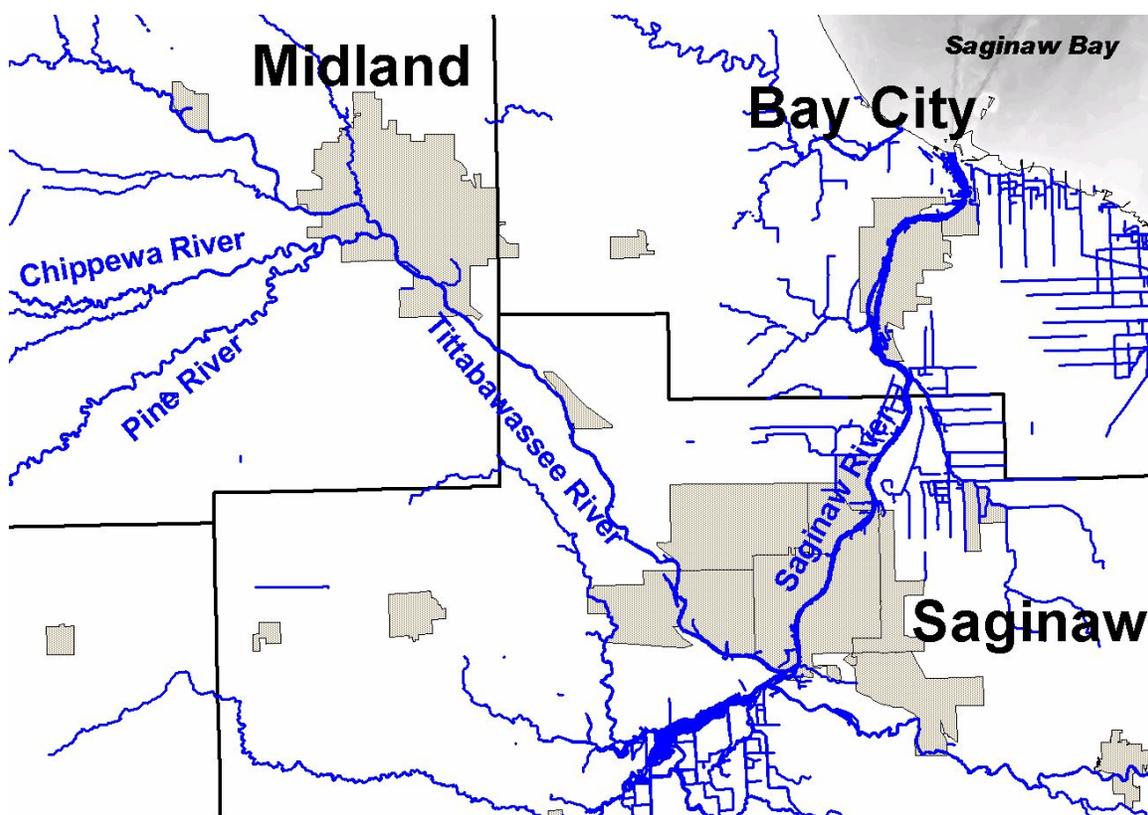


FINAL REPORT

Phase II Tittabawasse/Saginaw River Dioxin Flood Plain Sampling Study

JUNE 2003



Michigan Department of Environmental Quality
Remediation and Redevelopment Division
Revised August 2003

This is a complete version (appendices included) of the
Final Report
Phase II Tittabawassee/Saginaw River Dioxin Flood Plain Sampling Study

Note: An earlier, abbreviated version (no appendices) of this report was released in June 2003; since that time some changes have been made to the Table of Contents, and to pages 3, 5, 7, 8, 11, 12, and 19 of this report.

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Final Report

Phase II Tittabawassee/Saginaw River Dioxin Flood Plain Sampling Study

I. Executive Summary

Soil samples collected during the development of a wetland mitigation project identified elevated levels of dioxin and furan compounds (hereinafter collectively referred to as dioxin) in a farm field located near the confluence of the Tittabawassee and Saginaw Rivers. The samples, collected during April 2000, identified concentrations of dioxin as high as 2,200 parts per trillion (ppt) toxic equivalents (TEQ). The dioxin concentration was nearly 25 times the residential direct contact criterion (RDCC) of 90 ppt TEQ established under Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 201). The Part 201 RDCC of 90 ppt is the concentration of dioxin in soil determined to be safe for direct contact from residential exposure. Concern over the public and environmental health implications of these sample results prompted the Department of Environmental Quality (DEQ), Remediation and Redevelopment Division (RRD), to develop and implement a phased soil sampling and assessment program in the Tittabawassee River flood plain to determine the source and extent of the contamination.

Summary - Phase I

The Phase I portion of the soil sampling program was implemented during the period December 2000 through July 2001. The RRD collected 34 soil samples from five locations within a two-mile stretch of the Tittabawassee River flood plain between Center Road in Saginaw Township, Saginaw County, and the Saginaw River confluence. The Phase I sample locations are identified in Map 1. Soil samples were collected at depths ranging from the ground surface to 15 inches below ground level (bgl). Analytical results identified concentrations ranging from 35 to 7,300 ppt TEQ. Only 7 of the 34 samples contained dioxin TEQ concentrations less than the Part 201 RDCC (90 ppt TEQ). A summary of Phase I TEQ sample results is presented in Table 1. The Phase I individual dioxin congener results are presented in Appendix G.

Map 1: Phase I Sampling - - Tittabawassee/Saginaw River Flood Plain

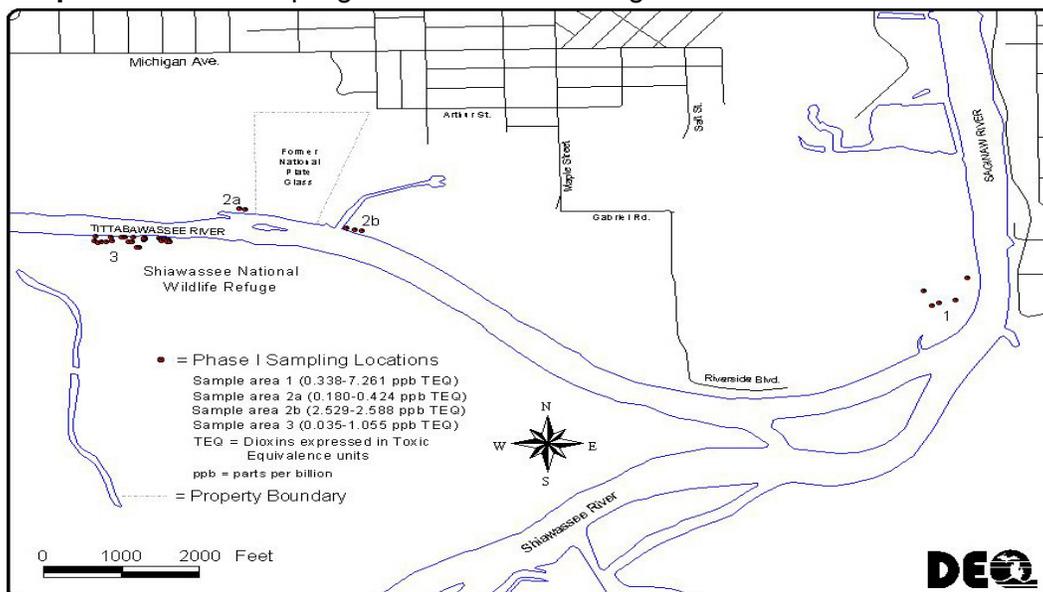


Table 1
Greenpoint-Tittabawassee River Dioxin/Furan Study Area
Phase I Sampling Study

Samples were analyzed by Triangle Laboratory, Durham, NC using US Environmental Protection Agency/USEPA Method 8290. All sample results are reported in pg/g (ppt) TEQ using USEPA Toxic Equivalency Factors (TEF) 1989

General Motors (GM) farm field (GM collected composite surface soil samples from the farm field) April 2000	
E3A	1,500
C1A	2,200

GM farm field (RRD collected discrete surface soil samples from farm field to verify April 2000 results) December 2000	
DX#1	390
DX#2	7,300
DX#3	6,300
DX#4	3,600
DX#5	340

LA Davidson (RRD collected discrete surface soil samples) May 2001	
From the farm field west of the LA Davidson site	
DX1 west	410
DX2 west	180
*From the golf course east of the LA Davidson site	
DX3 east	2,600
DX4 east	2,500

US Fish and Wildlife Service (USFWS) Shiawassee Wildlife Refuge (RRD collected discrete soil samples from wooded area) May 2001			
approximately < 6" bgl (below ground level)		approximately < 12" bgl	
GP1-6	39	GP1-12	58
GP2-6	130	GP2-12	360
GP3-6	59	GP3-12	57
GP4-6	35	GP4-12	160
GP5-6	130	GP5-12	1,100

USFWS Shiawassee Wildlife Refuge (RRD collected discrete soil samples from upland, open area) June 2001					
0 - 3" bgl		3 - 6" bgl		12 - 15" bgl	
SS1-3	390	SS1-6	590	SS1-12	58
SS2-3	770	SS2-6	420	SS2-12	280
SS5-3	390	SS5-6	540	SS5-12	250
SS6-3	590	SS6-6	550	SS6-12	110
SS7-3	490	SS7-6	660	SS7-12	68

DEQ residential direct contact criterion = 90 ppt (expressed as an equivalent concentration of 2,3,7,8-TCDD (TEQ))

The Phase I final report was completed during October 2001. The following determinations were presented in the final report:

- Elevated concentrations of dioxin were confirmed within the lower Tittabawassee River flood plain near the river's confluence with the Saginaw River.
- Dioxin concentrations were consistently found above the Part 201 RDCC (90 ppt TEQ), and were identified as high as 80 times the Part 201 RDCC.
- Human use of the flood plain increases upstream of the Phase I sample area. Residential properties are located within the flood plain, the majority located within the Shields area of Thomas Township and Saginaw Township. Public park lands and agricultural operations are also located within the flood plain.
- A Phase II sampling program was recommended to further evaluate the extent of contamination above the Part 201 RDCC occurring within the flood plain upstream of the Phase I sample area.

Summary – Sediment Study

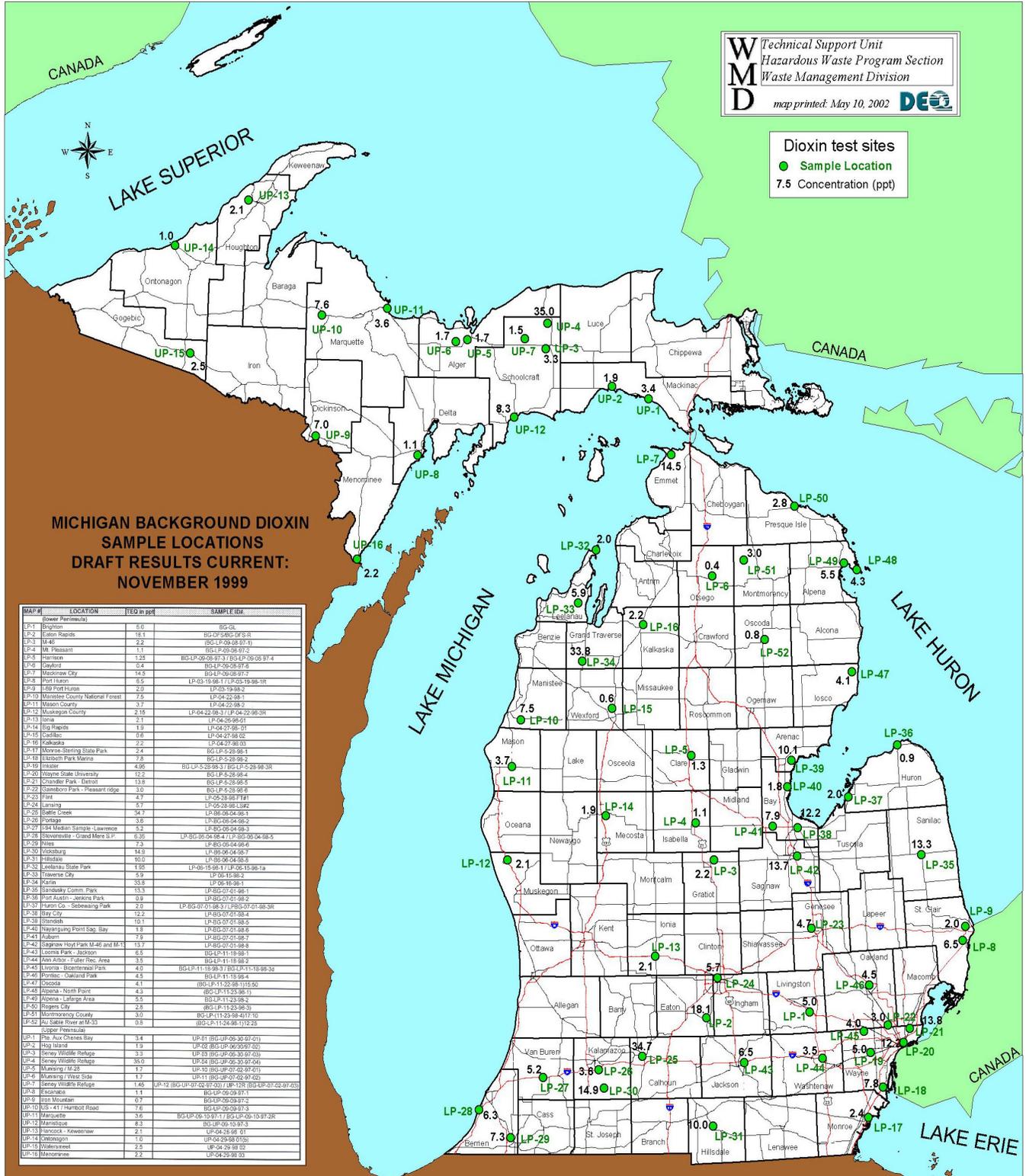
The DEQ collected and analyzed Tittabawassee River sediment samples during spring/summer 2001, as part of the Baseline Characterization of Saginaw Bay Watershed Sediment Study (DEQ Sediment Study). The objective of the DEQ Sediment Study was to provide baseline concentrations of contaminants in Tittabawassee River sediments both upstream and downstream of the city of Midland (Midland). Dioxins and furans were analyzed as part of this study. Surface sediment samples were collected from the Chippewa River, Pine River, and Tittabawassee River beginning immediately upstream of Midland and continuing downstream to the beginning of the Saginaw River. Sediment cores were collected and analyzed in select areas. Some flood plain soil samples were also collected for analysis. Sample locations and results are presented in Appendix H.

The DEQ Sediment Study final report was completed and distributed during the summer of 2002. The study results presented in the final report indicate the following:

- Dioxin concentrations from sediment and flood plain soil sample locations upstream of Midland are consistent with the average dioxin concentration in soil samples collected statewide from areas where there are no known dioxin release source(s) (hereinafter referred to as statewide background, see Figure 1).
- Dioxin is present at elevated concentrations in sediment and flood plain soil samples collected downstream of Midland. The extent of contamination is pervasive throughout the study area downstream of Midland. Sediment contamination ranged up to 2100 ppt TEQ and was present to the downstream limit of the study area, approximately 20 miles downstream of Midland. All flood plain soil samples collected downstream of Midland exceeded the Part 201 RDCC with concentrations ranging between 300 and 1500 ppt TEQ.
- The variability of dioxin concentrations in river sediment samples is believed to be a result of the variability of river water flow and site-specific sediment deposition characteristics.

Figure 1: Michigan Soil Background Dioxin Data

MICHIGAN SOIL BACKGROUND DIOXIN DATA

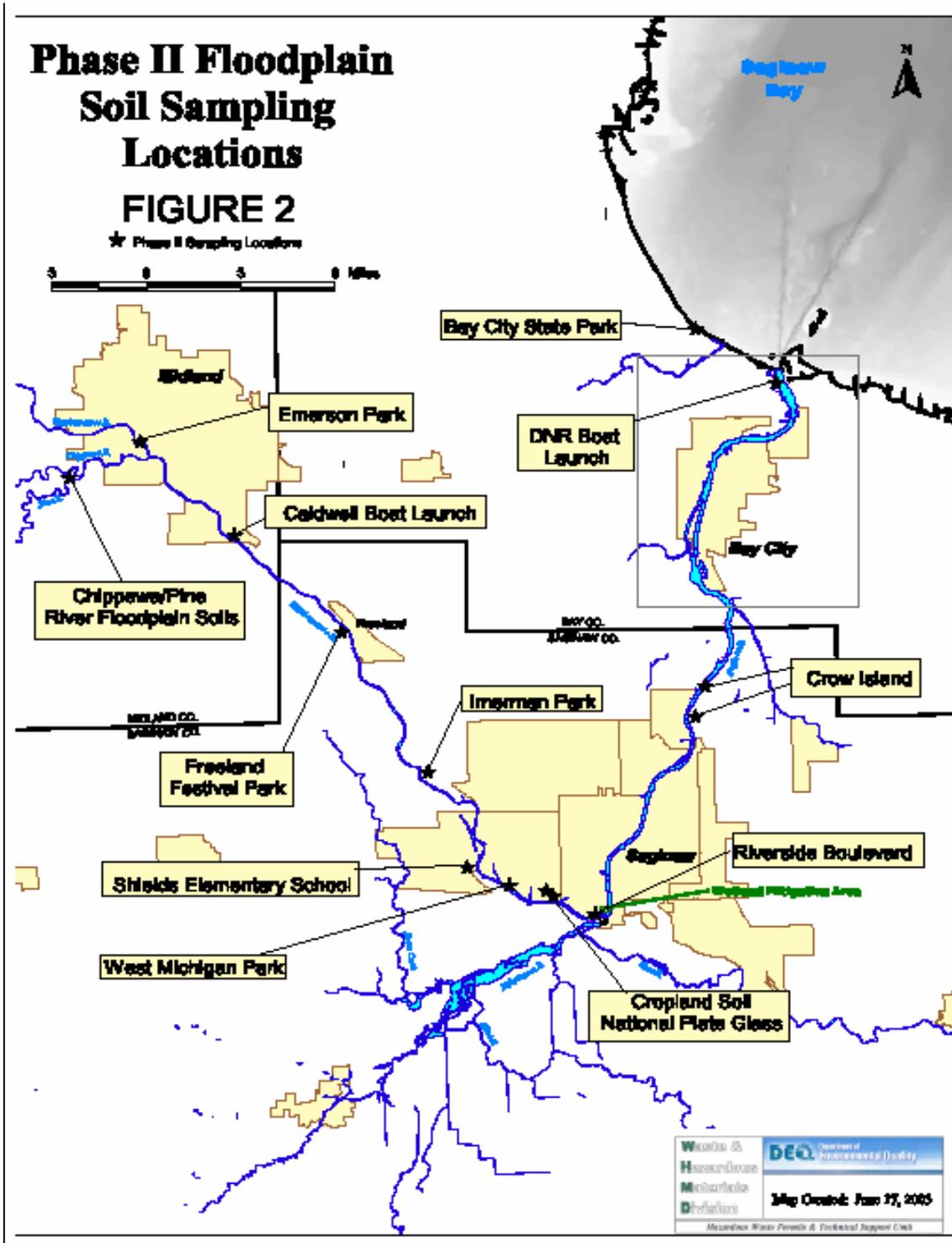


Summary – Phase II

A Phase II flood plain soil sampling program (Phase II) was developed based on the results of the Phase I Report and the DEQ Sediment Study. Flood plain soil samples were collected from the Chippewa, Pine, and Tittabawassee Rivers upstream of Midland, and at specific locations along the Tittabawassee River downstream of Midland to the beginning of the Saginaw River. Phase II soil samples were collected and analyzed during the period from May through December 2002 from the locations shown (see Figure 2). Initial observations of the Phase II sample results identified the following:

- The majority of flood plain soil sample dioxin concentrations downstream of Midland exceed the Part 201 RDCC, indicating that dioxin contamination of flood plain soil downstream of Midland is pervasive.
- Flood plain soil samples collected upstream of Midland contain dioxin concentrations consistent with statewide background concentrations.
- Dioxin concentrations from sample locations located downstream of Midland, but outside the estimated 100-year flood plain, are consistent with statewide background concentrations.
- The deepest initial Phase II soil sample (12-15 ") did not define the vertical extent of dioxin contamination. Soil samples were analyzed from three deep soil borings collected from Freeland Festival Park to improve understanding regarding the vertical extent of dioxin contamination. These additional samples indicate that dioxin contamination above statewide background concentrations exist at the park to a depth of four feet bgl. Additional deep soil sampling is necessary to determine if this vertical distribution of dioxin is consistent throughout the flood plain.
- The concentration of co-planar polychlorinated biphenyl (PCB) compounds represents an insignificant contribution to the total dioxin-like toxicity at all Phase II sample locations.
- Eggs from chickens that free range on flood plain soil exhibit elevated concentrations of dioxin. It is possible that food products from other animals raised on the flood plain could be affected.
- Dioxin concentrations in flood plain drinking water well samples were not determined to exceed applicable regulatory criteria.
- Saginaw River and Saginaw Bay navigation channel sediment samples collected in 1999 by the U.S. Army Corps of Engineers (USACE) indicate that dioxin contaminated sediment from the Tittabawassee River has migrated into the Saginaw River and the inner portions of the Saginaw Bay. Initial soil samples collected by the RRD from the Saginaw River and Saginaw Bay shoreline areas appear to confirm these results, though additional sampling of these areas is needed.

Figure 2: Phase II Soil Sampling Locations



The remainder of this report provides a detailed presentation of Phase II sampling objectives, methodology, sample results, congener profile characterization, conclusions, and recommendations.

II. Phase II Flood Plain Sampling Program Objectives

The following objectives were established for the Phase II flood plain sampling program:

- Investigate additional locations within the Tittabawassee River flood plain for the presence of dioxin.
- Assess dioxin distribution upstream and downstream of Midland.
- Assess dioxin distribution with respect to soil depth and elevation within the flood plain.
- Compare observed dioxin concentrations to applicable regulatory criteria.
- Assess if dioxin is present above applicable criteria in water supply wells located within potentially impacted flood plain areas.
- Evaluate the potential source(s) for the dioxin contamination.
- Assess whether soil dioxin concentrations in the public park areas in the flood plain pose an exposure hazard.
- Collect information on soil dioxin concentrations at two farms, one livestock and one crop operation, to provide preliminary information that will help determine the need for subsequent crop and animal data.
- Assess whether soil dioxin concentrations at residential properties along Riverside Boulevard pose an exposure hazard and provide preliminary information that will help determine the need for indoor dust and/or biological sampling data.

III. Sampling Methodology

Soil Samples

Soil samples were collected from locations upstream and downstream of Midland. Samples were also collected downstream beyond the Tittabawassee River into the Saginaw River and Saginaw Bay. Sampling locations are shown in Figure 2. The number of sample locations at each sample site varied based on the physical size of the sample site and the variety of unique physical features and human uses occurring at the sample site.

Sample Site	Distance from Midland	# Sample Locations
State of Michigan Property - Sanford	8 miles upstream; Tittabawassee River	2
Chippewa Nature Center	2 miles upstream; Chippewa River	2
Chippewa Nature Center	2 miles upstream; Pine River	2

Sample Site	Distance from Midland	# Sample Locations
Emerson Park	City of Midland	3
Caldwell Boat Launch	2 miles downstream	2
Freeland Festival Park	7 miles downstream	3 3 deep soil borings
Livestock Farm	9 miles downstream	6
Imerman Park	11½ miles downstream	14
Shields Elementary School	17 miles downstream	5
West Michigan Park	18 miles downstream	3
Crop Farm	20 miles downstream	5
National Plate Glass	20 miles downstream	1
19 Riverside Blvd.	22 miles downstream	5 soil, 4 egg
Saginaw River – Crow Island State Wildlife Refuge	31 miles downstream	3
Saginaw River – DNR Boat Launch	44 miles downstream	1 (surface only)
Saginaw Bay – DNR Bay City State Recreation Area	48 miles downstream	1 (surface only)

Samples were collected in accordance with the Phase II work plan, with these exceptions:

- Only one residential property was sampled along Riverside Boulevard due to property access issues.
- The number of sample locations was reduced at Emerson Park (6 to 3) and at the Crop Farm (8 to 5) based on an on-site field assessment of site characteristics.
- The following additional samples were collected and analyzed:
 - One soil sample location and two surface water samples from the former National Plate Glass site of environmental contamination.
 - Four eggs from chickens located at the Riverside Boulevard residence.
 - Three deep soil boring locations, with soil analysis conducted to a depth of five feet, at Freeland Festival Park.
 - Three soil sample locations from the Crow Island State Wildlife Refuge.
 - One surface soil sample location from the shoreline area at the Department of Natural Resources (DNR) Boat Launch Facility located near the mouth of the Saginaw River.
 - One soil sample location from the shoreline area at the DNR Bay City State Recreation Area.

Soil samples were collected from three soil layers at each sample location, these being 0-3", 3-6", and 12-15". At certain locations, based on property use, a surface soil sample was also collected from 0-1". Soil samples were manually collected using hand augers. Decisions regarding the exact location of a sample were made based on the physical characteristics of the sample site. Undisturbed and non-forested areas were preferred. Multiple auger holes were necessary at each location to provide a sufficient quantity of soil for sample analysis. Vegetative cover was removed prior to sample collection. For each soil layer, soil from the multiple auger holes was composited and homogenized in a disposable metal pan prior to transfer to the sample containers. Any soil remaining after all sample jars were filled was placed back into the auger holes at the end of sample collection activities. Auger holes were brought back to grade using available soil and supplemented as necessary with commercially purchased potting soil. The hand auger was decontaminated prior to sampling the next soil layer or soil sample location, and sample pans, spoons, and gloves were disposed. This procedure was repeated for each sample depth at all sample locations. The three deep soil borings located at Freeland Festival Park were collected using hydraulic soil-coring technology. Soil samples were collected from the cores at one foot intervals starting at the two foot depth.

Soil samples underwent analysis for dioxin and furan compounds (USEPA Method 1613), PCB (USEPA Method 1668), total organic carbon (MSA 29-3.5.2), percent solids (SW846-3550B), and soil grain size (ASTM-D422). Pesticide analysis was initially conducted, but was discontinued when pesticide concentrations were found to be an insignificant contribution to toxicity at sites located both upstream and downstream of Midland. The PCB analysis was conducted to assess whether any of the observed toxicity was related to the presence of PCB compounds. Information gathered from total organic carbon, percent solids, and soil grain size analysis was used to assess if there exists a correlation between these soil characteristics and observed dioxin concentrations.

Global positioning system coordinates were established for each sample location for mapping purposes and to re-locate sample sites, if necessary. Based on the information that has been collected to date, the position and elevation of a sample location within the estimated flood plain appear to be important factors to consider when determining the likelihood that a property, or portion of a property, is contaminated with dioxin.

Groundwater Samples

The majority of businesses and residences located within and adjacent to the Tittabawassee River flood plain are serviced by municipal drinking water supplies that use the Saginaw Bay of Lake Huron as the primary water source. However, some residences to the south and east of Midland along the east and west shorelines of the Tittabawassee River continue to acquire potable water from groundwater. Groundwater samples were collected from certain of these potable water wells that have the potential to be impacted by Tittabawassee River flood events. Initial sample collection activities were conducted by the Saginaw County Health Department. The DEQ collected additional water samples to augment and provide confirmation of the initial sample results. All water samples underwent analysis for dioxin (USEPA Method 1613) with the results reported in parts per quadrillion (ppq). Eventually 48 groundwater samples were collected and analyzed from 24 active potable water wells.

Analytical Laboratories

Four laboratories were used to complete soil and groundwater sample analysis.

Triangle Laboratory
2445 S. Alston Ave.
Durham, North Carolina

Soil dioxin analysis Phase I (Method 8290)
Soil dioxin analysis Phase II (Method 1613)
Co-planar PCB (Method 1668)
Water dioxin analysis (Method 1613)

Trimatrix Laboratories
5560 Corporate Exchange Ct. S.E.
Grand Rapids, MI

Percent solids (SW846-3550B)
Total Organic Carbon (MSA 29-3.5.2)

Midwest Laboratories
13611 "B" Street, Omaha, Nebraska

Grain size analysis (ASTM-D422)

Pace Analytical Laboratories
1700 Elm Street, Ste 200
Minneapolis, MN 55414

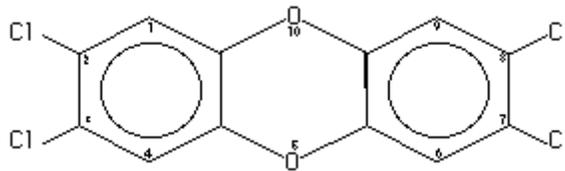
Water dioxin analysis (Method 1613)

IV. Dioxin Overview

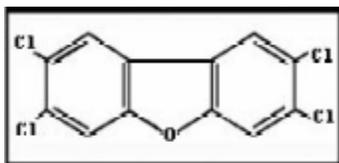
Dioxin is frequently used as a general term that refers to a group of chemical compounds, including furans, that are highly persistent in the environment and share similar chemical structures (see figures below). There are 210 different potential chemical configurations of these compounds that are individually referred to as congeners. Seventeen of these CDD and CDF congeners exhibit certain biological effects and are referred to in this report as "dioxin." Dioxin congeners exist as members of two closely related chemical families, these being the chlorinated dibenzo-*p*-dioxins (CDDs) and the chlorinated dibenzofurans (CDFs). Certain PCBs also possess toxicological properties similar to dioxin and are termed "dioxin-like."

The CDDs and CDFs are produced as a by-product of a variety of industrial production and other human activities, including but not limited to, waste incineration, pulp and paper bleaching, and chemical production. PCBs are manmade, but their production has been banned in the United States since the 1970s.

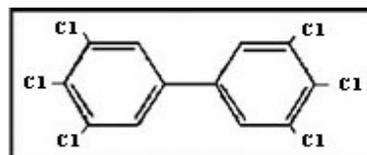
Chemical Structure of
2,3,7,8-tetrachlorodibenzo-*p*-dioxin
(CDD example)



Chemical Structure of
2,3,7,8-tetrachlorodibenzofuran
(CDF example)



Chemical Structure of
3,3',4,4',5,5'-hexachlorobiphenyl
(PCB example)



Individual congeners of CDDs, CDFs, and PCBs differ in form based on the number and location of the chlorine atoms within the chemical structures. If chlorine atoms exist in positions furthest from where the rings are linked together (refer to the figure of 2,3,7,8-tetrachlorodibenzo-para-dioxin - 2,3,7,8-TCDD) the shape is called “coplanar”. Of the hundreds of different dioxin congeners, there are only seven CDD congeners, 10 CDF congeners, and 12 PCB congeners that are coplanar. This coplanar shape is considered to be the most toxic form of dioxin because these congeners are most capable of disrupting the performance of biological systems. The 2,3,7,8-TCDD congener is considered the most toxic coplanar dioxin.

Long-term exposure to low levels of dioxin may cause a wide variety of effects on animals including cancer, liver damage, hormone disruption, immune system disorders, reproductive damage, miscarriages, and a variety of birth defects. People who have been exposed to high levels of dioxin have developed a condition known as chloracne, a disfiguring skin disease with severe acne-like pimples. Exposure to high levels of dioxin may also result in liver damage, long-term alterations in glucose metabolism, and changes in hormone levels. Fetuses, infants, and children are believed to be especially sensitive to dioxin exposure, but exact information on the effects of dioxin on children is limited. Based on currently available information, the USEPA has characterized dioxins as likely human carcinogens. The U.S. Department of Health and Human Services has identified 2,3,7,8-TCDD as “known to be a human carcinogen”.

Expressing Dioxin Toxicity – TEF and TEQ

Dioxin is found in the environment as a mixture of dioxin congeners. As a result, the additive toxic effects of all the congeners present in the environmental sample must be considered. The concept of toxic equivalency factors (TEFs) has been developed to provide a method to estimate the relative toxicity of different dioxin congeners present in an environmental sample, and to facilitate risk assessment and regulatory actions. The TEFs have been developed to compare the relative toxicity of other dioxins and dioxin-like compounds to that of 2,3,7,8-TCDD, the most toxic chemical in the dioxin group. The concentrations of other dioxin-like compounds are multiplied by a TEF to produce a 2,3,7,8-TCDD toxic equivalent (TEQ). The TEQ for each dioxin-like compound identified in a sample are then added together to determine the total TEQ for that sample. This method provides information on the combined toxicity of multiple dioxin congeners and provides a useful comparison of the relative congener concentrations at different sample locations.

World Health Organization (WHO) TEFs are used in the appendices to this report for calculating dioxin TEQ values. Since all the samples in both the Phase I and Phase II report did not have congener specific PCB data, and because PCB was found to represent a negligible contribution to the total dioxin TEQ, PCBs were not included in the TEQ values reported. The Phase II dioxin results for soil and egg samples are expressed as parts per trillion (ppt) of TEQ, whereas the Phase II dioxin results for water and groundwater are expressed as parts per quadrillion (ppq) of TEQ.

Establishing a TEQ – Non-Detectable Concentration Values

Modern laboratory analytical testing methods are capable of detecting very small concentrations of a wide variety of chemical compounds. This is true for dioxin test methods as well. However, for all laboratory test methods there is a lower limit below

which the test method is unable to detect the chemical compound. The lowest concentration value that can be accurately quantified by a test method is commonly referred to as the detection limit. However, just because a chemical compound is not identified in a sample above the detection limit does not mean that the chemical compound is not present in the sample. The chemical compound may be present in a sample but at concentrations below the detection limit of the test method.

It was a common occurrence at sample locations upstream of Midland and at locations downstream of Midland but outside of the flood plain, that certain dioxin and furan congeners were not identified in samples above the detection limit. The DEQ has calculated dioxin TEQs using three different methods to evaluate non-detectable concentration values, these being:

- The dioxin congener concentration is assumed to be the same as the detection limit (non-detection = detection limit).
- The dioxin congener concentration is assumed to be the same as $\frac{1}{2}$ of the detection limit (non-detection = $\frac{1}{2}$ detection limit).
- The dioxin congener is assumed not to be present in the sample (non-detection = zero).

All three dioxin TEQ calculations are included in the data tables presented in the appendices of this report. Based on these calculations it is the assessment of the DEQ that there was no meaningful difference among the three dioxin TEQ values. Dioxin TEQ data presented in the text of this report were calculated using $\frac{1}{2}$ of the detection limit for non-detectable concentration values.

Dioxin Congener Profile

Dioxins are stable chemicals and can persist for many years in the environment. Dioxins are generally found to be present in soil and water samples as a mixture of dioxin congeners. Determining the mixture of dioxin congeners that is present can assist efforts towards identifying the source for the dioxin release.

A graphical chart representation of the mixture of dioxin compounds present in an environmental sample has been created for this report. This chart is referred to in this report as a congener profile chart. The congener profile chart is constructed using the percent of total TEQ that a particular dioxin congener represents in a soil sample. Congener profile charts were created for all Phase II flood plain soil and egg samples, the DEQ Sediment Study, USACE sediment samples, Saginaw River/Bay shoreline soil samples, and Phase I soil samples. These charts are presented together in Appendix J to facilitate chart comparison. A preliminary assessment of the results of the dioxin congener profile analysis is provided later in this report.

Dioxin Soil Background Concentrations

Chemical manufacturing, industrial production, waste incineration, and chemical use activities over the past century have resulted in the widespread distribution of dioxin in soil, lake and river sediments, and water throughout the United States. During 1997 and 1998, the DEQ collected soil samples from 68 urban and rural locations in Michigan's

upper and lower peninsulas to gain an understanding of statewide dioxin background concentrations. The results of this assessment effort identified that dioxin soil background concentrations varied from less than 1.0 ppt TEQ to 35 ppt TEQ, with a statewide average soil background dioxin concentration calculated to be approximately 6.0 ppt TEQ. A similar nationwide effort conducted by the USEPA identified a calculated average United States soil background dioxin concentration of 10 ppt TEQ. These values are important to consider when evaluating dioxin TEQ concentrations. A map identifying state soil background sample locations and TEQ concentrations is included as Figure 1.

Dioxin Regulatory Criteria

Under the provisions of Part 201, the DEQ has established criteria for concentrations of hazardous substances in soil and groundwater that are believed to be safe for specific human exposure scenarios. For property designated for residential use, the concentration of dioxin in soil determined to be safe for direct contact, the RDCC, is 90 ppt TEQ. The RDCC is the criterion used by the DEQ to determine if a property or location requires some additional response activity, such as investigation, exposure barriers, use restrictions, or cleanup. The RDCC is a human health-based criterion and was developed using currently available risk-based exposure data and scenarios. The DEQ also uses a drinking water standard established by the USEPA of 30 ppq TEQ for the maximum concentration of dioxin in drinking water.

The U.S. Agency for Toxic Substance and Disease Registry (ATSDR) has established a screening value dioxin concentration of 50 ppt TEQ in soil. The ATSDR established this screening value based on currently available information concerning the human health effects of dioxin. Soil concentrations above this screening value is sufficient to warrant further study and evaluation to determine if a dioxin contamination problem exists at a property or location. The ATSDR has established a soil dioxin concentration of 1,000 ppt TEQ as an action level requiring that some form of response action be taken to address the identified contamination. This action level is based on ATSDR policy rather than the health effects of dioxin.

V. Polychlorinated Biphenyl Congeners (PCB)

During development of the Phase II sampling program, concerns were expressed to the DEQ regarding the contribution that PCBs may have to the total dioxin-like toxicity observed in a soil sample. It is known that certain PCB congeners can contribute to dioxin related toxicity. As a result, most soil samples underwent analysis for PCB. Data from this analysis confirmed that throughout the entirety of the Phase II study area, PCB represented a negligible contribution to the total dioxin TEQ. The maximum contribution for PCB identified during Phase II was 11 ppt TEQ at Imerman Park (IMP 1-15"), which was less than one percent of the total dioxin TEQ of 1,500 ppt identified at this location. From this data, it can be concluded that the dioxin TEQ observed at all Phase II soil samples is overwhelmingly the result of the presence of dioxin.

VI. Estimated 100-Year Flood Plain Contour

Initial evaluation of the Phase I and DEQ Sediment Study data indicated that dioxin congeners found in the Tittabawassee River sediments were similar in kind and relative abundance to those found in flood plain soil. To achieve Phase II study objectives it became important to develop a general understanding of the shape and extent of the Tittabawassee River flood plain downstream of Midland.

An estimate of the extent of the Tittabawassee River 100-year flood plain was developed using floodway data published by the U.S. Federal Emergency Management Agency. A 100-year flood plain can be described as that area of land located adjacent to a river that is expected to flood once every 100 years. It can also be described as that area of land located adjacent to a river that has a one percent chance of flooding during any given year. The shape and size of the estimated 100-year flood plain has been presented as a solid, color-enhanced (blue) contour line superimposed on maps and aerial photographs presented in this report. Any land or structure located between the Tittabawassee River shoreline and the contour line is considered to be within the estimated 100-year flood plain. Likewise, any land or structure located such that the contour line is located between it and the Tittabawassee River shoreline is considered to be outside the estimated 100-year flood plain.

VII. Phase II Sample Results - Soil

Soil Sample Labeling

More than 200 soil samples were collected and analyzed during the Phase II study. Samples were labeled to provide consistent information related to the location and depth of the soil sample. A unique identifier was established for the different Phase II sample sites. As an example, all samples collected at Imerman Park have an identifier of IMP. Following the identifier is a number that indicates the sample location within the sample site. The final number in the sample label identifies the soil layer depth from which the sample was collected. The larger number was used as the primary descriptor, so 3" means that the sample was collected from the 0-3" soil layer. Likewise, 15" means that the sample was collected from the 12-15" soil layer. As an example, the sample label IMP 7-6" indicates that the soil sample was collected from Imerman Park, at sample location #7, from the 3-6" soil layer. The DEQ has attempted to consistently use these sample labels in all data tables, maps, and reports.

Data Reporting

The data that is summarized in this report is reported to two significant figures. Please note that earlier results and Phase I data have been previously reported using more significant figures.

State of Michigan Property – Sanford

The property is located along the northern shoreline of the Tittabawassee River, south of the southern terminus of Cedar Street, near the City of Sanford. The property is located approximately eight miles upstream of Midland. Soil samples were collected from three soil layers (0-3", 3-6", 12-15") at two locations. Samples collected from this site were labeled SFD.

Photo 1: Sanford (SFD)



Dioxin concentrations ranged from 0.67 to 4.6 ppt TEQ. Soil dioxin concentrations were consistent with DEQ Sediment Study results and with concentrations identified by the statewide dioxin background study. Soil samples at this location underwent pesticide analysis and concentrations were found to be less than applicable Part 201 criteria. The PCB analysis was also completed for these soil sample locations and the contribution to total dioxin TEQ was found to be insignificant.

Tittabawassee River Flood Plain Soil, Sanford (SFD), Midland County Upstream	
Sample Identifier	Dioxin, ppt TEQ
SFD 1-3"	4.0
SFD 1-6"	3.3
SFD 1-15"	0.67
SFD 2-3"	3.3
SFD 2-6"	4.6
SFD 2-15"	1.2

Pine River – Chippewa Nature Center

The Pine River joins with the Chippewa River approximately two miles upstream of Midland. Soil samples were collected from three soil layers (0-3", 3-6", 12-15") at two locations along the north shore of the Pine River as it passes through the Chippewa Nature Center in Midland County, just upstream of the confluence of the Pine and Chippewa Rivers. Samples collected from this site were labeled PINE.

Photo 2: Pine River (PINE)



Dioxin concentrations ranged from 2.8 to 13 ppt TEQ. Soil dioxin concentrations were consistent with DEQ Sediment Study results, and with dioxin concentrations identified by the statewide dioxin background study. Soil samples at this location underwent pesticide analysis and concentrations were found to be insignificant. The PCB analysis was also completed for these soil sample locations and the contribution to total dioxin TEQ was found to be insignificant.

Pine River Flood Plain Soil (PINE), Chippewa Nature Center, Midland County	
Sample Identifier	Dioxin, ppt TEQ
PINE 1-3"	3.0
PINE 1-6"	2.8
PINE 1-15"	9.0
PINE 2-3"	8.9
PINE 2-6"	12
PINE 2-15"	13

Chippewa River – Chippewa Nature Center

The Chippewa River joins with the Pine River approximately two miles upstream of Midland. Soil samples were collected from three soil layers (0-3", 3-6", 12-15") at two locations along the south shore of the Chippewa River as it passes through the Chippewa Nature Center in Midland County, just upstream of the confluence of the Pine and Chippewa Rivers. Samples collected from this site were labeled CHW.

Photo 3: Chippewa River (CHW)



Dioxin concentrations ranged from 4.2 to 12 ppt TEQ. Soil dioxin concentrations were consistent with DEQ Sediment Study results and with dioxin concentrations identified by the statewide dioxin background study. Soil samples at this location underwent pesticide analysis and concentrations were found to be insignificant. The PCB analysis was also completed for these soil sample locations and the contribution to total dioxin TEQ was found to be insignificant.

Chippewa River Flood Plain Soil (CHW), Chippewa Nature Center, Midland County	
Sample Identifier	Dioxin, ppt TEQ
CHW 1-3"	4.7
CHW 1-6"	7.9
CHW 1-15"	12
CHW 2-3"	4.2
CHW 2-6"	7.0
CHW 2-15"	7.3

Emerson Park

Emerson Park is located within Midland along the Tittabawassee River just upstream of the confluence of the Tittabawassee and Chippewa Rivers. This is a multiple-use park with supported recreational activities including foot and bike paths, picnic areas, open areas, and softball/baseball facilities. Soil samples were collected from four soil layers (0-1", 0-3", 3-6", and 12-15") at three sample locations. Samples collected from this site are labeled EMP.

Photo 4: Emerson Park (EMP)



Dioxin concentrations at Emerson Park were elevated above concentrations observed at the three sample sites located upstream of Midland. Some of the observed concentrations exceed dioxin concentrations identified by the state-wide dioxin background study. Soil dioxin concentrations ranged from 5.2 to 100 ppt TEQ. Only one of the 12 samples, EMP 2-15", exceeded the Part 201 RDCC.

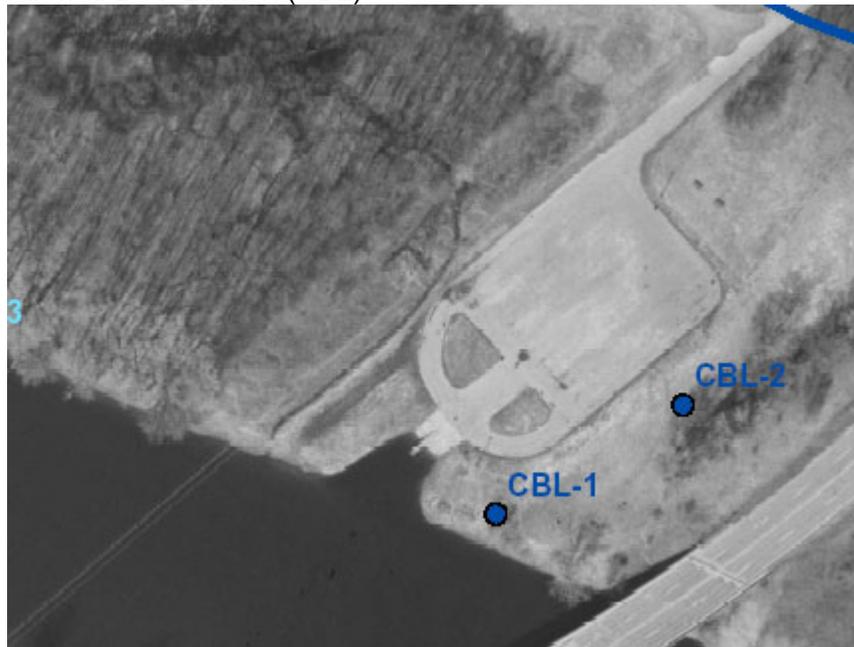
Emerson Park Soil (EMP), City of Midland Midland County	
Sample Identifier	Dioxin, ppt TEQ
EMP 1-1"	10
EMP 1-3"	7.5
EMP 1-6"	5.2
EMP 1-15"	22
EMP 2-1"	24
EMP 2-3"	29
EMP 2-6"	54
EMP 2-15"	100
EMP 3-1"	15
EMP 3-3"	21
EMP 3-6"	21
EMP 3-15"	5.6

An initial evaluation of the data appears to indicate that the distribution of dioxin congeners at Emerson Park is different from that found in soil samples collected within the flood plain downstream of Midland. As part of a separate soil investigation initiative, soil from properties located outside the flood plain, but within the city of Midland, was sampled to determine if dioxin concentrations have been elevated as a result of various chemical manufacturing and waste incineration processes that have occurred in the city since the early 1900s. This sampling effort confirmed that dioxin concentrations in Midland soil are elevated above statewide background concentrations, and in many instances above the Part 201 RDCC. Additional evaluation of the Phase II Emerson Park sample data may identify whether the data shares certain dioxin congener characteristics with the limited Midland soil data that is currently available. A more detailed discussion is provided in the section of this report entitled “Dioxin Congener Profile Data”.

Caldwell Boat Launch

The Caldwell Boat Launch facility is operated by the Midland Parks and Recreation Department and is located on the east shore of the Tittabawassee River approximately two miles downstream from Midland. Soil samples were collected from four soil layers (0-1”, 0-3”, 3-6”, and 12-15”) at two sample locations. Samples collected from this site are labeled CBL.

Photo 5: Caldwell Boat Launch (CBL)



Dioxin concentrations at Caldwell Boat Launch consistently exceed dioxin concentrations identified by the state-wide dioxin background study. Soil dioxin concentrations ranged from 35 to 270 ppt TEQ. Six of the eight soil samples exceeded the Part 201 RDCC. A soil sample was also collected during the DEQ Sediment Study from the wooded area adjacent to the boat launch. This sample exhibited a concentration of 690 ppt TEQ. Based on information currently available to the DEQ, it is believed that the Caldwell Boat Launch was constructed during the mid-1980s. It is

likely that earth moving activities associated with boat launch construction have affected the distribution of soil dioxin contamination on the property.

Caldwell Boat Launch Soil (CBL), Midland County	
Sample Identifier	Dioxin, ppt TEQ
CBL 1-1"	35
CBL 1-3"	140
CBL 1-6"	140
CBL 1-15"	270
CBL 2-1"	170
CBL 2-3"	180
CBL 2-6"	250
CBL 2-15"	210

Freeland Festival Park

The Freeland Festival Park is located approximately seven miles downstream of Midland. This is a multi-use park with fishing dock, picnic facilities, a walkway, and open areas. The park is managed by Tittabawassee Township. Soil samples were collected from four soil layers (0-1", 0-3", 3-6", and 12-15") at three sample locations. Samples collected from this site are labeled FFP. Please note that the labeling convention used for the Freeland Festival Park samples differs slightly from the labeling convention used at other sample sites. For these samples, the actual sample location is identified in parentheses, e.g., (LOC 1).

Photo 6: Freeland Festival Park (FFP)



Dioxin concentrations at Freeland Festival Park were the highest observed during the Phase II study. Soil dioxin concentrations ranged from 190 to 3,400 ppt TEQ. All soil samples exceeded the Part 201 RDCC. The greatest concentration of 3,400 ppt TEQ was found at FFP 1-15" (LOC 1), the deepest soil layer from the most inland sample location.

Freeland Festival Park Soil (FFP), Freeland, Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
(LOC 1) FFP 1-1"	1,500
(LOC 1) FFP 1-3"	1,400
(LOC 1) FFP 1-6"	2,600
(LOC 1) FFP 1-15"	3,400
(LOC 2) FFP 2-1"	1,200
(LOC 2) FFP 2-3"	1,500
(LOC 2) FFP 2-6"	1,600
(LOC 2) FFP 2-15"	2,400
(LOC 3) FFP 3-1"	360
(LOC 3) FFP 3-3"	360
(LOC 3) FFP 3-6"	190
(LOC 3) FFP 3-15"	750

Surface soil (0-1") dioxin concentrations ranged from 360 to 1,500 ppt TEQ, significantly exceeding the Part 201 RDCC. The greatest surface soil concentration of 1,500 ppt TEQ was at FFP 1-1" (LOC 1), the most inland sample location. These results suggest that all of the soil located within Freeland Festival Park is likely to be contaminated with dioxin above the Part 201 RDCC.

Three deep soil borings were collected from Freeland Festival Park during December 2002. The deep soil borings extended to a depth of five feet bgl and were collected using a DEQ hydraulic probe sampler. Deep soil borings were collected at Location 1 (LOC 1) and Location 2 (LOC 2). Deep soil samples from these locations were collected at one foot intervals starting at two feet bgl (i.e., 16-24", 25-36", 37-48", and 49-60"). A deep soil boring could not be collected at Location 3 due to obstructions. A new soil sample location was collected near the center of the park (LOC 4). Since LOC 4 was a new sample location, soil samples were also collected at 0-3", 3-6", and 12-15".

Deep Soil Borings Freeland Festival Park	
Sample Identifier	Dioxin, ppt TEQ
(LOC 1) FFP 2-24"	1,600
(LOC 1) FFP 2-36"	130
(LOC 1) FFP 2-48"	64
(LOC 1) FFP 2-60"	12
(LOC 2) FFP 3-24"	98
(LOC 2) FFP 3-36"	14
(LOC 2) FFP 3-48"	1.4
(LOC 4) FFP 1-3"	1,600
(LOC 4) FFP 1-6"	2,600
(LOC 4) FFP 1-15"	170
(LOC 4) FFP 1-24"	7.0
(LOC 4) FFP 1-36"	24
(LOC 4) FFP 1-48"	7.7
(LOC 4) FFP 1-60"	1.7

Soil dioxin concentrations in the deep soil borings ranged from 1.4 to 2,600 ppt TEQ. The deep soil borings were collected in an effort to gain understanding regarding the vertical extent of soil dioxin contamination. At Freeland Festival Park the deep soil samples indicate that concentrations of dioxin above the Part 201 RDCC could be encountered at depths extending between three and four feet bgl.

Livestock Farm

Phase II soil samples were collected from a livestock farm operation located approximately nine miles downstream of Midland. Samples collected from this site are labeled LIVE. Soil samples were collected from three soil layers (0-3", 3-6", and 12-15") at six sample locations. Sample locations were selected both within and outside of the estimated 100-year flood plain contour. A large portion of the livestock farm is located outside of the flood plain. Flooding conditions within the Tittabawassee River flood plain at the time of sample collection prevented access to the majority of the livestock farm property that is located within the estimated 100-year flood plain.

Photo 7: Livestock Farm (LIVE)



Sample locations LIVE 1 through LIVE 5 were located outside of the estimated flood plain. The dioxin concentration ranged from 0.36 to 5.3 ppt TEQ for all soil layers at these five sample locations. The observed concentrations are consistent with statewide background dioxin concentrations. In addition, the dioxin congener profiles were similar to those established at sample locations located upstream of Midland. In contrast, soil dioxin concentrations for all soil layers at LIVE 6 were elevated above the average statewide background dioxin concentration with soil concentrations ranging from 22 to 34 ppt TEQ. Also, the dioxin congener profile is consistent with flood plain soil and river sediment samples collected from locations downstream of Midland. A more detailed discussion is provided in the section of this report entitled "Dioxin Congener Profile Data".

Livestock Farm Soil (LIVE), River Road, Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
LIVE 1-3"	1.3
LIVE 1-6"	1.7
LIVE 1-15"	0.48
LIVE 2-3"	4.2
LIVE 2-6"	3.0
LIVE 2-15"	0.36
LIVE 3-3"	3.6
LIVE 3-6"	5.2
LIVE 3-15"	0.69
LIVE 4-3"	3.3
LIVE 4-6"	1.0
LIVE 4-15"	0.46
LIVE 5-3"	5.3
LIVE 5-6"	3.3
LIVE 5-15"	2.0
LIVE 6-3"	22
LIVE 6-6"	29
LIVE 6-15"	34

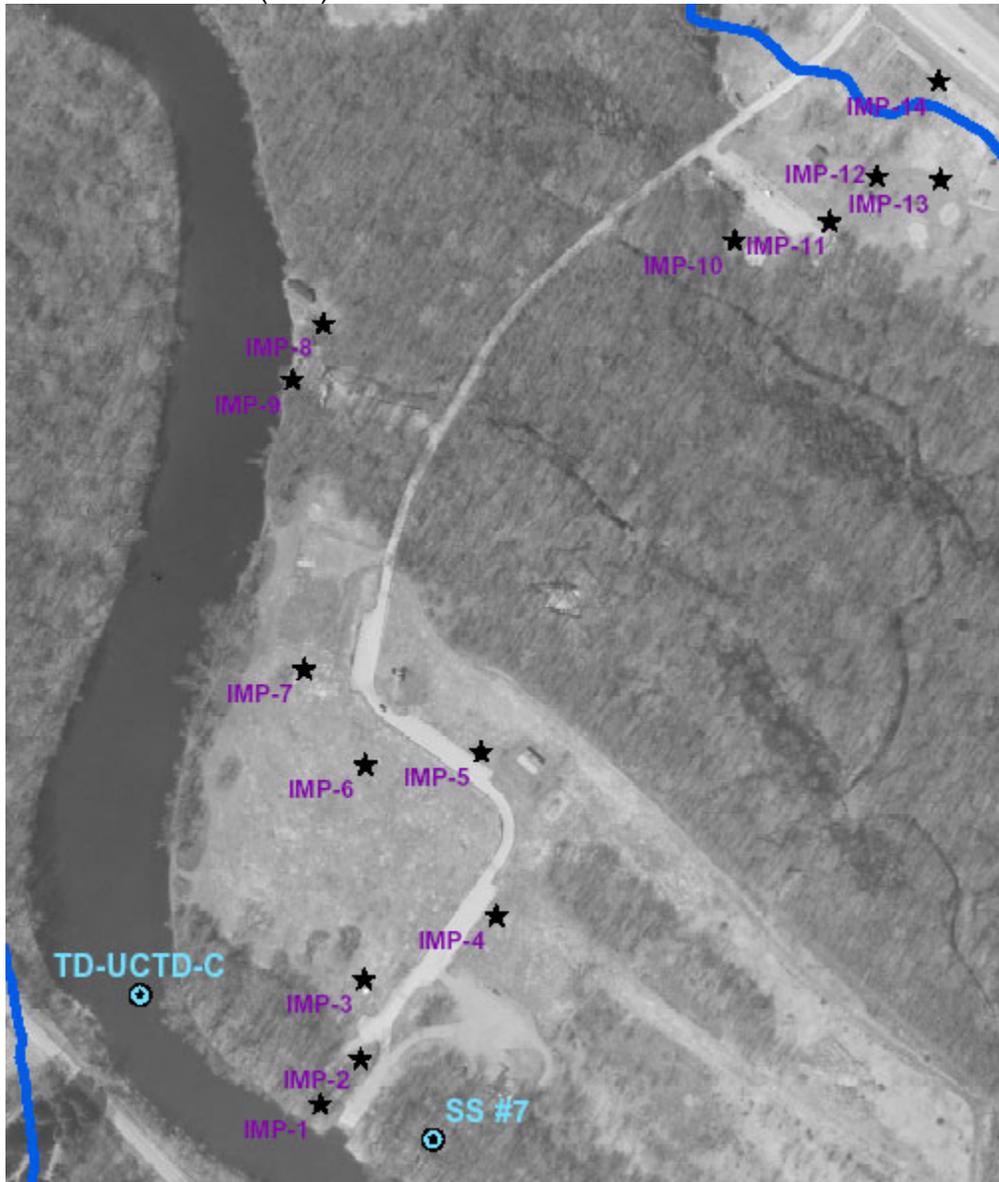
Imerman Park

Imerman Park is a large multi-use park operated by the Saginaw County Parks and Recreation Department, located approximately 11 miles downstream from Midland. The park provides a boat launch, canoe launch, pet exercise area, ball fields, open space, hiking trails, tennis courts, play sets, and picnic sites. The park is heavily used by local residents. The park property extends from the shoreline of the Tittabawassee River to M-47 (Midland Road). Although the vast majority of the park is located within the estimated 100-year flood plain a small portion along and adjacent to M-47 lies outside of the flood plain.

A total of 14 locations were sampled at Imerman Park. Samples collected from Imerman Park are labeled IMP. Soil samples were collected from three soil layers (0-3", 3-6", and 12-15") at 11 sample locations, these being IMP 1, 2, 3, 4, 5, 6, 10, 11, 12, 13, and 14. Soil samples were collected from four soil layers (0-1", 0-3", 3-6", and 12-15") at two sample locations, IMP 7 and 8. At IMP 9, samples were only collected from the upper three soil layers (0-1", 0-3", and 3-6"). A 12-15" sample was not collected due to the presence of subsurface obstructions

Dioxin concentrations at IMP 1 through IMP 10 exceeded the Part 201 RDCC at all soil layers, with concentrations ranging from 230 to 2,400 ppt TEQ. IMP 1 was collected at the boat launch near the river shoreline with sample locations continuing inland to IMP 10. IMP 10 is located at the picnic pavilion on the riverside of the upper parking lot. The highest concentration of 2,400 ppt TEQ was found at IMP 1-6" and represents the second highest soil dioxin concentration identified during the Phase II study. Surface soil samples (0-1") were collected at IMP 7, 8, and 9. The highest surface soil concentration was 1,400 ppt TEQ, located near the ball field, at IMP 7-1".

Photo 8: Imerman Park (IMP)



The estimated 100-year flood plain contour lies between the upper parking lot and M-47. Land elevation rises relatively quickly over this short distance. Sample locations IMP 11 through IMP 14 are located in this portion of the park. Although elevated above the statewide average background concentration, no sample collected from any soil layer at IMP 11 through IMP 14 identified dioxin concentrations exceeding the Part 201 RDCC with dioxin concentrations ranging from 2.9 to 40 ppt TEQ.

Imerman Park Soil (IMP), Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
Lower Elevation Sampling Locations	
IMP 1-3"	1,300
IMP 1-6"	2,400
IMP 1-15"	1,500
IMP 2-3"	1,200
IMP 2-6"	1,000
IMP 2-15"	900
IMP 3-3"	960
IMP 3-6"	940
IMP 3-15"	1,000
IMP 4-3"	610
IMP 4-6"	980
IMP 4-15"	670
IMP 5-3"	790
IMP 5-6"	620
IMP 5-15"	640
IMP 6-3"	1,100
IMP 6-6"	1,200
IMP 6-15"	570
IMP 7-1"	1,400
IMP 7-3"	1,600
IMP 7-6"	1,800
IMP 7-15"	1,200
IMP 8-1"	370
IMP 8-3"	670
IMP 8-6"	1,000
IMP 8-15"	380
IMP 9-3"	230
IMP 9-6"	630
IMP 10-1"	550
IMP 10-3"	310
IMP 10-6"	460
IMP 10-15"	440
Upper Elevation Sampling Locations	
IMP 11-3"	38
IMP 11-6"	40
IMP 11-15"	17
IMP 12-3"	11
IMP 12-6"	12
IMP 12-15"	5.4
IMP 13-3"	5.2
IMP 13-6"	4.8
IMP 13-15"	2.9
IMP 14-3"	37
IMP 14-6"	23
IMP 14-15"	14

Shields Elementary School

Shields Elementary School was added to the Phase II sampling study when initial Phase II sample results suggested that the majority of the estimated 100-year flood plain downstream of Midland was contaminated with elevated concentrations of dioxin. The school is located adjacent to the southern shoreline of the Tittabawassee River near the intersection of River and Stroebel Roads in James Township, approximately 17 miles downstream from Midland. The property was initially believed to be within the flood plain based on flood plain elevation information available to the DEQ.

Photo 9: Shields Elementary School (SES)



Soil samples collected from Shields Elementary School were labeled SES. Soil samples were collected from four soil layers (0-1", 0-3", 3-6", and 12-15") at five locations. It became apparent to DEQ staff during the sampling event, and from discussions with school administrators, that the school does not flood on a frequent basis. Although the school is surrounded by the 100-year flood plain it is constructed on land that is elevated above the estimated 100-year flood plain. The dioxin results from this location were consistent with statewide background concentrations, ranging from 0.28 ppt to 5.5 ppt TEQ.

Shields Elementary School (SES), 6900 Stroebel Rd., Saginaw County			
Sample Identifier	Dioxin, ppt TEQ	Sampler Identifier	Dioxin, ppt TEQ
SES 1-1"	3.9	SES 3-6"	3.1
SES 1-3"	4.5	SES 3-15"	0.89
SES 1-6"	1.8	SES 4-1"	5.4
SES 1-15"	0.80	SES 4-3"	2.5
SES 2-1"	3.9	SES 4-6"	1.3
SES 2-3"	2.9	SES 4-15"	0.59
SES 2-6"	0.74	SES 5-1"	2.2
SES 2-15"	0.28	SES 5-3"	5.5
SES 3-1"	3.8	SES 5-6"	2.5
SES 3-3"	4.4	SES 5-15"	1.8

West Michigan Park

West Michigan Park is located in Saginaw Township between Michigan Avenue and the Tittabawassee River approximately 18 miles downstream from Midland. The park, operated by the Saginaw Township Parks and Recreation Department, contains a fishing dock platform, play equipment, soccer field, picnic areas, and open space.

Photo 10: West Michigan Park (WMP)



Samples collected from West Michigan Park were labeled WMP. Samples were collected from four soil layers (0-1", 0-3", 3-6", and 12-15") at three sample locations. All soil samples contained dioxin at concentrations exceeding the Part 201 RDCC. Dioxin concentrations ranged from 140 to 670 ppt TEQ.

West Michigan Park Soil (WMP), Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
WMP 1-1"	460
WMP 1-3"	270
WMP 1-6"	350
WMP 1-15"	450
WMP 2-1"	510
WMP 2-3"	420
WMP 2-6"	670
WMP 2-15"	340
WMP 3-1"	270
WMP 3-3"	540
WMP 3-6"	540
WMP 3-15"	140

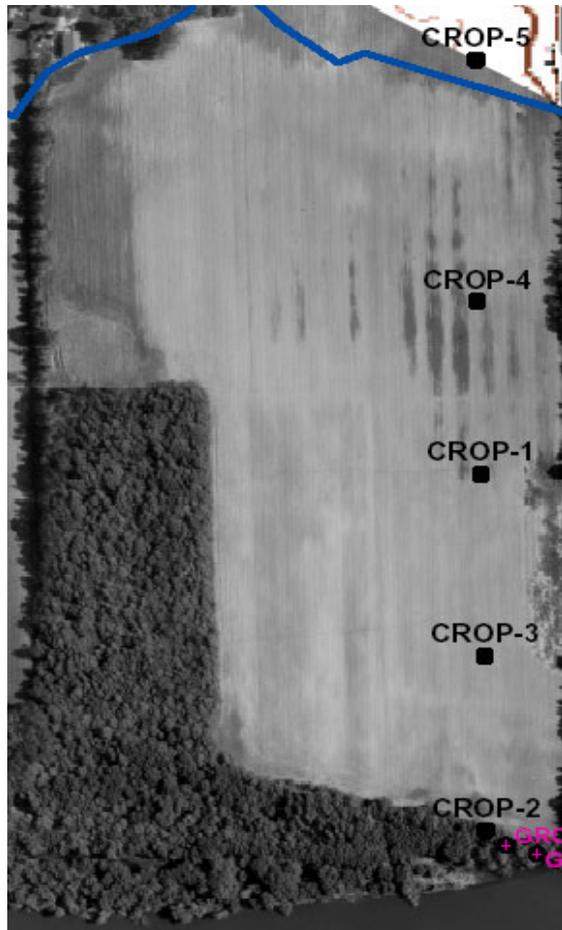
Crop Farm

The Phase II Crop Farm sample site is located approximately 20 miles downstream of Midland. The majority of the Crop Farm is located within the estimated 100-year flood plain. The former National Plate Glass (NPG) site of environmental contamination forms the eastern property boundary of the crop farm. A portion of the Crop Farm located adjacent to the Tittabawassee River is wooded. This wooded area was previously sampled as part of the Phase I.

Samples collected from this site are labeled CROP. Soil samples were collected from three soil layers (0-3", 3-6", and 12-15") at five sample locations. Dioxin concentrations at sample locations CROP 1 through CROP 3 ranged from 6.8 to 48 ppt TEQ. The dioxin concentrations observed at the crop farm were the lowest for any flood plain sample site downstream of Midland. All dioxin concentrations were less than the Part 201 RDCC and significantly less than Phase I soil sample results. Two Phase I soil samples collected from the wooded portion of the Crop Farm adjacent to the Tittabawassee River as part of the former NPG site assessment effort identified dioxin concentrations within the surface soil layer (0-1") of 180 and 410 ppt TEQ.

CROP 4 was located within the flood plain near the estimated 100-year flood plain contour, and CROP 5 was located just outside of the estimated flood plain contour. Dioxin concentrations at these sample locations were equivalent to statewide background with concentrations ranging from less than 0.15 to 1.9 ppt TEQ.

Photo 11: Crop Farm (CROP)



Given the pervasiveness of dioxin contamination within Tittabawassee River flood plain soil downstream of Midland, it is possible that there are local physical features that are impeding the deposition of dioxin onto Crop Farm soil. A forested area forms the southern and western boundaries of the Crop Farm. The forested area could be acting to slow the flow of the river during flood events resulting in the preferential deposition of river sediments within the forest area and reducing the amount available for deposition onto the Crop Farm. In addition, the NPG site is located directly to the east of the crop farm. As a result of glass production waste disposal practices that occurred during the period from 1900 through 1928, the elevation of the NPG property has been raised to a level approximately six to 10 feet higher than the adjacent Crop Farm property above the estimated 100-year flood plain elevation, and is acting as a barrier to river flow during flood events, forcing the flow of the Tittabawassee River to the south.

The Shiawassee Wildlife Refuge is located to the south, across the Tittabawassee River, from both the Crop Farm and NPG properties. Shiawassee Wildlife Refuge soil was sampled during Phase I (GP-1 through 5) with dioxin concentrations ranging from 35 to 1,100 ppt TEQ. In addition, soil from an island located in the river south of the former NPG was sampled (SS#2) during the DEQ Sediment Study and a dioxin concentration of 1,500 ppt TEQ was identified. Though not conclusive, these results appear to support a theory that physical features are affecting dioxin distribution at the Crop Farm area.

Crop Farm (CROP), West Michigan Avenue, Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
CROP 1-3"	19
CROP 1-6"	20
CROP 1-15"	19
CROP 2-3"	21
CROP 2-6"	21
CROP 2-15"	6.8
CROP 3-3"	48
CROP 3-6"	30
CROP 3-15"	22
CROP 4-3"	1.7
CROP 4-6"	1.3
CROP 4-15"	1.9
CROP 5-3"	0.52
CROP 5-6"	0.94
CROP 5-15"	0.15

National Plate Glass

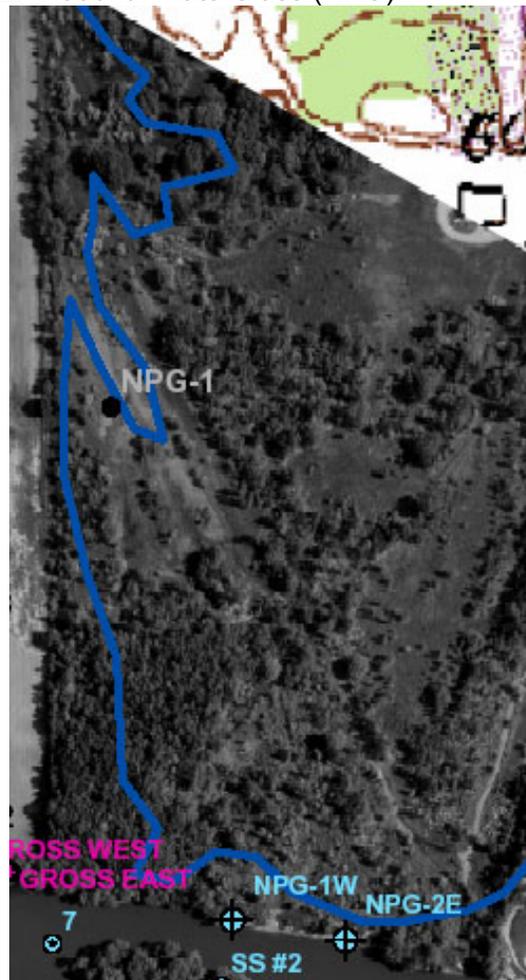
The former National Plate Glass site of environmental contamination (NPG) is located adjacent to the eastern boundary of the Crop Farm, approximately 20 miles downstream from Midland. As a result of glass production waste disposal practices that occurred during the period from 1900 through 1928 the elevation of the NPG property has been raised to a level approximately six to 10 feet higher than the adjacent Crop Farm property above the estimated 100-year flood plain elevation, and is acting as a barrier to river flow during flood events forcing the flow of the Tittabawassee River to the south. As a result, since the late 1920s it is probable that the former NPG property has not

been impacted by the vast majority of Tittabawassee River flood events that have occurred.

Soil samples collected from this site were labeled NPG. Soil samples were collected from three soil layers (0-3", 3-6", and 12-15") at one sample location. Dioxin concentrations were less than 1.0 ppt TEQ.

Former National Plate Glass Soil (NPG) Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
NPG 1-1"	0.97
NPG 1-3"	0.78
NPG 1-6"	0.57

Photo 12: National Plate Glass (NPG)



Groundwater that comes to be located within the elevated portion of the former NPG property eventually migrates overland to the Tittabawassee River. Water exiting the elevated area is commonly referred to as leachate. Two leachate water samples were collected. Dioxin concentrations in these water samples were 9.4 and 14 ppq TEQ.

Former National Plate Glass (NPG) Surface Water Run-off, Saginaw County	
Sample Identifier	Dioxin, ppq TEQ
NPG GW-1	9.4 ppq
NPG GW-2	14 ppq

Phase I soil samples collected from shoreline areas along the east and west boundaries identified the following dioxin TEQ concentrations:

National Plate Glass (NPG) May 2001 in ppt TEQ	
From the farm field west of NPG	
DX1 west	410
DX2 west	180
From the golf course east of the LA Davidson site	
DX3 east	2,600
DX4 east	2,500

It is probable that similar dioxin TEQ concentrations are present in shoreline soil located between the Phase I sample locations. The soil located along the southern boundary of the former NPG is sparsely vegetated and is susceptible to erosion. It is possible that leachate dioxin concentrations are the result of the suspension of dioxin contaminated soil particles in the water column as the leachate migrates across the shoreline soil.

Riverside Boulevard

Residences along Riverside Boulevard are located along the north shore of the Tittabawassee River near the confluence of the Tittabawassee and Shiawassee Rivers, approximately 22 miles downstream of Midland. Only one residential property was sampled on Riverside Boulevard because of property access issues. Samples collected from this site were labeled R 19. Soil samples were collected from three soil layers (0-3", 3-6", and 12-15") at R 19 1 and R 19 2, three soil layers (0-1", 0-3", and 3-6") at R 19 3, and one surface soil layer (0-1") at R 19 4 and R 19 5.

Photo 13: Riverside Boulevard (R)



All soil samples contained dioxin concentrations that exceeded statewide background concentrations. Nine of the 11 samples contain dioxin concentrations above the Part 201 RDCC. Dioxin concentrations ranged from 45 to 1,400 ppt TEQ with the highest concentration found at R 19 3-6”.

Riverside Boulevard (R 19) Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
R 19 1-3”	770
R 19 1-6”	530
R 19 1-15”	940
R 19 2-3”	240
R 19 2-6”	100
R 19 2-15”	140
R 19 3-1”	450
R 19 3-3”	1,100
R 19 3-6”	1,400
R 19 4-1”	45
R 19 5-1”	81

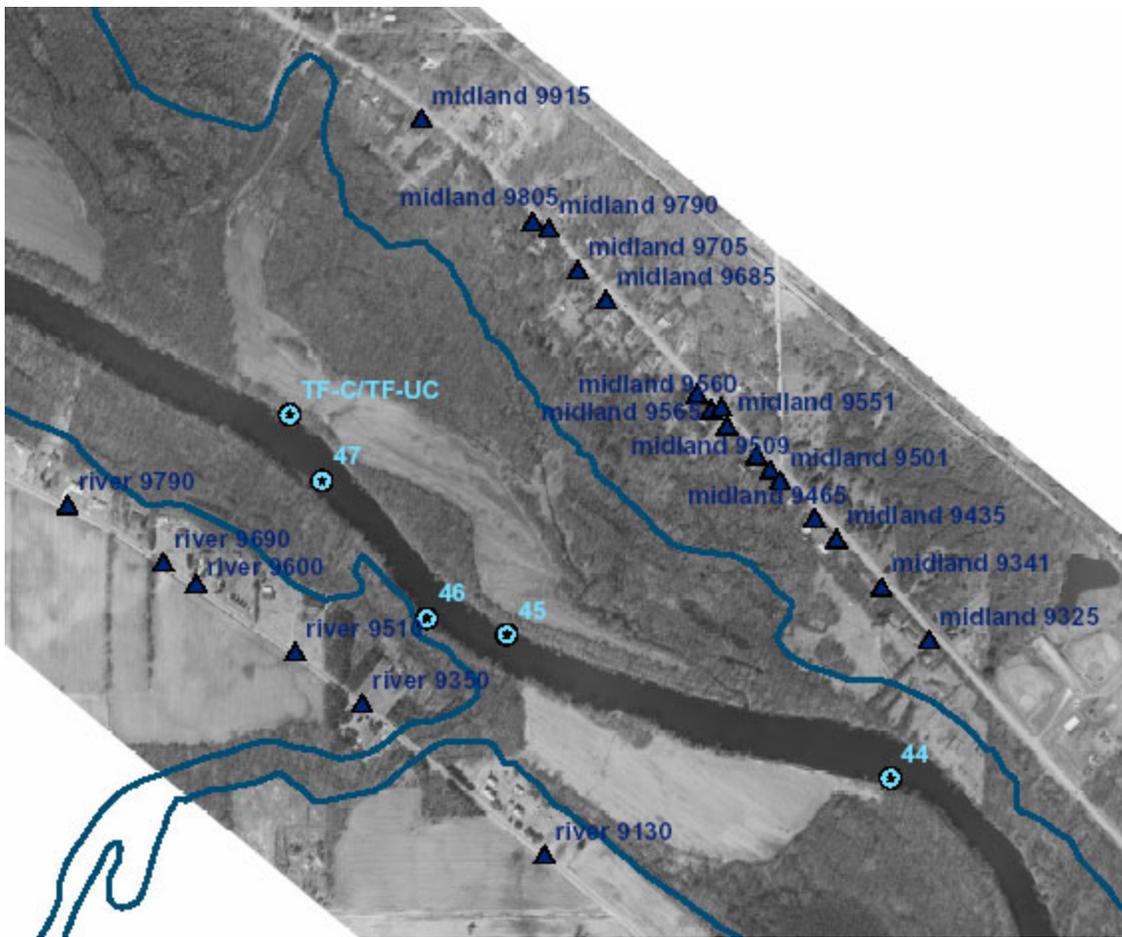
Chickens were being raised at this property for meat and eggs, which were subsequently consumed by the residents. The chickens were fed commercial feed, but they were also allowed to free range over the property. The property owners provided four eggs for dioxin analysis. Dioxin concentrations ranged from 16 to 49 ppt TEQ. Based on these results, the Department of Community Health (DCH) recommended that the property owners cease consumption of any food product from the chickens.

Eggs from Riverside Boulevard (R 19 Egg) Saginaw County	
Sample Identifier	Dioxin, ppt TEQ
R 19 egg 1	49
R 19 egg 2	42
R 19 egg 3	42
R 19 egg 4	16

VIII. Drinking Water Well Dioxin Data

The vast majority of businesses and residences located within and adjacent to the Tittabawassee River flood plain are serviced by municipal drinking water supplies. However, some residences to the south and east of Midland, along the east and west shorelines of the Tittabawassee River, continue to acquire potable water from groundwater. The Phase II included the collection of groundwater samples from selected residential drinking water wells.

Photo 14: Drinking Water Wells (private) with Street Addresses



The initial samples were collected by the Saginaw County Health Department based on a field assessment and recommendations by DEQ staff. Wells located in close proximity to the Tittabawassee River and most susceptible to inundation during flood events were selected for initial sampling. The DEQ collected additional water samples to augment and confirm the initial sample results. Twenty-two residential potable water wells were sampled along the portion of Midland Road between Buck and Sarle Roads and the portion of River Road between Smith's Crossing and Sarle Roads. The sample results did not confirm any dioxin concentration above the current drinking water criteria of 30 ppq of dioxin TEQ, established by the USEPA.

IX. Dioxin Congener Profile Data

As discussed previously in this report, dioxins and furans are a group of 210 chemicals commonly having similar structures and chemical properties. Each dioxin chemical has its own specific chemical structure, referred to as a congener. Dioxins are stable chemicals and can last for many years in the environment. In the environment dioxin is found as a mixture of the various dioxin congeners. Defining the type and amount of dioxin congeners present in an environmental sample can help to determine the source for the dioxin release. A quantitative assessment of the various congeners present in an environmental sample can be used to create a color bar chart commonly referred to as a congener profile chart. Each different color bar on the congener profile chart represents a different dioxin congener. The length of each of the color bar is proportional to the toxicity the congener contributes to the TEQ of the sample.

Dioxin and PCB congener profile charts were created for all Phase II soil and groundwater sample results. In addition, dioxin congener profile charts were created for the Phase I data, Midland Soil Study, and USACE Saginaw River/Saginaw Bay Dredge Sediment samples. These charts are presented in Appendix J. The congener profiles for the DEQ Sediment Study are presented in Appendix H.

Congener Profile Charts – Upstream of Midland

Congener profile charts illustrate the similarity of the type and relative abundance of dioxin congeners found at sample locations upstream of Midland. Upstream sample locations were located within the flood plains for the Tittabawassee, Chippewa, and Pine Rivers. Upstream sample locations include the following:

- Tittabawassee River – Sanford
- Chippewa River – Chippewa Nature Center
- Pine River – Chippewa Nature Center

Congener profile charts for upstream sample locations identify a mixture of dioxin congeners that is consistently different from the mixture of dioxin congeners present at all sample locations within the Tittabawassee River flood plain downstream of Midland. Downstream of Midland, within the flood plain, the mixture is dominated by certain furan congeners, whereas upstream the mixture is dominated by dioxin congeners.

Congener Profile Charts – Downstream of Midland Outside of the 100-Year Flood Plain

Congener profile charts illustrate the similarity of the type and relative abundance of dioxin congeners at sample locations downstream of Midland but outside of the estimated 100-year flood plain contour. Locations outside of the 100-year flood plain are not exposed to regular flooding by the Tittabawassee River. Downstream sample locations, outside of the 100-year flood plain, include the following:

- Livestock Farm (sample locations LIVE 1 through LIVE 4)
- Imerman Park (sample location IMP 14)
- Shields Elementary School
- Crop Farm (sample locations CROP 4 and CROP 5)
- National Plate Glass

Congener profile charts for these sample locations are similar to charts for upstream sample locations. Congener profile charts for these sample locations identify a mixture of dioxin congeners that is consistently different from the mixture of dioxin congeners present at all sample locations within the Tittabawassee River flood plain downstream of Midland, indicating a different source of dioxin contamination.

Congener Profile Charts – Downstream of Midland Within the Estimated Flood Plain

Congener profile charts illustrate the similarity of the type and relative abundance of dioxin congeners at sample locations downstream of Midland within the estimated 100-year flood plain contour. Soil dioxin contamination at these locations consists of a mixture of dioxin congeners that are dominated by furans. At locations upstream of Midland, and at downstream locations outside of the flood plain, the mixture is dominated by dioxin congeners. This is illustrated by the congener profile charts for the following Phase II sample locations:

- Caldwell Boat Launch
- Freeland Festival Park
- Livestock Farm (sample locations LIVE 5 and LIVE 6)
- Imerman Park (sample locations IMP 1 through IMP 13)
- West Michigan Park
- Crop Farm (sample locations CROP 1 through CROP 3)
- Riverside Boulevard

These locations are exposed to regular flooding by the Tittabawassee River. River flooding and sediment deposition appear to be the most probable mechanisms for distributing dioxin at these sample locations. The congener profile charts for these locations are similar amongst themselves and very different from sample locations located upstream of Midland, as well as sample locations downstream of Midland but outside of the flood plain. This similarity exists regardless of the quantity of dioxin found at the sample location. As an example, Crop Farm sample location CROP 2-15" has only 7.0 ppt TEQ dioxin, but the congener profile chart is similar to Freeland Festival Park sample location FFP 1-15" which had the highest Phase II dioxin concentration of 3,400 ppt TEQ.

Congener Profile Charts – Egg Samples

Chickens were being raised at the Riverside Boulevard sample location at the time of sample collection. The chickens were provided with commercial feed but were also allowed to free range over the property. Four eggs were collected and subsequent analysis identified dioxin concentrations ranging from 16 to 48 ppt TEQ. The congener profiles from the eggs are similar to the congener profiles that are present in flood plain soil downstream of Midland. Congener profile charts illustrate the similarity of the type and relative abundance of dioxin congeners in the egg samples with flood plain soil samples collected from flood plain soil at the Riverside Boulevard residence. This suggests that the source of the dioxin identified in the egg samples is the soil that the chickens are in contact with and ingesting as part of free range feeding practices.

Congener Profile Charts – Transitional Areas

Certain Phase II sample locations represent transition areas between locations upstream and downstream of Midland, and downstream locations within and outside of the estimated 100-year flood plain contour. These locations include:

- Emerson Park
- Livestock Farm (sample locations LIVE 4 through LIVE 6)
- Imerman Park (sample locations IMP 11 through IMP 14)
- Crop Farm (sample locations CROP 3 through CROP 5)

Emerson Park - Emerson Park is located in Midland along the Tittabawassee River just upstream of the confluence of the Chippewa and Tittabawassee Rivers. As discussed previously, concentrations of dioxin in Emerson Park soil are elevated above state-wide background concentrations, except for sample location EMP 2-15", below the Part 201 RDCC. Although concentrations at Emerson Park are elevated above concentrations observed at sample locations further upstream, the chart illustrates that the type and relative abundance of dioxin congeners is similar to upstream locations and Midland soil locations. It is possible that the increased concentrations observed at Emerson Park are related to the proximity of the park to the source of the dioxin release.

Livestock Farm (LIVE 4 – 6) - Soil samples were collected at the Livestock Farm from locations both outside and within the estimated 100-year flood plain. Sample location LIVE 6 is located within the flood plain, sample location LIVE 5 is located near but just outside of the estimated 100-year flood plain contour, and sample location LIVE 4 is located outside of the flood plain. The congener profile chart for the Livestock Farm reflects this, visually illustrating the transition from statewide background/upstream dioxin concentrations to the furan dominant congener distribution shared by all soil sample locations downstream of Midland within the Tittabawassee River flood plain.

Imerman Park (IMP 11 – 14) - The majority of Imerman Park is located within the estimated 100-year flood plain. Soil sample locations IMP 11 through IMP 14 were collected from that portion of the park located between the upper parking lot and Midland Road (M-47). Location IMP 14 was located between the tennis courts and M-47, just outside of the estimated 100-year flood plain. The congener profile chart visually illustrates the transition from statewide background/upstream dioxin concentrations to the furan dominant congener distribution shared by all soil sample locations downstream

of Midland within the Tittabawassee River flood plain, with the sole exception being IMP 14-15". However, debris indicative of fill material was encountered at this location which may be responsible for this result.

Crop Farm (CROP 3 – 5) - The majority of Crop Farm property is located within the estimated 100-year flood plain. Soil sample locations CROP 1 through CROP 4 are located within the flood plain with sample location CROP 5 located outside of the estimated flood plain. Congener profile charts for sample locations CROP 1 through CROP 3 are similar to the furan dominant congener distribution shared by all soil sample locations downstream of Midland within the Tittabawassee River flood plain. CROP 4, near the upper portion of the estimated 100-year flood plain, shows decreasing relative abundance of furan congeners, and at CROP 5 the congener profile chart identifies that the dioxin distribution outside of the flood plain is similar to upstream dioxin concentrations and congener distributions.

X. Grain Size Analysis

Grain size analysis of the soil samples was conducted for all samples collected during the Phase II study. Previous studies have shown that dioxin tends to preferentially adsorb to the surface of fine-grained colloidal soil particles. Establishing a correlation between the grain size distribution and dioxin contamination level in flood plain soils could provide a useful, relatively inexpensive tool to use in assessing the potential that any given property contains dioxin at sufficient concentrations to be of concern to human health and the environment. Qualitative evaluation of the relationship between grain size and dioxin concentration suggests that the higher levels of dioxin contamination are not necessarily associated with the finer grained soils. Further work is necessary to evaluate the relationship between grain size and dioxin concentration.

XI. Total Organic Carbon

All soil samples collected during the Phase II study underwent analysis to determine the total organic carbon content. Organic carbon is carbon-based material contained in soil that originated from biological processes. Total organic carbon analysis was conducted to determine if there exists a correlation between the amount of organic carbon present in a soil sample and the amount of dioxin contamination present in the sample.

Research has demonstrated that dioxin has a tendency to adsorb to the surface of fine-grain colloidal soil particles. Many of these colloidal particles found in soil originated as a result of biological processes. Establishing a correlation between the amount of total organic carbon present in a soil sample and the amount of dioxin present in the sample could provide a useful relatively inexpensive tool to use in assessing the potential that any given property contains dioxin at sufficient concentrations to be of concern to human health and the environment. Qualitative evaluation of the relationship between total organic carbon and dioxin concentration suggests that the higher levels of dioxin contamination are not necessarily associated with the presence of total organic carbon. Additional work is necessary to evaluate the correlation between total organic carbon and dioxin levels in flood plain soils.

XII. Other Data

U.S. Army Corps of Engineers (USACE) – Saginaw River/Bay Sediment Data

During February 2002 the RRD received a copy of excerpted data from a USACE funded assessment of dioxin concentrations in sediments that had come to be located in the commercial shipping channel located in the Saginaw River and Saginaw Bay (USACE Sediment Assessment). It is the understanding of the RRD that the USACE Sediment Assessment was conducted by the USACE as part of its ongoing efforts to dredge and properly dispose of dredged sediments as part of its shipping channel maintenance efforts. During 1998 and 1999, sediment samples were collected and analyzed from the Saginaw River and Saginaw Bay throughout the length of the shipping channel from the Sixth Street turning basin, located on the north side of the City of Saginaw, out to shipping channel locations in Saginaw Bay. The information provided to the RRD is summarized below.

U.S. Army Corps of Engineers Sediment Assessment Saginaw River and Saginaw Bay	
Sample Identifier	Dioxin, ppt TEQ
SR9901	84
SR9902	44
SR9903	330
SR9904	41
SR9905	340
SR9906	74
SR9907	11
SR9908	26
SR9909	93
SR9910	100
SR9911	550
SR9912	170
SR9913	3.0
SR9914	7.9
SR9915	3.1
SR9916	31
SR9917	210
SR9918	110
SR9919	130
SR9920	110
SR9921	140
SR9922	9.6
SR9923	110
SR9924	250
SR9925	130
SR9926	150
SB9901	190
SB9902	190
SB9903	130
SB9904	110
SB9905	180
SB9906	56
SB9907	29
SB9908	49
SB9909	42

Samples collected from Saginaw River sediments are labeled SR and samples collected from Saginaw Bay sediments are labeled SB. It is the understanding of the RRD that the samples were collected from commercial shipping channel sediments and as such may not reflect dioxin TEQ concentrations in areas of the Saginaw River and Saginaw Bay that are not subject to repeated dredging activity. Detailed sample results are presented in Appendix I.

The USACE Sediment Assessment data indicates that the dioxin contamination observed in the Saginaw River and Saginaw Bay is similar to the furan dominated mixture of dioxin congeners that has been identified in Tittabawassee River sediments and flood plain samples collected downstream of Midland. The congener profile charts illustrate correlation (Appendix J). The data suggests that dioxin contaminated sediment from the Tittabawassee River has migrated into the Saginaw River and out into the inner portions of the Saginaw Bay.

The USACE Sediment Assessment sampling locations are from the commercial shipping channel which is continuously dredged as part of USACE shipping channel maintenance efforts. It is likely that accumulated dioxin contamination is periodically removed from the shipping channel as it is dredged. It is possible that the level of dioxin contamination is different in those areas of the Saginaw River and Saginaw Bay that are not subject to maintenance dredging activity. The continuing presence of dioxin contamination in shipping channel sediments, given historical and ongoing maintenance dredging activities, indicates that dioxin contaminated sediments are continuing to migrate from the Tittabawassee River into the Saginaw River and Bay.

December 2002 DEQ Saginaw River and Bay Shoreline Dioxin Data

During December 2002, DEQ staff collected a limited number of soil samples from three shoreline areas along the Saginaw River and Saginaw Bay. Soil samples were collected from three locations within the shoreline areas of the Crow Island State Wildlife Refuge, one shoreline location at the Department of Natural Resources boat launch facility located near the mouth of the Saginaw River, and one shoreline location near the southern boundary of the Bay City State Recreation Area. The sample results are presented in ppt TEQ and are comparable to the results obtained by the USACE Sediment Assessment.

December 2002 DEQ Saginaw River/Bay Soil Samples	
Sample Identifier	Dioxin, ppt TEQ
CROW ISL 1 0-3"	5.4
CROW ISL 1 3-6"	12
CROW ISL 1 12-15"	0.85
CROW ISL 2 0-3"	130
CROW ISL 2 3-6"	37
CROW ISL 2 12-15"	190
CROW ISL 3 0-3"	140
CROW ISL 3 3-6"	0.94
DNR 1 0-2"	8.0
STATE PK 1 0-2"	220

Saginaw River, Saginaw Bay, and PCB

Industrial activities along the Saginaw River have released PCBs into the Saginaw River and Saginaw Bay ecosystems. The majority of these industrial facilities are currently engaged in site investigation and remediation activities in accordance with state and federal environmental laws. Significant remedial efforts have been completed that have contained or removed PCB contaminated soil from shoreline areas and removed PCB contaminated sediments from the Saginaw River. Even with these ongoing PCB remediation efforts, any future investigation into dioxin contamination of the Saginaw River sediments and flood plain, and Saginaw Bay sediments and shoreline, areas should also include an evaluation of any PCB contribution to dioxin-like toxicity. However, PCB data generated from the December 2002 soil samples are comparable to the Phase II PCB data and suggest that PCB represents a minor contribution to dioxin TEQ in the Saginaw River and Saginaw Bay shoreline soil.

XIII. Conclusions

Most of the soil samples that were collected from within the estimated 100-year flood plain downstream of Midland are contaminated with dioxin above the Part 201 RDCC. The highest Phase II dioxin concentration, 3,400 ppt TEQ, was encountered at Freeland Festival Park, seven miles downstream of Midland. A dioxin concentration of 1,400 ppt TEQ was identified approximately 22 miles downstream of Midland at a Riverside Boulevard property. The DEQ believes that the following conclusions can be drawn from the Phase I, Phase II, and DEQ Sediment Study and USACE Sediment Assessment data sets:

- Dioxin contamination within the estimated 100-year flood plain downstream of Midland is extensive. The Phase II study results suggest that much of the property located within the estimated 100-year flood plain downstream of Midland contains soil dioxin concentrations above the Part 201 RDCC.
- Soil samples collected upstream of Midland did not contain elevated levels of dioxins. Dioxin concentrations from these sample locations were consistent with statewide background concentrations.
- Samples collected downstream of Midland, but outside of the estimated 100-year flood plain, did not contain elevated dioxin concentrations. Dioxin concentrations in soils collected from these locations were consistent with statewide background concentrations. Existing information suggests that property located outside the estimated 100-year flood plain downstream of Midland may not be contaminated above state-wide background concentrations. However, property located outside the estimated 100-year flood plain that received soil or fill material from property located within the estimated 100-year flood plain has the potential to be contaminated with dioxin above statewide background concentrations. In addition, other pathways such as blowing dust have the potential to transport dioxins out of the flood plain at levels of concern.
- Properties located within the general boundaries of the estimated flood plain, but elevated above the flood plain due to the presence of local natural features or the introduction of clean fill material, may not contain elevated dioxin concentrations.

As an example, dioxin concentrations in the Shields Elementary School samples ranged between 0.28 and 5.5 ppt TEQ.

- Surface soil dioxin contamination within the 100-year flood plain is a significant concern. Surface soil dioxin concentrations significantly exceed the Part 201 RDCC at Imerman Park, Riverside Boulevard, Caldwell Boat Launch, West Michigan Park, and Freeland Festival Park.
- The Phase II study did not define the vertical extent of the dioxin contamination. At some sample sites the greatest dioxin contamination was identified at the deepest Phase II sample depth (12-15"). The highest concentration identified during the Phase II study, 3,400 ppt TEQ, was found at Freeland Festival Park, FFP 1-15. This indicated that dioxin contamination can extend beyond the lowest Phase II sample depth. In response to this observation, three deep soil borings were collected from Freeland Festival Park during December 2002. These deep soil samples indicate that concentrations of dioxin above The Part 201 RDCC could be encountered to depths of three to four feet below ground level (bgl).
- Dioxin contamination was encountered to depths of three to four feet bgl. The depth of contamination encountered during this investigation indicates that dioxin has been accumulating in the Tittabawassee River flood plain over an extended period of time.
- The presence of significant dioxin contamination in the floodplain is thought to be the result of the continuing redistribution of contaminated sediment throughout the flood plain during flood events.
- The type and relative distribution of dioxin congeners (i.e., congener profile) of impacted soil downstream of Midland are similar. A quantitative analysis of congener distributions should be pursued.
- Analysis of some samples included dioxin-like PCBs. The contribution of PCBs to the total dioxin TEQ for these samples was trivial relative to the contribution provided by dioxin and furan congeners. The dioxin TEQ values presented in this report do not incorporate PCB TEQ contributions, which are very small in comparison to the total dioxin TEQ.
- Dioxin concentrations were elevated in eggs that were sampled from chickens that free ranged on flood plain soil. It is possible that food products from other animals raised on the flood plain may also be affected. This has resulted in an advisory by the Departments of Community Health and Agriculture against consumption of any animal food product that has been raised on property located within the boundaries of the estimated 100-year flood plain. It is also possible that wildlife populations that reside within the flood plain may be similarly affected.
- Dioxin concentrations in flood plain soil do not appear to be related to total organic carbon or grain size soil characteristics. The Phase II data suggest that the amount of dioxin present in flood plain soil is related to the depositional

characteristics of a given property. Additional work is necessary to determine how total organic carbon and grain size correlate with the level of dioxin contamination in flood plain soils.

- Phase II drinking water well confirmation sample results were below applicable regulatory criteria.

The Phase II study identified that elevated dioxin concentrations were pervasive in Tittabawassee River 100-year flood plain soil downstream of Midland. The geographic distribution of the contamination, the similarity of the congener profiles, and the presence of dioxin contamination at depth in flood plain soils indicate that The Dow Chemical Company manufacturing facility (Dow) in Midland is the principal source of dioxin contamination in the Tittabawassee River sediments and the Tittabawassee River flood plain soils.

XIV. Recommendations

Investigation Activities

Over the past two years, samples were collected at a total of 17 sample sites along three rivers from an area extending eight miles upstream of Midland to approximately twenty-two miles downstream of Midland at the confluence of the Tittabawassee and Saginaw Rivers. The information generated from these investigation activities has provided a general understanding of the concentration and distribution of dioxin within flood plain soil and river sediments. Additional information is needed to better understand dioxin distribution within certain areas of the Tittabawassee River flood plain, establish the vertical extent of the dioxin contamination, and identify the downstream extent of the contamination. These investigation activities should be coordinated with off-site corrective action required by the Dow Part 111 hazardous waste and corrective action operating license. Recommended investigation activities include the following:

- Identify all residential properties within the 100-year flood plain that are at high risk to have significant dioxin soil contamination. Properties identified to be at high risk should undergo soil sampling and analysis to adequately assess dioxin contamination. Decisions on further interim response action would be made based on these results.
- Additional investigation is needed in Saginaw River sediments and the Saginaw River flood plain. The highest flood plain dioxin concentration, 7,300 ppt TEQ, was identified at the confluence of the Saginaw and Tittabawassee Rivers. The USACE data collected during 1999, show that sediments from the Saginaw River shipping channel contained elevated concentrations of dioxin. These data indicate that dioxin contamination extends to the inner portions of Saginaw Bay. There is no hydraulic barrier to prevent the continued migration of dioxin from the Tittabawassee River into the Saginaw River and Saginaw Bay. Therefore, it is reasonable to conclude dioxin contamination has migrated and is continuing to migrate from the Tittabawassee River into the Saginaw River. Additional investigation should be conducted to evaluate Saginaw River sediments located outside of the shipping channel, flood plain areas, and shoreline areas within inner portions of the Saginaw Bay.

- An ecological risk assessment should be conducted to determine the impact of dioxin contamination on resident aquatic and wildlife populations. Evaluating the ecological impact of dioxin contamination in the Tittabawassee and Saginaw Rivers is especially important given the presence of two wildlife refuges in the lower Tittabawassee and upper Saginaw River areas, and other wildlife areas located nearby along the Chippewa and Bad Rivers, and the shoreline of Saginaw Bay.
- Human consumption of game (e.g., deer and turkey) residing on the 100-year flood plain should be evaluated to determine if there is a human health concern.
- Sampling and analysis of residential water supply wells should be conducted immediately after a major flooding event, or when well casings have been flooded.
- Further identification and assessment of the exposure pathways and health risks to flood plain residents is necessary. This evaluation should be conducted by the DEQ in coordination with the DCH and the ATSDR and should include the consideration of indoor and outdoor exposure pathways.
- The Michigan Department of Agriculture investigations are necessary to quantify the impact of dioxin soil contamination on agricultural products grown and raised within the flood plain.
- An assessment of the pathways and risks associated with wind-borne transport of dioxin contaminated soil particles is necessary.
- Evaluation of the vertical distribution of dioxin contamination in flood plain soils at additional locations within the flood plain downstream of Midland is necessary.
- Additional investigation is needed at the Dow manufacturing complex in Midland to ensure that all potential pathways for dioxin release to the Tittabawassee River have been identified and eliminated.

Interim Response Activities

The Phase II study has confirmed that residential and public use properties located within the estimated 100-year flood plain downstream of Midland, and sampled as part of the study, contain significant concentrations of dioxin that exceed the Part 201 RDCC. The highest concentration identified at a public park area was over 40 times the Part 201 RDCC. The highest concentration identified at a residential property was nearly 20 times the RDCC. The pervasiveness of dioxin contamination found at locations sampled within the flood plain suggests that similar contamination conditions exist at other properties located within the flood plain. Interim response activities need to be implemented that immediately address the health risk presented by soil dioxin contamination on residential and public use of flood plain property. Recommended interim response activities include the following:

- Action should be initiated to eliminate unacceptable dioxin exposure to Riverside Boulevard residents and any other similarly contaminated residential properties that are located in frequently flooded areas within the 100-year flood plain downstream of Midland.
- Unacceptable exposures to dioxin contaminated soils in public areas (e.g., parks and boat launches) should be eliminated.
- Efforts should be initiated to reduce or eliminate activities occurring within contaminated portions of the flood plain that result in the movement and/or redistribution of contaminated soil in a manner that results in the exacerbation of existing contamination. Activities that result in increased human exposure to dioxin contamination or contamination of previously uncontaminated property need to be controlled.
- Remedial activities (e.g., sediment trap or other sediment collection and removal technologies) should be evaluated and tested to determine the effectiveness for use as an interim response or a final remedy.

Public Information

- Public information meetings should be regularly scheduled with affected residents and local government officials to ensure adequate discussion of information and to provide adequate access to Department staff.
- The DEQ should continue developing and distributing information bulletins to provide wider distribution of information and progress updates.

XV. For More Information

Information Contacts	Information Repositories
<p>Environmental sampling/analysis: Department of Environmental Quality (DEQ) Sue Kaelber-Matlock, Project Manager Saginaw-Bay District Office 503 N. Euclid Ave., Suite 9, Bay City, MI 989-686-8025/ext. 8303 matlocks@michigan.gov</p>	<p>Grace A. Dow Memorial Library 1710 W. St. Andrews Midland, Michigan 989-837-3457</p>
<p>ATSDR and public health: Department of Community Health (DCH) Dr. Linda Dykema, Toxicologist Environmental & Occupational Epidemiology 3423 N. Martin Luther King Jr Blvd, Lansing, MI 517-335-8566; DykemaL@michigan.gov</p>	<p>Zaue Memorial Library 3100 N. Center Saginaw, Michigan 989-799-2771</p>
<p>Residential/commercial agriculture/ gardening: Department of Agriculture (MDA) Brian Hughes, Toxicologist 525 W. Allegan, Lansing MI 517-337-5067; HughesB9@michigan.gov</p>	<p>DEQ Saginaw Bay District Office. 503 N. Euclid Avenue, Suite 9 Bay City, MI 48706-2965 989-686-8025</p>

XVI. Appendices

- Appendix A** - Phase II Soil and Egg Dioxin Results
- Appendix B** - Phase II Soil and Egg PCB Results
- Appendix C** - Dioxin Results from Surface Water at National Plate Glass
- Appendix D** - Residential Water Well Dioxin Results
- Appendix E** - Saginaw River and Bay Shoreline Soil Dioxin Results
- Appendix F** - Saginaw River and Bay Shoreline Soil PCB Results
- Appendix G** - Phase I Soil Dioxin Results
- Appendix H** - Selected DEQ Tittabawassee River Sediment Study Results and Maps (*also known as: Baseline Chemical Characterizations of Saginaw Bay Watershed Sediments*)
- Appendix I** - U.S. Army Corps of Engineer Dioxin Results of the Sediments in the Saginaw River and Saginaw Bay Shipping Channel (1998/1999)
- Appendix J** - Dioxin Congener Profile Charts

To view copies of the complete report (including appendices), please refer to the listing of Information Repository locations provided in Section XV of this Report, or go to the DEQ Home Page: www.michigan.gov/deg and select Land, then Dioxin Information (under Quick Links), then Tittabawassee River Flood Plain Contamination.