

Health Consultation

NORTH COUNTRY ENVIRONMENTAL SERVICES (NCES) LANDFILL
BETHLEHEM, GRAFTON COUNTY, NEW HAMPSHIRE

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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Division of Health Assessment and Consultation
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HEALTH CONSULTATION

NORTH COUNTRY ENVIRONMENTAL SERVICES (NCES) LANDFILL
BETHLEHEM, GRAFTON COUNTY, NEW HAMPSHIRE

Prepared By:

New Hampshire Department of Environmental Services
Environmental Health Program
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Summary

The New Hampshire Department of Environmental Services (DES), Air Resources Division, Environmental Health Program (EHP) has completed this environmental data evaluation in response to local resident concerns expressed during a recent public meeting held for the North Country Environmental Services, Inc. (NCES) Landfill located in Bethlehem, New Hampshire (site). Health concerns related to the site have been expressed by Bethlehem residents since an application was filed with the DES Solid Waste Management Bureau for a solid waste permit modification. The EHP has determined that conducting an evaluation of ambient air and surface/drinking water exposure potential near the site is the most appropriate course of action to address the concerns of residents and local officials. Accordingly, the EHP has reviewed the September 2006 *Air Dispersion Modeling*, and the September 2007 *Summary of Water Quality Monitoring* reports prepared by Sanborn, Head and Associates, Inc. (SHA) on behalf of NCES. The EHP also examined ambient air monitoring data collected by the DES in Bethlehem, NH from January 2001 to January 2002. The EHP reviewed these data and evaluated the potential for adverse health effects to occur from ambient air exposures as well as potential drinking water exposures to site-related compounds.

Site Description & Background

The NCES Landfill (site) is located to the east of Trudeau Road and to the south of Muchmore Road in Bethlehem, New Hampshire. Access to the site is from Trudeau Road. Forest land abuts the site to the east, southeast, and north to the Ammonoosuc River. Two residences owned by NCES are located on Laurel Lane, a dead end road extending off of Muchmore Road (1, 2).

The eastern portion of the site originally began operation as an unlined landfill in 1976. The landfill was purchased by Sanco, Inc. in April 1983. Sanco, Inc. received Permit #DES-SW-87-022 to construct and operate Stage I (a lined area with a leachate collection system) to the west of the unlined landfill. Permit # DES-SW-89-009 for Stage II, located adjacent to and northeast of Stage I, was granted with a condition that the unlined landfill contents be excavated and placed within the lined Stage I landfill. The relocation of this refuse was completed in October 1993. Stage III, located to the southeast of Stages I and II, received permits in 2000 and construction began during that summer and fall. Landfill operations are currently taking place in Stage III (2).

Demographics

The Site lies in the Town of Bethlehem, Grafton County, New Hampshire. According to the 2000 U.S. Census, approximately 2,199 people live within a 1-mile radius of Bethlehem. Bethlehem includes the villages of Maplewood and Pierce Bridge. It is home to Cushman and Strawberry Hill State Forests. The eastern half of the town is within the White Mountain National Forest. The Appalachian Trail crosses in the south (3).

Human Health Assessment Methods

The EHP uses a conservative, protective approach to determine whether contaminant levels constitute a potential health hazard. In general this involves a two-step methodology that is used to evaluate most of the potential contaminants identified in this study. First, monitoring and modeling data are gathered and a comprehensive list of site-related pollutants is compiled. Second, health-based comparison values (CVs) are used to identify contaminants that do not have a realistic possibility of causing adverse health effects. These are eliminated from further analysis. The remaining contaminants are deemed “contaminants of concern” and subjected to thorough scientific literature reviews to determine whether or not their levels present a public health hazard (4).

The CVs used in this report represent concentrations of contaminants that current scientific literature concludes are “harmless.” CVs are conservative, and include ample safety factors in consideration of sensitive populations such as children, the elderly, and those with chronic respiratory disease. Therefore, CVs are protective of public health in the vast majority of exposure situations. If a contaminant level is lower than its CV, it is unlikely that harmful effects will result, and is eliminated from further analysis. If a contaminant exceeds its CV, it is designated a “contaminant of concern” and examined in greater detail. This includes an analysis of the specific exposure scenario and a thorough scientific literature review to determine whether or not its level presents a public health hazard. Because CVs are based on conservative assumptions, the presence of concentrations greater than a CV does not necessarily indicate that adverse health effects will occur among exposed populations (4).

The EHP utilized appropriate and specific CVs developed either by the DES, the Environmental Protection Agency (EPA) and the Agency for Toxic Substances & Disease Registry (ATSDR) for comparison purposes in this report. When a pollutant has no traditional CV {e.g., total suspended particulates (TSP), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂)}, EPA’s Primary National Ambient Air Quality Standards (NAAQS) are employed for comparative purposes (5). The primary NAAQS are health-based standards set to protect public health, particularly sensitive groups such as children, the elderly, and those with asthma or other respiratory disease.

Exposure Pathways

Environmental contamination cannot affect a person’s health unless there is a “completed exposure pathway.” A *completed* exposure pathway exists when all of the following five elements are present: 1) a source of contamination; 2) transport through an environmental medium; 3) a point of exposure; 4) a route of human exposure; and 5) an exposed population. These five elements do not define exposure; rather they contribute to determining the probability of exposure. In a *potential* exposure pathway, one or more of the critical elements may not be present, but information is insufficient to eliminate or exclude it. For example, an exposure could have occurred in the past, could be occurring currently, or could occur in the future. An exposure pathway is *eliminated* if one or more of the critical elements are missing. Eliminated exposure pathways may also be referred to as incomplete (4).

The primary *completed* exposure pathway in this Health Consultation (inhalation of ambient air) is based on the following: 1) sources of contamination (all local and regional sources of air pollution, including the Site); 2) transport through an environmental medium (ambient air); 3) a point of exposure (the Bethlehem area); 4) a route of human exposure (respiration/breathing); and 5) a receptor population (Bethlehem area residents). An additional *potential* exposure pathway is the incidental ingestion and/or dermal absorption of downstream Ammonoosuc River surface water. Ingestion of drinking water from nearby public and private water wells was deemed to be eliminated but is nevertheless discussed in forthcoming sections

Offsite Pathways

Source	Environmental Transport And Media	Exposure Point	Exposure Route	Exposed Population	Time Frame	Status
Landfill Waste	Waste to Groundwater to Private Drinking Water Wells	Tap Water	Ingestion Dermal Inhalation	Residents	Past	Eliminated
					Present	Eliminated
					Future	Eliminated
Landfill Waste	Waste and Flare Emissions to Ambient Air	Ambient Air	Inhalation	Residents	Past	Completed
					Present	Completed
					Future	Completed
Landfill Waste	Waste to Groundwater to Surface Water	Ammonoosuc River	Ingestion Dermal	Swimmers Waders	Past	Potential
					Present	Potential
					Future	Potential

Air Dispersion Modeling

In September 2006 SHA submitted an Air Dispersion Modeling Report on behalf of NCES to the DES Air Resources Division. The report was prepared in support of the NCES Title V Operating Permit Application. SHA utilized an air dispersion model, Industrial Source Complex Short Term 3 (ISCST3), to estimate ambient air concentrations of criteria air pollutants and regulated toxic air pollutants (RTAPs) resulting from the combustion of landfill gas (LFG) in an on-site flare system, as well as fugitive landfill gas emissions (6).

The LFG collection and control system at the Site includes vertical extraction wells drilled into the landfill to collect LFG generated below the surface and horizontal collection trenches installed in the waste as it is placed. Both the vertical extraction wells and the horizontal collection trenches are connected to a common header pipe and blower that directs the landfill gas to the flares. NCES operates an enclosed flare with the capability to evaporate leachate while combusting LFG, and an open flare that is used as a secondary combustion device. The control system is designed to reduce air emissions of regulated toxic air pollutants (RTAPs) and greenhouse gases, and minimize odors

generated by LFG. The flares are designed to destroy 98 percent of LFG constituents including RTAPs (6).

The EHP evaluated the theoretical “worst case” annual ambient air pollutant concentrations as determined in the air dispersion modeling analyses conducted by SHA for the Bethlehem area. SHA’s modeling analyses (Scenario B) considered emissions from the landfill gas flares and fugitive air pollutant emissions from the existing permitted Site, as well as potential air pollutant emissions from the proposed Stage IV landfill expansion. Emission rates input into the model were based on the maximum estimated LFG generation rate expected to occur during the year 2018 {estimated using an EPA model entitled, *Landfill Gas Emission Model (LandGEM) – Version 3.02*} (6). Background contaminant concentrations were then added to each modeled value to produce cumulative theoretical maximum ambient air levels that an individual may be exposed to (assuming a continuous 24-hour exposure). The EHP used data from the Rural National Air Toxics Trend Station (NAATS) located in Underhill, Vermont as a background source (7). These cumulative air levels were then compared to health-based CVs developed by ATSDR and EPA (Tables 1A & 1B). The comparison reveals that all cumulative maximum ambient air levels of criteria pollutants in the Bethlehem area compare favorably with all health-based CVs, but six toxic air pollutants were above their CVs. Bolded font in Table 1B indicates that the CV was exceeded. The bolded “contaminants of concern”, as well as the role of background values, are further discussed in the Results & Public Health Implications Section.

Table 1A: Cumulative maximum ambient air levels (ug/m³) of criteria air pollutants near the NCES Landfill for the year 2018 using DES background data (5, 6).

Contaminant	Maximum Predicted Concentration (ug/m ³)	Background Concentration (ug/m ³)	Total Modeled Concentration (ug/m ³)	EPA NAAQS (ug/m ³)
PM-10	0.36	19	19.36	150
Nitrogen Dioxide	0.55	15	15.55	100
Sulfur Dioxide	7.7	5	12.7	80

Table 1B: Cumulative maximum ambient air levels (ug/m³) of regulated toxic air pollutants near the NCES Landfill for the year 2018 using background data collected from the Rural National Air Toxics Trend Station (NAATS) located in Underhill, Vermont (6, 7, 8, 9, 19).

Contaminant	Maximum Predicted Concentration (ug/m ³)	Background Concentration (ug/m ³)	Total Concentration (ug/m ³)	Non-cancer CV (ug/m ³)	Cancer CV (ug/m ³)
Chloroethane	0.0004	0.1037	0.1041	None	2.3 (e)
Chloromethane	0.0003	1.1367	1.1370	90(a)	None
1,1-Dichloroethane	0.0012	0.1283	0.1295	200(a)	None
1,2-Dichloroethane	0.00021	0.15363	0.15384	2000(b)	0.04(d)
1,1-Dichloroethene	0.0001	0.12403	0.1241	200(a)	None
1,2-Dichloropropane	0.00010	0.189853	0.18995	4(a)	None
Acrylonitrile	0.0017	0.1052	0.1069	2(a)	0.01(d)
Benzene	0.0008	0.3619	0.3627	10(b)	0.1(d)
1,1,2,2-Tetrachloroethane	0.0009	0.1824	0.1833	None	0.02(d)
Carbon disulfide	0.00022	None	0.00022	700(a)	None
1,1,1-Trichloroethane	0.0003	0.2585	0.2588	5000(a)	None
Carbon tetrachloride	0.000003	0.447647	0.44765	200(b)	0.07(d)
Trichloroethylene (TCE)	0.0019	0.1653	0.1672	500(c)	None
Vinyl Chloride	0.0023	0.0824	0.0847	100(a)	0.1(d)
Carbonyl sulfide	0.00015	None	0.00015	None	None
Chlorobenzene	0.00014	0.13838	0.13852	50(e)	None
Chloroform	0.000018	0.153603	0.153621	100(b)	0.04(d)
1,4 Dichlorobenzene	0.00016	0.26669	0.26685	60(b)	None
Dichloromethane (a.k.a. Methylene chloride)	0.0062	0.2883	0.2945	1000(b)	2(d)
Ethylbenzene	0.0025	0.2642	0.2667	1000(b)	None
Hexane	0.0029	None	0.0029	700(a)	None
Methyl ethyl ketone	0.0026	0.9164	0.9190	5000(a)	None
Methyl isobutyl ketone	0.0009	0.2112	0.2121	3000(a)	None
Tetachloroethylene	0.0031	0.2738	0.2769	300(b)	None
Toluene	0.0183	0.3770	0.3953	300(b)	None
Xylenes (total)	0.0065	0.3086	0.3151	100(a)	None
Acetone	0.0021	None	0.0021	30000(b)	None
Butane	0.0015	None	0.0015	None	None
Chlorodifluoromethane	0.0006	None	0.0006	50000(a)	None
Dichlorodifluoromethane	0.0096	3.1470	3.1566	200(e)	None
Dichlorofluoromethane	0.0014	None	0.0014	None	None
Ethanol	0.0063	None	0.0063	None	None
Ethylene dibromide	0.0000010	0.257353	0.257354	None	None
Ethyl mercaptan	0.0007	None	0.0007	None	None
Fluorotrchloromethane	0.0005	1.4813	1.4818	None	None
Hydrogen sulfide	0.43	None	0.43	2(a)	None
Methyl mercaptan	0.0006	None	0.0006	None	None
Pentane	0.0012	None	0.0012	None	None
2-Propanol	0.0152	None	0.0152	None	None

(a) EPA RfC "None" indicates that no comparison value has been established.

(b) ATSDR Chronic MRL/EMEG

(c) ATSDR Intermediate MRL/EMEG

(d) ATSDR CREG

(e) EPA Oak Ridge National Lab PRG

Water Quality Monitoring

Surface Water

The Ammonoosuc River north of the Site flows in a generally northwesterly direction. The river banks are relatively steep in the area northeast of the Site and localized groundwater seeps are present along the sharp slopes (2). According to the 2007 Annual Water Quality Report, volatile organic compound (VOC) contaminants were not detected in the seep, spring or surface water samples. Metals including iron and manganese, however, have been historically identified in samples (1). Once in the river, these metals mix with surface water and flow downstream toward residential properties located along the Ammonoosuc River on Muchmore Road. People who recreate (wade & possibly swim) in these downstream areas could be exposed to metal contaminants in the water. Exposure could occur by dermal skin absorption and/or by ingesting small amounts of water while recreating.

Accordingly, the EHP evaluated the average contaminant concentrations detected in Ammonoosuc River surface water flows from 1996 to 2007. Surface water sampling parameters that were undetected during laboratory analysis were also included at one-half of their analytical detection limit as a conservative measure. These contaminant concentrations were compared to relevant ATSDR, EPA, and DES non-cancer and cancer drinking water CVs (Table 2).

The use of drinking water CVs is very conservative for intermittent exposure while wading or swimming since immediate downstream areas are relatively shallow. Of the fifteen surface water contaminant levels measured in the Ammonoosuc River north of the site, only one exceeded a health-based cancer CV and was analyzed further (Table 2, *italics*).

Table 2: Summary of Ammonoosuc River Surface Water Concentrations and Respective Comparison Values (1, 9, 10, 11)

Substance	Surface Flow -1 (ppm)	Surface Water -1 (ppm)	Surface Water -2 (ppm)	Surface Water -3 (ppm)	Non-cancer CV (ppm)	Cancer CV (ppm)
Antimony	0.001*	0.001*	0.001*	0.001*	0.01 ₍₂₎	None
Arsenic	0.001*	0.001*	0.001*	0.001*	0.01 ₍₂₎	0.00002₍₃₎
Barium	0.01*	0.01*	0.01*	0.01*	7 ₍₄₎	None
Beryllium	0.001*	0.001*	0.001*	0.001*	0.07 ₍₄₎	None
Cadmium	0.0015*	0.0015*	0.0015*	0.0015*	0.007 ₍₄₎	None
Chromium	0.005*	0.005*	0.005*	0.005*	0.1 ₍₂₎	None
Iron	20.1	0.2	0.7	0.25	None	None
Lead	0.001*	0.001*	0.001*	0.001*	0.015 ₍₅₎	None
Manganese	1.0	0.019	0.1	0.025	2 ₍₂₎	None
Mercury	0.0005*	0.0005*	0.0005*	0.0005*	0.002 ₍₅₎	None
Nickel	0.01*	0.01*	0.01*	0.01*	0.7 ₍₂₎	None
Nitrate	0.75	0.3	0.2	0.21	10 ₍₁₎	None
Selenium	0.0025*	0.0025*	0.0025*	0.0025*	0.2 ₍₄₎	None
Silver	0.005*	0.005*	0.005*	0.005*	0.2 ₍₂₎	None
Thallium	0.0005*	0.0005*	0.0005*	0.0005*	0.002 ₍₅₎	None

* - indicates the substance was not detected by the laboratory (½ of the analytical detection limit stated as an conservative estimation).

(1) – EPA Maximum Contaminant Level (MCL)

(2) - ATSDR Reference-dose Media Evaluation Guide (RMEG)

(3) - ATSDR Cancer Risk Evaluation Guide (CREG)

(4) - ATSDR Environmental Media Evaluation Guide (EMEG)

(5) – GW-1 standards as defined in New Hampshire Department of Environmental Services (NHDES) Contaminated Sites Risk Characterization and Management Policy (RCMP)

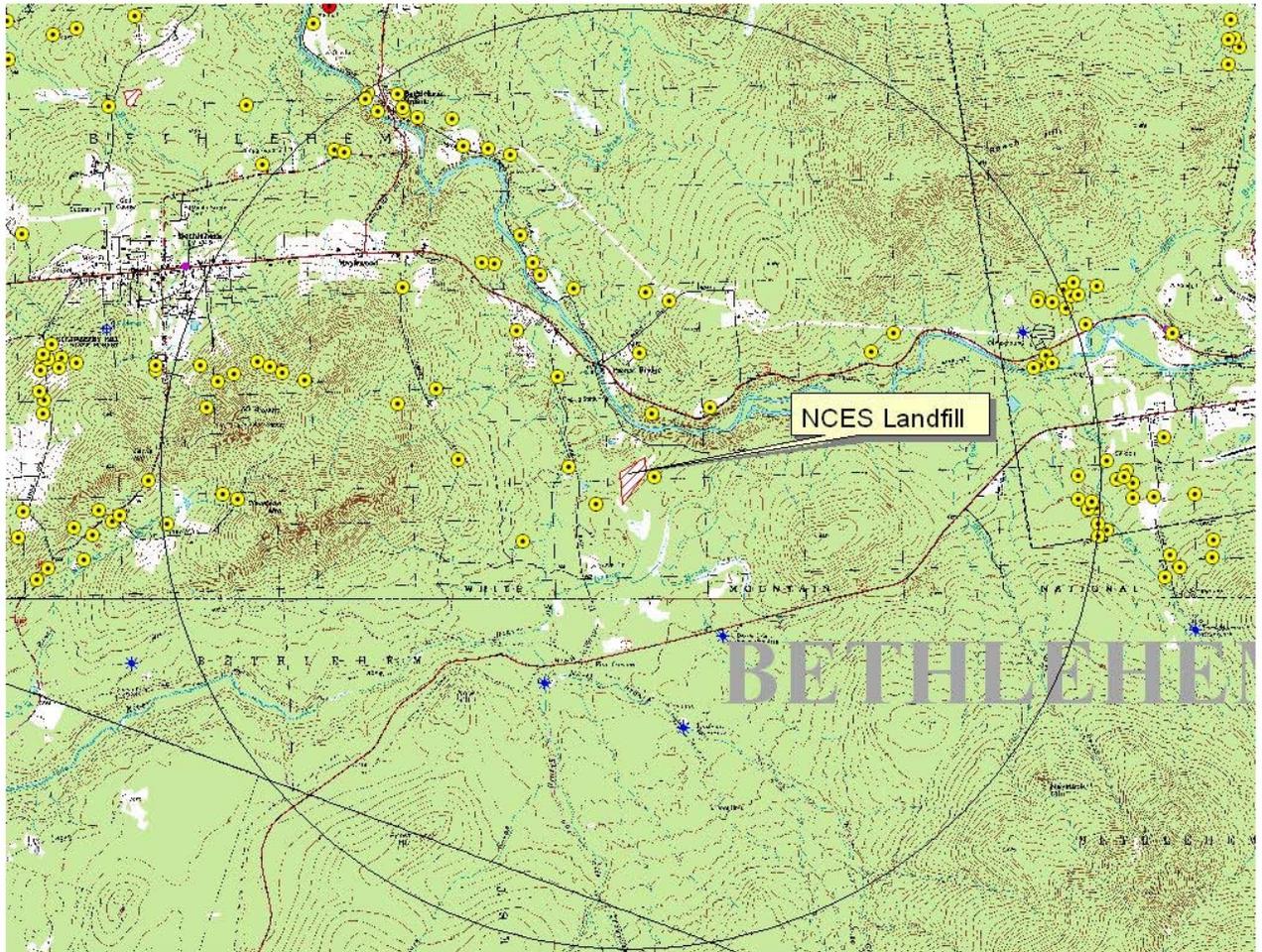
Groundwater and Drinking Water

Groundwater at the Site flows in an overall northerly direction with a northeasterly flow in the area northeast of Stage II. Site water quality monitoring has been performed in accordance with a DES groundwater permit first issued in 1986. Monitoring results are summarized and provided to DES each year in accordance with the permit. Based on analytical data from recent annual water quality reports, groundwater beneath the Site has been impacted by VOCs. According to SHA reports, these limited residual water quality impacts are related to the former unlined landfill and past leachate handling practices at the Site. Since the contents of the Site’s unlined landfill were excavated and placed in the lined Stage I, onsite groundwater well and surface water sampling data locations downgradient have shown improvements in water quality over time (2, 6).

As stated above, the direction of groundwater flow through the site is northerly and northeasterly toward the Ammonoosuc River. The DES has performed an extensive review of hydrogeologic data and water quality information to verify the extent of site contaminants. This research indicates that contaminants are contained within the delineated Groundwater Management Zone (GMZ) at the site. The DES records indicate that several public drinking water and private wells are located within an approximate 3-mile radius of the Site (**Figure 1**) (12). Water is not currently being consumed at any of these water supply wells located within the GMZ. A private water well, located across

from the NCES office, is utilized only for sanitary purposes and is not consumed by employees (13, 14). Additionally, the DES has no information to suggest that there are any water supply wells located outside of the established GMZ that would likely be impacted by activities at the site (15). Two known residences on Laurel Lane that are situated downgradient, receive drinking water from a Bethlehem Village District Public Water Supply well located to the south of the site (13, 14). Thus, based on current information, nearby local resident private wells are not believed to be using this VOC-contaminated ground water as a source of drinking water and are not being exposed. No impacts to nearby drinking water sources from the site are known or suspected at this time.

Figure 1. Private and Public Drinking Water Sources Near Bethlehem, NH (12).



Key

Blue Stars - Public Water Supply well
Yellow Dots - Private Water Wells

Ambient Air Monitoring

The EHP evaluated ambient air data collected between January 2001 and January 2002 at the DES monitoring station located at the United States Forest Service Ranger Station on Trudeau Road in Bethlehem, NH. These data were collected as part of a special DES project to address citizen concerns and to validate a prior evaluation of the exposure potential posed by leachate injection into the NCES landfill gas enclosed flare. Samples were collected for 24-hour durations every 6 days. Six Regulated Toxic Air Pollutants (RTAPs) were included in the evaluation (16). Their average levels were then compared to ATSDR and EPA cancer and chronic non-cancer comparison values (CVs). When calculating the average daily RTAP concentrations, substances not detected during a particular laboratory analysis round were included at one-half of their analytical detection limit. For example, if the analytical device was unable to detect the target compound, the EHP assigned a value one-half of the instrument's lowest measurable quantity (detection limit). Of the six pollutants, the average daily concentration of two exceeded their cancer

CVs and were analyzed further (Table 5-14, **bold**). The Results & Public Health Implications Section of this report presents this more in-depth analysis.

Table 3. Ambient air pollutant concentrations and comparison values: United States Forest Service Ranger Station Monitoring Station, Trudeau Road, Bethlehem, NH 1/1/01-1/2/02 (5, 8, 9, 16).

Substance	Average Daily Concentration Bethlehem ($\mu\text{g}/\text{m}^3$)	Cancer Comparison Value (CV) ($\mu\text{g}/\text{m}^3$)	Chronic Comparison Value (CV) ($\mu\text{g}/\text{m}^3$)
Arsenic	0.0006	0.0002 (₁)	0.03(₂)
Cadmium	0.0006	0.0006(₁)	1.4(₂)
Chromium (hexavalent)	0.0014	0.0001 (₁)	0.1(₅)
Lead	0.0023	0.013(₂)	1.5(₄)
Nickel (subsulfide)	0.0013	0.0051(₂)	0.09(₃)
Total Suspended Particulate (TSP)	12.5	None	150*

* PM_{10} NAAQS was used for comparison purposes. PM_{10} represents the fraction of TSP that can pass through the nose & throat and get into the lungs.

Comparison Value Sources

- (1) ATSDR CREG
- (2) EPA Oak Ridge National Lab PRG
- (3) ATSDR Chronic MRL/EMEG for nickel
- (4) EPA National Ambient Air Quality Standards for Lead
- (5) EPA RfC
- (6) EPA PM-10 NAAQS

Results & Public Health Implications

This section evaluates the public health implications of ambient air and surface water quality in Bethlehem. Analysis of available data indicates that the substances listed below were above their respective CVs, and are thus “contaminants of concern” warranting further review. The remaining substances initially included in this report were determined, during early stages of analysis, to not represent a health threat to Bethlehem residents.

- 1) *Ambient air modeling* - 1,2-dichloroethane, acrylonitrile, benzene, 1,1,2,2-tetrachloroethane, carbon tetrachloride, and chloroform.
- 2) *Surface water sampling* – arsenic.
- 3) *Ambient air monitoring* - arsenic and chromium.

Following is a review of the scientific literature on health effects for each “contaminant of concern.” The review is based on relevant environmental health studies and dose calculations (i.e., amount of contaminant that gets into a person’s body). It also considers background levels normally found in the environment.

- 1) *Ambient Air Modeling (Inhalation)* - **1,2-Dichloroethane, Acrylonitrile, Benzene, 1,1,2,2-Tetrachloroethane, Carbon tetrachloride, and Chloroform** –

The total concentration (maximum predicted concentration + background) of each of these contaminants of concern was above its Agency for Toxic Substances & Disease Registry (ATSDR) cancer comparison value (CV). In each case, however, the maximum predicted modeled concentrations alone were much lower than the CVs (6, 9). Background concentrations (amount normally found in the environment) were the sole reason why each CV was surpassed. That is, modeled concentrations of emissions from the Site did not cause a total level to surpass a CV. Background concentrations pose theoretical risks that are experienced by the general population regardless of location. Contaminant levels solely attributable to landfill emissions would not result in any detectable effect on cancer rates in the Bethlehem area now or in the future.

2) *Surface Water Sampling (Incidental Ingestion & Dermal Contact) - Arsenic*

Arsenic found in the environment combined with oxygen, chlorine, and sulfur is called inorganic arsenic. When combined with carbon and hydrogen is referred to as organic arsenic. Organic forms are usually less harmful than the inorganic forms. Oral doses of inorganic arsenic (ranging from about 0.3 to 30 parts-per-million in food or water), may irritate the stomach and intestines, with symptoms such as stomach ache, nausea, vomiting, and diarrhea. Other effects from ingesting inorganic arsenic also include decreased production of red and white blood cells which may cause fatigue, abnormal heart rhythm, blood-vessel damage resulting in bruising, and impaired nerve function causing a "pins and needles" sensation in your hands and feet. Direct skin contact with inorganic arsenic compounds may cause irritation with some redness and swelling, but skin contact is unlikely to lead to any serious internal effects. For these reasons, the EHP presumed the "total arsenic" detected in the Ammonoosuc River to be entirely inorganic arsenic for comparative purposes (17).

The arsenic concentration recorded in the Ammonoosuc River surface water (estimated at 0.001 ppm) exceeded the cancer comparison value of 0.00002 ppm (1, 9). As a result, the EHP evaluated an exposure scenario for a child who may be exposed to arsenic in surface water through incidental ingestion and dermal contact while recreating in the Ammonoosuc River. Based on conservative estimates, this exposure represents an insignificant increased theoretical cancer risk (the potential for <1 excess cancers if one million people were exposed over a lifetime of 70 years) for children who may recreate in the Ammonoosuc River.

3) *Ambient Air Monitoring (Inhalation) - Arsenic*

As stated in the Water Quality Monitoring section, arsenic found in the environment combined with oxygen, chlorine, and sulfur is called inorganic arsenic while when combined with carbon and hydrogen is referred to as organic arsenic. Organic forms are usually less harmful than the inorganic forms. Larger arsenic particles enter the air from windblown dust and soil as well as volcanic eruptions. Anthropogenic (man-made) sources of arsenic also include nonferrous metal smelting, coal, oil and wood combustion, and municipal waste incineration. This arsenic is attached to fine particles (<2.5 µm) and may be transported through the air for many days and over long distances. A regional average annual ambient air arsenic concentration measurement collected at

Nahant, MA (between September 1992 and September 1993) was $0.0012 \mu\text{g}/\text{m}^3$; with 75% of the arsenic particles less than $2.5 \mu\text{m}$. This concentration of arsenic is twice as much as calculated for the Bethlehem area ($0.0006 \mu\text{g}/\text{m}^3$) (17).

Most cases of human toxicity from arsenic have been associated with exposure to inorganic arsenic. The most common inorganic arsenical in air is arsenic trioxide (As_2O_3) which was used for comparative purposes in this report. This is a conservative assumption because Bethlehem monitoring data are reported as total arsenic, and the respective amounts of each arsenic compound cannot be determined. An additional conservative assumption concerns the bioavailability of inhaled arsenic. Bioavailability refers to the fraction of the inhaled amount of arsenic that is actually absorbed into the body; the lower the bioavailability of an inhaled toxin, the less toxic its effect. Studies have shown that the amount of arsenic bioavailable to humans is less than levels monitored in the environment, so the actual dose is lower. Therefore, inhalation of arsenic from ambient air is usually a minor exposure route for the general population (17).

Inhalation of inorganic arsenic is associated with sore throat, lung irritation (possibly leading to laryngitis, bronchitis, or rhinitis), adverse skin effects (dermatitis, warts, and corns) as well as circulatory and peripheral nervous disorders. Evidence from several epidemiologic studies demonstrates that inhalation exposure to inorganic arsenic also increases the risk of several lung cancers in humans (epidermoid carcinoma, small cell carcinoma, and adenocarcinoma). However, most studies involved occupational exposure to large doses of arsenic trioxide dust in air at copper smelters and mines, and arsenate exposure at chemical plants. Several environmental and health organizations including EPA and the United States Department of Health & Human Services (USDHHS) have concluded that inorganic arsenic is carcinogenic to humans (17).

The average ambient concentration of arsenic at the Bethlehem monitor during the study period ($0.0006 \mu\text{g}/\text{m}^3$) exceeded the ATSDR cancer comparison value of $0.0002 \mu\text{g}/\text{m}^3$ (9, 16). The data used to calculate this average concentration was “non-detect” in 54 of 62 samples. The data also are representative of a time when leachate was being injected into the NCES landfill gas flare; leachate is now collected and disposed of off site (16). Lifetime exposure to arsenic levels at the monitor (based on this worst-case scenario of exposure to inorganic arsenic & leachate injection to the enclosed flare and destruction) would result in a theoretical excess cancer risk of 1 case if one million people were exposed over a lifetime of 70 years. This would result in no detectable effect on cancer rates in the Bethlehem area now or in the future.

3) *Ambient Air Monitoring (Inhalation) - Chromium*

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium is also released into the atmosphere mainly by anthropogenic stationary point sources, including industrial, commercial, and residential fuel combustion, via the combustion of natural gas, oil, and coal. Additional anthropogenic sources of chromium air emissions include the metal industries, cement-producing plants, erosion of asbestos brake linings that contain chromium, incineration of

municipal refuse and sewage sludge, and emission from chromium-based automotive catalytic converters (18).

Chromium is present in the environment in several different forms (or "valence states"). The most common forms are chromium (0), trivalent [or chromium (III)], and hexavalent [or chromium (VI)]. Chromium (III) occurs naturally in the environment and is an essential nutrient required by the human body. However, chromium (VI) and chromium (0) are generally produced by industrial processes (by the oxidation of chromium (III) compounds). In general, chromium (VI) is more toxic than chromium (III). Of the estimated 2,700–2,900 tons of chromium emitted to the atmosphere annually from anthropogenic sources in the United States, less than 1% is in the hexavalent form (18).

In air, chromium compounds are present mostly as fine dust particles. The level of chromium in air is generally low. According to a study by Fishbein (18), the atmospheric total chromium concentration [both chromium (III) and chromium (VI)] in the United States is typically less than 0.01 ug/m³ in rural areas and 0.01 - 0.03 ug/m³ in urban areas. Chromium is primarily removed from the atmosphere by deposition and precipitation. According to Nriagu, the residence time of chromium in the atmosphere is expected to be less than 10 days (18).

The respiratory tract in humans is a major target of inhalation exposure to chromium compounds. When chromium particles in the air are inhaled, they can be deposited in the lungs. Particles that are deposited in the upper part of the lungs are likely to be coughed up and swallowed. However, particles deposited deep in the lungs are likely to remain long enough for some of the chromium to pass through the lining of the lungs and enter the bloodstream. Once in the bloodstream, chromium is distributed to all parts of the body. Chromium is then passed through the kidneys and eliminated in the urine in a few days (18).

Occupational exposure to high levels of chromium (VI) compounds has been associated with increased risk of respiratory system cancers, primarily bronchogenic and nasal. The inhalation risk may be exacerbated by cigarette smoking or exposure to environmental (second-hand) tobacco smoke. On the other hand, studies have shown that inhaling small amounts of chromium (VI) for even long periods of time does not cause a problem in most people. An epidemiologic study by Axelsson and Rylander (18) found no indication that residence near two chromium industries was associated with increased lung cancer risk. Based on occupational and animal studies, the United States Department of Health and Human Services has categorized certain chromium (VI) compounds as "known human carcinogens". Hexavalent chromium is categorized by EPA as a human carcinogen via the inhalation route. Trivalent chromium is not (18).

The average ambient air concentration of chromium at the Bethlehem monitor during the study period (0.0014 ug/m³) exceeded the ATSDR cancer comparison value (specific for the hexavalent form) of (0.0001 ug/m³) (9, 16). The data used to calculate this average concentration was "non-detect" in 42 of 62 samples. As with monitored ambient arsenic levels, the chromium data are also representative of a time when leachate was being injected into the NCES landfill gas enclosed flare; leachate is now collected and disposed of off site. Furthermore, since the Bethlehem ambient air monitoring data are reported as

total chromium, respective concentrations of hexavalent and trivalent chromium are not known (16). As noted earlier, less than one percent of chromium emitted from man-made sources is in the hexavalent form (18). To approximate a worst-case scenario, however, the assumption of this analysis is that all of the total chromium reported was in its most toxic form (hexavalent chromium). Lifetime exposure to these hypothetical hexavalent chromium levels would result in a theoretical excess cancer risk of 6 if one million people were similarly exposed over a lifetime of 70 years. This would result in no detectable effect on cancer rates in Bethlehem now or in the future (based on current data).

Conclusions

Based on a conservative evaluation of the data, adverse health effects are not expected for residents either recreating in the Ammonoosuc River surface water downstream of the site, or breathing ambient air in the Bethlehem area. There are also no water supply wells within the established Groundwater Management Zone (GMZ) for the NCES Landfill from which water is currently being consumed. DES has no information to suggest that there are any water supply wells located outside of the established GMZ that would likely be impacted by activities at the landfill site. Exposure near the site therefore poses *no apparent public health hazard*.

Recommendations

1. Continue to monitor on-site hydrogeologic data and water quality information collected from the site Ground Water Management Zone (GMZ). If future information suggests that any water supply wells located outside of the established GMZ may be impacted, DES should collect appropriate samples to assess whether drinking water supplies are being impacted. The EHP will evaluate such future groundwater data for possible impacts to human health.
2. Continue to collect surface water and seep data from Ammonoosuc River. If future information suggests that surface water contaminant levels have changed, the EHP will evaluate the additional data for possible impacts to human health.
3. Continue to conduct site inspections to assess compliance with applicable DES and EPA regulatory requirements.

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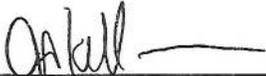
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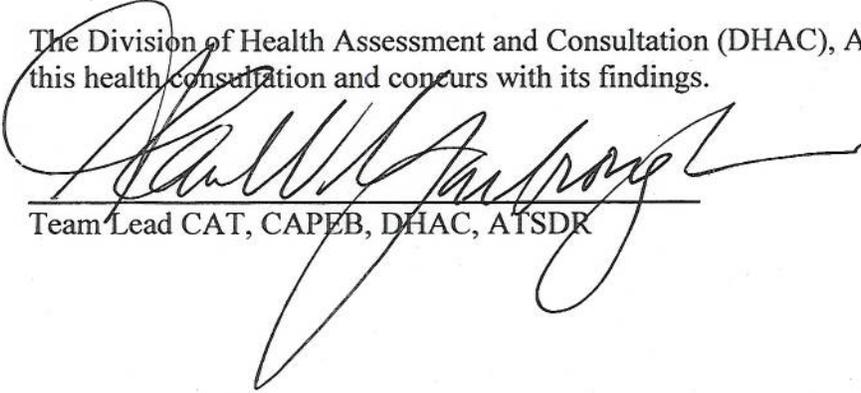
Certification

The Health Consultation for the North Country Environmental Services, Inc. (NCES) Landfill located in Bethlehem, New Hampshire was prepared by the New Hampshire Department of Environmental Services, Environmental Health Program, under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodologies and procedures existing at the time this health consultation was initiated. Editorial review was completed by the cooperative agreement partner.



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The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.



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