Appendix H

Selected
DEQ Tittabawassee River Sediment Study
Results and Maps

-- Note --
This document is an abbreviated version of
the full 163-page report entitled:
Baseline Chemical Characterization of Saginaw Bay Watershed Sediments
The full report can be accessed from this DEQ web site:
http://www.deq.state.mi.us/documents/deq-rrd-dioxin-FinalReport.pdf

BASELINE CHEMICAL CHARACTERIZATION OF SAGINAW BAY WATERSHED SEDIMENTS

A Report to the Office of the Great Lakes
Michigan Department of Environmental Quality

Prepared by: Allan B. Taylor, Senior Geologist
John M. McCabe, Environmental Quality Analyst
Waste Management Division
Michigan Department of Environmental Quality

August 29, 2002

Baseline Chemical Characterization of Saginaw Bay Watershed Sediments

Introduction

General: Persistent bioaccumulative compounds have historically been released from industrial entities in the Saginaw Bay watershed. Dioxins and furans, polychlorinated and polybrominated biphenyl compounds (PCBs and PBBs), pesticides, herbicides, and other persistent bioaccumulative compounds have been identified as significant pollutants in the Saginaw River and the Saginaw Bay (U.S.EPA, 1995).

In September of 2000, the Waste Management Division of the Michigan Department of Environmental Quality (MDEQ) was awarded a grant of $88,775.00 from the Michigan Great Lakes Protection Fund to conduct a study entitled: ìBaseline Chemical Characterization of Saginaw Bay Watershed Sediments (Baseline Study).î The Baseline Study area is shown below as Figure 1. A copy of the approved grant proposal and budget is attached as Appendix 1 of this Report.

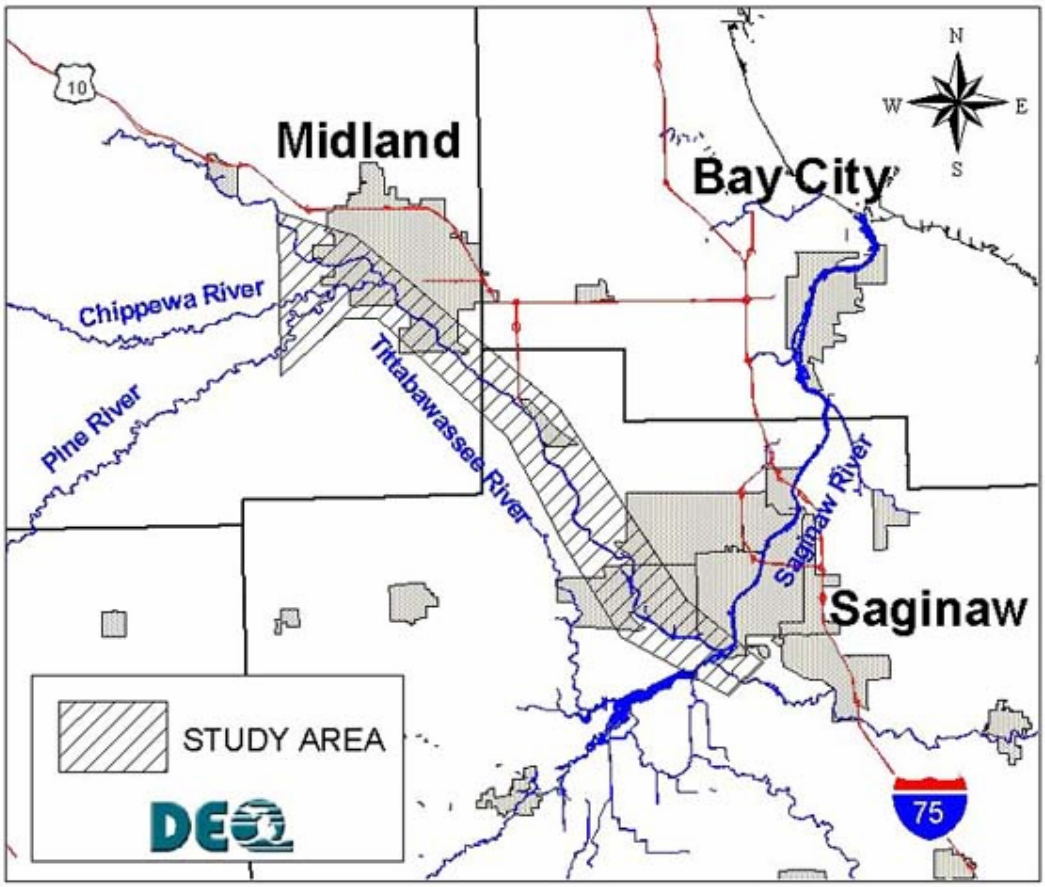


Figure 1

The focus of the Baseline Study is to characterize the sediments in the identified study area beginning upstream of Midland Michigan on the Pine, Chippewa, and Tittabawassee Rivers, and continuing downstream on the Tittabawassee to its confluence with the Saginaw River. The data and sampling locations from this study establish a year 2001 baseline level of contamination of watershed sediments that provides a benchmark against which future improvements in sediment and water quality can be measured. The analytical data from this project is also intended to serve as a screening level evaluation of sediment quality in the Tittabawassee River; to determine if contaminants are present at levels of environmental concern; and to determine if Tittabawassee River sediments are a potential source of ongoing releases to Lake Huron. Finally, analytical results from the study can be used to form the basis for a request for corrective action, if necessary, from regulated facilities within the watershed.

The Baseline Study was developed and conducted in a phased manner that consisted of a review of existing literature and data; the development of a sampling and analysis plan; the collection of samples; the analysis of the data; and the preparation of this Report. The Michigan State University Aquatic Toxicology Laboratory (MSU ATL), under the direction of Dr. John Giesy, assisted in the completion of this project by conducting a detailed literature review, assisting with the development of the study sampling and analysis plan (SAP), and conducting the dioxin and furan related analyses on the samples.

Literature and Data Review

The MSU-ATL conducted a literature search to identify appropriate literature to support the Baseline Study. This included all general literature on polychlorinated diaromatic hydrocarbons and specifically all of the literature, either in the open or gray literature and reports on the Saginaw River drainage system. The literature is compiled into an electronic data base (Reference ManagerÆ). A hard copy of the literature search is attached as Appendix 2 of this study.

The literature review indicates that significant sediment investigation work has been downstream of the study area in the Saginaw River and in the Saginaw Bay. In particular, the United States Environmental Protection Agency (U.S. EPA) has identified the Saginaw River and Saginaw Bay as an Area of Concern (U.S. EPA, 1995) as part of the Assessment and Remediation of Contaminated Sediments Program (ARCS Program). The ARCS Program resulted in the development of detailed sediment quality information on the lower Saginaw River and Saginaw Bay. Grab and core sediment samples from the ARCS study were analyzed for polyaromatic hydrocarbons, PCBs, chlorinated pesticides, polychlorinated dibenzo-p-

dioxins, polychlorinated dibenzofurans, and metals. General conclusions regarding the presence and risk of PCBs and certain metals in the sediments of the Area of Concern are presented in this study. In addition, to the ARCS Program, the Army Corps of Engineers (1999) has also conducted fairly extensive sampling and analysis of sediments in the navigable channel of the Saginaw associated with dredging projects.

Much less data is available on sediment quality in the Tittabawassee, Pine, and Chippewa Rivers upstream of the confluence of the Tittabawassee and the Saginaw Rivers. The Michigan Department of Community Health has issued fish advisories based on elevated levels of dioxins and furans and PCBs found in fish tissues in the Tittabawassee and Saginaw Rivers downstream of Midland. Fish advisories for PBBs and DDT have been issued for all species of fish on the Pine River downstream of the St. Louis impoundment.

Amendola and Barna (1986) reported of dioxin concentrations at up to 16 parts per billion (OCDD) in Tittabawassee River sediments in 1984. Dioxins were not detected in sediments upstream of The Dow Chemical Company facility in Midland, Michigan. Two studies have analyzed Tittabawassee River sediments for PCBs (MDNR, 1971, 1988). The Michigan Department of Natural Resources summaries of this work indicate that the sediment data from these studies is relatively sparse.

The MDEQ Surface Water Quality Division conducted an extensive review of existing information on the Tittabawassee River in 1993 during the evaluation of a potential Natural Resources Damage Assessment claim against The Dow Chemical Company (RCG/Hagler, Bailly Inc., 1993). That review identified data gaps in water quality and sediment quality with respect to dioxins and furans and PCBs.

The MDEQ conducted limited sediment sampling of the Tittabawassee and Chippewa Rivers in 1996 for a broad range of organic compounds, including dioxins and furans, and metals (MDEQ, 1996). This sampling event was concentrated adjacent to The Dow Chemical Company facility and immediately upstream of the facility.

Based on a review of existing data, it was clear that no comprehensive sediment characterization program has been conducted on the Tittabawassee River and that there is no program which routinely analyzes sediments to track changes in environmental quality of this portion of the Saginaw Bay watershed. It was also apparent that dioxins and furans were a significant issue in this watershed.

Methodology

Sampling and Analysis Plan: A SAP was developed for the collection and analysis of the samples. A copy of the SAP is attached as Appendix 3 to this Report. Unless otherwise stated, analyses were conducted in accordance with "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, Third Edition, November 1986, and its updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996), and IIIA (April 1998) (SW-846)

Study Design: The goals of this project were to (1) obtain a baseline chemical characterization of Tittabawassee River sediments and floodplain soils; and (2) to choose and document sampling locations so that the study might be replicated at a future date. These goals, in concert with financial and logistical realities, resulted in the sampling and analysis approach utilized in this project.

The parameters of interest in this study consisted of heavy metals, volatile and semivolatile organic compounds, pesticides, PCBs, dioxins, and furans. These parameters were chosen by the principal investigators as being the best indicators of the overall environmental health of the river system. A complete list of individual parameters is included in Table 1. In addition, analyses of physical parameters [Total Organic Carbon (TOC) and Total Organic Matter] were performed on all samples.

In addition to conventional dioxin and furan instrumental analysis (SW-846 Method 8290), each of the transect, composite, floodplain soils, and selected individual reach samples described below were analyzed using H4IIE-luc bioassay to determine relative dioxin-like activity. A subset of these samples were further analyzed in order to perform mass balance calculations to determine if other compounds are contributing significant dioxin like activity to Tittabawassee River sediments and soils.

The persistent bioaccumulative compounds of concern in this study are most frequently associated with fine particulate matter in the environment. Due to this association, an attempt was made to preferentially sample areas of fine particulate deposition. Preferred sampling locations included zones immediately downstream of large snags, bridge pilings, or other man-made structures, the inside bend of river meanders and other areas where fine particulates were observed to accumulate. Field personnel frequently tested possible sampling locations by poling with a boat oar to determine if there was suitable sediment accumulation. Figure 2 illustrates typical river sampling locations.

The location of each sample collected during this study was memorialized using hand-held Global Positioning System technology. Location coordinates in decimal degrees latitude and longitude for each sampling location in this study are identified in Table 2.

Figure 2. Typical River Sample Locations

Transect Sampling Locations: Sampling locations were chosen to provide geographic coverage of the study area and to preferentially sample depositional areas where the parameters of concern were most likely to be found. Nine locations (hereinafter referred to as transects) were chosen in order to provide coverage along the approximately 22 miles of river comprising the study area. Transect locations were tentatively identified by reviewing maps of the study area and locations finalized by the identification of depositional zones in the field. Transect locations are shown in Figure 3.

Two types of sampling were typically performed at each transect location. A sediment core sample was obtained by driving a four-inch diameter acetate or polyvinyl chloride (PVC) tube into the river bottom to a depth of one and a half to two feet (0.45 to 0.6 meter) at one discrete location per transect. Stones larger than º inch and leaves and twigs were removed from the sample before compositing in a stainless steel bowl. Aliquots of the composite sample were taken for analysis for each of the study parameters. Figure 4 illustrates a typical core sample.

Figure 4. Typical Core sample

A composite sample of the surficial sediments was obtained by using a petite Ponar dredge to collect a sample of the upper one to two inches of sediment at three to five locations per transect along a line between each bank of the river. The number of locations per transect was a field decision based on stream width, particle size of the sediment, and practical considerations in obtaining a sample. The individual dredge samples were composited by mixing with a stainless steel scoop in a

stainless steel bowl. Stones larger than º inch and leaves and twigs were removed from the sample before compositing in a stainless steel bowl. Figure 5 illustrates a typical upper composite sample. Aliquots of the composite sample were taken for analysis for each of the study parameters.

Figure 5. Typical Composite Sample

Discrete Sediment Samples: A series of discrete sediment samples were collected at locations between transects to characterize individual reaches of the river and obtain good geographic coverage of the study area. Between three and 20 reach samples were taken between each transect. Reach sample locations were identified in the field and were preferentially located in depositional zones. Reach samples consisted of the upper one to two inches of sediment collected with a petite Ponar dredge. Stones larger than º inch and leaves and twigs were removed from the sample before compositing in a stainless steel bowl. Reach sample locations are identified in Figure 3. Because of resource limitations and holding time limitations, reach samples were analyzed for dioxins, furans and physical parameters only.

Adjacent individual reach samples were carefully split and mixed in the lab to form a composite sample prior to analysis. A total of 19 reach ìcompositeî samples were analyzed for dioxins and furans. The individual reach samples and the reach composites are shown on Figure 3 and listed in Table 3.

In addition to the composites, individual analyses were completed on each of the reach samples that make up Composites #4, #11, #15, and #17. These composites were selected for additional analysis based on the results of the H4IIE-luc bioassay as described in further detail below. An individual analysis was also performed on reach sample #23 which was distinguished from the other samples by a much higher TOC content.

Floodplain Soil Samples: Ten floodplain soil samples were also collected as part of the study. Low lying areas immediately adjacent to the river were selected, based on field judgment, as likely sites of significant fine particle deposition. The locations of the floodplain soil samples are identified in Figure 3. Latitudes and longitudes of floodplain soil sample locations are included in Table 2. Floodplain soil samples were collected from a one square foot location. The top one to two inches of soil was collected using a stainless steel scoop and thoroughly mixed in a stainless steel bowl. Large organic matter such as leaves and twigs were removed. Aliquots were taken for analysis of each of the study parameters listed in Table 1. A typical floodplain soil sampling location is shown in Figure 6.

Figure 6. Typical Floodplain Soil Sampling Location

Field Quality Control: As a quality control measure, duplicate samples were taken at river sediment location TF-C and floodplain soil location SS-7. These duplicate samples were analyzed for all study parameters.

Reference Locations: As the study area was the Tittabawassee River between the confluence of the Pine and Chippewa Rivers in the northwest to the Shiawassee River in the southeast, a transect core, composite, and

several discrete (reach) sediment and floodplain soil samples were taken above the confluence of the Tittabawassee and the Pine and the Tittabawassee and the Chippewa to serve as upstream controls. These upstream reference locations are listed in Table 4.

Additional Samples

Due to a broken chain-of-custody, dioxin and furan samples had to be recollected at transect sampling locations TC-C and TC-UC, and discrete reach sampling locations 1, 2, 3, and 11. Additional aliquots for the other study parameters were taken at the transect locations and serve as quality control replicates. The second set of samples collected from these locations is designated by an asterisk (1*, 2*, 3*, 11*, TC-C* and TC-UC*).

Analytical Methods

Analyses of sediments and flood plain soils at the selected locations were conducted using generally accepted sediment sampling and analytical techniques as identified below. Table 1 summarizes the analyses conducted on each sample and lists individual analytical parameters.

Volatile Organics: River sediment and floodplain soil samples for analysis of volatile organic compounds (VOCs) were methanol preserved in the field. Extraction was according to SW-846 Method 5035. Extracts were analyzed according to SW-846 Method 8260B. The list of analytes and detection limits is provided with the results in Table 5. Due to the lack of detections, no samples for VOCs were collected upstream of Transect F.

Semivolatile Organics: Semivolatile Organics (base neutral and acid extractable compounds and polynuclear aromatic hydrocarbons) were extracted using SW-846 Method 3510 and analyzed according to SW-846 Method 8270. The list of analytes and detection limits is provided with the results in Table 6.

Pesticides and PCBs: Pesticides and PCBs were extracted using SW-846 Method 3510 and analyzed according to SW-846 Method 8070. The list of analytes and detection limits is provided with the results in Table 7.

Metals: Samples were analyzed for metals using SW-846 6000 and 7000 series methods. The list of analytes and detection limits is provided with the results in Table 8.

Dioxins and Furans Chemical Analysis: Concentrations of seventeen 2,3,7,8-substituted polychlorinated dibenzo-p-dioxins (PCDDs) and

dibenzofurans (PCDFs) were analyzed by modifications of previously described methods (Yamashita et al., 2000; Kannan et al., 2001; Im et al., 2002). A copy of MSU-ATLís ìStandard Operating Procedure for the Extraction and Analysis of 2,3,7,8-substituted PCDDs and PCDFs in Sediments using High Resolution Gas Chromatography ñ High Resolution Mass Spectrometryî is attached as Appendix 4 of this Report.

In Vitro Bioassay Analysis: H4IIE-luc bioassay was used to determine total dioxin-like activity (TCDD-EQs) in sediments. The bioassay procedures are described in detail in Appendix 5 of this Report, and in Villeneuve et al., 2000 and Hilscherova et al. 2001. Samples were tested as raw extracts and as acid-treated extracts using the *in vitro* H4IIE-luc recombinant cells for dioxin-like activity. A mass balance analysis of dioxin-like activity derived from instrumental and bioassay analyses was used to test for the presence of other dioxin-like compounds that can bind to the aromatic hydrocarbon receptor (AhR). Mass balance analysis (or potency balance analysis) was also used to examine whether or not the known composition of a sample (identified by instrumental analysis) can account for the magnitude or potency of biological response observed.

Total Organic Matter: Sediment and floodplain soil samples were analyzed for Total Organic Matter by the Michigan State University Soil Analysis Laboratory using their ìLoss by Ignitionî protocol.

Total Organic Carbon: Sediment and floodplain soil samples were analyzed for TOC by the Michigan State University Soil Analysis Laboratory using their ìDry Combustion using Microcarbon Analyzerî protocol.

Results

Results for VOCs, semivolatile organic compounds, pesticides, PCBs, and metals are presented in Tables 5, 6, 7 and 8, respectively. Geographic distribution of semivolatiles, PCBs, and pesticides are presented in Figure 7.

Dioxin and furan results are presented in Table 9. A full copy of the dioxin and furan analytical and bioassay results and quality assurance data is being retained by the MDEQ Waste Management Division. Table 9 also includes the results of the TOC and total organic matter analyses of these samples. The geographic distribution of dioxins and furans is presented in Figure 8.

Discussion

Volatiles:
Only one VOC was detected during this study. Tetrachloroethene was detected at 95 ppb at sample location TC-UC. Due to the flow regime of the Tittabawassee River, the lack of detectable volatile organic compounds is not surprising. The Tittabawassee is a shallow, fast moving river with considerable turbulence and scour during storm events. Volatile compounds, should they be released to the river, are not likely to persist in sediments that are frequently agitated. Given the lack of detects, the decision was made to cease sampling for VOCs above Transect F. None of the floodplain soil samples showed detectable levels of VOCs.

Semivolatiles:
Semivolatile organic compounds, when found, were typically present at very low concentrations. Semivolatile organic compounds, including phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, and chrysene, were detected at sample locations TC-C, TF-CR, TE-C, TF-C, TF-UC, and TG-UC at levels below 400 ug/kg. Sample location TF-CR, in addition to having phenanthrene, fluoranthene, pyrene, and chrysene at very low levels, displayed hexachlorobenzene at 1300 ug/kg, a level that might indicate potential adverse impact to benthic organisms. Floodplain soil results were similar in displaying low levels of the same six semivolatile compounds at low levels (all below 510 ug/kg).

Pesticides and PCBs:
No PCBs were detected in sediment or floodplain soil samples. 4,4-DDT at 1,100 ug/kg and 4,4 DDD at 83 ug/kg in sediment sample TI-UC were the only target pesticides detected in sediment samples. Low levels of DDT and its breakdown products were detected at floodplain soil sampling locations SS-4 (Pine River), SS-5, and SS-7. There is a historical source of DDT on the Pine River that may have contributed to these detections. Hexabromobenzene was also detected at low levels at floodplain soil sampling locations SS-2, SS-4, and SS-7R. Detected levels of pesticides are not expected to have any significant impact on human health or the environment.

Metals:
Levels of metals in sediments are generally consistent with background levels. Of the floodplain soil samples, only SS-1 and SS-2 had concentrations that indicated the potential for minor aquatic life impacts (arsenic, chromium, copper, lead, mercury, nickel, and zinc). It is notable that SS-2 is immediately adjacent to and SS-1 is downstream of a former plate glass manufacturing facility which is known to have released metals to the river.

Dioxins and Furans:
Dioxins and furans were detected at each of the transect, reach, and individual sediment sampling locations analyzed during this study. Dioxins and furans were also present in each of the flood plain soil samples analyzed during this study. The concentrations of each of the 17 2,3,7,8-substituted PCDD and PCDF congeners, the calculated total toxic equivalent concentration (TEQ) relative to 2,3,7,8-TCDD, and the concentrations of the total tetra, penta, hexa, and hepta isomer groups are presented in Table 9 for each dioxin and furan sampling location.

The geographic distribution of the TEQ results is presented on Figure 8.

In general, the geographic distribution of dioxins and furans in the study area points to a source in the Midland area. The concentrations of dioxin in river sediments were less than 5 parts per trillion (ppt) TEQ in the seven reference samples that were taken above the junction of the Chippewa and Tittabawassee Rivers. Below the junction of the Chippewa and Tittabawassee Rivers, TEQ concentrations ranged from 5 to 2,000 ppt.

The concentrations of dioxins and furans were not significantly correlated with the TOC content of the samples. Correlation with the grain size of the samples with dioxin concentration was not completed in this study because the high levels of dioxins and furans in the samples resulted in an unanticipated health and safety concern during grain size analysis which involves drying and shaking of the samples. It is recommended that this evaluation be completed under the appropriate laboratory conditions.

Transect Results:
These samples are identified on Figure 8 by green boxes. The core composite samples are identified with a ìCî suffix (e.g. TA-C). The upper composite (dredge composite) samples are identified with a ìUCî suffix (e.g., TA-UC). The core sample results represent a mix of the surficial sediments and deeper sediments. The upper composite results represent only the top several inches of sediment.

In general, the concentrations of dioxins and furans were much higher in transect samples collected below the junction of the Tittabawassee and Chippewa Rivers than in the upstream reference samples. The transect reference samples were each less than 5 ppt total TEQ. Samples collected below the junction of the Tittabawassee River ranged in TEQ concentration from 5.1 ppt to 2000 ppt. It should be noted that the 5.1 ppt TEQ transect sample was collected at location TG-UC. No core sample could be collected from this location because of the coarse grained nature of the sediments. It is possible that the coarse grained nature of the sediments resulted in a relatively low concentration at this location.

The TEQ of the upper composite samples was similar to the core concentrations in most of the samples, with the exception of transects TC and TD where the concentration of dioxin and furans in the deeper cores was significantly higher than the upper composite samples. This suggests that in some parts of the study area, a reservoir of dioxin and furans may be present in deeper sediments. Further detailed coring work should be completed to determine if higher levels of dioxins and furans are present at lower depths in the river sediments.

Composite Results:
These samples show the distribution of dioxin and furans in the upper several inches of sediment in sediment accumulation areas in the study area. Due to resource limitations, adjacent sediment samples were carefully split and mixed in the lab to form a composite sample prior to analysis. The results of these analyses are shown on the maps as ìComposite #1 through Composite #19.î

These results show that the composite concentrations are significantly elevated and quite variable below the junction of the Tittabawassee and Chippewa Rivers. This variability is probably reflective of the flow and depositional characteristics of the different segments of the river system.

In order to evaluate the variability within the composite locations, individual reach samples were analyzed at four locations in addition to the composite analyses. This analysis revealed that there can be considerable variability in the TEQ concentrations of the individual reach samples that were used to form a composite sample. In the case of Composite #15, the concentrations varied from 22 to 2000 ppt TEQ with a composite average analysis of 960 ppt. Composite #11 varied from 130 to 1000 ppt TEQ with a composite average analysis of 480 ppt TEQ. Based on the recognized variability, any future studies that are conducted to more fully understand of the distribution of dioxin contamination should avoid compositing samples.

Flood Plain Soil Samples:
Ten flood plain soil samples were taken as a part of this study. These samples are identified on Figure 8 by red hexagons. These samples were collected by scraping the upper one inch of soil from a one square foot area in selected low lying flood plain areas adjacent to the Tittabawassee River. Sample locations were also based on property access agreements.

Dioxin results in floodplain soils ranged from 2 to 11 ppt TEQ in control samples above the junction of the Chippewa and Tittabawassee Rivers. Below the junction, TEQ concentrations ranged from 300 to1500 ppt. With the exception of SS#6, all of the samples were taken in the flood plain

within 100 feet of the edge of the river. SS#6 was taken from a recently tilled farm field several hundred yards away from the edge of the river.

The upstream reference sample results are consistent with Michiganís soil background dioxin levels. The soil concentrations below the confluence of the Tittabawassee and Chippewa are significantly elevated over Michiganís background soil concentration and exceed Michiganís Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, generic residential soil protection criterion of 90 ppt TEQ.

The downstream soil concentrations also exceed the Agency for Toxic Substances and Disease Registry (ATSDR) interim policy guidelines for PCDDs/PCDFs in residential soils near or on hazardous waste sites (De Rosa et al., 1997). When concentrations of TEQs exceed 50 pg /g TEQ dry weight, the ATSDR recommends evaluation of site-specific factors such as pathway analysis and soil cover. When soil concentrations exceed 1000 pg/g TEQ dry weight, the ATSDR recommends health surveillance and exposure investigations.

Based on the results of this investigation and follow up work conducted by the MDEQ in 2002, additional work is needed to determine if the level of exposure in the flood plain is resulting in health and/or ecological impacts.

Bioassay and Mass Balance Results:
H4IIE-luc bioassay was used to determine total dioxin-like activity (TCDD-EQs) in sediments and to direct the instrumental analyses. A mass balance analysis of dioxin-like activity derived from instrumental and bioassay analyses was used to test for the presence of other dioxin-like compounds that can bind to the aromatic hydrocarbon receptor (AhR). Earlier studies have demonstrated that the H4IIE-luc bioassay coupled with instrumental analysis is useful in the integrated assessment of dioxin-like activity in sediment (Khim et al., 1999; Hilscherova et al., 2000; Khim et al., 2001).

The instrumental and bioanalytical approaches provide different and complementary information. While instrumental analysis is a useful tool to identify the compounds of interest and to evaluate the concentrations of environmental contaminants, it provides little information regarding the integrated biological relevance of a complex mixture of compounds associated with environmental samples such as sediment. Where appropriate, bioassay-directed fractionation and mass balance analysis is a powerful tool to characterize the causative agents responsible for bioassay responses observed. Recent studies have indicated that organic extracts of sediments elicit both dioxin-like responses significantly *in vitro,* although the chemical concentrations often did not explain the bioassay

activities observed (Khim et al., 1999; Kannan et al., 2000; Hilscherova et al., 2001). Empirical bioassay results and mass balance analyses can suggest the magnitude of contribution of target organic compounds to total dioxin-like activity of sediment extracts. Thus, the use of bioassay-based toxicity identification and evaluation (TIE) and mass balance analysis are important approach to assess sediment contamination since the sediment extracts may contain many potentially AhR-active compounds, which were not analyzed by instrumental methods.

The results of this study showed that the results of the bioassay analyses matched very well with the results of the instrumental analysis. Therefore, the bioassay technique proved valuable in determining which samples showed significant dioxin-like activity. The bioassay technique could be used to direct further investigation in the watershed by screening out low activity samples and identifying areas of high dioxin like activity that would warrant follow up chemical confirmation.

Appendix 5 contains the results of the bioassay analyses and the mass balance calculations. The results suggest that PCDDs/PCDFs, are the major sources of dioxin-like activity in sediments/soils from the Tittabawassee River and that little, if any, activity was due to other compounds, such as PCBs, that exhibit dioxin-like activity. This was further supported by the lack of detectable concentrations of PCBs in soils and sediments.

Sources of Dioxins and Furans in the Tittabawassee River Watershed:

Figures 9, 10, 11, and 12 are congener profiles of the dioxin and furan samples collected during this study. The TEQ concentration of each sample has been normalized to 100 percent (%) and the normalized toxic equivalent concentration of each congener is plotted on the resulting bar chart. Congeners that were not detected at a specific sampling location were assigned a value of zero. The resulting bar chart is a ìfingerprintî of the 17 dioxins and furans that exhibit dioxin-like toxicity. The upstream reference samples are plotted at the top of each of the graphs and are marked with an asterisk.

As can be seen by review of the graphs, all of the samples taken from below the confluence of the Chippewa and Tittabawassee Rivers are fairly similar to each other and markedly different from the upstream reference samples. The chemical fingerprint of the sediment samples is similar to the chemical fingerprint of the floodplain soil samples, indicating that the dioxins and furans in these media are likely from the same source(s).

The bulk of the dioxin-like toxicity in the downstream samples is contributed by furan congeners. 2,3,7,8-TCDF and 2,3,4,7,8-PeCDF

contribute the bulk of the dioxin-like toxicity in the study area downstream of the confluence of the Tittabawassee and Chippewa Rivers. 1,2,3,7,8 ñ PeCDF and 1,2,3,4,7,8-HxCDF also make significant contributions to the dioxin-like toxicity of downstream sediment and soil samples. 2,3,7,8-TCDD, the most potent dioxin-like compound, typically contributes less than five percent of the TEQ in the downstream samples.

Different sources of PCDDs/PCDFs are characterized by different congener and homologue patterns (Kannan et al., 1998). Furthermore, differences in the physicochemical (mobility, solubility, etc.) and biological (biodegradation, bioaccumulation, etc.) properties may alter the congener profiles.

The fingerprints of PCDD and PCDF congeners in sediments collected from the Tittabawassee River downstream of Midland are all similar, suggesting the presence of a single major source. As noted above, the pattern of relative concentrations of PCDD/PCDF congeners was also different in soils and sediment collected downstream of Midland than in those collected upstream of the reference locations. A large proportion of OCDD and HpCDD has been suggested to be due to the sources originating from chlorophenol-related sources (Masunaga et al., 2001). Greater proportions of TCDFs suggest sources originating from PCB mixtures, chlorobenzenes, chlor-alkali processes, and incineration of PCBs and polyvinyl chloride (Wakimoto et al., 1988; Masunaga et al., 2001; Swami et al., 1992; Kannan et al., 1998). Total concentrations of PCBs in sediments from the Tittabawassee River were less than 150 nanograms/gram. This suggests that PCBs are not the source of the PCDD/PCDFs, but rather other sources such as chlorophenol and chlorobenzene production, incineration, or chlor-alkali processes are the sources of the PCDFs found in Tittabawassee River sediments collected below Midland.

The Dow Chemical Company (Dow) has a long history as a major manufacturer of chlorobenzenes, chlorophenols, and chlor-alkali products in Midland, Michigan. Additionally, Dow has conducted chemical waste incineration for many years. The geographic distribution of the contaminants combined with the dioxin and furan congener profile information strongly suggests that Dowís Midland facility is the most likely source of the elevated levels of dioxins and furans in the Tittabawassee River.

Conclusions and Recommendations

Summary: The data reviewed indicates that the potential for impacts to aquatic life to occur from the sediment chemicals analyzed, other than dioxins and furans, is minimal.

With regard to dioxins and furans, the following conclusions can be drawn:

1. The concentrations of dioxins and furans in sediments and soils represent a potential environmental and human health issue in the Tittabawassee River watershed that requires further study.

2. In the study area, the bulk of the dioxin-like toxicity in sediments and soils is contributed by the polychlorinated dibenzo-p-dioxins and furans. In particular, 2,3,7,8-TCDF and 2,3,4,7,8-PeCDF contribute the bulk of the dioxin-like toxicity to the samples collected from below the confluence of the Tittabawassee and Chippewa Rivers. Little dioxin-like toxicity appears to be contributed by other compounds that exhibit dioxin-like activity, such as PCBs.

3. The downstream extent of dioxin and furan contamination in sediments and floodplain soils has not been completely defined.

4. Deeper sediment cores are needed to determine the vertical extent of sediment contamination in the Tittabawassee and downstream in the Saginaw River.

5. The distribution of dioxins and furans in the study area sediments appears heterogeneous. This is most likely related to the flow regime of the Tittabawassee River. Any follow up sampling that is conducted should not involve compositing sediment samples. The relationship of grain size to dioxin and furan concentrations in the study area needs to be investigated.

6. The H4IIE-luc bioassay technique can be successfully used as a tool to direct further investigation of dioxin and furan contamination in the study area.

7. The most probable historic source of dioxins and furans in the Tittabawassee River watershed, based on the geographic distribution of the contaminants and the chemical profiles of the dioxin and furan congeners, is located in Midland, Michigan.

Recommendations:
Based on these conclusions, additional sampling is recommended to more completely define the horizontal and vertical distribution of dioxins and furans in the Tittabawassee River and Saginaw River watersheds. Periodic resampling should be conducted to determine if concentrations

are changing over time. The existing information should be used along with other available information to conduct an assessment of the risk to human health and the environment from the elevated concentrations of dioxins and furans present in the study area.

TABLES

TABLE 9
Part 1

Part 1																
				TB-UC					TC-C					TC-UC		
Analyte	TEF		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect
			pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero
2378-TCDD	1		1.20	1.2000	1.2000	1.2000		0.92	0.9200	0.9200	0.9200		1.60	1.600	1.600	1.6000
12378-PeCDD	0.5	ND	0.50	0.2500	0.1250	0.0000	ND	0.50	0.2500	0.1250	0.0000		0.54	0.270	0.270	0.2700
123478-HxCDD	0.1		10.41	1.0410	1.0410	1.0410		13.32	1.3320	1.3320	1.3320		10.54	1.054	1.054	1.0540
123678-HxCDD	0.1		3.44	0.3440	0.3440	0.3440		1.43	0.1430	0.1430	0.1430	ND	0.50	0.050	0.025	0.0000
123789-HxCDD	0.1	ND	0.50	0.0500	0.0250	0.0000	ND	0.50	0.0500	0.0250	0.0000	ND	0.50	0.050	0.025	0.0000
1234678-HpCDD	0.01		53.56	0.5356	0.5356	0.5356		31.74	0.3174	0.3174	0.3174		23.64	0.236	0.236	0.2364
12346789-OCDD	0.001		483.51	0.4835	0.4835	0.4835		208.19	0.2082	0.2082	0.2082		186.10	0.186	0.186	0.1861
2378TCDF	0.1		547.68	54.7680	54.7680	54.7680		33.80	3.3800	3.3800	3.3800		162.20	16.220	16.220	16.2200
12378-PeCDF	0.05		198.27	9.9135	9.9135	9.9135		14.27	0.7135	0.7135	0.7135		96.44	4.822	4.822	4.8220
23478-PeCDF	0.5		130.15	65.0750	65.0750	65.0750		8.26	4.1300	4.1300	4.1300		52.75	26.375	26.375	26.3750
123478-HxCDF	0.1		90.04	9.0040	9.0040	9.0040		10.01	1.0010	1.0010	1.0010		54.51	5.451	5.451	5.4510
123678-HxCDF	0.1		23.34	2.3340	2.3340	2.3340		1.54	0.1540	0.1540	0.1540		12.66	1.266	1.266	1.2660
234678-HxCDF	0.1		10.21	1.0210	1.0210	1.0210	ND	0.50	0.0500	0.0250	0.0000		4.85	0.485	0.485	0.4850
123789-HxCDF	0.1		0.87	0.0870	0.0870	0.0870	ND	0.50	0.0500	0.0250	0.0000	ND	0.50	0.050	0.025	0.0000
1234678-HpCDF	0.01		91.15	0.9115	0.9115	0.9115		43.12	0.4312	0.4312	0.4312		60.70	0.607	0.607	0.6070
1234789-HpCDF	0.01		8.37	0.0837	0.0837	0.0837		4.05	0.0405	0.0405	0.0405		69.57	0.696	0.696	0.6957
12346789-OCDF	0.001		88.81	0.0888	0.0888	0.0888		55.54	0.0555	0.0555	0.0555		39.12	0.039	0.039	0.0391
nondetects = detection limit			TEQ=	147.1906				TEQ=	13.2263				TEQ=	59.4573		
nondetects = 1/2 d.l.			*teq=*		*147.0406*			*teq=*		*13.0263*			*teq=*		*59.3823*	
nondetects = zero			teq=			146.8906		teq=			12.8263		teq=			59.3073
Moisture content (%)				18.59					18.64					20.77		
Organic carbon (%)				0.26					0.18					0.33		
Total organic matter (%)				0.45					0.31					0.57		
Sample I.D.			TB-UC					TC-C					TC-UC			
tetra-PCDF (TCDF)			548.0					33.8					162.0			
penta-PCDF (PeCDF)			328.0					22.5					149.0			
hexa-PCDF (HxCDF)			124.0					11.6					72.0			
hepta-PCDF (HpCDF)			99.5					47.2					130.0			
octa-PCDF (OCDF)			88.8					55.5					39.1			
tetra-PCDD (TCDD)			1.2					0.9					1.6			
penta-PCDD (PeCDD)		ND	0.5				ND	0.5					0.5			
hexa-PCDD (HxCDD)			13.9					14.8					10.5			
hepta-PCDD (HpCDD)			53.6					31.7					23.6			
octa-PCDD (OCDD)			484.0					208.0					186.0			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 1

Part 1																
				TD-C					TD-UC					TE-C		
Analyte	TEF		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect
			pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero
2378-TCDD	1		1.56	1.560	1.560	1.560		0.97	0.970	0.970	0.9700		1.95	1.950	1.950	1.9500
12378-PeCDD	0.5		1.03	0.515	0.515	0.515		0.60	0.300	0.300	0.3000		0.74	0.370	0.370	0.3700
123478-HxCDD	0.1		32.32	3.232	3.232	3.232		1.44	0.144	0.144	0.1440		63.47	6.347	6.347	6.3470
123678-HxCDD	0.1		2.06	0.206	0.206	0.206	ND	1.20	0.120	0.060	0.0000		14.68	1.468	1.468	1.4680
123789-HxCDD	0.1		2.11	0.211	0.211	0.211	ND	1.20	0.120	0.060	0.0000		3.34	0.334	0.334	0.3340
1234678-HpCDD	0.01		131.46	1.315	1.315	1.315		25.25	0.253	0.253	0.2525		207.34	2.073	2.073	2.0734
12346789-OCDD	0.001		911.49	0.911	0.911	0.911		287.56	0.288	0.288	0.2876		2139.70	2.140	2.140	2.1397
2378TCDF	0.1		3084.98	308.498	308.498	308.498		267.47	26.747	26.747	26.7470		2577.95	257.795	257.795	257.7950
12378-PeCDF	0.05		4891.86	244.593	244.593	244.593		139.34	6.967	6.967	6.9670		1496.96	74.848	74.848	74.8480
23478-PeCDF	0.5		1660.30	830.150	830.150	830.150		91.78	45.890	45.890	45.8900		980.42	490.210	490.210	490.2100
123478-HxCDF	0.1		5020.21	502.021	502.021	502.021		49.60	4.960	4.960	4.9600		663.00	66.300	66.300	66.3000
123678-HxCDF	0.1		1014.95	101.495	101.495	101.495		10.06	1.006	1.006	1.0060		177.19	17.719	17.719	17.7190
234678-HxCDF	0.1		219.77	21.977	21.977	21.977		4.91	0.491	0.491	0.4910		80.29	8.029	8.029	8.0290
123789-HxCDF	0.1		63.91	6.391	6.391	6.391		1.10	0.110	0.110	0.1100		5.22	0.522	0.522	0.5220
1234678-HpCDF	0.01		844.04	8.440	8.440	8.440		53.23	0.532	0.532	0.5323		436.54	4.365	4.365	4.3654
1234789-HpCDF	0.01		346.97	3.470	3.470	3.470		7.37	0.074	0.074	0.0737		52.29	0.523	0.523	0.5229
12346789-OCDF	0.001		594.49	0.594	0.594	0.594		38.01	0.038	0.038	0.0380		485.02	0.485	0.485	0.4850
nondetects = detection limit			TEQ=	2035.5797				TEQ=	89.0091				TEQ=	935.4784		
nondetects = 1/2 d.l.			*teq=*		*2035.5797*			*teq=*		*88.8891*			*teq=*		*935.4784*	
nondetects = zero			teq=			2035.5797		teq=			88.7691		teq=			935.4784
Moisture content (%)				17.82					24.44					33.27		
Organic carbon (%)				0.12					0.33					1.27		
Total organic matter (%)				0.21					0.57					2.19		
Sample I.D.			TD-C					TD-UC					TE-C			
tetra-PCDF (TCDF)			3085.0					267.0					2578.0			
penta-PCDF (PeCDF)			6552.0					231.0					2477.0			
hexa-PCDF (HxCDF)			6319.0					65.7					926.0			
hepta-PCDF (HpCDF)			1191.0					60.6					489.0			
octa-PCDF (OCDF)			594.0					38.0					485.0			
tetra-PCDD (TCDD)			1.6					1.0					1.9			
penta-PCDD (PeCDD)			1.0					0.6					0.7			
hexa-PCDD (HxCDD)			36.5					1.4					81.5			
hepta-PCDD (HpCDD)			131.0					25.2					207.0			
octa-PCDD (OCDD)			911.0					288.0					2140.0			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 1

Part 1																
				TE-UC					TF-C					TF-CR		
Analyte	TEF		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect
			pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero
2378-TCDD	1		2.94	2.9400	2.9400	2.9400		2.15	2.150	2.1500	2.1500		2.97	2.970	2.9700	2.9700
12378-PeCDD	0.5		2.16	1.0800	1.0800	1.0800		1.28	0.640	0.6400	0.6400		1.20	0.600	0.6000	0.6000
123478-HxCDD	0.1		44.45	4.4450	4.4450	4.4450		48.48	4.848	4.8480	4.8480		84.18	8.418	8.4180	8.4180
123678-HxCDD	0.1		36.72	3.6720	3.6720	3.6720		12.96	1.296	1.2960	1.2960		12.62	1.262	1.2620	1.2620
123789-HxCDD	0.1		5.53	0.5530	0.5530	0.5530		3.09	0.309	0.3090	0.3090		2.62	0.262	0.2620	0.2620
1234678-HpCDD	0.01		715.59	7.1559	7.1559	7.1559		302.17	3.022	3.0217	3.0217		270.92	2.709	2.7092	2.7092
12346789-OCDD	0.001		4904.67	4.9047	4.9047	4.9047		3880.96	3.881	3.8810	3.8810		2763.04	2.763	2.7630	2.7630
2378TCDF	0.1		423.68	42.3680	42.3680	42.3680		1085.39	108.539	108.5390	108.5390		1243.66	124.366	124.3660	124.3660
12378-PeCDF	0.05		218.95	10.9475	10.9475	10.9475		590.27	29.514	29.5135	29.5135		614.32	30.716	30.7160	30.7160
23478-PeCDF	0.5		134.41	67.2050	67.2050	67.2050		313.37	156.685	156.6850	156.6850		367.97	183.985	183.9850	183.9850
123478-HxCDF	0.1		144.23	14.4230	14.4230	14.4230		318.40	31.840	31.8400	31.8400		294.10	29.410	29.4100	29.4100
123678-HxCDF	0.1		23.23	2.3230	2.3230	2.3230		74.01	7.401	7.4010	7.4010		72.19	7.219	7.2190	7.2190
234678-HxCDF	0.1		8.30	0.8300	0.8300	0.8300		25.94	2.594	2.5940	2.5940		25.92	2.592	2.5920	2.5920
123789-HxCDF	0.1		1.83	0.1830	0.1830	0.1830		6.50	0.650	0.6500	0.6500		5.72	0.572	0.5720	0.5720
1234678-HpCDF	0.01		625.86	6.2586	6.2586	6.2586		359.70	3.597	3.5970	3.5970		611.81	6.118	6.1181	6.1181
1234789-HpCDF	0.01		47.51	0.4751	0.4751	0.4751		41.18	0.412	0.4118	0.4118		39.96	0.400	0.3996	0.3996
12346789-OCDF	0.001		2134.61	2.1346	2.1346	2.1346		617.51	0.618	0.6175	0.6175		775.25	0.775	0.7753	0.7753
nondetects = detection limit			TEQ=	171.8984				TEQ=	357.9945				TEQ=	405.1372		
nondetects = 1/2 d.l.			*teq=*		*171.8984*			*teq=*		*357.9945*			*teq=*		*405.1372*	
nondetects = zero			teq=			171.8984		teq=			357.9945		teq=			405.1372
Moisture content (%)				24.67					25.96					26.8		
Organic carbon (%)				0.71					0.65					0.62		
Total organic matter (%)				1.22					1.12					1.07		
Sample I.D.			TE-UC					TF-C					TF-CR			
tetra-PCDF (TCDF)			424.0					1085.0					1244.0			
penta-PCDF (PeCDF)			353.0					904.0					982.0			
hexa-PCDF (HxCDF)			178.0					425.0					398.0			
hepta-PCDF (HpCDF)			673.0					401.0					652.0			
octa-PCDF (OCDF)			2135.0					618.0					775.0			
tetra-PCDD (TCDD)			2.9					2.2					3.0			
penta-PCDD (PeCDD)			2.2					1.3					1.2			
hexa-PCDD (HxCDD)			86.7					64.5					99.4			
hepta-PCDD (HpCDD)			716.0					302.0					271.0			
octa-PCDD (OCDD)			4905.0					3881.0					2763.0			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 1

Part 1																
				TF-UC					TG-UC					TH-C		
Analyte	TEF		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect
			pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero
2378-TCDD	1		2.56	2.560	2.5600	2.5600	ND	0.50	0.500	0.2500	0.0000	ND	0.500	0.500	0.2500	0.0000
12378-PeCDD	0.5	ND	0.50	0.250	0.1250	0.0000	ND	0.50	0.250	0.1250	0.0000	ND	0.500	0.250	0.1250	0.0000
123478-HxCDD	0.1		24.71	2.471	2.4710	2.4710		0.92	0.092	0.0920	0.0920	ND	0.500	0.050	0.0250	0.0000
123678-HxCDD	0.1		9.13	0.913	0.9130	0.9130		5.85	0.585	0.5850	0.5850	ND	0.500	0.050	0.0250	0.0000
123789-HxCDD	0.1		4.61	0.461	0.4610	0.4610	ND	0.50	0.050	0.0250	0.0000	ND	0.500	0.050	0.0250	0.0000
1234678-HpCDD	0.01		121.15	1.212	1.2115	1.2115		31.80	0.318	0.3180	0.3180		6.382	0.064	0.0638	0.0638
12346789-OCDD	0.001		1099.11	1.099	1.0991	1.0991		224.25	0.224	0.2243	0.2243		52.715	0.053	0.0527	0.0527
2378TCDF	0.1		1718.24	171.824	171.8240	171.8240		8.96	0.896	0.8960	0.8960		2.790	0.279	0.2790	0.2790
12378-PeCDF	0.05		959.43	47.972	47.9715	47.9715		5.28	0.264	0.2640	0.2640		1.346	0.067	0.0673	0.0673
23478-PeCDF	0.5		507.40	253.700	253.7000	253.7000		2.52	1.260	1.2600	1.2600	ND	0.500	0.250	0.1250	0.0000
123478-HxCDF	0.1		428.50	42.850	42.8500	42.8500		6.20	0.620	0.6200	0.6200		2.430	0.243	0.2430	0.2430
123678-HxCDF	0.1		90.64	9.064	9.0640	9.0640		0.78	0.078	0.0780	0.0780	ND	0.500	0.050	0.0250	0.0000
234678-HxCDF	0.1		33.59	3.359	3.3590	3.3590	ND	0.50	0.050	0.0250	0.0000	ND	0.500	0.050	0.0250	0.0000
123789-HxCDF	0.1		3.59	0.359	0.3590	0.3590	ND	0.50	0.050	0.0250	0.0000	ND	0.500	0.050	0.0250	0.0000
1234678-HpCDF	0.01		234.05	2.341	2.3405	2.3405		30.42	0.304	0.3042	0.3042		3.730	0.037	0.0373	0.0373
1234789-HpCDF	0.01		27.71	0.277	0.2771	0.2771		2.59	0.026	0.0259	0.0259		0.640	0.006	0.0064	0.0064
12346789-OCDF	0.001		356.53	0.357	0.3565	0.3565		31.31	0.031	0.0313	0.0313		2.953	0.003	0.0030	0.0030
nondetects = detection limit			TEQ=	541.0672				TEQ=	5.5987				TEQ=	2.0525		
nondetects = 1/2 d.l.			*teq=*		*540.9422*			*teq=*		*5.1487*			*teq=*		*1.4025*	
nondetects = zero			teq=			540.8172		teq=			4.6987		teq=			0.7525
Moisture content (%)				23.9					25.18					27.01		
Organic carbon (%)				0.33					0.26					0.41		
Total organic matter (%)				0.57					0.45					0.71		
Sample I.D.			TF-UC					TG-UC					TH-C			
tetra-PCDF (TCDF)			1718.0					9.0					2.8			
penta-PCDF (PeCDF)			1467.0					7.8					1.3			
hexa-PCDF (HxCDF)			556.0					7.0					2.4			
hepta-PCDF (HpCDF)			262.0					33.0					4.4			
octa-PCDF (OCDF)			357.0					31.3					3.0			
tetra-PCDD (TCDD)			2.6				ND	0.5				ND	0.5			
penta-PCDD (PeCDD)		ND	0.5				ND	0.5				ND	0.5			
hexa-PCDD (HxCDD)			38.4					6.8				ND	0.5			
hepta-PCDD (HpCDD)			121.0					31.8					6.4			
octa-PCDD (OCDD)			1099.0					224.0					52.7			
Summary concentrations of the homolog gı																
Concentrations of all compound (except of																
Recalculation for internal standards accoun																
* OCDF concentrations were calculated ba:																
if required, OCDF concentrations can be n																
ND = non detected, the detection limits wil																

TABLE 9
Part 1

Part 1																
				TH-UC					TI-C					TI-UC		
Analyte	TEF		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect
			pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero
2378-TCDD	1	ND	0.50	0.500	0.2500	0.0000		1.23	1.230	1.2300	1.2300	ND	0.50	0.500	0.2500	0.0000
12378-PeCDD	0.5	ND	0.50	0.250	0.1250	0.0000	ND	0.50	0.250	0.1250	0.0000	ND	0.50	0.250	0.1250	0.0000
123478-HxCDD	0.1	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000
123678-HxCDD	0.1	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000
123789-HxCDD	0.1	ND	0.50	0.050	0.0250	0.0000		0.50	0.050	0.0500	0.0500	ND	0.60	0.060	0.0300	0.0000
1234678-HpCDD	0.01		3.25	0.033	0.0325	0.0325		20.56	0.206	0.2056	0.2056		11.17	0.112	0.1117	0.1117
12346789-OCDD	0.001		31.55	0.032	0.0316	0.0316		178.72	0.179	0.1787	0.1787		82.66	0.083	0.0827	0.0827
2378TCDF	0.1		1.01	0.101	0.1010	0.1010		7.18	0.718	0.7180	0.7180		2.42	0.242	0.2420	0.2420
12378-PeCDF	0.05		0.73	0.037	0.0365	0.0365		2.22	0.111	0.1110	0.1110		1.99	0.100	0.0995	0.0995
23478-PeCDF	0.5	ND	0.50	0.250	0.1250	0.0000		2.87	1.435	1.4350	1.4350		1.49	0.745	0.7450	0.7450
123478-HxCDF	0.1		1.42	0.142	0.1420	0.1420		3.16	0.316	0.3160	0.3160		1.16	0.116	0.1160	0.1160
123678-HxCDF	0.1	ND	0.50	0.050	0.0250	0.0000		1.21	0.121	0.1210	0.1210	ND	0.50	0.050	0.0250	0.0000
234678-HxCDF	0.1	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000
123789-HxCDF	0.1	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000	ND	0.50	0.050	0.0250	0.0000
1234678-HpCDF	0.01		2.90	0.029	0.0290	0.0290		17.90	0.179	0.1790	0.1790		6.32	0.063	0.0632	0.0632
1234789-HpCDF	0.01		0.53	0.005	0.0053	0.0053		1.02	0.010	0.0102	0.0102		0.82	0.008	0.0082	0.0082
12346789-OCDF	0.001		2.61	0.003	0.0026	0.0026		11.28	0.011	0.0113	0.0113		4.18	0.004	0.0042	0.0042
nondetects = detection limit			TEQ=	1.6805				TEQ=	5.0158				TEQ=	2.5324		
nondetects = 1/2 d.l.			*teq=*		*1.0305*			*teq=*		*4.7908*			*teq=*		*2.0024*	
nondetects = zero			teq=			0.3805		teq=			4.5658		teq=			1.4724
Moisture content (%)				20.93					36.61					34.14		
Organic carbon (%)				0.49					1.28					0.87		
Total organic matter (%)				0.85					2.21					1.5		
Sample I.D.			TH-UC					TI-C					TI-UC			
tetra-PCDF (TCDF)			1.0					7.2					2.4			
penta-PCDF (PeCDF)			0.7					5.1					3.5			
hexa-PCDF (HxCDF)			1.4					4.4					1.2			
hepta-PCDF (HpCDF)			3.4					18.9					7.1			
octa-PCDF (OCDF)			2.6					11.3					4.2			
tetra-PCDD (TCDD)		ND	0.5					1.2				ND	0.5			
penta-PCDD (PeCDD)		ND	0.5				ND	0.5				ND	0.5			
hexa-PCDD (HxCDD)		ND	0.5					0.5				ND	0.5			
hepta-PCDD (HpCDD)			3.3					20.6					11.2			
octa-PCDD (OCDD)			31.5					179.0					82.7			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				C1					C2					C-3		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		1.52	1.520	1.5200	1.5200		2.27	2.270	2.2700	2.2700		3.13	3.130	3.1300	3.1300
12378-PeCDD	0.5	ND	0.50	0.250	0.1250	0.0000	ND	0.50	0.250	0.1250	0.0000		0.98	0.490	0.4900	0.4900
123478-HxCDD	0.1		45.03	4.503	4.5030	4.5030		17.28	1.728	1.7280	1.7280		63.20	6.320	6.3200	6.3200
123678-HxCDD	0.1		4.86	0.486	0.4860	0.4860		6.07	0.607	0.6070	0.6070		13.87	1.387	1.3870	1.3870
123789-HxCDD	0.1	ND	0.50	0.050	0.0250	0.0000		1.14	0.114	0.1140	0.1140		3.44	0.344	0.3440	0.3440
1234678-HpCDD	0.01		78.44	0.784	0.7844	0.7844		60.90	0.609	0.6090	0.6090		141.34	1.413	1.4134	1.4134
12346789-OCDD	0.001		659.09	0.659	0.6591	0.6591		476.34	0.476	0.4763	0.4763		1100.78	1.101	1.1008	1.1008
2378TCDF	0.1		625.06	62.506	62.5060	62.5060		3600.50	360.050	360.0500	360.0500		747.63	74.763	74.7630	74.7630
12378-PeCDF	0.05		353.71	17.686	17.6855	17.6855		1145.95	57.298	57.2975	57.2975		411.60	20.580	20.5800	20.5800
23478-PeCDF	0.5		211.16	105.580	105.5800	105.5800		812.82	406.410	406.4100	406.4100		235.92	117.960	117.9600	117.9600
123478-HxCDF	0.1		160.78	16.078	16.0780	16.0780		359.52	35.952	35.9520	35.9520		163.82	16.382	16.3820	16.3820
123678-HxCDF	0.1		32.84	3.284	3.2840	3.2840		93.16	9.316	9.3160	9.3160		30.18	3.018	3.0180	3.0180
234678-HxCDF	0.1		11.68	1.168	1.1680	1.1680		43.55	4.355	4.3550	4.3550		11.48	1.148	1.1480	1.1480
123789-HxCDF	0.1		2.54	0.254	0.2540	0.2540		8.64	0.864	0.8640	0.8640		3.01	0.301	0.3010	0.3010
1234678-HpCDF	0.01		254.43	2.544	2.5443	2.5443		147.40	1.474	1.4740	1.4740		351.97	3.520	3.5197	3.5197
1234789-HpCDF	0.01		13.89	0.139	0.1389	0.1389		19.50	0.195	0.1950	0.1950		28.17	0.282	0.2817	0.2817
12346789-OCDF	0.001		155.26	0.155	0.1553	0.1553		198.13	0.198	0.1981	0.1981		267.76	0.268	0.2678	0.2678
nondetects = detection limit			TEQ=	217.65				TEQ=	882.17				TEQ=	252.41		
nondetects = 1/2 d.l.			*teq=*		*217.50*			*teq=*		*882.04*			*teq=*		*252.41*	
nondetects = zero			teq=			217.35		teq=			881.92		teq=			252.41
Moisture content (%)				21.74					22.27					27.11		
Organic carbon (%)				0.37					0.36					0.94		
Total organic matter (%)				0.64					0.61					1.62		
Sample I.D.			C-1					C-2					C-3			
tetra-PCDF (TCDF)			625					3601					748			
penta-PCDF (PeCDF)			565					1959					648			
hexa-PCDF (HxCDF)			208					505					208			
hepta-PCDF (HpCDF)			268					167					380			
octa-PCDF (OCDF)			155					198					268			
tetra-PCDD (TCDD)			1.5					2.3					3.1			
penta-PCDD (PeCDD)		ND	0.5				ND	0.5					1			
hexa-PCDD (HxCDD)			49.9					24.5					80.5			
hepta-PCDD (HpCDD)			78.4					60.9					141			
octa-PCDD (OCDD)			659					476					1101			

Summary concentrations of the homolog groups [pg/g dry weight]
Concentrations of all compound (except of OCDF) are calculated based on internal standard calibration
Recalculation for internal standards accounts for the recoveries
* OCDF concentrations were calculated based on external standard and they were not recalculated for recoveries since no specific internal standard (no 13C-OCDF) was available
if required, OCDF concentrations can be normalized for 13C-OCDD recoveries
ND = non detected, the detection limits will be specified on individual sample bases

TABLE 9
Part 2

Part 2 (continued)

				C-4					C-5					C-6		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		1.54	1.540	1.5400	1.5400		1.57	1.570	1.5700	1.5700		1.74	1.740	1.7400	1.7400
12378-PeCDD	0.5	ND	0.50	0.250	0.1250	0.0000		4.45	2.225	2.2250	2.2250		0.93	0.465	0.4650	0.4650
123478-HxCDD	0.1		53.25	5.325	5.3250	5.3250		23.59	2.359	2.3590	2.3590		32.64	3.264	3.2640	3.2640
123678-HxCDD	0.1		14.47	1.447	1.4470	1.4470		20.19	2.019	2.0190	2.0190		8.70	0.870	0.8700	0.8700
123789-HxCDD	0.1		3.29	0.329	0.3290	0.3290		5.66	0.566	0.5660	0.5660		2.09	0.209	0.2090	0.2090
1234678-HpCDD	0.01		149.46	1.495	1.4946	1.4946		95.30	0.953	0.9530	0.9530		95.18	0.952	0.9518	0.9518
12346789-OCDD	0.001		1281.52	1.282	1.2815	1.2815		715.05	0.715	0.7151	0.7151		974.11	0.974	0.9741	0.9741
2378TCDF	0.1		5449.06	544.906	544.9060	544.9060		1025.88	102.588	102.5880	102.5880		1716.96	171.696	171.6960	171.6960
12378-PeCDF	0.05		2261.76	113.088	113.0880	113.0880		1064.92	53.246	53.2460	53.2460		509.79	25.490	25.4895	25.4895
23478-PeCDF	0.5		1617.75	808.875	808.8750	808.8750		540.82	270.410	270.4100	270.4100		378.61	189.305	189.3050	189.3050
123478-HxCDF	0.1		895.98	89.598	89.5980	89.5980		551.68	55.168	55.1680	55.1680		220.90	22.090	22.0900	22.0900
123678-HxCDF	0.1		160.95	16.095	16.0950	16.0950		95.57	9.557	9.5570	9.5570		44.01	4.401	4.4010	4.4010
234678-HxCDF	0.1		97.50	9.750	9.7500	9.7500		50.15	5.015	5.0150	5.0150		28.92	2.892	2.8920	2.8920
123789-HxCDF	0.1		5.74	0.574	0.5740	0.5740		6.83	0.683	0.6830	0.6830		3.14	0.314	0.3140	0.3140
1234678-HpCDF	0.01		388.22	3.882	3.8822	3.8822		255.26	2.553	2.5526	2.5526		229.01	2.290	2.2901	2.2901
1234789-HpCDF	0.01		45.92	0.459	0.4592	0.4592		39.16	0.392	0.3916	0.3916		15.55	0.156	0.1555	0.1555
12346789-OCDF	0.001		450.79	0.451	0.4508	0.4508		139.79	0.140	0.1398	0.1398		182.65	0.183	0.1827	0.1827
nondetects = detection limit			TEQ=	1599.35				TEQ=	510.16				TEQ=	427.29		
nondetects = 1/2 d.l.			*teq=*		*1599.22*			*teq=*		*510.16*			*teq=*		*427.29*	
nondetects = zero			teq=			1599.10		teq=			510.16		teq=			427.29
Moisture content (%)			22.1					24.59					23.93			
Organic carbon (%)			0.66					0.38					0.49			
Total organic matter (%)			1.13					0.66					0.84			
Sample I.D.			C-4					C-5					C-6			
tetra-PCDF (TCDF)			5449					1026					1717			
penta-PCDF (PeCDF)			3880					1606					888			
hexa-PCDF (HxCDF)			1160					704					297			
hepta-PCDF (HpCDF)			434					294					245			
octa-PCDF (OCDF)			451					140					183			
tetra-PCDD (TCDD)			1.5					1.6					1.7			
penta-PCDD (PeCDD)		ND	0.5					4.5					0.9			
hexa-PCDD (HxCDD)			71					49.4					43.4			
hepta-PCDD (HpCDD)			149					95.3					95.2			
octa-PCDD (OCDD)			1282					715					974			

Summary concentrations of the homolog gr
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				C-7					C-8					C-9		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		4.67	4.6700	4.6700	4.6700	ND	1.40	1.4000	0.7000	0.0000		2.99	2.9900	2.9900	2.9900
12378-PeCDD	0.5		4.27	2.1350	2.1350	2.1350		2.21	1.1050	1.1050	1.1050	ND	0.75	0.3750	0.1875	0.0000
123478-HxCDD	0.1		103.43	10.3430	10.3430	10.3430		64.35	6.4350	6.4350	6.4350		30.09	3.0090	3.0090	3.0090
123678-HxCDD	0.1		26.09	2.6090	2.6090	2.6090		3.25	0.3250	0.3250	0.3250		19.33	1.9330	1.9330	1.9330
123789-HxCDD	0.1		7.11	0.7110	0.7110	0.7110		2.29	0.2290	0.2290	0.2290		2.20	0.2200	0.2200	0.2200
1234678-HpCDD	0.01		271.62	2.7162	2.7162	2.7162		234.30	2.3430	2.3430	2.3430		186.48	1.8648	1.8648	1.8648
12346789-OCDD	0.001		2943.76	2.9438	2.9438	2.9438		1645.38	1.6454	1.6454	1.6454		1540.70	1.5407	1.5407	1.5407
2378TCDF	0.1		1045.95	104.5950	104.5950	104.5950		333.59	33.3590	33.3590	33.3590		1024.03	102.4030	102.4030	102.4030
12378-PeCDF	0.05		665.06	33.2530	33.2530	33.2530		239.80	11.9900	11.9900	11.9900		673.81	33.6905	33.6905	33.6905
23478-PeCDF	0.5		362.66	181.3300	181.3300	181.3300		141.93	70.9650	70.9650	70.9650		356.56	178.2800	178.2800	178.2800
123478-HxCDF	0.1		392.42	39.2420	39.2420	39.2420		127.71	12.7710	12.7710	12.7710		243.52	24.3520	24.3520	24.3520
123678-HxCDF	0.1		84.80	8.4800	8.4800	8.4800		34.49	3.4490	3.4490	3.4490		54.00	5.4000	5.4000	5.4000
234678-HxCDF	0.1		41.46	4.1460	4.1460	4.1460		2.69	0.2690	0.2690	0.2690		20.47	2.0470	2.0470	2.0470
123789-HxCDF	0.1		3.67	0.3670	0.3670	0.3670		2.10	0.2100	0.2100	0.2100		31.81	3.1810	3.1810	3.1810
1234678-HpCDF	0.01		601.20	6.0120	6.0120	6.0120		364.28	3.6428	3.6428	3.6428		211.18	2.1118	2.1118	2.1118
1234789-HpCDF	0.01		33.21	0.3321	0.3321	0.3321		25.62	0.2562	0.2562	0.2562		26.44	0.2644	0.2644	0.2644
12346789-OCDF	0.001		389.61	0.3896	0.3896	0.3896		291.78	0.2918	0.2918	0.2918		401.07	0.4011	0.4011	0.4011
nondetects = detection limit			TEQ=	404.27				TEQ=	150.69				TEQ=	364.06		
nondetects = 1/2 d.l.			*teq=*		*404.27*			*teq=*		*149.99*			*teq=*		*363.88*	
nondetects = zero			teq=			404.27		teq=			149.29		teq=			363.69
Moisture content (%)			25.05					34.35					24.86			
Organic carbon (%)			0.43					1.3					0.51			
Total organic matter (%)			0.74					1.24					0.88			
Sample I.D.			C-7					C-8					C-9			
tetra-PCDF (TCDF)			1046					334					1024			
penta-PCDF (PeCDF)			1028					382					1030			
hexa-PCDF (HxCDF)			522					167					350			
hepta-PCDF (HpCDF)			634					390					238			
octa-PCDF (OCDF)			390					292					401			
tetra-PCDD (TCDD)			4.7				ND	1.4					3			
penta-PCDD (PeCDD)			4.3					2.2				ND	0.75			
hexa-PCDD (HxCDD)			137					69.9					51.6			
hepta-PCDD (HpCDD)			272					234					186			
octa-PCDD (OCDD)			2944					1645					1541			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				C-10					C-11					C-12		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		8.00	8.0000	8.0000	8.0000	ND	1.00	1.0000	0.5000	0.0000	ND	1.00	1.000	0.500	0.0000
12378-PeCDD	0.5		1.50	0.7500	0.7500	0.7500		0.59	0.2950	0.2950	0.2950	ND	1.00	0.500	0.250	0.0000
123478-HxCDD	0.1		82.69	8.2690	8.2690	8.2690		41.84	4.1840	4.1840	4.1840		31.65	3.165	3.165	3.1650
123678-HxCDD	0.1		10.62	1.0620	1.0620	1.0620		6.82	0.6820	0.6820	0.6820		10.46	1.046	1.046	1.0460
123789-HxCDD	0.1		2.82	0.2820	0.2820	0.2820	ND	1.20	0.1200	0.0600	0.0000	ND	1.10	0.110	0.055	0.0000
1234678-HpCDD	0.01		293.86	2.9386	2.9386	2.9386		65.03	0.6503	0.6503	0.6503		218.37	2.184	2.184	2.1837
12346789-OCDD	0.001		4383.43	4.3834	4.3834	4.3834		854.33	0.8543	0.8543	0.8543		2337.80	2.338	2.338	2.3378
2378TCDF	0.1		1972.76	197.2760	197.2760	197.2760		1376.10	137.6100	137.6100	137.6100		725.61	72.561	72.561	72.5610
12378-PeCDF	0.05		1304.55	65.2275	65.2275	65.2275		792.08	39.6040	39.6040	39.6040		371.88	18.594	18.594	18.5940
23478-PeCDF	0.5		664.49	332.2450	332.2450	332.2450		470.51	235.2550	235.2550	235.2550		242.30	121.150	121.150	121.1500
123478-HxCDF	0.1		597.68	59.7680	59.7680	59.7680		391.52	39.1520	39.1520	39.1520		170.73	17.073	17.073	17.0730
123678-HxCDF	0.1		126.67	12.6670	12.6670	12.6670		106.53	10.6530	10.6530	10.6530		40.24	4.024	4.024	4.0240
234678-HxCDF	0.1		50.19	5.0190	5.0190	5.0190		33.47	3.3470	3.3470	3.3470		15.82	1.582	1.582	1.5820
123789-HxCDF	0.1		1.68	0.1680	0.1680	0.1680		1.52	0.1520	0.1520	0.1520	ND	1.00	0.100	0.050	0.0000
1234678-HpCDF	0.01		670.77	6.7077	6.7077	6.7077		287.08	2.8708	2.8708	2.8708		275.84	2.758	2.758	2.7584
1234789-HpCDF	0.01		53.22	0.5322	0.5322	0.5322		26.62	0.2662	0.2662	0.2662		23.43	0.234	0.234	0.2343
12346789-OCDF	0.001		434.54	0.4345	0.4345	0.4345		113.81	0.1138	0.1138	0.1138		300.27	0.300	0.300	0.3003
nondetects = detection limit			TEQ=	705.73				TEQ=	476.81				TEQ=	248.72		
nondetects = 1/2 d.l.			*teq=*		*705.73*			*teq=*		*476.25*			*teq=*		*247.86*	
nondetects = zero			teq=			705.73		teq=			475.69		teq=			247.01
Moisture content (%)			24.55					28.37					23.18			
Organic carbon (%)			0.45					0.82					0.44			
Total organic matter (%)			0.78					1.42					0.76			
Sample I.D.			C-10					C-11					C-12			
tetra-PCDF (TCDF)			1973					1376					726			
penta-PCDF (PeCDF)			1969					1263					614			
hexa-PCDF (HxCDF)			776					533					227			
hepta-PCDF (HpCDF)			724					314					299			
octa-PCDF (OCDF)			435					114					300			
tetra-PCDD (TCDD)			8				ND	1				ND	1			
penta-PCDD (PeCDD)			1.5					0.6				ND	1			
hexa-PCDD (HxCDD)			96.1					48.7					42.1			
hepta-PCDD (HpCDD)			294					65					218			
octa-PCDD (OCDD)			4383					854					2338			

Summary concentrations of the homolog gr
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				C-13					C-14					C-15		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		0.54	0.540	0.540	0.540		0.55	0.550	0.550	0.5500		2.40	2.400	2.400	2.4000
12378-PeCDD	0.5	ND	1.00	0.500	0.250	0.000		2.29	1.145	1.145	1.1450		1.44	0.720	0.720	0.7200
123478-HxCDD	0.1		21.87	2.187	2.187	2.187		32.09	3.209	3.209	3.2090		49.78	4.978	4.978	4.9780
123678-HxCDD	0.1		3.19	0.319	0.319	0.319		15.76	1.576	1.576	1.5760		18.47	1.847	1.847	1.8470
123789-HxCDD	0.1	ND	1.00	0.100	0.050	0.000	ND	1.00	0.100	0.050	0.0000		1.33	0.133	0.133	0.1330
1234678-HpCDD	0.01		116.71	1.167	1.167	1.167		277.48	2.775	2.775	2.7748		252.82	2.528	2.528	2.5282
12346789-OCDD	0.001		1293.06	1.293	1.293	1.293		3260.86	3.261	3.261	3.2609		3902.75	3.903	3.903	3.9028
2378TCDF	0.1		279.45	27.945	27.945	27.945		637.85	63.785	63.785	63.7850		2734.66	273.466	273.466	273.4660
12378-PeCDF	0.05		175.84	8.792	8.792	8.792		313.39	15.670	15.670	15.6695		1798.75	89.938	89.938	89.9375
23478-PeCDF	0.5		82.92	41.460	41.460	41.460		172.21	86.105	86.105	86.1050		961.52	480.760	480.760	480.7600
123478-HxCDF	0.1		94.83	9.483	9.483	9.483		148.70	14.870	14.870	14.8700		715.08	71.508	71.508	71.5080
123678-HxCDF	0.1		17.40	1.740	1.740	1.740		28.18	2.818	2.818	2.8180		155.24	15.524	15.524	15.5240
234678-HxCDF	0.1		7.58	0.758	0.758	0.758		13.99	1.399	1.399	1.3990		56.28	5.628	5.628	5.6280
123789-HxCDF	0.1		0.90	0.090	0.090	0.090		1.99	0.199	0.199	0.1990		19.94	1.994	1.994	1.9940
1234678-HpCDF	0.01		156.34	1.563	1.563	1.563		290.16	2.902	2.902	2.9016		538.14	5.381	5.381	5.3814
1234789-HpCDF	0.01		19.87	0.199	0.199	0.199		28.79	0.288	0.288	0.2879		55.97	0.560	0.560	0.5597
12346789-OCDF	0.001		254.60	0.255	0.255	0.255		434.54	0.435	0.435	0.4345		564.28	0.564	0.564	0.5643
nondetects = detection limit			TEQ=	98.39				TEQ=	201.09				TEQ=	961.83		
nondetects = 1/2 d.l.			*teq=*		*98.09*			*teq=*		*201.04*			*teq=*		*961.83*	
nondetects = zero			teq=			97.79		teq=			200.99		teq=			961.83
Moisture content (%)			29.29					30.35					29.66			
Organic carbon (%)			0.87					1.04					0.62			
Total organic matter (%)			1.5					1.79					1.07			
Sample I.D.			C-13					C-14					C-15			
tetra-PCDF (TCDF)			279					638					2735			
penta-PCDF (PeCDF)			259					486					2760			
hexa-PCDF (HxCDF)			121					193					947			
hepta-PCDF (HpCDF)			176					319					594			
octa-PCDF (OCDF)			255					435					564			
tetra-PCDD (TCDD)			0.5					0.5					2.4			
penta-PCDD (PeCDD)		ND	1					2.3					1.4			
hexa-PCDD (HxCDD)			25.1					48					70			
hepta-PCDD (HpCDD)			117					277					253			
octa-PCDD (OCDD)			1293					3261					3903			

Summary concentrations of the homolog gr
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				C-16					C-17					C-18		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1	ND	1.00	1.0000	0.5000	0.0000	ND	1.00	1.000	0.5000	0.0000	ND	1.00	1.000	0.5000	0.0000
12378-PeCDD	0.5		3.24	1.6200	1.6200	1.6200		1.28	0.640	0.6400	0.6400	ND	1.00	0.500	0.2500	0.0000
123478-HxCDD	0.1		2.42	0.2420	0.2420	0.2420	ND	1.50	0.150	0.0750	0.0000	ND	1.30	0.130	0.0650	0.0000
123678-HxCDD	0.1		14.60	1.4600	1.4600	1.4600	ND	1.50	0.150	0.0750	0.0000	ND	1.30	0.130	0.0650	0.0000
123789-HxCDD	0.1		3.43	0.3430	0.3430	0.3430		1.49	0.149	0.1490	0.1490	ND	1.30	0.130	0.0650	0.0000
1234678-HpCDD	0.01		499.92	4.9992	4.9992	4.9992		9.76	0.098	0.0976	0.0976		8.31	0.083	0.0831	0.0831
12346789-OCDD	0.001		7068.38	7.0684	7.0684	7.0684		104.60	0.105	0.1046	0.1046		83.25	0.083	0.0833	0.0833
2378TCDF	0.1		27.98	2.7980	2.7980	2.7980		4.38	0.438	0.4380	0.4380		3.11	0.311	0.3110	0.3110
12378-PeCDF	0.05		13.07	0.6535	0.6535	0.6535		3.39	0.170	0.1695	0.1695	ND	1.70	0.085	0.0425	0.0000
23478-PeCDF	0.5		5.82	2.9100	2.9100	2.9100		1.14	0.570	0.5700	0.5700	ND	1.70	0.850	0.4250	0.0000
123478-HxCDF	0.1		22.98	2.2980	2.2980	2.2980		1.41	0.141	0.1410	0.1410	ND	1.00	0.100	0.0500	0.0000
123678-HxCDF	0.1		5.54	0.5540	0.5540	0.5540	ND	1.30	0.130	0.0650	0.0000		13.20	1.320	1.3200	1.3200
234678-HxCDF	0.1	ND	1.30	0.1300	0.0650	0.0000	ND	1.00	0.100	0.0500	0.0000	ND	1.00	0.100	0.0500	0.0000
123789-HxCDF	0.1	ND	1.00	0.1000	0.0500	0.0000	ND	1.00	0.100	0.0500	0.0000	ND	1.00	0.100	0.0500	0.0000
1234678-HpCDF	0.01		263.91	2.6391	2.6391	2.6391		9.16	0.092	0.0916	0.0916		5.93	0.059	0.0593	0.0593
1234789-HpCDF	0.01		18.78	0.1878	0.1878	0.1878	ND	1.95	0.020	0.0098	0.0000	ND	2.65	0.027	0.0133	0.0000
12346789-OCDF	0.001		675.27	0.6753	0.6753	0.6753		7.55	0.008	0.0076	0.0076		4.93	0.005	0.0049	0.0049
nondetects = detection limit			TEQ=	29.68				TEQ=	4.06				TEQ=	5.01		
nondetects = 1/2 d.l.			*teq=*		*29.06*			*teq=*		*3.23*			*teq=*		*3.44*	
nondetects = zero			teq=			28.45		teq=			2.41		teq=			1.86
Moisture content (%)			30.26					28.54					30.65			
Organic carbon (%)			0.58					0.61					0.95			
Total organic matter (%)			1.00					1.05					1.65			
Sample I.D.			C-16					C-17					C-18			
tetra-PCDF (TCDF)			28					4.4					3.1			
penta-PCDF (PeCDF)			18.9					4.5					0			
hexa-PCDF (HxCDF)			28.5					1.4					13.2			
hepta-PCDF (HpCDF)			283					9.2					5.9			
octa-PCDF (OCDF)			675					7.5					4.9			
tetra-PCDD (TCDD)		ND	1				ND	1				ND	1			
penta-PCDD (PeCDD)			3.2					1.3				ND	1			
hexa-PCDD (HxCDD)			20.4					1.5				ND	1.3			
hepta-PCDD (HpCDD)			500					9.8					8.3			
octa-PCDD (OCDD)			7068					104.6					83.3			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				C-19					13					14		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1	ND	1.00	1.000	0.5000	0.0000		3.55	3.550	3.5500	3.5500		6.98	6.980	6.9800	6.9800
12378-PeCDD	0.5	ND	1.00	0.500	0.2500	0.0000		1.03	0.515	0.5150	0.5150	ND	1.00	0.500	0.2500	0.0000
123478-HxCDD	0.1	ND	1.00	0.100	0.0500	0.0500		50.84	5.084	5.0840	5.0840		69.79	6.979	6.9790	6.9790
123678-HxCDD	0.1		2.06	0.206	0.2060	0.2060		26.61	2.661	2.6610	2.6610		5.89	0.589	0.5890	0.5890
123789-HxCDD	0.1	ND	1.15	0.115	0.0575	0.0000	ND	1.40	0.140	0.0700	0.0000		1.69	0.169	0.1690	0.1690
1234678-HpCDD	0.01		15.98	0.160	0.1598	0.1598		1269.61	12.696	12.6961	12.6961		211.08	2.111	2.1108	2.1108
12346789-OCDD	0.001		121.31	0.121	0.1213	0.1213		18577.63	18.578	18.5776	18.5776		1909.95	1.910	1.9100	1.9100
2378TCDF	0.1		36.21	3.621	3.6210	3.6210		3024.20	302.420	302.4200	302.4200		2839.23	283.923	283.9230	283.9230
12378-PeCDF	0.05		31.34	1.567	1.5670	1.5670		1958.51	97.926	97.9255	97.9255		1362.21	68.111	68.1105	68.1105
23478-PeCDF	0.5		14.61	7.305	7.3050	7.3050		1156.55	578.275	578.2750	578.2750		862.09	431.045	431.0450	431.0450
123478-HxCDF	0.1		20.08	2.008	2.0080	2.0080		815.44	81.544	81.5440	81.5440		618.89	61.889	61.8890	61.8890
123678-HxCDF	0.1	ND	1.35	0.135	0.0675	0.0000		213.41	21.341	21.3410	21.3410		137.71	13.771	13.7710	13.7710
234678-HxCDF	0.1	ND	1.35	0.135	0.0675	0.0000		88.29	8.829	8.8290	8.8290		59.10	5.910	5.9100	5.9100
123789-HxCDF	0.1	ND	1.00	0.100	0.0500	0.0000	ND	1.36	0.136	0.0680	0.0000		7.51	0.751	0.7510	0.7510
1234678-HpCDF	0.01		12.22	0.122	0.1222	0.1222		909.54	9.095	9.0954	9.0954		525.50	5.255	5.2550	5.2550
1234789-HpCDF	0.01	ND	2.15	0.022	0.0108	0.0000		81.57	0.816	0.8157	0.8157		49.93	0.499	0.4993	0.4993
12346789-OCDF	0.001		9.02	0.009	0.0090	0.0090		2288.67	2.289	2.2887	2.2887		315.35	0.315	0.3154	0.3154
nondetects = detection limit			TEQ=	17.23				TEQ=	1145.89				TEQ=	890.71		
nondetects = 1/2 d.l.			*teq=*		*16.17*			*teq=*		*1145.76*			*teq=*		*890.46*	
nondetects = zero			teq=			15.17		teq=			1145.62		teq=			890.21
Moisture content (%)			29.12					27.54					24.33			
Organic carbon (%)			0.58					0.94					1.17			
Total organic matter (%)			1.00					1.63					2.01			
Sample I.D.			C-19					13					14			
tetra-PCDF (TCDF)			36.2					3024					2839			
penta-PCDF (PeCDF)			45.9					3115					2224			
hexa-PCDF (HxCDF)			20.1					1117					823			
hepta-PCDF (HpCDF)			12.2					991					575			
octa-PCDF (OCDF)			9					2289					315			
tetra-PCDD (TCDD)		ND	1					3.6					7			
penta-PCDD (PeCDD)		ND	1					1				ND	1			
hexa-PCDD (HxCDD)			2.1					77.4					77.4			
hepta-PCDD (HpCDD)			16					1270					211			
octa-PCDD (OCDD)			121					18578					1910			

Summary concentrations of the homolog gr
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)																
				15					16					23		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		2.33	2.330	2.3300	2.3300		2.53	2.530	2.5300	2.5300		15.54	15.540	15.5400	15.5400
12378-PeCDD	0.5		2.10	1.050	1.0500	1.0500	ND	1.00	0.500	0.2500	0.0000		12.38	6.190	6.1900	6.1900
123478-HxCDD	0.1		51.09	5.109	5.1090	5.1090		41.24	4.124	4.1240	4.1240		121.86	12.186	12.1860	12.1860
123678-HxCDD	0.1		28.82	2.882	2.8820	2.8820		3.77	0.377	0.3770	0.3770		52.62	5.262	5.2620	5.2620
123789-HxCDD	0.1		1.85	0.185	0.1850	0.0000		1.99	0.199	0.1990	0.1990		15.85	1.585	1.5850	1.5850
1234678-HpCDD	0.01		480.00	4.800	4.8000	4.8000		142.76	1.428	1.4276	1.4276		882.86	8.829	8.8286	8.8286
12346789-OCDD	0.001		3460.10	3.460	3.4601	3.4601		1306.73	1.307	1.3067	1.3067		9539.41	9.539	9.5394	9.5394
2378TCDF	0.1		2117.93	211.793	211.7930	211.7930		5673.44	567.344	567.3440	567.3440		691.92	69.192	69.1920	69.1920
12378-PeCDF	0.05		1531.82	76.591	76.5910	76.5910		2131.69	106.585	106.5845	106.5845		538.39	26.920	26.9195	26.9195
23478-PeCDF	0.5		886.75	443.375	443.3750	443.3750		1413.24	706.620	706.6200	706.6200		329.69	164.845	164.8450	164.8450
123478-HxCDF	0.1		950.83	95.083	95.0830	95.0830		1000.74	100.074	100.0740	100.0740		279.69	27.969	27.9690	27.9690
123678-HxCDF	0.1		209.74	20.974	20.9740	20.9740		204.43	20.443	20.4430	20.4430		48.34	4.834	4.8340	4.8340
234678-HxCDF	0.1		85.80	8.580	8.5800	8.5800		100.29	10.029	10.0290	10.0290		30.70	3.070	3.0700	3.0700
123789-HxCDF	0.1		1.70	0.170	0.1700	0.1700		2.03	0.203	0.2030	0.0000	ND	1.95	0.195	0.0975	0.0000
1234678-HpCDF	0.01		554.31	5.543	5.5431	5.5431		485.14	4.851	4.8514	4.8514		1236.97	12.370	12.3697	12.3697
1234789-HpCDF	0.01		60.62	0.606	0.6062	0.6062		61.23	0.612	0.6123	0.6123		77.28	0.773	0.7728	0.7728
12346789-OCDF	0.001		578.04	0.578	0.5780	0.5780		344.26	0.344	0.3443	0.3443		863.59	0.864	0.8636	0.8636
nondetects = detection limit			TEQ=	883.11				TEQ=	1527.57				TEQ=	370.16		
nondetects = 1/2 d.l.			*teq=*		*883.11*			*teq=*		*1527.32*			*teq=*		*370.06*	
nondetects = zero			teq=			882.92		teq=			1526.87		teq=			369.97
Moisture content (%)			23.15					27.22					59.75			
Organic carbon (%)			0.38					0.46					4.05			
Total organic matter (%)			0.66					0.8					6.98			
Sample I.D.			15					16					23			
tetra-PCDF (TCDF)			2118					5673.0					692			
penta-PCDF (PeCDF)			2419					3545.0					868			
hexa-PCDF (HxCDF)			1248					1307.0					359			
hepta-PCDF (HpCDF)			615					546.0					1314			
octa-PCDF (OCDF)			578					344.0					864			
tetra-PCDD (TCDD)			2.3					2.5					15.5			
penta-PCDD (PeCDD)			2.1				ND	1.0					12.4			
hexa-PCDD (HxCDD)			81.8					47.0					190			
hepta-PCDD (HpCDD)			480					143.0					883			
octa-PCDD (OCDD)			3460					1307.0					9539			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)																
				37					38					39		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		5.13	5.130	5.1300	5.1300	ND	1.00	1.000	0.5000	0.0000	ND	1.00	1.000	0.5000	0.0000
12378-PeCDD	0.5	ND	1.00	0.500	0.2500	0.0000	ND	1.00	0.500	0.2500	0.0000	ND	1.00	0.500	0.2500	0.0000
123478-HxCDD	0.1		90.60	9.060	9.0600	9.0600		13.22	1.322	1.3220	1.3220		8.46	0.846	0.8460	0.8460
123678-HxCDD	0.1		18.20	1.820	1.8200	1.8200		10.01	1.001	1.0010	1.0010		2.16	0.216	0.2160	0.2160
123789-HxCDD	0.1		2.71	0.271	0.2710	0.2710		10.35	1.035	1.0350	1.0350		1.30	0.130	0.1300	0.1300
1234678-HpCDD	0.01		168.61	1.686	1.6861	1.6861		91.38	0.914	0.9138	0.9138		47.13	0.471	0.4713	0.4713
12346789-OCDD	0.001		2017.35	2.017	2.0174	2.0174		563.92	0.564	0.5639	0.5639		377.90	0.378	0.3779	0.3779
2378TCDF	0.1		2327.82	232.782	232.7820	232.7820		559.37	55.937	55.9370	55.9370		281.15	28.115	28.1150	28.1150
12378-PeCDF	0.05		1781.65	89.083	89.0825	89.0825		493.93	24.697	24.6965	24.6965		314.81	15.741	15.7405	15.7405
23478-PeCDF	0.5		1043.81	521.905	521.9050	521.9050		273.21	136.605	136.6050	136.6050		135.13	67.565	67.5650	67.5650
123478-HxCDF	0.1		1046.97	104.697	104.6970	104.6970		233.31	23.331	23.3310	23.3310		151.64	15.164	15.1640	15.1640
123678-HxCDF	0.1		247.59	24.759	24.7590	24.7590		46.51	4.651	4.6510	4.6510		29.45	2.945	2.9450	2.9450
234678-HxCDF	0.1		105.88	10.588	10.5880	10.5880		16.51	1.651	1.6510	1.6510		12.39	1.239	1.2390	1.2390
123789-HxCDF	0.1	ND	1.72	0.172	0.0860	0.0000	ND	1.95	0.195	0.0975	0.0000	ND	1.00	0.100	0.0500	0.0000
1234678-HpCDF	0.01		581.90	5.819	5.8190	5.8190		121.12	1.211	1.2112	1.2112		87.65	0.877	0.8765	0.8765
1234789-HpCDF	0.01		163.43	1.634	1.6343	1.6343		23.47	0.235	0.2347	0.2347		11.83	0.118	0.1183	0.1183
12346789-OCDF	0.001		188.70	0.189	0.1887	0.1887		71.01	0.071	0.0710	0.0710		42.99	0.043	0.0430	0.0430
nondetects = detection limit			TEQ=	1012.11				TEQ=	254.92				TEQ=	135.45		
nondetects = 1/2 d.l.			*teq=*		*1011.78*			*teq=*		*254.07*			*teq=*		*134.65*	
nondetects = zero			teq=			1011.44		teq=			253.22		teq=			133.85
Moisture content (%)			35.03					23.82					20.63			
Organic carbon (%)			1.63					0.29					0.11			
Total organic matter (%)			2.81					0.51					0.19			
Sample I.D.			37					38					39			
tetra-PCDF (TCDF)			2328.0					559.0					281.0			
penta-PCDF (PeCDF)			2825.0					767.0					450.0			
hexa-PCDF (HxCDF)			1400.0					296.0					193.0			
hepta-PCDF (HpCDF)			745.0					145.0					99.5			
octa-PCDF (OCDF)			189.0					71.0					43.0			
tetra-PCDD (TCDD)			5.1				ND	1.0				ND	1.0			
penta-PCDD (PeCDD)		ND	1.0				ND	1.0				ND	1.0			
hexa-PCDD (HxCDD)			112.0					33.6					11.9			
hepta-PCDD (HpCDD)			169.0					91.4					47.1			
octa-PCDD (OCDD)			2017.0					563.9					377.9			
Summary concentrations of the homolog gı																
Concentrations of all compound (except of																
Recalculation for internal standards accoun																
* OCDF concentrations were calculated ba:																
if required, OCDF concentrations can be n																
ND = non detected, the detection limits wil																

TABLE 9
Part 2

Part 2 (continued)																
				52					53					54		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1	ND	1.10	1.100	0.5500	0.0000		20.37	20.370	20.3700	20.3700	ND	1.10	1.100	0.5500	0.0000
12378-PeCDD	0.5	ND	1.00	0.500	0.2500	0.0000	ND	1.00	0.500	0.2500	0.0000		0.89	0.445	0.4450	0.4450
123478-HxCDD	0.1		13.58	1.358	1.3580	1.3580		29.87	2.987	2.9870	2.9870		40.51	4.051	4.0510	4.0510
123678-HxCDD	0.1		1.39	0.139	0.1390	0.1390		7.42	0.742	0.7420	0.7420		10.37	1.037	1.0370	1.0370
123789-HxCDD	0.1	ND	1.30	0.130	0.0650	0.0000	ND	1.70	0.170	0.0850	0.0000		3.08	0.308	0.3080	0.3080
1234678-HpCDD	0.01		26.23	0.262	0.2623	0.2623		126.69	1.267	1.2669	1.2669		139.40	1.394	1.3940	1.3940
12346789-OCDD	0.001		288.55	0.289	0.2886	0.2886		1354.62	1.355	1.3546	1.3546		1375.84	1.376	1.3758	1.3758
2378TCDF	0.1		61.80	6.180	6.1800	6.1800		1880.57	188.057	188.0570	188.0570		1060.58	106.058	106.0580	106.0580
12378-PeCDF	0.05		32.71	1.636	1.6355	1.6355		1395.81	69.791	69.7905	69.7905		298.69	14.935	14.9345	14.9345
23478-PeCDF	0.5		17.49	8.745	8.7450	8.7450		991.73	495.865	495.8650	495.8650		223.09	111.545	111.5450	111.5450
123478-HxCDF	0.1		12.97	1.297	1.2970	1.2970		595.09	59.509	59.5090	59.5090		122.99	12.299	12.2990	12.2990
123678-HxCDF	0.1		3.80	0.380	0.3800	0.3800		143.57	14.357	14.3570	14.3570		28.36	2.836	2.8360	2.8360
234678-HxCDF	0.1	ND	1.00	0.100	0.0500	0.0000		92.61	9.261	9.2610	9.2610		15.16	1.516	1.5160	1.5160
123789-HxCDF	0.1	ND	1.00	0.100	0.0500	0.0000		7.06	0.706	0.7060	0.7060	ND	1.00	0.100	0.0500	0.0000
1234678-HpCDF	0.01		33.05	0.331	0.3305	0.3305		281.26	2.813	2.8126	2.8126		279.48	2.795	2.7948	2.7948
1234789-HpCDF	0.01		4.35	0.044	0.0435	0.0435		43.24	0.432	0.4324	0.4324		19.21	0.192	0.1921	0.1921
12346789-OCDF	0.001		21.94	0.022	0.0219	0.0219		201.11	0.201	0.2011	0.2011		238.67	0.239	0.2387	0.2387
nondetects = detection limit			TEQ=	22.61				TEQ=	868.38				TEQ=	262.22		
nondetects = 1/2 d.l.			*teq=*		*21.65*			*teq=*		*868.05*			*teq=*		*261.62*	
nondetects = zero			teq=			20.68		teq=			867.71		teq=			261.02
Moisture content (%)			21.77					27.84					22.02			
Organic carbon (%)			0.31					0.52					0.29			
Total organic matter (%)			0.54					0.89					0.49			
Sample I.D.			52					53					54			
tetra-PCDF (TCDF)			61.8					1881					1061			
penta-PCDF (PeCDF)			50.2					2388					522			
hexa-PCDF (HxCDF)			16.8					838					167			
hepta-PCDF (HpCDF)			37.4					325					299			
octa-PCDF (OCDF)			21.9					201					239			
tetra-PCDD (TCDD)		ND	1.1					20.4				ND	1.1			
penta-PCDD (PeCDD)		ND	1.0				ND	1.00					0.9			
hexa-PCDD (HxCDD)			15.0					37.3					54			
hepta-PCDD (HpCDD)			26.2					127					139			
octa-PCDD (OCDD)			288.6					1355					1376			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				55					59					60		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		4.34	4.340	4.3400	4.3400	ND	1.00	1.000	0.5000	0.0000	ND	1.10	1.100	0.5500	0.0000
12378-PeCDD	0.5		2.18	1.090	1.0900	1.0900	ND	1.00	0.500	0.2500	0.0000	ND	1.20	0.600	0.3000	0.0000
123478-HxCDD	0.1		155.02	15.502	15.5020	15.5020	ND	1.30	0.130	0.0650	0.0000	ND	1.30	0.130	0.0650	0.0000
123678-HxCDD	0.1		40.51	4.051	4.0510	4.0510	ND	1.30	0.130	0.0650	0.0000	ND	1.30	0.130	0.0650	0.0000
123789-HxCDD	0.1		1.44	0.144	0.1440	0.1440	ND	1.30	0.130	0.0650	0.0000	ND	1.30	0.130	0.0650	0.0000
1234678-HpCDD	0.01		531.96	5.320	5.3196	5.3196		17.41	0.174	0.1741	0.1741		8.40	0.084	0.0840	0.0840
12346789-OCDD	0.001		6670.02	6.670	6.6700	6.6700		142.08	0.142	0.1421	0.1421		63.71	0.064	0.0637	0.0637
2378TCDF	0.1		5518.05	551.805	551.8050	551.8050		6.52	0.652	0.6520	0.6520		8.23	0.823	0.8230	0.8230
12378-PeCDF	0.05		3949.58	197.479	197.4790	197.4790		4.53	0.227	0.2265	0.2265		6.13	0.307	0.3065	0.3065
23478-PeCDF	0.5		2029.73	1014.865	1014.8650	1014.8650	ND	1.40	0.700	0.3500	0.0000		1.78	0.890	0.8900	0.8900
123478-HxCDF	0.1		2035.24	203.524	203.5240	203.5240		2.12	0.212	0.2120	0.2120		3.75	0.375	0.3750	0.3750
123678-HxCDF	0.1		376.46	37.646	37.6460	37.6460	ND	1.45	0.145	0.0725	0.0000	ND	1.60	0.160	0.0800	0.0000
234678-HxCDF	0.1		148.05	14.805	14.8050	14.8050	ND	1.00	0.100	0.0500	0.0000	ND	1.60	0.160	0.0800	0.0000
123789-HxCDF	0.1		25.80	2.580	2.5800	2.5800	ND	1.00	0.100	0.0500	0.0000	ND	2.00	0.200	0.1000	0.0000
1234678-HpCDF	0.01		1359.68	13.597	13.5968	13.5968		7.53	0.075	0.0753	0.0753		5.08	0.051	0.0508	0.0508
1234789-HpCDF	0.01		139.72	1.397	1.3972	1.3972	ND	1.00	0.010	0.0050	0.0000	ND	2.50	0.025	0.0125	0.0000
12346789-OCDF	0.001		1522.50	1.523	1.5225	1.5225		6.10	0.006	0.0061	0.0061		5.62	0.006	0.0056	0.0056
nondetects = detection limit			TEQ=	2076.34				TEQ=	4.43				TEQ=	5.23		
nondetects = 1/2 d.l.			*teq=*		*2076.34*			*teq=*		*2.96*			*teq=*		*3.92*	
nondetects = zero			teq=			2076.34		teq=			1.49		teq=			2.60
Moisture content (%)			32.94					26.34					21.01			
Organic carbon (%)			0.49					0.23					0.6			
Total organic matter (%)			0.85					0.4					1.04			
Sample I.D.			55					59					60			
tetra-PCDF (TCDF)			5518					6.5					8.2			
penta-PCDF (PeCDF)			5979					4.5					7.9			
hexa-PCDF (HxCDF)			2586					2.1					3.8			
hepta-PCDF (HpCDF)			1499					7.5					5.1			
octa-PCDF (OCDF)			1523					6.1					5.6			
tetra-PCDD (TCDD)			4.3				ND	1.0				ND	1.1			
penta-PCDD (PeCDD)			2.2				ND	1.0				ND	1.2			
hexa-PCDD (HxCDD)			197				ND	1.3				ND	1.3			
hepta-PCDD (HpCDD)			532					17.4					8.4			
octa-PCDD (OCDD)			6670					142.2					63.7			

Summary concentrations of the homolog gr
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				SS-1					SS-2					SS-3		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		15.31	15.310	15.3100	15.3100		33.38	33.380	33.3800	33.3800		1.52	1.520	1.5200	1.5200
12378-PeCDD	0.5		11.89	5.945	5.9450	5.9450		17.97	8.985	8.9850	8.9850	ND	1.00	0.500	0.2500	0.0000
123478-HxCDD	0.1		99.18	9.918	9.9180	9.9180		208.10	20.810	20.8100	20.8100	ND	1.30	0.130	0.0650	0.0000
123678-HxCDD	0.1		58.69	5.869	5.8690	5.8690		105.33	10.533	10.5330	10.5330	ND	1.30	0.130	0.0650	0.0000
123789-HxCDD	0.1		23.36	2.336	2.3360	2.3360		31.82	3.182	3.1820	3.1820	ND	1.30	0.130	0.0650	0.0000
1234678-HpCDD	0.01		1016.20	10.162	10.1620	10.1620		2735.37	27.354	27.3537	27.3537		36.32	0.363	0.3632	0.3632
12346789-OCDD	0.001		11122.56	11.123	11.1226	11.1226		26560.18	26.560	26.5602	26.5602		369.60	0.370	0.3696	0.3696
2378TCDF	0.1		950.14	95.014	95.0140	95.0140		2443.05	244.305	244.3050	244.3050		13.64	1.364	1.3640	1.3640
12378-PeCDF	0.05		584.12	29.206	29.2060	29.2060		1430.97	71.549	71.5485	71.5485		9.07	0.454	0.4535	0.4535
23478-PeCDF	0.5		356.00	178.000	178.0000	178.0000		888.76	444.380	444.3800	444.3800		6.94	3.470	3.4700	3.4700
123478-HxCDF	0.1		482.45	48.245	48.2450	48.2450		1059.99	105.999	105.9990	105.9990		6.06	0.606	0.6060	0.6060
123678-HxCDF	0.1		73.48	7.348	7.3480	7.3480		186.34	18.634	18.6340	18.6340		1.29	0.129	0.1290	0.1290
234678-HxCDF	0.1		51.16	5.116	5.1160	5.1160		97.83	9.783	9.7830	9.7830	ND	1.00	0.100	0.0500	0.0000
123789-HxCDF	0.1		3.95	0.395	0.3950	0.3950		2.69	0.269	0.2690	0.2690	ND	1.00	0.100	0.0500	0.0000
1234678-HpCDF	0.01		1973.82	19.738	19.7382	19.7382		4060.38	40.604	40.6038	40.6038		15.66	0.157	0.1566	0.1566
1234789-HpCDF	0.01		76.70	0.767	0.7670	0.7670		204.74	2.047	2.0474	2.0474	ND	1.90	0.019	0.0095	0.0000
12346789-OCDF	0.001		2066.98	2.067	2.0670	2.0670		6795.69	6.796	6.7957	6.7957		11.90	0.012	0.0119	0.0119
nondetects = detection limit			TEQ=	446.56				TEQ=	1075.17				TEQ=	9.55		
nondetects = 1/2 d.l.			*teq=*		*446.56*			*teq=*		*1075.17*			*teq=*		*9.00*	
nondetects = zero			teq=			446.56		teq=			1075.17		teq=			8.44
Moisture content (%)			41.17					30.88					28.32			
Organic carbon (%)			6.46					5.06					4.00			
Total organic matter (%)			11.14					8.72					6.89			
Sample I.D.			SS-1					SS-2					SS-3			
tetra-PCDF (TCDF)			950					2443					13.6			
penta-PCDF (PeCDF)			940					2320					16			
hexa-PCDF (HxCDF)			611					1347					7.3			
hepta-PCDF (HpCDF)			2051					4265					15.7			
octa-PCDF (OCDF)			2067					6796					11.9			
tetra-PCDD (TCDD)			15.3					33.4					1.5			
penta-PCDD (PeCDD)			11.9					18				ND	1.0			
hexa-PCDD (HxCDD)			181					345				ND	1.3			
hepta-PCDD (HpCDD)			1016					2735					36.3			
octa-PCDD (OCDD)			11123					26560					369.6			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				SS-4					SS-5					SS-6		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		1.55	1.550	1.5500	1.5500		40.99	40.990	40.9900	40.9900		2.25	2.250	2.2500	2.2500
12378-PeCDD	0.5	ND	1.00	0.500	0.2500	0.0000		27.75	13.875	13.8750	13.8750		1.21	0.605	0.6050	0.6050
123478-HxCDD	0.1	ND	1.00	0.100	0.0500	0.0000		287.88	28.788	28.7880	28.7880		10.11	1.011	1.0110	1.0110
123678-HxCDD	0.1		2.09	0.209	0.2090	0.2090		142.84	14.284	14.2840	14.2840		22.40	2.240	2.2400	2.2400
123789-HxCDD	0.1	ND	1.50	0.150	0.0750	0.0000		53.02	5.302	5.3020	5.3020		5.82	0.582	0.5820	0.5820
1234678-HpCDD	0.01		61.29	0.613	0.6129	0.6129		2998.75	29.988	29.9875	29.9875		221.05	2.211	2.2105	2.2105
12346789-OCDD	0.001		380.13	0.380	0.3801	0.3801		34835.28	34.835	34.8353	34.8353		2462.16	2.462	2.4622	2.4622
2378TCDF	0.1		1.52	0.152	0.1520	0.1520		1315.76	131.576	131.5760	131.5760		831.82	83.182	83.1820	83.1820
12378-PeCDF	0.05		1.44	0.072	0.0720	0.0720		699.72	34.986	34.9860	34.9860		429.69	21.485	21.4845	21.4845
23478-PeCDF	0.5	ND	1.00	0.500	0.2500	0.0000		456.51	228.255	228.2550	228.2550		294.11	147.055	147.0550	147.0550
123478-HxCDF	0.1		7.49	0.749	0.7490	0.7490		619.14	61.914	61.9140	61.9140		216.36	21.636	21.6360	21.6360
123678-HxCDF	0.1	ND	1.00	0.100	0.0500	0.0000		115.82	11.582	11.5820	11.5820		45.67	4.567	4.5670	4.5670
234678-HxCDF	0.1	ND	1.00	0.100	0.0500	0.0000		68.36	6.836	6.8360	6.8360		27.18	2.718	2.7180	2.7180
123789-HxCDF	0.1	ND	1.00	0.100	0.0500	0.0000		1.70	0.170	0.1700	0.1700	ND	1.40	0.140	0.0700	0.0000
1234678-HpCDF	0.01		38.05	0.381	0.3805	0.3805		4131.74	41.317	41.3174	41.3174		297.60	2.976	2.9760	2.9760
1234789-HpCDF	0.01	ND	2.25	0.023	0.0113	0.0000		243.70	2.437	2.4370	2.4370		21.94	0.219	0.2194	0.2194
12346789-OCDF	0.001		18.83	0.019	0.0188	0.0188		7565.38	7.565	7.5654	7.5654		227.08	0.227	0.2271	0.2271
nondetects = detection limit			TEQ=	5.70				TEQ=	694.70				TEQ=	295.57		
nondetects = 1/2 d.l.			*teq=*		*4.91*			*teq=*		*694.70*			*teq=*		*295.50*	
nondetects = zero			teq=			4.12		teq=			694.70		teq=			295.43
Moisture content (%)			29.84					21.51					16.46			
Organic carbon (%)			4.36					2.38					1.30			
Total organic matter (%)			7.52					4.10					2.24			
Sample I.D.			SS-4					SS-5					SS-6			
tetra-PCDF (TCDF)			1.5					1316					832			
penta-PCDF (PeCDF)			1.4					1156					724			
hexa-PCDF (HxCDF)			7.5					805					289			
hepta-PCDF (HpCDF)			38.0					4375					320			
octa-PCDF (OCDF)			18.8					7565					227			
tetra-PCDD (TCDD)			1.5					41					2.2			
penta-PCDD (PeCDD)		ND	1.0					27.8					1.2			
hexa-PCDD (HxCDD)			2.1					484					38.3			
hepta-PCDD (HpCDD)			61.3					2999					221			
octa-PCDD (OCDD)			380.1					34835					2462			

Summary concentrations of the homolog gı
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)

				SS-7					SS-7r					SS-8		
Analyte	TEF		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero		sampled pg/g	toxic eq. pg/g	*nondetect 1/2 d.l.*	nondetect zero
2378-TCDD	1		5.71	5.710	5.7100	5.7100		7.80	7.800	7.8000	7.8000		4.25	4.250	4.2500	4.2500
12378-PeCDD	0.5		5.08	2.540	2.5400	2.5400		4.17	2.085	2.0850	2.0850		3.71	1.855	1.8550	1.8550
123478-HxCDD	0.1		77.78	7.778	7.7780	7.7780		86.94	8.694	8.6940	8.6940		51.30	5.130	5.1300	5.1300
123678-HxCDD	0.1		85.83	8.583	8.5830	8.5830		68.48	6.848	6.8480	6.8480		19.15	1.915	1.9150	1.9150
123789-HxCDD	0.1		39.06	3.906	3.9060	3.9060		20.32	2.032	2.0320	2.0320		4.93	0.493	0.4930	0.4930
1234678-HpCDD	0.01		1209.01	12.090	12.0901	12.0901		917.28	9.173	9.1728	9.1728		422.36	4.224	4.2236	4.2236
12346789-OCDD	0.001		9453.71	9.454	9.4537	9.4537		11577.69	11.578	11.5777	11.5777		3765.17	3.765	3.7652	3.7652
2378TCDF	0.1		3920.61	392.061	392.0610	392.0610		3274.44	327.444	327.4440	327.4440		2637.92	263.792	263.7920	263.7920
12378-PeCDF	0.05		1917.22	95.861	95.8610	95.8610		1997.95	99.898	99.8975	99.8975		1579.22	78.961	78.9610	78.9610
23478-PeCDF	0.5		1137.82	568.910	568.9100	568.9100		1214.53	607.265	607.2650	607.2650		888.32	444.160	444.1600	444.1600
123478-HxCDF	0.1		1042.46	104.246	104.2460	104.2460		1068.01	106.801	106.8010	106.8010		865.35	86.535	86.5350	86.5350
123678-HxCDF	0.1		254.61	25.461	25.4610	25.4610		197.43	19.743	19.7430	19.7430		150.76	15.076	15.0760	15.0760
234678-HxCDF	0.1		106.63	10.663	10.6630	10.6630		83.06	8.306	8.3060	8.3060		59.84	5.984	5.9840	5.9840
123789-HxCDF	0.1		3.94	0.394	0.3940	0.3940		3.07	0.307	0.3070	0.3070		4.08	0.408	0.4080	0.4080
1234678-HpCDF	0.01		1131.51	11.315	11.3151	11.3151		1251.47	12.515	12.5147	12.5147		727.99	7.280	7.2799	7.2799
1234789-HpCDF	0.01		129.21	1.292	1.2921	1.2921		112.18	1.122	1.1218	1.1218		153.80	1.538	1.5380	1.5380
12346789-OCDF	0.001		859.23	0.859	0.8592	0.8592		2231.17	2.231	2.2312	2.2312		1364.57	1.365	1.3646	1.3646
nondetects = detection limit			TEQ=	1261.12				TEQ=	1233.84				TEQ=	926.73		
nondetects = 1/2 d.l.			*teq=*		*1261.12*			*teq=*		*1233.84*			*teq=*		*926.73*	
nondetects = zero			teq=			1261.12		teq=			1233.84		teq=			926.73
Moisture content (%)			24.18					24.11					24.07			
Organic carbon (%)			3.38					3.21					1.19			
Total organic matter (%)			5.82					5.54					2.05			
Sample I.D.			SS-7					SS-7r					SS-8			
tetra-PCDF (TCDF)			3921					3274					2638			
penta-PCDF (PeCDF)			3055					3212					2468			
hexa-PCDF (HxCDF)			1408					1352					1080			
hepta-PCDF (HpCDF)			1261					1364					882			
octa-PCDF (OCDF)			859					2231					1365			
tetra-PCDD (TCDD)			5.7					7.8					4.2			
penta-PCDD (PeCDD)			5.1					4.2					3.7			
hexa-PCDD (HxCDD)			203					176					75.4			
hepta-PCDD (HpCDD)			1209					917					422			
octa-PCDD (OCDD)			9454					11578					3765			

Summary concentrations of the homolog gr
Concentrations of all compound (except of
Recalculation for internal standards accoun
* OCDF concentrations were calculated ba
if required, OCDF concentrations can be n
ND = non detected, the detection limits wil

TABLE 9
Part 2

Part 2 (continued)											
				SS-9					SS-10		
Analyte	TEF		sampled	toxic eq.	*nondetect*	nondetect		sampled	toxic eq.	*nondetect*	nondetect
			pg/g	pg/g	*1/2 d.l.*	zero		pg/g	pg/g	*1/2 d.l.*	zero
2378-TCDD	1		4.58	4.580	4.5800	4.5800	ND	1.00	1.000	0.5000	0.0000
12378-PeCDD	0.5		4.39	2.195	2.1950	2.1950		0.72	0.360	0.3600	0.3600
123478-HxCDD	0.1		71.64	7.164	7.1640	7.1640	ND	1.20	0.120	0.0600	0.0000
123678-HxCDD	0.1		33.44	3.344	3.3440	3.3440		1.50	0.150	0.1500	0.1500
123789-HxCDD	0.1		7.17	0.717	0.7170	0.7170		1.37	0.137	0.1370	0.1370
1234678-HpCDD	0.01		574.20	5.742	5.7420	5.7420		11.73	0.117	0.1173	0.1173
12346789-OCDD	0.001		6320.70	6.321	6.3207	6.3207		103.53	0.104	0.1035	0.1035
2378TCDF	0.1		3406.24	340.624	340.6240	340.6240		1.00	0.100	0.1000	0.1000
12378-PeCDF	0.05		3084.30	154.215	154.2150	154.2150		1.21	0.061	0.0605	0.0605
23478-PeCDF	0.5		1460.63	730.315	730.3150	730.3150		1.13	0.565	0.5650	0.5650
123478-HxCDF	0.1		1749.01	174.901	174.9010	174.9010	ND	1.00	0.100	0.0500	0.0000
123678-HxCDF	0.1		318.54	31.854	31.8540	31.8540	ND	1.00	0.100	0.0500	0.0000
234678-HxCDF	0.1		116.26	11.626	11.6260	11.6260	ND	1.00	0.100	0.0500	0.0000
123789-HxCDF	0.1		13.30	1.330	1.3300	1.3300	ND	1.00	0.100	0.0500	0.0000
1234678-HpCDF	0.01		1243.62	12.436	12.4362	12.4362		3.91	0.039	0.0391	0.0391
1234789-HpCDF	0.01		125.09	1.251	1.2509	1.2509	ND	2.00	0.020	0.0100	0.0000
12346789-OCDF	0.001		1782.44	1.782	1.7824	1.7824	ND	3.40	0.003	0.0034	0.0000
nondetects = detection limit			TEQ=	1490.40				TEQ=	3.18		
nondetects = 1/2 d.l.			*teq=*		*1490.40*			*teq=*		*2.41*	
nondetects = zero			teq=			1490.40		teq=			1.63
Moisture content (%)			18.58					25.38			
Organic carbon (%)			2.24					3.56			
Total organic matter (%)			3.85					6.14			
Sample I.D.			SS-9					SS-10			
tetra-PCDF (TCDF)			3406					1.0			
penta-PCDF (PeCDF)			4545					2.3			
hexa-PCDF (HxCDF)			2197				ND	1.0			
hepta-PCDF (HpCDF)			1369					3.9			
octa-PCDF (OCDF)			1782				ND	3.4			
tetra-PCDD (TCDD)			4.6				ND	1.0			
penta-PCDD (PeCDD)			4.4					0.7			
hexa-PCDD (HxCDD)			112					2.9			
hepta-PCDD (HpCDD)			574					11.7			
octa-PCDD (OCDD)			6321					104.0			
Summary concentrations of the homolog gı											
Concentrations of all compound (except of											
Recalculation for internal standards accoun											
* OCDF concentrations were calculated ba:											
if required, OCDF concentrations can be n											
ND = non detected, the detection limits wil											

TABLE 9
Part 3

DATA FLAGS

In order to assist with data interpretation, data qualifier flags are used on the final reports. The most commonly used flags are:

ND = analyte not detected. Value is the detection limit.

B = analyte has been detected in the laboratory method blank as well as in an associated field sample.

E = indicates a concentration based on an analyte to internal standard ratio which exceeds the range of the calibration curve. Values which are outside the calibration curve are estimates only.

I = indicates labeled standards have been interfered with on the GC column by coeluting, interferent peaks.

J = indicates a concentration based on an analyte to internal standard ration which is below the calibration curve. Values outside the calibration curve are estimates only.

PR = indicates that a GC peak is poorly resolved. The concentrations or amounts reported for such peaks are most likely overestimated.

Q = indicates the presence of QC ion instabilities caused by quantitative interferences.

S = indicates that the response of a specific PCDD/PCDF isomer has exceeded the normal dynamic range of the mass spectrometer detection system. The corresponding signal is saturated and the reported analyte concentration is a 'minimum estimate'. Results for saturated analytes are reported as greater than the upper calibration limit.

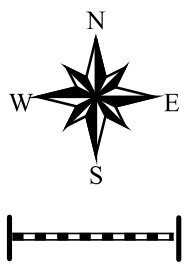
U = indicates that a specific isomer cannot be resolved from a large, coleluting interferent GC peak. The specific isomer is reported as not detected as a valid concentration cannot be determined. The calculated detection limit, therefore, should be considered an underestimated value.

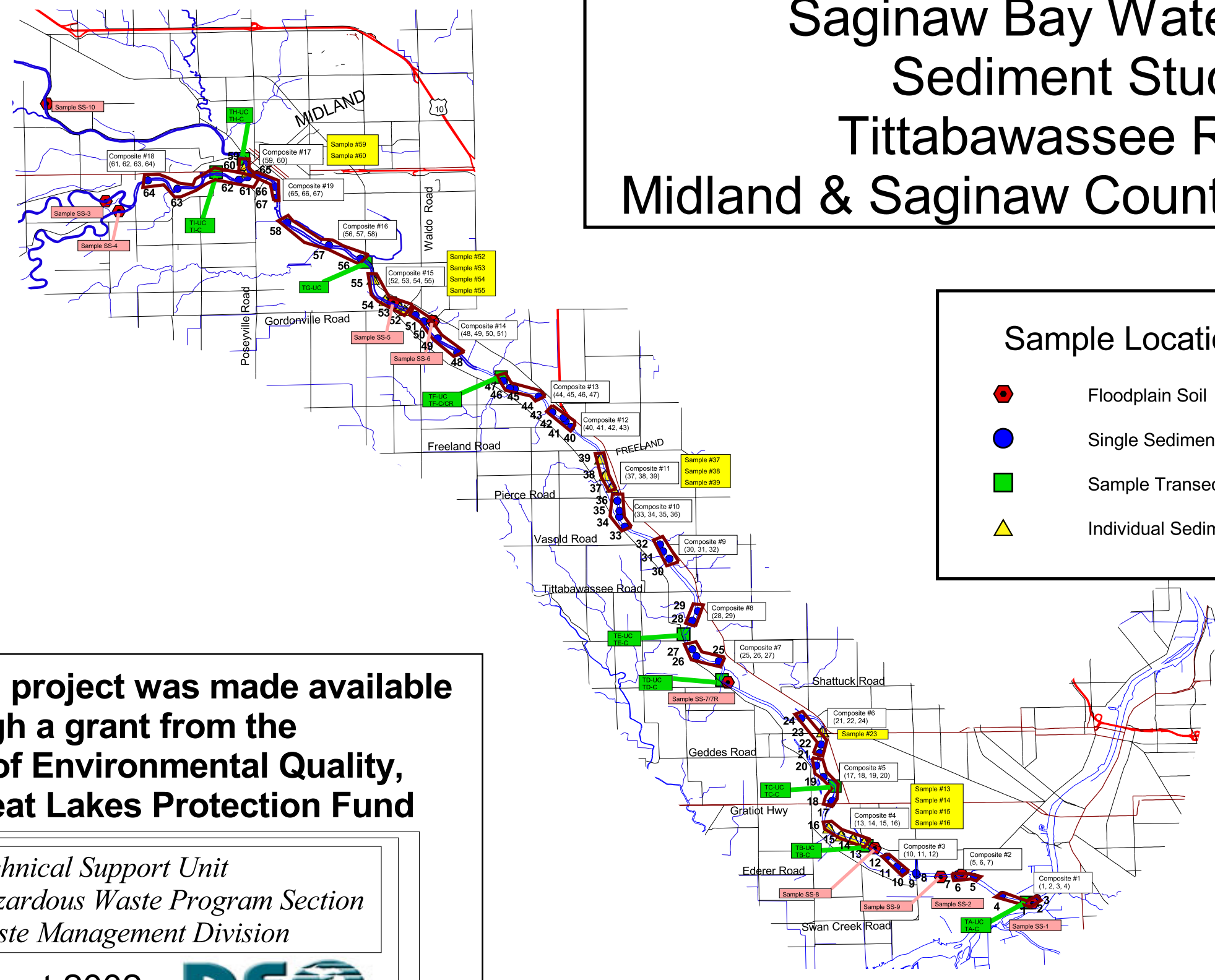
V = indicates that, although the percent recovery of a labeled standard may be below a specific QC limit, the signal-to-noise ratio of the peak is greater than ten-to-one. The standard is considered reliably quantifiable. All quantitations derived from the standard are considered valid as well.

X = indicates that a polychlorodibenzofuran (PCDF) peak has eluted at the same time as the associated diphenyl ether (DPE) and that the DPE peak intensity is at least ten percent of the total PCDF peak intensity. Total PCDF values are flagged "X" if the total DPE contribution to the total PCDF value is greater than ten percent.

FIGURES

Saginaw Bay Watershed
Sediment Study
Tittabawassee River
Midland & Saginaw Counties, Michigan





Sample Locations

- Floodplain Soil
- Single Sediment Samples
- Sample Transects of River
- Individual Sediment Samples

Funding for this project was made available through a grant from the Department of Environmental Quality, Michigan Great Lakes Protection Fund

WMD

Technical Support Unit
Hazardous Waste Program Section
Waste Management Division

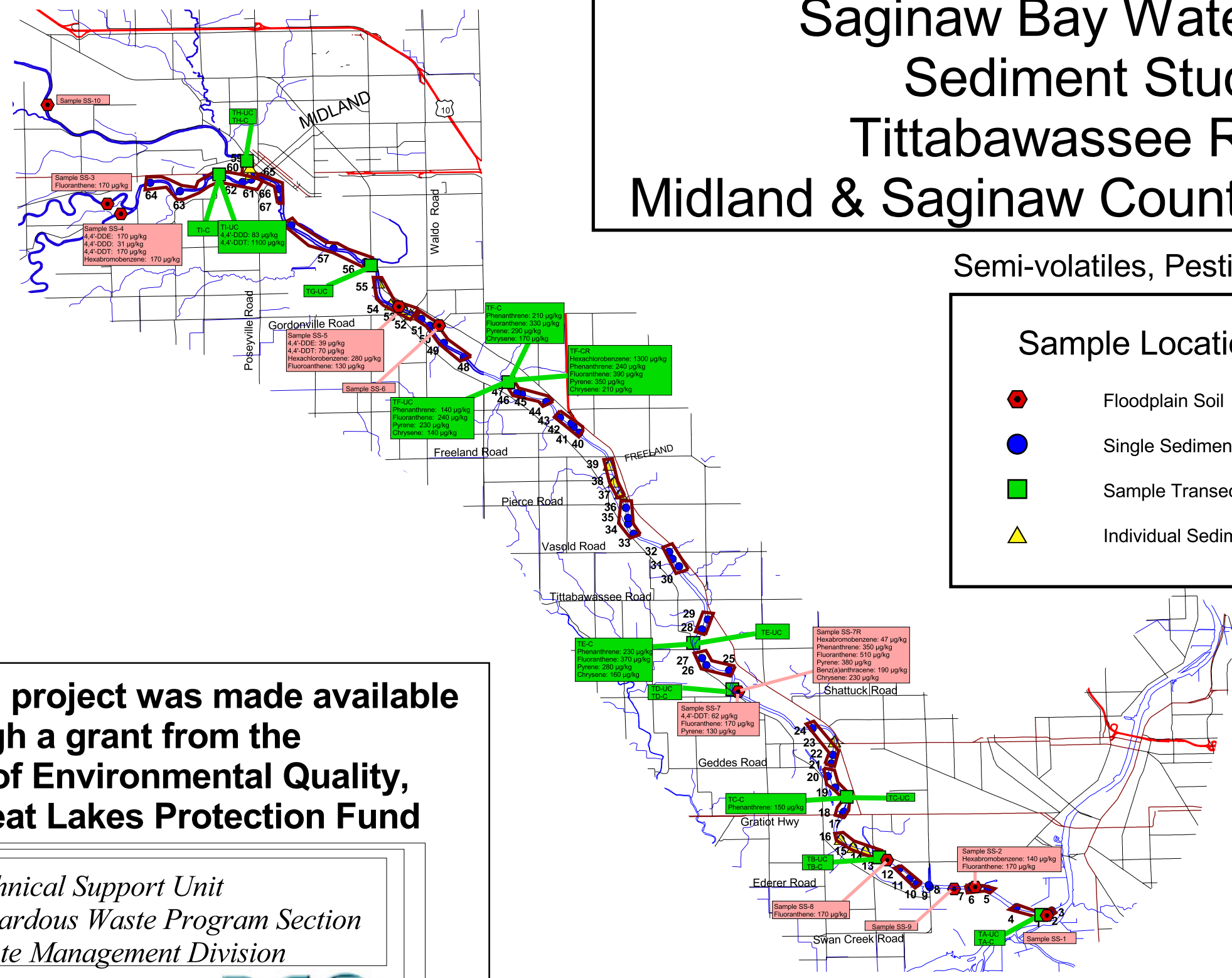
August 2002

DEQ

Figure 3

Saginaw Bay Watershed
Sediment Study
Tittabawassee River
Midland & Saginaw Counties, Michigan

Semi-volatiles, Pesticides and PCBs



Funding for this project was made available through a grant from the Department of Environmental Quality, Michigan Great Lakes Protection Fund

WMD

Technical Support Unit
Hazardous Waste Program Section
Waste Management Division

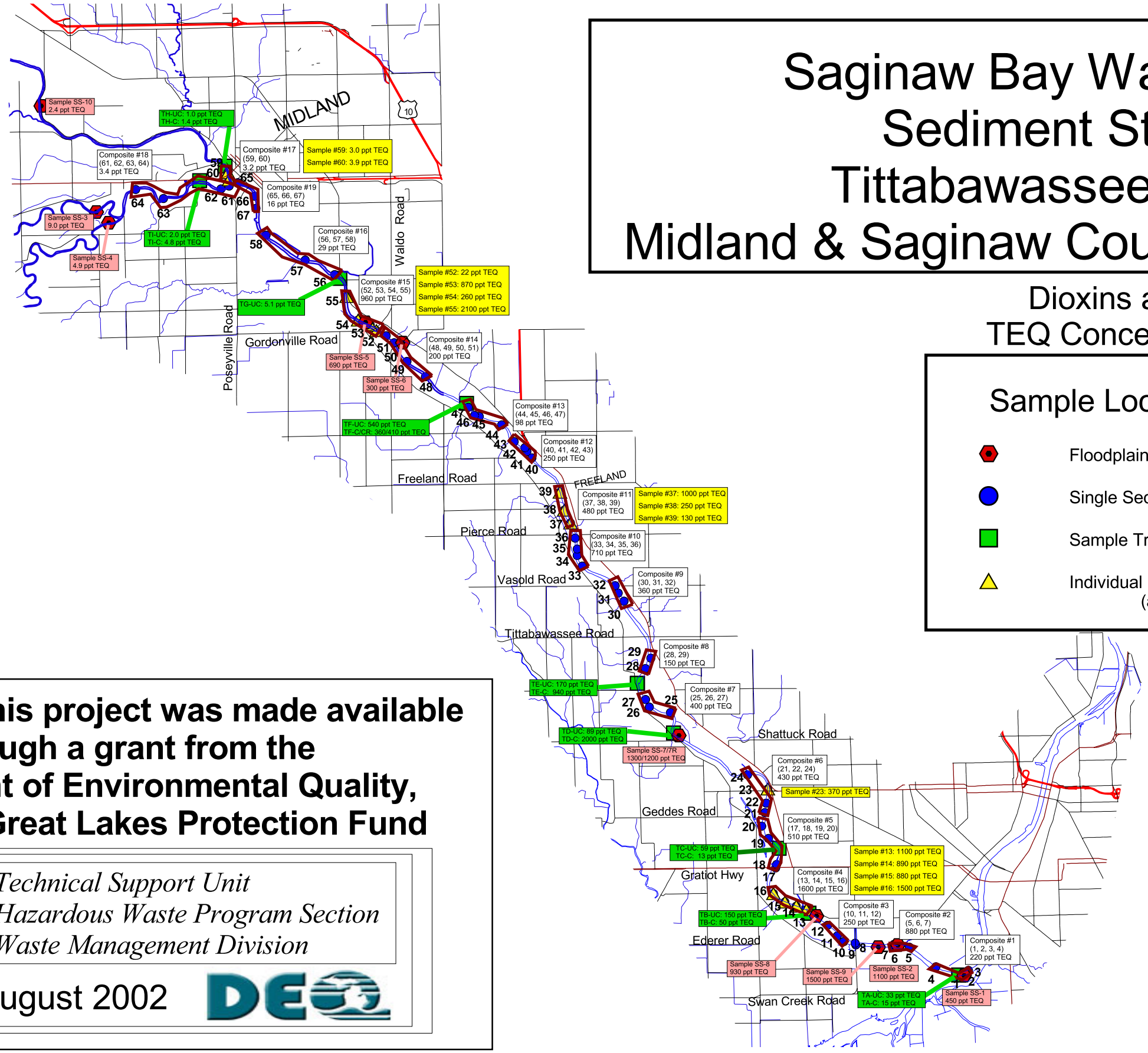
August 2002

DEQ

Figure 7

Saginaw Bay Watershed Sediment Study Tittabawassee River Midland & Saginaw Counties, Michigan

Dioxins and Furans
TEQ Concentration in ppt



N
W E
S

2 Miles

Sample Locations

- Floodplain Soil
- Single Sediment Samples
- Sample Transects of River
- Individual Sediment Samples (analyzed separately)

Funding for this project was made available through a grant from the Department of Environmental Quality, Michigan Great Lakes Protection Fund

WMD

Technical Support Unit
Hazardous Waste Program Section
Waste Management Division

August 2002

DEQ

Figure 8

Figure 9

TITTABAWASSEE RIVER STUDY Transect Analyses

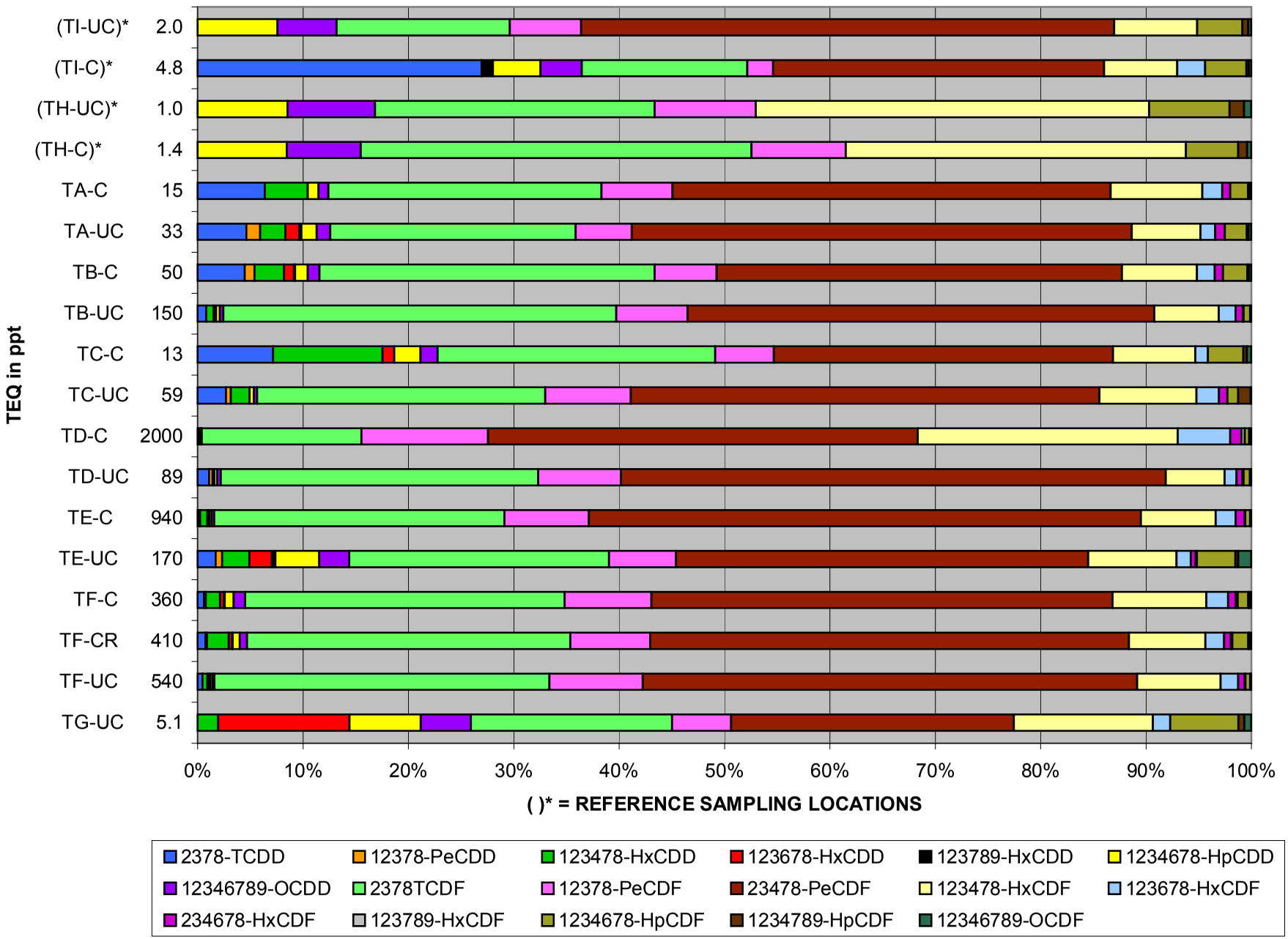


Figure 10

TITTABAWASSEE RIVER STUDY Composite Analyses

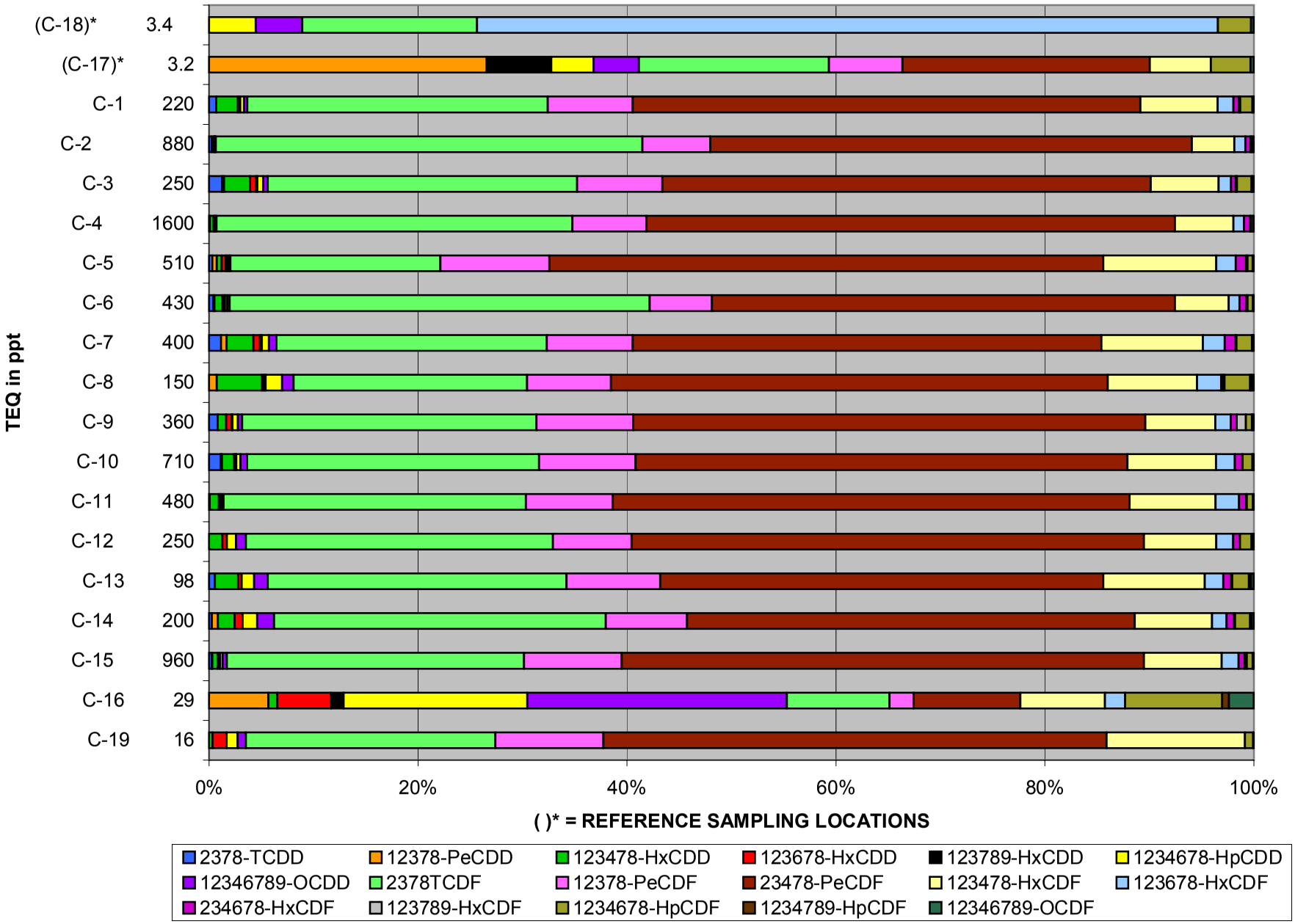


Figure 11

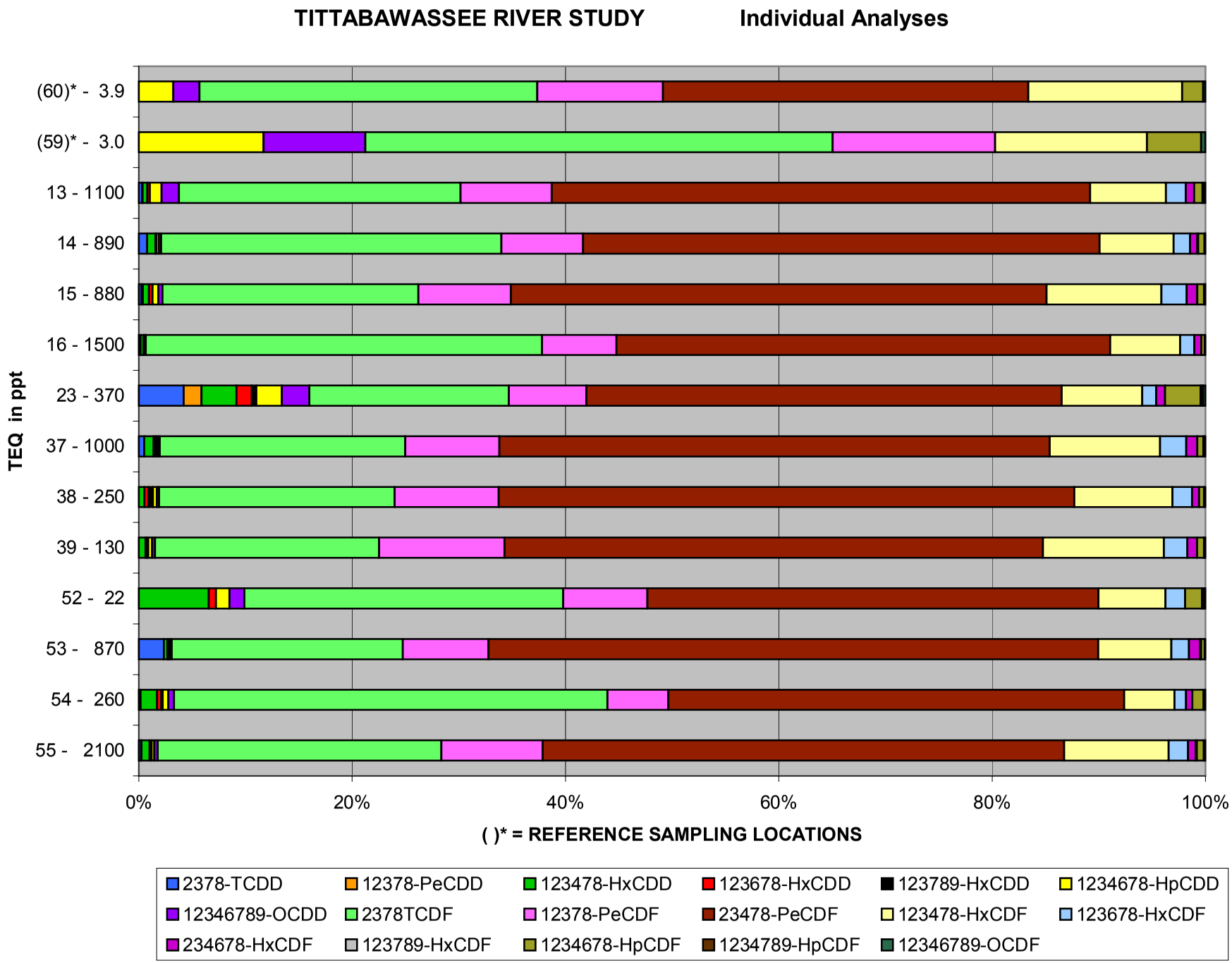
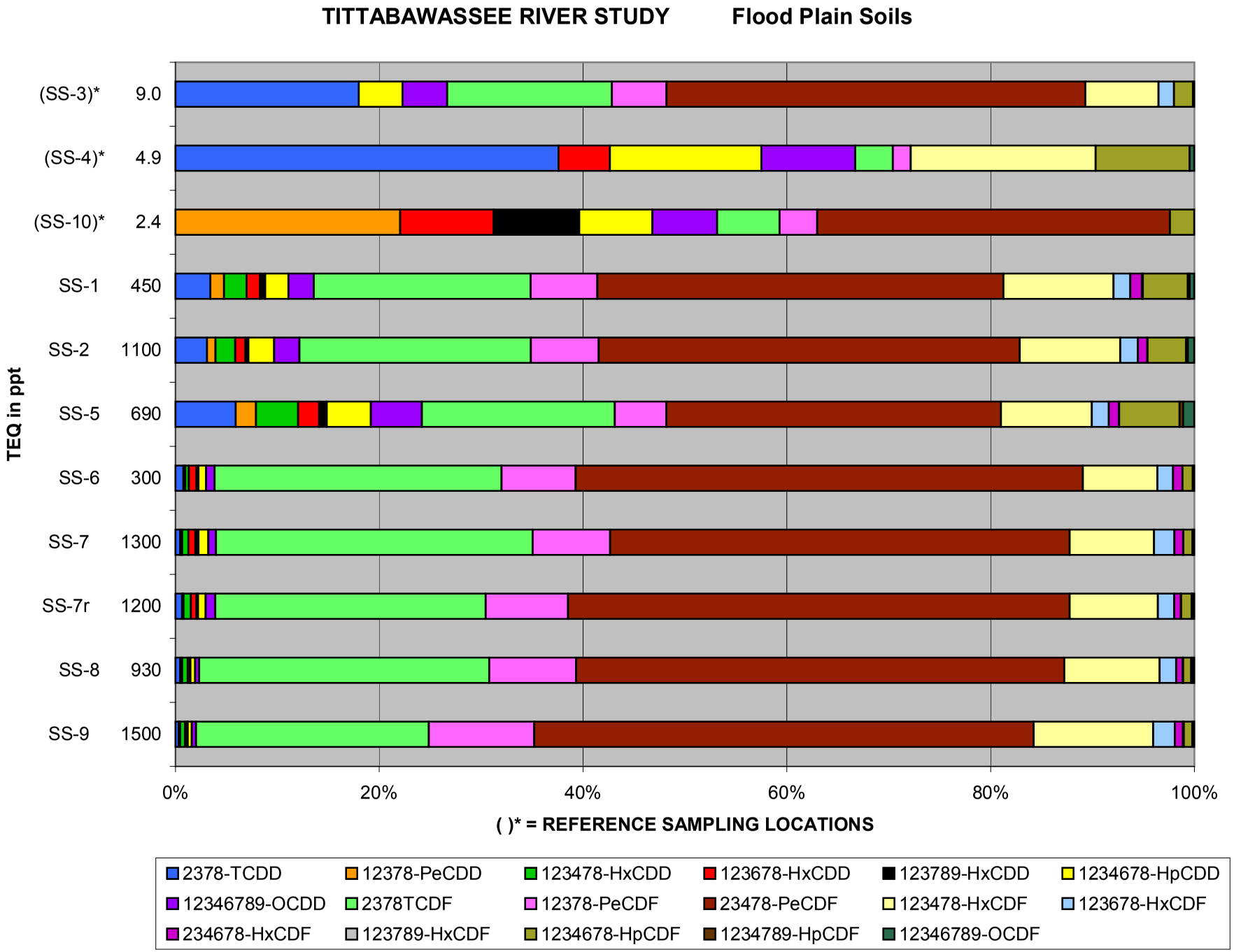

TITTABAWASSEE RIVER STUDY
Individual Analyses
(60)* - 3.9
(59)* - 3.0
13 - 1100
14 - 890
15 - 880
16 - 1500
23 - 370
37 - 1000
38 - 250
39 - 130
52 - 22
53 - 870
54 - 260
55 - 2100
TEQ in ppt
0%
20%
40%
60%
80%
100%
( )* = REFERENCE SAMPLING LOCATIONS
2378-TCDD
12378-PeCDD
123478-HxCDD
123678-HxCDD
123789-HxCDD
1234678-HpCDD
12346789-OCDD
2378TCDF
12378-PeCDF
23478-PeCDF
123478-HxCDF
123678-HxCDF
234678-HxCDF
123789-HxCDF
1234678-HpCDF
1234789-HpCDF
12346789-OCDF

Figure 12


TITTABAWASSEE RIVER STUDY
Flood Plain Soils
TEQ in ppt
(SS-3)* 9.0
(SS-4)* 4.9
(SS-10)* 2.4
SS-1 450
SS-2 1100
SS-5 690
SS-6 300
SS-7 1300
SS-7r 1200
SS-8 930
SS-9 1500
0%
20%
40%
60%
80%
100%
( )* = REFERENCE SAMPLING LOCATIONS
2378-TCDD
12378-PeCDD
123478-HxCDD
123678-HxCDD
123789-HxCDD
1234678-HpCDD
12346789-OCDD
2378TCDF
12378-PeCDF
23478-PeCDF
123478-HxCDF
123678-HxCDF
234678-HxCDF
123789-HxCDF
1234678-HpCDF
1234789-HpCDF
12346789-OCDF

Acknowledgements

The principle investigators would like to acknowledge the following individuals, without whose assistance this study would not have been possible:

Gerry Saalfeld, Christine Ailleo, and, particularly, Rick Lundgren of MDEQ Surface Water Quality Division for assistance in sampling design, technical support, field work and, most significantly, the boat.

John Giesy, Kurunthachalum Kannan, Klara Hilscherova and Patrick Bradley of the Michigan State University Aquatic Toxicology Lab for sampling design and the dioxin and furan bioassays and instrumental analyses, as well as lots of good advice.

Jack Schinderle and Joe Rogers of MDEQ Waste Management Division for field support.

Dave Slayton, Dale Bridgford and Steve McQuillan of MDEQ Waste Management Division for the maps and graphics that appear in this report.

Janice Combest of MDEQ Waste Management Division for data entry and collation.

Jim Sygo, Chief of MDEQ Waste Management Division for helping us clear the administrative hurdles.

Carole Brunner of the MDEQ Waste Management Division for helping us keep project finances in order.

Jim Bredin and Emily Finnell of the MDEQís Office of the Great Lakes for being such pleasant taskmasters.

References Not Included in Appendix 2

De Rosa, C.T.; Brown, D.; Dhara, R.; Garrett, W.; Hansen, H.; Holler, J.; Jones, D.; Jordan-Izaguirre, D.; OíConnor, R.; Pohl, H.; Xintaras, C. Dioxin and dioxin-like compounds in soil, Part 1:ATSDR interim policy guideline. *Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services Atlanta, Georgia* **1997,** 13, 759-768.

Hilscherova, K., Machala, M., Kannan, K., Blankenship, A.L. and Giesy, J.P. (2000). Environ. Sci. Pollut. Res., 7, 159-171.

Hilscherova, K., Kannan, K., Kang, Y-S., Holoubek, I., Machala, M., Masunaga, S., Nakanishi, J. and Giesy, J.P. (2001). Environ. Toxicol. Chem. 20, 2768-2777.

Im, S.H., Kannan, K., Matsuda, M., Giesy, J.P. and Wakimoto, T. (2002). Environ. Toxicol. Chem., 21, 245-252.

Kannan, K., Kober, J.L., Kang, Y-S., Masunaga, S., Nakanishi, J., Ostaszewski, A. and Giesy, J.P. (2001). Environ. Toxicol. Chem., 20, 1878-1889.

Kannan, K., Villeneuve, D.L., Yamashita, N., Imagawa, T., Hashimoto, S., Miyazaki, A. and Giesy, J.P. (2000). Environ. Sci. Technol. 34, 3560-3567.

Kannan, K., Watanabe, I. and Giesy, J.P. (1998). Toxicol. Environ. Chem., 67, 135-146.

Khim J.S., Villeneuve D.L., Kannan K., Koh C.H., and Giesy J.P. (1999). Environ Sci Technol 33:4199-4205.

Khim, J.S., Lee, K.T., Villeneuve, D.L., Kannan, K., Giesy, J.P. and Koh, C.H. (2001). Arch. Environ. Contam. Toxicol., 40, 151-160.

Masunaga, S., Takasuga, T. and Nakanishi, J. (2001). Dioxin and dioxin-like PCB impurities in some Japanese agrochemical formulations. Chemosphere, 44, 873-885.

Swami, K., Narang, A.S., Narang, R.S. and Eadon, G.A. (1992). Thermally induced formation of PCDD and PCDF from tri- and tetrachlorobenzene in dielectric fluids. Chemosphere, 24, 1845-1853.

Villeneuve DL, Blankenship AL, Giesy JP. 2000. Derivation and application of relative potency estimates based on in vitro bioassay results. *Environ Toxicol Chem 19, 2835-2843.*

Villeneuve, D.L., Khim, J.S., Kannan, K., Giesy, J.P. 2000. Aquat. Toxicol., 54, 125-141.

Wakimoto, T., Kannan, N., Ono, M., Tatsukawa, R. and Masuda, Y. (1988). Isomer-specific determination of polychlorinated dibenzofurans in Japanese and American polychlorinated biphenyls. Chemosphere, 17, 743-750.

Yamashita, N., Kannan, K., Imagawa, T., Villeneuve, D.L., Hashimoto, S., Miyazaki, A. and Giesy, J.P. 2000. Environ. Sci. Technol., 34, 3560-3567.