

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

Renée D. Coleman-Mitchell, MPH
Commissioner



Ned Lamont
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Susan Bysiewicz
Lt. Governor

Environmental Health Section

Evaluation of Recreational Exposures to Soil at Locations Tested as Part of the Town of Fairfield Department of Public Works Fill Pile Investigation

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Prepared by Margaret L. Harvey, MPH
Environmental and Occupational Health Assessment Program, Environmental Health Section

Background about the Fairfield Department of Public Works Fill Pile Issue

The Town of Fairfield Department of Public Works (DPW) operated an aggregate fill facility to accept construction-related bulky materials and mix these materials with clean soils to create a recycled aggregate soil product suitable for use in specific areas such as beneath roads, sidewalks and parking lots. The product was never intended to be used in recreational areas such as school grounds, parks or playgrounds. For a period of time (approximately May 2013-December 2016), the aggregate soil product was used inappropriately in areas such as school fields and parks. Separately, in late 2016, the contractor hired by the town to manage the DPW fill pile allegedly allowed one delivery of contaminated construction waste materials in the DPW pile. This material was tested and remediated at that time. During the summer 2019, glass and shingle pieces were identified in surface soil along the sidewalk area of Gould Manor Park. This park had received aggregate soil product from the DPW pile as part of a sidewalk reconstruction project. This finding prompted the town to conduct a review of locations that may have inappropriately received the aggregate soil product. Through this review, the town identified locations for soil testing. The locations include school and town recreational fields and town parks. Soil testing was focused in areas on the fields or parks where town records indicated that fill had been placed. Separately, the Fairfield Schools Board of Education decided to test all school playgrounds even though town records did not identify any of the playgrounds as locations receiving the DPW aggregate soil product. Details about the DPW Fill Pile and the Town's actions to address the pile can be found at the Town's dedicated website for fill use issues (fairfieldct.org/fillissues).



Phone: (860) 509-7740 • Fax: (860) 509-7785
Telecommunications Relay Service 7-1-1
410 Capitol Avenue, P.O. Box 340308
Hartford, Connecticut 06134-0308
www.ct.gov/dph

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Purpose of this Evaluation

The Town of Fairfield requested that the CT Department of Public Health (CTDPH) use recreational exposure assumptions to evaluate direct contact with soil. Under Connecticut's Remediation Standard Regulations (CT General Statutes 22a-133k-2d), a risk assessment can be done to derive alternative soil cleanup criteria. These criteria are alternative to the default residential and industrial/commercial direct exposure soil criteria established in regulation. Because the locations in Fairfield are recreational settings (not residential or commercial/industrial settings), the Town asked CTDPH to use the alternative cleanup criteria process allowed in the regulations to evaluate the locations using recreational exposures that are more closely aligned with how the areas are used.

Locations Evaluated by CTDPH

CTDPH reviewed soil data provided by the Town's consultant (Tighe and Bond) from school fields and grounds, playgrounds and parks. Soil was tested for extractable total petroleum hydrocarbons (ETPH), asbestos, metals, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). Table A in the Appendix lists the locations for which CTDPH received soil data to evaluate. For each location, the Table indicates whether there were any soil results exceeding residential direct exposure criteria for soil (R-DEC). As shown in the Table, at some locations the 95% Upper Confidence Limit (95% UCL) was less than the R-DEC. What this means is that at these locations, Tighe and Bond collected a second round of soil testing near the specific area where the elevated level of contamination was initially found. This additional testing provides a better understanding of the extent of contamination in a particular location and provides enough samples to calculate an average concentration. The type of average that was calculated is a 95% upper confidence level of the arithmetic mean (95% UCL). A 95% UCL is a conservative (health protective) estimate of the average. More specifically, a 95% UCL is a statistical estimate of the "true" average that has a very low probability of underestimating the "true" average. In all locations where a second round of testing occurred, the 95% UCL did not exceed R-DECs.

Table A shows that there are a number of locations where soil concentrations are greater than residential soil criteria. At these locations, CTDPH used recreationally-based criteria as comparison criteria.

Contaminants Found in Soil at the Tested Locations

The most commonly detected chemicals at concentrations exceeding R-DEC were PAHs. Arsenic, ETPH, lead and PCBs were found less frequently. The Town's dedicated website for fill use issues (fairfieldct.org/fillissues) provides links to background information about chemicals detected in soil at a concentration exceeding R-DEC.

At two locations (Burroughs Park and Gould Manor Park), pieces of tile shingles were visible in surface soil. Tests of these pieces revealed that they contained asbestos (up to 20%). Asbestos was tested in soil at all locations (including Burroughs and Gould Manor) and was not detected in soil at any location. This indicates that the asbestos has remained bound to the shingle matrix and is not friable.

Soil Criteria Based on Recreational Exposures and Risks

CT DPH used the process established in the Remediation Standard Regulations to derive alternative criteria based on recreational exposures. As specified in regulation, alternative soil criteria must protect human health and the environment from cancer and non-cancer risks associated with direct exposure to polluted soil. The regulations specify the cancer and non-cancer risk limits that alternative criteria must meet. These risk limits are the same as the limits used to derive the default residential and commercial/industrial direct exposure criteria for soil that are established in regulation.

Recreational Exposure Assumptions

CTDPH worked with the Fairfield Director of Health in developing recreational exposure assumptions that are reasonable and health protective, given how the athletic fields, parks and playgrounds are used. We assumed that children have direct contact with soil while playing on the fields, in the playgrounds and in the parks. We also assumed that exposure continues into adulthood because adults may continue to use the fields while coaching children, visiting playgrounds with children and using parks as residents or visitors. CTDPH used standard published risk assessment sources for inputs such as body weights and soil ingestion rates. CTDPH developed recreational criteria based on cancer and non-cancer risks from exposure to contaminants in soil.

The Appendix provides details about the recreational exposure assumptions and risk calculations. For all contaminants that are carcinogens, the cancer risk based soil criteria were lower (more restrictive) than the criteria based on non-cancer risks.

Cancer Risk Limit Explained

CT's Remediation Standard Regulations state that for alternative criteria, the concentration of each carcinogenic substance must not exceed a 1×10^{-6} (one-in-one million) excess lifetime cancer risk *or* for areas polluted with multiple carcinogenic substances, the cumulative excess lifetime cancer risk for all carcinogenic substances in soil must not exceed 1×10^{-5} (one-in-one hundred thousand). The cumulative risk limit of 1×10^{-5} is intended to be used only when there are 10 or more carcinogenic substances present in the soil (clarified via personal communication with CT Department of Energy and Environmental Protection, September 26, 2019). The fill locations tested in Fairfield do not have more than 10 carcinogenic substances. Thus, the recreational criteria are set at 1×10^{-6} cancer risk for each contaminant rather than the cumulative risk limit of 1×10^{-5} .

In layman's terms, an excess lifetime cancer risk of 1×10^{-6} means that if one million people are exposed to the contaminated soil (at the recreational soil concentration and with the recreational exposure assumptions), there is a statistical probability of one excess cancer caused by the exposure among the million people exposed. The range of background cancer rates in the U.S. tells us that 1 out of 3 to 1 out of 2 people will receive a cancer diagnosis in their lifetime. This means that in a population of one million people, 333,333 to 500,000 people

will receive a cancer diagnosis in their lifetime. Exposure to contaminated soil that has been cleaned up to a risk limit of 1×10^{-6} means a probability of one additional cancer from exposure to the contaminated soil. This “additional” cancer means in addition to the background number of cancers (333,333 to 500,000 in a population of one million). A cancer risk limit of 1×10^{-6} is considered “de minimis” (minor or insignificant).

Non-cancer Risk Limit Explained

CT’s Remediation Standard Regulations state that for alternative criteria, the concentration of each non-carcinogenic substance must not exceed a hazard index (HI) of one or a cumulative HI of one for chemicals acting on the same target organ. Similar to cancer risks, the cumulative HI of one is intended to be used only when there are 10 or more substances present in the soil. The fill locations tested in Fairfield do not have more than 10 substances. Thus, the recreational criteria are set at a HI limit of one.

In layman’s terms, a HI limit of one means that the dose of contaminant a person receives from exposure does not exceed the “safe” dose (also referred to as the Reference Dose). Chemical-specific safe doses are published (for many chemicals) by national environmental and public health protection agencies such as the Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease Registry (ATSDR).

Recreational Soil Criteria

Table 1 below lists the criteria based on recreational exposure assumptions. Recreational criteria were developed for contaminants detected in soil at concentrations exceeding R-DEC. There is no R-DEC for asbestos but it was not found in soil at detectable levels. There is no recreational criterion for lead in Table 1 because lead is not evaluated using a Reference Dose (safe dose) approach. Rather, it is evaluated using a blood lead mathematical model (IEUBK Model). Lead was detected at a concentration exceeding R-DEC at only one location, Gould Manor Park. Gould Manor Park had arsenic detected at a concentration exceeding the Recreational criterion so it is on the list of locations needing exposure reduction measures because of arsenic. Therefore, CTDPH did not generate a recreational-based criteria for lead using the IEUBK model. As shown in Table 1, the criteria based on cancer risks are lower (more protective) than the criteria based on non-cancer risks.

Table 1. Recreational Soil Criteria for Contaminants detected at concentrations greater than CT Residential Direct Contact Criteria (R-DEC) during Fairfield Fill Pile Investigations, August/September 2019.

Contaminants	Recreational Soil Criteria (mg/kg, ppm)	
	Based on Cancer Risk Limit of 1×10^{-6}	Based on non-cancer HI of 1
Arsenic	10*	300
ETPH	Not a carcinogen	10,300
Lead	Not a carcinogen	Not calculated^
PCBs	2	20
PAHs		
Benzo(a)pyrene	4	300
Benzo(a)anthracene	40	30,000
Benzo(b)fluoranthene	40	30,000
Dibenzo(ah)anthracene	4	3,000
Benzo(k)fluoranthene	40	30,000
Chrysene	525	Not calculated^
Indeno(1,2,3-cd)pyrene	6	Not calculated^

*Default to the background concentration of 10 mg/kg because risk-based value is below 10 mg/kg.

^Lead is not evaluated using a Reference Dose (safe dose) approach.

Evaluation of Locations using Recreational Criteria

CTDPH compared soil concentrations with recreational criteria. Table 2 below provides the results of this comparison. As stated previously, when soil concentrations (95% UCL or single soil result if a 95% UCL was not calculated) did not exceed R-DEC, the comparison with recreational criteria was not done. This is because the residential criteria are more restrictive than the recreational criteria. As Table 2 shows, there are several locations that exceed recreational criteria.

Table 2. Comparison of Locations with Recreational Criteria

Location	Exceeds Recreational Criteria?	Contaminant(s) Exceeding Recreational Criteria, (Max. conc., mg/kg)	Notes about exceedance(s)
Jennings Playground	Yes	Arsenic (13.7)	Grass area just outside playground border
Dwight Playground	No		
McKinley School	Yes	Arsenic (25.2)	Grass area at west end of field, not within playground.
Mill Hill Elementary	Yes	benzo(a)pyrene (13) indeno(1,2,3-cd)pyrene (9.4)	Along sidewalk leading to playground
Stratfield Playground	Yes	benzo(a)pyrene (7.3)	Beneath landscape fabric and 2-2 ½ ft of mulch
Holland Hill Playground	Yes	Arsenic (15.5)	Beneath landscape fabric and ½ - 1 ½ ft of mulch
Jennings Beach	Yes	Arsenic (93.4)	Grass area (east of playground)
Tennis facility	Yes	PCBs (2.3)	Behind building
Gould Manor Park	Yes	Arsenic (15.2)	Along sidewalk
Ludlowe Courtyard	No		

Recommendations

CTDPH offers the following recommendations to the Town of Fairfield. CTDPH recognizes that the Town has already accomplished or is in the process of implementing many of these recommendations.

1. The Town should take measures to reduce the potential for ongoing direct contact exposure with soil at locations listed in Table 2 where soil concentrations exceed recreational criteria. If additional recreational locations are found where soil concentrations exceed recreational criteria, the Town should take exposure reduction measures at those locations as well.
2. The Town should work with its consultant to identify measures that will result in reduced potential for ongoing direct contact with soil. These measures could include capping or covering the area with a suitable thickness of clean soil, mulch, grass or other material such as pavement or rubber matting. Landscaping fabric or other fabric barrier beneath the cap material can provide an added level of protection. A suitable measure could also consist of excavating soil and replacing with clean soil.
3. In areas where capping or covering is used as a remedy, the Town should prepare a management plan describing how the cap or cover will be inspected and maintained so that it continues to work as intended.
4. The Town should seek concurrence from CTDPH and CTDEEP on the exposure reduction measures that it selects.
5. The Town should remove visible asbestos-containing shingles and other visible construction debris from soil in areas where it has been noted, even if concentrations of contaminants in the soil do not exceed recreational criteria.

Table A. Locations where CTDPH evaluated soil data from testing performed by Tighe and Bond for Town of Fairfield or Board of Education, August and September 2019.

Location	Contaminants in soil exceed R-DEC?	Which Contaminants Exceed R-DEC	Comments
Gould Manor Park	Yes	Lead, arsenic	Visible asbestos-containing tile shingle pieces in surface soil along sidewalk.
Burr School	No	n/a	
Burr School Playground	No	n/a	
Dwight Elem. School	No	n/a	
Dwight Playground	Yes	PAHs	PAHs beneath landscape fabric and 1.75 – 2 feet of mulch
Jennings Elem. Playground	Yes	Arsenic	Arsenic near playground, arsenic elevated in wood tie
Jennings Elem. Field	No	n/a	
McKinley Elem. School	Yes	PAHs, Arsenic	PAHs and arsenic at west end of field.
McKinley Playground	No	n/a	
Mill Hill Elem. School	Yes	PAHs	PAHs elevated along sidewalk, not in fields
Mill Hill Playground	No	n/a	
N. Stratfield Elem. School	No	n/a	
N. Stratfield Playground	No	n/a	
Stratfield Playground	Yes	PAHs	PAHs beneath landscape fabric and 2-2.5 feet of mulch
Riverfield School	Yes*	PAHs	95% UCL using additional soil results less than R-DECs
Riverfield Playground	No	n/a	
Woods Middle School	No	n/a	
Burroughs Park	No	n/a	Visible asbestos-containing tile shingle pieces in field.
Dougiello Softball Field	No	n/a	
Holland Hill School	No	n/a	
Holland Hill Playground	Yes	Arsenic	Arsenic beneath landscape fabric and 0.5 – 1.5 feet of mulch
Jennings Beach	Yes	PAHs, Arsenic	Grass area, east of playground
Tennis Facility	Yes*	PAHs, PCBs	95% UCL for PAHs using additional soil results less than R-DECs
Oldfield School	No	n/a	
Kiwanis Softball	No	n/a	
South Pine Creek Field	Yes*	ETPH	95% UCL using additional soil results less than R-DEC
Sullivan Pop Warner Field	Yes*	Arsenic	95% UCL using additional soil results less than R-DEC
Town Hall Fields	Yes*	PAHs	95% UCL using additional soil results less than R-DECs
Tunxis Hill	No	n/a	
Warde High School	Yes*	PAHs	95% UCL using additional soil results less than R-DECs
Ludlowe HS Courtyard	Yes	PAHs, ETPH	
Osborn Hill Playground	No	n/a	
Sherman Elem. Playground	No	n/a	

*one or more individual soil results exceed R-DEC but 95% UCL does not.

Recreational Exposure Assumptions, Toxicity Values and Equations:

Receptor Age: School aged child age 5-17 years and adult age 18-36 years.

Exposure Duration Child: 13 years

Exposure Duration Adult: 17 years

Total Exposure Duration: 30 years

Soil Ingestion Rate Child: 100 mg/day (ATSDR Exposure Dose Guidance for Soil and Sediment Ingestion, 2016)

Soil Ingestion Rate Adult: 50 mg/day (ATSDR Exposure Dose Guidance for Soil and Sediment Ingestion, 2016)

Exposure Frequency: 180 days/year

Child Body Weight: 49 kg (ATSDR Exposure Dose Guidance Body Weight, 2016)

Adult Body Weight: 80 kg (ATSDR Exposure Dose Guidance Body Weight, 2016)

The ingestion pathway was the only pathway evaluated because it contributes the majority of the dose (as compared with the dermal pathway). Also, the dermal pathway is not included in the default residential and industrial/commercial direct contact soil criteria in the Remediation Standard Regulations.

Toxicity Values used to derive the Recreational Criteria:

Contaminant	Cancer Potency Factor (risk/mg/kg-d) (Source)	Non-Cancer Reference Dose (mg/kg-d) (Source)
Arsenic	1.5 (EPA IRIS)	0.0003 (EPA IRIS)
PCBs	2.0 (EPA IRIS)	0.00002 (EPA IRIS)
ETPH	Not a carcinogen	0.01 (CT DEEP 2012)
Benzo(a)pyrene	1.0 (CTDPH 2018)	0.0003 (CTDPH 2018)
Benzo(a)anthracene	0.1 (CTDPH 2018)	0.03 (CTDPH 2018)
Benzo(b)fluoranthene	0.1 (CTDPH 2018)	0.03 (CTDPH 2018)
Dibenzo(ah)anthracene	1.0 (CTDPH 2018)	0.003 (CTDPH 2018)
Benzo(k)fluoranthene	0.1 (CTDPH 2018)	0.03 (CTDPH 2018)
Chrysene	0.0073 (CTDPH 2018)	Not available
Indeno(1,2,3-cd)pyrene	0.73 (CTDPH 2018)	Not available

CT DEEP Technical Support Document - Petroleum Hydrocarbons Using the EPH/VPH/APH Analytical Methods and Criteria Development, July 2012.

https://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/Technical_Support_Document_EPHVPHAPH.pdf

CT Department of Public Health. April 4, 2018 and May 8, 2018 Memoranda from Gary Ginsberg to Traci Iott.

Risk Equations: The equations below are the basic equations used to calculate risk. To calculate soil criteria that equate with a specific risk limit, DPH used the rearranged version of these equations that appear in the remediation standard regulations (22a-133k-2 (b)(4)).

Non-Cancer (child age 5-17):

$$ADD = [\text{Soil}] * CF * IR * ED * EF * 1/BW * 1/AP$$

$$HI = ADD/RfD$$

Cancer (child age 5-17 + adult age 18-34)

$$LADD = [\text{Soil}] * CF * ((IR\text{-}child * ED\text{-}child * EF * 1/BW\text{-}child * 1/AP) + (IR\text{-}adult * ED\text{-}adult * EF * 1/BW\text{-}adult * 1/AP))$$

$$ELCR = LADD * CPF$$

Where:

ADD = average daily dose, mg/kg-d

[Soil] = contaminant concentration in soil, mg/kg

CF = conversion factor (kg/mg) 1×10^{-6}

IR = soil ingestion rate (mg/d), adults = 50 and children = 100

ED = Exposure Duration, years, children = 13 and adults = 17 for a total exposure duration = 30 years (cancer calculations)

EF = Exposure Frequency, days/year, 180

BW = body weight, kg, adults = 80 and children = 49

AP = Averaging Period, days, cancer = 25550 and non-cancer = 4745

LADD = Lifetime average daily dose, mg/kg-d

HI = Hazard Index, HI limit = 1

RfD = Reference Dose, mg/kg-d

CPF = cancer potency factor, risk per mg/kg-d

ELCR = Excess Lifetime Cancer risk, risk limit = 1×10^{-6}