattern is similar to that of PCB in the Upper Lyons Creek East sediments, with cleaner historical sediments overlain by a layer of more contaminated sediments and topped by a layer of cleaner recent sediments at the surface. Dioxins and furans were not selected as COCs, since concentrations in the top, middle and bottom sections of the core were all below the current residential standard of 1000 pg TEQ/g, (MOE, 1996c) and the top 10 cm of the core was, at 42.0-43.0 pg TEQ/g (depending on whether MDL or 0.5MDL is used to sum the TEQ), below the interim screening guideline of 50 pg TEQ/g developed by the ATSDR (ATSDR, 1998) and used by MOE for assessing PCDD/PCDF in sediments at other sites.

Therefore, PCB, and DL-PCB, have been identified as contaminants of potential concern for the detailed HHRA.

3.1.1 Screening PCB Concentrations in Sediments

PCB are the focus of concern for the human health risk assessment for the Upper and Lower Lyon's Creek East study areas. The MOE has not developed human health based screening guidelines for sediment. The mechanisms that govern human exposure to sediments do not differ from those that govern human exposure to soil. Therefore, standard risk assessment practice assesses human exposures to sediments in the same manner as human exposures to soils. Therefore, the use of soil screening guidelines to determine COC in sediment is appropriate.

The MOE (MOE, 1996c) provides screening criteria for several different land-uses including agricultural, residential/parkland and commercial/industrial land use. A distinction is also made between potable and non-potable groundwater use. Lyon's Creek East would generally be considered as parkland. The lands adjacent to the creek are a mixture of residential, agricultural and industrial lands. Homes back onto Lyon's Creek over much of the length of the study area. Therefore, residential land-use is likely to represent the largest adjacent land-use. Further, residential land-use considers potential exposures for people of all ages. There is also a potential for domestic use of groundwater in the area, and the results of the survey indicate that some members of the community use water from Lyon's Creek East for watering activities. Therefore, Upper and Lower Lyon's Creek East are considered to be residential/parkland for the purposes of the HHRA. The UCL concentrations for PCB in sediments in Upper and Lower Lyon's Creek East were compared to the MOE Table 2 Standard for PCB in soil for residential/parkland in an area where groundwater is considered to be potable (Table 3-1). PCB concentrations are expressed in mg/kg.

Table 3-1: Screening PCB in Sediment

Study area	UCL (mg/kg)	Table 2 Standard (mg/kg)	Carry as a COC
Upper Lyon's Creek East	21.98	5.0	Yes
Lower Lyon's Creek East	1.99	5.0	No

The UCL concentration of PCB in the Upper Lyon's Creek East study area is above the MOE Table 2 standard for residential parkland. Therefore, PCB have been identified as a COC in sediments in the Upper Lyon's Creek East study area. The UCL concentration of PCB in the Lower Lyon's Creek East study area is below the MOE Table 2 standard for residential soil. Therefore, PCB in sediments in the Lower Lyon's Creek study area have not been identified as a potential concern.

3.1.2 Screening PCB Concentrations in Soil

As noted in Section 2.2.2, measurable PCB concentrations were reported in only 7 soil samples. Because this is an insufficient number upon which to base the calculation of a UCL, the maximum reported concentration in soil was used to screen against the residential MOE Table 2 standard for residential/parkland for PCB (Table 3-2). The soil data summarized in Section 2.2.2 were collected

from the Upper Lyon's Creek East study area. Data were not available for soil from the Lower Lyon's Creek East study area, but would not be expected to reveal higher soil PCB concentrations, given the markedly lower concentrations in Lower Lyons Creek East sediments. Therefore, the soil data have been applied to both study areas and are considered conservative for the purposes of the assessment. The maximum reported concentration of 1.48 mg/kg is below the residential screening criterion of 5 mg/kg. Therefore, PCB have not been identified as a COC in soil for either the Upper or Lower Lyon's Creek East study areas.

Table 3-2: Screening PCB in Soil

PCB	Screening Criteria		Maximum (mg/kg)	Carry as a COC
	Residential			
	mg/kg	Source		Residential
PCB	5	MOE, 2004	1.48	**No**

3.1.3 Screening PCB Concentrations in Surface Water

Dillon collected 10 surface water samples from areas in the Upper and Lower Lyon's Creek East study areas. As noted in Section 2.2.3, PCBs were not detected in any of the surface water samples collected. The data collected, and the *Estimated Quantitation Limits* (EQLs) reported by the laboratory have been compared to the MOE Table 2 potable groundwater standard for PCB (Table 3-3). The EQLs reported by the laboratory are approximately 10-fold lower than the MOE Table 2 standard for PCB in potable water. PCB concentrations in Lyons Creek East surface water are well below the levels considered acceptable to a drinking water source and therefore do not represent a potential concern for human health in the Upper and Lower Lyon's Creek East study areas.

Table 3-3: Screening PCB in Surface water

Sample Location	Concentratoin	EQL	Potable Groundwater Standard (mg/L)
	mg/L	mg/L	
SW1	N.D.	0.000025	0.0002
SW2	N.D.	0.000025	0.0002
SW3	N.D.	0.000025	0.0002
SW4	N.D.	0.000025	0.0002
SW5	N.D.	0.000025	0.0002
SW6	N.D.	0.000025	0.0002
SW6 (repeat)	N.D.	0.000025	0.0002
SW7	N.D.	0.000025	0.0002
SW8	N.D.	0.000025	0.0002
SW9	N.D.	0.000025	0.0002
SW10	N.D.	0.000025	0.0002

3.1.4 Screening PCB Concentrations in Fish Tissue

Screening criteria are not readily available for PCB in fish tissue. The HHSLRA concluded that the consumption of sport fish may make a significant contribution to total daily exposure to PCB for

people in the Cooks Mills area. To ensure that exposures that may occur through the consumption of sport fish are adequately assessed, data on PCB concentrations in fish tissue have been used directly in the HHRA. PCB residues in fish collected by the MOE in the area of Highway 140 have been used to represent PCB concentrations in fish tissue for the Upper Lyon's Creek East study area. PCB residue data for fish collected from the Cooks Mills area have been used to represent PCB concentrations in fish tissue for the Lower Lyon's Creek East study area.

3.2 Identification of Potential Receptors

The Upper and Lower Lyon's Creek East study areas incorporate the section of Lyon's Creek that lies between the Welland Canal Bypass in the west and Montrose Road in the east. The area adjacent to the creek would be conservatively considered as recreational parkland. As noted in Section 2, lands adjacent to Lyon's Creek include a mix of commercial, residential and agricultural land uses. Residential land use, particularly in the Cooks Mills area, represents the largest land-use component along the creek within the study area and provides the greatest potential for people of all ages to come into contact with contaminants in Lyon's Creek sediments on a regular basis. People living outside the Cooks Mills area can also be expected to make use of Lyon's Creek for recreational purposes. However, the exposures experienced by these non-resident users would be expected to be less frequent than the exposures experienced by residents of Cooks Mills who can more readily access Lyon's Creek. For the purposes of the HHRA, residential receptors of all ages have been considered as the primary receptors of concern. The HHRA has assumed that people who live on properties that back on to Lyon's Creek will have the greatest access to Lyon's Creek.

These assumptions of maximum likely exposure represented by the local community extend to the consideration of potential consumption of fish from Lyons Creek East by visitors from outside the community. Although Lyons Creek is accessible at several road crossings, there was little evidence of significant fishing activity noted during site visits to the study area. Such evidence typically includes well-developed footpaths, trampled or cut vegetation along the banks and discarded fishing line, bait/lure packages and drink containers. Some such evidence was noted in the Lower Lyons Creek East study area, particularly around road crossings, but there was none observed at Upper Lyons Creek East. Further, the open water habitats within reach of the road crossings and banks of Lyons Creek East are quite limited in area and are characterized by very shallow depths and thick weed growth, much of which is not particularly amenable to fishing. Fish may be captured in the scour holes associated with culverts and bridges, particularly in the Lower Lyons Creek East study area where these appeared to be more extensive. It is possible that some visitors may fish portions of Lyons Creek by canoe, but this would not likely be at a frequency greater than that of local residents, especially given that better fishing may be found in numerous nearby watercourses and lakes. There was no sign of regular boat or canoe access to Lyons Creek at the road crossings within the study area that would provide access to visitors. Some residents reported regular canoeing on the creek, but would access the creek from their back yards. As such, visiting anglers are not considered in the HHRA.

The age groups that have been considered in the HHSLRA include:

- Infants (0-6 months of age)
- Toddlers (7 months through 4 years of age)

- Children (5 years through 11 years of age)
- Teens (12 years through 19 years of age)
- Adults (20+ years of age).

The age groupings for the residential receptor are consistent with the age groupings typically used by the MOE in assessing potential human health risks and are also consistent with the age grouping recommended by Health Canada (Health Canada, 2004).

3.3 Site Conceptual Model

In assessing potential exposures to PCB and DL-PCB for residents in the Upper and Lower Lyon's Creek East Study areas, it is necessary to identify the exposure pathways that are potentially complete in each study area. Results from the Community Survey have been used in combination with observations of the site characteristics and use of the site by the local community to establish fishing, recreational use and other activity patterns in both study areas to aid in the identification of exposure pathways that are relevant in each study area. Listings of the potentially complete exposure pathways in the Upper and Lower Lyon's Creek East study areas are provided in the following sections.

3.3.1 Identifying Exposure Pathways for Upper Lyon's Creek East

A listing of the exposure pathways considered for the Upper Lyon's Creek East study area is provided in Table 3-4. This table provides the rationale to support the inclusion of active pathways and the exclusion of pathways that are considered incomplete. Based on the information provided in Table 3-4, the potentially complete exposure pathways include;

- Dermal contact with sediment.

Although PCB and DL-PCB are present in sediments, the incidental ingestion of sediments has not been identified as a potentially complete exposure pathway for the Upper Lyon's Creek East study area. The available information on PCB concentrations in soil collected at 1m, 5m and 25m from the banks of Upper Lyon's Creek East shows that PCB concentrations in soil are all below the MOE Table 2 soil standard for residential/parkland (see Section 2.2.2). Therefore, exposure to PCB in soil/sediment along the banks of the Upper Lyon's Creek East study area would not represent a potential concern for human health. Access to sediments in Upper Lyon's Creek East is limited and would only be likely to occur for people engaging in boating or similar recreational activities, as the creek is not used for swimming. Under these conditions incidental ingestion is not expected to occur, but dermal exposure to PCB in sediments can be expected to occur while launching and beaching canoes or other craft and may occur on occasions when paddles come into contact with sediments during boating activities.

As results of the community survey and field observations made during the course of this study did not reveal fish consumption from Upper Lyons Creek, the associated risk was not calculated as part of this study. However, there remains the possibility that some people could, now or in the future, catch and eat fish from the portion of the creek upstream of Highway 140. Anyone who wishes to consume fish from that area should consult the Guide to Eating Ontario Sport Fish. Details of the

Guide and related Ministry of the Environment contact information is provided in Section 7.2 of this report.

Table 3-4: Potentially Complete Exposure Pathways for the Upper Lyon's Creek East Area

Media	Exposure Route	Pathway	Retained	Rationale
Sediment	Inhalation	Inhalation of re-entrained sediment dusts	No	Sediments will either be wet or under water. Therefore, sediments will not be re-entrained in the air column as a result of wind action.
	Ingestion	Incidental ingestion of sediment	No	PCB are located in sediments in the creek bed and would not be expected to be available for incidental ingestion exposures (see discussion in text).
		Uptake into plants and consumption of plants	No	Residents are not expected to consume plants from Lyon's Creek.
		Uptake into animals and consumption of animals	No	Direct data on contaminant concentrations in fish and snapping turtles is available. (See below)
	Dermal Contact	Dermal contact with sediment	Yes	Dermal contact with sediment is a potentially complete exposure pathway (see discussion in text).
Soil	Inhalation	Inhalation of re-entrained soil & dust	No	Available data show that PCB concentrations in soil along the banks of Upper Lyon's Creek East are below the MOE Table 2 standard for residential/parkland and therefore would not be considered a potential concern for human health. In addition, PCB were not detected in surface water. Therefore, the movement of PCB from Lyon's Creek onto residential properties through water activities would not contribute PCB to residential soil. Therefore, exposure to PCB through contact with soil is not considered to be a potentially complete exposure pathway for the Upper Lyon's Creek East study area.
	Ingestion	Ingestion of soil		
		Uptake into plants and consumption of plants		
		Uptake into animals and consumption of animal products		
	Dermal Contact	Dermal contact with soil		
Air	Inhalation	Inhalation of compounds in indoor air	No	PCB are not volatile and therefore, the inhalation of vapours is not a potentially complete exposure pathway.
Drinking Water	Ingestion	Ingestion of compounds in drinking water derived from on-site groundwater	No	Testing has shown that PCB are not present I surface water and are unlikely to be present in groundwater due to the presence of a confining layer between the sediments in Upper Lyon's Creek and any underlying aquifer.
Surface Water	Ingestion	Incidental Ingestion of surface water while swimming/wading	No	Analysis of surface water shows that PCB are not detected. Further, the EQL reported by the Laboratory are approximately 10-fold lower than the MOE Table 2 Standard for PCB in potable water.
	Dermal Contact	Dermal contact with surface water while swimming of wading		
Fish	Ingestion	Ingestion of contaminants from sport fish	No	Survey results indicate that residents in the Lyon's Creek East study area do not catch and consume fish from Upper Lyon's Creek.
Other Biota	Ingestion	Ingestion of contaminants through the consumption of other biota	No	Survey results indicate that residents in the Lyon's Creek East study area do not catch and consume game or waterfowl from the Upper Lyon's Creek East study area. The consumption of snapping turtles was not reported in any of the survey responses received.
Supermarket Food and Consumer Products			No	These exposures will be the same as the general population.

3.3.2 Identifying Exposure Pathways for Lower Lyon's Creek East

A listing of the exposure pathways considered for the Lower Lyon's Creek East study area is provided in Table 3-5. This table provides the rationale to support the inclusion of active pathways and the exclusion of pathways that are considered incomplete. Based on the information provided in Table 3-5, the potentially complete exposure pathways include;

- Consumption of Sport Fish.

Total PCB concentrations are available for sport fish from Lower Lyon's Creek East, and form the basis of this aspect of the risk assessment. Congener data do not exist for those fish and, hence, DL-PCB was not addressed as a COC in relation to Lower Lyon's Creek East fish consumption.

Although survey results indicate that there is limited consumption of game and waterfowl from the Lower Lyon's Creek east study area, potential exposures to PCB through the consumption of deer and/or waterfowl are not considered to be a concern for the human health risk assessment. The rationales for excluding these as potentially complete exposure pathways are provided below.

- **Consumption of Deer:**
  Two respondents indicated that they consumed deer from Lyon's Creek East; one from areas east of Highway 140 and one from east of Cooks Mills, both areas that would be considered as part of the Lower Lyon's Creek East study area. White-tailed deer are terrestrial herbivores. Their primary habitat is represented by the woodlots, wooded valley and fields surrounding Lyons Creek East. The creek would represent only a small portion of the range of deer in the area. PCB concentrations in sediments in this area are below the MOE Table 2 standard of 5.0 mg/kg PCB for residential/parkland but above the MOE Table 2 standard of 0.5 mg/kg PCB in agricultural soil. This latter standard is based on the potential for PCB to accumulate through grazing livestock into the human food supply. This suggests that the potential accumulation of PCB is deer taken from the Lyon's Creek East area could be a potential concern. However, as noted in Section 2.2.2, PCB are generally not detected in soil along the banks of the Upper Lyon's Creek East area and have only been detected in 7 samples at low concentrations. In addition, PCB were not detected in vegetation samples collected from the banks of Lyon's Creek East (MOE, 1996a). In addition, as noted in Section 2.2.3, PCB were not detected in surface water samples collected from various locations on Lyon's Creek East. Therefore, it is unlikely that deer would be exposed to PCB through vegetation or through drinking water from Lyon's Creek East. Further, because the sediments of Lyon's Creek East are soft and would not support deer, it is unlikely that deer would come into contact with the sediments on a regular basis or to any measurable degree.

  For the reasons outlined above, it is felt that the potential for deer to come into contact with PCB in the sediments of Lyon's Creek East is extremely low and the potential for deer to accumulate PCB in tissues is correspondingly low. Therefore, human exposure to PCB through the consumption of deer taken from the Lyon's Creek East area is not considered to be a potentially complete exposure pathway.

- **Consumption of Waterfowl:**
  Three respondents indicated that they consume waterfowl from Lyon's Creek East from areas east of Cooks Mills. Waterfowl typically targeted by hunters in habitats like Lyons Creek East include Canada goose and dabbling ducks, such as the mallard, which have been observed periodically in and around the creek during site visits undertaken during the HHSLRA and HHRA. Canada goose is primarily herbivorous and mallards are omnivorous, reducing the likelihood of these species accumulating substantial concentrations of PCB in their tissues. As part of the ecological risk assessment undertaken for Lyons Creek East (Dillon 2006, *final draft report in progress*), even fish-eating birds were shown to be at low risk due to PCB, despite a diet likely to have higher PCB concentrations than vegetation.

  Furthermore, geese and ducks tend to forage over a wide area, including terrestrial and agricultural environments, and are at least locally migratory, vacating the Lyons Creek East area during the winter freeze-up for open water associated with the Great Lakes or for more southerly wintering grounds. Nevertheless, a review of the PCB concentrations in sediment samples collected east of the Cooks Mills area (LC-29 – LC-36, Figure 3-C) shows that PCB concentrations are generally below the MOE Table 2 standard of 0.5 mg/kg PCB in agricultural soil. The UCL for the 9 sediment samples is 0.45 mg/kg (see Appendix A). Thus, the levels of PCB in sediments are below the agricultural standard and are unlikely to represent a potential concern for human health as a result of accumulation through the food chain, even if the waterfowl were confined to Lyons Creek East.

  Therefore, exposure to PCB through the consumption of waterfowl is not considered a potentially complete exposure pathway.

Table 3-5: Potentially Complete Exposure Pathways for the Lower Lyon's Creek East Area

Media	Exposure Route	Pathway	Retained	Rationale
Sediment	Inhalation	Inhalation of re-entrained sediment dusts	No	The UCL concentration for PCB is below the MOE Table 2 Standard for soil for residential/parkland. Therefore exposure to PCB in the sediments from the Lower Lyon's Creek East study area would not be considered to represent a potential concern for human health.
	Ingestion	Incidental ingestion of sediment	No	
		Uptake into plants and consumption of plants	No	
		Uptake into animals and consumption of animals	No	
	Dermal Contact	Dermal contact with sediment	No	
Soil	Inhalation	Inhalation of re-entrained soil & dust	No	Available data show that PCB concentrations in soil along the banks of Upper Lyon's Creek East are below the MOE Table 2 standard for residential/parkland and therefore would not be considered a potential concern for human health. In addition, PCB were not detected in surface water. Therefore, the movement of PCB from Lyon's Creek onto residential properties through watering activities would not contribute PCB to residential soil. Therefore, exposure to PCB through contact with soil is not considered to be a potentially complete exposure pathway for the Upper Lyon's Creek East study area.
	Ingestion	Ingestion of soil		
		Uptake into plants and consumption of plants		
		Uptake into animals and consumption of animal products		
	Dermal Contact	Dermal contact with soil		
Air	Inhalation	Inhalation of compounds in indoor air or outdoor air	No	PCB are not volatile and therefore, the inhalation of vapours is not a potentially complete exposure pathway.
Drinking Water	Ingestion	Ingestion of compounds in drinking water derived from on-site groundwater	No	Testing has shown that PCB are not present I surface water and are unlikely to be present in groundwater due to the presence of a confining layer between the sediments in Upper Lyon's Creek and any underlying aquifer.
Surface Water	Ingestion	Incidental Ingestion of surface water while swimming/wading	No	Analysis of surface water shows that PCB are not detected. Further, the EQL reported by the Laboratory are approximately 10-fold lower than the MOE Table 2 Standard for PCB in potable water.
	Dermal Contact	Dermal contact with surface water while swimming of wading		
Fish	Ingestion	Ingestion of contaminants from sport fish	Yes	Exposure to contaminants through the consumption of sport fish from Lyon's Creek represents a potentially complete exposure pathway.
Other Biota	Ingestion	Ingestion of contaminants through the consumption of other biota	No	Survey results indicate that the consumption of snapping turtles is not a concern in the Lower Lyon's Creek East study area. Although survey results indicate that there is limited consumption of game and waterfowl in the Lower Lyon's Creek East study area, the consumption of game and waterfowl is not considered to be a concern (see text for discussion).
Supermarket Food and Consumer Products			No	These exposures will be the same as the general population.

3.4 Problem Formulation Summary

Summaries of the Problem Formulation stages of the HHRA for the Upper and Lower Lyon's Creek East study areas are provided in Table 3-6 and Table 3-7 respectively. These tables identify the land-uses, receptor groups, critical receptor age groups and exposure pathways considered in each of the assessments.

Table 3-6: Problem Formulation Checklist, Upper Lyon's Creek East

Land Uses		Receptor Groups		Critical Receptors		Exposure Pathways	
	Agricultural		General Public		Infant		Soil Ingestion
Y	Residential/Urban Parkland		Employees	Y	Toddler		Soil Dermal Contact
	Commercial with Daycare		Construction Workers	Y	Child		Particulate Inhalation
	Commercial without Daycare		Canadian Native Communities	Y	Teen		Vapour Inhalation
	Industrial	Y	Residents	Y	Adult		Groundwater Ingestion
	Remote Site						Surface Water Ingestion
							Surface Water Dermal Contact
							Sediment Ingestion
						Y	Sediment Dermal Contact
							Produce Ingestion
							Fish Ingestion
							Wild game Ingestion

Table 3-7: Problem Formulation Checklist, Lower Lyon's Creek East

Land Uses		Receptor Groups		Critical Receptors		Exposure Pathways	
	Agricultural		General Public	Y	Infant		Soil Ingestion
Y	Residential/Urban Parkland		Employees	Y	Toddler		Soil Dermal Contact
	Commercial with Daycare		Construction Workers	Y	Child		Particulate Inhalation
	Commercial without Daycare		Canadian Native Communities	Y	Teen		Vapour Inhalation
	Industrial	Y	Residents	Y	Adult		Groundwater Ingestion
	Remote Site						Surface Water Ingestion
							Surface Water Dermal Contact
							Sediment Ingestion
							Sediment Dermal Contact
							Produce Ingestion
						Y	Fish Ingestion
							Wild game Ingestion

4. EXPOSURE ASSESSMENT

4.1 Identifying Receptor Activity Patterns

4.1.1 Activity Patterns for the Upper Lyon's Creek East Study Area

The level of exposure to contaminants in the sediments in Lyon's Creek that a person could experience depends on how often a person comes into contact with the sediment. How often a person comes into contact with the sediment is determined by the activity patterns that are assumed for each receptor. The HHSLRA evaluated potential dermal exposures to PCB in sediments for the entire Lyon's Creek East study area. These exposure estimates were based on a number of assumptions regarding the amount of time that residents from the Cooks Mills area could be expected to spend in contact with sediments in Lyon's Creek East. The lack of activity data specific to the Cooks Mills community was identified as a data gap in the HHSLRA (Dillon, 2005).

Information related to the potential for people to come into contact with sediments in Lyon's Creek East was collected as part of the Community Survey conducted in the spring of 2005. The results of this survey are presented in Appendix B. As noted in Section 2.3, 44 of the 167 responses indicated the use of Lyon's Creek East for recreational activities. The most common recreational activity was boating (generally identified as canoeing). Hiking and fishing were also relatively common activities. A breakdown of the identified activities, their relative frequencies and durations, is provided below.

- Boating, 25 respondents, frequency weekly to yearly, duration 1 to 2 hours;
- Hiking, 17 respondents, frequency weekly to monthly, duration ½ to 2 hours;
- Fishing for consumption; 3 respondents, frequency daily to yearly, duration ½ hour to 2 hours;
- Fishing without consumption ("catch and release"); 11 respondents;
- Wading; 2 respondents, frequency 2 – 3 times per year, duration 1 to 2 hours;
- Winter activities were reported by 11 respondents; and
- Unspecified activities; 4 respondents, frequency twice per year, 1 to 2 hours.

Of the 44 responses, 5 were received from the Upper Lyon's Creek East study area. Boating, fishing, hiking and skating were identified as recreational activities in this area. During the winter months when Lyon's Creek is frozen, there is no potential for recreational users to come into contact with the sediments. Therefore, winter activities have not been included in the assessment of potential exposures to sediments. Survey responses related to the frequency of fishing, hiking and boating activities were used to establish activities patterns for assessing dermal contact with PCB in the Upper Lyon's Creek East study area. As none of the Upper Lyon's Creek East respondents indicated the consumption of fish from the Upper Lyons Creek area, fish consumption was not assessed for that area.

As noted in Section 3.3.1, PCB levels along the banks of the Upper Lyon's Creek East study area are below the MOE Table 2 standard for PCB in residential/parkland soil. Therefore hiking would not be expected to result in contact with PCB in sediments. The survey responses that indicated fishing as a recreational activity did not indicate if the fishing was done from the bank of Lyon's Creek East or if

it was done from a boat. For the purposes of this assessment it has been assumed that the fishing is done from the bank. Under these conditions, fishing would not be expected to result in contact with PCB in sediments. Boating is therefore the only recreational activity that could be expected to result in contact with PCB in sediments.

Survey results for the Upper Lyon's Creek East study area indicate that some residents engage in boating activities 2 to 3 times per week over the summer months. This information has been used as the basis for assessing potential dermal exposures to PCB in sediments in the Upper Lyon's Creek East study area. For the purposes of this assessment it has been assumed that boating occurs three times per week every week from the beginning of May through the end of September. This is a period of approximately 22 weeks. Based on a frequency of three days per week, this results in 66 days of boating over the summer (May through September).

4.1.2 Activity Patterns for the Lower Lyon's Creek East Study Area

The consumption of sport fish was identified as the only potentially complete exposure pathway for people in the Lower Lyon's Creek East study area. Dermal contact was also an exposure pathway, but was not assessed since PCBs are below MOE Table 2 values. The HHSLRA evaluated exposures to PCB through the consumption of sport fish for the entire Lyon's Creek East study area. These exposure estimates were based on a number of assumptions regarding the amount of fish from the Lyon's Creek East area that residents from the Cooks Mills area may consume. The lack of fish consumption data specific to the Cooks Mills community was identified as a data gap in the HHSLRA (Dillon, 2005).

Information related to the consumption of sport fish from Lyon's Creek East was collected as part of the Community Survey conducted in the spring of 2005. The results of this survey are presented in Appendix B. As noted in Section 2.3, three respondents indicated that they caught and ate fish from Lyon's Creek. The responses indicate that:

- Fish were caught in the Cooks Mills area or east of Cooks Mills;
- No fish from upstream of the Cooks Mills area (i.e., Upper Lyons Creek East study area) were consumed;
- Fish consumption rates ranged from once per year to once every 3 or 4 years;
- Fish species consumed included pumpkinseed, catfish and largemouth and smallmouth bass from the Lower Lyons Creek East study area.

Information related to the amount of fish consumed in a meal was not provided in the survey. Therefore it has been necessary to estimate the amount of fish consumed in a meal. For the purposes of this assessment it has been assumed that a fish meal would contain 227 gram of fish. This is consistent with the assumptions used in the Guide to Eating Ontario Sport Fish, 2005.

4.2 Exposure Averaging Factors

The toxicity reference values (TRVs) developed by regulatory agencies are averaged daily exposure values and represent daily exposures that can occur over a life-time without resulting in adverse

human health effects or unacceptable increases in life-time cancer risk. The exposures to PCB in the sediments, experienced by residents in the Upper Lyon's Creek East study area, and the exposures to PCB through the consumption of sport fish in the Lower Lyon's Creek East study area are considered to be intermittent exposures, because exposures will only occur on the days when people are either boating in the Upper Lyons Creek East area or are consuming fish caught from the Lower Lyon's Creek East area. Before these intermittent exposures can be compared to the toxicity reference value for PCB values, the intermittent exposures must be adjusted to account for the differences in exposure duration between the intermittent exposures in Lyon's Creek and the continuous exposures that were assumed in the development of the toxicity reference value. The difference in exposure duration is calculated as an *Exposure Averaging Factor* (AF). The activity patterns identified in Section 4.1.1 and Section 4.1.2 have been used to calculate the averaging factors for each of the receptor age groups in the Upper and Lower Lyon's Creek East study areas.

The calculation of exposure averaging factors depends on the type of exposure being considered. For example, inhalation occurs on a continuous 24-hour basis regardless of whether a person is on-site or off-site. Therefore, the inhalation exposure experienced by people on a site is a function of both the time spent on-site in a given day and the number of days spent on-site in a given year. Exposures of this nature are considered *Time Driven*. Exposures such as dermal contact with sediment or the consumption of sport fish can only occur when a person is present on-site or eating fish taken from Lyon's Creek East. Both of these exposures are considered to be *Event Driven* exposures. A discussion of the calculation of the *Event Driven* exposure averaging factors is provided below.

4.2.1 Event Driven Exposure Averaging Factors

The calculation of *Event Driven* averaging factors is a function of the number of days per year spent on activities that can result in dermal contact with sediments in the Upper Lyon's Creek East study area or the number of days per year where fish caught from Lyon's Creek East is consumed. Because scientific information relating to the apportionment of dermal exposures between on-site and off-site sources is limited, the risk assessment process conservatively assumes that on the days that a person is on site, all of the daily dermal contact with soil occurs while on site. The calculation of the AF for *Event Driven* exposures is based on the number of days exposures are assumed to occur compared with the number of days in a given year. The AF for *Event Driven* exposures is calculated as shown in Equation 4-1.

Eq 4-1: Calculation of Exposure Averaging Factor for *Event Driven* Exposures

$$AF_E = \frac{\left(EF_n \times EW_n \times Years_{(n)}\right)}{\left(365^{days}/_{year} \times Years_{(a)}\right)}$$

Where:	AF	= Averaging Factor	Unitless
	EF_n	= Exposure Frequency for receptor "n"	days/week
	EW_n	= Weeks per year on-site for receptor "n"	weeks/year
	$Years_n$	= Years of exposure	years
	$Years_a$	= Years for averaging exposure	years

Exposure Frequency (EF_n)

The exposure frequency is defined as the number of days per week that a person is expected to be present on-site.

Weeks (EW_n)

The weeks of exposure is defined as the number of weeks per year that a person is assumed to be present on-site.

$Years_{(n)}$

The number of years in an exposure scenario over which exposures are expected to occur. The number of years in the exposure scenario for each receptor, is equivalent to the number of years that a receptor spends in each age group. For example, children are considered to be between the ages of 5 and 12 years of age. For this receptor group, the ***$Years_{(n)}$*** would be 7 years.

$Years_{(a)}$

This represents the number of years over which the exposure is to be averaged. The number of years in the exposure scenario for each receptor is equivalent to the number of years that a receptor spends in each age group. For example, children are considered to be between the ages of 5 and 12 years of age. For this receptor group, the ***$Years_{(a)}$*** would be 7 years.

4.2.2 Exposure Averaging Factor for Dermal Exposures to PCB in Upper Lyon's Creek East

The exposure averaging factors for assessing dermal exposures to PCB in sediments in Upper Lyon's Creek East is provided in Table 4-1. This AF has been calculated using the activity pattern data collected from the Community Survey. In determining the averaging factors it has been assumed that infants would not have the potential to come into contact with sediments in the Upper Lyon's Creek East area. However toddlers, children and teens are assumed to participate in boating activities that could lead to dermal exposure to sediments.

Table 4-1: Dermal Exposure Averaging Factors for Upper Lyon's Creek East

Event Driven Exposure Factors: Upper Lyons Creek Sediments					
Receptor	**Days/year**	**Years**	**Days per year**	**Years**	**AF**
Dermal Contact with Sediment					
Toddler	66	4.5	365	4.5	0.180821918
Child	66	7	365	7	0.180821918
Teen	66	8	365	8	0.180821918
Adult	66	50	365	50	0.180821918

Exposure Averaging Factors for Sport Fish Consumption in Lower Lyon's Creek East

As noted in Section 4.1.2, results for the Community Survey indicate that the consumption of fish from Lyon's Creek East is limited. The highest consumption rate reported in the survey was once per year. The amount of fish consumed was not determined by the survey. Therefore, the amount of fish consumed per meal has been assumed to be 227 grams (1/2 pound) of fish. This consumption rate is based on an average-sized adult of 70 kg body weight. It has also been assumed that the consumption rate is proportional to body weight and that smaller adults and children will eat proportionally less fish and larger adults will consume more. The yearly averaged daily consumption rates are calculated as shown in Equation 4-2. The yearly averaged daily sport fish consumption rates are shown in Table 4-2.

EQ 4-2:

$$SP_{ya} = \left(\frac{\left(CR_{std} \left(\frac{BW_r}{BW_{std}} \right) \right) \times MF \times D}{365 \, days/year} \right)$$

Where:

SP_{ya}	= Yearly averaged daily sport fish consumption	g/day
CR_{std}	= Standard consumption rate	g/day
BW_r	= Receptor-specific body weight	kg
BW_{std}	= Standard body weight	kg
MF	= Meals per month	meals/ month
D	= Months per year	months/year
365	= Days per year	days/year

Table 4-2: Estimating Yearly Averaged Daily Fish Consumption Rates

Receptor	CR_{std}	BW_r	BW_{std}	MF	D	Total Yearly Consumption	Days/year	Yearly Averaged Daily Consumption
	g/day	kg	kg	meals/month	months/year	grams/year	days/Year	grams/day
Infant	227	8.2	70	1	1	27	183	0.14531
Toddler	227	16.5	70	1	1	54	365	0.14659
Child	227	32.9	70	1	1	107	365	0.29230
Teen	227	59.7	70	1	1	194	365	0.53041
Adult	227	70.7	70	1	1	229	365	0.62814

4.3 Physical and Physiological Parameters for Receptors

Physical and physiological factors such as body weight and inhalation rate and behavioural factors such as the consumption of fish and game all affect the potential daily exposures experienced by each of the receptors considered in the HHRA. Physical and physiological parameters are available from a number of sources including the MOE, Health Canada and the US EPA. The MOE has recently completed a review of available parameters and has identified values that it has used in assessing potential exposures to contaminants in the environment (MOE, 2002). These parameters have been used to assess potential human exposures in the HHRA for the Upper and Lower Lyon's Creek East areas. The parameters used to assess dermal contact with sediments are summarized in Table 4-3

Table 4-3: Physical, Physiological and Behavioural Parameters

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference
Age Range		0-6 m	7 m - 4 yrs	5 - 11 yrs	12-19 yrs	>20yrs	MOE, 2002
Years within an Age Group	years	0.5	4.5	7	8	50	MOE, 2002
Body Weight	kg	8.2	16.5	32.9	59.7	70.7	MOE, 2002
Soil Ingestion Rate	g/day	0.02	0.1	0.1	0.02	0.02	MOE, 2002
Skin Surface Area							
Hands	cm^2	320	430	590	800	890	MOE, 2002
Feet	cm^2	250	430	720	1080	1190	MOE, 2002
Totals	cm^2	570	860	1310	1880	2080	MOE, 2002
Soil Loading to Skin							
Soil Adhesion to Skin	g/cm2	7.0E-05	2.0E-04	2.0E-04	7.0E-05	7.0E-05	MOE, 2002

4.3 Quantifying Exposure for the Upper Lyon's Creek East Study Area

This section provides an overview of the calculations used to estimate dermal exposure to PCB in sediments in the Upper Lyon's Creek east study area. Calculations are provided for all receptor groups as indicated above.

The uptake of contaminants from sediment through the skin depends on the concentration of the chemical in the sediment, the surface area of skin exposed to sediments on a daily basis, the amount of sediment that adheres to the skin and the permeability of the skin to the contaminant. The estimation of the daily exposures to contaminants from dermal contact with sediment is calculated as shown in Equation 4-3. For the purposes of this assessment, it has been conservatively assumed that on the days when a person is assumed to be engaged in recreational activities on Upper Lyon's Creek East, all dermal contact with sediment is derived from sediments from Upper Lyon's Creek East. Thus, dermal contact exposures are considered to be *event driven* exposures. The dermal exposure averaging factors calculated in Section 4.2.2 have been used to estimate dermal exposures for toddlers, children, teens and adults. Estimates of exposure to PCB and DL-PCB through dermal contact with sediments are provided in Table 4-4.

Eq 4-3:

$$EDI_{dc} = \frac{C_{sed} \times SA \times SLF \times DAF \times CF \times AF}{BW}$$

Where:

Parameter	Description	Units
EDI_{dc}	= Intake from dermal contact with sediment	mg/kg-day
C_{sed}	= Contaminant concentration in sediment	mg/kg
SA	= Surface area of exposed skin	cm^2/day
SLF	= Sediment Loading Factor	g/cm^2
DAF	= Dermal absorption factor	Unitless
CF	= g to kg conversion factor	0.001
AF	= Exposure averaging factor	Unitless
BW	= Receptor body weight	Kg

The sediment-loading factor represents the amount of sediment that adheres to the skin over a given surface area. The sediment loading factors used in the present assessment were taken from the values used by the MOE in previous assessments of dermal exposure to contaminants in soil (MOE, 2002). The loading factors are based on soil adhesion to the skin. It is reasonable to expect that a greater amount of sediment could adhere to the skin given that, in general, sediment would be expected to be wetter than soil. Although a thicker layer of sediment may adhere to skin than soil, the area covered by soil and sediment can be expected to be the same. The uptake of contaminants from soil or sediment through the skin is governed by the layer of soil/sediment that is in direct contact with the skin. Contaminants in soil/sediment that are not in direct contact with the skin do not contribute to dermal uptake. Therefore, using soil-loading factors to estimate uptake from sediments will provide reasonable estimates of potential exposure. For the purposes of this assessment it has been assumed that people's hands and feet would be exposed to sediments from the Upper Lyon's Creek East area. This is based on foot contact with sediments while launching and landing, and conservatively assumes a lack of footwear that might otherwise limit exposure. Hands could be exposed while handling paddles or anchors covered with sediment, or by touching sediments on the feet or on footwear.

The uptake of chemicals through the skin is chemical-specific. The dermal absorption factor used to estimate the absorbed doses of PCB and DL-PCB is based on the value recommended by the US EPA (USEPA, 2001).

Table 4-4: Exposure from Dermal Contact With Sediment: Upper Lyon's Creek East

Receptor	Concentration in Soil	Skin Surface Area	Soil Adhesion Factor	Dermal Absorption Factor	Exposure Averaging Factor	Conversion Factor	Body Weight	Estimated Daily Intake
	mg/kg	cm^2	g/cm^2	Unitless	Unitless	kg to g	Kg	mg/kg-day
PCB								
Toddler	2.2E+01	430	2.0E-04	0.14	0.18	0.001	16.5	2.9E-06
Child	2.2E+01	720	2.0E-04	0.14	0.18	0.001	32.9	2.4E-06
Teen	2.2E+01	1080	7.0E-05	0.14	0.18	0.001	59.7	7.0E-07
Adult	2.2E+01	1190	7.0E-05	0.14	0.18	0.001	70.7	6.6E-07
DL-PCB								
Toddler	3.4E-05	430	2.0E-04	0.14	0.18	0.001	16.5	4.5E-12
Child	3.4E-05	720	2.0E-04	0.14	0.18	0.001	32.9	3.8E-12
Teen	3.4E-05	1080	7.0E-05	0.14	0.18	0.001	59.7	1.1E-12
Adult	3.4E-05	1190	7.0E-05	0.14	0.18	0.001	70.7	1.0E-12

4.4 Quantifying Exposure for the Lower Lyon's Creek East Study Area

This section provides an overview of the calculations used to estimate exposures to PCB through the consumption of sport fish from the Lower Lyon's Creek East study area. Calculations are provided for all receptor groups as indicated above. Exposure to contaminants through the consumption of sport fish depends on the levels of contaminants present in the edible portions of the fish and the amount of fish consumed on a daily or yearly basis. Exposures to contaminants through the consumption of fish are calculated as shown in Equation 4-4. Estimates of PCB exposure through the consumption of sport fish are provided in Table 4-5.

EQ 4-4:

$$EDI_{fish} = \frac{C_{fish} \times IR_{fr}}{BW_r}$$

Where:

Parameter	Description	Units
EDI_{fish}	= Intake from fish/game consumption	mg/kg-day
C_{fish}	= Contaminant concentration in fish/game tissue	mg/kg
IR_{fr}	= Yearly averaged daily ingestion rate for fish/game for receptor r	g/day
BW	= Receptor body weight	kg

Table 4-5: PCB Exposures from the Consumption of Sport Fish: Lower Lyon's Creek East

Receptor	Concentration in Fish Tissue	Yearly Averaged Daily Fish Consumption Rate	Conversion Factor	Body Weight	Estimated Daily Intake
	mg/kg	g/day	kg to g	kg	mg/kg-day
PCB					
Infant	1.5E-01	0.15	0.001	8.2	2.66E-06
Toddler	1.5E-01	0.15	0.001	16.5	1.33E-06
Child	1.5E-01	0.29	0.001	32.9	1.33E-06
Teen	1.5E-01	0.53	0.001	59.7	1.33E-06
Adult	1.5E-01	0.73	0.001	70.7	1.55E-06

5. TOXICITY ASSESSMENT

An essential part of the risk assessment process is the identification of toxicologically-based toxicity values that can be compared to exposure estimates. This section provides a listing of the toxicological reference values (TRVs) used in the HHRA. In selecting appropriate TRVs, toxicity values for Health Canada and the US EPA *Integrated Risk Information System* (IRIS) and the World Health Organization (WHO) were considered. Preference was given to the most recently developed TRVs because these values incorporate the most up-to-date assessments of available toxicological information and may include toxicological information that was unavailable during the development of older toxicity values. For PCB, the WHO TRV of 0.00002 mg/kg-day represents the most recent assessment of PCB toxicity and has been selected to use in the current assessment (WHO, 2003). In addition DL-PCB were assessed based on a TRV of 2.0 pg/kg-day.

Table 5-1 lists the TRVs for PCB and DL-PCB used in the assessment. Dermal exposure and fish consumption were identified as the potentially complete exposure pathways. TRVs are not generally available for dermal exposures. Oral TRVs have been used to assess dermal exposures and are applicable to fish consumption as well. As congener-specific data do not exist for fish in Lower Lyons Creek East, only the PCB TRV is applicable to that exposure pathway for the purposes of the HHRA. Inhalation exposures were not identified as potentially complete exposure pathways for the present assessment. Therefore, TRVs for inhalation exposures have not been provided in Table 5-1.

Table 5-1: Toxicological Reference Values for the Chemicals of Concern

Chemical	Exposure Route	Toxicity Value	Biological End-point	Agency
PCB	Oral/Dermal	0.00002 mg/kg-day	Hepatic and Immunological Effects	WHO, 2003
DL-PCB	Oral/Dermal	2.0 pg/kg-day	Reproductive Effects	Health Canada, 2004

6. RISK CHARACTERIZATION

The risk characterization stage of the HHRA process compares the exposures estimated for each of the receptors with the identified toxicity values to determine if site-related exposures exceed the identified limits. For non-carcinogenic endpoints, the potential for exposures to result in adverse human health effects is based on the ratio between the estimated exposure and the identified toxicity value. This ratio is called the *Hazard Quotient* (HQ) and is calculated as shown in Equation 6-1. The HQ provides an indication of whether estimated exposures are large enough to be of concern for human health. A HQ of less than 1.0 indicates that exposures are below the toxicity value and would not be expected to result in adverse human health effects. Because of the conservative assumptions used by regulatory agencies in the development of toxicity values, HQ values greater than 1.0 do not mean that adverse human health effects will occur, but the likelihood that an adverse effect will occur increases as the HQ value rises above 1.0.

Eq: 6-1:

$$HQ = \frac{EDI_{total}}{TRV}$$

Where:

Parameter	Description	Units
HQ	= Hazard Quotient	unitless
$EDI_{t(r)}$	= Estimated Daily Intake EDI_{total} for receptor r	mg/kg-day
TRV	= Identified toxicological reference value	mg/kg-day

The HHRA for Upper and Lower Lyon's Creek East only considered exposures that could result from contact with PCB and DL-PCB in sediments and PCB in fish from Lyon's Creek East. Exposures from other sources, such and supermarket food and consumer products have not been considered. In cases where exposures from all sources are not considered, standard risk assessment practice estimates potential hazards against a hazard benchmark of 0.2. This ensures that site-related exposures do not exceed twenty percent (20%) of the TRV on a daily basis. If the estimated exposures are less than 20% of the TRV, it can be concluded that exposures to PCB and DL-PCB in the sediments of Upper Lyon's Creek East and to PCB in sport fish from Lower Lyon's Creek East do not pose a potential hazard to human health. The HQ values calculated for the appropriate receptors for the Upper and Lower Lyon's Creek East areas are discussed in the following sections.

6.1 Characterizing Hazards for Dermal Exposures to PCB in Upper Lyon's Creek East

The hazard quotients associated with exposure to PCB and DL-PCB in the sediments in Upper Lyon's Creek East for toddler, child, teen and adult receptors, are presented in Table 6-1.

For PCB, all HQs are below the benchmark of 0.2. For all age groups, the daily exposures to PCB (total daily intakes) are below the TRV of 0.00002 mg/kg-day, and the maximum HQ, for the toddler, is only 0.15. Therefore, exposure to PCB in the sediment in Upper Lyon's Creek East would not be

expected to result in any adverse human health effects for people in any of the age groups considered in the assessment (toddlers through adults).

With respect to DL-PCB, exposure in the sediment in Upper Lyon's Creek East results in HQ values equal to or below 0.0022 for all receptors. Therefore, exposure to DL-PCB would not be expected to result in any adverse human health effects for people in any of the age groups considered.

As noted in Section 4.2.2, infants would not be expected to come into contact with sediments in the Upper Lyon's Creek East area. Therefore, HQs have not been calculated for the infant receptor. The data in Table 6-1 show that the HQs calculated for toddlers, children, teens and adults are below the hazard acceptability benchmark of 0.2 for both PCB and DL-PCB. Therefore, exposures to PCB and DL-PCB in sediments in Upper Lyon's Creek East would not be expected to result in adverse health effects for people who use the area for recreational activities.

Dioxins and furans were mentioned earlier in this report in the context of a focused investigation involving the analysis of core sections to determine dioxin/furan concentrations. Analysis of the core was not intended to yield dioxin and furan data for numerical modeling purposes as part of the risk assessment, but rather to inform a decision regarding the need to include dioxins/furans, which were screened off based on the low TEQ concentrations. However, it is worthy of note that addition of the surface dioxin and furan TEQ concentration to the maximum surface DL-PCB TEQ concentration results in HQ values that are still orders of magnitude below the 0.2 hazard acceptability benchmark.

The max concentration of DL-PCB was 0.034 ng/g TEQ in sample 03LC08C. Addition of the single surface dioxin/furan concentration of 0.042 ng/g TEQ slightly more than doubles the total TEQ to 0.076 ng/g TEQ. The addition of the dioxin/furan TEQ results in HQs ranging from 0.005 for toddler to 0.0011 for adult. As expected, based on the low TEQs involved, dioxin/furan concentrations in the Upper Lyons Creek sediments do not appear to represent an undue risk to human health and were appropriately screened off earlier in the risk assessment.

Table 6-1: Hazard Quotients for Dermal Contact with PCB and DL-PCB, Upper Lyon's Creek East

Receptor	Total Daily Intake (mg/kg-day)	Toxicity Value (mg/kg-day)	Hazard Quotient (Unitless)
PCB			
Toddler	2.9E-06	2.0E-05	0.15
Child	2.4E-06	2.0E-05	0.12
Teen	7.0E-07	2.0E-05	0.035
Adult	6.6E-07	2.0E-05	0.033
DL-PCB			
Toddler	4.5E-12	2.0E-09	0.0022
Child	3.8E-12	2.0E-09	0.0019
Teen	1.1E-12	2.0E-09	0.00054
Adult	1.0E-12	2.0E-09	0.00051

6.2 Characterizing Hazards Sport Fish Consumption in Lower Lyon's Creek East

The hazard quotients associated with exposure to PCB in fish from Lower Lyon's Creek East for infant, toddler, child, teen and adult receptors, are presented in Table 6-2. Exposures that exceed the HQ benchmark of 0.2 would be shown in bold, however the data in Table 6-2 show that the HQ values for receptors in all age groups are below the hazard acceptability benchmark of 0.2. Therefore, exposure to PCB through the consumption of sport fish from the Lower Lyon's Creek area would not be expected to result in adverse human health effects.

Table 6-2: Hazard Quotients for Exposure to PCB in Sport Fish, Lower Lyon's Creek East

Receptor	Total Daily Intake (mg/kg-day)	Toxicity Value (mg/kg-day)	Hazard Quotient (Unitless)
Infant	2.7E-06	2.0E-05	0.13
Toddler	1.3E-06	2.0E-05	0.067
Child	1.3E-06	2.0E-05	0.067
Teen	1.3E-06	2.0E-05	0.067
Adult	1.6E-06	2.0E-05	0.078

It is important to note that these PCB exposure estimates are based on information related to fish consumption rates provided in the Community Survey. As noted in Section 2.3, the majority (99%) of respondents indicated that they do not eat fish from Lyon's Creek East. Of the respondents who indicated that they do eat fish, the highest reported frequency of consumption was once per year. These estimates have been applied to the general population in the Cooks Mills area and therefore, overestimate potential exposures for most of the community.

7. DISCUSSION OF UNCERTAINTIES

Uncertainty is an important consideration in quantitative risk assessment. It is important to define uncertainty in the risk assessment process in order to quantify the range of possibilities of the results. If the uncertainty associated with a particular input factor is great, the range of possibilities for that specific value may produce a profound difference in the resulting risk calculation, depending on the particular value that is selected for that factor. An example of the potential impact of uncertainty on the results of the risk assessment may be illustrated by the soil ingestion factor for a child. The range of possibilities for daily soil ingestion may be anywhere from 0 to 100 milligrams per day per child. Even for a site-specific risk assessment, it is impossible to assess the amount of soil ingested by a particular child so that a unique value may be selected for each child in a study area. For this reason a value must be predicted from the scientific literature and inserted into the risk assessment calculations to represent the soil ingestion rate. If a value close to zero, such as 1 milligram per day is selected, the resulting predicted potential risk for a child will be 100-fold lower than the potential risks that would be predicted if a soil ingestion rate of 100 milligrams per day were used.

Since it is standard and customary to overestimate the potential risks, but unacceptable to underestimate them, regulatory guidance dictates that values from the high end of the range of factors be selected for use in estimating exposures and the associated potential hazards or risks. This section of the report presents a discussion of the uncertainties associated with many of the risk assessment factors used in this assessment. It also includes a sensitivity analysis that provides an indication of the effect that the main factors have on the estimates of potential hazard and risk.

7.1 Survey Results

The characterization of activity patterns in Upper and Lower Lyon's Creek East is based on information provided by respondents to the Community Survey. Overall, the survey achieved a 46% response rate. Households in the community who did not return surveys were contacted by phone. Most declined to participate. The response rate provides an indication of activity patterns in the community, but it is not possible to eliminate the possibility that members of the community who have not responded to the survey consume more fish from Lyon's Creek than has been assumed in the present study or engage in recreational activities that would result in higher exposures to sediments than have been assumed in the present study. For the Lower Lyon's Creek East study area, exposure to sediments in not a concern because PCB concentrations in the sediments are below the MOE Table 2 standard for residential/parkland soil. A higher rate of exposure to sediments could be a concern in the Upper Lyon's Creek East study area if there are members in the community who come into contact with the sediments more frequently than has been assumed in the current report.

7.2 Fish Consumption Patterns

Survey results indicate that residents do not consume fish from the Upper Lyon's Creek east area. As noted in the HHSLRA (Dillon, 2005), consumption of fish from the Highway 140 area would result in exposures that exceed the TRV for PCB. Therefore, if residents consume fish from the Upper Lyon's Creek East area, there is a potential for unacceptable exposures to PCB.

Likewise, there is a possibility that visiting anglers, unlike the resident respondents to the Community Survey, could regularly keep and consume fish from Upper Lyons Creek East. This possibility is considered to be low, however, given that local anglers are more likely to fish the creek and visiting anglers are more likely to be attracted to better fishing conditions in more substantial water bodies in the area. The site conditions at the public access points to Upper Lyons Creek East are not entirely conducive to angling, and there was general lack of evidence of sustained or substantial fishing effort throughout the study area.

However, anyone who wishes to consume fish from Upper Lyon's Creek East should consult the Guide to Eating Ontario Sport Fish, which is available on the Ministry of the Environment web site at www.ene.gov.on.ca and through the Public Information Centre, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5. The current version of the Guide at the time of drafting of this report was 2005-2006 Twenty-third Edition, Revised. Page 65 of that Edition provides consumption advice for a range of lengths of nine species of fish from "Lyons Creek at Highway 140". Users of the Guide should also read the text of the Guide before referring to the advisory tables. The Guide is published every other year. In alternate years, major changes in fish consumption advice are made public by the Ministry through its Public Information Centre, the Ministry web site and media notification. The public can also contact the Sport Fish Contaminant Monitoring Program at (416) 327-6816 or 1-800-820-2716 or e-mail sportfish@ene.gov.on.ca with questions on the status of specific advisories.

7.3 Other Game Consumption Patterns

The consumption of deer and waterfowl from the Lower Lyon's Creek East area was identified in several survey responses. The Lower Lyons Creek East area is more rural in nature and could support hunting activities. There was no evidence of hunting in the Upper Lyons Creek East area, and the close proximity of the Highway, Welland Canal Bypass, businesses, residences and trails would not make the area conducive to hunting. Information on PCB concentrations in tissues from deer and waterfowl were not available for animals taken from the Lower Lyon's Creek East area. However, as noted in Section 3.3.2, the consumption of deer and waterfowl from the Lower Lyon's Creek East study area is not expected to result in exposure to PCB for people who consume game from this area. This is due to the low PCB concentrations within the soils, sediments, water and vegetation in the Lower Lyons Creek East area, combined with the habits of these game species that limits their exposure duration and/or frequency.

The current consumption of snapping turtle from Lyons Creek East was not indicated in any of the Community Survey responses. One respondent indicated consumption up to eight years prior to the survey. Turtle capture and consumption is not considered to be a particularly widespread activity among Southern Ontario sportsmen, although it was more common with previous generations and seems to enjoy a following in parts of the United States. Further, the observation and easy capture of large snapping turtles at road access points suggests that turtle populations are not heavily exploited, if at all, in the Lyons Creek East study area. Nevertheless, the possibility that someone may consume turtles from Lyons Creek East cannot be ruled out and remains as an uncertainty of this risk assessment.

8. CONCLUSIONS AND RECOMMENDATIONS

The human health risk assessment (HHRA) for the Lyon's Creek East study area builds on the conclusions and recommendations of the human health screening level risk assessment (HHSLRA) completed for the area in 2005 (Dillon, 2005). The HHSLRA concluded that PCB were the only contaminants that may represent a potential concern for human health. Focused sampling undertaken as part of the HHRA confirmed that dioxins and furans were not present in the sediments in concentrations that would warrant inclusion of these compounds as COCs. Adding the dioxin and furan TEQs to the maximum DL-PCB TEQ failed to raise the HQ closer than a couple order of magnitude below the 0.2 HQ threshold. Therefore, the HHRA focused on potential exposures to PCB, and added an assessment of DL-PCB where supported by existing PCB congener data for sediments in the Lyon's Creek East study area. Congener analysis was not completed on the fish collected in Lower Lyons Creek East, so the assessment of fish consumption in that area focused on total PCB.

The HHSLRA considered exposures to PCB based on an *Upper Concentration* Limit (UCL) of 9 mg/kg calculated for the entire sediment quality data set. As noted in the HHSLRA, this approach over estimated potential exposures to PCB for residents in the Cooks Mills area. To provide exposure estimates that better reflect potential exposures for residents in the Cooks Mills area and in the homes adjacent to Lyon's Creek in the vicinity of Highway 140, the Lyon's Creek East site was divided into Upper and Lower Lyon's Creek East study areas. A review of the sediment quality data indicates that PCB concentrations in sediments are highest in the section between the Welland Canal Bypass and Highway 140 and that PCB concentrations decrease with distance downstream from the CN railway crossing east of Highway 140. Therefore the site division was set at the CN crossing. The section between the Welland Canal Bypass and the CN crossing was designated as the Upper Lyon's Creek East study area and the section from the CN crossing downstream to Montrose Road was designated as the Lower Lyon's Creek East study area. The sediment quality data collected by the Ministry between 1991 and 2003 were used to estimate PCB UCL concentrations of 21.98 and 1.99 mg/kg in the Upper and Lower Lyon's Creek Study areas respectively.

In the Upper Lyon's Creek East area, the UCL concentration of 21.98 mg/kg PCB is above the MOE Table 2 standard of 5.0 mg/kg PCB for residential/parkland soil. Therefore potential exposures to PCB in sediments were assessed for the Upper Lyon's Creek East study area. In the Lower Lyon's Creek East study area, the PCB UCL concentration of 1.99 mg/kg is below the MOE Table 2 standard. Therefore, exposure to PCB in sediments in the Lower Lyon's Creek East study area would not be considered a potential concern for human health and exposures to PCB in sediments in this area were not assessed in the HHRA.

A Community Survey was conducted with the participation of residents in the Upper and Lower Lyon's Creek East study areas to establish the number of people in the community who catch and eat fish and game from Lyon's Creek East, undertake other recreational uses of Lyon's Creek East or use water from Lyon's Creek East for any domestic purposes. A total of 365 surveys were hand delivered to homes in the Upper and Lower Lyon's Creek East areas. A total of 167 responses were received, including those that were mailed back and those that were filled out over the telephone. The results of the survey indicate:

- The consumption of fish from Lyon's Creek East is limited (3 of 167 responses);
- The highest reported rate of fish consumption was once per year;
- Fish that were consumed were taken either from the Cooks Mills area or downstream from Cooks Mills;
- Fish from the Highway 140 area were not consumed by any survey respondents;
- Deer and waterfowl taken from the Lower Lyon's Creek East area were consumed by members of the community (5 of 167 responses);
- Game or waterfowl were not taken from the Upper Lyon's Creek East study area;
- Recreational use of Upper and Lower Lyon's Creek East is common (44 of 167 responses) with hiking and boating being the most frequently reported activities; and
- Use of water from Lyon's Creek East for watering lawns and vegetable gardens also occurs (7 of 167 responses).

The results of the survey were used to refine many of the activity pattern assumptions used in the HHSLRA to provide exposure estimates that reflect conditions in the community. These refinements include:

- Fish consumption is not a concern in the Upper Lyon's Creek East study area;
- Recreational activities occur over the summer months with the highest reported frequency being for boating at 2 – 3 times per week. This estimate was used to assess exposures to PCB in sediments;
- Watering activities occur and were addressed; and
- Consumption of game and waterfowl from the Lyon's Creek area occurs and were addressed.

Detailed consideration of activity patterns and the potential for PCB movements in environmental media resulted in the identification of potentially complete exposure pathways for the Upper and Lower Lyon's Creek East study area. The pathways considered for each study area were:

- Upper Lyon's Creek East: Dermal contact with sediments; and
- Lower Lyon's Creek East: Consumption of sport fish.

Assessment of dermal exposure to PCB in the Upper Lyon's Creek East area showed that exposures to PCB were below the toxicity reference value for PCB. Hazard quotient (HQ) values ranged between 0.15 for the toddler and 0.033 for the adult. Both are below the hazard acceptability benchmark of 0.2 established by the Ontario Ministry of the Environment.

Assessment of dermal exposure to DL-PCB in the Upper Lyon's Creek East area yielded much lower HQs, ranging from 0.00051 for the adult receptor to 0.0022 for the toddler. In all cases, HQs related to DL-PCB in Upper Lyon's Creek East are below the hazard acceptability benchmark of 0.2.

Assessment of exposure to PCB through the consumption of sport fish taken from Lower Lyon's Creek East showed that exposures for all receptor age groups (infants, toddlers, children, teens and adults) are below the toxicity reference value for PCB. Hazard quotient values ranged between 0.13

for the infant to 0.067 for the toddler, child and teen receptors. Based on these results it can be concluded that:

- Exposure to PCB and DL-PCB in sediments in Upper Lyon's Creek East would not be expected to result in adverse human health effects;
- Exposure to PCB through the consumption of sport fish taken from Lower Lyon's Creek East would not be expected to result in adverse human health effects; and
- PCB concentrations in sediments in Lower Lyon's Creek East are below the MOE Table 2 Standard for PCB in residential soil and therefore would not be considered to pose a potential hazard to human health.

Based on the exposure estimates used in this assessment, results of the detailed human health risk assessment indicate that remediation of either the Upper or Lower Lyon's Creek East areas to address potential human health concerns is not warranted.

9. REFERENCES

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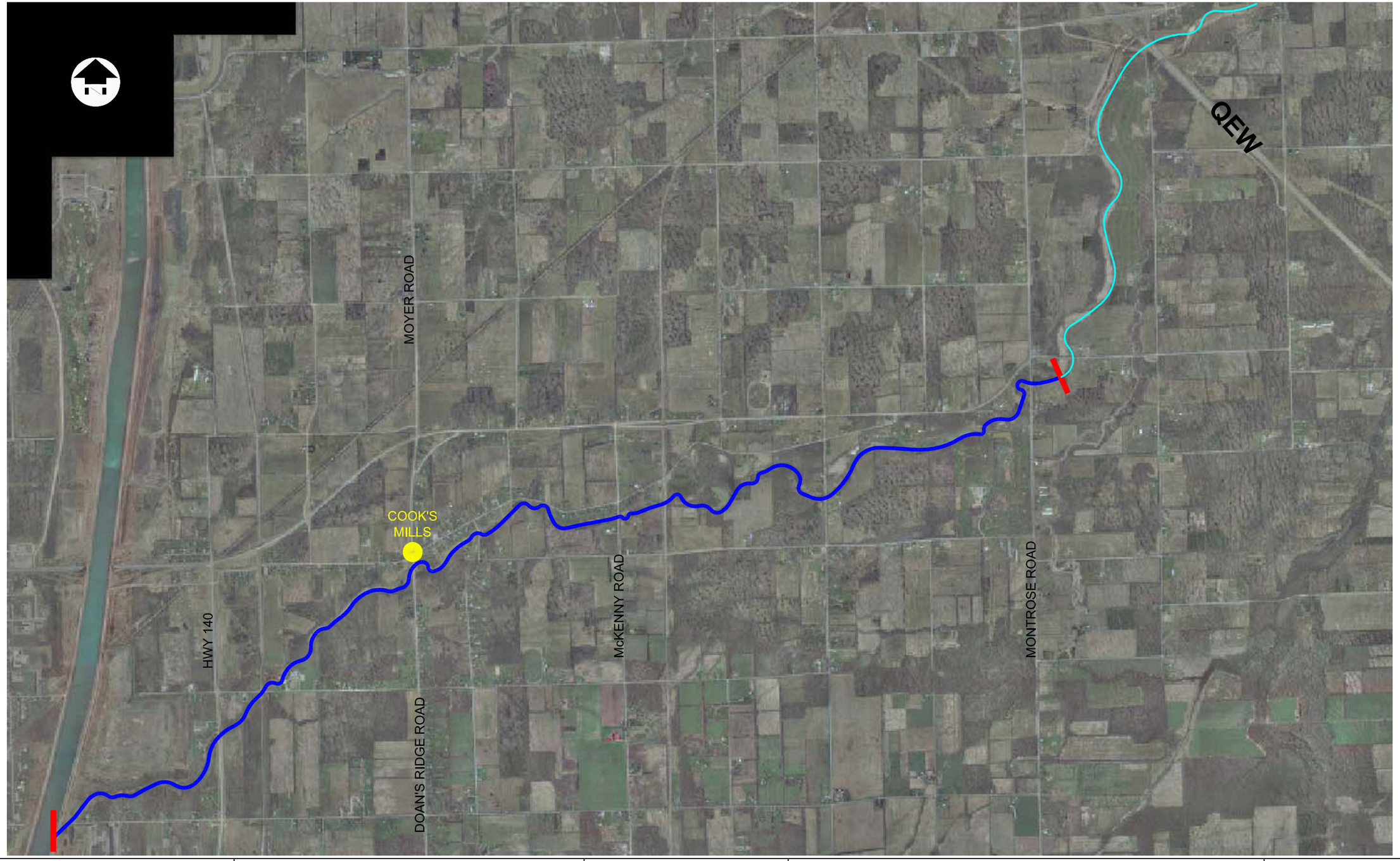
FIGURES



LEGEND

LYONS CREEK STUDY AREA

LYONS CREEK

STUDY AREA BOUNDARY

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

DATE **NOVEMBER 2007**

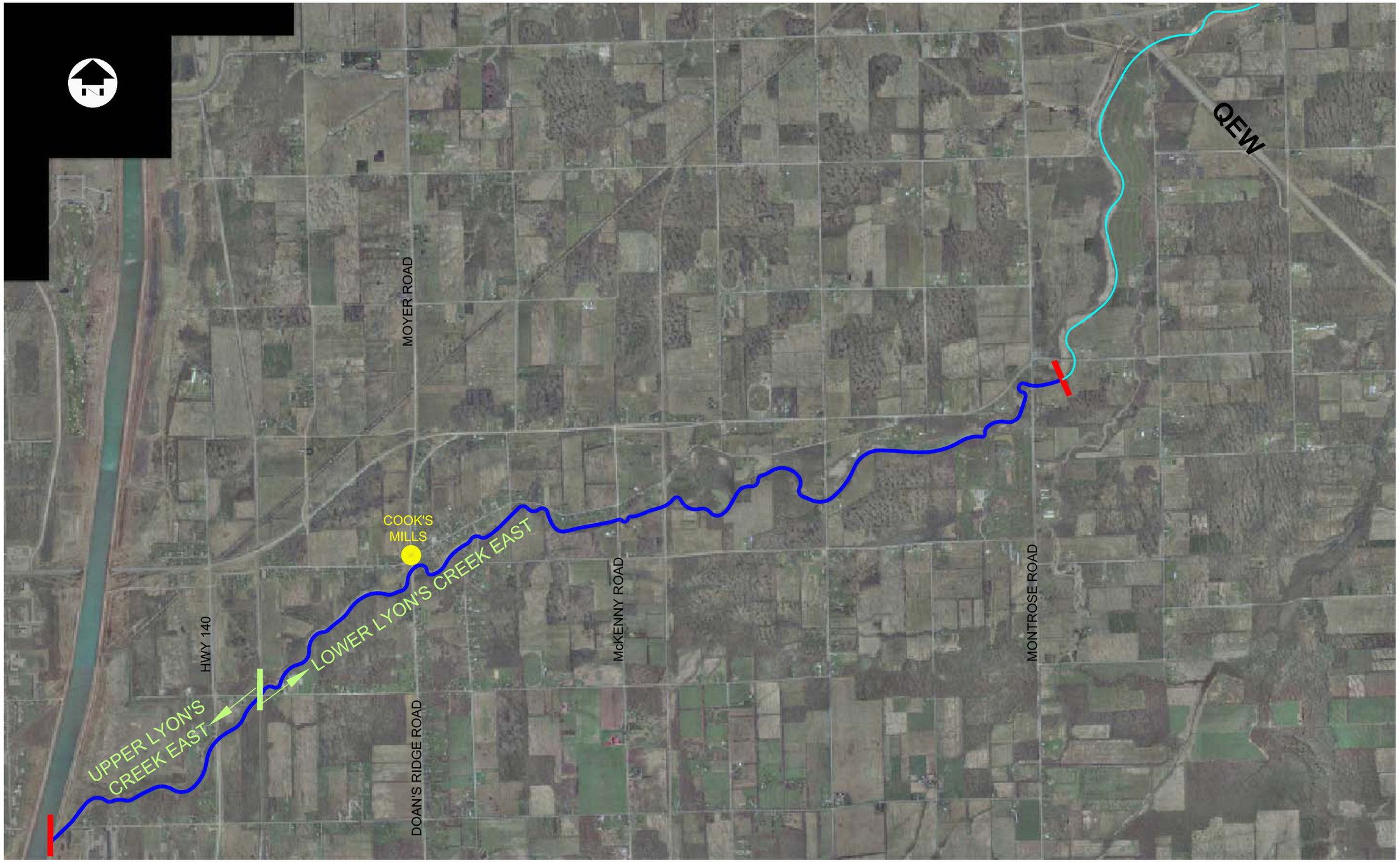
LYON'S CREEK EAST STUDY AREA BOUNDARIES

LYON'S CREEK

PROJECT NO. **04-2907**

FIGURE NO. **1**

Plotted: Jun 03, 2008 – 3:03pm File: G:\cad\2004\04-2907 Lyons Creek\FIGURE1 & 2.dwg



LEGEND

- LYONS CREEK STUDY AREA
- LYONS CREEK
- STUDY AREA BOUNDARY
- STUDY AREA SECTIONS

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

DATE NOVEMBER 2007

UPPER AND LOWER LYON'S CREEK EAST STUDY AREAS

LYON'S CREEK

PROJECT NO. **04-2907**

FIGURE NO. **2**

Plotted: Jun 03, 2008 – 3:02pm File: G:\cad\2004\04-2907 Lyons Creek\FIGURE1 & 2.dwg

LEGEND

LYONS CREEK STUDY AREA

LYONS CREEK

LC32 SAMPLE IDENTIFICATION

SAMPLE LOCATIONS

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

DATE NOVEMBER 2007

SEDIMENT SAMPLE LOCATIONS FROM MOE, 1992

LYON'S CREEK

PROJECT NO. **04-2907**

FIGURE NO. **3A**

Plotted: Jun. 03, 2008 – 3:04pm File: G:\cad\2004\04_2907_Lyons_Creek\FIGURE3A.dwg

File: G:\cad\2004\04_2907 Lyons Creek\FIGURE3B.dwg
Plotted: Jun 03, 2008 - 3:05pm

LEGEND

- LYONS CREEK STUDY AREA
- LYONS CREEK
- LC32 SAMPLE IDENTIFICATION
- SAMPLE LOCATIONS

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

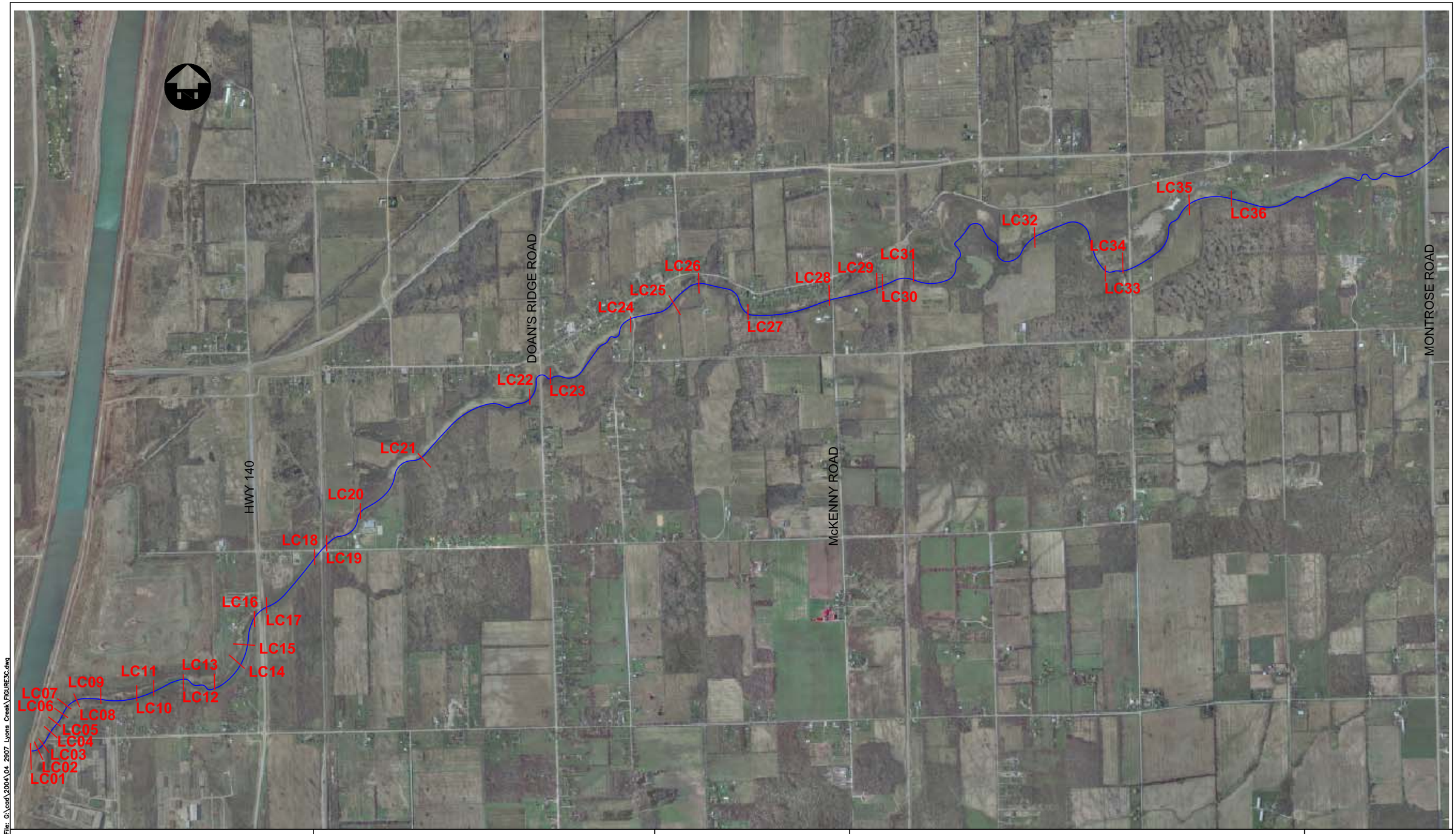
DATE NOVEMBER 2007

SEDIMENT SAMPLE LOCATIONS FROM MOE, 1996

LYON'S CREEK

PROJECT NO. **04-2907**

FIGURE NO. **3B**



File: G:\ccd\2004\04 2907 Lyons Creek\FIGURE3C.dwg

Plotted: Jun 03, 2008 - 3:06pm

LEGEND

LYONS CREEK STUDY AREA

LYONS CREEK

LC32 SAMPLE IDENTIFICATION

SAMPLE LOCATIONS

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

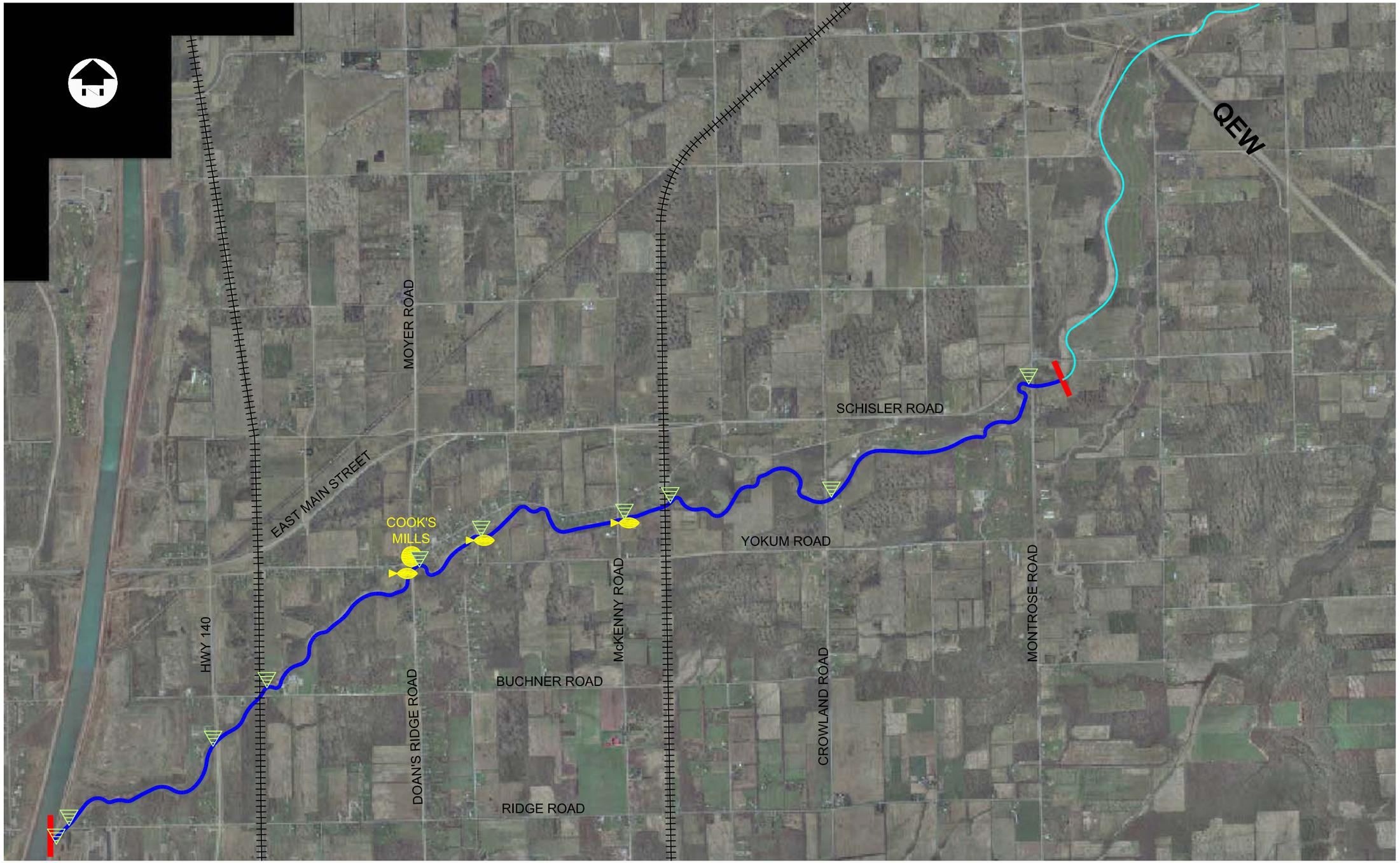
DATE NOVEMBER 2007

SEDIMENT SAMPLE LOCATIONS FROM MOE, 2004

LYON'S CREEK

PROJECT NO. **04-2907**

FIGURE NO. **3C**



LEGEND

- LYONS CREEK STUDY AREA
- LYONS CREEK
- STUDY AREA BOUNDARY
- WATER SAMPLE
- FISH SAMPLE

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

DATE **NOVEMBER 2007**

DILLON'S 2005 SURFACE WATER AND FISH SAMPLING LOCATIONS

LYON'S CREEK

PROJECT NO. **04-2907**

FIGURE NO. **4**

Plotted: Jun 03, 2008 – 3:06pm File: G:\cad\2004\04-2907 Lyons Creek\FIGURE4 & B1.dwg

APPENDIX A
Summary of Available Sediment Quality Data and Sport Fish Data

Upper Lyon's Creek East: PCB Concentration in Sediment (0 - 50 cm)

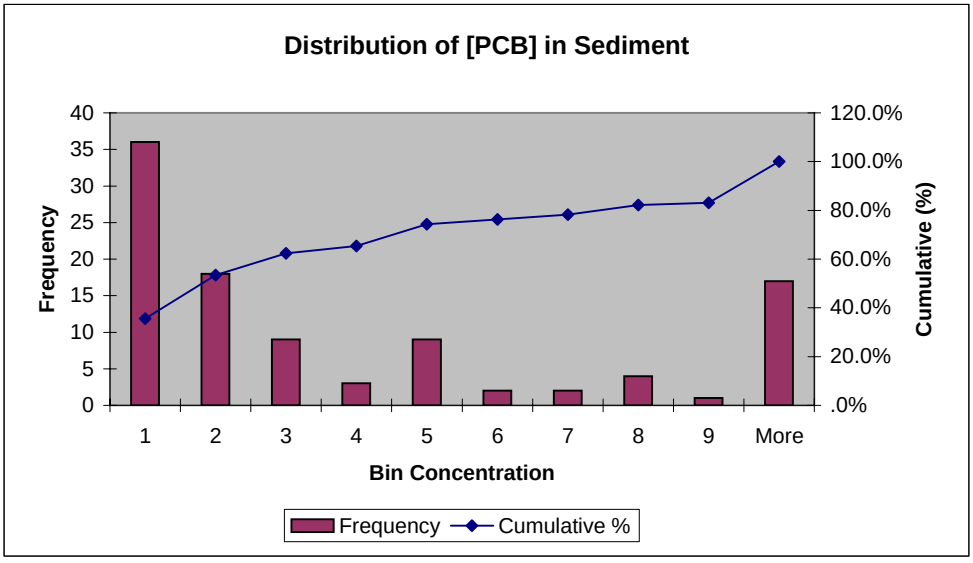
ProUCL Statistical Summary	Variable: PCB mg/kg		
Mean	9.7239703	95% UCL (Assuming Normal Distribution)	
Median	3.31	Student's-t UCL	13.9466843
Standard Deviation	23.7866866		
Variance	506.330763	Gamma Distribution Test	
Coefficient of Variation	3.56779894	A-D Test Statistic	9.35419719
Skewness	9.55455324	A-D 5% Critical Value	1.58624571
		K-S Test Statistic	0.67655004
Gamma Statistics		K-S 5% Critical Value	0.2899851
k hat	5.10092692	Data do not follow gamma distribution	
k star (bias corrected)	4.42487605	at 5% significance level	
Theta hat	19.552841		
Theta star	19.8833454	95% UCLs (Assuming Gamma Distribution)	
nu hat	270.231364	Approximate Gamma UCL	12.6435423
nu star	242.292469	Adjusted Gamma UCL	12.7212434
Approx.Chi Square Value (.05)	194.16601		
Adjusted Level of Significance	0.08562376	Lognormal Distribution Test	
Adjusted Chi Square Value	191.887252	Lilliefors Test Statisitic	0.44620253
		Lilliefors 5% Critical Value	0.9931603
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	-4.1043949		
Maximum of log data	7.138867	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	0.98378599	95% H-UCL	21.9762974
Standard Deviation of log data	2.34872244	95% Chebyshev (MVUE) UCL	25.7381401
Variance of log data	3.96218763	97.5% Chebyshev (MVUE) UCL	31.7571093
		99% Chebyshev (MVUE) UCL	43.580209
		95% Non-parametric UCLs	
		CLT UCL	13.8873582
		Adj-CLT UCL (Adjusted for skewness)	15.5657628
		Mod-t UCL (Adjusted for skewness)	14.2084815
		Jackknife UCL	13.9466843
		Standard Bootstrap UCL	11.471961
		Bootstrap-t UCL	16.4194075
RECOMMENDATION		Hall's Bootstrap UCL	27.8236991
Data are lognormal (0.05)		Percentile Bootstrap UCL	11.8904653
		BCA Bootstrap UCL	13.2326733
Use H-UCL		95% Chebyshev (Mean, Sd) UCL	20.7570414
		97.5% Chebyshev (Mean, Sd) UCL	25.5310601
		99% Chebyshev (Mean, Sd) UCL	34.9086954

Upper Lyon's Creek East: PCB Concentration in Sediment (0 - 50 cm) and Sample Location

Report	Sample Location	PCB_{total}	Report	Sample Location	PCB_{total}	Report	Sample Location	PCB_{total}
MOE, 1991	T1C L	0.125	MOE, 1992	T2C S	0.675	MOE, 1996a	T7A	4.44
MOE, 1991	T1D L	0.09	MOE, 1992	T2D S	1.81	MOE, 1996a	T7B	7.24
MOE, 1991	G1M	0.31	MOE, 1992	T3A S	1.69	MOE, 1996a	T7C	9.86
MOE, 1991	G1 L	0.07	MOE, 1992	T3B S	1.01	MOE, 2004	0LYONS01	0.1
MOE, 1991	T2A M	0.195	MOE, 1992	T3C S	0.47	MOE, 2004	0LYONS02	15
MOE, 1991	T2C M	1.4	MOE, 1992	T3D S	4.6	MOE, 2004	0LYONS03	6.9
MOE, 1991	T2DM	7.77	MOE, 1992	T4A S	0.82	MOE, 2004	0LYONS04	2.5
MOE, 1991	T2A L	6.3	MOE, 1992	T4B S	0.26	MOE, 2004	0LYONS05	3.1
MOE, 1991	T2B L	0.675	MOE, 1992	T4C S	0.99	MOE, 2004	0LYONS06	1.9
MOE, 1991	T2C L	3.25	MOE, 1992	T4D S	0.69	MOE, 2004	0LYONS07	2.3
MOE, 1991	T2D L	1.42	MOE, 1992	T5A S	0.84	MOE, 2004	0LYONS08	8.2
MOE, 1991	T3A M	26	MOE, 1992	T5B S	0.58	MOE, 2004	0LYONS09	4.7
MOE, 1991	T3B M	21	MOE, 1992	T5C S	0.9	MOE, 2004	0LYONS10	5.7
MOE, 1991	T3C M	11.4	MOE, 1992	T5D S	1.28	MOE, 2004	0LYONS11	4.1
MOE, 1991	T3DM	180	MOE, 1992	G1	0.02	MOE, 2004	0LYONS12	1.6
MOE, 1991	T3A L	15	MOE, 1992	G2	0.73	MOE, 2004	0LYONS13	1.8
MOE, 1991	T3B L	0.15	MOE, 1992	G3	0.38	MOE, 2004	0LYONS14	5.7
MOE, 1991	T3C L	4.8	MOE, 1992	G4	1.05	MOE, 2004	0LYONS15	1.2
MOE, 1991	T3D L	16.9	MOE, 1992	G5	0.43	MOE, 2004	0LYONS16	19
MOE, 1991	T4A L	1.95	MOE, 1996a	T6A	14	MOE, 2004	LC01	1.3
MOE, 1991	T4B L	10.9	MOE, 1996a	T6B	3.84	MOE, 2004	LC03	4.2
MOE, 1991	T4C L	4.8	MOE, 1996a	T6C	9.46	MOE, 2004	LC16	52
MOE, 1991	T4D L	2.04	MOE, 1996a	T7A	0.78	MOE, 2004	LC17	1.7
MOE, 1991	T5A L	2	MOE, 1996a	T7B	2.3	MOE, 2004	LC017<10	1.3
MOE, 1991	T5B L	1.87	MOE, 1996a	T7C	1.16	MOE, 2004	LC017 10-25	0.89
MOE, 1991	T5C L	24.5	MOE, 2004	LC01<10	0.42	MOE, 2004	0LYONS17	2.8
MOE, 1991	T5D L	0.68	MOE, 2004	LC01 10-25	1.1	MOE, 2004	0LYONS18	2.9
MOE, 1992	T1A S	0.07	MOE, 2004	LC03<10	120	MOE, 1996a	G6	0.16
MOE, 1992	T1B S	0.02	MOE, 2004	LC03 10-25	50			

Histogram data

Bin	*Frequency*	*Cumulative %*
1	36	35.6%
2	18	53.5%
3	9	62.4%
4	3	65.3%
5	9	74.3%
6	2	76.2%
7	2	78.2%
8	4	82.2%
9	1	83.2%
More	17	100.0%
# of Samples	86	
Minimum	0.011	
Maximum	180	



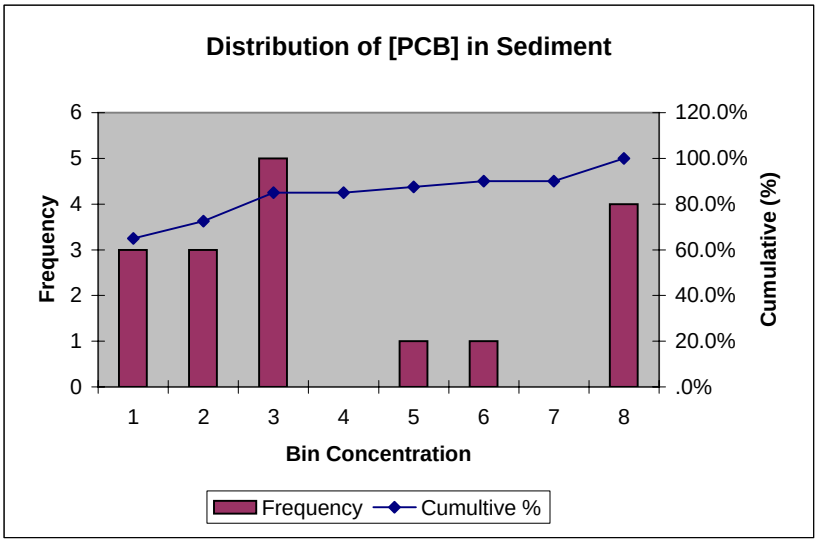
Lower Lyon's Creek East: PCB Concentration in Sediment (0 - 50 cm)

ProUCL Statistical Summary		Variable: PCB mg/kg	
Mean	1.45375	95% UCL (Assuming Normal Distribution)	
Median	0.69	Student's-t UCL	1.91352474
Standard Deviation	1.725867582		
Variance	2.97861891	Gamma Distribution Test	
Coefficient of Variation	1.187183203	A-D Test Statistic	0.54433512
Skewness	1.814919211	A-D 5% Critical Value	0.78510939
		K-S Test Statistic	0.13226605
Gamma Statistics		K-S 5% Critical Value	0.14447052
k hat	0.846205704	Data follow gamma distribution	
k star (bias corrected)	0.799406943	at 5% significance level	
Theta hat	1.717962893		
Theta star	1.818535619	95% UCLs (Assuming Gamma Distribution)	
nu hat	67.69645633	Approximate Gamma UCL	1.99718028
nu star	63.95255544	Adjusted Gamma UCL	2.02135586
Approx.Chi Square Value (.05)	46.55114427		
Adjusted Level of Significance	0.044	Lognormal Distribution Test	
Adjusted Chi Square Value	45.99438896	Shapiro-Wilk Test Statisitic	0.97368995
		Shapiro-Wilk 5% Critical Value	0.94
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	-3.21887582		
Maximum of log data	1.943048917	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-0.3221103	95% H-UCL	2.91131337
Standard Deviation of log data	1.288789333	95% Chebyshev (MVUE) UCL	3.3772133
Variance of log data	1.660977945	97.5% Chebyshev (MVUE) UCL	4.14456975
		99% Chebyshev (MVUE) UCL	5.65189291
		95% Non-parametric UCLs	
		CLT UCL	1.90260362
		Adj-CLT UCL (Adjusted for skewness)	1.98627659
		Mod-t UCL (Adjusted for skewness)	1.92657603
		Jackknife UCL	1.91352474
		Standard Bootstrap UCL	1.89147493
		Bootstrap-t UCL	2.05007978
RECOMMENDATION		Hall's Bootstrap UCL	2.01410024
Data follow gamma distribution (0.05)		Percentile Bootstrap UCL	1.9175
		BCA Bootstrap UCL	1.9935
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	2.64322214
		97.5% Chebyshev (Mean, Sd) UCL	3.15790769
		99% Chebyshev (Mean, Sd) UCL	4.16890779

Lower Lyon's Creek East: PCB Concentration in Sediment (0 - 50 cm)

MOE, 1996a	T9B	3.64
MOE, 1996a	T9C	5.32
MOE, 1996a	T10A	1.64
MOE, 1996a	T10B	1.18
MOE, 1996a	T10C	2.02
MOE, 1996a	T11A	0.44
MOE, 2004	LC029<10	0.44
MOE, 2004	LC029 10-25	0.38
MOE, 1996a	T8A	4.82
MOE, 1996a	T8B	2.12
MOE, 1996a	T8C	0.12
MOE, 1996a	T9A	2.24
MOE, 1996a	T9B	0.2
MOE, 1996a	T9C	0.1
MOE, 1996a	T10B	0.24
MOE, 1996a	T10C	0.06
MOE, 1996a	T11A	1.32
MOE, 2004	0LYONS19	2
MOE, 2004	0LYONS20	1.6
MOE, 2004	0LYONS21	0.84
MOE, 2004	0LYONS22	1.7
MOE, 2004	0LYONS23	1.3
MOE, 2004	0LYONS24	0.26
MOE, 2004	0LYONS25	0.74
MOE, 2004	0LYONS26	0.46
MOE, 2004	0LYONS27	0.96
MOE, 2004	0LYONS28	0.46
MOE, 2004	0LYONS29	0.48
MOE, 2004	0LYONS30	0.64
MOE, 2004	0LYONS31	0.26
MOE, 2004	0LYONS32	0.34
MOE, 2004	0LYONS33	0.26
MOE, 2004	0LYONS34	0.32
MOE, 2004	0LYONS35	0.12
MOE, 2004	0LYONS36	0.04
MOE, 2004	LC29	0.55
# of Samples	40	
Minimum	0.04	
Maximum	6.98	

Bin	*Frequency*	*Cumultive %*
1.5	3	65.0%
2.0	3	72.5%
2.5	5	85.0%
3.0	0	85.0%
3.5	1	87.5%
4.0	1	90.0%
4.5	0	90.0%
More	4	100.0%



PCB Levels in Fish Tissue

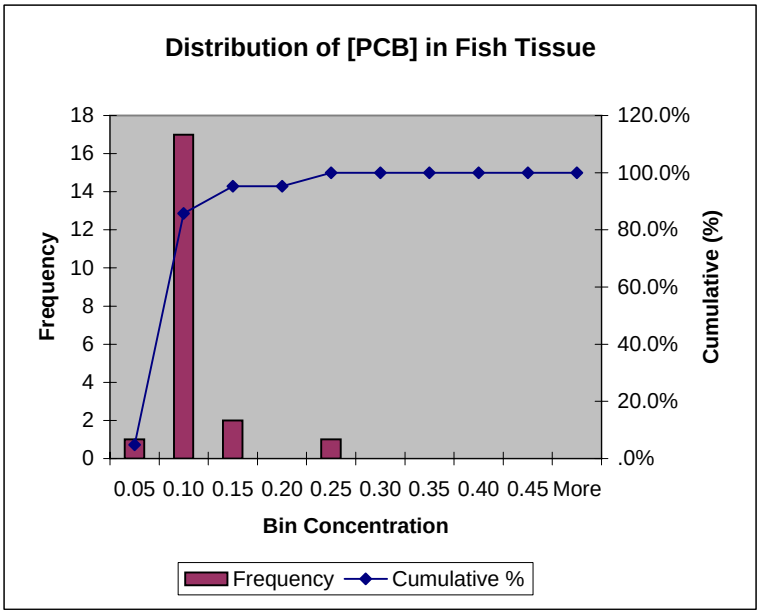
ProUCL Statistical Summary		Variable: PCB mg/kg	
Mean	0.06375	95% UCL (Assuming Normal Distribution)	
Median	0.05	Student's-t UCL	0.07985837
Standard Deviation	0.04604464		
Variance	0.00212011	Gamma Distribution Test	
Coefficient of Variation	0.72226883	A-D Test Statistic	3.73156484
Skewness	2.33178457	A-D 5% Critical Value	0.75228027
		K-S Test Statistic	0.36153203
Gamma Statistics		K-S 5% Critical Value	0.17949627
k hat	2.70372899	Data do not follow gamma distribution	
k star (bias corrected)	2.39354064	at 5% significance level	
Theta hat	0.02357855		
Theta star	0.02663418	95% UCLs (Assuming Gamma Distribution)	
nu hat	129.778991	Approximate Gamma UCL	0.08036292
nu star	114.889951	Adjusted Gamma UCL	0.08169578
Approx.Chi Square Value (.05)	91.1394782		
Adjusted Level of Significance	0.0392	Lognormal Distribution Test	
Adjusted Chi Square Value	89.6525397	Shapiro-Wilk Test Statisitic	0.69549308
		Shapiro-Wilk 5% Critical Value	0.916
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-4.6051702		
Maximum of log data	-1.6094379	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-2.9489686	95% H-UCL	0.08705135
Standard Deviation of log data	0.65825421	95% Chebyshev (MVUE) UCL	0.10458567
Variance of log data	0.4332986	97.5% Chebyshev (MVUE) UCL	0.12198503
		99% Chebyshev (MVUE) UCL	0.15616271
		95% Non-parametric UCLs	
		CLT UCL	0.07920969
		Adj-CLT UCL (Adjusted for skewness)	0.08398978
		Mod-t UCL (Adjusted for skewness)	0.08060397
		Jackknife UCL	0.07985837
		Standard Bootstrap UCL	0.07925964
		Bootstrap-t UCL	0.09795686
RECOMMENDATION		Hall's Bootstrap UCL	0.16971166
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	0.07958333
		BCA Bootstrap UCL	0.08458333
Use 95% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	0.10471852
		97.5% Chebyshev (Mean, Sd) UCL	0.12244563
		99% Chebyshev (Mean, Sd) UCL	0.1572671

PCB Levels in Fish Tissue

Sample #	Species	Total Length (mm)	PCB Concentration mg/kg (wet weight)
LC01	green sunfish (*Lepomis cyanellus*)	142	0.05
LC02	green sunfish (*Lepomis cyanellus*)	142	0.05
LC03	green sunfish (*Lepomis cyanellus*)	126	0.05
PF01	yellow perch (*Perca flavescens*)	187	0.1
LM01	bluegill (*Lepomis macrochirus*)	167	0.05
LG01	pumpkinseed (*Lepomis gibbosus*)	136	0.05
LG02	pumpkinseed (*Lepomis gibbosus*)	131	0.2
LG03	pumpkinseed (*Lepomis gibbosus*)	141	0.1
LG04	pumpkinseed (*Lepomis gibbosus*)	143	0.05
LG05	pumpkinseed (*Lepomis gibbosus*)	163	0.05
LG06	pumpkinseed (*Lepomis gibbosus*)	161	0.01
LG07	pumpkinseed (*Lepomis gibbosus*)	126	0.05
LG08	pumpkinseed (*Lepomis gibbosus*)	128	0.05
LG09	pumpkinseed (*Lepomis gibbosus*)	127	0.05
LG10	pumpkinseed (*Lepomis gibbosus*)	121	0.05
LG11	pumpkinseed (*Lepomis gibbosus*)	121	0.05
LG12	pumpkinseed (*Lepomis gibbosus*)	122	0.05
LG13	pumpkinseed (*Lepomis gibbosus*)	120	0.05
LG14	pumpkinseed (*Lepomis gibbosus*)	127	0.05
LG15	pumpkinseed (*Lepomis gibbosus*)	121	0.05
LG16	pumpkinseed (*Lepomis gibbosus*)	117	0.05
#of Samples			21
Min			0.01
Max			0.2

Histogram data

Bin	*Frequency*	*Cumulative %*
0.05	1	4.8%
0.10	17	85.7%
0.15	2	95.2%
0.20	0	95.2%
0.25	1	100.0%
0.30	0	100.0%
0.35	0	100.0%
0.40	0	100.0%
0.45	0	100.0%
More	0	100.0%



Upper Lyon's Creek East: Coplanar and Mono-Otho PCBs in Sediment and Calculated TEQs

All values in ng/g d.w.		3,3',4,4'-TeCB	3,4,4',5-TeCB	2,3,3'4,4'-PeCB	2,3,4,4',5-PeCB	2,3'4,4',5-PeCB	2'3,4,4',5-PeCB	3,3'4,4',5-PeCB	2,3,3'4,4'5-HxCB	2,3,3'44'5'-HxCB	23',44',55'-HxCB	3,3'4,4'55'-HxCB	233'44'55'-HpCB	Total toxic PCB congeners / TEQ ng/g
IUPAC No.		**77**	**81**	**105**	**114**	**118**	**123**	**126**	**156**	**157**	**167**	**169**	**189**	
TEF_{Mamm}		0.0001	0.0001	0.0001	0.0005	0.0001	0.0001	0.1	0.0005	0.0005	0.00001	0.01	0.0001	
Concentration in Sediment (ng/g d.w.)														
03LC06*	Sed	0.2 <=W	0.5 <=W	0.1 <=W	0.97	33	8.2	0.1 <=W	0.7	0.2 <=W	0.2 <=W	0.1 <=W	0.2 <=W	42.87
03LC08A*	Sed	2.7	0.5 <=W	18	4.4	37	13	0.1 <=W	4.4	0.2 <=W	0.2 <=W	0.1 <=W	0.2 <=W	79.5
03LC08B*	Sed	0.2 <=W	0.5 <=W	2 MPC	7.7	51	22	0.1 <=W	7.4	0.2 <=W	4	0.1 <=W	1.2	95.3
03LC08C*	Sed	0.5	0.5 <=W	21 MPC	7.7	210	25	0.1 <=W	8.8	0.2 <=W	0.6	0.1 <=W	1	274.6
03LC10*	Sed	3	0.5 <=W	9.9	2.7	86	8.3	0.1 <=W	3.4 MPC	0.2 <=W	3.6	0.1 <=W	0.2 <=W	116.9
03LC12	Sed	1.4	0.5 <=W	7.6	1.4	48	2.4 MPC	0.1 <=W	1.3	0.2 <=W	0.4	0.1 <=W	0.2 <=W	61.2
03LC14	Sed	4.7	0.5 <=W	4.9	0.63	27	4.9	0.1 <=W	0.2 <=W	0.2 <=W	0.2 <=W	0.1 <=W	0.2 <=W	42.13
03LC14*	Sed	2.6	0.5 <=W	14	2.2	80	7.3	0.1 <=W	2.6 MPC	0.2 <=W	0.6	0.1 <=W	0.2 <=W	109.3
03LC16*	Sed	6.4	0.5 <=W	5.8	1.2	37	7.2 MPC	0.1 <=W	0.6	0.2 <=W	1	0.1 <=W	0.2 <=W	59.2
03LC17	Sed	2	0.5 <=W	4.4	0.51	19	1.8	0.1 <=W	1.8	0.2 <=W	1.2	0.1 <=W	0.2 <=W	30.71
Calculated TEQs (ng/g d.w.) based on mammalian TEF														
03LC06*	TEQ_{Mamm}	0.00002 <=W	0.00005 <=W	0.00001 <=W	0.00049	0.0033	0.0008	0.01 <=W	0.00035	0.0001 <=W	0.000002 <=W	0.001 <=W	0.00002 <=W	0.004955
03LC08A*	TEQ_{Mamm}	0.00027	0.00005 <=W	0.0018	0.0022	0.0037	0.0013	0.01 <=W	0.0022	0.0001 <=W	0.000002 <=W	0.001 <=W	0.00002 <=W	0.01147
03LC08B*	TEQ_{Mamm}	0.00002 <=W	0.00005 <=W	0.0002 MPC	0.00385	0.0051	0.0022	0.01 <=W	0.0037	0.0001 <=W	0.00004	0.001 <=W	0.00012	0.01521
03LC08C*	TEQ_{Mamm}	0.00005	0.00005 <=W	0.0021 MPC	0.00385	0.021	0.0025	0.01 <=W	0.0044	0.0001 <=W	0.000006	0.001 <=W	0.0001	0.034006
03LC10*	TEQ_{Mamm}	0.0003	0.00005 <=W	0.00099	0.00135	0.0086	0.0008	0.01 <=W	0.0017 MPC	0.0001 <=W	0.000036	0.001 <=W	0.00002 <=W	0.013806
03LC12	TEQ_{Mamm}	0.00014	0.00005 <=W	0.00076	0.0007	0.0048	0.0002 MPC	0.01 <=W	0.00065	0.0001 <=W	0.000004	0.001 <=W	0.00002 <=W	0.006644
03LC14	TEQ_{Mamm}	0.00047	0.00005 <=W	0.00049	0.00032	0.0027	0.0005	0.01 <=W	0.0001 <=W	0.0001 <=W	0.000002 <=W	0.001 <=W	0.00002 <=W	0.004465
03LC14*	TEQ_{Mamm}	0.00026	0.00005 <=W	0.0014	0.0011	0.008	0.0007	0.01 <=W	0.0013 MPC	0.0001 <=W	0.000006	0.001 <=W	0.00002 <=W	0.012796
03LC16*	TEQ_{Mamm}	0.00064	0.00005 <=W	0.00058	0.0006	0.0037	0.0007 MPC	0.01 <=W	0.0003	0.0001 <=W	0.00001	0.001 <=W	0.00002 <=W	0.00655
03LC17	TEQ_{Mamm}	0.0002	0.00005 <=W	0.00044	0.00026	0.0019	0.0002	0.01 <=W	0.0009	0.0001 <=W	0.000012	0.001 <=W	0.00002 <=W	0.003887

DIBENZODIOXINS / FURANS (HRMS) IN SOIL

MAXXAM JOB #: A531498
MAXXAM SAMPLE #: F67862
Sampling Date: 2005/04/15

PROJECT NAME:
PROJECT #: 2552270
Report Date: 2005/06/24

CONC. UNITS = ppt = pg/g
MDL Units = ppt = pg/g

Compounds	TOP CONC	TOP MDL	TOXIC EQUIVALENCY TEF	TEQ(MDL)	TEQ(0.5MDL)	ISOMERS PER CONGENER GRP	% RECOVERY C13 SURROGATES
2,3,7,8-Tetra CDD *	1.55	1.13	1.00	1.55	1.55		78
1,2,3,7,8-Penta CDD	7.89	0.773	0.500	3.95	3.95		72
1,2,3,4,7,8-Hexa CDD	6.70	0.647	0.100	0.670	0.670		
1,2,3,6,7,8-Hexa CDD	29.8	0.586	0.100	2.98	2.98		80
1,2,3,7,8,9-Hexa CDD	22.7	0.614	0.100	2.27	2.27		
1,2,3,4,6,7,8-Hepta CDD	399	1.37	0.0100	3.99	3.99		84
Octa CDD	8560	0.888	0.00100	8.56	8.56		84
Total Tetra CDD	10.5	1.13					
Total Penta CDD	21.6	0.773					
Total Hexa CDD	184	0.615					
Total Hepta CDD	818	1.37					
2,3,7,8-Tetra CDF **	64.0	3.75	0.100	6.40	6.40		87
1,2,3,7,8-Penta CDF	5.02	1.44	0.0500	0.251	0.251		90
2,3,4,7,8-Penta CDF	11.7	1.31	0.500	5.85	5.85		
1,2,3,4,7,8-Hexa CDF	13.5	0.727	0.100	1.35	1.35		
1,2,3,6,7,8-Hexa CDF	20.4	0.691	0.100	2.04	2.04		86
2,3,4,6,7,8-Hexa CDF	9.19	0.796	0.100	0.919	0.919		
1,2,3,7,8,9-Hexa CDF	0	0.892	0.100	0.0892	0.0446		
1,2,3,4,6,7,8-Hepta CDF	0	191	0.0100	1.91	0.955		93
1,2,3,4,7,8,9-Hepta CDF	0	5.90	0.0100	0.0590	0.0295		
Octa CDF	157	0.887	0.00100	0.157	0.157		
Total Tetra CDF	991	3.75					
Total Penta CDF	214	1.37					
Total Hexa CDF	385	0.769					
Total Hepta CDF	238	0.851					
TOTAL TOXIC EQUIVALENCY				43.0	42.0		

* CDD = CHLORO DIBENZO-P-DIOXIN
** CDF = CHLORO DIBENZOFURAN
MDL = METHOD DETECTION LIMIT
0 values = U = NOT DETECTED
TR = TRACE AMOUNT DETECTED
TEF = Toxic Equivalency Factor

DIBENZODIOXINS / FURANS (HRMS) IN SOIL

MAXXAM JOB #: A531498
MAXXAM SAMPLE #: F67863
Sampling Date: 2005/04/15

PROJECT NAME:
PROJECT #: 2552270
Report Date: 2005/06/24

CONC. UNITS = ppt = pg/g
MDL Units = ppt = pg/g

Compounds	MIDDLE CONC	MDL	TOXIC EQUIVALENCY TEF	TEQ(MDL)	TEQ(0.5MDL)	ISOMERS PER CONGENER GRP	% RECOVERY C13 SURROGATES
2,3,7,8-Tetra CDD *	4.92	4.20	1.00	4.92	4.92		84
1,2,3,7,8-Penta CDD	34.7	2.87	0.500	17.4	17.4		77
1,2,3,4,7,8-Hexa CDD	19.9	2.32	0.100	1.99	1.99		
1,2,3,6,7,8-Hexa CDD	147	2.10	0.100	14.7	14.7		90
1,2,3,7,8,9-Hexa CDD	58.3	2.20	0.100	5.83	5.83		
1,2,3,4,6,7,8-Hepta CDD	859	2.81	0.0100	8.59	8.59		93
Octa CDD	10500	2.02	0.00100	10.5	10.5		92
Total Tetra CDD	11.8	4.20					
Total Penta CDD	130	2.87					
Total Hexa CDD	794	2.20					
Total Hepta CDD	1470	2.81					
2,3,7,8-Tetra CDF **	0	121	0.100	12.1	6.05		97
1,2,3,7,8-Penta CDF	0	13.3	0.0500	0.665	0.333		93
2,3,4,7,8-Penta CDF	22.3	12.0	0.500	11.2	11.2		
1,2,3,4,7,8-Hexa CDF	46.3	5.24	0.100	4.63	4.63		
1,2,3,6,7,8-Hexa CDF	0	73.6	0.100	7.36	3.68		96
2,3,4,6,7,8-Hexa CDF	46.9	5.73	0.100	4.69	4.69		
1,2,3,7,8,9-Hexa CDF	0	6.42	0.100	0.642	0.321		
1,2,3,4,6,7,8-Hepta CDF	1500	3.94	0.0100	15.0	15.0		100
1,2,3,4,7,8,9-Hepta CDF	28.3	5.41	0.0100	0.283	0.283		
Octa CDF	770	1.55	0.00100	0.770	0.770		
Total Tetra CDF	1390	11.8					
Total Penta CDF	950	12.6					
Total Hexa CDF	2590	5.54					
Total Hepta CDF	3200	4.56					

TOTAL TOXIC EQUIVALENCY		
	121	111

* CDD = CHLORO DIBENZO-P-DIOXIN
** CDF = CHLORO DIBENZOFURAN
MDL = METHOD DETECTION LIMIT
0 values = U = NOT DETECTED
TR = TRACE AMOUNT DETECTED
TEF = Toxic Equivalency Factor

DIBENZODIOXINS / FURANS (HRMS) IN SOIL

MAXXAM JOB #: A531498
MAXXAM SAMPLE #: F67864
Sampling Date: 2005/04/15

PROJECT NAME:
PROJECT #: 2552270
Report Date: 2005/06/24

CONC. UNITS = ppt = pg/g
MDL Units = ppt = pg/g

Compounds	BOTTOM CONC	BOTTOM MDL	TOXIC EQUIVALENCY TEF	TEQ(MDL)	TEQ(0.5MDL)	ISOMERS PER CONGENER GRP	% RECOVERY C13 SURROGATES
2,3,7,8-Tetra CDD *	1.92	0.777	1.00	1.92	1.92		86
1,2,3,7,8-Penta CDD	4.02	1.05	0.500	2.01	2.01		80
1,2,3,4,7,8-Hexa CDD	5.67	0.863	0.100	0.567	0.567		
1,2,3,6,7,8-Hexa CDD	11.5	0.782	0.100	1.15	1.15		92
1,2,3,7,8,9-Hexa CDD	14.9	0.818	0.100	1.49	1.49		
1,2,3,4,6,7,8-Hepta CDD	306	0.982	0.0100	3.06	3.06		96
Octa CDD	15200	7.81	0.00100	15.2	15.2		70
Total Tetra CDD	20.9	0.777					
Total Penta CDD	22.0	1.05					
Total Hexa CDD	131	0.819					
Total Hepta CDD	728	0.982					
2,3,7,8-Tetra CDF **	0	37.0	0.100	3.70	1.85		95
1,2,3,7,8-Penta CDF	4.43	0.940	0.0500	0.222	0.222		97
2,3,4,7,8-Penta CDF	7.87	0.853	0.500	3.94	3.94		
1,2,3,4,7,8-Hexa CDF	14.5	0.795	0.100	1.45	1.45		
1,2,3,6,7,8-Hexa CDF	11.9	0.755	0.100	1.19	1.19		98
2,3,4,6,7,8-Hexa CDF	5.40	0.869	0.100	0.540	0.540		
1,2,3,7,8,9-Hexa CDF	0	0.974	0.100	0.0974	0.0487		
1,2,3,4,6,7,8-Hepta CDF	0	45.8	0.0100	0.458	0.229		99
1,2,3,4,7,8,9-Hepta CDF	0	4.35	0.0100	0.0435	0.0218		
Octa CDF	64.6	0.834	0.00100	0.0646	0.0646		
Total Tetra CDF	370	3.03					
Total Penta CDF	116	0.895					
Total Hexa CDF	117	0.841					
Total Hepta CDF	58.8	0.822					
TOTAL TOXIC EQUIVALENCY				37.1	35.0		

* CDD = CHLORO DIBENZO-P-DIOXIN
** CDF = CHLORO DIBENZOFURAN
MDL = METHOD DETECTION LIMIT
0 values = U = NOT DETECTED
TR = TRACE AMOUNT DETECTED
TEF = Toxic Equivalency Factor

APPENDIX B
Community Survey Results

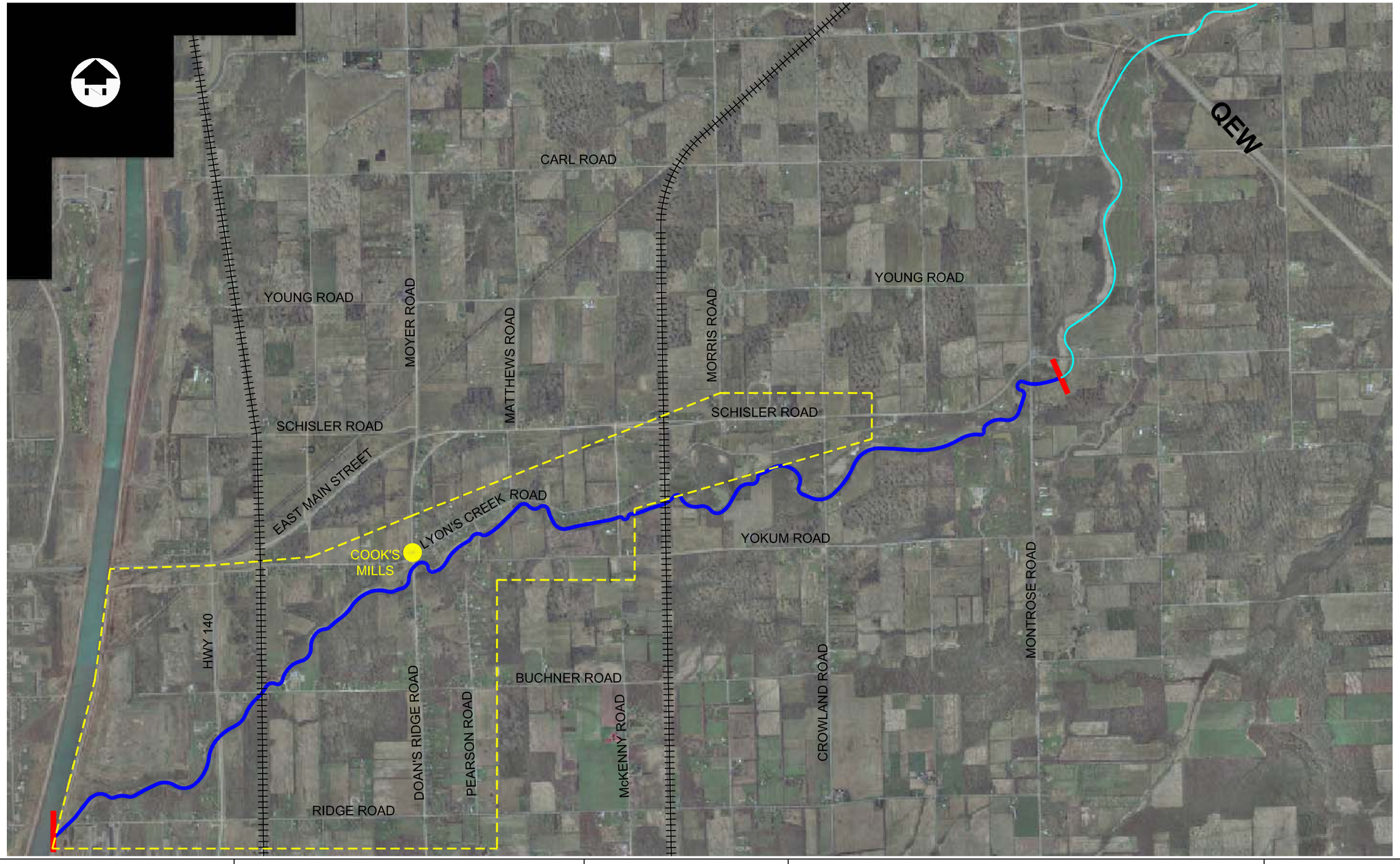
Lyon's Creek East Community Survey

A Community Survey was undertaken to collect information to address data gaps identified in the Human Health Screening Level Risk Assessment (HHSLRA). The survey, a copy of which is included as part of this appendix, was designed to gather information related to the consumption of fish, game and waterfowl from the Lyon's Creek east area. It also solicited information regarding the community's use of Lyon's Creek East for recreational activities and as a source of domestic water. A stamped, addressed return envelope was provided with each survey to facilitate return.

The survey was hand-delivered to 365 homes in the Cook's Mills community, in the area indicated on Figure B-1, included as part of this appendix. Initial response was very good, with greater than a hundred surveys returned by mail. In order to maximize the return, households that had not provided a response to the survey by the beginning of April were then contacted by telephone and invited to participate, either by completing and returning the survey by mail or by completing the survey over the phone. As a result, a total of 167 responses were obtained.

The compiled results of the survey are provided in tabular form in this appendix, and discussed where appropriate within the main report. Names and addresses of respondents have not been included for reasons of confidentiality.

FIGURES



LEGEND

- LYONS CREEK STUDY AREA
- LYONS CREEK
- STUDY AREA BOUNDARY
- SURVEY AREA

NIAGARA PENINSULA CONSERVATION AUTHORITY

DILLON CONSULTING

DATE **NOVEMBER 2007**

LYON'S CREEK EAST COMMUNITY SURVEY AREA

PROJECT NO. **04-2907**

LYON'S CREEK

FIGURE NO. **B1**

Plotted: Jun 04, 2008 – 8:27am File: G:\cad\2004\04-2907 Lyons Creek\FIGURE4 & B1.dwg

Fish and Wildlife Consumption Survey

Eating fish and wildlife caught from areas of Lyon's Creek where PCBs are present in the sediments can be a possible route of exposure for people in the community. Recreational activities such as swimming and boating in these areas can also be possible routes of exposure for community members. The Dillon Study Team is requesting local resident participation in a brief survey that will help us understand how people in the community use Lyon's Creek. The survey is aimed at finding out if people in the area eat fish or wildlife from Lyon's Creek and what sorts of recreational activities are typical.

Name:_____
(Optional)

Address:_____
(Optional)

Part A. Fish Consumption Survey

1. Do you, or members of your family catch and eat fish from Lyon's Creek?

☐ Yes ☐ No

If no, go to Part B.

2. If yes, where do you typically fish and how often?

√	Where?	How Often?
	Canal to Hwy 140	
	Hwy 140 to Cook's Mill	
	Cook's Mill	
	East of Cook's Mill	
	other	

3. If yes, what types of fish?

☐ Black Crappie
☐ Bluegill
☐ Bowfin
☐ Brown Bullhead
☐ Carp
☐ Largemouth Bass
☐ Pumpkinseed
☐ Others
☐
☐

4. How often do you eat fish from Lyon's Creek?

☐ More than once per week in summer
☐ Once per week in summer
☐ Once every two weeks in summer
☐ More than once per week year round
☐ Once per week year round
☐ Once per month year round
☐ Other (please Specify)
☐

5. Have you noticed if people from outside the community fish in the Cook's Mill area of Lyon's Creek

☐ Yes ☐ No

6. If yes, have you noticed how often this happens?

☐ Once per week in summer
☐ Once every two weeks in summer
☐ Once per week in summer
☐ Other

7. If yes, have you noticed where this happens?

√	Where?	How Often?
	Canal to Hwy 140	
	Hwy 140 to Cook's Mill	
	Cook's Mill	
	East of Cook's Mill	
	other	

Part B. Wildlife Consumption Survey

8. Do you, or members of your family catch and eat wildlife from Lyon's Creek?

☐ Yes ☐ No

If no, go to part C.

9. If yes, where do you typically catch wildlife and how often?

√	Where?	How Often?
	Canal to Hwy 140	
	Hwy 140 to Cook's Mill	
	Cook's Mill	
	East of Cook's Mill	

10. If yes, what types?

☐ Snapping Turtles
☐ Waterfowl
☐ Others
☐

11. How often do you eat wildlife from Lyon's Creek?

☐ Once per week in season
☐ Once per month in season
☐ Once or twice per season
☐ Other (please Specify)
☐

12. Have you noticed if people from outside the community fish in the Cook's Mill area of Lyon's Creek

☐ Yes ☐ No

13. If yes, have you noticed how often this happens?

☐ Once per week in summer
☐ Once every two weeks in summer
☐ Once per week in summer
☐ Other

14. If yes, have you noticed where this happens?

√	Where?	How Often?
	Canal to Hwy 140	
	Hwy 140 to Cook's Mill	
	Cook's Mill	
	East of Cook's Mill	
	other	

Part C. Recreational Use Survey

15. Do you use Lyon's Creek for recreational activities?

☐ Yes ☐ No

If no, go to Part D.

16. If yes, what recreational activities do you use Lyon's Creek for?

☐ Swimming
☐ Wading
☐ Hiking
☐ Boating
☐ Ice Fishing
☐ Other
☐

17. How often do you use Lyon's Creek for recreational activities?

√	Activity	How Often?
	Swimming	
	Wading	
	Hiking	
	Boating	
	Ice Fishing	
	Other	

18. How long does each use typically last?

- ☐ Less than ½ hour
- ☐ 1 to 2 hours
- ☐ Longer than 2 hours (specify)
- ☐

Part D. Water Use Survey

19. Do you use water from Lyon's Creek?

☐ Yes ☐ No

If no, go to Part E.

20. If yes, what do you use the water for?

	Watering Lawns
	Watering vegetable gardens
	Filling swimming pools
	Laundry
	Other

21. How often do you use the water for each purpose?

√	Water Use	Times/year
	Watering Lawns	
	Watering vegetable gardens	
	Filling swimming pools	
	Laundry	
	Other	
	Don't Know	

Part E. Contact Information

The Study Team would like to thank you for your participation in the survey. A summary of the survey results will be included as part of the community-based risk assessment report. Individual surveys will remain confidential.

Should you wish to complete the survey in advance, the study team will collect it while it is in your community.

If you have any questions or would like additional information, or if you would like to complete the survey over the phone, you are encouraged to contact the Study Co-ordinator, Dr. Bryan Leece at (905) 975-0646 or by e-mail at bleece@dillon.ca.

Sincerely,

Bryan Leece, Ph.D.
Project Manager
Dillon Consulting Limited

Survey Question		Total Number of Responses	Response Summary							
Question 1	Do you or members of your family catch and eat fish from Lyon's Creek?	167	Yes	No	Catch and Release					
			2%	92%	7%					
Question 2 **Eating**	If yes, where do you typically fish?	3	Canal to Hwy 140	Hwy 140 to Cook's Mill	Cook's Mill	East of Cook's Mill	Other			
			0%	0%	33%	67%	0%			
	How often?	3	Daily	Weekly	Monthly	Other				
			0%	0%	33%	67%				
Question 2 **Catch & Release**	If yes, where do you typically fish?	11	Canal to Hwy 140	Hwy 140 to Cook's Mill	Cook's Mill	East of Cook's Mill	Other			
			27%	0%	27%	0%	45%			
	How often?	11	Daily	Weekly	Monthly	Other				
			0%	0%	0%	100%				
Question 3	If yes, what types of fish?	19	Black Crappie	Bluegill	Bowfin	Brown Bullhead	Carp	Largemouth Bass	Pumpkinseed	Others
			0%	11%	5%	0%	11%	26%	16%	32%
Question 4	How often do you eat fish from Lyon's Creek?	3	More than once per week in summer	Once per week in summer	Once every two weeks in summer	More than once per week year round	Once per week year round	Once per month year round	Other (please specify)	
			0%	0%	0%	0%	0%	0%	100%	
Question 5	Have you noticed if people from outside the community fish in the Cook's Mill area of Lyon's Creek?	80	Yes	No						
			58%	43%						
Question 6	If yes, have you noticed how often this happens?	46	Once per week in summer	Once every two weeks in summer	Once per month in summer	Other				
			30%	15%	4%	50%				
Question 7	If yes, have you noticed where this happens?	58	Canal to Hwy 140	Hwy 140 to Cook's Mill	Cook's Mill	East of Cook's Mill	Other			
			12%	24%	40%	12%	12%			
Question 8	Do you, or members of your family, catch and eat wildlife from Lyon's Creek?	166	Yes	No						
			3%	97%						
Question 9	If yes, where do you typically catch wildlife and how often?	7	Canal to Hwy 140	Hwy 140 to Cook's Mill	Cook's Mill	East of Cook's Mill				
			0%	29%	14%	57%				
	How often?	4	Daily	Weekly	Monthly	Yearly	Other			
			0%	0%	0%	50%	50%			
Question 10	If yes, what types?	6	Snapping Turtles	Waterfowl	Others					
			17%	50%	33%					
Question 11	How often do you eat wildlife from Lyon's Creek?	6	Once per week in season	Once per month in season	Once or twice per season	Others (please specifiy)				
			33%	0%	33%	33%				
Question 12	Have you noticed if people from outside the community fish in the Cook's Mill area of Lyon's Creek?	25	Yes	No						
			64%	36%						
Question 13	If yes, have you noticed how often this happens?	15	Once per week in summer	Once every two weeks in summer	Once per month	Other				
			40%	13%	0%	47%				
Question 14	If yes, have you noticed where this happens?	22	Canal to Hwy 140	Hwy 140 to Cook's Mill	Cook's Mill	East of Cook's Mill	Other			
			9%	32%	36%	18%	5%			
	How often?	2	Daily	2-3 days per week	Weekly	Monthly	Other			
			0%	100%	0%	0%	0%			
Question 15	Do you use Lyon's Creek for recreational activities?	165	Yes	No						
			27%	73%						

Survey Question		Total Number of Responses	Response Summary							
Question 16	If yes, what recreational activities do you use Lyon's Creek for?	61	Swimming	Wading	Hiking	Boating	Ice Fishing	Other		
			0%	3%	28%	41%	2%	26%		
Question 17	How often do you use Lyon's Creek for recreational activities?	59	Daily	Weekly	Monthly	Yearly	Other			
	Swimming	0	0%	0%	0%	0%	0%			
	Wading	2	0%	0%	0%	0%	100%			
	Hiking	17	6%	12%	41%	6%	35%			
	Boating	24	0%	13%	4%	21%	63%			
	Ice Fishing	0	0%	0%	0%	0%	0%			
	Other	16	6%	6%	0%	6%	81%			
Question 18	How long does each use typically last?	46	Less than 1/2 hour	1 to 2 hours	Longer than 2 hours (specifiy)					
			28%	65%	7%					
Question 19	Do you use water from Lyon's Creek?	167	Yes	No						
			5%	95%						
Question 20	If yes, what do you use the water for?	11	Watering lawns	Watering vegetable gardens	Filling swimming pools	Laundry	Other			
			36%	27%	0%	0%	36%			
Question 21	How often do you use the water for each purpose (times per year)?	9	Daily	Weekly	Monthly	Yearly	Other	Don't know		
	Watering lawns	3	0%	0%	0%	0%	100%	0%		
	Watering vegetable gardens	3	0%	0%	0%	0%	100%	0%		
	Filling swimming pools	0	0%	0%	0%	0%	0%	0%		
	Laundry	0	0%	0%	0%	0%	0%	0%		
	Other	3	0%	33%	0%	0%	33%	33%		

APPENDIX C
Toxicity Profiles

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Appendix C
Toxicity Profiles

1 Introduction

An essential part of the risk assessment process is the identification of toxicologically based toxicity values against which exposures can be compared. Toxicity values have been established by several regulatory agencies including Health Canada, the United States Environmental Protection Agency (US EPA), and the World Health Organization (WHO). Additional detailed review of the toxicological information for individual chemicals is available from the Agency for Toxic Substances and Disease Registry (ATSDR). In addition to these primary sources of toxicological information, secondary sources such as the US based Health Effects Assessment Summary Tables (HEAST) can provide additional toxicity information. This latter source must be used with some caution because the data available from this source is not updated as frequently as the primary regulatory sources and often contains information that has been withdrawn by other agencies.

In the selection of toxicity values, preference has been given to the most recently developed values because it was felt that these would incorporate the most recent toxicological information and would provide the best basis upon which to assess potential health hazards/risks. Additional consideration was given to toxicity values for which the underlying toxicological rationales were available. The high degree of scrutiny to which this project will be subject means that it is essential that each decision be transparent and fully defensible. Therefore, it is essential that the toxicological rationale behind the development of each toxicity value be available for evaluation and scrutiny. If supporting documentation was not available for a given toxicity value, the toxicity value was not selected for use in the current risk assessment.

This toxicity assessment presents brief toxicological profiles for each of the contaminants of concern considered and outlines the toxicological effects associated with chronic ingestion, dermal contact and inhalation exposures.

2 Total PCBs

Polychlorinated biphenyls (PCBs) are a group of synthetic, organic chemicals known to cause adverse health effects in humans. PCBs exist as either oily liquids or solids, are colourless to light yellow, and are potentially volatile in some cases (ATSDR, 2000). In the past, PCBs were used as coolants and lubricants in transformers, capacitors, and other electrical equipment (ATSDR, 2000). PCBs are no longer produced in North America, due to the health implications associated with their presence in the environment. These compounds do not readily degrade and are, thus, quite environmentally persistent. In addition, many PCBs are subject to long-range transport resulting in the presence of these compounds worldwide. The bioaccumulative nature of PCBs is of concern, as concentrations of these chemicals increase with each trophic level of the food chain. As a result, humans are not only exposed to PCBs via the environment, but also

via food sources. Of particular concern are women who breastfeed, as PCBs accumulate in fat compartments, i.e. breast milk, and may be passed on to breastfed infants (ATSDR, 2000).

Typically, PCBs were produced in mixtures, with seven mixtures accounting for the majority of PCBs in the environment. These mixtures are often referred to as Aroclor mixtures and are made up of numerous individual PCB congeners. For example, Aroclor 1254 represents a mixture of which 54% is chlorine, by weight (ATSDR, 2000). In a carcinogenic assessment by MOE (MOE, 2005), Arocolor 1254 was found to be the most toxic congener followed by Aroclor 1260, Aroclor 1242 and Aroclor 1016.

Data regarding the respiratory effects of inhalation exposure to PCBs are limited. Occupational exposure studies reported upper respiratory tract irritation, chest pain and changes in lung function (Fischbein *et al*., 1979; Warshaw *et al*., 1979; Emmett *et al*., 1988; Kuratsune, 1989; Rogan, 1989; Nakanishi *et al*., 1985; Shigematsu *et al*., 1971). Gastrointestinal damage, characterized by loss of appetite, anorexia, nausea, vomiting, abdominal pain, and/or epigastric distress, was also reported in workers exposed to airborne PCBs (Emmett *et al*., 1988; Fischbein *et al*., 1979; Smith *et al*., 1982; Maroni *et al*., 1981a; Kuratsune, 1989). Clinical studies of PCB workers reported associations between increased serum levels of liver-related enzymes, lipids and cholesterol and serum PCBs, suggesting PCBs cause hepatic effects (ATSDR, 2000). The results of a number of studies suggest that PCBs can induce thyroid toxicity and a variety of changes in thyroid hormone levels. Increased thyroid gland volume was reported in workers at a PCB manufacturing facility (Langer *et al*., 1998). Chloracne and other dermal alterations were also reported in workers exposed to PCBs (ATSDR, 2000). Occular effects, including general eye irritation, hypersecretion of the Meibomian glands and abnormal pigmentation of the conjunctiva, were reported in subjects occupationally exposed to PCBs (Emmett *et al*. 1988; Ouw *et al*. 1976; Smith *et al*. 1982; Fischbein *et al*., 1985). Limited information is available concerning the immunological effects of PCBs in humans, as the majority of studies available do not include an assessment of immunocompetence. Reports of neurological effects subsequent to occupational exposure to PCBs are also limited and inconclusive.

The majority of oral exposure data for PCBs was derived from the Yusho and Yu-Cheng incidents, where humans were exposed to contaminated rice oil, and contaminated fish and animal products, respectively. Respiratory effects noted in both Yusho and Yu-Cheng patients included severe respiratory infections and chronic bronchitis (Kuratsune, 1989; Rogan, 1989; Nakanishi *et al*., 1985; Shigematsu *et al*., 1971, 1977). Cardiovascular effects were noted in Alabama residents exposed to PCBs via the consumption of contaminated fish (Kreiss *et al*., 1981). Hematological effects, such as normocytic anemia and leukocytosis, were noted in Yu-Cheng patients (Rogan, 1989). Hepatic effects (serum cholesterol and triglycerides) were found to occur in consumers of contaminated fish. An elevated odds ratio for goiter was found among the Yu-Cheng cohort, indicating the potential for adverse effects to the endocrine system (Guo *et al.* 1999).

As with inhalation exposure, chloracne and other dermal alterations were reported with oral exposure, i.e., the Yusho and Yu-Cheng cohorts (Fischbein *et al*. 1979, 1982; Guo *et al*. 1999; Hsu *et al*. 1994; Maroni *et al.* 1981a, 1981b; Masuda 1994). Also similar to inhalation exposure, ocular effects consisting of hypersecretion of the Meibomian glands and abnormal pigmentation

of the conjunctiva, were reported in the Yusho and Yu-Cheng cohorts (Masuda, 1994). Although studies of immunological effects are limited, they do suggest an increased susceptibility to respiratory tract infections, increased prevalence of ear infections in children, decreased serum IgA and IgM antibody levels, and/or changes in T lymphocyte subsets (ATSDR, 2000).

With respect to neurological effects, there is a great deal of concern surrounding the transfer of PCBs to the fetus of women who consume contaminated food. In addition, there is concern for these same women who may breastfeed their infants, as PCBs tend to accumulate in breast milk. Studies have provided evidence that PCBs contribute to subtle neurobehavioral alterations in newborn children. In addition, neurodevelopmental changes were noted in women who accidentally consumed rice oil contaminated with PCBs (ATSDR, 2000).

Reproductive effects in orally exposed humans include menstrual disturbances in females and effects on fertility in males. Increased PCB levels were observed in women with late miscarriages, and a reduction in the months of lifetime lactation was associated with increasing PCB levels in breast milk (ATSDR, 2000). The results of studies examining the developmental effects (anthropometric measures at birth and physical growth during infancy) associated with exposure to PCBs are conflicting. Some studies found significant positive associations, some found significant negative associations and some found no association at all between PCB exposure and developmental effects (ATSDR, 2000).

The results of numerous studies indicate that exposure to PCBs is related to cancer at several sites, namely the liver, biliary tract, intestines, and skin (melanoma). In contrast, there is no clear association between occupational exposures to PCBs and cancer in the brain, hematopoietic and lymphatic systems (ATSDR, 2000). There is some indication that certain subgroups of women may be at an increased risk for breast cancer. Overall, human study results do provide evidence that commercial PCB mixtures are carcinogenic (ATSDR, 2000). The IARC (1987) has concluded that the evidence for carcinogenicity to humans is limited. US EPA IRIS (1987), has classified total PCBs as a probable human carcinogen (B2) based on sufficient evidence of carcinogenicity in animals. More specifically, the US EPA based their oral slope factors for total PCB on the development of liver hepatocellular adenomas, carcinomas, cholangiomas or cholandiocarcinomas on female Sprague-Dawley rats exposed to PCBs via the diet (Brunner *et al*., 1996; Norback and Weltman, 1985).

It should be noted, however, that the majority of information on the carcinogenic potential of PCBs is based on cohort mortality epidemiological studies of workers exposed to PCBs. The ATSDR (2000) has concluded that, although the results of some of these studies do suggest carcinogenicity with high exposures to PCBs, many of the studies are confounded by possible exposures to chlorinated dioxins and related compounds. In addition, PCBs are not genotoxic and would, therefore, not initiate neoplastic transformation, which is believed to be an initial step in the onset of cancer. SDB recommends that PCBs be assessed via threshold (non-genotoxic) dose response only, and that they be assessed as total PCBs and as dioxin-like PCBs.

Source	Route of Exposure	TRV	Basis
Total PCBs			
US EPA IRIS (1997)	Oral	Slope Factor: 0.04 mg/kg-d	Lowest risk and persistence; central-estimate slope factor; linear extrapolation below LED10s
US EPA IRIS (1997)	Oral	Slope Factor: 2.0 mg/kg-d	High risk and persistence; upper-bound slope factor; linear extrapolation below LED10s
US EPA IRIS (1997)	Oral	Drinking Water Unit Risk: $1x10^{-5}$ per ug/L	Low risk and persistence, upper-bound slope factor
Health Canada (2004)	Oral	PTDI: 1.0 ug/kg-d	
WHO (2003)	Oral	0.02 ug/kg-d	Hepatic and immunological effects
US EPA IRIS (1997)	Inhalation	Air Unit Risk: $1x10^{-4}$ per ug/m^3	Linear extrapolation below LED10s. Low risk and persistence; upper-bound unit risk. Based on oral exposure study (Brunner *et al*., 1996; Norback and Weltman, 1985).
Aroclor 1016			
US EPA IRIS (1993)	Oral	RfD: $7x10^{-5}$ mg/kg-d	Based on reduced birth weights in a monkey reproductive bioassay (Barsotti and van Miller, 1984; Levin *et al*., 1988; Schantz *et al*., 1989, 1991). NOAEL: 0.007 mg/kg-d, UF = 100
Balagopal *et al*. (2005)	Oral	0.880 ug/kg-d	
Aroclor 1254			
US EPA IRIS (1996)	Oral	RfD: $2x10^{-5}$ mg/kg-d	Based on ocular exudates, inflamed and prominent Meibomian glands, distorted growth of finger and toe nails, decreased antibody (IgG and IgM) response to sheep erythrocytes from monkey clinical and immunologic studies (Arnold *et al*., 1994a,b; Tryphonas *et al*., 1989, 1991 a,b). LOAEL: 0.005 mg/kg-d, UF = 300.
Balagopal *et al*. (2005)	Oral	0.032 ug/kg-d	

Source	Route of Exposure	TRV	Basis
Aroclor 1242			
Balagopal *et al*. (2005)	Oral	0.170 ug/kg-d	
Aroclor 1260			
Balagopal *et al*. (2005)	Oral	0.110 ug/kg-d	

References

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3 Dioxin-Like PCBs

The various isomers and congeners of polychlorinated dibenzo-*p*-dioxins (PCDDs), polychclorinated dibenzofurans (PCDFs) and dioxin-like PCBs (DL-PCBs) all have the same biological mechanism of action (*ie.* they all work on the body in the same way). However, they differ in their levels of toxicity. The WHO TEFs are used to relate the toxicities of the various PCDDs, PCDFs and DL-PCBs to the most potent PCDD in the group (2,3,7,8-PCDD), which is assigned a potency factor or TEF of 1.0. The concentrations of the individual PCDD, PCDF and DL-PCB isomers and congeners are multiplied by their respective TEF to provide a toxic equivalent concentration or TEQ. For example if the soil concentration of octachlorodibenzo-p-dioxin (OCDD) is reported as 500 pg/g, this is converted to a TEQ concentration by multiplying the reported concentration by the TEF for OCDD (500 pg/g x 0.0001 = 0.5 pg TEQ/g). Similar calculations are completed for each PCDD, PCDF and DLPCB and the TEQ concentrations are summed to provide a total or overall TEQ for the sample. These overall TEQ concentrations are then used in the HHRA to estimate exposure and potential hazards. The MOE supports the use of the TEQ approach for the assessment of exposures to PCB mixtures (Manca *et al*., 2005).

Officially, the Health Canada and TDI for PCDD/PCDF is 10 pg TEQ/kg-d (Health Canada, 2004); however, the WHO/FAO Joint Expert Committee on Food Additives and Contaminants (JECFA) recently proposed a revised Provisional Tolerable Monthly Intake (PTMI) of 70 pg/kg-month (JECFA, 2002). On a daily basis, this PTMI is equivalent to a Provisional Tolerable Daily Intake (PTDI) of 2.3 pg TEQ.kg-d. This revised TDI is being implemented by the federal government and MOE. This TDI is in use by the MOE Sport fish Advisory group and will be incorporated into upcoming revisions of MOE's soil and air guidelines. The current model for calculating TEQ is the 1997 WHO TEF scheme for mammals (applies to humans) (van den Berg *et al*., 1998)

The JECFA PTMI is based on the most sensitive adverse effects of dioxin on developmental endpoints in rats (specifically, effects on the reproductive system of male offspring of female rats

treated with dioxin) similar to those and other endpoints considered by WHO, 1998 and SCF, 2001. Essentially, WHO 1998 set a range (1-4 pg/kg/day) and the SCF, 2001 and JECFA, 2002 select midpoints in this range (SCF = 2 pg/kg/d, JECFA = 2.3 pg/kg/d).

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