Appendix 7C

Health Effects and Toxicity

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1.0 Introduction

Exposures to hydrocarbons may result in either chronic or acute toxic impacts to human beings. This appendix reviews in more detail some of the pathways by which these impacts may take effect, providing additional support for considerations made in the process of the EA.

2.0 Acute Effects

A pipeline failure constitutes a rare emergency; as such it will be addressed rapidly, particularly in highly populated areas. Therefore, assuming proper spill response and remediation, pipeline failures cause exposures that are short-lived.

Acute effects of a pipeline failure are possible, including and up to death. Starting from the pipeline failure, hydrocarbons may cause significant air emissions; they can form a pool; they can also ignite. Leaked petroleum products can run off into watercourse and lakes, and percolate into the ground water. In the process, they will contaminate soil. All these phenomena are associated with various exposure routes, which are briefly discussed in the following paragraphs.

2.1 Dermal Exposures

Voluntary direct (dermal) contact with spilled hydrocarbons is unlikely, since people will not typically voluntarily contact hydrocarbons. The main exception is spraying of people in the immediate vicinity of a spraying leak; because this scenario requires a spraying leak and immediate proximity (less than 100 feet) to the pipeline, it has a very low probability of occurrence. If dermal contact does occur, such impacts would be acute and could cause immediate health effects such as skin rashes and respiratory distress.

2.2 Ingestion Pathways

Ingestion or other exposure to contaminated water is the next pathway. In case of a pipeline failure, replacement water supplies will be provided to affected water users as long as surface or ground water supplies are demonstrated to be contaminated, thereby avoiding acute effect.

2.3 Recreational Areas

Recreational surface water use is another pathway. The duration of any significant concentration of gasoline constituents in any given river or stream should be short, as the effected plume of contaminated water passes downstream. However, due to retention within surface reservoirs, concentrations of benzene may be in exceedance of drinking water standards for some portion of time. For example, spill modeling results indicate 670 kg of benzene could end up in an affected lake arm. This would result in 26 μg/L of benzene in a one-mile stretch of this lake arm for a short period of time. Therefore, it would be necessary for the affected area to be evacuated and remain off-limits until the water MCL of 5 μg/L has been reached. Such evacuation is expected to prevent acute or via this route.

Note that the stretches of pipeline in the vicinity of such recreational surface water uses lake have been listed as sensitive because of recreational impacts (See Section 7.6.3.1 of the EA, Volume 1, and Appendix 7E in Volume 2). Likewise, ingestion through fish consumption is not a concern since fishing and fish consumption can easily be banned for the duration of the emergency (fishing in the areas of concern is purely recreational).

2.4 Air Emissions

Air emissions from a spill may be approached as an acute problem. Pooled hydrocarbon liquid would have high VOC emissions for some time period following a major release. These exposures are expected to be short-lived, due to volatility, and a high priority given to recovery activities in populous areas. Additionally, in the short term, when the acute impacts would be highest, evacuation of the area surrounding the hydrocarbon pool would be necessary for safety, further minimizing the chances for an acute exposure. However, there is a serious concern that in the minutes immediately following a spill, acute effects from VOC inhalation could result.

A more likely exposure route to airborne hazardous chemicals would be from contaminated soil during the time interval prior to remediation and contaminated soil removal. It is anticipated that such remediation could take weeks or even months.

Radian conducted a short modeling exercise on likely atmospheric emissions from a large area of gasoline-saturated soil. We used the worst-case scenario for densely populated areas illustrated in Table 6-15 of the EA, namely a 1-million-square-foot (approximately 23 acres) pool near Hillcrest Elementary in Austin. To estimate emission factors, we used a study in which soil was saturated with gasoline. The findings are described in Attachment 1.

Petroleum products contain several hazardous chemicals, and all have various listed levels of exposure, as discussed in Attachment 2. A review of these data indicates that the most limiting compound for inhalation and ingestion is clearly benzene, hence our focus on this compound. Benzo(a)pyrene has a lower MCL and RBEL, but it is less limiting because a) its concentration in petroleum products is approximately four orders of magnitude lower than benzene, b) it is far less soluble in water, and c) it is far less volatile. Therefore, our analysis of acute respiratory impacts focused on benzene.

The conclusion is that benzene concentrations can peak near the short-term exposure limit (STEL) 200-ft downwind from the contaminated area, during the first 24 hours after removal of the gasoline pool (the air concentrations decline rapidly after that). This implies that an area extending several hundred feet outward from the edge of the contaminated area would require evacuation until volatilization can be curtailed, through natural or induced conditions.

Over time, volatilization rates will decrease through loss of product due to volatilization. In our modeled example, approximately 300,000 kg of gasoline could be released to the environment. Conservatively assuming that half of this soaks into the ground, and half is recovered in the hours following the spill, the soil could be saturated with 150,000 kg of gasoline. At a flux of 307 mg/m^2-min, approximately 1,750 kg/hr of the gasoline will volatilize over the hours following the release, resulting in a maximum ground level concentration of 83.5

ppmv total hydrocarbons, and 2.3 ppmv benzene. At this volatilization rate, the half-life of the gasoline in the soil would be around 42 hours.

In actuality, the emission flux will drop rapidly as the gasoline closer to the surface volatilizes, and the modeled maximum impact will rapidly decrease. Additional remedial actions are available to minimize the amount of time that conditions approaching acutely hazardous could exist, including spraying a long-lasting foam on the soil and rapid initiation of soil remediation.

In summary, due to the immediate effects of the gasoline pool, the possibility of extreme acute impacts due to inhalation, up to and including death, exists. The probability of mortality could be minimized through prompt evacuation. Conditions approaching acutely hazardous could exist due to volatilization from soils for hours or possibly one or two days following cleanup of the gasoline pool that would result from a spill, though modeling indicates that the short term exposure limit would not be exceeded.

2.5 Fire Impacts

The probability and impact of fire are thoroughly discussed in Sections 6 and 7 of the EA. Here too, the exposure is acute and includes outcomes up to death.

3.0 Chronic Impacts

Chronic impacts are not expected to result from the spill of petroleum products contained in the pipeline. Dermal and respiratory chronic impacts should be prevented by proper response and remediation at the spill site. Impacts from ingestion of contaminated drinking water should be prevented by institutional and regulatory controls on public drinking water supplies, and by the requirements that Longhorn provide adequate replacement for any contaminated private water supplies.

On additional chronic pathway which has been suggested is the effects of hydrocarbons which have become trapped in karst formations under portions of Austin, where they may be difficult to remediate. However, as pointed out by a commentor, volatilization will not provide a major pathway for loss of hydrocarbons from a karst aquifer. Using the commentor's modeling, the high water vapor concentration in the air in unsaturated karst conduits, along with the continuous rainfall-runoff flushing of petroleum products from karst formations in the Edwards Aquifer-Balcones Fault Zone, should greatly limit the volatilization rates of benzene and other toxics. The commentor calculated a flux rate of 8.7×10^{-10} grams/cm^2 – sec for benzene in the aquifer, a rate which is 9 orders of magnitude lower than the flux rate modeled for soils at the surface. Because of this low flux rate and the expected residence time in the Balcones Fault Zone, there are no anticipated chronic effects which should be suffered from residing above or close to any recharge features.

ATTACHMENT 1

M E M O R A N D U M

TO: Robert Legrand

FROM: Bart Eklund

DATE: February 24, 2000

SUBJECT: Air Impacts of Fuel Spill

A modeling exercise was performed to meet the following objectives:

1. Evaluate the potential worst-case ambient air concentrations resulting from a spill of gasoline onto soil; and

2. Determine the downwind extent of the resulting emission plume with benzene concentrations of $\geq$2.5 ppmv and total hydrocarbons (THC) concentrations of $\geq$500 ppmv [as toluene]. These are the STELs for these compounds (see Attachment 2).

The emission flux resulting from the spill was assumed to be:

Species	Emission Flux	
	mg/m^2-min	**g/m^2-sec**
Total hydrocarbons	307	0.0051
Benzene	7.27	0.00012

The emission fluxes are taken from page 3-12 of a report I wrote titled, "Short-Term Fate and Persistence of Motor Fuels in Soils" dated July 31, 1989. The emission fluxes were measured from a 4yd^3 pilot-scale soil pile immediately after it was constructed. The soil pile was prepared using 7,900 pounds (3,580 Kg) of soil and 6.16 gallons (23.3 L) of gasoline/MTBE mixture. These emission fluxes represent a reasonably worst-case scenario - emission fluxes at an actual spill site might be lower initially and certainly would be lower in the days following the spill.

The spill site was assumed to have a surface area of 1,021,000 ft^2 (94,850 m^2) based on a circular area with a diameter of 1,140 ft (347m)(LHEA, Table 6-15). The emission fluxes shown above were used as the source term to the SCREEN3 atmospheric dispersion model, which is the recommended screening model of the US EPA. The most recent (1998) version of the model was used; it is available at www.epa.gov/ttn/scram. The modeling was performed assuming a ground-level source, ground-level receptors, worst-case meteorology, and urban dispersion coefficients. The source was assumed to be a square that is 308m on each side. The model output is available on request.

For both benzene and THC, the highest ambient concentrations are predicted to occur 218m downwind of the area source under very stable atmospheric conditions (e.g., cloudy, nighttime conditions) and minimal wind speeds of 1 m/s (2.2 mph). Constraining the model to a very conservative mixing height of 2m did not affect the results (see THC Run #2). The maximum concentrations are:

Benzene = 7,523 $\mu g/m^3$ (2.3 ppmv)

THC = 319,700 $\mu g/m^3$ (83.5 ppmv)

In both cases, the emission plume at the point of maximum concentration is below the concentrations of interest (see Objective #2, above).

An alternate set of modeling runs was performed using an area source with a 5:1 rectangular shape (see THC Run #3 and Benzene Run #2). Using this source geometry, the maximum ambient concentrations are slightly higher.

ATTACHMENT 2

MCLs and RBELs for Petroleum Product Components

Compound	Groundwater Ingestion MCL (mg/l)	Air Inhalation RBEL Carcinogenic (mg/m^3)	Air Inhalation RBEL Non-carcinogenic (mg/m^3)
Benzene	5.0E-03	3.1E-03	6.3E-03
Ethylbenzene	7.0E-01	--	1.0E+00
Toluene	1.0E+00	--	4.2E-01
Xylene	1.0E+01	--	4.5E-01
MTBE	1.5E-02	5.4E-01	3.1E+00
Benzo(a)pyrene	2.0E-04	2.8E-05	--

MCL – Maximum Contaminant Levels

RBEL – Risk-Based Exposure Limit defined as "the concentration of a chemical of concern at the point of exposure within an exposure medium (e.g., soil, sediment, vegetables, groundwater, surface water, or air) which is protective for human health. Risk-based exposure limits are the fundamental risk-based values which are initially determined and used in the development of protective concentration levels. Risk-based exposure limits do not account for cumulative effects from exposure to multiple chemicals of concern, combined exposure pathways, and cross-media or lateral transport of chemicals of concern within environmental media.

All numbers located in the Texas Risk Reduction Program of the Texas Natural Resource Conservation Commission (9/23/99).

In using the inhalation RBELs, the Commission notes:

"The Commission agrees that OSHA standards have a place in this rule making, but does not agree that they should be considered institutional controls. The provisions of 350.74(b)(1) include allowance for consideration of OSHA standards as RBELs when addressing the inhalation exposure pathway. However, the OSHA standards are not in and of themselves an appropriate basis to warrant a qualitative screening of the exposure pathway. Additionally, the commission takes the position that the required use of personal protective equipment is not an adequate remedial endpoint. If a property cannot be used in the absence of personal protective equipment such as impermeable clothing or air purification due to the presence of environmental contaminants, then that property has not been sufficiently restored or otherwise rendered adequately protective. The goal of the rulemaking is to restore the active and productive use of land, and not perpetuate such unprotective conditions into the future."

TLVs and STELs for Petroleum Product Components

Compound	TLV-TWA	TLV-STEL/C	Notation	Critical Effects
Benzene	0.5 ppm	2.5 ppm	Skin; A1; BEI	Cancer
Ethylbenzene	100 ppm	125 ppm	BEI	Irritation, CNS
Toluene	50 ppm	--	Skin; A4; BEI	CNS
Xylene	100 ppm	150 ppm	A4, BEI	Irritation
MTBE	40 ppm	--	A3	Irritation; kidney; reproduction
Benzo(a)pyrene	--	--	A2	Cancer
Gasoline	300 ppm	500 ppm	A3	Irritation; CNS

Definitions

Threshold Limit Value – Time Weighted Average (TLV-TWA) – the time-weighted average concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Threshold Limit Value – Short-Term Exposure Limit (TLV-STEL) – The concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. It is not a separate independent exposure limit; rather, it supplements the time-weighted average (TWA) limit where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature. STELs are recommended only where toxic effects have been reported from high short-term exposures in either humans or animals.

An STEL is defined as a 15-minute TWA exposure which should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV-TWA. Exposures above the TLV-TWA up to the STEL should not be longer than 15 minutes and should not occur more than four times per day. There should be at least 60 minutes between successive exposures in this range. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

Threshold Limit Value – Ceiling (TLV-C) – The concentration that should not be exceeded during any part of the working exposure. In conventional industrial hygiene practice if instantaneous monitoring is not feasible, then the TLV-C can be assessed by sampling over a period that should not exceed 15 minutes, except for those substances that may cause immediate irritation when exposures are short.

A1 – Confirmed Human Carcinogen.
A2 – Suspected Human Carcinogen.
A3 – Confirmed Animal Carcinogen with Unknown Relevance to Humans.
A4 – Not classifiable as a Human Carcinogen.

Biological Exposure Indices (BEIs) – The note "BEI" is listed in the "Notations" column when a BEI is also recommended for the substance listed. Biological monitoring should be instituted for such substances to evaluate the total exposure from all sources, including dermal, ingestion, or non-occupational.

Skin – This notation refers to the potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes, either by contact with vapors or, of probable greater significance, by direct skin contact with the substance.

Reference

American Conference of Governmental Industrial Hygienists. "1999 TLVs and BEIs: Based on Documentations for Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices," 1999.