Health Consultation

for the

Flying Cloud Sanitary Landfill

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Prepared by the Minnesota Department of Health
Division of Environmental Health
Section of Health Risk Assessment

BACKGROUND

In its present state, the FCSL does not appear to pose any human health concern. Potential health concerns have been addressed through remedial actions and environmental monitoring. Such monitoring must be continued to adequately protect potentially exposed persons in the future.

I Background

The Flying Cloud Sanitary Landfill, Eden Prairie, Minnesota, is on the Minnesota state Superfund list. The site is southwest of the Twin Cities Metropolitan Area, in southern Hennepin County. It is situated roughly 200 feet above the Minnesota River.

The waste deposit (the landfill) occupies roughly 100 square acres within a 340-acre parcel owned by BFI (see Figure 1.). For the purposes of this Health Consultation, the term "landfill" refers specifically to the area which holds refuse. Distances from the landfill are determined from the outer edges of this landfill footprint.

Flying Cloud Drive (Minnesota Highway 169) borders the Site's west side. Beyond Highway 169, is the Flying Cloud Airport. To the east, are open lands. Residential areas are due north, northeast, and southeast, within one-half mile from the landfill.

Wastes were compacted and covered with six inches of fill daily. Since April 1988, between 3 and 15 feet of cover materials were placed over the waste deposit.

Currently, activity on the landfill is very limited, involving mainly field sampling, maintenence, and remediation workers. BFI haulers use the parking area and shop facilities and BFI/WSS employees have offices to the west of the landfill.

Access to the BFI property is strictly controlled. To the east, beyond the fenced area, an undeveloped open area is owned by BFI. This latter area extends eastward over 1,000 feet east of the fenced area.

Land use surrounding the Site includes transportation, commercial, residential, agriculture, and recreation. A single family residence is over 1,000 feet west -- this is the nearest dwelling to the Landfill. Across the highway to the west, are the Flying Cloud Airport and a flight training center. Immediately north, fields controlled by the Metropolitan Airports Commission serve as an approach zone for the Airport and are also farmed. Small commercial buildings, a church and cemetery, and a few homes are also north, along Pioneer Trail (Co. Road No. 1). The closest of these are over 1,000 feet north of the landfill.

Within one-half mile to the east are the Hillsborough and Bluffs West developments. A small city park lies between these subdivisions along Homeward Hills Road. The nearest home to the southeast is roughly 1,200 feet from the edge of the waste deposit; the closest Hillsborough homes are roughly 2,000 feet away. Another resident of the area lives below the bluffs.

In 1982 and 1985, volatile organic compounds (VOCs) were found in groundwater samples taken on and near the landfill. A remedial investigation determined that the source of contaminants was within the landfilled solid waste. The

bulk of contaminants which had leached to the groundwater (the plume) was found to be localized, mainly south of the Site in the shallow groundwater. The hydrology (patterns of water movement) of the area suggests that groundwater flowing under the landfill may eventually reach surface waters in the Minnesota River Valley. In 1988, the landfill was ordered to close by MPCA.

A system of ten barrier wells to remove and treat contaminated groundwater was chosen to remedy existing groundwater contamination and as a means to prevent future contaminant movement off-site. This pump-and-treat method is supported by the MPCA, a Feasibility Study of alternatives, and a risk assessment of predicted air-stripper emissions at this Site.

Nearby residents (Homeward Hills Homeowners Association) are apprehensive about what was dumped in the landfill, about groundwater contamination, and about potential methane migration. Some community members oppose a proposed plan to use air stripping to treat contaminated groundwater at the site. Because they are fearful about any VOC emissions, they have asked for the addition of a carbon/activated-charcoal filtration step.

Co-disposal records and maps of filling sequences indicated wastes were concentrated in the northwestern, west central, and southwestern portions of the landfill.

Results of analyses for metals were reported for only the first samples from 24 of the monitoring wells. In seven of these wells, at least one metal was detected at a concentration which would be a potential concern for a private drinking-water well. The highest concentrations of these metals were 920 ug/l zinc from W3b, 380 ug/l manganese from W32, and 11 ug/l arsenic from W11.

Monitoring results are presented below for the VOCs detected at concentrations of greatest importance; other compounds were also found, but typically at much lower levels. Maximum contaminant concentrations found between 1985 and 1988 are summarized in Table 1. The recommended allowable limits (RALs) are also shown in the table. The RALs are health-based guidelines for private drinking water.

Monitoring well W26 sampled groundwater in the Lower Drift aquifer under the southern edge of the disposal area. This well near the landfill's boundary produced the highest total VOC levels (2431.7 ug/l) at the Site. Dichlorodifluoromethane (2,000 ug/l), vinyl chloride (3.2 ug/l), methylene chloride (140 ug/l), and 1,1,2,2-tetrachloroethylene (26 ug/l) were found in at least one sample from this well.

Samples from W3b near the landfill boundary and wells W7 and W13 near the BFI property boundary showed relatively high levels of organic contamination in the upper portion of the Lower Drift aquifer. In total, 24 VOCs were recovered from these three wells. Maximum concentrations of vinyl chloride from these wells ranged from 2.8 to 74 ug/l. Other compounds found in these wells were: methylene chloride (300 ug/l), 1,1-dichloroethylene (15 ug/l), cis-1,2-dichloroethylene (110 ug/l), 1,1-dichloroethane (96 ug/l), 1,2-dichloropropane (20 ug/l), trichloroethylene (130 ug/l), tetrachloroethylene (87 ug/l), tetrahydrofuran (130 ug/l), and benzene (13 ug/l).

The original drive-in well yielded several chlorinated solvents; the maximum detections during sampling in 1985 to 1987 were cis-1,2-dichloroethylene at 86 ug/l, 1,2-dichloropropane at 6.7 ug/l, trichloroethylene at 26 ug/l, and tetrachloroethylene at 15 ug/l. Benzene estimated at 6.4 ug/l and tetrahydrofuran estimated at 98 ug/l were also found in addition to low levels of several other compounds (see Table 1). The concentrations for benzene and tetrahydrofuran were estimated, because these compounds were also present in reagent blanks. The theatre property is currently owned and controlled by BFI -- therefore, this well is no longer off-site.

No assessment of ambient air off-site has been performed. Although limited in scope, on-site air monitoring did not detect any significant impacts to air. Most of the gas produced in the landfill is controlled by the gas-collection systems. Although low levels of VOCs may be emitted, they are volatile and will rapidly disperse and be diluted to ambient levels.

Four classes of organic compounds were detected in groundwater -- chlorinated hydrocarbons and fluorocarbons with lower levels of non-chlorinated solvents and gasoline-derived compounds. Twenty eight of the compounds detected in groundwater were above background levels in on-site monitoring wells. Relatively, high levels (parts per million range) of total volatile compounds were found during the RI (2,431.7 ug/l total VOCs in W-26 and 1,116.6 ug/l total VOCs in W-13). Most of the contamination in these wells was due to freon compounds.

Overall, the bulk of groundwater contaminants were located in the Drift aquifers directly beneath the landfill and to the south, southeast, and the southwest. The highest levels were found south of the landfill's center. Lower levels in wells to the north, east, and west indicate diffusion and dispersion of contaminants under the Site. The plume's western extent appears to be limited to between the landfill and the western edge of the BFI property. The plume surrounds the existing waste deposit and extends south toward the Minnesota River Valley; its extent appears to be localized downgradient from the Site, dropping off quickly with distance.

In later samples, VOC concentrations generally increased over 1985 results. For many of the monitoring wells, total VOC concentrations peaked in 1986 sampling rounds. Later samples showed lower total VOC concentrations, but most remained above the 1985 levels.

In general, VOCs high Vapor Pressures and relatively high Henry's Law Constants which indicate that these chemicals readily evaporate to the air from near-surface soils and surface water.

Wastes were deposited in a depression in the Upper Drift aquifer, which is a thick layer (100-250 feet) of unconsolidated sand and gravel deposits with occasional layers or lenses of clay. Below this, the Till layer is a relatively thick layer of fine-grained silt and clay which is probably present under most of the landfill. The water table is in the Upper Drift or the Till where that layer protrudes upward. Both the Till and the Upper Drift unit are terminated by steep bluffs south of the Site. Underlying the Till, fine- to medium-grained sands and gravels of the lower Drift unit are interbedded with silt lenses.

Slug tests were conducted for a number of wells in the Upper and Lower Drift units. In the Upper and Lower Drift, permeability estimates were similar for the two sand units; on the order of 10^{-2} to 10^{-3} centimeters per second (cm/sec). In contrast, permeability in the Till was estimated to be on the order of 10^{-6} cm/sec. Groundwater velocity was not formally calculated due to incomplete collection and tabulation of water level data. The velocity of groundwater in the sand layers is expected to be on the order of a few hundred feet per year. In the Upper Drift, groundwater flows primarily horizontally into the landfill area from the west, north, and east -- this is inferred from water level data measured in the surrounding area. This flow pattern is due to the less permeable Till. A flow divide on the east-northeast side of the landfill property is a prominent feature of the Upper Drift. Groundwater in the Upper Drift flows over the Till at the landfill's southern edge where both units are interrupted.

The Prairie du Chien Group and Jordan Sandstones are hydrologically connected -- that is, groundwater moves between these two aquifers without physical impediment. These units are fairly extensive. Below the Prairie du Chien/Jordan, the low-permeability St. Lawrence Formation, which functions as an aquitard, overlies the Franconia aquifer. West of the Site, the Franconia Formation is used extensively for wells. Beneath these units, the Mt. Simon-Hinckley Formation is a major aquifer of the area.

Because the lowest part of the landfill is 50 feet above the water table, wastes do not contact the water table. Instead, compounds are mobilized by precipitation percolating through the wastes. Regionally, groundwater in the Prairie du Chien and the Lower Drift flows upward as it approaches the river valley and eventually discharges to the river or surface waters of the valley.

Because volatilization is the major fate process for the VOC constituents, gases emitted to the air should rapidly dissipate to ambient levels. The effects of diffusion, mixing with clean air (dilution), and air movement all greatly reduce the level of any VOCs released to the open air. VOCs also degrade rapidly by chemical reactions in the atmosphere, further accelerating their removal from the local environment.

Chemical-Specific Factors

The contaminants of most importance based on their toxicity and detected concentrations are described below in terms of their probable environmental fate.

Tetrachloroethylene, trichloroethylene, cis-1,2-dichloroethylene, and vinyl chloride

Trichloroethylene and smaller amounts of vinyl chloride and the dichloroethenes are produced by anaerobic microbial degradation tetrachloroethylene. When released to soil and surface waters, these chlorinated solvents (and products) will volatilize to the air fairly rapidly. Atmospheric removal is by chemical reactions with hydroxyl radicals. Photodegradation (reactions involving energy from sunlight) also contributes to their removal from waters containing humic materials. It is believed that these compounds are somewhat resistant to microbial degradation under aerobic (in the presence of oxygen) conditions. Chemical reactions are unlikely to be significant fate processes in soil and water.

Methylene chloride

In water, methylene chloride (dichloromethane) will be removed mainly through volatilization. Slow biodegradation is also possible in surface waters, and may contribute to removal. Methylene chloride is not expected to adsorb to sediments or bioaccumulate in aquatic organisms. Soil mobility of this compound is increased as the organic content of the materials decreases. Methylene chloride can be mobile in soils and leach to groundwater, where its fate is unknown. Atmospheric reaction with hydroxyl radicals can degrade methylene chloride (half-life of several months). Photooxidation may also contribute to its removal from the atmosphere.

Benzene

Volatilization is the most important fate process for benzene which readily escapes from both water and soil to the atmosphere. Rapid chemical degradation prevents this compound from accumulating in the atmosphere. In addition, benzene is soluble in water and will dissolve in leachate when it has been buried in soils. If infiltration is sufficient, benzene may be leached to groundwater. Degradation primarily involves scavenging by hydroxy radicals in the atmosphere and aerobic biodegradation in the soil and water.

Methane

In addition to VOCs, methane is produced in the landfill by the natural anaerobic decay of refuse. Numerous other sources of methane include bacteria, manure, decaying vegetation, swamps, coal deposits, and volcanoes. Methane is a light and very mobile compound which coelutes with or precedes the movement of higher molecular weight gas constituents. Because it is only sparingly soluble in water, methane will not be a groundwater contaminant.

3. Site-Specific Factors

The landfill wastes are covered currently, although not by an approved RCRA cap. Because the cover decreases infiltration, leachate production and future groundwater impacts should decrease.

The public is not allowed to enter the site without permission. Security is sufficient to ensure that trespassing onto the landfill does not occur. A buffer zone around the waste deposit ensures that the general public remains physically seperated from the potential source of contaminants by distance. The closest residence is greater than 1,000 feet west from the landfill's edge. The residential developments to the north and east are even more distant.

3. Air

Gases produced in the landfill are emitted through the surface or collected by the gas-control systems. Although gases may be emitted on-site, diffusion and mixing with air should rapidly dilute gases to low levels. Therefore, significant exposures to landfill gases are not likely and any potential exposures should be limited to persons on the landfill surface.

MPCA Air Toxics staff evaluated the proposed air stripper's potential impacts on local air quality using dispersion models and risk calculations. MDH reviewed these efforts and found that MPCA experts used a number of conservative assumptions to develop a worst-case estimate of potential dispersion (extent of contaminant spread). This approach is protective of health as it intentionally overestimates both the areal extent and the magnitude (concentrations) of contaminant emissions and distribution. The method used, follows U.S. Environmental Protection Agency guidelines and allows for a much better assessment than air sampling.

In reviewing the MPCA air-stripper risk assessment, MDH also performed air transport modeling to predict potential contaminant dispersion. The results of this work were similar to estimates derived by MPCA. Despite, using elevated VOC levels in the groundwater, worst-case emissions from the stripper, and lower than expected rates of removal from the atmosphere, both models predicted that VOC levels were very low and decreased quickly as they moved away from the stripper. At approximately 1,000 feet (estimated distance from the stripper to the nearest residence) the levels dropped to parts per trillion range (ie. in the range of 100 parts total VOCs, or less, in 1,000,000,000,000 parts air). Farther away, at 3,000 and 4,500 feet (estimated distances from the stripper to nearest developments) the VOC levels decreased to the parts per quadrillion range -- that is, roughly 1,000,000 times lower than the that on the landfill. It is important to note that these estimated levels are predicted under worst-case scenarios -- as such, they are intended to overestimate the levels which may actually occur by several orders of magnitude.

Persons frequently on the landfill surface may be exposed to low levels of gas constituents emitted to the air. One gas probe sample (a time-weighted average of 3 ppm vinyl chloride) exceeded the 1 ppm time-weighted average for work-place exposure set by the Occupational Safety and Health Administration (OSHA). This result only qualitatively demonstrates that low level emissions of vinyl chloride are possible and could result in exposure on-site. The National Institute of Occupational Safety and Health (NIOSH) considers vinyl chloride to be a potential human carcinogen and recommends the lowest reliably detectable concentration as the recommended exposure limit (REL) for occupational exposures. NIOSH also recommends the most protective respirators for exposure to this substance. Off-site concentrations of vinyl chloride are expected to be extremely low (to nondetectable), if present at all. The below-detection findings of vinyl chloride at the flare unit, are not a concern as long as the flame tube is operating.

Site workers may also be exposed to contaminants under the cover if wastes are excavated or the cover is disrupted. Although such potential exposures are not likely to involve high levels of contaminants or be frequent, the need for for personal protection should be assessed if such situations arise.

Area residents have also expressed concerns about methane from the landfill. Methane is a non-poisonous gas at low levels, but it may present fire and explosion hazards if it accumulates in a confined space, such as a poorly ventilated building. Methane emitted to the open air around the Site is not a health concern.

Both MPCA and MDH have independently performed modeling to assess potential dispersion of VOCs from the air stripper if it is used. Both models showed that stripper emissions would be very low and decrease quickly with distance. The levels of VOCs in air at points of potential regular public exposure were predicted to be in the parts per quadrillion range. These elevated estimates (worst-case predictions) are far below established health-based standards for air and below levels which practically could be detected. Based on the dispersion modeling results and past experience with similar air-stripping devices, MDH concludes that the effect of air stripping VOCs on local air quality will be virtually insignificant and not likely to affect public health. This conclusion is supported by the very low levels of VOCs detected in groundwater on and off-site, the dilution that will occur due to pumping and air stripping process, the fate of volatile chemicals in the open air, and the distance to the nearest homes.

CONCLUSIONS

In conjunction with capping, future and present groundwater impacts will be addressed by a system of barrier/collection wells installed recently. VOCs may be removed from extracted groundwater by air-stripping and the treated water will be discharged to the river valley. The pump and treat system provides significant dilution of the already very low contaminant levels in the groundwater.

Collection and combustion of landfill gases is expected to largely control emissions. Currently, an interconnected system of gas-extraction wells line the landfill's western perimeter, enclose the southeastern corner, and cover a large portion of the central part of the landfill. Forty-five methane probes are between the landfill's north and east boundaries and the residential developments.

Although the landfill is currently covered, long-term measures to prevent the production and migration of leachate are needed. Closure plans call for installation of a low permeability cap, consiting of two feet of compacted clay and six inches of topsoil, in addition to the materials already in place.

Residents of the nearby neighborhoods are concerned about VOCs emitted from the proposed treatment system and they would like a carbon removal step added. Based on the results of dispersion modeling, MDH concludes that the possibility of health effects among nearby residents due to emissions from the proposed air stripper is extremely low. Therefore, the use of carbon filtration is not a public health issue.

Because the use of air-stripping technology as the final treatment option has not been decided yet, additional efforts to evaluate stripper operation are underway. If any data become available which alter the present undestanding of potential impacts due to the groundwater treatment method, MDH will make any further recommendations which are needed to ensure the public is adequately protected.

long-term on-site groundwater monitoring is necessary to provide ongoing measurement of groundwater contamination and the response action's effectiveness. MDH recommends regular groundwater monitoring on-site and extracted water.

Because low levels of landfill gases may be present in air at the landfill's surface and localized higher emissions might be encountered on-site if the cover is disturbed or the collection system fails, on-site workers must be protected from possible exposures to gases and any contaminated soils or wastes. Monitoring and/or personal protection may be needed, depending upon the activities involved and the type and concentration of contaminants contacted. Air at work areas on the landfill should be evaluated whenever exposures are possible. All on-site work must be in compliance with OSHA workplace safety standards.

Table 1
Groundwater Sampling Results 1985 - 1988
Maximum Contaminant Concentrations from 59 Wells
(concentrations are in micrograms per liter)

Compound	Upper Drift	Lower Drift	Prairie du Chien	Drive-In	RAL
Dichlorodifluoromethane	44	2000	210	74	1000.0
Dichlorofluoromethane	15	280	180	20	NE
Trichlorofluoromethane	15	60	6.1	2.6	2000.0
Trichlorotrifluoroethane	1.8	11	ND	ND	20000.0
Vinyl chloride	3.0	74	6.3	ND	0.1
Chloroethane	pp	46	pp	pp	NE
Chloroform	ND	9.4b	0.4	ND	60.0
Methylene chloride	5.1	300	11	5.0	50.0
1,1-Dichloroethylene	ND	15	pp	pp	6.0
1,1-Dichloroethane	3.2	96	4.2	16	70.0
1,2-Dichloroethylene, cis	0.4c	110	13	86	70.0
1,2-Dichloroethylene, trans	0.4c	31	0.8	ND	100.0
1,2-Dichloroethane	0.4	25	3.7	1.3	4.0
1,1,1-Trichloroethane	9.3	84	2.3	2.1	600.0
1,2-Dichloropropane	0.3	20	0.9	6.7	5.0
Trichloroethylene	5.8	140	11	26	30.0
Tetrachloroethylene	14b	100	4.1	15	7.0
1,1,2,2-Tetrachloroethane	ND	2.4	ND	ND	2.0
Bromodichloromethane	0.5	ND	ND	0.4	3.0
Acetone	ND	75	ND	ND	700.0
Tetrahydrofuran	ND	130	ND	83b	100.0
Ethyl ether	ND	49	6.7b	34b	1000.0
Methyl ethyl ketone	190b	ND	ND	ND	300.0
Methyl isobutyl ketone	2.2	2.6	12	5.0	300.0
Benzene	1.8	13	2.6	5.4b	10.0
Toluene	41b	44	40	16b	2420.0
Ethyl benzene	2.1	4.2	1.4	pp	700.0
m-Xylene	3.7	8.3	5.4b	5.6	10000.0*
o-Xylene	2.4	ND	7.9b	2.0	"
p-Xylene	2.4	ND	7.9b	2.0	"
Cumene	pp	1.3	pp	ND	300.0
Dibromomethane	ND	4.8	ND	ND	NE

Notes:

Drive-In well results are from the original well screened in the Lower Drift.

b - compound present in reagent blank below method detection limit (MDL); value shown is estimated. See discussion of indeterminate results in Quality Control section (page 11).
c - compounds coelute; analysis did not distinquish between the compounds.
pp - a chromatogram peak corresponding to the compound was detected; compound was present, but at a level too low to quantify.
ND - compound was not detected.
* - the RAL for total xylenes (m, o, and p) is 10,000 ug/l.