EPA-905/4-88-008
DECEMBER 1988

RISK MANAGEMENT RECOMMENDATIONS

FOR

DIOXIN CONTAMINATION AT MIDLAND, MICHIGAN

FINAL REPORT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V
CHICAGO, ILLINOIS 60604

ACKNOWLEDGEMENTS

The Michigan Dioxin Studies and the resulting risk assessment and risk management recommendations have been conducted and developed under the auspices of the United States Environmental Protection Agency (USEPA) Region V Dioxin Task Force. David Stringham was chairman of the Dioxin Task Force from its inception in 1983 until 1986, when Howard Zar assumed the chair. Gary Amendola was USEPA's project manager for the Michigan Dioxin Studies.

Amendola was the principal author of this report. Zar and Jonathan Barney collaborated with Amendola in developing and refining the risk management recommendations. Section III, a summary of the risk assessment, was initially prepared by ICF-Clement Associates, Inc., and edited by Barney. Zar provided Regional policy guidance and coordinated the extensive reviews by Region V, USEPA Headquarters, and the Agency for Toxic Substances Disease Registry (ATSDR). This report was reviewed by the following Region V staff: David Barna, Daniel Bicknell, Donald Bruce, Dr. J. Milton Clark, David DeVault, Cynthia Fuller, Carlton Nash, Walter Redmon, Vacys Saulys, Martin Trembly, and Carol Witt. Comments were also received from Dr. Donald Barnes, Office of Pesticides and Toxic Substances; from David Cleverly, Office of Research and Development (ORD); and from other USEPA staff in ORD and the Office of Solid Waste, as well as from ATSDR.

Many other current and former Region V staff have contributed or participated in the investigations of dioxin contamination in the Midland, Michigan, area over the past ten years. These include Curtis Ross, Director, Central Regional Laboratory; Charles Elly, Marcia Kuehl, Francis Thomas, and Kevin Bolger of the laboratory staff; and Charles Beier, Karl Bremer, Thomas Daggett, Larry Fink, David Dolan, Philip Gehring, Joseph Good, Willie Harris, John Perrecone, Vanessa Musgrave, and William Reynolds. Staff in a number of USEPA laboratories have contributed to the development of analytical results. Included are Robert Harless at the Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina; Dr. Douglas Kuehl and Brian Butterworth at the Environmental Research Laboratory, Duluth, Minnesota; and Dr. Aubry Dupuy and Danny McDaniel at the Pesticides Monitoring Laboratory, Stennis Space Center, Mississippi. The staffs of the Michigan Departments of Natural Resources and Public Health contributed significantly to the planning and implementation of many aspects of the investigative programs.

USEPA acknowledges the cooperation and assistance of local government officials, notably Mayor Joseph Mann and City Manager Clifford Miles, City of Midland; the many citizens of Midland and surrounding communities who cooperated in the studies and provided thoughtful comments; and the Dow Chemical Company in conducting the field studies and for providing analytical services when requested. Finally, USEPA wishes to acknowledge the efforts of Emilia Parker and the staff of the Midland Public Library, Kurt Shaffner of Ingersoll Township, and Winifred Oyen of the Midland County Health Department, who have maintained information repositories for this undertaking.

TABLE OF CONTENTS

I

INTRODUCTION

Environmental Risk Assessment is a scientific process in which facts and assumptions are integrated and used to estimate the potential for adverse effects on human health or the environment that may result from exposures to specific pollutants. The risk assessment protocol followed by the United States Environmental Protection Agency (USEPA) includes the following components (USEPA 1986):

- o Hazard Identification
- o Dose-Response Assessment
- o Human Exposure Assessment
- o Risk Characterization

The hazard identification is a qualitative risk assessment, establishing the potential toxicity or hazard of a particular substance. The dose-response assessment defines the relationship between the dose of a substance and the probability of induction of adverse health effects. The human exposure assessment is conducted to estimate, in a specific situation or setting, what are the probable and maximum human exposures to a substance (i.e., dose rates), including evaluations of potential high risk groups. In risk characterization, the results of the dose-response and human exposure evaluations are combined to estimate potential adverse health impacts, with a review of the uncertainties in the overall analysis. The risk assessment for dioxin contamination in and around Midland, Michigan, is fully described in a companion report to this document, Risk Assessment for Dioxin Contamination at Midland, Michigan (USEPA 1988a), referred to hereafter as the Risk Assessment.

Risk management, on the other hand, is a decision-making process which can involve much more than consideration of the results of a risk assessment. Often, such factors as technological feasibility, economic information about costs and benefits, statutory requirements, and public concerns can heavily influence risk management. This report sets out risk management recommendations for contamination with 2,3,7,8-tetrachlorodibenzo-p-dioxin (2378-TCDD) and other polychlorinated dibenzo-p-dioxins (CDDs) and polychlorinated dibenzo-furans (CDFs) in and around Midland, Michigan (see Figure I-1).

On April 28, 1988, USEPA conducted a public meeting in Midland to present, and accept public comment on, the results of the risk assessment and a series of proposed risk management actions. The public comment period extended until June 3, 1988. This report has been revised to include a summary of the public comments and responses (Appendix A); recent information regarding contaminant levels in game fish from the Tittabawassee River (Appendix B); limited data for homegrown vegetables in Midland (Appendix C); revised risk estimates based upon the recent fish contaminant levels; and final risk management recommendations. The outline and content of this report are similar to those in the public review draft report, Proposed Risk Management Actions for Dioxin Contamination at Midland, Michigan (USEPA 1988b).

the necessary information to answer questions related costs.

USEPA developed the final risk management recommendations presented in this report taking into account the Risk Assessment, all of the public comments, the current status of ongoing remedial actions, and the recent fish contaminant data presented in Appendix B. We believe that these are reasonable and necessary measures which can be implemented through existing regulatory mechanisms at the state and federal levels. USEPA believes that the measures relating to the Dow Chemical plant can most effectively be implemented through existing air, solid waste, and water pollution control programs managed by MDNR and USEPA Region V. Measures relating to fish consumption advisories can most effectively be managed through the existing framework established by the Michigan Department of Public Health.

This document provides: (1) a brief summary of the results of a number of studies undertaken by the USEPA, the State of Michigan, and Dow Chemical Company; (2) a summary of possible health risks to Midland area residents resulting from exposures to CDDs and CDFs; (3) actions for minimizing emissions and discharges to the environment from Dow Chemical; (4) recommendations for people living in the Midland area on how to minimize their exposures to CDDs and CDFs, and thus the possible health risks associated with those exposures; and (5) additional monitoring programs, some of a continuing nature, for the purposes of establishing long-term trends in emissions and discharges of CDDs/CDFs, and to document changes in environmental contamination for the more significant human exposure routes. As noted above, a summary of public comments and responses for the Risk Assessment and proposed Risk Management Actions is presented in Appendix A.

II

SUMMARY OF ENVIRONMENTAL AND POINT SOURCE INVESTIGATIONS

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (CDDs and CDFs, respectively) are closely-related families of highly toxic and persistent organic chemicals which have been formed as unwanted by-products in some commercially significant chemical reactions, during high temperature decomposition and combustion of certain chlorinated organic chemicals, and through other reactions involving chlorine and organic materials.

Dow Chemical has manufactured over 1,000 different inorganic and organic chemicals at the Midland facility. The manufacture of chlorinated phenols and herbicides, and the formulation of pesticides and other products derived from them have been major operations at the Dow Midland facility for many years. Commercial production of chlorinated phenols began in the 1930's and continued at substantial levels into the late 1970's. Dow Chemical reports that only two chlorinated phenolic products--2,4-dichlorophenol and 2,4-dichlorophenoxyacetic acid (2,4-D)--are currently manufactured at Midland (Dow 1984). Incineration has been practiced since at least the 1930's with varying levels of emission controls. Currently, Dow Chemical operates a rotary kiln incinerator for combustion of both hazardous and non-hazardous wastes. Prior to 1980, a "tar burner" was also operated at the site to dispose of still bottoms and other hazardous chemical residuals (Dow 1988a).

In June 1978, Dow Chemical informed the Michigan Department of Natural Resources (MDNR) and USEPA that rainbow trout exposed to a mixture of Dow Chemical's treated effluent prior to discharge from outfall 031 to the Tittabawassee River accumulated significant levels of 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2378-TCDD), the most toxic of the CDD/CDF compounds (Dow 1978). Supplemental analyses of edible portions of Tittabawassee River catfish, previously collected in 1976 downstream of the discharge from the Dow Chemical facility, showed concentrations of 2378-TCDD ranging from 70 to 230 parts per trillion (ppt). Dow Chemical also reported 2378-TCDD analyses for catfish, carp, rock bass, crappie, and perch collected in 1977. The results of these studies prompted the Michigan Department of Public Health (MDPH) to issue a formal advisory in June 1978 warning against consumption of any fish collected from the Tittabawassee River downstream of Dow Dam (MDNR 1978). The advisory remained in effect until March 1986, when the MDPH modified it to apply only to catfish and carp, after reviewing 1985 monitoring data showing that walleyes and other game fish were contaminated at levels below a 10 ppt criterion established by MDPH using its own risk assessment/risk management methodologies. (The advisory has since been strengthened twice, in April and December 1988. See section IV(B)(1) below.)

In response to the Dow Chemical findings, the MDNR and USEPA, Region V undertook a number of investigations during the period 1978-1981 to determine whether, or to what extent, the Dow Chemical operations at Midland contributed to 2378-TCDD contamination in Tittabawassee River fish. These investigations included a caged fish bioaccumulation study and an experimental large volume wastewater effluent sampling program conducted in September 1981. The results of

those studies conclusively demonstrated that the Dow Chemical wastewater effluent was a significant source of 2378-TCDD to the Tittabawassee River. The preliminary results from those studies were released in March 1983 with a series of recommendations for more comprehensive CDD/CDF studies in Midland and elsewhere (USEPA 1983a). Most of those recommendations were subsequently incorporated into USEPA's Dioxin Strategy and National Dioxin Study (USEPA 1983b, 1987a).

Also, in March 1983, the State of Michigan made a formal request to the then acting administrator of USEPA for assistance in conducting a comprehensive multi-media investigation of CDD/CDF emissions and discharges from Dow Chemical and CDD/CDF contamination in the Midland area (MDNR 1983). In the spring and summer of 1983, USEPA collaborated with the Michigan Departments of Agriculture, Natural Resources, and Public Health, and the Michigan Attorney General's Office in planning for the requested studies. At about the same time, local environmental groups petitioned USEPA pursuant to Section 21 of the Toxic Substances Control Act for broad scale toxic pollutant investigations of an eight-county area in mid-Michigan including Midland County (ECOMM and Foresight 1983). Although USEPA subsequently denied that petition, some of the requested investigations were within the scope of those being planned by Region V and the State agencies for the Midland area (USEPA 1983c).

The studies conducted by USEPA and the State were formally called the Michigan Dioxin Studies and included the following major elements:

1. Supplemental fish and sediment sampling in the Tittabawassee River.

2. Surface soil sampling at Dow Chemical, in the city of Midland, and at comparison sites.

3. Evaluation of public and private potable water supplies and Dow Chemical brine operations.

4. Supplemental Dow Chemical wastewater and sewer system sampling.

5. Incinerator emissions testing and limited ambient air monitoring.

These investigations included analyses of CDDs and CDFs and other toxic pollutants that might be present, and were consistent with the then-evolving USEPA Dioxin Strategy. Since the Dow Chemical Plant was considered to have operations within Tiers 1, 2, 3, 4, and 6 of the Dioxin Strategy, funding for the studies was provided principally through the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) program. All Tier 1 and 2 facilities in the Dioxin Strategy were studied through Superfund.

In 1983, Dow Chemical initiated its own independent point source investigation of CDDs and CDFs at the Midland Plant. That work included comprehensive surface soil sampling at the plant, untreated and treated process wastewater sampling, incinerator emissions testing and limited ambient air monitoring (Dow 1984). Dow Chemical has also conducted supplemental incinerator emissions testing in 1987 (Dow 1987a), supplemental monitoring of Tittabawassee River fish in response to a consent order with USEPA (U.S. v. Dow 1984), and twice-monthly

monitoring for 2378-TCDD in the treated process wastewater discharge to the Tittabawassee River (Dow 1984-1988).

Studies by Dow and USEPA revealed widespread contamination of the surface soil at the Midland facility (on the average, less than 0.5 ppb 2378-TCDD) (Dow 1984, USEPA 1985a). Several small areas within the facility were found to be more highly contaminated (2-50 ppb). USEPA studies indicated lower-level contamination of the soils throughout the community with CDDs/CDFs (average <0.1 ppb 2378-TCDD) (USEPA 1985a). Since these studies were undertaken, Dow has been ordered to remediate areas of high on-site contamination to prevent the spread of contaminated soil (USEPA 1985c). The sources of the on-site soil contamination appear to have been leaks or fugitive emissions from one or more of the production processes discussed above and fallout from the waste incinerator. The off-site soil contamination has been attributed to airborne emissions of CDDs/CDFs from the waste incinerator, wind-borne transport of contaminated soil from the facility, and possibly past fugitive emissions from production operations.

Studies by Dow Chemical indicate the hazardous waste incinerator is the most significant current air emission source at the Midland Plant (Dow 1984). Emissions testing by USEPA in 1984 (Trembly and Amendola 1987) and Dow Chemical in 1987 (Dow 1987a) indicated substantially reduced emission levels from those measured in 1983 by Dow.

Significant levels of CDDs/CDFs have also been detected in the effluent from the Dow wastewater treatment system to the Tittabawassee River (0.01-0.05 ppt 2378-TCDD in 1984; <0.002 to 0.008 ppt 2378-TCDD currently) (Dow 1984-1988). The current lower levels are the direct result of the 1984 Final Order of Abatement issued by the Michigan Water Resources Commission (MWRC) and the MDNR, requiring Dow Chemical to install a final effluent filtration system and implement a plant-wide program to reduce CDDs/CDFs (MWRC 1984). Studies conducted by USEPA, the U.S. Food and Drug Administration (USFDA), the MDPH and MDNR, and Dow Chemical between 1979 and 1985 revealed that 2378-TCDD persisted at levels of concern in Tittabawassee River fish, despite shutdown of the Dow Midland production facilities for the manufacture of 2,4,5-trichlorophenol, the derivative 2,4,5-T herbicide, and pentachlorophenol, chemicals known to be contaminated with CDDs and CDFs. Sampling and analysis of Tittabawassee River sediments in 1978 and 1984 failed to detect 2378-TCDD, but did establish the presence of a number of other CDDs and CDFs in patterns indicating Dow Chemical as the most probable source. The levels found were not judged high enough to warrant removal of sediments, but the extent of the data was not sufficient to rule out the possibility of more highly contaminated areas elsewhere. (Amendola and Barna 1986).

Recent data collected by the MDNR, MDPH, USEPA and Dow (MDNR 1988, USEPA 1988c, Dow 1988c) indicate 2378-TCDD levels in game fish have declined from levels found in 1983-1985 (see Appendix B). Data collected in 1985 and 1988 also show that Tittabawassee River fish collected downstream of Dow Chemical are contaminated with several other organic chemicals, the most significant being PCBs. Dow Chemical is not believed to be a significant source of PCBs. Chemicals other than CDDs/CDFs were not found in any other media (air, soil, etc.) at levels that would warrant specific consideration in this report.

The USEPA has compiled the data from its testing programs (USEPA 1985a, Barna and Amendola 1985, Amendola and Barna 1986, Trembly and Amendola 1987) and all available data from other investigations and has prepared a comprehensive Risk Assessment (USEPA 1988a) for individuals living in the Midland area. A summary of the Risk Assessment, with revised risk estimates based upon the recent fish contaminant data, is presented in Section III.

III

SUMMARY OF USEPA RISK ASSESSMENT

In keeping with guidelines established by USEPA and by the National Academy of Sciences and other scientific advisory bodies, USEPA's Risk Assessment for Midland, Michigan, involved four distinct activities: hazard identification, dose-response assessment, exposure assessment, and risk characterization. As noted earlier, the first step, hazard identification, defines the basic toxicologic properties of CDDs/CDFs and identifies the most important toxic effects observed both in studies of animals exposed to these compounds and in human epidemiological studies. Dose-response assessment, the second step, consists of further review and analysis of these studies in order to develop an understanding of the relationships between the amount of CDDs/CDFs to which humans may be exposed and the likelihood and severity of adverse health effects.

The exposure assessment consists of a review of the available data regarding the levels of CDDs/CDFs found in and around Midland and the development of quantitative estimates of the amount of CDDs/CDFs to which Midland area residents may be exposed. Finally, risk characterization involves the combination of the dose-response information and the exposure estimates to derive an assessment of the levels of risks faced by the various exposed populations in Midland.

Also included in the Risk Assessment are discussions of the extent of uncertainty associated with the exposure and risk estimates. For each route of exposure (inhalation of ambient air, contact with contaminated soils, etc.) more than one exposure scenario was developed using ranges of assumptions about environmental levels of CDDs/CDFs and exposure-related behavior of the exposed populations.

A. HAZARD IDENTIFICATION

Chlorinated dibenzo-p-dioxins (CDDs) and dibenzofurans (CDFs) constitute a family of over 200 related chemical compounds (congeners) with varying chemical, physical, and toxicologic properties. The congener that appears to be the most toxic and has generally raised the greatest health concerns is 2,3,7,8-tetrachlorodibenzo-p-dioxin, abbreviated as 2378-TCDD.

Experimental studies with 2378-TCDD in animal systems have demonstrated a variety of toxic effects resulting from exposure to this compound (USEPA 1985b). These effects include carcinogenesis, cancer promotion, reproductive and teratogenic effects, immunotoxic effects, thymus atrophy, liver damage, and effects on the skin and thyroid. Limited toxicological testing of other CDDs/CDFs has demonstrated that several of these compounds cause similar toxicological effects, but that higher doses are generally required to cause effects of comparable magnitude to those induced by 2378-TCDD.

USEPA has determined that the critical end points of concern for purposes of assessing risks associated with exposure to CDDs/CDFs in the Midland area are cancer and reproductive and teratogenic effects. In addition, under certain conditions, toxic effects on the liver and immune system may also be significant

in risk assessment. The evidence for these health effects is discussed in more detail in Chapter II of the Risk Assessment.

B. DOSE-RESPONSE ASSESSMENT FOR 2378-TCDD

The evidence for the carcinogenic (cancer-causing) action of 2378-TCDD is provided mainly by several long-term studies of laboratory animals exposed to the substance. On the basis of these animal studies and associated factors, USEPA has concluded that 2378-TCDD is an animal carcinogen and should be regarded as a probable human carcinogen (USEPA 1986). Applying its established procedures, USEPA used the experimental animal data to estimate an upper bound on the cancer potency factor (referred to as "q_1^*") for 2378-TCDD of 1.6×10^{-4} $(pg/kg/day)^{-1}$ over a 70-year lifetime. Note: "pg" stands for picogram = 10^{-12} gram.

While the above value remains USEPA's current position on the potency of 2378-TCDD, and, therefore, was the one used in preparing the Risk Assessment, a formal reassessment of its derivation is under way (USEPA 1988d). Final results of that reassessment are not expected for at least several months.

2378-TCDD has been shown to be teratogenic and to cause adverse reproductive effects in a number of animal species, including subhuman primates (USEPA 1985b). USEPA has examined the data in detail and has selected a value of 1 pg/kg/day as the Reference Dose (RfD)* for 2378-TCDD (USEPA 1987b). This value is used in the risk assessment to evaluate the potential for non-cancer effects resulting from long-term exposures to CDDs/CDFs. USEPA is also concerned about doses which pregnant women might ingest over a short period at a critical time in the development of the fetus. USEPA therefore has adopted a "health advisory" (HA) dose-level of 300 pg/kg/day for protection against teratogenic effects. This HA dose-level is appropriate for comparison with single-dose or single-day exposures, whereas the RfD of 1 pg/kg/day is more appropriate for comparison with long-term or lifetime exposures.

Although USEPA has determined that reproductive/teratogenic effects are the critical noncarcinogenic toxic effects for dose-response assessment of 2378-TCDD, based upon a review of several animal studies, USEPA has concluded that the RfD of 1 pg/kg/day also is appropriate to protect against possible liver damage in all populations experiencing long-term exposures to CDDs/CDFs (USEPA 1985b). For short-term exposures (a few days to a few weeks), the animal data support an HA for liver effects of 28 pg/kg/day, and, for single-dose or single-day exposures, an HA of 280 pg/kg/day has been adopted, which is close to the single-dose HA derived for reproductive/teratogenic effects. The toxicologic parameters used in the Risk Assessment are summarized in Table III-1.

---

*The RfD, which is used for assessing toxic effects other than cancer, can be defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure (daily dose, e.g., in pg/kg/day) of a human population (including sensitive subpopulations) that is likely to be without an appreciable risk of adverse health effects even if exposure occurs daily during a lifetime.

TABLE III-1

TOXICOLOGIC PARAMETERS FOR CDDs/CDFs
USED IN THE MIDLAND, MICHIGAN, RISK ASSESSMENT

Toxicologic End Point	Type of Parameter	Parameter Value
Cancer	Dose-Response Slope Parameter (95% upper confidence limit)	1.6×10^{-4} $(pg/kg/day)^{-1}$ ["B2"]*
Teratogenesis/Reproductive Effects:		
long-term exposures	RfD	1 pg/kg/day
single-dose exposures	HA	300 pg/kg/day
Hepatotoxicity (liver effects):		
long-term exposures	RfD	1 pg/kg/day
short (10-day) exposures	HA	28 pg/kg/day
single-dose exposures	HA	280 pg/kg/day

*In USEPA's weight-of-evidence classification system for carcinogens, B2 indicates that the evidence for carcinogenicity in animals is "sufficient", while the human evidence for carcinogenicity is "inadequate." B2 is placed in quotation marks, because the classification was for 2378-TCDD alone, whereas total TEQs are being evaluated here, in accordance with USEPA interim science policy.

All of the toxicological dose-response estimates described above--cancer potency, Reference Dose, and Health Advisory--were derived by extrapolating animal test results to humans through the use of mathematical models and/or application of uncertainty factors. This approach is necessary because accurate data on human exposures to CDDs/CDFs, and on the resulting toxic effects, are not available. USEPA believes that its methods for dose-response assessment are conservative, and that the estimates so derived are unlikely to be exceeded when humans are exposed to CDDs/CDFs. The Agency recommends that the estimates be used for assessing risks and for decision-making related to the protection of human health, keeping in mind the uncertainties inherent in their derivation.

C. DOSE-RESPONSE ASSESSMENT FOR CDD/CDF MIXTURES

Studies have generally shown that most CDDs and CDFs cause similar effects to those caused by 2378-TCDD in the same bioassay systems, but that 2378-TCDD is the most potent. USEPA has adopted as interim science policy the "toxicity equivalence factor (TEF)" approach for use until sufficient additional data are available to derive a more accurate procedure that can be scientifically validated (USEPA 1987c). The TEF approach uses correlations between structure and chemical activity to estimate the toxicity of any CDD/CDF mixture with regard to both carcinogenic and noncarcinogenic endpoints. The result is expressed as an equivalent amount of 2378-TCDD.

The TEF approach was used in the Risk Assessment to convert reported quantities of CDDs/CDFs in environmental samples to "2378-TCDD toxicity equivalents" (TEQs), which were then treated as if they were concentrations of 2378-TCDD. The TEF approach and its limitations are discussed in more detail in Part II.C of the Risk Assessment.

D. EXPOSURE ASSESSMENT

Quantitative estimates were developed for the significant routes of exposure to CDDs/CDFs in the Midland area as outlined below.

1. Exposure to Ambient Air

Two scenarios were developed to estimate exposures of Midland area residents to CDDs/CDFs in ambient air. The "fenceline case" represents exposure for a hypothetical individual residing near the Dow Chemical plant boundary at a location downwind (according to the prevailing wind direction) from the incinerator and production areas; the "residential area case" represents exposures further away from the plant, in the more densely populated areas of Midland to the north of the facility. For each scenario, average exposure (dose rate) estimates were derived for four specific age ranges as well as for an entire lifetime. The procedures used to develop the air exposure estimates and their limitations and associated uncertainties are described in detail in Section III.B of the Risk Assessment.

2. Exposure to Contaminated Soil

The "lower estimate" and "upper estimate" of exposure were developed using lower and higher estimates for (1) the frequency of exposure, (2) the amounts of

soil ingested as a result of outdoor activities, and (3) the fraction of CDDs/CDFs absorbed into the body from the ingested soil. Individual lifetime segment and lifetime average estimates of exposure/dose rates were derived as for air. The methods used to derive these estimates and their limitations and associated uncertainties are discussed in detail in Section III.C of the Risk Assessment.

3. Exposure Through Consumption of Contaminated Fish

The five exposure scenarios which have been developed (see Table III-2) vary with regard to the amounts and types of fish consumed (all fish is assumed to come from the Tittabawassee River except for half of the fish eaten by the "general consumer"). Long-term consumption rates were used to estimate 70-year lifetime CDD/CDF ingestion or dose rates to assess excess cancer risks and for comparison with the RfD for non-cancer effects. Single-meal CDD/CDF ingestion rates also were developed to compare with the short-term HA values. Note that the 1988 fish contaminant data indicate a decline in the 2378-TCDD TEQ concentration exceeding 50 percent from the average value for game fish collected in the 1983-1987 period (see Appendix B).

The exposure assessment established that consumption of contaminated fish was clearly the dominant route of CDD/CDF exposure for some populations, with exposure and intake levels being as much as several orders of magnitude higher than those associated with other exposure routes. The methods used to develop these estimates and their limitations and associated uncertainties are described in detail in Section III.E of the Risk Assessment.

4. Other Possible Routes of Exposure

Several other possible routes of human exposure were evaluated in the Risk Assessment (Section III.F). Consumption of ground water or surface water were found unlikely to be associated with CDD/CDF exposure. Other routes that were considered were exposure to potentially-contaminated house dust and exposure of infants through breast milk.

Since no measurements were available of the levels of CDDs/CDFs in household dust in Midland, no quantitative estimates of exposure through this route could be conducted. It was concluded, however, based upon studies of other situations where exposures to toxic pollutants in house dust had been measured, that this route of exposure could be comparable to some of the other exposures that were quantifiable.

Similarly, CDD/CDF levels in breast milk from the Midland area have not been measured. However, a simple pharmacokinetic model (Smith 1987) was employed to estimate intakes for nursing infants.

Finally, sufficient data are not available which would allow a quantitative assessment of the exposures from consumption of CDDs/CDFs contained in or deposited on home-grown vegetables. An initial sampling program by USEPA in the fall of 1987 did not indicate uptake of CDDs/CDFs by root crops grown in Midland soils, but neither the range of vegetables sampled nor the overall number of samples was large enough to yield final conclusions.

TABLE III-2

FISH CONSUMPTION SCENARIOS
FOR TITTABAWASSEE RIVER, MICHIGAN

Scenario	Consumption Rate	Type of Fish[a]
Plausible Maximum Consumer	Long-term: 100 g/day[b] (6.7 lbs/month) Single Meal: 255 g[c]	50% Bottom feeders + 50% Game fish
High Sports Fisherman		
-- Level 1	Long-term: 100 g/day[b] (6.7 lbs/month) Single Meal: 255 g[c]	100% Game fish
-- Level 2[d]	Long-term: 48 g/day[e] (3.2 lbs/month) Single Meal: 113 g[f]	100% Game fish
Great Lakes Consumer[g]	Long-term: 16 g/day[h] (1.1 lbs/month) Single Meal: 113 g[f]	100% Game fish
General Consumer	Long-term: 7.8 g/day[i] (0.52 lbs/month) Single Meal: 113 g[f]	50% Game fish + 50% Clean fish

[a]All fish are assumed to be from the Tittabawassee River except "clean" fish which are assumed to be free from CDD/CDF contamination. The fish tissue concentrations used in the Risk Assessment (1983-1987 data) and those found in the most recent sampling are provided below (all are means):

Type of Fish	Partial TEQs (ppt) 1983-1987 Data	TEQs (ppt) 1988 Data
Bottom feeders	58	(Only game fish sampled)
Game fish	13	5.7
Clean fish (by definition)	0	0

[b]90th percentile consumption rate for a cohort of Lake Michigan sports fishermen who ate more than 24 lbs of fish per year (Humphrey et al. 1976).

[c]90th percentile fish meal size (USDA 1982).

[d]Referred to in Risk Assessment as "Median Sports Fisherman."

[e]Median for a cohort of Lake Michigan sports fishermen who ate more than 24 lbs of fish per year (Humphrey 1983).

[f]Median fish meal size (USDA 1982).

[g]Added following completion of Risk Assessment, using the information and procedures contained in that document.

[h]FDA-estimated upper 90th percentile consumption rate of freshwater fish in the Great Lakes area (USEPA 1984a).

[i]Average consumption of "finfish other than canned, dried, and raw" (USDA 1982). Figures for Tittabawassee River fish only would be 3.9 g/day and 0.26 lbs/month).

E. RISK CHARACTERIZATION

Quantitative estimates of the risks associated with CDD/CDF exposures by the routes just discussed were developed by combining the exposure and intake estimates with the toxicologic parameters discussed in the Dose-Response Assessment. For long-term exposures to air and soil contamination, two measures of risks were developed, an upper-bound estimate of the additional cancer risks associated with lifetime exposures at the predicted levels, and a Hazard Index (HI)* for non-carcinogenic effects.

For a given exposure scenario, an HI of less than 1.0 indicates that exposures are not likely to be associated with adverse non-cancer effects (reproductive toxicity, teratogenicity, or liver toxicity). If the HI approaches or exceeds 10, the likelihood of adverse effects is increased to the point where action to reduce human exposure should be considered. Owing to the uncertainties involved with these estimates, HI values between 1 and 10 may be of concern, particularly when additional significant risk factors are present (e.g., other contaminants at levels of concern).

The risk levels predicted for each of the three major exposure routes are summarized in Tables III-3 through III-6. For air exposures, (see Table III-3) the predicted incremental, lifetime cancer risks (upper bound) range from 5×10^{-6}["B2"] to 6×10^{-5}["B2"], depending upon the exposure scenario and the method used to calculate TEQs. Many of the HIs for the various age groups and scenarios are less than 0.1, and all but one are less than 1.0.

The upper-bound excess cancer risk estimates associated with exposures to contaminated soil (see Table III-4) are slightly lower than those for the air route; estimated lifetime risks are 5×10^{-7} ["B2"] for the "lower estimate" scenario and 1×10^{-5} ["B2"] for the "upper estimate". The HIs for non-cancer effects are likewise lower than for air exposures.

Both the cancer and non-cancer risks calculated for CDD/CDF exposures via contaminated fish are much greater than for the other two pathways (see Table III-5). For comparison purposes, risk estimates are presented for the 1983-1987 fish contaminant data used in the Risk Assessment and for the walleye data collected in 1988. Generally speaking, the 2378-TCDD TEQ concentrations for the walleyes have decreased by somewhat more than half. Thus, the risk estimates are reduced by about a factor of two, assuming the same consumption patterns. Upper-bound estimates of incremental lifetime cancer risks range from 6×10^{-5} ["B2"] for the "general consumer" (1988 walleye data) to as high as 1×10^{-2} ["B2"] for the "plausible maximum consumer" (1983-1987 carp and catfish data). Although 1988 catfish and carp data are not available, it is likely that the concentrations of 2378-TCDD TEQs are lower than those measured in 1983-1987. The estimated risks would be reduced accordingly. The HIs approach or exceed 10 for several of the scenarios, based upon the 1988 walleye data and taking into account the estimated increased exposures of small children and breast-fed

---

*Defined as the ratio of the estimated average daily dose to the previously defined RfD (or HA for single or short-term exposures).

TABLE III-3

RISK CHARACTERIZATION FOR INHALATION OF CDDs/CDFs
IN AMBIENT AIR IN MIDLAND, MICHIGAN
(September 1984 Samples)

Exposure Scenario[a]	Upper-Bound Cancer Risk[b] A-Method[d]	Upper-Bound Cancer Risk[b] B-Method[d]	Hazard Index[c] (Long Term) A-Method[d]	Hazard Index[c] (Long Term) B-Method[d]
1. Fenceline Case:				
Infants 0-1 year	--	--	0.4	0.1
Children:				
1-6 years	--	--	1	0.4
6-12 years	--	--	0.7	0.3
Adults (12-70)	--	--	0.3	0.1
Lifetime	6×10^{-5}["B2"][e]	2×10^{-5}["B2"]	--	--
2. Residential Area				
Infants 0-1 year	--	--	0.05	0.02
Children:				
1-6 years	--	--	0.2	0.08
6-12 years	--	--	0.1	0.06
Adults (12-70)	--	--	0.05	0.02
Lifetime	1×10^{-5}["B2"]	5×10^{-6} ["B2"]	--	--

[a]From Section II.B.6*. All exposure estimates assume 24 hr/day exposure to outdoor concentrations, long-term residence (lifetime for cancer risks).

[b]Upper-bound estimate of additional lifetime cancer risk, obtained by multiplying exposure estimate in Table III-12* by cancer potency factor of 1.6×10^{-4} $(pg/kg/day)^{-1}$ and multiplying by relative bioavailability factor of 1.8 (see Section IV.C*).

[c]Ratio of exposure estimate in Table III-12* to RfD of 1 pg/kg/day, multiplied by relative bioavailability factor of 1.8, for exposures lasting several months or more. Shorter exposures (a few days to a few weeks) would yield indices about 28-times lower.

[d]A-Method assumes all Pe-, Hx- and Hp-CDDs and CDFs are 2378-substituted. B-Method assumes all congeners within these groups are equally prevalent (see Part II*).

[e]In USEPA's weight-of-evidence classification system for carcinogens, B2 indicates that the evidence for carcinogenicity in animals is "sufficient", while the human evidence for carcinogenicity is "inadequate." B2 is placed in quotation marks, because the classification was for 2378-TCDD alone, whereas total TEQs are being evaluated here, in accordance with USEPA interim science policy.

*In Risk Assessment

TABLE III-4

RISK CHARACTERIZATION FOR INGESTION OF CDDs/CDFs
IN SOIL IN MIDLAND, MICHIGAN
(October 1983 Samples)

Exposure Scenario[a]	Upper-Bound Lifetime Cancer Risk[b]	Hazard Index[c] (Long Term)
Lifetime Average Exposure:		
1. Lower Estimate:		
Infants 0-1 year	--	0.02
Children:		
1-6 years	--	0.03
6-12 years	--	0.009
Adults (12-70)	--	0.0003
Lifetime average	5×10^{-7}["B2"][d]	--
2. Upper Estimate:		
Infants 0-1 year	--	0.5
Children:		
1-6 years	--	0.6
6-12 years	--	0.2
Adults (12-70)	--	0.01
Lifetime average	1×10^{-5}["B2"]	--

[a]Assumptions and parameters are listed in Table III-19*. Note that the estimates do not include children with pica. Individuals with this disorder could incur risks 10-fold higher.

[b]Upper-bound estimate of additional lifetime cancer risk, obtained by multiplying lifetime average TEQs dose rate from Table III-20* by cancer potency factor of 1.6×10^{-4} $(pg/kg/day)^{-1}$, and multiplying by relative bioavailability factor of 1.8 (see Section IV.C*).

[c]Ratio of adult TEQs dose rate from Table III-20* to RfD of 1 pg/kg/day, multiplied by relative bioavailability factor of 1.8.

[d]In USEPA's weight-of-evidence classification system for carcinogens, B2 indicates that the evidence for carcinogenicity in animals is "sufficient", while the human evidence for carcinogenicity is "inadequate." B2 is placed in quotation marks, because the classification was for 2378-TCDD alone, whereas total TEQs are being evaluated here, in accordance with USEPA interim science policy.

*In Risk Assessment

TABLE III-5

RISK CHARACTERIZATION FOR INGESTION OF CDDs/CDFs[a]
IN FISH FROM THE TITTABAWASSEE RIVER, MICHIGAN

Long-Term Exposures

Exposure Scenario[c]	Upper-Bound Cancer Risk[d,e]		Hazard Index[b,e,f]	
	1983-1987 Data	1988 Data	1983-1987 Data	1988 Data
Plausible Maximum Consumer (bottom + game fish)[h]	$1x10^{-2}$["B2"][g]	NA	50	NA
High Sports Fisherman (game fish only)				
-- Level 1	$4x10^{-3}$["B2"]	$2x10^{-3}$["B2"]	20	8
-- Level 2	$2x10^{-3}$["B2"]	$8x10^{-4}$["B2"]	9	4
Great Lakes Consumer (game fish only)	$6x10^{-4}$["B2"]	$3x10^{-4}$["B2"]	3	1
General Consumer (game + clean fish)	$1x10^{-4}$["B2"]	$6x10^{-5}$["B2"]	0.7	0.3

[a]Consideration of PCBs, found in the fish, would result in significantly increased estimated cancer risks and would add to the Hazard Index values (see Table III-7 in this document and Appendix B*).

[b]Note that Hazard Indices will be about 2-3 times higher for small children (Table III-32*). Breast-fed infant could be 10-times higher than mother.

[c]From data in Section III.E.2* and Tables III-30* and III-31*. Also see Table III-2 in this document. Long-term dose rate for Great Lakes Consumer is 3.0 pg/kg/day.

[d]Upper-bound estimate of additional lifetime cancer risk, obtained by multiplying dose rate from Table III-31* (for 1983-7 data and calculated similarly for 1988 data using mean fish tissue concentration of 5.7 pg/g) by cancer potency factor of 1.6×10^{-4} $(pg/kg/day)^{-1}$ and multiplying by a factor of 1.3 to incorporate contribution of higher intakes in childhood to average lifetime intake in pg/kg/day (from data in Table III-33*).

[e]Note that for 1983-1987 data, all estimates of intake are "partial TEQs," including only 2378-TCDD, other TCDDs, HxCDDs, HpCDDs, and 2378-TCDF. For 1988 data, estimates are based upon complete TEQs.

[f]Ratio of dose rate from Table III-31* to RfD of 1 pg/kg/day.

[g]In USEPA's weight-of-evidence classification system for carcinogens, B2 indicates that the evidence for carcinogenicity in animals is "sufficient," while the human evidence for carcinogenicity is "inadequate." B2 is placed in quotation marks, because the classification was for 2378-TCDD alone, whereas total TEQs are being evaluated here, in accordance with USEPA interim science policy.

[h]1988 carp and catfish contaminant data not available. Substitution of 1988 walleye data for 1983-1987 walleye data does not change cancer risk or HI.

*In Risk Assessment

infants (see footnote b, Table III-5). The estimated single-meal CDD/CDF intake levels result in HIs approaching 10 for meals comprising the maximum concentration bottom feeder from the 1983 fish collection (see Table III-6). (It is not likely that carp or catfish in the Tittabawassee River now contain concentrations of that magnitude.) All other single meal HIs are less than 1.0.

Note that the risk levels presented in Tables III-5 and III-6 are for consumption of Tittabawassee River fish contaminated with CDDs and CDFs. Fish from the river also are contaminated with other toxic chemicals, most importantly PCBs. Table III-7 presents a summary of estimated, upper-bound, excess, lifetime cancer risks resulting from 2378-TCDD TEQs and PCBs using the Sports Fisherman, Great Lakes Consumer, and General Consumer fish consumption scenarios set out in Table III-2. These data indicate that the risks associated with consumption of Tittabawassee River fish are dominated by PCBs as opposed to CDDs and CDFs. The estimated additional lifetime cancer risk (upper bound) for a person eating a single quarter-pound meal per month of game fish from the Tittabawassee River would be about 5×10^{-4} (1 in 2,000). The estimated cancer and non-cancer risks associated with the other contaminants found in the fish are not significant when compared to those associated with the PCBs and CDDs/CDFs.

The cancer risk estimates calculated for all of the exposure routes are summarized in Table III-8, and the HIs for non-cancer effects are summarized in Table III-9 (CDDs/CDFs only). Because of the overall uncertainty in the exposure and risk estimates, cancer risk estimates are displayed only to the nearest order of magnitude. Non-cancer hazard indices less than 0.1 are rounded to "<0.1" in order to simplify the table. As previously noted these estimates are upper-bound values that are unlikely to be exceeded by actual risks to humans.

TABLE III-6

RISK CHARACTERIZATION FOR INGESTION OF CDDs/CDFs[a]
IN FISH FROM THE TITTABAWASSEE RIVER, MICHIGAN

Single Meal (Bolus) Exposures[b]

Fish Meal Size	Type of Fish	TEQs[c]		Hazard Index[d,e]	
		1983-1987 Data	1988 Data	1983-1987 Data	1988 Data
255 g (9 oz)	Bottom-feeder (catfish/carp)				
	-- maximum	690 ppt	NA[f]	8	NA
	-- mean	58 ppt	NA	0.7	NA
	Game Fish (walleye, etc.)				
	-- maximum	39 ppt	16 ppt	0.5	0.2
	-- mean	13 ppt	5.7 ppt	0.2	<0.1
113 g (4 oz)	Bottom-feeder (catfish/carp)				
	-- maximum	690 ppt	NA[f]	4	NA
	-- mean	58 ppt	NA	0.3	NA
	Game Fish (walleye, etc.)				
	-- maximum	39 ppt	16 ppt	0.2	<0.1
	-- mean	13 ppt	5.7 ppt	<0.1	<0.1

[a]PCBs, found in the fish, add to the Hazard Index values (see Appendix B*).

[b]From data in Section III.E.2* and Tables III-30*, III-31*, and III-32*. Also see Table III-2 in this document.

[c]Note that for 1983-1987 data, all estimates of intake are "partial TEQs," including only 2378-TCDD, other TCDDs, HxCDDs, HpCDDs, and 2378-TCDF (1983-1987 data). For 1988 data, estimates are based upon complete TEQs.

[d]Ratio of bolus dose from Table III-32* to single-dose HA of 300 pg/kg/day.

[e]Note that Hazard Indices will be about 2-3 times higher for small children (Table III-33*).

[f]1988 carp and catfish contaminant data not available.

*In Risk Assessment

TABLE III-7

COMPARISON OF RISKS FROM INGESTION OF CDDs/CDFs AND PCBs[a]
IN FISH FROM THE TITTABAWASSEE RIVER, MICHIGAN
(Fish Collected in 1988)

Long-Term Exposures

Exposure Scenario[b]	Upper-Bound Cancer Risk[c,d]	
	CDDs/CDFs	PCBs
High Sports Fisherman (game fish only)		
-- Level 1	2×10^{-3}["B2"]	1×10^{-2}[B2]
-- Level 2	8×10^{-4}["B2"]	6×10^{-3}[B2]
Great Lakes Consumer (game fish only)	3×10^{-4}["B2"]	2×10^{-3}[B2]
General Consumer (game + clean fish)	6×10^{-5}["B2"]	5×10^{-4}[B2]

[a]Sum of Aroclors 1248 and 1254.

[b]From data in Section III.E.2* and Tables III-30* and III-31*. Also see Table III-2 in this document.

[c]Values for CDDs/CDFs from Table III-5 (1988 data). For data on PCBs, see Appendix B. Upper-bound estimates of additional lifetime cancer risk for PCBs obtained by multiplying dose rate (consumption rate from Table III-2 multiplied by mean 1988 concentration of 0.81 ug/g and divided by human body weight of 70 kg) by cancer potency factor of 7.7×10^{-3} $(ug/kg/day)^{-1}$ and multiplying by a factor of 1.3 to incorporate contribution of higher intakes in childhood to average lifetime intake.

[d]In USEPA's weight-of-evidence classification system for carcinogens, B2 indicates that the evidence for carcinogenicity in animals is "sufficient," while the human evidence for carcinogenicity is "inadequate." B2 is placed in quotation marks for the CDDs/CDFs, because the classification was for 2378-TCDD alone, whereas total TEQs are being evaluated here, in accordance with USEPA interim science policy.

*In Risk Assessment

TABLE III-8

SUMMARY OF UPPER BOUND CANCER RISK ESTIMATES
FROM EXPOSURE TO CDD/CDF CONTAMINATION IN MIDLAND, MICHIGAN

Exposure Route	Upper Bound Cancer Risk (Exposure Scenario)	
	Higher Estimate	Lower Estimate
Fish	10^{-2} (plausible maximum consumer)	10^{-4} (Great Lakes consumer)
	10^{-3} (high sports fisherman--level 1)	10^{-4} (general consumer)
Soil	10^{-5} (upper estimate)	10^{-6} (lower estimate)
	10^{-4} (child with pica)	--
Air	10^{-4} (fenceline)	10^{-5} (residential area)

Notes: (1) 10^{-2}, 10^{-3}, 10^{-4}, etc., indicate risks of 1 in 100, 1 in 1,000, 1 in 10,000, etc.

(2) Other contaminants such as PCBs, found in the fish, add to the risk from that exposure route (see text and Appendix B in the Risk Assessment.

(3) Sources: Tables III-3, III-4, and III-5. Risks for fish consumption: plausible maximum consumer based upon 1983-1987 data; others based upon 1988 data.

(4) USEPA is currently reevaluating the cancer potency factor for 2378-TCDD; a final determination will not be available for at least several months.

TABLE III-9

SUMMARY OF HAZARD INDICES FOR NON-CANCER EFFECTS
FROM EXPOSURE TO CDD/CDF CONTAMINATION IN MIDLAND, MICHIGAN

Exposure Route	Exposure Scenario	Hazard Index (HI)[a] Long-Term	Short-Term
Fish[b]	Plausible maximum consumer[c]	50	5
	High sports fisherman--level 1	8	0.7
	Great Lakes consumer	1	0.3
	General consumer	0.3	0.2
Soil	Upper estimate young child		
	-- with pica	6	0.2
	-- normal	0.6	<0.1
	Lower estimate young child	<0.1	<0.1
	Upper estimate adult	<0.1	<0.1
Air[d]	Infant at fenceline	4	0.1
	Child at fenceline	1	<0.1
	Child in residential area	0.2	<0.1
	Adult in residential area	<0.1	<0.1

[a]Hazard Index is the ratio of intake dose to:

-- RfD (1 pg/kg/day) for long-term exposures (several months or more)
-- 10-day HA (28 pg/kg/day) for short-term exposures (few days to few weeks)

[b]Small child could be at 2-3 times higher risk than adult. Breast-fed infant could be at 10-times higher risk than mother. Other contaminants such as PCBs, found in the fish, add to the Hazard Index values (see text and Appendix B of the Risk Assessment).

[c]Long-term and short-term hazard indices for plausible maximum consumer based upon 1983-1987 fish contaminant data for catfish, carp, and walleyes (substitution of 1988 walleye data does not change HIs). Hazard indices for other consumers based upon 1988 fish contaminant data for walleyes. Soil and air estimates based upon Midland field measurements during 1983-1984 period.

[d]All HI values calculated using the "A method." Infant exposure includes exposure from breast-feeding.

Note: See Table III-6 for HIs for single meal (bolus) exposures.

IV

RISK MANAGEMENT

Collectively, the point source and environmental studies conducted by USEPA, the State of Michigan, and Dow Chemical over the past several years clearly indicate that the Dow Chemical Michigan Division plant at Midland has been the most significant, if not the only significant, source of CDD/CDF contamination of the plant site and the general Midland area environment. As a result of these investigations Dow Chemical has undertaken several actions, some unilaterally, some required by environmental permits or administrative orders issued by the State of Michigan or USEPA, to minimize emissions and discharges of CDDs and CDFs and other toxic pollutants. Dow Chemical has completed or is implementing the following actions:

- Terminated production of chlorinated benzenes, and most chlorinated phenols, including 2,4,5-trichlorophenol and derivatives and pentachlorophenol (late 1970s).

- Installed a riverbank revetment system to collect contaminated ground waters from a significant portion of the plant site (1979-1981); additional sections of the riverbank have undergone similar treatment (1984-1987).

- Upgraded air emission controls on the hazardous waste incinerator (late 1970s); landfilling rather than incinerating contaminated wastewater treatment sludges; upgrading operational controls and practices at the hazardous waste incinerator.

- Undertook extensive point source and underground investigations of CDD/CDF contamination plant site (1983-1987).

- Installed a wastewater effluent filtration system for the entire wastewater discharge to the Tittabawassee River (1985).

- Replaced open wastewater ditches on the plant site with enclosed sewers. Isolated high contamination areas of the plant sewerage system from the wastewater treatment system (1986-1987).

- Implemented plant-wide dust-suppression program (1986).

- Capped areas in the plant with high levels of surface soil contamination; limited access to an area on the plant boundary with moderate levels of CDD/CDF contamination (1986).

- Provided preliminary treatment of incinerator scrubber waters prior to commingling with other process wastewaters (1987).

Recent data are beginning to show reduced incinerator emissions, reduced wastewater effluent discharge levels, and reduced fish contamination levels. Overall, it appears conditions have improved significantly over the last ten

years. Nevertheless, the levels of discharge and environmental contamination as depicted by point source and environmental data collected during the past five years, including the fish data collected in 1988, indicate that further remedial work at the plant site and actions by the public to minimize exposures could be helpful in reducing the possible public health risks described earlier.

The estimated risk levels presented in the Risk Assessment and summarized in Section III are upper-bound cancer risks and upper-bound risks of non-cancer health effects based upon conservative assumptions regarding the toxicological effects of 2378-TCDD, the possible toxicological effects of other CDDs and CDFs which have not been studied to the same extent as 2378-TCDD, and the exposures of Midland area residents to 2378-TCDD and other CDDs and CDFs in their environment. Thus, the actual risks to Midland area residents are not likely to be higher than those presented here, and they could be significantly lower. However, USEPA believes it is prudent public health policy to consider actions to mitigate or minimize exposures to contaminants when estimated excess lifetime cancer risks exceed the 10^{-5} to 10^{-6} range, and when non-cancer health effects are estimated to be significant through the use of a hazard index or other such measures for comparing estimated exposures with reference doses and health advisories.

As highlighted in the preceding section, the greatest potential public health risks (cancer and non-cancer health effects) are associated with consumption of contaminated fish from the Tittabawassee River. Possible public health risks associated with ambient air contamination from current Dow Chemical incinerator emissions are estimated to be less significant. Possible risks associated with exposure to contaminated soils in the community, which are related to current and past incinerator emissions, past process emissions, and windblown dusts from the plant site, are estimated to be less than estimated risks from consumption of fish or from exposure to contaminated ambient air.

Even if USEPA adopted for use in risk assessments a carcinogenic potency factor for CDDs/CDFs an order of magnitude lower (less conservative), the estimated cancer risks associated with the higher levels of fish consumption would still be quite high (10^{-3} to 10^{-5}). Furthermore, the estimated risks associated with the PCB contamination of the fish, as discussed above, would not change. If one were to employ such a lower cancer potency factor in evaluating the other routes of exposure, estimated risks for air and soil would be at or below 10^{-6} for all exposed groups except children with pica, for whom the estimated risk would be about 10^{-5}. The estimated non-cancer health effects, which would not be affected by a change in the USEPA cancer potency factor for 2378-TCDD, are clearly of concern for children, pregnant women, and women of child-bearing age, as well as for others with high rates of fish consumption; the non-cancer health effects also could be of marginal concern for some worst-case air exposures. (These worst-case air exposures are unlikely to occur.) Actions to minimize risk for fish consumers are thus the highest priority, based upon this risk assessment.

Presented below are USEPA's final risk management recommendations for dioxin contamination at Midland, Michigan. These actions include point and nonpoint controls by Dow Chemical, recommended precautionary measures that can be implemented by the public to minimize exposures and possible risks, and a series of point source and environmental monitoring programs. These mitigative measures

are essentially the same as those presented in the public review draft of this report (USEPA 1988b).

A. POINT AND NONPOINT SOURCE CONTROLS AT DOW CHEMICAL

1. Wastewater Discharges

Figure IV-1 presents a summary of monthly average Dow Chemical wastewater discharges of 2378-TCDD for the period July 1984 to August 1988. Dow Chemical began full scale operation of the final effluent mixed-media filtration system in November 1985 and began full-scale operation of an incinerator wastewater pretreatment system in July 1987 (Dow 1988a). The level of discharge was initially reduced by about 75 percent upon operation of the mixed-media filtration system. Another significant reduction has been realized after preliminary treatment for incinerator wastewaters was instituted. Overall, the average mass discharge has been reduced by nearly 90 percent from 1984 and 1985 levels. The level of discharge remains above the level deemed necessary by the MDNR for protection of public health (0.1 ppq) (MDNR 1987b). That level is not detectable with current sampling and analytical methodologies. Computer modeling studies conducted at the direction of USEPA indicate that 2378-TCDD levels in Tittabawassee River fish are mostly related to Dow Chemical wastewater discharges as opposed to less significant sources including runoff from city soils and air emissions (GSC 1987).

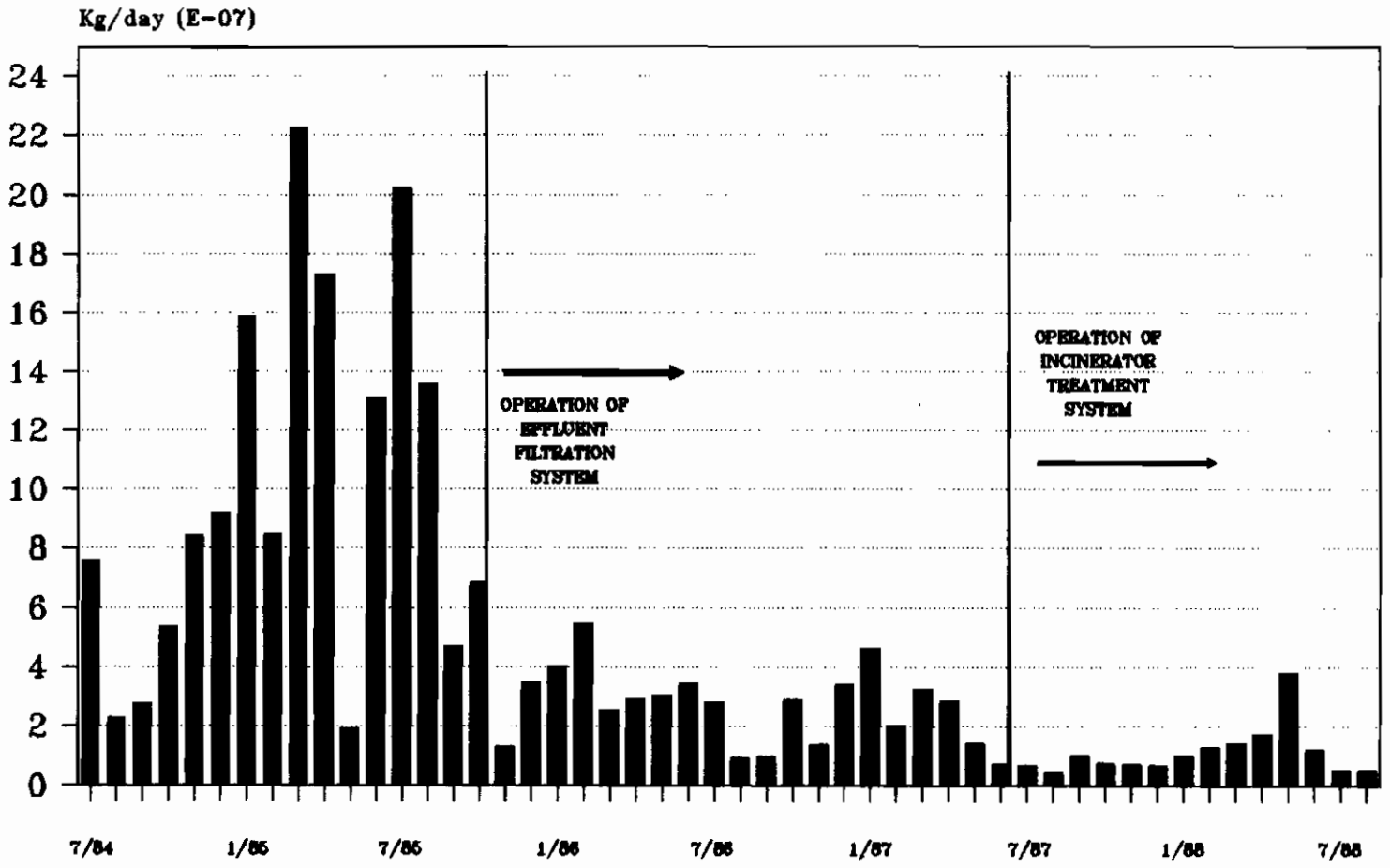
Given the complexity of the wastewater treatment system and the sources and sinks of 2378-TCDD and other CDDs and CDFs at Dow Chemical, it is not possible to predict to what extent further progress in reducing the discharge will occur without additional remedial actions. USEPA has evaluated alternate end-of-pipe wastewater treatment technologies and supplemental in-plant controls for additional treatment of 2378-TCDD at Dow Chemical and concluded there are no available performance data for the treatment systems considered and it is not possible to predict discharge reductions for either the treatment systems considered or possible in-plant controls. Accordingly, USEPA recommended to MDNR a series of special NPDES permit conditions for the next NPDES permit for Dow Chemical (1987d). These include:

- o Feasibility and end-of-pipe wastewater treatability studies for CDDs and CDFs.
- o An assessment of the amount of 2378-TCDD in tertiary pond sediments and a study to determine to what extent resuspended sediments containing CDDs and CDFs pass through the filtration system.
- o An evaluation of the effectiveness of the performance of the incinerator wastewater pretreatment system.

The proposed NPDES special conditions set out in the above-referenced report have been included by MDNR in the NPDES permit and accompanying administrative order for Dow Chemical (MWRC 1988). The results from these special conditions should allow a proper assessment of the extent to which additional controls can be installed to further reduce discharge levels. Any further regulatory actions would be implemented through the NPDES or RCRA permit programs.

FIGURE IV - 1

2378-TCDD DISCHARGES
DOW CHEMICAL - MIDLAND PLANT



MONTHLY AVERAGE MASS LOADINGS

2. Incinerator Emissions

The limited data available for Dow Chemical hazardous waste incinerator emissions from 1978 through 1987 indicate that the emission rates of CDDs and CDFs are considerably lower today than in the late 1970's. Emissions testing by USEPA in 1984 (Trembly and Amendola 1987) and Dow Chemical in 1987 (Dow 1987a) indicate emission rates of 2378-TCDD (Partial TEQs) have been reduced by more than 90 percent from emission levels measured by Dow Chemical in 1983 (Dow 1984).

The investigations of air emission sources at the Midland plant conducted by Dow Chemical clearly show the incinerator was the most significant point source at that time (Dow 1984). However, estimated cancer and non-cancer risks for air exposures in the Risk Assessment are related more to the actual measured ambient air concentrations than to the estimates of ambient air concentrations resulting from dispersion modeling of the incinerator emissions. These results suggest historical deposition from past incinerator emissions, possible process emissions, and windblown dusts from the plant site impact the ambient air around the perimeter of the plant and, to some extent, out in the community more than the current incinerator emissions.

Based upon the above considerations and the estimated health risks associated with incinerator emissions alone, there does not appear to be sufficient justification for recommending major changes in incinerator operations at this time (e.g., change in waste feeds, installation of additional emission control technology), although improvements might be required in the future by new regulations. On the other hand, additional measures to optimize combustion conditions within the incinerator and to optimize operation of the existing emission controls should be pursued to further reduce emissions below current levels to the extent possible.

At the present time it appears that the results from supplemental monitoring of incinerator emissions and ambient air as described in Section IV.C are necessary to determine whether, or to what extent, additional incinerator emission controls are necessary. The RCRA permit for the Midland plant includes the recommended incinerator emissions testing and ambient air monitoring programs (USEPA 1988e).

3. Dust Suppression Program

A considerable portion of the Dow Chemical Midland plant site is either paved roadway, paved open areas around process buildings, or paved parking lots. Some portions of the plant site are capped landfills with grass cover. The remainder of the site is occupied by buildings or is unpaved dirt or gravel covered open areas. Surface soil sampling conducted by Dow Chemical and USEPA indicate the entire plant site is contaminated with 2378-TCDD (and other CDDs and CDFs) with a mean surface soil 2378-TCDD concentration of less than 0.5 ppb (Dow 1984, USEPA 1985a). During dry weather periods, vehicular traffic through the plant has been observed to raise considerable particulate matter from roadways. Wind-blown dusts have undoubtedly contributed some CDDs and CDFs to ambient air within the plant and around the plant perimeter. Impacts on nearby commercial and residential areas are determined by wind direction and velocity.

In 1986, Dow Chemical began implementing a fugitive dust suppression control program which calls for regular flushing of paved roads and parking lots, application of chemical dust suppressants to unpaved roads, and controls for storage piles and loading and unloading of materials from pollution control equipment (Dow 1988b). This program was revised in 1987 and appears to address most sources of fugitive dusts from the plant site that may be contaminated with CDDs and CDFs. The effectiveness of this program will be evaluated through the ambient air monitoring program presented in section C.2.c below. Depending upon the results, all or some combination of the following actions, or similar measures, could be implemented to further minimize worker exposure levels and migration of CDDs and CDFs from contaminated soils within the plant:

- o Paving or planting grasses over some of the remaining sand and gravel areas.

- o Modified road dust suppression program or paving program for unpaved roads. Modified spraying and sweeping programs for paved roadways to further minimize fugitive particulate emissions.

4. Ground Water Contamination

Ground water and subsurface soil sampling conducted by Dow Chemical at the Midland plant pursuant to Resource Conservation and Recovery Act (RCRA) requirements, revealed contamination with 2378-TCDD at a number of locations (Dow 1987b). Areas near former trichlorophenol production facilities were found to be the most highly contaminated. USEPA sampling of sediments from a riverbank revetment system collection sump revealed contamination with 2378-TCDD and other CDDs and CDFs (Amendola and Barna 1986). Also, ground water monitoring by Dow Chemical near the Poseyville Road landfill has demonstrated certain hazardous constituents emanating from the landfill and migrating north to northeast (Dow 1987b). (CDDs and CDFs have not been studied in the ground water.) Dow Chemical has installed a purge system to collect the release, and constructed a slurry wall at the landfill to prevent future releases.

The contaminated ground water at the plant is largely contained within the site. There are no potable ground water wells within the immediate area of the plant and monitoring of both public and private potable ground water wells near the plant and near Dow Chemical landfills showed no detectable CDDs or CDFs (Barna and Amendola 1985). The RCRA permit for the Dow plant has as a principal focus the issue of ground water contamination at the plant and at nearby landfills. Accordingly, additional point or non-point source controls beyond those required under the RCRA permit for the protection of ground water do not appear necessary to protect public health.

B. PRECAUTIONARY MEASURES RECOMMENDED TO THE PUBLIC

Although operations at Dow Chemical have caused widespread contamination of the Midland area with 2378-TCDD and other CDDs and CDFs, USEPA believes that the levels of contamination, with the exception of the Tittabawassee River fish, do not present unacceptable or unmanageable health risks to the Midland community. USEPA does not believe that massive remedial measures such as those implemented at Times Beach, Missouri, or Newark, New Jersey, are warranted in Midland. There

are, however, a number of actions people can take to minimize exposures, and thus minimize possible health risks associated with CDDs and CDFs. Most of these recommendations focus on avoiding or minimizing ingestion of materials that contain 2378-TCDD and other CDDs and CDFs.

1. Tittabawassee River Fish

In Michigan, legal responsibility for the evaluation of health risks and issuance of health advisories resides with the Michigan Department of Public Health (MDPH). Prior to April 1988, MDPH had in place a fish consumption advisory warning against consumption of catfish and carp taken from the Tittabawassee River (MDNR 1987a). These fish contain high levels of 2378-TCDD and other organic chemicals. As shown in the Risk Assessment, regular consumption of even relatively small amounts of these fish over the long term may pose substantial risks of cancer. Also, long-term consumption or, in certain circumstances, short-term consumption of these fish may pose significant risks of adverse impacts other than cancer.

The Risk Assessment highlights possibly significant risks from consumption of game or sports fish (e.g., walleye, northern pike, smallmouth bass, and white bass) by children and women of childbearing age, related to possible reproductive effects, teratogenic effects, liver damage, and cancer. These risks may be associated with both short-term and long-term consumption. Risks from consumption of game or sports fish for other less sensitive groups are also presented in the Risk Assessment and summarized in Section III. Note that the risks associated with PCB contamination of Tittabawassee River walleyes exceed those associated with CDDs/CDFs. In April 1988, as an interim, precautionary measure, the MDPH modified its fish consumption advisory to warn pregnant women and women of childbearing age against consuming more than one meal per month of Tittabawassee River walleye. MDPH further strengthened the advisory in December 1988, adding that no one should eat large quantities of any species from the river (MDPH 1988). USEPA supports Michigan Department of Public Health actions to make the fish consumption advisory for the Tittabawassee River more restrictive.

Individuals who choose to consume fish caught in the Tittabawassee River should clean them in accordance with MDPH recommendations to minimize contaminant levels. Fillets should be skinned, with all visible traces of surface fat removed. All belly fat from the fillet should be removed, as well as the dark tissue along the lateral line on each fillet. Certain cooking methods that permit fats and juices to drain from the fish can result in lower contaminant levels in the cooked fish.

The 1988 fish contaminant data for spring walleyes developed by MDNR, MDPH, Dow Chemical, and USEPA are presented in Appendix B. These data indicate a relationship between 2378-TCDD and PCB concentration and size class:

CDDs/CDFs and PCBs in Tittabawassee River Walleyes (1988)

Length	Average Weight	2378-TCDD TEQs Concentration Range	2378-TCDD TEQs Concentration Mean	PCB* Concentration Range	PCB* Concentration Mean
15" - 18"	1.6 lbs	2.0-3.9 ppt	3.1 ppt	0.26-0.64 ppm	0.43 ppm
18" - 22"	3.1 lbs	3.0-7.4 ppt	4.9 ppt	0.36-1.2 ppm	0.72 ppm
22" - >26"	5.8 lbs	4.1-15.9 ppt	8.2 ppt	0.48-2.2 ppm	1.2 ppm

*Sum of results for Aroclors 1248 and 1254.

These results indicate that smaller walleyes are likely to contain less CDDs/CDFs and PCBs than larger fish. Thus, for those who choose to eat fish from the Tittabawassee River, ingestion of contaminants can be reduced by eating only the smaller fish caught.

2. City of Midland Surface Soils

The overall estimated cancer and non-cancer risks from exposures to surface soils in Midland are not considered to be significant except possibly for children with pica. Children with pica are those who intentionally consume inordinate amounts of soil. Pica, considered a medical disorder, is believed to affect an average of about 1 in 200 children.

Some possible routes of exposure to 2378-TCDD and other CDDs and CDFs in city of Midland soils include direct ingestion by children at play outdoors; ingestion of soil attached to home-grown vegetables, whether or not the contaminants were absorbed or transported into the edible portion of the plant; absorption through the skin which comes in contact with the soil through play, gardening, or other activities; inhalation of contaminated particulates from the soil; and ingestion of household dusts which may be contaminated from outdoor soils. Note that the results of the USEPA soil study showed that 2378-TCDD (and other CDDs and CDFs by inference) tend to concentrate in areas near roof downspouts or driplines (USEPA 1985a).

Although currently available information indicates that only children with pica are at possibly significant risk from the soil contamination in Midland, the commonsense practices presented below are recommended as generally useful for minimizing exposure to soil contamination or bacteria, whether the soil is found in Midland or elsewhere:

- Children at play, particularly toddlers and children with pica, should be encouraged to keep soil or dirt out of their mouths. Areas near downspouts and roof driplines are likely to have higher levels of 2378-TCDD and other CDDs and CDFs than open yard areas.

- Children and adults should wash their hands after exposure to outdoor soils, particularly before meals.

- o Home-grown vegetables, both leafy vegetables and root crops, should be thoroughly washed prior to consumption to remove soil particles. Peeling root crops might be helpful in removing 2378-TCDD which may be in soil on the skins or absorbed into the skins.

- o Household interiors should be regularly cleaned to minimize contaminated dusts which can be inhaled or ingested.

C. POINT SOURCE AND ENVIRONMENTAL MONITORING PROGRAMS

As noted earlier, there have been many remedial actions taken over the past few years to minimize emissions and discharges of CDDs and CDFs from the Dow Chemical Midland plant. The limited data collected recently indicate contaminant levels outside the plant may be declining. Presented below are a series of proposed point source and environmental monitoring programs designed to document the effectiveness of the remedial programs and to characterize or evaluate other possible, but less likely, routes of exposure which were not evaluated initially as part of the Michigan Dioxin Studies. Some of the proposed monitoring programs are current requirements of Dow Chemical environmental control permits or orders; others are new programs that have been included in the RCRA permit or could be required under other existing regulatory mechanisms. Final decisions regarding implementation of these proposed monitoring programs will be made as part of the permit issuance processes for the NPDES, RCRA, and other permits for the Dow Chemical Midland plant.

Each required or proposed program is described in the following sections. Study designs and sampling and analytical protocols would be approved by MDNR, MDPH, and/or USEPA Region V.

1. Dow Chemical Point Source Monitoring

a. Wastewater discharge monitoring

Dow Chemical currently monitors the outfall 031 wastewater discharge to the Tittabawassee River twice per month for 2378-TCDD as required by NPDES permit MI0000868. The current discharge levels reported by Dow Chemical are in the range of less than 1 to 8 parts per quadrillion (ppq or pg/l). Data collected for the last six months of 1987 indicate the discharge had been fairly stable from month to month remaining less than 3 ppq. However, data collected in May, June and July of 1988 showed a few concentrations in the 4 to 8 ppq range. MDNR has determined that 0.1 ppq of 2378-TCDD in Dow Chemical's effluent would be protective of human health, by minimizing bioaccumulation of 2378-TCDD in fish (MDNR 1987b). Dow Chemical should conduct experiments to determine what measures might be feasible to attain analytical method detection levels of 0.1 ppq for 2378-TCDD (e.g., larger sample size, enhanced sample cleanup, high resolution mass spectrometry).

b. Incinerator emissions testing

Over the past few years Dow Chemical has been modifying the operation of its hazardous waste incinerator to optimize combustion conditions and minimize emissions of 2378-TCDD and other CDDs and CDFs. The most recent stack tests were

conducted by Dow Chemical during June 1987 (Dow 1987a). In Section IV.A.2, USEPA proposes that Dow Chemical continue efforts to optimize incinerator emissions. At some point over the next two years, preferably during the warm, dry-weather seasons of 1988 or 1989, another series of stack tests should be performed to characterize the emissions of 2378-TCDD and other CDDs and CDFs, and to determine the particle size distribution of the stack emissions. The particle size data are useful for estimating incineration emissions deposition for purposes of exposure assessments and for distinguishing the incinerator emissions from other sources of CDD/CDF contamination in the ambient air. Ideally, the incinerator emissions testing would be conducted concurrently with the ambient air monitoring program proposed below. These efforts should be coordinated with the incinerator emissions trial burns for 2378-TCDD required for RCRA permitting.

2. Proposed Supplemental Environmental and Food Chain Monitoring Programs

a. Environmental Monitoring Programs

(1) Ambient air monitoring program

Concurrent with the incinerator emissions testing noted above, a limited ambient air monitoring program should be conducted to determine particle size distribution, particulate levels, and current concentrations of 2378-TCDD and other CDDs and CDFs. A network of at least seven monitoring sites (one upwind of plant, three downwind near the fenceline, three downwind in the community) would be necessary. Two of the downwind sites should be located in the vicinity of the estimated point of maximum ground level impact of the incinerator emissions. An extended particulate monitoring program should be conducted over a period of a few months. CDD and CDF determinations should be made on at least three separate days with wind blowing from the upwind monitors toward the downwind monitors. Analyses of CDDs and CDFs under other conditions could also be considered. The specific monitoring protocols should be developed by the MDNR and Region V air and waste management programs in consultation with Dow Chemical.

(2) Soil and dust monitoring program

Surface soil sampling near each air monitoring station (10-15 samples, total) should be conducted to reveal the presence of contaminated soils that could influence the particulate samples through resuspension. Limited surface soil sampling throughout the community (20 samples) also should be conducted to document current surface soil concentrations in Midland. Selected sites sampled in the 1983 USEPA survey should be resampled to measure changes that may have occurred. Appropriate control sites should be established for this effort. Collection and analysis of a limited number of household dust samples would permit evaluation of the significance of this route of exposure.

(3) Tittabawassee River sediments

Tittabawassee River sediments and the river flood plain, from upstream of Dow Chemical to about five miles downstream from outfall 031, should be thoroughly surveyed, evaluated, and classified in order to locate any pockets of organic contamination or deposition zones containing clay, silt, or other fine particles of a type with the potential to adsorb CDDs/CDFs. The survey should

include extensive grab and/or core sampling with visual evaluation of the samples by an experienced sediment classifier, supplemented by the appropriate use of a gross measure of organic material such as TOC (total organic carbon). Samples with relatively high organic content or other indications of potential contamination (e.g., large amounts of fine particles) would be analyzed for 2378-TCDD, other CDDs and CDFs, and other contaminants to determine whether or to what extent sediment removal might be appropriate.

b. Food Chain Monitoring

(1) Tittabawassee River fish

Dow Chemical is currently required by the terms of a consent order with USEPA to conduct monitoring of Tittabawassee River fish every two years through 1991 (U.S. v. Dow 1984). The MDNR has proposed to modify that program by requiring fish monitoring every two years during even-numbered years (MDNR 1988). The MDPH, MDNR, Dow Chemical, and USEPA collaborated in developing an expanded fish monitoring program for 1988. The results from that program are presented in Appendix B and were reviewed above.

(2) Other aquatic life, avian, and animal monitoring program

A limited monitoring program should be conducted in 1988 or 1989 for bivalves or gastropods present in the Tittabawassee River as well as for turtles, fish-eating birds that nest in the vicinity of the river, and fish eating mammals such as the muskrat and raccoon. About 20 samples should be adequate for screening these organisms for 2378-TCDD and other CDDs and CDFs.

(3) Dairy sampling

A limited screening sampling program (10 to 15 samples) should be conducted at dairy operations that may be located within 10 to 15 miles of the Dow Chemical plant. Samples of whole milk, milk fat, and cheese should be collected and analyzed for 2378-TCDD and other CDDs and CDFs.

(4) Garden vegetable sampling

Although preliminary monitoring by USEPA did not indicate uptake of CDDs/CDFs by the root crops sampled, additional data are needed to confirm this conclusion and to test for uptake in other crops. A limited garden vegetable and garden soil sampling program (20 to 30 samples) should be conducted in 1988 to supplement the limited data collected by USEPA for 1987 samples. These data would be used to document whether, or to what extent, migration of 2378-TCDD and other CDDs and CDFs occurs from contaminated soil into (or onto) garden vegetables.

REFERENCES

AMENDOLA, G.A. and BARNA, D.R. 1986. Dow Chemical wastewater characterization study: Tittabawassee River sediments and native fish. Environmental Services Division, Region V, USEPA, Westlake, Ohio. July. EPA-905/4-88-003.

BARNA, D.R., and AMENDOLA, G.A. 1985. Screening survey of surface water supplies, potable ground water, and Dow Chemical brine operations. Environmental Services Division, USEPA, Westlake, Ohio. December.

DOW CHEMICAL COMPANY (Dow). 1978. Letter from E.H. Blair, U.S. Area Research and Development, Midland, Michigan, to Document Control Officer, Chemical Information Division, Office of Toxic Substances, USEPA, Washington DC. June 28.

DOW CHEMICAL COMPANY (Dow). 1984. Point sources and environmental levels of 2378-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) on the Midland plant site of the Dow Chemical Company and in the city of Midland, Michigan. Midland, Michigan. November 5.

DOW CHEMICAL COMPANY (Dow). 1984-1988. Discharge monitoring reports, NPDES Permit No. MI0000868. Environmental Sciences Division, Region V, USEPA, Westlake, Ohio.

DOW CHEMICAL COMPANY (Dow). 1987a. Letter from J.M. Rio, Manager, Engineering, Computers, and Environmental, Michigan Division, Dow Chemical U.S.A., Midland, Michigan, to G.A. Amendola, Environmental Sciences Division, Region V, USEPA, Westlake, Ohio. October 20.

DOW CHEMICAL COMPANY (Dow). 1987b. Michigan Division ground water containment strategy: Investigation of historical point sources of 2378-TCDD to the Midland plant site wastewater system of the Dow Chemical Company (4 vols.). Michigan Division, Midland, Michigan. June.

DOW CHEMICAL COMPANY (Dow). 1987c. Letter from R.M. Croyle, Manager, Environmental Services, Michigan Division, Dow Chemical U.S.A., Midland, Michigan, to G.A. Amendola, Environmental Sciences Division, Region V, USEPA, Westlake Ohio. December 27.

DOW CHEMICAL COMPANY (Dow). 1988a. Personal communication from J.E. Garvey, Environmental Specialist, Environmental Services, Michigan Division, Dow Chemical U.S.A., Midland, Michigan, to G.A. Amendola, Environmental Sciences Division, Region V, USEPA, Westlake, Ohio. February 24.

DOW CHEMICAL COMPANY (Dow). 1988b. Letter from W.I. Delaney, Environmental Services, Michigan Division, Dow Chemical U.S.A., Midland, Michigan, to G.A. Amendola, Environmental Sciences Division, Region V, USEPA, Westlake, Ohio. March 15.

DOW CHEMICAL COMPANY (Dow). 1988c. Letter from J.E. Garvey, Environmental Specialist, Environmental Services, Michigan Division, Dow Chemical U.S.A., Midland, Michigan, to L. Duling, Surface Water Quality Division, Michigan Department of Natural Resources, Lansing, Michigan. June 23.

ENVIRONMENTAL CONGRESS OF MID-MICHIGAN (ECOMM) and FORESIGHT SOCIETY (Foresight). 1983. Citizens petition for an investigation and enforcement action. A.K. Wilson, Director, ECOMM, and L. Fink, Director, Foresight. Filed with J.W. Hernandez, Acting Administrator, USEPA, Washington DC. March 16.

GENERAL SCIENCES CORPORATION (GSC). 1987. GEMS multi-media modeling of 2378-TCDD at Midland, Michigan. Prepared for Office of Pesticides and Toxic Substances, USEPA, Washington DC (Contract No. 68-02-3970, Task No. 3-11). June 19.

HUMPHREY, H.E.B. 1983. Population studies of PCBs in Michigan residents. In D'Itri, F.M., and Kamrin, M.A., eds., PCBs: Human and Environmental Hazards. Butterworth Publishers, Boston. Pp. 299-310.

HUMPHREY, H.E.B., RICE, H.A., and BUDD, M.L. 1976. Evaluation of changes of the level of polychlorinated biphenyls (PCB) in human tissue. Final Report to FDA. Michigan Department of Public Health, Lansing, Michigan.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES (MDNR). 1978. Michigan fishing guide. Lansing, Michigan.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES (MDNR). 1983. Letter from H.A. Tanner, Director, Lansing, Michigan, to J.W. Hernandez, Acting Administrator, USEPA, Washington DC. March 23.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES (MDNR). 1987a. Michigan fishing guide. Lansing, Michigan.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES (MDNR). 1987b. Public Notice of proposal to modify Final Order of Abatement No. 2022 for Michigan Division, Dow Chemical U.S.A., Midland, Michigan. Lansing, Michigan. September 25.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES (MDNR). 1988. [Results of chemical analysis of Tittabawassee River fish collected April 12, 1988.] Transmitted by L. Duling, Fish Contaminant Monitoring Program, Surface Water Quality Division, to H. Zar, Water Division, Region V, USEPA, Chicago, Illinois. July 29.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH (MDPH). 1988. Public health advisory. Center for Environmental Health Sciences, Lansing, Michigan. December.

MICHIGAN WATER RESOURCES COMMISSION (MWRC). 1984. Final order of abatement no. 2022. Cosigned by Michigan Department of Natural Resources and Michigan Attorney General. Lansing, Michigan. May 17.

MICHIGAN WATER RESOURCES COMMISSION (MWRC). 1988. NPDES permit no. MI0000868 (Michigan Division, Dow Chemical Company, Midland, Michigan). Lansing, Michigan. September 15, 1988.

SMITH, A.H. 1987. Infant exposure assessment for breast-milk dioxins and furans derived from waste incineration emissions. Risk Analysis 7:347-353.

TREMBLY, G., and AMENDOLA, G.A. 1987. Dow Chemical Building 703 incinerator exhaust and ambient air study. Environmental Services Division, Region V, USEPA, Westlake, Ohio. March. EPA 905/4-88-004.

U.S. DEPARTMENT OF AGRICULTURE (USDA). 1982. Foods commonly eaten by individuals: Amount per day and per eating occasion. By Poa, E.M., Fleming, K.H., Guenther, P.M., and Mickle, S.J. Home Economics Research Report Number 44.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1983a. Dow Chemical Company Midland Plant wastewater characterization study: Preliminary summary of results. Environmental Services Division, Region V, Westlake, Ohio. March 28.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1983b. Dioxin strategy. Office of Water Regulations and Standards, Office of Solid Waste and Emergency Response, Dioxin Strategy Task Force, Washington, DC. October 20.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1983c. Toxic and hazardous substances control; dioxin and furan pollution; denial of Central Michigan citizens petition for investigation and enforcement action. W.D. Ruckelshaus, Administrator, Washington DC. 48 FR 33739-33746. July 25.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1985a. Soil screening survey at four Midwestern sites. Environmental Services Division, Region V, Westlake, Ohio. June. EPA 905/4-85-005.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1985b. Health assessment document for polychlorinated dibenzo-p-dioxins. EPA 600/8-84-014F. Office of Research and Development, Washington DC. September.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1985c. CERCLA Section 106 Order. Region V, Chicago, Illinois.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1986. Guidelines for carcinogen risk assessment. 51 FR 33992-34003.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987a. National dioxin study report to Congress. Office of Solid Waste and Emergency Response, Washington DC. August. EPA/530-SW-87-025.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987b. Health advisory for 2,3,7,8-tetrachlorodibenzo-p-dioxin. Office of Drinking Water, Washington DC.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987c. Interim procedures for estimating risks associated with exposures to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans. Risk Assessment Forum, Washington DC. March.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987d. Technical support document for proposed best available technology effluent limitations and special NPDES permit conditions, NPDES permit MI0000868, Dow Chemical, Midland plant, outfall 031. Environmental Sciences Division, Region V, Westlake, Ohio. August.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988a. Risk assessment for dioxin contamination at Midland, Michigan. Region V, Chicago, Illinois. March. EPA 905/4-88-005.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988b. Proposed risk management actions for dioxin contamination, Midland, Michigan. Region V, Chicago, Illinois. April. EPA 905/4-88-006.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988c. Memorandum from B. Butterworth, Environmental Research Laboratory, Duluth, Minnesota, to Howard Zar, Region V, Chicago, Illinois. May 26.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988d. A cancer risk-specific dose estimate for 2378-TCDD. Office of Health and Environmental Assessment. Washington DC. EPA 600/6-88-007Aa. June. (External review draft).

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988e. Resource Conservation and Recovery Act (RCRA) Operating Permit for Michigan Division, Dow Chemical U.S.A., Midland, Michigan (Facility no. MID000724724). Region V, Chicago, Illinois. September 30.

U.S. v. Dow. 1984. Consent decree, civil action no. 83-CV7011BC. United States of America, Plaintiff, vs. the Dow Chemical Company, d/b/a Dow Chemical U.S.A., Michigan Division, Defendant. March 30.

APPENDIX A

RESPONSE TO PUBLIC COMMENTS

ON

RISK ASSESSMENT FOR DIOXIN CONTAMINATION
AT MIDLAND, MICHIGAN; EPA-905/4-88-005, APRIL 1988

AND

PROPOSED RISK MANAGEMENT ACTIONS FOR DIOXIN
CONTAMINATION AT MIDLAND, MICHIGAN; EPA-905/4-88-006, APRIL 1988
(PUBLIC REVIEW DRAFT)

DECEMBER 1988

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN STREET
CHICAGO, ILLINOIS 60604

PUBLIC COMMENTS RECEIVED

1. April 28, 1988 Public Meeting, Midland, Michigan

Chairman

Howard Zar, Chairman, Dioxin Task Force
Water Division, Region V, USEPA, Chicago IL

Panel Members

Gary Amendola, Manager, MI Dioxin Studies
Eastern District Office, Region V, USEPA
Westlake OH

Donald Barnes, Ph.D., Chairman
Chlorinated Dioxins Workgroup
Office of Pesticides and Toxic Substances
USEPA, Washington DC

J. Milton Clark, Ph.D., Toxicologist
Pesticides and Toxic Substances Branch
Region V, USEPA, Chicago IL

Mark McClanahan, Ph.D., Toxicologist
Agency for Toxic Substances and Disease Registry
Atlanta GA

Ian C.T. Nisbet, Ph.D., Consultant
I.C.T. Nisbet and Associates
Lincoln MA

Commentors

Lawrence Chadzynski, M.P.H.
Michigan Department of Public Health

Diane Hebert
Midland, Michigan

John Hesse
Michigan Department of Public Health

Benjamin Johnson, M.D.
Michigan Department of Public Health

PUBLIC COMMENTS RECEIVED (Continued)

Commentors (Continued)

Sandy Mannion
Hemlock, Michigan

Doug Martin

Terry Miller
Bay County

Pat Moore
Ingersoll Township

Wendell Mullison

Winifred Oyen
Midland County Public Health Department

John Palum

Harry Pine
Midland, Michigan

Several unidentified persons

2. May 30, 1988 — Letter from Sandy Mannion, Hemlock, Michigan

3. June 1, 1988 — Letter from R. M. Croyle, Dow Chemical Company, Midland, Michigan

4. June 2, 1988 — Letter from Barbara S. Glenn, National Wildlife Federation, Ann Arbor, Michigan

INTRODUCTION

In April 1988, the United States Environmental Protection Agency (USEPA) released a final risk assessment document entitled, Risk Assessment for Dioxin Contamination at Midland, Michigan (USEPA 1988a) and a public review draft of a risk management document entitled, Proposed Risk Management Actions for Dioxin Contamination at Midland, Michigan (USEPA 1988b). Also issued in April 1988 was a fact sheet entitled, Summary of Risk Assessment and Proposed Risk Management Actions, Midland, Michigan. USEPA conducted a public meeting to discuss the risk assessment and risk management documents on April 28, 1988, at the Northeast Intermediate School in Midland. A panel of six experts, four from USEPA and one each from a private consulting firm and the Agency for Toxic Substances and Disease Registry, presented explanations of the procedures followed in the Midland studies and subsequently responded to a number of questions and comments from the audience. Written comments were solicited during the period from April 25 through June 3, 1988, and three letters were received, as indicated above.

The comments and suggestions received concerning the risk assessment and risk management documents all have been noted and are greatly appreciated. An attempt has been made to summarize and respond to all of the written comments received. However, inasmuch as the risk assessment document is a final report that has gone through Agency review procedures, no revisions currently are contemplated. The draft risk management document, on the other hand, has been revised, and appropriate changes have been incorporated therein (USEPA 1988c). With a few exceptions, the comments received at the April 28, 1988, public meeting in Midland were satisfactorily responded to during the meeting itself. However, a few of the meeting comments and questions that were not covered in any of the written comments or that appeared to call for expansion or clarification have been included in this document (see Section II) along with the Agency's responses. Transcripts of the meeting and copies of the written comments are available for review at the Michigan Dioxin Studies document repositories in Midland (see below).

Michigan Dioxin Studies Document Repositories

Grace A. Dow Memorial Public Library
Emilia Parker
1710 West St. Andrews Drive
Midland, Michigan 48640
(517) 835-7157

Ingersoll Township Hall
Kurt Shaffner, Supervisor
4400 Brooks Road
Midland, Michigan 48640
(517) 835-5289

Midland Health Department
Dr. Winifred Oyen, Director
125 Main Street
Midland, Michigan 48640
(517) 832-6655

I.

COMMENTS RECEIVED IN WRITING

Comment: USEPA should not have split soil samples from the Midland area and comparison sites with Dow Chemical. This allowed the company to determine the validity of the data, damaging the credibility of the study. What other samples from this study were split with Dow? Why? Why were Dow data and USEPA data compared before completion of the study?

Response: The protocols for collection of soil samples, sample handling, and analysis are fully described in the report for the soil study, Soil Screening Survey at Four Midwestern Sites, EPA-905/4-85-005, June 1985, available for review at the Michigan Dioxin Studies document repositories. As stated on pages 8 and 9 of that report, samples were provided to USEPA and Dow Chemical laboratories on a blind basis, and results were compared only after analyses were complete. USEPA believes the results and conclusions from the study are well supported by the high quality and comparable data generated by two independent laboratories using different analytical techniques. At no time during or after the soil study did USEPA allow Dow Chemical to determine the validity of data.

All samples from this study were not split with Dow Chemical, and the company did not analyze every split sample provided by USEPA. In addition to the soil study samples, all samples collected inside the Dow plant, and some of the potable water samples for dioxin analysis were split with the company. For the soil study and part of the drinking water study, USEPA and Dow Chemical results were compared prior to completion of the reports so that all relevant data could be included in the final reports for those studies.

Comment: USEPA deliberately attempted to discourage reading and commenting or questioning of data by citizens at opportune times such as public meetings.

Response: USEPA attempted to provide ample opportunity for public review and comment on each aspect of the Michigan Dioxin Studies. Public meetings were held in August and October 1983 to accept comment on the general study plans. A public meeting was held in April 1985 to review the results of the soil study, and small group meetings were held in December 1985 and July 1986 for the drinking water and Dow Chemical wastewater characterization studies, respectively. Finally, on April 28, 1988, USEPA conducted a public meeting to review the results of USEPA's risk assessment and proposed risk management actions for dioxin contamination in Midland. To the extent possible, public information summaries and technical reports were distributed for review prior to public or small group meetings. Also, USEPA has responded to numerous public inquiries about various aspects of the studies and has been available for additional small group meetings or meetings with individuals. USEPA has not attempted to discourage or limit public review or questioning of data in this matter.

Comment: The risk assessment incorrectly uses data from only the last five years to calculate exposure rather than those from earlier years during which exposures were likely to have been much higher.

Response: The primary purpose of the risk assessment was to determine current risk levels in order to allow decisions to be made regarding the need for further risk reduction measures. The calculations of current exposure levels emphasized the last five years because this was the primary period for which data were available, and also because estimates of current and future exposures based on data from this period were expected to be conservative (due to continuing clean-up work). Exposure levels <u>are</u> believed to have been higher in prior years. The existence of this downward trend tends to support the Agency's assumption that the calculations of <u>current</u> exposure are conservative. Furthermore, underestimation of risk in this situation is made even less likely by the assumption that the contamination will remain at current levels over the next half century. The conservatism of the estimates for exposure to fish contaminants has already been borne out in the most recent analyses of Tittabawassee walleye samples obtained in the Spring of 1988. The average fish levels were found to be less than 50 percent of the concentrations utilized in the risk assessment, which were based on data from the 1983-1987 period.

Comment: Midland residents were not told that the soil screening survey revealed that Midland soils contained considerably higher levels of dioxin than either of the comparison community sites in the study. They were never told that the concern over chlorinated dibenzofurans (CDFs) in the Midland environment is nearly as great for 2378-TCDD.

Response: USEPA disagrees. The public information documents and the full report of the soil study clearly state that Midland has higher dioxin soil concentrations than any of the comparison sites. This fact was fully discussed at the April 1985 and April 1988 public meetings. Also, with respect to CDFs, all data were reported and considered in the risk assessment. As noted in the risk assessment, 2378-TCDD is the most important compound, accounting for 40% (fish) to 90% (soil) of the total 2378-TCDD toxicity equivalents found.

Comment: The study was incomplete, because sampling of house dust, dairy products, and breast milk was not done; vegetable samples had not yet been analyzed; and air sampling was apparently flawed.

Response: The Midland study was an extraordinarily extensive environmental study. The sampling and analytical techniques were state-of-the-art and were implemented at considerable effort and cost. Sampling focussed on the issues of highest priority in the opinion of USEPA and cooperating agencies. USEPA agrees that further sampling would be helpful to quantify some of what are believed to be less-significant exposure routes. The most significant exposure routes, namely fish consumption, air inhalation, and soil ingestion, were the principal focus of the Michigan dioxin studies. The draft risk management document sets out the proposed further sampling programs to be performed by Dow Chemical.

Comment: Poseyville Landfill, a dioxin disposal site, is leaking. It is built over an artesian system with private wells in close proximity. The draft risk management document states (pages 36-37) that contaminants have migrated off site, but that the groundwater is largely contained within the site. What data are these conclusions based upon, what are the contaminants, and what does "largely contained" mean? Why is this exposure in Midland declared acceptable? Who will monitor the groundwater to make certain that private wells remain uncontaminated?

Response: The Poseyville Road Landfill is an inactive landfill formerly used by the Dow Chemical Company for disposal of solid wastes, some process wastes, and rubble from building demolition. Some of these materials are likely to be contaminated with dioxin. The proposed risk management report (pages 36-37) indicates that ground water monitoring by Dow Chemical revealed a plume of contamination emanating from the landfill in a north- to northeasterly direction. The plume contains the following major constituents:

1,1-Dichloroethane
Benzene
Chlorobenzene
Toluene

USEPA is not aware of any monitoring for 2378-TCDD or other CDDs/CDFs in the ground water at the Poseyville Road Landfill. The artesian conditions underneath the site may prevent downward migration of contaminants toward the usable regional aquifer. Most of the private wells in the area are within the deep regional aquifer or major sand seams in the till. A ground water purge system was installed by Dow Chemical pursuant to an order issued by the Michigan Department of Natural Resources (MDNR) to prevent flow towards private wells. The containment of Poseyville Landfill will be addressed further as a part of the Resource Conservation and Recovery Act (RCRA) permit for the Dow facility, to assure long-term protection. Dow Chemical is required to monitor the site, and the MDNR collects samples periodically to confirm the company's testing. The USEPA has not sampled the site through the RCRA program, but monitoring is required in the RCRA permit. The proposed risk management report (page 37) indicates that contaminated ground water at the plant (as opposed to Poseyville Road Landfill) is largely contained within the site. This conclusion is based upon the installation of the riverbank revetment collection system by Dow Chemical and analysis of the company's RCRA permit application. Because of historical contamination at the facility, Dow Chemical has been required, under the RCRA program, to study the ground water flow paths beneath the entire 1900 acres of property. Although ground water is known to flow towards the collection systems along the river, the study will determine if there are any areas, not close to the river, where the flow direction is toward the site boundary. Any such areas will be studied further to determine if contaminants are migrating off-site. Any identified releases will then be addressed through the RCRA program. USEPA and the MDNR will monitor compliance with the study requirements and will sample occasionally to cross check the company's results.

Comment: PCB and 7 other carcinogens that were found in Tittabawassee River walleyes along with the dioxins were not given adequate attention in the widely distributed summary and were not fully evaluated in the risk assessment itself.

Response: USEPA agrees that PCB levels in Walleyes and their associated risks may be of significant concern. The analysis of risks in Appendix B of the risk assessment document indicated that, at the levels of PCBs and CDDs/CDFs considered in the risk assessment, health risks associated with PCBs in fish were probably similar to those from dioxins and furans that were the primary subject of the study. The contributions of the other contaminants to the total toxicity are negligible due to the small amounts found and the relatively lower potencies and toxicities of these compounds. The tables in the draft risk management document indicate that PCBs add to the risk.

If the conservative assumption were to be made that risks from CDDs/CDFs and PCBs are additive, then estimates of the total risk of exposure to fish contaminant levels found in the Tittabawassee River would increase by almost an order of magnitude over the risk from CDDs/CDFs alone. Nevertheless, this assumption would not appreciably change the advice given to fish consumers.

Inasmuch as dioxin risk is the primary issue addressed in the Midland study and reports, the Agency chose to emphasize dioxin in the Summary. USEPA does, however, agree with the commentor that PCBs deserve additional attention. The discussion in the final risk management document has been expanded, using the recently obtained analytical results on dioxin and PCBs in fish taken from the Tittabawassee River in April 1988. A new Table III-7 compares the cancer risks estimated on the basis of CDDs/CDFs and PCBs for the 1988 data. While the PCB risks are dominant, no change in the risk management recommendations, including the advice to the public, is called for.

Comment: The phrase "does not pose an unacceptable risk," referring to the dioxin levels found in the study, should not have been used. It is awkward English and is an attempt to divert attention from the actual meaning.

Response: The Agency concedes the awkwardness of the phrase in question, which has become something of a standard expression in discussions of health risk. However, USEPA does not believe that this interferes seriously with any reader's comprehension of the Agency's conclusions concerning the air and soil contamination. While estimates of the risks posed by exposure to Midland air and soils can be calculated under the assumptions of the study, the resulting numbers are so low as to be negligible in comparison to the health risks Americans are comfortable about accepting as part of their daily lives. The same cannot be said about consumption of fish from the Tittabawassee River.

Comment: The chairman of the April 28 public meeting discouraged questions from the audience and was rude to citizens who posed questions.

Response: The chairman called on people from various parts of the audience, generally limiting people to a few questions at a time. The intention was to give everyone in the audience a fair opportunity to pose questions. While this commentor apparently did not ask all the questions desired during the

course of the meeting, it is true that the commentor was silent at the end of the meeting when several last calls for questions were made.

Following the meeting, the commentor did advise the chairman that she had unanswered questions. In consequence, the chairman telephoned the commentor the following week to advise that additional opportunities could be made available to her. First, that several USEPA personnel would be attending a public meeting scheduled on May 12, 1988, by the Michigan Toxic Substances Control Commission, and that questions on the documents could again be posed at that time. Second, that a conference call could be arranged at government expense for her to pose remaining questions to USEPA staff. The commentor declined to pursue these opportunities.

The chairman handled the questions with reasonable fairness and without intentional rudeness, despite numerous interruptions. Nevertheless, USEPA regrets any impression of rudeness that the commentor may have received.

Comment: Has USEPA changed its opinion regarding the significance of windblown dusts from the Dow plant as a source of contamination outside the plant?

Response: USEPA has not changed its view that windblown dusts from the Dow Chemical plant site may have been a contributing source of off-site contamination along with past and current hazardous waste incinerator emissions and possible past process emissions.

Comment: Why was the final risk assessment done by USEPA contractors instead of by USEPA staff such as Milton Clark? Is this normal procedure?

Response: USEPA frequently uses contractors to do risk assessments. The contractor is able to focus extensive manpower and expertise on the problem in a short period of time in a way that USEPA staff usually cannot. This is particularly important in a situation such as Midland where a number of different kinds of risk assessment must be made.

In the case of Midland, USEPA was fortunate to have a number of people on staff, including Dr. Clark, Donald Barnes, and David Cleverly, who were able to contribute to the risk assessment and who had done preliminary risk assessments that the contractor could utilize. The combination of efforts resulted in a strong document with which all of the authors and other contributors are pleased.

Comment: Figure III-9 and page III-61 in the risk assessment report indicate TCDF analyses were not conducted for soil samples obtained inside the Dow Chemical plant.

Response: Reference is made to page 3 of Appendix C, Quality Control Summary in Soil Screening Survey at Four Midwestern Sites (USEPA 1985a), available for review at the Michigan Dioxin Studies document repositories. Analyses for 2378-TCDF were completed for the soil samples in question. However, the analyses may not be isomer-specific, because sufficient reference standards for the other tetrachlorodibenzofuran isomers (TCDFs) were not available at the time the analyses were undertaken. At this writing, the required

standards still are not widely distributed among the analytical community. The analyses for TCDFs as a homologue were attempted, but several of the isomers could not be quantified, because they co-eluted with certain TCDD isomers. Analysis of the TCDFs could have been completed using a separate analytical procedure. However, owing to the relatively low toxicity equivalence factor for TCDFs other than 2378-TCDF (0.001), the supplementary analyses were not conducted.

Comment: Overall, the risk assessment is too conservative. All of the risk estimates, both upper bound and lower bound, are based on worst-case potency factors, and most are based on worst-case exposure values. The reader should not be led to believe that the real world falls within the USEPA-derived scenarios.

Response: USEPA does not agree that the risk assessment is overly conservative. Great care was taken in this effort to follow the procedures specified in the Agency's Guidelines for Carcinogen Risk Assessment (USEPA 1986a), and this approach is consistent with that proposed by the National Research Council of the National Academy of Sciences (NRC 1983) and with the scientific principles of carcinogen risk assessment developed by the President's Office of Science and Technology Policy (OSTP 1985).

Every attempt was made to base the exposure scenarios developed in the risk assessment on realistic values, including the reasonable worst case scenarios. The exposure ranges developed for air, soil, and fish were derived from the literature, are consistent with USEPA policy and guidance, and were reviewed and approved by the Agency's specialists in exposure assessment. USEPA believes that most residents of Midland experience dioxin exposures and risks from air and soil that fall within the ranges of estimates in the document. Likewise, the Agency believes that the exposures and risks due to fish are realistic for those who consume fish from the Tittabawassee River. (See also the first comment and response in Section II below.)

Possible additive effects or synergism of mixtures of chemicals cannot be assessed using current risk assessment methods, raising the possibility that the risks are underestimated. Use of the upper 95 percent confidence limit on the cancer potency factor is conservative by convention. Other factors, however, discussed on pages II-20 and 21 of the risk assessment indicate that the Agency's approach may not be so conservative (e.g., the longer biological half-life of dioxins in humans compared to animals and the internal exposure from existing human body burdens of dioxins).

Comment: The risk assessment should have included a worst-case scenario for a worker inside the Dow plant, who lived near the fence line and ate contaminated fish from the river.

Response: USEPA generally does not assess risks to workers arising from their exposures in the work place, as this falls under the purview of the Occupational Safety and Health Administration (OSHA). It is likely that, aside from any direct exposures to contaminated soils, wastes, or production-related chemical mixtures, most workers' exposure levels would fall within the conservative ranges for the fence-line scenarios. Except for a small group of individuals who may have had significant direct exposures in the past, the

greatest risk for Dow workers is expected to be consumption of Tittabawassee River fish, just as it is for other Midland residents.

Comment: The statement on page III-49 of the risk assessment, line 10, is incorrect, since there are no residences located even close to the Dow fence line in that area.

Response: Ambient air data collected at the fence line were pooled to represent a "reasonable worst case" air exposure scenario. This is properly characterized as such in the risk assessment and draft risk management reports.

Comment: The risk assessment should include the statement that the true value of the risk to humans from dioxin exposure "is unknown and may be as low as zero," in accordance with USEPA policy. Considerable epidemiologic evidence collected to date has not shown serious adverse effects -- cancer, reproductive, or other -- among humans exposed to dioxin at relatively high levels, some sufficient to cause chloracne.

Response: Owing to incomplete exposure information and other well-established constraints, human epidemiologic studies are inherently capable of detecting only comparatively large increases in adverse effects. Negative results from such studies cannot prove the absence of any effect. USEPA, based upon review of all available human and animal cancer data, as reviewed in Health Assessment Document for Polychlorinated Dibenzo-p-dioxins, has concluded that 2378-TCDD is a probable human carcinogen:

> 2,3,7,8-TCDD has induced hepatocellular carcinomas in two strains of female rats and both sexes of one mouse strain, along with the induction of thyroid tumors, subcutaneous fibrosarcomas and tumors of the lung, nasal turbinates/hard palate in male rats, and tongue tumors in female rats. These effects notable occur at extremely low doses. There is evidence that 2,3,7,8-TCDD is also a promoter and a cocarcinogen. The evidence of carcinogenicity for 2,3,7,8-TCDD in animals is regarded as "sufficient" using the EPA interim weight-of-evidence classification system for carcinogens (USEPA 1984).
>
> The human evidence for the carcinogenicity of 2,3,7,8-TCDD alone is regarded as "inadequate" using the EPA classification criteria, because of the difficulty of attributing the observed effects solely to the presence of 2,3,7,8-TCDD that occurs as an impurity in the phenoxyacetic acids and chlorophenols. However, the human evidence for the carcinogenicity of chlorinated phenoxyacetic herbicides and/or chlorophenols with chlorinated dibenzodioxin impurities is judged to be "limited" according to the EPA criteria.
>
> The overall evidence for carcinogenicity, considering both animal and human studies, would place 2,3,7,8-TCDD alone in the B2 category of EPA's classification scheme, and 2,3,7,8-TCDD in association with the phenoxy herbicides and/or chlorophenols in the B1 category. Chemicals in category B are regarded as being "probably" carcinogenic in humans (USEPA 1985b).

Moreover, given the frank teratogenic and liver effects of dioxin at low doses, as demonstrated in a number of animal studies, it would be difficult to conclude that substantial exposure to dioxin (e.g., via consumption of Tittabawassee River fish) could result in a risk of zero for humans.

Consequently, USEPA did consider, but chose not to use, the phrase, "may be as low as zero" to describe the risk of exposure to dioxin in the Midland risk assessment. While this wording has been included in some previous USEPA documents and appears in the Agency's Guidelines for Carcinogen Risk Assessment (USEPA 1986a), it is by no means mandated by USEPA policy, and it was judged inappropriate in this case. On the other hand, the uncertainties and caveats involved in generation of the risk estimates are clearly and thoroughly presented in the Midland document, including the statement, "...the actual risk is not likely to be greater than these levels; the actual risks could be significantly lower," which appears on pages IV-7, IV-10, and IV-18.

Comment: The statement on page II-8 of the risk assessment that 2378-TCDD has been shown to be teratogenic in rats does not appear to be correct based upon a review of three studies.

Response: USEPA believes that 2378-TCDD has been clearly demonstrated to be teratogenic in rats. A teratogenic effect is any structural or functional defect in the offspring of exposed animals. Courtney and Moore (1971) found kidney abnormalities in the fetuses of pregnant rats exposed to dosage levels of 0.5 ug/kg-bw-day and 2 ug/kg-bw-day. Giavini (1982 and 1983) observed cystic kidney anomalies and dilated renal pelvises in fetuses of exposed Sprague-Dawley rats. Murray et al. (1979) observed increases in dilated renal pelvises in the F_1 generation of a 3-generational study of Sprague-Dawley rats. These studies are discussed in further detail in the Health Assessment Document for Polychlorinated Dibenzo-p-dioxins (USEPA 1985b).

Comment: The statement on cancer promotion mechanisms at page II-6 of the risk assessment, tenth line from the bottom, reflects differences in scientific opinion and is resolved by policy decision, not by scientific consensus. The document also appears to contradict in several places the direction of the ongoing internal Agency review of dioxin cancer potency.

Response: USEPA believes that scientific consensus is the preferred approach to resolving disputes of this kind. The proposed new USEPA cancer potency factor for dioxin has been a subject of debate among Agency scientists, and differing points of view have been common. The proposed revision was published in the Federal Register on June 28, 1988, for public review and comment. All scientists now have the opportunity to provide their opinions, which will help develop the basis for USEPA science policy on the issue. For the purposes of the Midland risk assessment, the dioxin cancer potency factor used was, properly, the value officially sanctioned by the Agency at that time. The same potency factor is still in effect at this writing.

Comment: Following completion of USEPA's review of the carcinogenic potency of 2378-TCDD, will the Agency revise the Midland risk assessment?

Response: The Agency currently has no plans to revise the risk assessment. The estimated carcinogenic risks in the document would increase or decrease in simple, direct proportion to any increase or decrease in the potency. If the position of the Agency should change to such a degree that the risk management conclusions were significantly affected, USEPA would consider reissuance of the risk management document. A change of this magnitude is considered highly unlikely.

Comment: Page II-21 of the risk assessment indicates that the U.S. population already has a substantial body burden of CDDs/CDFs. Why were existing body burdens and the consequent internal dose levels not further considered in the risk assessment, and why were human fat samples not analyzed to determine the actual levels for Midland residents?

Response: By the cited discussion, the risk assessment acknowledges the likelihood that prior exposures to dioxin have resulted in substantial body burdens. Some Midland residents, particularly those who have eaten fish from the Tittabawassee River, could have body burdens exceeding the national average. USEPA's calculations suggest that the background body burden of dioxin in U.S. residents, if incurred during the early life stages, would yield estimated lifetime cancer risks in the 10^{-5} to 10^{-4} range. Consequently, future exposures to air and soil in Midland would not be expected to increase the <u>total</u> risk more than a negligible amount, particularly if the early lifestage (background) risk was closer to 10^{-4}. For those Midland residents who have accumulated historical body burdens of dioxin higher than the national average, the additional risks from exposure to Midland soils and air would be even lower by comparison.

It is important to note that the risk assessment assumes lifetime exposure to the currently measured concentrations of CDDs and CDFs in air, soil, and fish, which is unlikely to occur. Remedial measures such as dust control, cessation of chlorophenol production at the plant, improved incineration controls, and general clean-up of the site should result in declines in air levels over time. For soils, lifetime cancer risks may be closer to 10^{-6}, based upon lower <u>measured</u> soil intake rates reported in recent studies of children. The risk management report also provides advice on ways to reduce exposures from contaminated soils. CDD/CDF contamination in Tittabawassee River fish is expected to decline at some unknown rate reflecting the decreases in the Dow plant wastewater effluent and the results of the other remedial efforts.

Finally, sampling body fat in order to measure dioxin involves a surgical procedure. USEPA does not believe that the results of such a study would alter the proposed actions and advice already provided in the risk management document.

Comment: Page 59 of the Ambient Air Study lists a number of data limitations, and page 70 states that the analytical results should be considered minimum values, as the air sampling method employed was not formally validated at the time the study occurred. Please explain how the health risks from these emission levels can be called acceptable in view of past higher emission levels, the difficulty with the collection of samples, and the limited three-day sampling.

Response: At the time the ambient air sampling study was conducted (September 1984), the monitoring system employed (modified high-volume air sampler with standard high-volume glass fiber filter and extended throat with polyurethane foam (PUF) plug) was believed to be the state-of-the-art with respect to collection of PCDDs and PCDFs from ambient air. This monitoring system was selected with advice and assistance from the USEPA Environmental Monitoring Systems Laboratory located at Research Triangle Park, North Carolina. The survey results demonstrated that more higher-chlorinated CDDs and CDFs were captured on the glass fiber filter and more lower-chlorinated CDDs and CDFs were captured on the PUF plug.

Although the collection efficiency of this system had not been fully validated at the time of the survey, these data suggest that the combination of capture devices is far more efficient than a glass fiber filter alone for sampling tetra- through octa-CDDs and CDFs. Because it is possible that some fraction of the CDDs and CDFs may have passed through the PUF plug, the report notes that the results should be considered minimum values. It is important to note that the "minimum" concentrations measured in ambient air were higher than those estimated from the then current Dow Chemical incinerator emissions, suggesting that soil particles contaminated by past incinerator emissions, and contaminated windblown dusts from the plant site, may have been contributing to the ambient air levels.

When conducting risk assessments, the cancer risk estimates are normally expressed as "upper bounds." The "upper bound" designation derives from the many conservative assumptions made regarding the toxicology of the pollutant in question and the human exposure patterns considered in the analysis. Also, as explained at the April 28, 1988, public meeting, the risk assessment conducted for Midland was prospective; that is, it evaluated then-current exposures and projected them forward -- for 70 years, for example, for estimating cancer risks. Finally, the excess lifetime cancer risks from air exposures, or from any other exposures evaluated are nowhere described as "acceptable." For the specific case of ambient air concentrations, which can be influenced by incinerator emissions and windblown dusts from the Dow plant site, the estimated cancer risks and non-cancer health impacts based upon 1984 data were not so high that additional remedial measures beyond those implemented since 1984 (improved incinerator operations and plant-wide dust suppression program) appeared warranted. This was a risk management conclusion. To insure that this conclusion was appropriate, the proposed risk management actions include follow-up ambient air monitoring to assess current levels.

Comment: Why were immunotoxic effects not fully considered in the risk assessment? It was noted in the report that animal studies suggest that immunotoxic effects may occur at exposure levels lower than the Reference Dose

(RfD)* of 1 pg/kg/day. This effect appears to be a more sensitive indicator of toxicity for these compound than reproductive, teratogenic, or hepatic effects.

Response: Several studies have reported immunotoxic effects from dioxin in animals at low doses. Clark (1981 and 1983) found that 0.004 ug/kg-bw-week or 0.6 ng/kg-bw-day caused replicative impairment of T-cells. This is very close to the lowest observed adverse effect level (LOAEL) of about 1 to 1.5 ng/kg-bw-day observed in the animal reproductive studies. As discussed in the Midland risk assessment, an uncertainty factor of 1000** is applied to derive an RfD of 1 pg/kg-bw-day for long-term exposure. Applying the same procedure to the Clark studies, which reported the lowest observed immunological effects to date, an "RfD" of 0.6 pg/kg-bw-day would be derived -- very similar to the RfD based upon the reproductive studies. Therefore, 1 pg/kg-bw-day should be protective of both immunological and reproductive effects.

USEPA and CDC have derived RfDs and Health Advisories (HAs) using studies showing less equivocal, more serious effects, such as birth defects. The significance for humans of T-cell replication impairment by dioxin at low doses is unclear at this time, and there is no precedent or generally-accepted procedure for the use of immunotoxicity data in establishing RfDs or HAs. The Agency believes it is being most protective of human health by using the data on adverse reproductive and liver effects caused by dioxin. Accordingly, possible immunotoxic effects were not considered in a quantitative manner, as were cancer and other, non-cancer health impacts.

Comment: Should ground water analysis have included furans to be complete and accurate in the assessment of its safety for human consumption?

Response: CDFs and CDDs other than 2378-TCDD were not analyzed in the potable ground waters or major potable surface water supplies included in the drinking water portion of the Michigan Dioxin Studies. A more complete analysis of additional CDDs and the CDFs was not considered necessary, owing to the affinity of the CDDs and CDFs to solid particles and their general lack of mobility in soils not affected by high levels of organic solvents.

Comment: Deer hunting is popular in and around Midland, and many deer are probably consumed by residents. The risk assessment should have considered this route of exposure, since soil levels lower than 1 part per billion (ppb) have been cited as of concern for grazing animals.

---

*The RfD can be defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure of the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effect during a lifetime. The RfD supersedes, and is generally equivalent to, the Acceptable Daily Intake (ADI) values previously used by USEPA and other agencies to define dose levels for non-cancer endpoints.

**Includes subfactors of 10 because the lowest administered dose was not a "no observed adverse effect level (NOAEL)," 10 to account for possible inter-species differences in sensitivity, and 10 to account for possible intra-species differences in sensitivity.

Response: Given the low levels of dioxins and furans in soils off the plant site, USEPA does not anticipate that concentrations of concern would accumulate in deer. The company will be collecting soil samples from grazing areas so that the potential for accumulation in deer or cattle can be assessed. Unlike cattle, deer generally do not eat large amounts of grass and other low-lying ground vegetation and, thus, are much less likely to consume significant quantities of soil, which provides the main exposure route for cattle. Finally, deer muscle (venison) contains significantly less fat (marbling) than that of cattle (beef) and consequently would not tend to contain as much dioxin, given equivalent levels in the animals' food.

Comment: In the potable well water analyses lab data, levels for calcium, magnesium, sodium, and potassium are listed for private wells I through P, but not for wells A through H.

Response: Calcium, magnesium, sodium, and potassium were not analyzed in samples from wells A through I collected in August 1984. A sample from well G was also collected in December 1984 and was analyzed for the elements noted above. The results presented below were inadvertently omitted from the drinking water report:

Well G -- December 1984

Magnesium	22.6 mg/L
Calcium	60 mg/L
Sodium	21.2 mg/L
Potassium	1.96 mg/L

These results are well within applicable drinking water criteria and have been provided to the well owner.

Comment: The soil screening survey indicates that the laboratory analysis for soil samples was conducted on a blind basis (page 9). Was the air sample analysis also done on a blind basis?

Response: The analyses by USEPA's contract laboratory for the air study were not conducted on a blind basis, as were those for the soil study. Since the ambient air sampling and incinerator emissions testing were conducted only in Midland, with no comparison sites, the source of the samples could not be fully concealed as was done for the soil study.

Comment: In the soil screening survey report, an April 4, 1985, letter from Donald Barnes to Michael Cook states that the CDDs/CDFs in the Midland soils outside the Dow plant are below the 1 ppb CDC level of concern. However, page III-53 of the risk assessment states that the majority of Midland soil samples were analyzed for 2378-TCDD only. Please explain Dr. Barnes's conclusion given the limited sampling analysis.

Response: The conclusion reached by Dr. Barnes regarding levels of CDDs/CDFs in Midland soils is based upon a review of the 2378-TCDD data reported for all soils analyzed in Midland and the 2378-TCDD toxicity equivalents for the

smaller number of Midland soils analyzed for 2378-TCDD and other CDDs and CDFs.

Comment: Is MRI a USEPA laboratory?

Response: MRI (Midwest Research Institute), is not a USEPA laboratory. MRI, located in Kansas City, Missouri, is a private contract laboratory hired by USEPA for analysis of certain samples from the Michigan Dioxin Studies.

Comment: Were deep core samples from the Dow plant ever analyzed? If so, what were the results?

Response: 2378-TCDD analyses of soil core samples at several locations within the Dow plant were conducted by Dow Chemical at the request of USEPA's hazardous waste management program. The results were reported to the public at an MDNR meeting in Midland on June 2, 1987, by Carol Witt of USEPA and also were summarized in The National Dioxin Study Report to Congress (USEPA 1987b). In a separate study, subsurface soil samples were collected and analyzed by Dow Chemical from the two areas of high surface soil contamination in response to a CERCLA (Superfund) Section 106 order issued by USEPA. The areas of subsurface soil contaminated with 2378-TCDD (ranging in concentration from below detection to 1500 ppb) were found to be isolated and confined to locations where production-related spills or leaks had occurred in the past. The highest concentrations were found in a small volume of soil 5 to 15 feet below the surface near a former chlorophenols manufacturing operation. The contamination in these areas has been, or is being, controlled in connection with the RCRA permit for the facility. The analytical data are available upon written request from the USEPA Region V Waste Management Division.

Comment: USEPA has made very little attempt to interpret the risks of fish consumption for the public.

Response: USEPA strongly disagrees. Through a variety of reports and public statements, Agency personnel and its contractors, both alone and in conjunction with the staff of other agencies, have made a considerable effort to advise the public of the risks of consumption of fish from the Tittabawassee River. Chief among USEPA's efforts has been the publication and dissemination of a series of documents which describe and interpret the risks at varying levels of technical detail. Included are the risk assessment document, which provides the background technical discussion; the draft risk management document, which discusses the topic at a level of detail suitable for a somewhat larger audience; and an eight-page summary or "fact sheet," which deals with the issue in concise fashion and has been widely distributed.

In addition, the Agency issued a press release, and Agency staff spent considerable time discussing the matter with members of the press who were preparing articles on the topic. Lastly, the Agency held public meetings in April 1985 and April 1988, in which the risks of fish consumption were discussed in considerable detail, and in which questions from the public were answered by a number of experts brought in for the purpose.

In all of these efforts, USEPA has consistently stated what the estimated risks are for particular consumption patterns and exposure groups in the most specific terms possible. The Agency has made it clear that these risks may be significant, particularly for large-quantity consumers, children, pregnant women, and women of child-bearing age.

USEPA has recommended that people follow the state's fish consumption advisory and has assisted the state in further evaluation of the problem, in part by chemical analysis of fish samples collected from the river in 1988.

Comment: An objective should be included in the monitoring program for Tittabawassee River fish to better characterize the concentrations of penta-CDD and CDFs in fish tissues.

Response: The 1988 fish collection program for the Tittabawassee River described in the draft risk management document included analyses of penta-CDDs and CDFs. These data are reported in the final risk management report.

Comment: While the objective of the dioxin risk assessment is to report dioxin levels and associated risks in Midland, Michigan, the document gives no comparative data from other locations to put the dioxin issue in perspective. The report should give a more general perspective, because it currently misleads the reader into believing that dioxin contamination is only observed in Midland, Michigan.

Response: While the risk assessment is specific to the environmental contamination and human exposures for Midland, Michigan, environmental contamination at other locations was described in other reports of the Michigan Dioxin Studies. For example, data from several comparison sites were presented in the soil study report, and contamination at several other National Dioxin Study Tier 1 and 2 sites was described in the public information documents accompanying the soil study report.

Comment: Much data on dioxin in fish has been collected over the past several years, showing low levels of dioxin in many areas throughout the world. The risk assessment document isolates the data on fish from the Tittabawassee River. The discussion on fish in Section III should not be viewed in isolation relative to other dioxin sources and other locations. The reader is led to believe that low levels of dioxin are only seen in fish from the Tittabawassee River.

Response: There have been several publications by USEPA describing dioxin data in fish. Most notable among these are the following:

Polychlorinated Dioxins and Polychlorinated Furans in Fish from the Great Lakes and Midwest (DeVault 1984);
Dioxin in Great Lakes Fish (USEPA 1986b);
The National Dioxin Study, Tiers 3, 5, 6, and 7 (USEPA 1987a); and
The National Dioxin Study Report to Congress (USEPA 1987b).

Comment: Because the analyses were not isomer specific, assumptions were made with regard to the isomer distributions. This uncertainty could be significantly

reduced by using the isomer distribution ratios found in Point Sources and Environmental Levels of 2378-TCDD on the Midland Plant Site of the Dow Chemical Company and in the City of Midland, Michigan (Dow 1984).

Response: To the extent possible, data from the above-cited report were included in the derivation of the 2378-toxicity equivalents for Dow plant emission sources that were used in the exposure assessment.

Comment: The conclusions of the risk assessment should be qualified to the extent they are based upon analytical results reported as "not detected (ND)."

Response: The ND data exerted a significant influence only in the exposure assessment for ambient air. The implications of the approach used to handle these data in the Midland risk assessment are fully explored in the discussions on pages III-50 to 52 and IV-7.

Comment: A listing of comparative cancer risks could have been included in the risk assessment to help the lay person put the estimated risks from dioxin exposure in perspective (e.g., 3 in 10 overall average lifetime cancer risk and 1 in 8 risk from smoking cigarettes).

Response: Some comparative information was provided by the panel during the public meeting in Midland on April 28, 1988. USEPA will consider adding such a listing if the risk assessment document should be revised.

Comment: There is no mention in the study of Dow's massive cleanup efforts before the sampling began. Soil was removed from the plant site, and the incinerator was scrubbed.

Response: This comment is similar to one received by USEPA after the soil study report was released, alleging that USEPA sampled "new dirt" inside the Dow Chemical plant after a cleanup by Dow prior to the in-plant soil sampling study. USEPA believes the soil study results clearly indicate that any cleanup efforts that may have been undertaken by Dow Chemical did not materially impact the conclusions of the study. 2378-TCDD was detected in every targeted and random soil sample collected. These data were used by USEPA to issue a CERCLA (Superfund) Section 106 order to Dow Chemical for corrective actions at the plant.

Comment: Page I-8, paragraph 2: The average represents an average of soil suspected of being contaminated; i.e., the most highly contaminated areas were sampled.

Response: The USEPA in-plant soil sampling program included both targeted and random sampling with about an equal number of samples devoted to each type of sampling. The Dow Chemical in-plant soil sampling effort was principally directed at areas that were likely to be contaminated, with a lesser degree of "background" sampling within the plant. In any event, USEPA agrees that the degree of contamination across the site would probably be better described as "on the average, less than 0.5 ppb" rather than "an average of 0.5 ppb." The final risk management document has been revised accordingly.

Comment: On page II-9 of the risk assessment, last paragraph, the teratology no observed adverse effect level (NOAEL) is incorrectly used as a lowest observed adverse effect level (LOAEL).

Response: As discussed in the text, there has been debate over whether the Murray et al. (1979) study showed a NOAEL or a LOAEL. USEPA has concluded that the lowest dose tested was a LOAEL.

Comment: On page II-14 of the risk assessment, first paragraph, the comments concerning the potential for risks existing below the RfDs and HAs appear to be highly speculative. Is this consistent with Agency policy?

Response: USEPA policy on the use of immunotoxicity data for the development of RfDs and HAs is currently under review. Because the studies cited on the referenced page of the risk assessment indicate the possibility of toxic effects below the current LOAEL, adoption of a procedure utilizing the immunotoxicity data could lower the RfD and HAs.

Comment: On page II-19 of the risk assessment, indent 2, there is a need for greater emphasis on the limited information on carcinogenicity for some of the isomers included in the TEF calculations.

Response: The Agency is aware of the assumptions made in developing the TEF procedure which it has adopted as interim science policy, and it intends to issue periodic updates. A complete discussion of this matter can be found in Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and -Dibenzofurans (CDDs and CDFs) (USEPA 1987c).

Comment: On page III-3 of the risk assessment, line 2, and page III-15, line 3, the word "significant" should be replaced with "detectable".

Response: USEPA agrees that the "significance" of the results reported here is limited to the fact that CDDs/CDFs were detected.

Comment: On page III-15 of the risk assessment, paragraph 2 and the section as a whole assume that Site 1 is ambient and the other sites are influenced by the Dow waste incinerator. Actually, Site 1 is also downwind of the heaviest concentration of auto exhaust and home heating.

Response: Site 1 is described in the risk assessment and in the ambient air study report as "upwind" not "ambient." This site was selected to distinguish any additional dioxin contamination impacts on Sites 2 and 4, located "downwind" of the incinerator and major production areas of the plant. Based upon prevailing wind directions, Site 1 is not downwind of the heaviest concentrations of auto exhausts. Also, since the ambient air study was conducted during mid-September, home heating could not have had a significant impact on the results, even if home heating were a significant source of CDD and CDF emissions, which the Agency believes is extremely unlikely.

Comment: On page III-16 of the risk assessment, paragraph 2, the Dow Point Source Survey should be reflected in the statement concerning availability of data.

Response: The Dow study is cited in line 6 of this paragraph as "Dow 1984." While primary emphasis was placed upon the USEPA data for the reasons stated, the Dow data were fully reviewed and considered in the preparation of the risk assessment.

Comment: On page III-35 of the risk assessment, third line from the bottom, the downwind increment of 136 degrees (58 percent of the total time) seems very high. There ought to be a profile giving time vs. percent of maximum on a more narrow basis.

Response: USEPA agrees that the downwind increment selected (58 percent of the time) is on the high side. However, this increment is supported by the analysis of available meteorological data and is consistent with the conservative nature of the risk assessment.

Comment: On page III-37 of the risk assessment, the statement that monitoring Site 3 was less downwind than Sites 2 and 4 is not correct. Air dispersion modelling using USEPA's ISCLT program with the FLINT77 STAR deck show that maximum predicted concentrations are directly north of a source and fall off equally on each side of north up to about 15 degrees off north. Therefore, Sites 2 and 3 were equally downwind, and Site 4 was less directly downwind.

Response: Based upon a review of the meteorological data obtained at the time of the ambient air study, only those samples from Sites 2 and 4 collected on the following dates were analyzed:

Date	Average Wind
September 8-9, 1984	199 degrees, 6 mph
September 12-13, 1984	191 degrees, 6 mph
September 22-23, 1984	212 degrees, 5 mph

Accordingly, most of the data were collected when Sites 2 and 4 were, in fact, more in the downwind direction than Site 3. The statement made on page III-37 of the risk assessment is that Site 3 is "...less directly downwind of the incinerator and major production area." Given the meteorology on the sampling days, this statement is correct.

Comment: With regard to the statement on page III-45 of the risk assessment, line 8, it should be noted that there are no residences located at or near 0.6 miles north and northeast of the incinerator.

Response: The statement in question refers to the estimated location of the maximum annual average ground level concentrations of CDDs and CDFs, not the location of residences.

Comment: On page III-69, the assumption that exposure to soil is possible for 247 days per year is high for Midland. Snow-covered and frozen ground reduce the number of days below 247.

Response: Recent studies by Clausing (1987) and Calabrese (1988), as well as previous work (see Hawley 1985), indicate that young children may be exposed to indoor dusts, which typically have the same contaminant concentrations as soils found outside. Therefore, exposures may occur throughout the year. Adults, too, could be exposed to indoor dusts on a daily basis. Because ranges of the soil exposure parameters, from typical to worst-case, were used in the assessment, the total number of days of exposure becomes less critical, as does the issue of exposure to indoor dust.

II.

COMMENTS RECEIVED AT THE PUBLIC MEETING

Comment: The fish consumption scenarios evaluated by USEPA in the risk assessment are unrealistically conservative when considered in light of the results of MDPH's recent creel survey of Tittabawassee River fishermen.

Response: Results from the MDPH creel survey (Smith and Enger 1988) for those respondents who reported that they caught and consumed fish from the Tittabawassee River (49 percent), in fact, tend to support the fish consumption scenarios developed for the risk assessment . The consumption rates presented below were developed from the creel survey data, making the assumption that the size of a typical fish meal ranged from 113 to 255 grams, or 4 to 9 ounces (the same assumption used in the risk assessment). The principal focus of the risk assessment is on those people who actually eat fish from the river.

COMPARISON OF TITTABAWASSEE RIVER FISH CONSUMPTION RATES

USEPA RISK ASSESSMENT*		TITTABAWASSEE RIVER CREEL SURVEY**	
Scenario	Consumption Rate	Results Reported for 343 Respondents Who Catch and Eat Tittabawassee Fish	
General Consumer	3.1 lbs/yr	58% Eat Less Than	3.0 to 6.7 lbs/yr
Great Lakes Consumer	12.9 lbs/yr	28% Eat About	3.0 to 6.7 lbs/yr
High Sports Fisherman			
Level 1	38.6 lbs/yr	10% Eat About	12.9 to 29.2 lbs/yr
Level 2	80.4 lbs/yr		
		4% Eat More Than	12.9 to 29.2 lbs/yr
Plausible Maximum Consumer	80.4 lbs/yr		

*From Table III-2, Risk management document (USEPA 1988c)
**Annual consumption rate ranges based upon 4 oz to 9 oz meal sizes.

The creel survey data also show that about 14% of 360 fishermen responding process (clean and freeze for later consumption) from 24 to 59 lbs/year of game fish, and about 10% process more than 50 lbs/year. There were seven people reporting that they process from 24-49 lbs/year of carp or catfish and three people reporting processing more than 50 lbs/year of carp or catfish. A number of respondents reported sharing their catch with other family members including children. Accordingly, Region V believes these data are consistent with the fish consumption rates selected for the risk assessment.

Comment: Removal of fat according to the directions in the Michigan Fishing Guide and cooking in ways that allow additional fat to drip away can reduce contaminants in the fish actually eaten. According to new data from testing of "restructured" carp fillets [surimi], combined trimming and cooking reductions can amount to 90 percent, and charbroiling alone will produce a 40 to 70 percent reduction. Why did USEPA do the risk assessment on uncooked, skin-on fillets?

Response: As a matter of policy, USEPA and the Great Lakes states provide fish consumption advice based upon the analysis of edible-portion samples. The Agency and the Great Lakes states have agreed that the best representation of the edible portion is a skin-on fillet. Fish cleaning and cooking advice is provided that, if followed, should result in some reduction in risk. The extent of this reduction has never been well-documented and is variable, depending upon the skill of the fish cleaner, the detailed cooking conditions, and, probably, the fish species and the nature of the contaminants. There is no generally-accepted value available for risk assessment calculations. The following is a statement of the agreed policy for the Great Lakes area, as published by Michigan (Humphrey and Hesse 1986):

> It was agreed that all monitoring for Great Lakes fish shall be done on a skin-on fillet basis, unless otherwise specified. No adjustments should be made in risk estimations based on anticipated reduction in contaminants from recommended trimming and cooking techniques, although all agencies should broadly publicize these methods as a means of further reducing one's exposure to contaminants from fish consumption.

Comment: The U.S. Food and Drug Administration (FDA) permits fish to be sold for consumption with higher levels of these pollutants--25 parts per trillion (ppt) 2378-TCDD and 2 parts per million (ppm) PCBs--than are present in the Tittabawassee River game fish.

Response: The FDA regulates fish in interstate commerce and has made clear that its action levels are not directly applicable to consumption by sports fishermen and other localized situations where specific subpopulations are exposed to contaminants in fish. To accomplish its mission, the FDA uses procedures and assumptions quite different from those of USEPA, making comparisons of the "acceptable levels" difficult. For example, for 2378-TCDD, FDA assumed that the average contaminant level in the fish was only one-third of the guideline level cited (i.e., about 8 ppt). FDA further assumed that the average person ate 15.7 g/day of fish, but that only 10 percent of these fish were contaminated. Additional differences appear in the methods used to

interpret the results of the critical animal tests and in the calculations used to move from the animal model to humans. As explained above, USEPA has carried out its Midland risk assessment in conformity with its established procedures and policies for human health risk assessment (USEPA 1986a). The protocols and assumptions utilized by USEPA have been set out in great detail in the risk assessment document and herein. Ultimately, it is up to the State to determine the levels of contaminants that are acceptable in the food supply of its residents and at what point action should be taken to restrict consumption.

Comment: Epidemiological studies of human populations exposed to dioxins, including those at Seveso, Italy, and Times Beach, Missouri, have not shown adverse reproductive effects attributable to the exposures.

Response: USEPA does not believe that the findings to date are conclusive one way or the other. For additional detail, please refer to the response to the second comment on page 7 of Section I, above.

Comment: Pica is not as uncommon a disorder as the risk assessment implies.

Response: Pica can be defined as consumption by children of soil at rates in excess of the normal range of about 0.1 to 0.5 grams per day -- often as much as 10 grams per day or more. It occurs, on the average, in about 1 out of every 200 children.

Comment: With regard to a sample collected at the Rockwell dump that had been sent to USEPA's Minneapolis laboratory, why did Mr. Zar [the chairman of the meeting] instruct Mr. Larry Fink, then an USEPA employee, not to discuss this sample?

Response: Mr. Zar could not recall any such conversation at the time of the meeting. However, he contacted Mr. Fink, who was no longer with USEPA, the following day and was reminded of a conversation that took place at the Agency's Duluth laboratory in August 1985, regarding a sample from the Mapleton Public Well that had just been received by the laboratory. Mr. Fink remembered Mr. Zar advising him in strong terms that it would be inappropriate to discuss the sample publicly until final analytical results had been obtained.

The sample in question subsequently was analyzed by the Duluth laboratory, and by the Dow Chemical Company as well. Neither laboratory found 2378-TCDD in the sample, although analysis of a previous sample had yielded an apparently false positive at one of three participating laboratories. These results and further discussion are presented on pages 23 and 25 of Michigan Dioxin Studies: Screening Survey of Surface Water Supplies, Potable Ground Water, and Dow Chemical Brine Operations (Barna and Amendola 1985), available for review in the Michigan Dioxin Studies document repositories.

The results for the above sample and the other results published in the above-cited report were the subject of a public meeting held by USEPA in Midland on December 19, 1985, and were further discussed in a number of newspaper articles during the next several days. USEPA is satisfied that the Mapleton

well was adequately tested and that the results were fully reported to the public.

Comment: What is an acceptable level of dioxin in the sediments of the Tittabawassee River? What could be done about contaminated sediments?

Response: Currently there are no published criteria specifying safe levels of dioxin in river, lake, or harbor sediments. USEPA's concern with regard to the sediments is that remaining pockets of relatively highly contaminated sediments might be contributing significant amounts of dioxins to the fish either directly or via other organisms or the water column itself. The clean-up of the water and the fish might be retarded by such a reservoir of contaminants, even though the levels in wastewater and other external inputs continue to drop. In the river studies performed to date, 2378-TCDD has not been detected in the sediments, and the bottom of the river has appeared to be composed rather uniformly of sand and gravel, which would not be conducive to dioxin accumulation. Monitoring proposed in Section IV(C)(2)(b) of the risk management document is aimed at confirming whether or not pockets of organic sediments do exist downstream of the Dow Chemical plant and, if so, whether they contain detectable levels of dioxins. If significantly contaminated sediments were found and confirmed, serious consideration would be given to removal by dredging or excavation.

Comment: What is the range of soil concentrations of concern, for the chemical 2378-TCDD.

Response: In his response to the previous comment at the meeting, Dr. McClanahan indicated that the level of concern in a particular situation could be in the neighborhood of 1 part per billion (ppb), but that the specifics of the individual site would govern. Basically, one has to go through a site-specific analysis of the kind that has been done for Midland. The levels found in Midland residential and public use area soils were all well under 1 ppb, and USEPA's assessment indicates that the component of risk to the residents via this route of exposure is negligible, with the possible exception of children who eat large amounts of soil due to the medical disorder, pica.

Comment: If no 2378-TCDD was found at the Saginaw Bay drinking water intake at a detection limit of 5 to 10 parts per quadrillion (ppq), how does USEPA account for the findings of high levels in common terns and tern eggs--25 and up to 3763 parts per trillion (ppt), respectively--in the Saginaw River and Bay area?

Response: Terns are at the top of the aquatic food chain and are extraordinarily efficient at concentrating chemicals such as dioxin. It is not unusual to observe bioconcentration factors of 100 thousand or a million between water and the tern eggs. Consequently, there is no inconsistency in finding 2378-TCDD at hundreds or even thousands of ppt in tern eggs and not finding it in the water at less than 10 ppq.

Comment: Were the contaminants other than dioxins that were found in the fish considered in developing the fish consumption advisory?

Response: Fish consumption advisories are the responsibility of the Michigan Department of Public Health (MDPH). At the public meeting, John Hesse of the MDPH responded that the other chemicals were considered individually as to the need for an advisory. In addition, the "10-percent rule" was applied: if more than 10 percent of the fish population were found to require advisories, regardless of the contaminant, then an advisory was put in place.

Comment: Why did USEPA recommend that the 1988 walleye sampling be done in the spring after the fish have been out in the bay all winter?

Response: It is the Agency's understanding that the fish are in the river and the mouth for some time prior to the spring run. Samples collected in 1985 showed little difference in dioxin concentration between those caught in the spring and those caught in the summer. Furthermore, the spring run is the most heavily fished period of the year, so it is likely to be more representative in terms of the fish that people are eating.

Comment: [By a resident of Ingersoll Township] Ingersoll Township has been in favor of USEPA's involvement with the Dow Chemical Company Midland plant site from the very beginning. The whole investigation process has been very beneficial from the standpoint of the community and the company.

Response: USEPA acknowledges and appreciates the comment.

Comment: [By a representative of Dow Chemical Company] Dow would like to thank USEPA for conducting the study and thank the community members for urging Dow, through the years, to change the way it does business. The study was a positive experience for Dow and is probably as comprehensive, substantive, and exhaustive a study as has ever been done on any community. The study probably will serve as a model for future USEPA efforts. Dow pledges its continued efforts to resolve this problem.

Response: USEPA acknowledges and appreciates the comment.

REFERENCES

BARNA, D.R., and AMENDOLA, G.A. 1985. Screening survey of surface water supplies, potable ground water, and Dow Chemical brine operations. Environmental Services Division, Region V, USEPA, Westlake, Ohio.

CALABRESE, E. 1988. Preliminary results of University of Massachusetts, Amherst, epidemiological soil and dust ingestion study. Presentation at Colloquium on Oral and Dermal Exposure to Soil and Dust. Risk Assessment Forum, USEPA, Washington D.C. March 23.

CLARK, D.A., GAULDIE, J., SZEWCSIL, M.R., and SWEENET, G. 1981. Enhanced suppressor cell activity as a mechanism of immunosuppression by 2,3,7,8-tetrachlorodibenzo-p-dioxin. Proc. Soc. Exp. Biol. Med., 168(2):290.299.

CLARK, D.A., SWEENEY, G., SAFE, S., HANCOCK, E., KILBURN, D.G., and GAULDIE, J. 1983. Cellular and genetic basis for suppression of cytotoxic T cell generation by haloaromatic hydrocarbons. Immunopharmacology 6:143-153.

CLAUSING, P., BRUNEKREEF, B., and VAN WIJNEN, J.H. 1987. A method for estimating soil ingestion by children. Int. Arch. Occup. Environ. Health 59:73-82.

COURTNEY, K.D., and MOORE, J.A. 1971. Teratology studies with 2,4,5-T and 2,3,7,8-TCDD. Toxicol. Appl. Pharmacol. 20:396-403.

DEVAULT, D. 1984. Polychlorinated dioxins and polychlorinated furans in fish from the Great Lakes and Midwest. EPA-905/3-84-006. Great Lakes National Program Office, USEPA, Chicago, Illinois. October.

DOW CHEMICAL. 1984. Point sources and environmental levels of 2378-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) on the Midland Plant site of the Dow Chemical Company and in the city of Midland, Michigan. Dow Chemical Company, Midland, Michigan. November 5.

GIAVINI, E., PRATI, M., AND VISMARA, C. 1982. Effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin administered to pregnant rats during the preimplantation period. Environ. Res. 29(1):185-189.

GIAVINI, E., PRATI, M., AND VISMARA, C. 1983. Embryotoxic effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin administered to female rats before mating. Environ. Res. 31:105-110.

HAWLEY, J.K. 1985. Assessment of health risk from exposure to contaminated soil. Risk Analysis 5:289-302.

HUMPHREY, H.E.B., and HESSE, J.L. 1986. Sport-caught fish consumption advisories: Philosophy, procedures and process. Draft procedural statement. Center for Environmental Health Sciences, Michigan Department of Public Health. November.

MURRAY, F.J., SMITH, F.A., NITSCHKE, K.D., HUMISTON, C.G., KOCIBA, R.J., and SCHWETZ, B.A. 1979. Three-generation reproduction study of rats given 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the diet. Toxicol. Appl. Pharmacol. 50:241-251.

NATIONAL RESEARCH COUNCIL (NRC). 1983. Risk assessment in the Federal Government: Managing the process. National Academy Press, Washington, D.C.

OFFICE OF SCIENCE AND TECHNOLOGY POLICY (OSTP). 1985. Chemical carcinogens: A review of the science and its associated principles. Executive Office of the President. February. Fed. Reg. 50:10371-10442 (March 14).

SMITH, B.F., and ENGER, E.D. 1988. A survey of attitudes and fish consumption of anglers on the lower Tittabawassee River, Michigan. Under contract for Center for Environmental Health Sciences, Michigan Department of Public Health. April 26.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1984. Ambient water quality criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin. EPA 440/5-84-007. Office of Water Regulations and Standards. February.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1985a. Soil screening survey at four midwestern sites. EPA 905/4-85-005. Environmental Services Division, Region 5. Westlake, Ohio.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1985b. Health Assessment Document for polychlorinated dibenzo-p-dioxins. EPA 600/8-84-014F. Office of Research and Development. Washington, D.C.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1986a. Guidelines for carcinogen risk assessment. 51 FR 33992-34003.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1986b. Dioxin in Great Lakes fish. Great Lakes National Program Office and Region V, Chicago, Illinois. May.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987a. National dioxin study, tiers 3, 5, 6, and 7. EPA-440/4-87-003. February.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987b. National dioxin study report to Congress. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/530-SW-87-025. August.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1987c. Interim procedures for estimating risks associated with exposures to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans. EPA/625/3-87/012. Risk Assessment Forum. March.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988a. Risk assessment for dioxin contamination at Midland, Michigan. EPA-905/4-88-005. Region V. April.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988b. Proposed risk management actions for dioxin contamination at Midland, Michigan. EPA-905/4-88-006. Region V. April.

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1988c. Risk management recommendations for dioxin contamination at Midland, Michigan. EPA-905/4-88-008. Region V. November.

APPENDIX B

1988 TITTABAWASSEE RIVER FISH MONITORING PROGRAM

Twenty spring run, Tittabawassee River walleyes were collected near Midland by the Michigan Department of Natural Resources on April 12, 1988. Skin-on fillets from each fish were analyzed for PCBs, PBBs, chlorinated styrenes, hexachlorobenzene, and several chlorinated pesticides and derivatives by the Michigan Department of Public Health. Each sample was analyzed for 2378-TCDD by Dow Chemical Company, and four samples were analyzed by both Dow Chemical Company and USEPA for 2378-substituted CDDs and CDFs. The analytical results are attached.

Presented below is a comparison of recent Tittabawassee River walleye (skin-on fillet) monitoring data for 2378-TCDD and PCBs (all are mean concentrations):

	2378-TCDD		PCBs		
				Tissue Conc.	
Year	Number of Fish	Tissue Conc.	Number of Fish	Aroclor 1254	Aroclors 1248+1254
1983	5	3.9 ppt	--	--	--
1985	19	4.5 ppt	14	0.59 ppm	--
1987	3	1.3 ppt	--	--	--
1988	20	3.1 ppt	20	0.57 ppm	0.81 ppm

These data indicate a decrease in 2378-TCDD levels in 1987-1988 walleye from those measured in 1983-1985. This trend generally follows the reduction in 2378-TCDD discharge levels from the Michigan Division plant of Dow Chemical Company. Comparison of the average PCB data indicates no change in fish concentrations from 1985 to 1988. On the following page is a presentation of the 1988 data for 2378-TCDD, 2378-TCDD TEQs, and PCBs by size class, demonstrating higher contaminant levels in larger fish. A full listing* of the analytical results is attached.

*[Results of chemical analysis of Tittabawassee River fish collected April 12, 1988.] Transmitted by L. Duling, Fish Contaminant Monitoring Program, Surface Water Quality Division, Michigan Department of Natural Resources, to H. Zar, Water Division, Region V, USEPA, Chicago, Illinois. July 29, 1988.

TABLE B-1

CDDs/CDFs AND PCBs IN 1988 SPRING WALLEYE FROM THE TITTABAWASSEE RIVER

Number of Fish	Size Class	Weight (g)		2378-TCDD (ppt)		2378-TCDD TEQs (ppt)		PCBs (ppm)	
		Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
6	15" - 18"	680-780	703	1.1-2.1	1.7	2.0-3.9	3.1	0.26-0.64	0.43
6	18" - 22"	1240-1640	1450	1.6-4.0	2.7	3.0-7.4	4.9	0.36-1.2	0.72
8	22" - 26+"	2170-3660	2650	2.2-8.6	4.4	4.1-16.	8.2	0.48-2.2	1.2
				Average (20 fish)	3.1		5.7		0.81

Notes: (1) Analyses by Michigan DNR; Dow Chemical Company; and USEPA, Duluth MN.
(2) 2378-TCDD TEQ estimated from four USEPA analyses with mean TEQ/2378-TCDD ratio of 1.85 (range: 1.63 to 2.23).
(3) PCB values are the sum of measurements for Aroclors 1248 and 1254.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: Tittabawassee River STORET No.: 560143 Collection Date: 4/12/88
Location: Midland Grid No.: Lab : Dow, EPA, MDNR

ID#	Species	Sex	length (in)	Weight (lbs)	Sample Type	% Fat	% Fat (Replicate)	Comments
88001-01	Walleye	M	16.54	1.52	F	1.2		
88001-03	Walleye	M	17.13	1.52	F	1.4		
88001-05	Walleye	M	17.13	1.50	F	1.8		
88001-06	Walleye	M	17.13	1.54	F	1.6		
88001-09	Walleye	M	16.93	1.72	F	2.7		
88001-10	Walleye	M	17.52	1.50	F	1.6	1.6	
88001-13	Walleye	M	20.87	3.02	F	2.2		
88001-14	Walleye	M	21.06	3.20	F	2.0		
88001-15	Walleye	M	21.26	3.17	F	1.8		
88001-16	Walleye	M	20.47	2.73	F	1.25		
88001-17	Walleye	M	21.06	3.04	F	2.65		
88001-18	Walleye	F	21.46	3.62	F	1.2	1.2	
88001-22	Walleye	M	23.62	5.18	F	5.00		
88001-25	Walleye	M	23.23	5.07	F	2.95		
88001-26	Walleye	F	25.20	6.15	F	2.25		
88001-27	Walleye	F	26.77	6.13	F	1.85		
88001-28	Walleye	M	25.20	5.64	F	3.1		
88001-29	Walleye	M	24.02	4.78	F	2.3		
88001-30	Walleye	F	24.02	5.69	F	2.4		
88001-31	Walleye	F	24.02	8.07	F	1.6	1.7	Lyepocystis

F indicates skin-on fillet.
Fs indicates skin-off fillet.
E indicates egg sample only.
W indicates whole fish.
O indicates other sample type.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: Tittabawassee River
Location: Midland

Collection Date: 4/12/88

ID#	a-Chlordane (mg/kg)	cis-Nonachlor (mg/kg)	trans-Nonachlor (mg/kg)	Oxy chlordane (mg/kg)	g-chlordane (mg/kg)	Dieldrin (mg/kg)	Hexachloro-benzene (mg/kg)	Octachloro-styrene (mg/kg)	Pentachloro-styrene (mg/kg)	PCB A-1248 (mg/kg)	PCB A-1254 (mg/kg)
88001-01	0.002	0.001	0.002	0.001K	0.001	0.001K	0.004	0.003	0.006	0.17	0.09
88001-03	0.002	0.001K	0.001	0.001K	0.001	0.001K	0.001	0.001	0.002	0.21	0.14
88001-05	0.003	0.002	0.002	0.001K	0.002	0.001K	0.001	0.002	0.005	0.37	0.27
88001-06	0.002	0.001	0.001	0.001K	0.001	0.001K	0.001	0.001	0.003	0.22	0.16
*											
88001-09	0.004	0.001	0.002	0.001K	0.002	0.001K	0.001	0.002	0.006	0.33	0.24
88001-10	0.003	0.002	0.001	0.001K	0.001	0.001K	0.001	0.002	0.004	0.23	0.17
*	0.003	0.001	0.001	0.001K	0.001	0.001K	0.001	0.002	0.004	0.22	0.18
88001-13	0.009	0.006	0.003	0.003	0.003	0.001K	0.003	0.002	0.005	0.20	0.39
88001-14	0.010	0.008	0.004	0.004	0.004	0.001K	0.004	0.003	0.006	0.37	0.42
88001-15	0.005	0.003	0.007	0.002	0.002	0.001K	0.002	0.003	0.008	0.43	0.39
*											
88001-16	0.004	0.003	0.006	0.001	0.002	0.001K	0.001	0.002	0.004	0.26	0.27
88001-17	0.014	0.009	0.018	0.007	0.005	0.006	0.002	0.004	0.012	0.59	0.61
88001-18	0.003	0.002	0.004	0.001K	0.002	0.001K	0.001	0.002	0.005	0.22	0.14
*	0.003	0.003	0.004	0.001K	0.002	0.001K	0.002	0.002	0.006	0.23	0.14
88001-22	0.021	0.006	0.015	0.006	0.009	0.001K	0.006	0.005	0.012	0.87	0.95
88001-25	0.016	0.004	0.012	0.004	0.008	0.013	0.002	0.003	0.007	0.02	0.97
88001-26	0.004	0.002	0.003	0.002	0.001	0.002	0.001	0.002	0.005	0.03	0.45
88001-27	0.011	0.004	0.011	0.004	0.005	0.005	0.001	0.002	0.004	0.02	0.7
88001-28	0.028	0.028	0.062	0.008	0.010	0.014	0.003	0.006	0.010	0.10	1.86
*											
*											
88001-29	0.025	0.026	0.055	0.007	0.009	0.011	0.003	0.007	0.015	0.09	2.08
88001-30	0.004	0.004	0.008	0.002	0.001K	0.005	0.001	0.002	0.006	0.06	0.35
88001-31	0.009	0.005	0.010	0.002	0.005	0.004	0.005	0.006	0.015	0.07	0.55
*	0.010	0.005	0.011	0.002	0.005	0.004	0.005	0.006	0.015	0.06	0.55

K indicates undetected at the detection level shown.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: Tittabawassee River
Location: Midland

Collection Date: 4/12/88

ID#	PBB (Firemaster BP-6) (ng/kg)	Heptachlor-Epoxide (ng/kg)	Toxaphene* (ng/kg)	4,4'-DDD (ng/kg)	4,4'-DDE (ng/kg)	4,4'-DDT (ng/kg)	2,3,7,8-TCDD (ng/kg)	1,2,3,7,8-PeCDD (ng/kg)	1,2,3,4,7,8-HxCDD (ng/kg)	1,2,3,6,7,8-HxCDD (ng/kg)
88001-01	0.005K	0.001	0.050K	0.004	0.022	0.002	1.5			
88001-03	0.005K	0.001	0.050K	0.001	0.033	0.002K	2.1			
88001-05	0.005K	0.002	0.050K	0.023	0.056	0.003	2.1			
88001-06	0.005K	0.001	0.050K	0.018	0.037	0.002	1.10	1.27K	2.47K	1.85K
*							1.5	0.9	1K8	
88001-09	0.005K	0.002	0.050K	0.021	0.048	0.004	2			
88001-10	0.005K	0.001	0.050K	0.016	0.036	0.003	1.4			
*	0.005K	0.001	0.050K	0.017	0.035	0.002				
88001-13	0.005K	0.002	0.111	0.005	0.110	0.012	2.7			
88001-14	0.005K	0.002	0.140	0.035	0.120	0.014	2.9			
88001-15	0.005K	0.002	0.050K	0.030	0.090	0.005	2.86	0.79	2.46K	1.88K
*							2.8	1.2	1K8	
88001-16	0.005K	0.001	0.050K	0.021	0.053	0.003	1.9			
88001-17	0.005K	0.004	0.050K	0.049	0.202	0.018	4			
88001-18	0.005K	0.002	0.050K	0.020	0.033	0.002	1.6			
*	0.005K	0.001	0.050K	0.018	0.021	0.003				
88001-22	0.005K	0.006	0.050K	0.072	0.243	0.027	5.3			
88001-25	0.005K	0.003	0.240	0.036	0.181	0.021	3.5			
88001-26	0.005K	0.003	0.050K	0.019	0.039	0.004	2.2			
88001-27	0.005K	0.002	0.220	0.023	0.144	0.019	3.3			
88001-28	0.010N	0.004	0.60	0.067	0.336	0.04	5.60	2.57	2.47K	2.16K
*							5.53	2.44	2.46K	0.59
*							5.7	2.6	18	
88001-29	0.010N	0.003	0.50	0.077	0.361	0.04	8.6			
88001-30	0.005K	0.002	0.050K	0.024	0.074	0.005	3.1			
88001-31	0.005K	0.001	0.050K	0.053	0.054	0.006	3.73	1.70	2.47K	2.37K
*	0.005K	0.002	0.050K	0.049	0.06		4.4	2.2	18	

K indicates undetected at the detection level shown.
N indicates substance was not found at the lowest quantifiable level indicated.
* toxaphene values have been estimated.
8 This value is the total 1,2,3,4,7,8 and 1,2,3,6,7,8 isomers.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: Tittabawassee River
Locations: MLocations: Midland
Collection Dates: 4/12/88

ID#	1,2,3,7,8,9-HxCDD (ng/kg)	1,2,3,4,6,7,8-HpCDD (ng/kg)	OCDD (ng/kg)	2,3,7,8-TCDF (ng/kg)	2,3,6,7-TCDF (ng/kg)	3,4,6,7-TCDF (ng/kg)	2,4,6,8-TCDF (ng/kg)	1,2,3,7,8-PeCDF (ng/kg)	2,3,4,7,8-PeCDF (ng/kg)	2,3,4,6,7-PeCDF (ng/kg)	1,2,3,6,8-PeCDF (ng/kg)
88001-04											
88001-03											
88001-05											
88001-06	1.38K	1.47K	5.20	6.83	0.49K	0.49K		1.25	2.05K	1.04K	
•	1K		3K	8.5				1.2	1.7		
88001-09											
88001-10											
•											
88001-13											
88001-14											
88001-15	1.37K	2.09K	99.60	12.87	0.53K	0.49K	0.60	3.46	2.44	0.88	3.20
•	1K		2K	15				1.6	2.7		
88001-16											
88001-17											
88001-18											
•											
88001-22											
88001-25											
88001-26											
88001-27											
88001-28	1.38K	1.86K	1.2	16.12	0.56K	0.49K	1.12	2.45	3.06	1.23	4.48
•	1.37K	2.19K	3.30	16.11	0.58K	0.49K	0.93	3.03	3.65	2.11	6.95
•	1K		3	20				2.2	4.4		
88001-29											
88001-30											
88001-31	1.38K	3.69K	1.5	25.82	0.52K	0.49K	0.68	6.17	5.07	1.10	3.68
•	1K		2K	29				4.6	5.4		

K indicates undetected at the detection level shown.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: Tittabawassee River
Location: Midland
Collection Date: 4/12/88

ID#	1,2,3,4,7,8-HxCDF (ng/kg)	1,2,3,6,7,8-HxCDF (ng/kg)	2,3,4,6,7,8-HxCDF (ng/kg)	1,2,3,7,8,9-HxCDF (ng/kg)	1,2,4,6,8,9-HxCDF (ng/kg)	1,2,3,4,6,7,8-HpCDF (ng/kg)	1,2,3,4,7,8,9-HpCDF (ng/kg)	OCDF (ng/kg)	Total Equivalency Concentration
88001-01									
88001-03									
88001-05									
88001-06	2.9UK	2.8UK	1.9UK	2.7UK		1.4UK	2.6UK	4.7UK	1.91
•	0.5UB		0.7K	0.9K		0.8K	1K	2K	
88001-09									
88001-10									
•									
88001-13									
88001-14									
88001-15	4.1UK	2.8UK	1.9UK	2.7UK		1.5UK	2.6UK	4.7UK	3.14
•	0.40		0.8K	0.6K		0.8K	1K	2K	
88001-16									
88001-17									
88001-18									
•									
88001-22									
88001-25									
88001-26									
88001-27									
88001-28	6.5UK	2.8UK	2.3UK	2.7UK		2.0UK	2.6UK	4.7UK	9.05
•	6.9UK	2.8UK	2.4UK	2.7UK		1.9UK	2.6UK	4.7UK	9.06
•	1.40		0.6K	0.7K		0.7	0.8K	2K	
88001-29									
88001-30									
88001-31	0.8K	2.8UK	2.0UK	2.7UK	1.25	2.3UK	2.6UK	4.7UK	8.32
•	1.00		0.8K	0.8K		1.1	0.7K	2K	

K indicates undetected at the detection level shown.
B This value is the total 1,2,3,4,7,8 and 1,2,3,6,7,8 isomers.

APPENDIX C

1987 USEPA PRELIMINARY VEGETABLE SAMPLING PROGRAM

In November 1987, Region V, with the cooperation of the Michigan Departments of Agriculture, Health, and Natural Resources conducted a preliminary screening program of home-grown vegetables from two gardens in Midland, Michigan, and a control garden in Eagle, Michigan. Samples were collected by the Michigan Department of Agriculture. Because the sampling was conducted after the end of the growing season, certain vegetables were obtained from homeowners after they had been cleaned and frozen. These were sent to the laboratory as obtained. The others were collected directly from the gardens, rinsed off with tap water, and sent to the laboratory. Composite soil samples from each garden, made up of six-inch soil plugs, were obtained in the immediate areas where the vegetables were grown.

Samples were analyzed for CDDs and CDFs at Triangle Laboratories, Research Triangle Park, North Carolina, a contract laboratory for USEPA. A summary of the results is presented in terms of 2378-TCDD and 2378-TCDD TEQs in the attached table. The results indicate laboratory blank contamination at sub-part-per-trillion levels for certain 2378-substituted CDDs and CDFs, and, in one blank sample, for 2378-TCDD.

For Garden 1 (Midland), the soil contained 34 ppt 2378-TCDD (48 ppt 2378-TCDD TEQs). There was no detectable 2378-TCDD in peeled carrots or onions, and, given the low levels of blank contamination, there was no discernable uptake of other CDDs and CDFs (expressed as 2378-TCDD TEQs) in these vegetables. The laboratory solvent blank for analysis of a lettuce sample contained 0.3 ppt 2378-TCDD and 2.1 ppt 2378-TCDD TEQs, indicating severe blank contamination, and rendering the analysis of this sample unacceptable. The remaining sample volume was insufficient for a reanalysis.

For Garden 2 (Midland), the soil contained 11 ppt 2378-TCDD (17 ppt 2378-TCDD TEQs). An unpeeled beet sample contained less than 0.1 ppt 2378-TCDD and 2378-TCDD TEQs, indicating no significant contamination. For Garden 3 (Eagle - Control), the soil contained less than 0.1 ppt 2378-TCDD and about 0.3 ppt 2378-TCDD TEQs. 2378-TCDD was not detected in unpeeled beets or carrots, and there was no discernable uptake of 2378-TCDD TEQs.

In summary, the limited screening study did not indicate uptake of 2378-TCDD or 2378-TCDD TEQs in root crops grown in Midland and a control site. Results with respect to one lettuce sample grown in Midland were inconclusive due to laboratory solvent blank contamination.

TABLE C-1

USEPA PRELIMINARY GARDEN VEGETABLE SAMPLING
MIDLAND, MICHIGAN
NOVEMBER 1987

SAMPLE	SAMPLE TYPE	2378-TCDD (ppt)	TEQs (ppt)
Garden 1 - Midland			
TLI Blank #7	--	ND(<0.1)	<0.1
Soil (3561E-6)	Garden/composite(20)	34	48
TLI Blank #1	--	ND(<0.1)	<0.1
Peeled Carrots (3561E-3)	Frozen/composite(pkg)	ND(<0.1)	<0.1
Peeled Onions (3561E-5)	Garden/composite(3)	ND(<0.1)	<0.1
TLI Blank - Veg	--	0.3	2.1
Lettuce (3561E-4)	Garden/composite(3)	NA	NA
Garden 2 - Midland			
TLI Blank #7	--	ND(<0.1)	<0.1
Soil (3561E-2)	Garden/composite(10)	11	17
Unpeeled Beets (3561E-1)	Garden/composite(3)	<0.1	<0.1
Garden 3 - Control (Eagle, Michigan)			
TLI Blank #7	--	ND(<0.1)	<0.1
Soil (3561E-9)	Garden/composite(10)	<0.1	0.3
Unpeeled Beets (3561E-7)	Garden/composite(3)	ND(<0.1)	<0.1
TLI Blank #1	--	ND(<0.1)	<0.1
Unpeeled Carrots (3561E-8)	Garden/composite(3)	ND(<0.1)	<0.1

Notes: (1) ND -- Not detected at stated detection level.
(2) NA -- Data not acceptable due to severe blank contamination.
(3) TEQs -- 2378-TCDD toxicity equivalents.