Health Consultation

Dioxin in Dust in Schools and Community Center

NITRO SCHOOL DIOXIN SITE
NITRO, KANAWHA COUNTY, WEST VIRGINIA

APRIL 18, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

Dioxin in Dust in Schools and Community Center

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NITRO, KANAWHA COUNTY, WEST VIRGINIA

Prepared By:

West Virginia Department of Health and Human Resources
Under Cooperative Agreement with
The U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Atlanta, Georgia

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Foreword

This document summarizes public health concerns for the "Nitro School Dioxin" site. The public health concerns are related to the detection of dioxin in indoor dust and outdoor soil at two schools and a community center. People who could come into contact with dioxin are students and teachers/staff at Nitro Elementary School and High School, daycare children/workers, and senior citizens at Nitro Community Center.

The steps taken in completing a health consultation are as follows:

Evaluating exposure: The West Virginia Department of Health and Human Resources ATSDR Cooperative Partners Program (WVDHHR) starts by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed. WVDHHR typically does not collect environmental samples. WVDHHR relies on others to provide accurate, factual, and reliable information.

Evaluating health effects: If evidence indicates that people are being exposed, or could be exposed, to hazardous substances, WVDHHR scientists will take steps to evaluate whether that exposure could be harmful to human health. The evaluation is based on existing scientific information. The report of this evaluation is the health consultation. The health consultation focuses on public health - the health impact on the community as a whole.

Developing recommendations: WVDHHR outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to contaminants. The role of WVDHHR at a site is primarily advisory. For that reason, the health consultation will typically recommend actions to be taken by other agencies, including WVDEP and EPA.

Soliciting community input: The evaluation process is interactive. WVDHHR starts by soliciting and evaluating information from various governmental agencies, the organizations responsible for cleaning up sites, and the community surrounding the site. Any conclusions about the site are shared with groups and organizations that provided the information.

If you have questions or comments about this report, we encourage you to:

write: Program Manager
ATSDR Cooperative Partners Program
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Bureau for Public Health
West Virginia Department of Health and Human Services
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Summary

This health consultation reports the results of the West Virginia Department of Health and Human Resources (WVDHHR) evaluation of exposure to dioxin in indoor dust and outdoor soil associated with Nitro Elementary School, Nitro High School and Nitro Community Center in Nitro, Kanawha County, West Virginia, known as the Nitro School Dioxin site.

Indoor dust and outdoor soil samples collected from Nitro Elementary School, Nitro High School and Nitro Community Center were found to contain dioxin. Kanawha County Board of Education and officials from the Nitro Community Center petitioned WVDHHR to evaluate the public health hazard associated with the contamination.

WVDHHR prepared this health consultation to respond to community health concerns, to determine whether children and adults at the three facilities could contact harmful levels of dioxin, and if necessary, to make appropriate recommendations to protect their health.

WVDHHR assessed the public health implications of dioxin in indoor dust solely based on the available indoor dust data. The estimated exposure doses were calculated as if the children at school were frequently exposed to the dust in seldom accessed or inaccessible areas. WVDHHR believes the actual human exposure threat and consequent health hazard at this site is less than the exposure dose estimates for the following reasons:

- A paper published in 1996 reported significantly higher amounts of dioxin in an attic compared to apartment living area [1].
- Indoor dust sampling locations are in areas where people would not likely contact the dust.
- The areas sampled had accumulated dust over a long period of time and the sources of dioxin are unknown. The amount of dioxin in the environment has been significantly reduced in recent years as a result of reductions in the number of chemical plants in the area and the employment of more stringent environmental controls. About one-third of interior dust comes from outdoor soil. The outdoor soil near these facilities contained much less dioxin than found in the dust sampled. Therefore, indoor dust on frequently cleaned and contacted surfaces (e.g. top of desks, chairs, and floors) should contain less dioxin than the sampled dust.

The dust sampling methods were not approved by EPA or WVDEP and analytical quality control data was not provided to WVDHHR.

Based on the evaluation of available environmental information and data associated with the three facilities on the site, WVDHHR concluded:

- Evaluation of the site-specific exposures and potential human health effects indicate that incidental ingestion of indoor dust poses no apparent public health hazard. No adverse noncarcinogenic health effects are likely and the excess cancer risk is less than 1 in 10,000, which is considered a very low risk.

- Dioxin in outdoor soil poses no apparent public health hazard to people who are in the three facilities on a daily basis, because the amounts detected in soil are well below levels where exposure might cause adverse health effects should daily exposure occur.

I. Purpose and Statement of Issues

Kanawha County Board of Education and officials from the Nitro Community Center asked the West Virginia Department of Health and Human Resources (WVDHHR) to evaluate the public health implications from exposure to dioxin found in dust and soil at the Nitro Elementary School, Nitro High School and Nitro Community Center.

Samples of indoor dust and outdoor soil were collected at these locations in spring of 2005. Some people suspected that past releases from nearby chemical plants may have impacted local schools based on samples collected in other areas of the city in late 2004.

Preliminary dust sample results were released August 2005 about a month before the first day of school. Parents and school officials were concerned that dioxin in and around the school may affect children's health. WVDHHR coordinated a meeting with officials from the Kanawha County Board of Education, West Virginia Department of Education, Agency for Toxic Substances (ATSDR), and US Environmental Protection Agency (EPA) to determine if the actions were necessary to protect the health and safety of students and employees in these facilities. EPA and ATSDR concluded that:

- Exposure estimates to dioxin in the indoor dust samples were at levels that would not be expected to cause adverse health effects, and therefore, should not prohibit the schools from opening nor restrict operations at the daycare center in the Community Center.
- The locations of the dust samples were reported to be in areas where children would not likely contact the dust. Conclusions could not be finalized until dioxin levels in soil near the school were assessed as a portion of indoor dust comes from outside soil.
- Dioxin was not likely to be found in air. Therefore, air samples were not recommended [2].

WVDHHR prepared this health consultation under a cooperative agreement with ATSDR.

II. Background

II.A. Site Description and History

The town of Nitro was developed during World War I. It was named for the "Nitro-cellulose" made in a munitions plant. The plant covered 1,800 acres on the east bank of the Kanawha River. When the war ended, many chemical manufacturing companies used the area [3, 4]. Chemicals with dioxin by-products were manufactured here.

The northeast part of Nitro is still considered the "industrial area". Some chemical manufacturers are still in operation. Environmental remediation has occurred at several closed sites and is anticipated at others.

The Nitro School Dioxin site includes three facilities; Nitro Elementary School, Nitro High School and Nitro Community Center. The three facilities are in mixed commercial and residential areas.

The Nitro Elementary School and Community Center are on adjacent properties while the Nitro High School is closer to the industrial area. For purposes of identification, the site address is 1921 19th Street, Nitro, Kanawha County, West Virginia.

Nitro Elementary School, 1921 19th Street, operates from kindergarten to grade 5. The facility is bordered to the west by commercial properties, to the east by woods, to the south by residential properties and to the north by the Nitro Community Center. Nitro Elementary School is a 32,000 square foot one-story facility. It was constructed in 1951. Additions were constructed in 1959 and 1992. The school is south-east of the industrial area.

Nitro High School (grades 9 – 12) is located at 1300 Park Ave. The facility is bordered to the north by the Nitro community park and a retirement rental property, to the south and west by residential properties, and to the east by commercial properties on WV State Route 25. It is an 112,000 square foot two-story building, about 1.5 miles south of the industrial area. The building was constructed in 1959 and used originally as Nitro Middle School. It was expanded in 1966 and 1992. The Baker Annex, a part of Nitro High School, was constructed in 1959 and expanded in 1966.

Nitro Community Center is a two-story facility at 302 21st Street. The building was constructed in 1954 and used originally as Nitro High School. It is bordered to the west by a museum and City Hall, to the south by Nitro Elementary School, to the north by commercial buildings, and to the east by mixed commercial and residential properties. It is about a mile south-east of the industrial area. Many groups use the building, most notably a daycare center accepting babies as young as 2-months-old.

II.B. Demographics

About 860 students attend Nitro High School. Seventy-five teachers and staff work in the building full time during the school year.

The current enrollment at Nitro Elementary School is 380. Thirty-nine full-time and five part-time teachers/staff work at the facility during the school year.

Groups using the Nitro Community Center are:

- a year-round daycare center serving about 100 children from 2-months to 8-years-old,
- a private school with about 20 students in grades 6 through 12,
- a Senior Center serving about 80 seniors each day, and
- people using or working at a fitness center, police station, and various other small businesses and offices.

II.C. Dioxin

"Dioxin" is the generic name for a group of chemicals including both polychlorinated dibenzodioxins and polychlorinated dibenzofurans. Each unique individual compound in this group is called a congener. Among all compounds of this group, 2,3,7,8-tetrachloro-p-dioxin (TCDD) is the most studied and believed to be the most toxic. Sometimes, the term "dioxin" is also used to refer to TCDD [5].

Dioxins in very small amounts are found almost everywhere in the environment. Dioxin is formed naturally and unintentionally during forest fires, backyard burning, chlorine bleaching in paper manufacturing, some chemical manufacturing processes, and burning of gasoline and diesel. Dioxins are often found in higher amounts in industrial areas.

Dioxin is quite persistent in the environment. Dioxins tend to bind tightly to soils and sediment and are found in low amounts in water. They are not likely to be in air as a vapor.

TCDD has been shown to cause a variety of health effects in humans and animals. TCDD is very harmful to some animals [6]. The effects depend on the species of animal, the amount of exposure, and the route of exposure. Human studies on dioxin's effects in reproductive and developmental systems have been inconclusive even though these effects have been observed in many animal species. Some of the effects seen in animals are skeletal deformities, kidney defects, altered level of sex hormones, reduced production of sperm, and increased rates of miscarriage [7]. TCDD has been found to cause cancer in animals but evidence of carcinogenicity in humans is less clear. Three organizations classify TCDD's carcinogenicity as: "probable human carcinogen" (EPA), "carcinogenic to humans" (International Agency for Research on Cancer or IRAC), and "known human carcinogen" (National Toxicology Program or NTP) [7].

II.D. Dioxin TEF and TEQ

Toxicity equivalency factors (TEFs) were developed to relate the toxicity of dioxin congeners to that of TCDD. This comparison is based on the assumption that dioxin congeners act through the same mechanism of action as TCDD. The TEF for TCDD is defined as "1", whereas TEF values for all other congeners are between 0 and 1. A TEF value of 1 means the congener is as toxic as TCDD. Congeners with TEF value less than 1 means that it has less toxicity than that of TCDD.

Two sets of TEF values are currently widely used to calculate dioxin TEQs; World Health Organization's (WHO's) and EPA's. Some of the dioxin congeners were assigned different TEF values by these two organizations due to different opinions toward their relative toxicity compared to TCDD.

The concentration of each dioxin is multiplied by its TEF to obtain the toxicity equivalent (TEQ). For example, if the detected 1,2,3,4,6,7,8,9-octachlorinated-dibenzo-p-dioxin (OCDD) concentration is 500 parts per trillion (ppt), and the TEF of OCDD is 0.0001 (meaning it is 10,000 times less toxic than TCDD), then the TEQ of OCDD is 0.05 ppt (500 x 0.0001).

All the TEQs are added together to obtain the TCDD TEQ, which is an estimate of the toxicity of the congeners in the material in terms of TCDD toxicity.

II.E. Indoor Dust

Dust in undisturbed or infrequently accessed areas can represent the long-term accumulation of material that has been influenced for many years by the natural movement of air, penetration of outdoor contaminants, accumulation of building material particles and chemicals used indoors, and the eventual deposition of dust on many surfaces [1, 8]. Due to the slower degradation of contaminants indoors than outdoors, contaminants in undisturbed indoor dust can accumulate over time [9]. A study in 1996 concluded that attic dust had dioxin levels 1,000 times higher than that found in the apartments below [1].

On the other hand, dust on frequently cleaned surfaces (e.g. desk tops, chair tops, classroom floors) reflects more recent deposits [8]. It has been estimated that as much as 31% of indoor dust in living areas could be from nearby outdoor soil [10]. In addition to fine particles of tracked-in soil, indoor dust may also contain small particles from the indoor environment (i.e., carpet fibers), compounds used in the building (i.e., cleaning compounds and pesticides), skin flakes and clothing fibers.

III. Discussion

III.A. Methodology

The methodology used in this health consultation includes three components:

1. Data review.
    a. Review and evaluate available environmental sampling information and data.
    b. Select samples needing further review by comparing the environmental sampling data to the appropriate environmental concentrations against ATSDR's environmental guideline comparison values (CVs).
2. Review of exposures in completed pathways.
    a. Identify human exposure pathways, or routes of human contact with chemicals.
    b. Estimate site-specific exposure doses in completed pathways.
    c. Select exposure doses that need evaluation of potential adverse health effects by comparing them to ATSDR's health guideline CVs.
3. Evaluation of health effects.
    a. Evaluate exposures where the estimated exposure doses exceed the CVs. The further evaluation is conducted by reviewing relevant toxicological data.

III.B. Data Review

As can be seen in the following figures, 2,3,7,8,-TCDD, the most toxic congener of dioxin family, is at much lower concentration than that of hepta- and octa- dioxin congeners . The decimal percentage of the total dioxin was plotted against the dioxin congeners [11], however, in order to show the smallest values, the square root of the decimal percentage of total dioxin was used in Figures 1, 2, and 3.

Figure 1. Nitro Elementary School

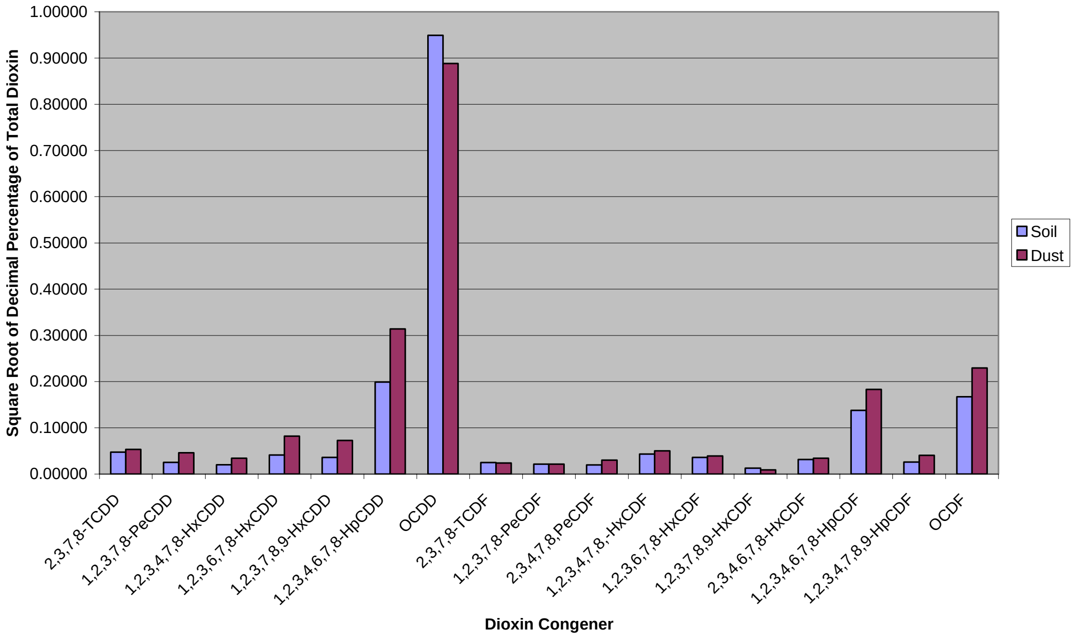


Figure 2. Nitro High School

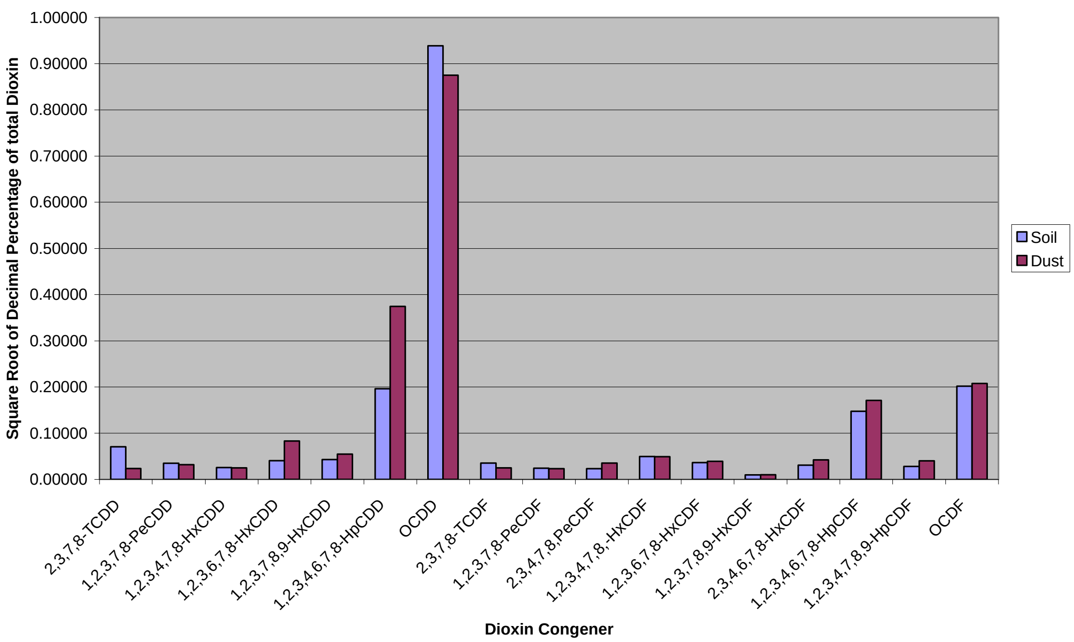
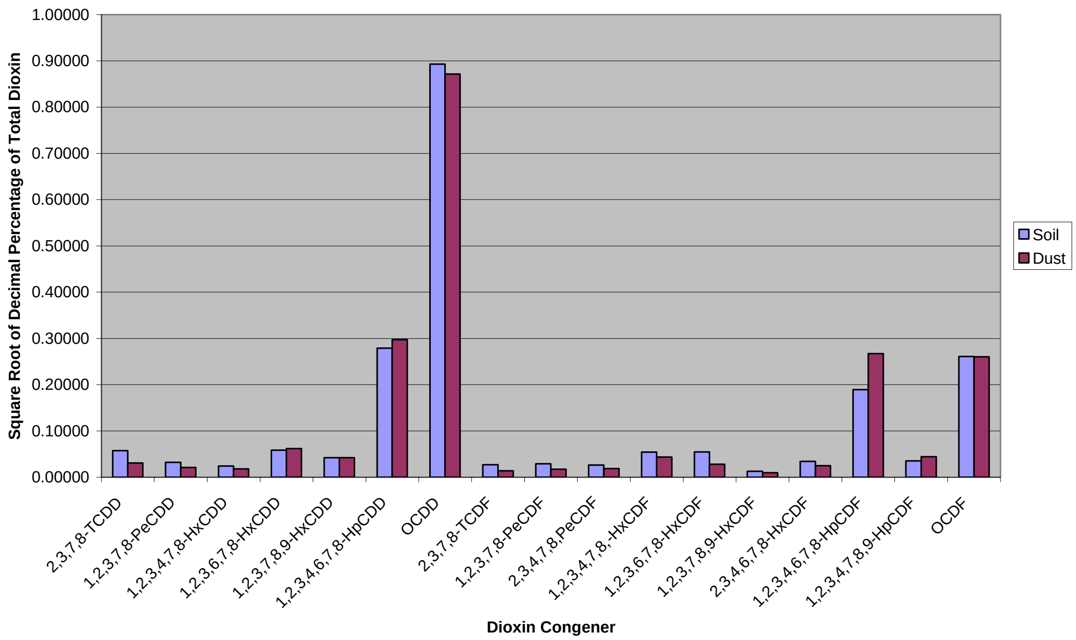


Table 3. Nitro Community Center



WVDHHR obtained the complete data package for the dust and soil samples at this site in October 2005. The conclusions of this report must be evaluated based on the fact that dust sampling methods used were not approved by the WVDEP or EPA. Indoor dust samples were collected using a HVS-3 forensic vacuum. Most samples combined dust from multiple locations. In addition, no quality control data for the dust samples were included in the data package [12].

All samples were analyzed for 17 of the 2,3,7,8-substituted dioxin and furan congeners that are necessary to evaluate the TCDD TEQ of a mixture of dioxins and furans. The report estimated exposure doses using the EPA's TEF system as recommended by ATSDR. Calculations using both WHO and EPA TEFs for each indoor dust and soil sample can be found in Tables 1 and 2 in Appendix B.

1. Indoor dust samples

Estimates of exposure to dioxin in dust should reflect locations where people are in daily contact with dust. However, sample locations were selected based on places where dust was likely to accumulate. These were not areas where children or staff would likely come into contact with the dust.

Four grab samples were collected from the Nitro Community Center, four from Nitro High School and one composite from Nitro Elementary School by 3TM International, Inc. on May 14 and 15 2006. The highest detected TCDD TEQ level, 1,002.9 ppt, was found in the dust above ceiling tile on the second floor at Nitro Community Center. The contribution of dust from each location listed in Table A, as reported, do not always add up to 100% [12]. The reason is unknown.

Table A. Dioxin level in indoor dust

Facilities where samples were collected	Sample ID	Dust locations description	Samples % contribution from each location	TCDD TEQ (ppt)*
Nitro Community Center	mn-vc-302-43	Top of lockers	50%	323.1
		Above ceiling tiles at office	35%	
	mn-vc-302-44	Gym ledge	70%	393.3
		Behind bleachers on rails	30%	
	mn-vc-302-45	Above ceiling tile, 2nd floor	100%	1002.9
	mn-vc-302-46	Top of boiler	55%	99.6
		Vent in men's and women's restroom	40%	
Nitro High School	mn-vc-1301-39	Top of electrical box, boiler room	55%	403.1
		Boiler, tank	10%	
		Bookshelf custodian office	10%	
		Hallway ledges	1%	
		Picture rack	1%	
		Top of soda machines, students lounge	20%	
	mn-vc-1301-40	Ledges above lockers at hallway	85%	107.1
		Window ledge, room 106B	5%	
		Vent in boys restroom	10%	
	mn-vc-1301-41	Hallway ledge	25%	200.07
		Room210, I-beam above ledge, intercom speaker	15%	
		Above lockers, ledge	70%	
	mn-vc-1301-41	Mechanical room, top of generator	50%	536.1
		Mechanical room, top of circuit breaker	5%	
		Top of pipe rack, locker room entry	20%	
		Top of hanging fluorescent light	15%	
		Top of junction box	10%	
Nitro Elementary	mn-vc-1921-Composite sample	Classroom vent	20%	166.8
		Top of lockers	64%	
		Room ledge	4%	
		Bookshelves	12%	

**TCDD TEQs from Table 1 in Appendix B, using EPA TEF system*

2. Outdoor soil samples

The soil samples data reviewed were taken on or close to the surface of the ground (0-2 inches below the ground) where humans could contact the contaminants found in the soil. All samples were taken from grass-covered areas near the buildings by 3TM International Inc. on May 16 and 17, 2006.

Outdoor soil contains much less TCDD TEQs than the indoor dust (Table B).

3. Comparing sample data to ATSDR's environmental guideline CV's

ATSDR's soil environmental guideline comparison value used in this health consultation is the child chronic environmental media exposure guide (EMEG) for TCDD. It is 0.00005 milligram per kilogram (mg/kg) or 50 ppt. A chronic EMEG is the amount of chemical in environment media (e.g. soil or dust) that even sensitive people can be exposed to on a daily basis for longer than one year that is not expected to result in adverse non-carcinogenic health effects.

Comparison values are not thresholds of toxicity. Rather, they are screening levels. When a contaminant concentration is above a CV, it does not mean that health effects could be expected. However, it does represent a point at which further evaluation is warranted.

Table B indicates:

- Dioxin levels in indoor dust at the three facilities exceeded the ATSDR's environmental guidelines CV. Exposure to dioxin in indoor dust will be evaluated further.
- Dioxin levels in soil samples are well below ATSDR's environmental guidelines CVs. Adverse health effects are unlikely from direct contact with soil, and further evaluation is not necessary.

Table B. Comparison of TCDD TEQs in indoor dust and outdoor soil samples to environmental guideline CVs

Sampling Areas	TCDD TEQs (part per trillion, ppt)		Child's Chronic EMEG[a] (ppt)
	Indoor dust	Outdoor soil	
Nitro Elementary School	166.8	3.2 – 13.5	50
Nitro High School	107.1 – 536.1	2.2 – 17.6	50
Nitro Community Center	99.6 – 1,002.9	14.2	50

a: Child's chronic EMEG is ATSDR's environmental media evaluation guideline for a child exposed to TCDD for 365 days or more

TCDD Toxic equivalency quotients (TEQs) from Tables 1 and 2 in Appendix B, using EPA TEF system

III.C. Review of indoor dust samples

For a public health hazard to exist, people must come in contact with contaminants at levels high enough and for a long enough time to affect their health. To further evaluate the human health impact of dioxin levels detected in indoor dust, WVDHHR first evaluated routes of human exposure. Estimated exposure doses were calculated based on the exposure routes identified. Then the exposure doses were compared to the ATSDR minimal risk level (MRL) for TCDD. Those estimated exposure doses above the MRL were evaluated further for noncarcinogenic effects. All exposures to indoor dust were reviewed for carcinogenic effects.

1. Exposure pathway analysis

There are several routes through which people may come into contact with contaminants from environment:

- ingestion, i.e., eating, drinking, and hand-to-mouth activities
- dermal exposure, i.e., absorbing the chemical through the skin
- by inhalation, i.e., breathing air

Dust particles cling to hands when people touch dust, such as when children crawl on floors. Incidental ingestion of the dust occurs when people put their hands onto or into their mouth. Factors that affect whether people have contact with contaminated indoor dust include the:

- location and quantity of the indoor dust
- activities that children engage in daily and where the activities take place
- time spent in contact with the dust
- frequency of building maintenance activities
- personal habits

The source of dioxin in these facilities is unknown. Dioxins are pervasive in the environment and come from multiple sources. People in these three facilities have been exposed to dioxins in indoor dust by ingesting it through normal hand-to-mouth activities and through skin contact. Exposure through breathing air is not likely under the conditions existing at this site. Therefore, there is a completed pathway for incidental ingestion of and dermal exposure to indoor dust. A completed pathway means that people have been exposed to chemicals. However, the existence of a completed pathway *does not necessarily mean* that a public health hazard existed in the past, exists currently, or is likely in the future. The exposure to the chemical must be assessed to determine if there is a public health hazard.

2. Estimating exposure doses

Exposure doses are estimates of how much chemical may get into a person's body. The calculations rely on the sample data and assumptions that identify how much, how often, and how long a person may come into contact with a chemical. Exposure doses are expressed as the amount of contaminant that a person intakes daily per unit of body weight. It is expressed as milligrams chemical per kilogram per day (mg/kg/day).

Indoor dust oral ingestion exposure dose is the estimated amount of dioxin a person is exposed to daily via hand-to-mouth activity. It is estimated based on the

- amount of dust ingested via normal hand-to-mouth activity,

- amount of dioxin found in the dust,[1]
- amount of ingested dioxin that is absorbed into the body,
- amount of time in contact with the dust, and
- body weight of the person exposed.

The method for calculating the exposure doses and the assumptions made are presented in detail in Appendix A. The estimated oral exposure doses to dioxin from indoor dust are presented in Table 3 in Appendix B.

The body weight of children in the daycare center is assumed to be 16 kilogram (kg) (about 35 pounds), the average weight of children from 1-6 years-old. Although there are smaller children at the daycare center, they are less mobile than children who can walk and are not as likely to contact dust as the older children.

Although dermal exposure to the dioxin in indoor dust can contribute to the accumulation of dioxin in people, estimates of dermal absorption at this site indicate it is a minor source of exposure. Absorption efficiencies are above 87% [13] from oral ingestion, and 3% for dermal absorption [14]. Dermal exposure dose calculations are explained in Appendix A. The estimated dermal exposure doses to dioxin in indoor dust are presented in Table 4 in Appendix B.

3. Evaluating exposure doses using site-specific assumptions

Exposure doses were calculated for children in the three facilities and adults in the Community Center using age-appropriate body weights and the average amount of TCDD TEQs found in dust.

Since children do not play in one area, the average concentration of dioxin in dust from all samples is a better estimate of actual exposures than the maximum concentration. In addition, the exposure frequency used reflected the actual hours and days per year during which children and adults are in the facilities. These calculations are in Appendix A.

The site-specific analysis for noncarcinogenic effects yields an exposure dose for children at the daycare in the Community Center of 1.3E-09 mg/kg/day (Table 3 in Appendix B). This was the only estimated exposure dose that exceeds the MRL, 1.0E-09 mg/kg/day. A further evaluation for possible adverse health effects will be conducted for daycare children.

4. Estimating excess cancer risk

An estimate of excess cancer risk is an extrapolation of the number of *additional* cases of cancer in a population that may be caused from exposure to TCDD at this site under the assumed exposure conditions. This estimate is meant to be an estimate of *additional* cancer cases beyond the expected "*background*" rate of cancer. Currently, in the U.S. we estimate that 1 out of every 3 Americans will experience a diagnosis of cancer of some type over his or her lifetime. Excess cancer risk calculations only give the estimates of risk as many uncertainties exist and conservative assumptions were applied in the process. Some of these are:

1 The maximum dioxin found in the dust in terms of 2,3,7,8-TCDD TEQ calculated using the EPA TEF system from Table 1.

- Past exposures to carcinogenic chemicals were the same as those at currently measured levels.
- Effects from short exposures, such as the few years at the daycare or in school are averaged over a 70-year lifetime.
- All chemicals causing cancer have some effect even at the lowest exposures.
- The cancer slope factor is based on the most sensitive range of responses, the 95% upper bound risk. The excess cancer risk would be lower if the average response was used to calculate the cancer slope factor.

This means the actual risk of cancer is probably lower than the calculated number, perhaps by several orders of magnitude.[2] The true excess cancer risk is unknown and could be as low as zero.

Considering many uncertainties, it is WVDHHR's policy that estimated theoretical cancer risks lower than 1 in 10,000 are considered very low which needs no further review, between 1 and 9.9 in 10,000 are classified as low, between 10 and 99 in 10,000 are classified moderate, and greater than 99 in 10,000 are considered significant.

The method of estimating excess cancer risk and assumptions used in the calculations can be found in Appendix A.

WVDHHR calculated the estimated excess cancer risks from oral exposure to dioxin in indoor dust at the three facilities using EPA's cancer slope factor for TCDD, 1.5×10^5 $(mg/kg/day)^{-1}$ [15]. The estimated excess cancer risks for the three facilities ranged from 0.01 to 0.17 excess cancers in 10,000 people (Table 3 in Appendix B). Considering the worst case scenario: a child spends 6 years at Nitro Community Daycare Center, and thereafter 6 years at Nitro Elementary School, and then 4 years at Nitro High school, the estimated excess cancer risk is 0.2 in 10,000, less than 1 in 10000. This is a very low theoretical additional risk of cancer.

5. Evaluation of possible health effects

Indoor dust dioxin exposures to young children in the daycare at the Community Center were estimated at 1.3E-09 mg/kg/day, slightly above the chronic oral MRL for dioxin, 1.0E-09 mg/kg/day. Excess cancer risks were estimated to be less than 1 in 10,000.

Given the inaccessible nature of the dust sampled, and the likelihood that the dust in areas where people would be expected to have regular contact contains less dioxin (because of the expectation that contamination levels in the dust in accessible areas would be consistent with the contamination levels found in the outdoor soil), we expect that the actual exposure doses are likely to be less than what we projected for children and adults in these facilities.

This evaluation concludes that adverse health effects are not likely to children or adults exposed to dioxin in dust in the Nitro Elementary School, Nitro High School, or Nitro Community Center.

2. One order of magnitude is 10 times greater or lower than the original number. Similarly, two orders of magnitude are 100 times greater or lower than the original number.

IV. Community health concerns

Parents, school and daycare officials were concerned that dioxin exposures at the facilities at this site could cause adverse health effects. This assessment indicates there is no apparent public health hazard from these exposures. Some parents, however, may wish to reduce their children's exposure to dioxin in dust and soil. They may do so by encouraging children to wash hands after playing and before eating food and by reducing hand-to-mouth activity.

V. Child health considerations

Infants and children may be more sensitive to exposures in communities with contaminated water, soil, air, or food. This sensitivity is a result of a number of factors. Children are more likely to be exposed because they play outdoors and they use hand-to-mouth behaviors more often than adults. Children are shorter than adults, which means they breathe dust, soil, and heavy vapors close to the ground. Children are smaller, potentially resulting in higher doses of chemical exposure per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Finally, children are dependent on adults for risk identification, housing decisions, and access to medical care. This health consultation considered potential health effects to children to assist adults who make decisions regarding their children's health.

Children as young as 2-months-old at the daycare center located at Nitro Community Center are the most sensitive population in term of potential exposures to dioxin at this site. This report considered the potential health effects to children in daycare and schools in the three facilities.

VI. Conclusions

The five public health hazard categories used by ATSDR are: no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

WVDHHR assessed the public health implications of dioxin in indoor dust solely based on the available indoor dust data. The estimated exposure doses were calculated as if the children at school were frequently exposed to the dust in seldom accessed or inaccessible areas. WVDHHR believes the actual human exposure threat and consequent health hazard at this site is less than what the exposure doses estimate for the following reasons:

- A paper published in 1996 reported significantly higher amounts of dioxin in an attic compared to apartment living area [1].
- The indoor dust samples evaluated in this health consultation were collected from areas where people would not likely come into contact with this dust.
- The areas sampled had accumulated dust over a long period of time and the sources of dioxin are unknown. The amount of dioxin in the environment has been significantly reduced in recent years as a result of reductions in the number of chemical plants in the area and the employment of more stringent environmental controls. About one-third of interior dust comes from outdoor soil. The outdoor soil near these facilities contained much less dioxin than found in the dust sampled. Therefore, indoor dust on frequently cleaned and contacted surfaces (e.g. top of desks, chairs, and floors) is expected to contain less dioxin than the sampled dust.

As mentioned earlier, the dust sampling methods were not approved by EPA or WVDEP and analytical quality control data was not provided to WVDHHR. In addition, of the exposures evaluated, assumptions regarding contact with observed contamination were generally very conservative (protective) and therefore, likely overestimate actual or potential risks. On the other hand, other sources of exposure, such as through the food chain or through contact of dioxins from other areas than the three facilities could contribute to an individual's overall risk as well. These potential contributions are not reflected in the risk estimates provided in this report. As with all projections of potential risk, uncertainties exist that can impact conclusions to varying degrees.

Based on the evaluation of available environmental information and data associated with the three facilities on the site, WVDHHR concluded:

- Evaluation of the site-specific exposures and potential human health effects indicate that incidental ingestion of indoor dust poses no apparent public health hazard. No adverse noncarcinogenic health effects are likely and the excess cancer risk is less than 1 in 10,000 which is considered a very low risk.
- Dioxin level in outdoor soil poses no apparent public health hazard to people who are in three facilities on a daily basis, because the amounts detected in soil are well below levels expected to cause adverse health effects even if the exposure occurs daily.

VII. Recommendations

No recommendations are needed to avoid potential health effects from exposure to dioxin at this site based on the information available.

VIII. Public health action plan

Although no apparent public health hazard exists, WVDHHR responded to community concerns regarding dioxin at the site. Last fall, WVDHHR health professionals talked to concerned parents as soon as the preliminary evaluation was completed. Daycare and school officials were asked to refer concerned parents to WVDHHR for consultation, and the conclusions of the preliminary evaluation were widely reported by the local media. As a result, there was only one daycare child transferred to other facilities, and no students have been known to transfer to other facilities.

WVDHHR will provide education to parents, school officials, and other community members in the future when concerns are expressed.

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Certification

This Nitro Dioxin Site health consultation was prepared by West Virginia Department of Health and Human Resources (WVDHHR) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation of ATSDR has reviewed this public health consultation and concurred with its findings.

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APPENDIX A: Estimation of Exposure Doses

Dust and Soil Ingestion Exposure Doses

Soil oral exposure dose is estimated using following formula:

$$D = (C \times IR \times EF \times CF) / BW$$

Where,

D = Estimated exposure doses, expressed in “mg of contaminant per kg of body weight per day, or mg/kg.day

C = Concentration of the contaminant, expressed in “mg of contaminant / kg of soil”, or mg/kg

IR = Intake rate of contaminated soil, expressed in “mg of soil/day”, or mg/day

CF = Conversion factor, 10^{-6} kg/mg

EF = Exposure frequency, unitless

EF = (Actual exposure days/Year x Exposure years x 8hrs/day) / (365days /year x Exposure years x 24hrs/day)

BW = body weight, kg

Chronic Oral Exposure Doses are calculated based on following exposure inputs:

C: Average concentration of the contaminant(s)

IR: Child: 200mg/day; High school students: 100mg/day; Adult: 50mg/day

EF: Assuming a child attends a daycare center 5days/week and 50 weeks/year for 6 years the EF is:

$EF_{daycare\ children}$ = (5days/week x 50 weeks/years x 6years x 8hrs/day) / (365days/year x 6 years x 24hrs/day) = 0.23

Similarly,

$EF_{grade\ school\ students}$ = (180 days/years x 6years x 8hrs/day) / (365 days/year x 6 years x 24 hrs/day = 0.16

$EF_{grade\ school\ teacher}$ = (200 days/years x 25years x 8hrs/day) / (365days/year x 25 years x 24 hrs/day) = 0.18

$EF_{high\ school\ students}$ = (180 days/years x 4 years x 8hrs/day) / (365 days/year x 25 years x 24hrs/day) = 0.16

$EF_{high\ school\ teachers}$ = (200 days/year x 25years x 8 hrs/day) / (365 days/year x 25 years x 24hrs/day) = 0.16

$EF_{adults\ at\ community\ center}$ = (250 days/year x 25 years x 8 hrs/day) / (365 days/year x 25 years x 24 hrs/day) = 0.23

BW: Daycare child: 16 kg [16]

Grade school students: 30 kg [16]

High school students: 55 kg [16]

Adults: 70 kg [17]

See Table 3 in Appendix B for chronic oral exposure doses

Dust and Soil Dermal Exposure Doses

Soil dermal exposure dose is estimated using the following formula:

D = (C x A x AF x EF x CF) / BW

Where:

D = Dose (mg/kg.day)

C = Concentration of contaminant (mg/kg)

A = Total soil adhering to skin (mg)

A = SA x Ad = skin area available for contact (cm^2) x soil-skin adherence factor (mg/cm^2)

Where: SA, the skin areas available for contact (cm^2) are assumed as the following:

Daycare children: 2227 cm^2 [16]

Adults : 4546 cm^2 [17]

High school students: 4266 cm^2 [17]

Elementary school students: 2625 cm^2 [17]

Where: Ad: the default soil-skin adherence factor is assumed as the following:

Children: 0.2 mg/cm^2

Adults: 0.07 mg/cm^2 for adults

AF = Bioavailability factor for dermal absorption (unitless) = 3% [14].

EF = Exposure frequency (unitless) (using the same EF as for oral exposures)

CF = conversion factor (10^{-6} kg/mg)

BW = body weight (kg) (using the same BW as for oral exposures)

See Table 4 in Appendix B for chronic dermal exposure doses

Estimation of Cancer Risk

Cancer Risk = cancer slope factor x exposure doses over life time (70 Years)

APPENDIX B: Tables

Table 1. Dust Data and Calculated Dioxin TEQ in Indoor Dust

Dioxin/Furan Congeners Detected	TEF		Nitro Elementary School	Nitro High school				Nitro Community Center			
			Sampled 5/14/05	Sampled: 5/15/2005				Sampled: 5/18/2005			
	WHO	EPA	Sample #1	Sample #1	Sample #2	Sample #3	Sample #4	Sample #1	Sample #2	Sample #3	Sample #4
			ppt	ppt	ppt	ppt	ppt	ppt	ppt	ppt	ppt
2,3,7,8-TCDD	1	1	55.8	57.5	11.6	16.8	9.94	28.6	9.75	59	40.4
1,2,3,7,8-PeCDD	1	0.5	41.7	91.9	25.6	29.9	21.2	27.5	15.2	77.3	13.3
1,2,3,4,7,8-HxCDD	0.1	0.1	23.2	46.4	21.1	13.3	2.7	17	13.2	52.9	10.1
1,2,3,6,7,8-HxCDD	0.1	0.1	133	268	75.2	82	1400	361	269	1110	56.2
1,2,3,7,8,9-HxCDD	0.1	0.1	105	156	65.5	39.2	359	104	80	249	56.3
1,2,3,4,6,7,8-HpCDD	0.01	0.01	1950	5190	1680	6820	22500	7720	8040	22300	1360
OCDD	0.0003	0.001	15600	39300	12300	69100	52300	74700	73000	174000	10900
2,3,7,8-TCDF	0.1	0.1	11.4	49.6	18.9	12.1	6.38	11.7	5.63	16.6	6.9
1,2,3,7,8-PeCDF	0.03	0.05	9.11	49.2	14.7	7.54	7.95	7.09	9.29	29.6	12
2,3,4,7,8,PeCDF	0.3	0.5	17.9	139	29.2	11.6	16.8	9.24	27.9	47	10.4
1,2,3,4,7,8,-HxCDF	0.1	0.1	49.3	263	54.3	27.1	43.3	115	281	384	27.3
1,2,3,6,7,8-HxCDF	0.1	0.1	29.9	136	41.8	18	41.9	33.2	102	128	16.4
1,2,3,7,8,9-HxCDF	0.1	0.1	1.52	7.08	3.45	0.883	2.4	2.14	4.52	13	3.08
2,3,4,6,7,8-HxCDF	0.1	0.1	23	163	46	14.7	70.1	22.2	68.9	147	11.7
1,2,3,4,6,7,8-HpCDF	0.01	0.01	661	2410	442	325	3180	4790	11600	24500	290
1,2,3,4,7,8,9-HpCDF	0.01	0.01	32.6	94.6	40.8	20.2	149	213	170	530	22.7
OCDF	0.0003	0.001	1040	2510	827	665	5260	7190	8030	22900	307
2,3,7,8-TCDD TEQ (WHO TEF system)			172.20	390.97	104.59	163.72	504.55	277.51	338.43	893.71	96.07
2,3,7,8-TCDD TEQ (EPA TEF system)			166.76	403.07	107.12	200.07	536.15	323.07	393.32	1002.88	99.58

TEQ reported in parts per trillion (ppt). Multiply the number in ppt by 0.000001 to express in parts per million (ppm)

Table 2. Soil Dioxin Data and Calculated Dioxin TEQ

Dioxin/Furan Congeners Detected	TEF		Nitro Elementary School Surface Soil Samples (top 2 inch soil) Soil sample collection date: 5/16/06					
	WHO	EPA	Sample #1	Sample #2	Sample #2 (duplicate)	Sample #3	Sample #4[a]	Sample #5
			ppt	ppt	ppt	ppt	ppt	ppt
2,3,7,8-TCDD	1	1	1.34	1.13	1.05	2.55	6.19	8.21
1,2,3,7,8-PeCDD	1	0.5	0.81	0.21	0.40	1.09	1.94	1.91
1,2,3,4,7,8-HxCDD	0.1	0.1	1.34	0.26	0.41	1.07	1.10	0.58
1,2,3,6,7,8-HxCDD	0.1	0.1	4.48	1.30	1.13	3.62	6.39	2.27
1,2,3,7,8,9-HxCDD	0.1	0.1	3.99	1.21	1.36	3.06	3.33	1.76
1,2,3,4,6,7,8-HpCDD	0.01	0.01	103.62	32.96	35.48	77.62	146.43	47.30
OCDD	0.0003	0.001	5184.70	865.51	942.50	2329.39	1500.64	1060.89
2,3,7,8-TCDF	0.1	0.1	0.56	1.03	0.08	1.22	1.34	1.45
1,2,3,7,8-PeCDF	0.03	0.05	0.27	0.18	0.35	0.25	1.55	1.46
2,3,4,7,8,PeCDF	0.3	0.5	0.28	0.19	0.42	0.22	1.29	1.09
1,2,3,4,7,8,-HxCDF	0.1	0.1	1.56	1.09	1.15	2.89	5.52	5.42
1,2,3,6,7,8-HxCDF	0.1	0.1	1.76	0.75	0.78	1.87	5.64	2.63
1,2,3,7,8,9-HxCDF	0.1	0.1	0.49	0.26	0.26	0.08	0.29	0.16
2,3,4,6,7,8-HxCDF	0.1	0.1	2.28	0.76	0.87	1.79	2.18	2.39
1,2,3,4,6,7,8-HpCDF	0.01	0.01	38.22	11.13	12.13	23.96	67.40	46.13
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.71	0.66	0.61	0.73	2.33	1.24
OCDF	0.0003	0.001	37.43	17.34	24.96	30.91	128.13	45.93
2,3,7,8-TCDD TEQ (WHO TEF system)			6.78	2.61	2.95	6.99	13.45	13.44
2,3,7,8-TCDD TEQ (EPA TEF system)			10.06	3.20	3.52	8.15	14.23	13.50

2,3,7,8-TCDD TEQ is calculated using 1/2 the detection limit for data below the detection limit. Quantities below the detection limit are indicated by the detection limit in italics.

[a] Sampled between Nitro Elementary and Nitro Community Center

WHO: World Health Organization
EPA: Environmental Protection

Table 2. Soil Dioxin Data and Calculated Dioxin TEQ

Dioxin/Furan Congeners Detected	TEF		Nitro High School Surface Soil Sample (top 2 inch soil) Soil Samples collection Date: 5/16/2005							
	WHO	EPA	Sample #1	Sample #2	Sample #3	Sample #4	Sample #5	Sample #6	Sample #7	Sample #8
			ppt	ppt	ppt	ppt	ppt	ppt	ppt	ppt
2,3,7,8-TCDD	1	1	2.93	0.79	2.71	3.10	4.31	3.51	3.52	1.94
1,2,3,7,8-PeCDD	1	0.5	0.81	0.27	0.79	0.95	1.04	1.09	0.91	0.47
1,2,3,4,7,8-HxCDD	0.1	0.1	0.35	0.18	0.27	0.29	0.47	0.84	0.55	0.21
1,2,3,6,7,8-HxCDD	0.1	0.1	0.74	0.41	0.78	0.83	1.06	1.93	1.25	0.66
1,2,3,7,8,9-HxCDD	0.1	0.1	0.76	0.50	0.65	0.85	0.98	2.21	1.62	0.92
1,2,3,4,6,7,8-HpCDD	0.01	0.01	22.00	13.25	27.33	27.68	23.35	55.31	32.02	15.66
OCDD	0.0003	0.001	1012.05	789.94	611.77	633.76	260.30	953.46	957.04	559.65
2,3,7,8-TCDF	0.1	0.1	0.67	0.68	0.96	1.12	0.73	1.27	0.92	0.77
1,2,3,7,8-PeCDF	0.03	0.05	0.45	0.16	0.42	0.36	0.67	0.70	0.54	0.31
2,3,4,7,8,PeCDF	0.3	0.5	0.30	0.17	0.39	0.38	0.45	0.77	0.48	0.22
1,2,3,4,7,8,-HxCDF	0.1	0.1	2.85	0.50	1.43	1.52	2.59	2.64	1.84	0.97
1,2,3,6,7,8-HxCDF	0.1	0.1	1.59	0.25	0.68	0.80	1.36	1.61	0.98	0.57
1,2,3,7,8,9-HxCDF	0.1	0.1	0.04	0.02	0.05	0.04	0.09	0.06	0.07	0.16
2,3,4,6,7,8-HxCDF	0.1	0.1	0.78	0.22	0.46	0.54	0.87	1.18	0.73	0.28
1,2,3,4,6,7,8-HpCDF	0.01	0.01	60.04	3.38	10.62	11.52	19.04	21.60	13.46	6.60
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.72	0.15	0.32	0.38	0.60	0.89	0.50	0.65
OCDF	0.0003	0.001	175.69	7.05	18.27	19.70	27.33	55.08	19.60	7.36
2,3,7,8-TCDD TEQ (WHO TEF system)			5.80	1.76	4.73	5.36	6.79	7.11	6.12	3.29
2,3,7,8-TCDD TEQ (EPA TEF system)			6.30	2.23	4.86	5.43	6.58	7.44	6.47	3.50

WHO: World Health Organization
EPA: Environmental Protection

2,3,7,8-TCDD TEQ is calculated using 1/2 the detection limit for data below the detection limit.
Quantities below the detection limit are indicated by the detection limit in italics.
a Sampled between Nitro Elementary and Nitro Community Center

Table 2. Soil Dioxin Data and Calculated Dioxin TEQ

Dioxin/Furan Congeners Detected	TEF		Nitro High School Surface Soil Sample (top 2 inch soil) Soil Samples collection Date: 5/17/2005							
	WHO	EPA	Sample #9	Sample #10	Sample #11	Sample #12	Sample #13	Sample #14	Sample #15	Sample #16
			ppt	ppt	ppt	ppt	ppt	ppt	ppt	ppt
2,3,7,8-TCDD	1	1	2.10	1.89	4.17	2.71	5.23	3.77	9.88	2.09
1,2,3,7,8-PeCDD	1	0.5	0.54	0.48	1.79	0.55	0.80	0.72	2.37	0.53
1,2,3,4,7,8-HxCDD	0.1	0.1	0.26	0.33	1.15	0.33	0.46	0.49	0.80	0.39
1,2,3,6,7,8-HxCDD	0.1	0.1	0.61	0.64	3.03	1.00	1.23	1.13	2.58	0.65
1,2,3,7,8,9-HxCDD	0.1	0.1	0.96	1.12	3.10	1.07	1.45	1.12	2.12	1.05
1,2,3,4,6,7,8-HpCDD	0.01	0.01	14.40	19.36	45.23	20.25	30.47	23.52	62.92	18.19
OCDD	0.0003	0.001	881.34	1132.74	753.33	215.03	352.39	255.91	3461.61	1193.12
2,3,7,8-TCDF	0.1	0.1	0.74	0.81	0.85	0.76	0.70	0.73	1.16	0.91
1,2,3,7,8-PeCDF	0.03	0.05	0.23	0.22	0.63	0.24	0.37	0.30	1.11	0.20
2,3,4,7,8,PeCDF	0.3	0.5	0.22	0.23	0.52	0.25	0.32	0.31	0.99	0.23
1,2,3,4,7,8,-HxCDF	0.1	0.1	1.10	0.95	2.23	1.00	1.89	1.33	4.08	0.89
1,2,3,6,7,8-HxCDF	0.1	0.1	0.62	0.48	1.18	0.63	1.04	0.73	2.48	0.40
1,2,3,7,8,9-HxCDF	0.1	0.1	0.13	0.03	0.02	0.04	0.03	0.06	0.09	0.04
2,3,4,6,7,8-HxCDF	0.1	0.1	0.31	0.33	0.96	0.46	0.72	0.64	1.86	0.33
1,2,3,4,6,7,8-HpCDF	0.01	0.01	6.85	6.08	18.74	10.60	17.83	12.17	35.13	8.44
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.37	0.20	0.65	0.43	0.69	0.63	0.83	0.18
OCDF	0.0003	0.001	7.28	8.00	25.03	20.30	33.29	25.59	48.80	7.77
2,3,7,8-TCDD TEQ (WHO TEF system)			3.62	3.47	8.23	4.21	7.45	5.62	16.08	3.73
2,3,7,8-TCDD TEQ (EPA TEF system)			4.03	4.08	7.99	4.15	7.39	5.53	17.57	4.36

WHO: World Health Organization
EPA: Environmental Protection

2,3,7,8-TCDD TEQ is calculated using 1/2 the detection limit for data below the detection limit.
Quantities below the detection limit are indicated by the detection limit in italics.
a Sampled between Nitro Elementary and Nitro Community Center

Table 3. Estimated dioxin oral doses and cancer risk from exposure to indoor dust

Exposure input		Nitro Elementary School		Nitro High School		Nitro Community Center	
		Student	Teacher	Student	Teacher	Daycare Children	Adult
Initial screen for noncarcinogenic effects: D = (C*IR*EF*CF)/BW							
C	Max. Dioxin Conc. (mg/kg)	1.67E-04	1.67E-04	5.36E-04	5.36E-04	1.00E-03	1.00E-03
IR	Dust Intake Rate (mg/day)	200	100	100	100	200	100
EF	Exposure Frequency	1	1	1	1	1	1
CF	Conversion Factor (kg/mg)	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06
BW	Body Weight (kg)	10	70	10	70	10	70
D	Initial Screen Dose (mg/kg.day)	3.3E-09	2.4E-10	5.4E-09	7.7E-10	2.0E-08	1.4E-09
	Does "D" exceed the MRL (1.0E-09)?	YES	NO	YES	NO	YES	YES
		▼		▼		▼	▼
Site-specific screen for noncarcinogenic effects: D = (C*IR*EF*CF)/BW							
C	Avg.Dioxin Conc.(mg/kg)	1.67E-04		3.12E-04		4.55E-04	4.55E-04
IR	Dust Intake Rate (mg/day)	200		100		200	100
EF*	Exposure Frequency*	0.16		0.16		0.23	0.23
CF	Conversion Factor (kg/mg)	1.0E-06		1.0E-06		1.0E-06	1.0E-06
BW	Body Weight (kg)	30		55		16	70
D	Site-specific screen dose (mg/kg.day)	1.8E-10		9.1E-11		1.3E-09	1.5E-10
	Exceeds the MRL (1.0E-09)?	NO		NO		YES	NO
						▼	
						see text	

Table 3. Estimated dioxin oral doses and cancer risk from exposure to indoor dust

Exposure input		Nitro Elementary School		Nitro High School		Nitro Community Center	
		Student	Teacher	Student	Teacher	Daycare Children	Adult
Site-specific screen for carcinogenic effects: D = ((C*IR*EF*CF)/BW)*CSF							
C	Avg.Dioxin Conc.(mg/kg)	1.67E-04	1.67E-04	3.12E-04	3.12E-04	4.55E-04	4.55E-04
IR	Dust Intake Rate (mg/day)	200	100	100	100	200	100
EF**	Exposure Frequency - carcinogenic**	0.01	0.07	0.01	0.07	0.02	0.08
CF	Conversion Factor (kg/mg)	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06
BW	Body Weight (kg)	30	70	55	70	16	70
CSF	Cancer Slope Factor (mg/kg.day)-1	1.5E+05	1.5E+05	1.5E+05	1.5E+05	1.5E+05	1.5E+05
D	(Initial Screen Dose (mg/kg.day) x CSF)	1.67E-06	2.51E-06	8.50E-07	4.67E-06	1.71E-05	7.79E-06
	Number of excess cancers/10,000 people	0.02	0.03	0.01	0.05	0.17	0.08
Exposure frequency calculations							
EF-hours	Exposure duration - hours/day	8	8	8	8	8	8
EF-days	Frequency of Exposure (days/yr)	180	200	180	200	250	250
EF-years	Exposure Duration (yrs)	6	25	4	25	6	25
EF(chronic-noncancer) = (Exposure Days/yr x Exposure Years x 8hrs/day)/ (365days/yr x Exposure Yrs x 24hrs/day)							
EF*	Exposure Frequency - noncarcinogenic*	0.16	0.18	0.16	0.18	0.23	0.23
EF (carcinogenic) = (Exposure days/yr x yrs of exposure x 8hrs/day) / (365days/yr x 70 yrs x 24hrs/day)							
EF**	Exposure Frequency - carcinogenic**	0.01	0.07	0.01	0.07	0.02	0.08

Table 4. Estimated dermal exposure doses from indoor dust

	Exposure input	Nitro Elementary		Nitro High School		Nitro Community	
		Student	Teacher	Student	Teacher	Daycare Children	Adult
C	Maximum dioxin concentration (mg/kg)	1.67E-04	1.67E-04	5.36E-04	5.36E-04	1.00E-03	1.00E-03
SA	Skin area available for contact (cm^2)	2625	4656	4266	4656	2227	4656
AF	Soil-to skin adherence factor (mg/cm^2)	0.2	0.07	0.2	0.07	0.2	0.07
ABS	Absorption Factor	0.03	0.03	0.03	0.03	0.03	0.03
fc	Days per year exposed	180	200	180	200	250	250
ed	*Number of years exposed*	6	25	4	25	6	25
ed-t	*Total number of years exposed (carcinogenic estimate)*	70	70	70	70	70	70
h	*Hours per day exposed*	8	8	8	8	8	8
EF-nc	Exposure frequency-noncarcinogenic estimate	0.16	0.18	0.16	0.18	0.23	0.23
EF-c	Exposure frequency-carcinogenic estimate	0.01	0.07	0.01	0.07	0.02	0.08
CF	Conversion factor (1 kg = 1,000,000 mg)	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06
BW	Body Weight (kg)	30	70	55	70	16	70
D	Dermal Exposure Dose (mg/kg.day)	1.4E-11	4.3E-12	4.1E-11	1.4E-11	1.9E-10	3.2E-11
D-c	Dermal exposure dose (using the EF-c) (mg/kg/day)	1.2E-12	1.5E-12	2.3E-12	4.9E-12	1.6E-11	1.1E-11
CSF	Cancer slope factor $(mg/kg.day)^{-1}$	1.5E+05	1.5E+05	1.5E+05	1.5E+05	1.5E+05	1.5E+05
ECR	Excess cancer risk	1.8E-07	2.3E-07	3.5E-07	7.3E-07	2.5E-06	1.7E-06
Dermal Dose Formula: D = (C x A x AF x ABS x EF x CF) / BW							
A: Total Soil Adhered (mg) A = Soil-to-skin Adherence Factor (mg/cm2)AF x Exposed Areas (SA) ATSDR default soil							
ABS: Bioavailability Factor, EPA's deafult absorption factor for 2,3,7,8-TCDD of 3% is used in this calculation							
EF: Exposure frequency, EF(Chronic) = (exposure days/yr x exposure years x 8hrs/day) / (365 days/year x exposure years x 24hrs/day)							