

DRAFT

OUTLINE OF OPINIONS

Amoco Sugar Creek Refinery Case – Paul Hedrick

By

Stephen E. Petty, P.E., C.I.H.

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Norledge Tributary of Sugar Creek – Norledge and Carlisle – October 25, 2005

Court: Circuit Court of Jackson County, Missouri at Independence

Case No.: 04CV-209360, Division 16

Plaintiff: Paul Hedrick and Joyce Hedrick

Defendants: BP Corporation North America Inc. and BP Products North America Inc. –
Former American Oil Company (AMOCO) Site.

Scope of Work:

This scope of work was to determine Paul Hedrick's likely inhalation benzene exposure, while he lived near the refinery, from when he was born on July 8, 1951 (Exhibit 01, pg.7), until he was diagnosed with Hodgkins disease in January of 1980 (Exhibit 01, pg. 240).

Introduction:

The Sugar Creek, MO neighborhoods, where the plaintiff and his babysitter lived, were located primarily to the south and southeast of the former American Oil Company (AMOCO) refinery. This refinery covered approximately 430 acres and operated from 1904 until about 1982. The Amoco Refinery, addressed in this report, was located at 1000 North Sterling Road, in the City of Sugar Creek, Missouri. Dismantling of refinery operations began in 1986 and was completed in 1991. Storage tanks in the Tank Farm are still used for product storage today. During its seventy-eight (78) years of operation, the crude refining capacity expanded from about 12,000 barrels per day to a final capacity of some 100,000 barrels per day.

Sugar Creek, MO had a population of 3,982 in 1990; is located in Jackson County on the Missouri River, is east/northeast of Kansas City, MO, and is located at 39°08'N 94°24'W.

As early as 1908, a water plant official from the city of Independence, Missouri, reported that the refinery was discharging materials to Sugar Creek, which were negatively impacting their Missouri River water supply. Ultimately, as a result of a shifting sand bar and wintertime conditions, the situation worsened, resulting in a lawsuit on/about 1920 against the refinery (known as Standard Oil at that time). By as early as March 6, 1950, internal American Oil Company (later Amoco and now BP-Amoco) correspondence noted that oil (later identified more properly as gasoline) was reported in a spring on Burton Street, in the Sugar Creek neighborhood, south of the refinery. By 1953, tank leaks were documented as being responsible for oil leaks seen in this spring and creek (Sugar Creek) that flowed through the neighborhood. Available documentation of residents complaining of gasoline odors and of visible oil seen in the neighborhood can be found as early as April 6, 1964. By 1982, it was estimated that as much as 8,232,000 gallons of oil had leaked into the ground and that approximately 1,900,000 gallons of free product had been recovered by various means from 1988 to 1995. Expert reports by Dr. Agostino (Exhibit 21) and Dr. Bedient (Exhibit 22) concluded that a considerable amount of hydrocarbon remains in the ground and that:

“The inhalation of hydrocarbon vapors (in particular, benzene) was and is hazardous to the individuals living in off-site areas, such as the Norledge and Norledge/Carlisle areas” – Exhibit 21, page 13.

“Given the steep topography on-site, the locations of leaking tanks upgradient, and the confirmed contamination on-site and off-site, it is evident that the Amoco Refinery has contributed to massive subsurface contamination to the residential neighborhoods located to the south and south-west of the site” – Exhibit 22, page 7).

This led Dr. Bedient (Exhibit 22, pg. 7) to conclude that:

“The site is one of the worst I have seen in terms of lack of care in handling contamination and remediation.”

Data strongly suggests that the term “oil”, as it applies to oil contamination in/near Sugar Creek was premium leaded gasoline, known to contain up to 5% benzene. Other products have been shown to contain upwards of 15% benzene. Even after the initiation of remedial activities in 1997, groundwater benzene concentrations in the center of the petroleum plume were reported to be at levels up to 21.7 mg/L. Peak concentrations in groundwater under homes were up to 0.5 mg/L.

Sources of Information Utilized and Limitations:

In forming my opinions on Paul Hedrick’s inhalation benzene exposure, I have depended on several sources of information, including that from the offices of the Walters Law Firm, Paul Hedrick’s deposition and affidavit, Amoco documents and information from published literature. I also have relied on information contained in previous reports I have written for the Walters Law Firm for the Ryan, Detal and Reid cases and a telephone conversation I had with Mr. Paul Hedrick. The information that I have primarily considered and/or relied on is summarized in Appendices A, B, C and D. I have also relied on my knowledge and experience and training as a Chemical Engineer and Certified Industrial Hygienist (CIH), textbooks and reports on practices by industry for the design of oil/gas unit operations and systems and the control of petroleum contaminants and wastes, and my risk assessment and work experience on petroleum contaminated sites.

I leave open the possibility of adding to or modifying my opinions, based on additional information I may receive or review.

Opinions:

My opinions regarding exposure are:

1. Paul Hedrick's inhalation benzene exposure, while living at homes on Scarritt from 1951 to 1980, was 102.1 PPM-YRS. This exposure result does not include dermal or ingestion exposures.
2. Using a Monte Carlo simulation, based on variations of the benzene content of gasoline, the 95% range of inhalation exposure was from 47.0 PPM-YRS to 163.5 PPM-YRS with an average of 102.0 PPM-YRS.

I will also, if asked, have the same opinions regarding this site as contained in my background Ryan report.

Background Information on Paul Hedrick:

Paul Hedrick was born on July 8, 1951 (Exhibit 1, pg. 7). In January of 1979, at the age 28, he was diagnosed with Hodgkin' disease (Exhibit 1, pg. 140). He is now 56 years old.

Paul Hedrick lived at two locations in Sugar Creek, MO near the Amoco Refinery. From the time he was born until he was nearly 20 years old, he lived at his parent's home at 11100 Scarritt. He left the area for approximately four to five year, returning to a home near his parents at 10836 Scarritt in 1975 or 1976 where his lives today.

A map of the locations of both of Paul's homes is shown Figure 1:

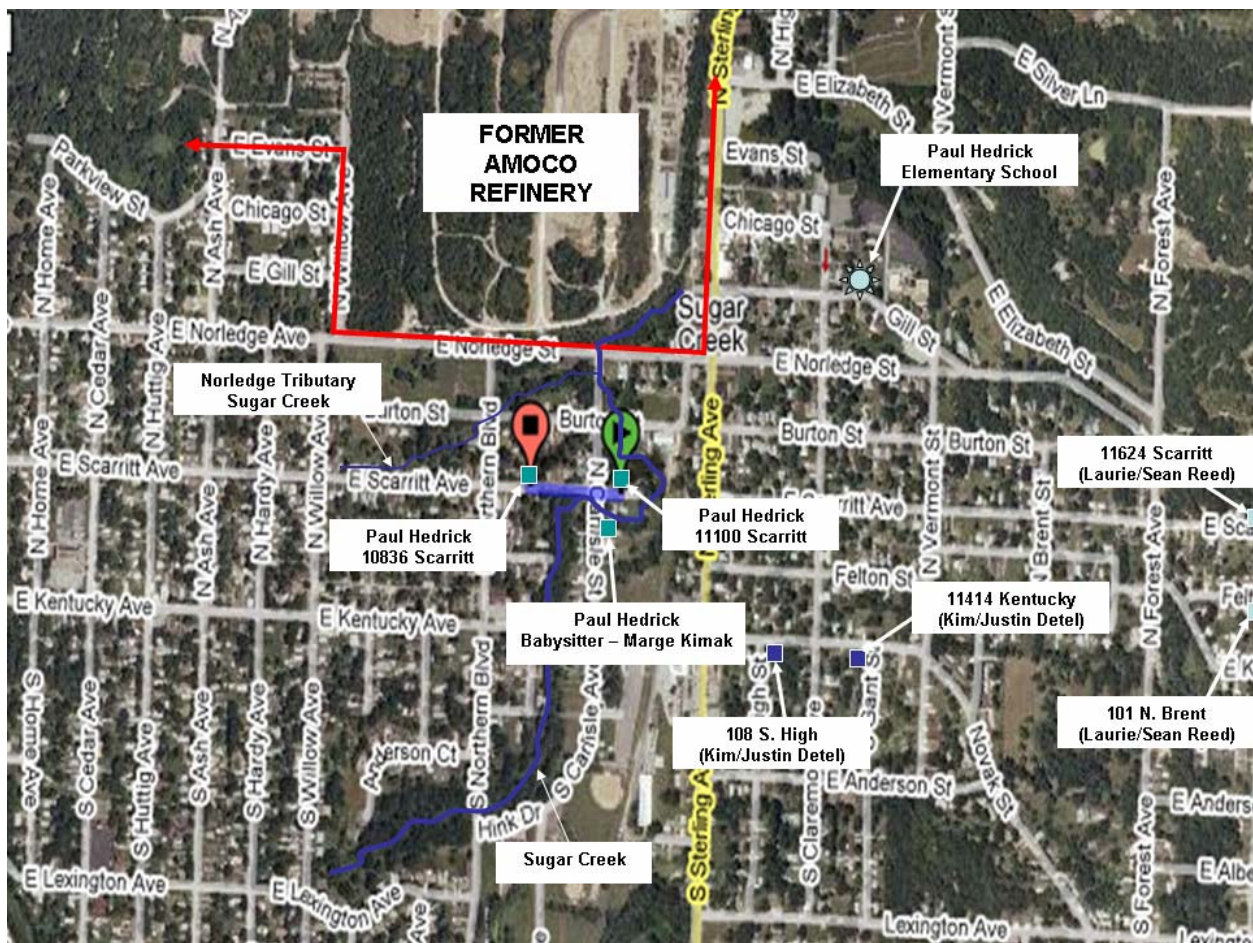


Figure 1: Areas Where Paul Hedrick Lived in Sugar Creek, MO

Figure 1 illustrates that both home locations were close together and south of the former Amoco Refinery site. His babysitter's home was just south of his parent's home. He played, swam, caught and ate crawdads from Sugar Creek. He also played near the Norledge tributary to Sugar Creek which he reported was known to contain gasoline.

Note that the Detel and Reed home locations have also been shown on Figure 1. These homes were in close proximity to the Hedrick homes. Both Kim Detel and Laurie

Reed reported smelling gasoline at their homes 75% of the time in the early to mid 1980s.

Overview and Background Information Regarding Paul Hedrick's School, Work and Home Location History:

A summary of background information from Paul Hedrick's deposition, affidavit, work and deed records used in determining his exposure to benzene are summarized in Table 2:

Table 2: General History

DOCUMENT	DATE(S)/ TIMEFRAME	INFORMATION/COMMENTS
Exhibit 1, page 7; Exhibit 35, page 1.	July 8, 1951	Born.
Exhibit 1, page 31; Exhibit 35, page 1.	Late 1950s to early 1960s	Raised at home located at 11100 Scarritt, Sugar Creek, MO.
Exhibit 1, pages 73 - 86	1950s and 1960s	Swam/waded in Sugar Creek until the age of two or three to the age of 13. Sheen of gasoline on creek from Norledge bridge. Source appeared to be the Norledge tributary of Sugar Creek; fewer crawdads below this point. Caught and ate Crawdads once per month from age 5 to 8; mother cooked them. Didn't play in creek with gasoline too much because would get in trouble from the smell. Played on banks in this area where they made forts and bunkers.
Exhibit 1, pages 186-188, 224-225	Late 1950s to early 1960s	Would occasionally drink water (cup once a year) from well at property on 11100 Scarritt. Consumed no more than a gallon of water from well.
Exhibit 1, page 64	September 1956 to June 1964	Attended Sugar Creek elementary school (K to 7 th grades). Walked to school.
Exhibit 1, pages 77-78	1964/1965	Lifeguard at Sugar Creek pool.
Exhibit 1, pages 63 – 64, 68	September 1964 to June 1966	Attended Nowlin middle school for two years (8 th and 9 th grades). Bused to school. Sometimes walked; four miles from home.
Exhibit 1, pages 167-168	1967 to 1969	Worked part time for the city of Sugar Creek collecting trash and helping with snow removal. Worked part time after school and on weekends.
Exhibit 1, pages 153 – 157.	1967 or 1968 to 1990.	Started smoking in 1967 or 1968; smoked a pack or less per day. Quit in 1980 til 1984. 1984 to 1990 smoked again. By end of 1984 up to a half a pack a day; then from 1985 to 1990 smoked about one pack per day.
Exhibit 1, pages 63 – 64, 68-69.	September 1966 to June 1969	Graduated from VanHorn H.S. in Independence in 1969. Attended H.S. for three years (10 th , 11 th and 12 th grades). Bussed or at times personal car.
Exhibit 1, pages 178, 182-184	Mid to late 1960s	As teens, spent three to four hours per week in basement at 11100 Scarritt; they were outside kids. Odors always coming from the refinery.

DOCUMENT	DATE(S)/ TIMEFRAME	INFORMATION/COMMENTS
Exhibit 35, page 1.	1966	Worked at A&P grocery store at Northern and Highway 24 for six months. Worked 5 days per week, 4 hours per week.
Exhibit 35, page 1.	1967	Worked at Mattie's Car Hop at Sterling and Gill on Friday, Saturday and Sunday evenings.
Exhibit 35, page 1.	1968 – July 8, 1969	Worked for city of Sugar Creek from 1968 to 18 th birthday in 1969. In summer worked full time; in winter performed snow removal as needed.
Exhibit 1, pages 90, 99-110, 119-120.	July 8, 1969 to 2002	Hired in with Ford. First position was motor decker (~1 year); then a utility man (~20 years) and then an electric forklift operator (from 1994 to 2002). Used propane forklifts. Plant is 5 miles away. No exposure to paints or solvents. Worked 58 hours per week (5 – 10s and 1 – 8 on Saturday) when he started. Worked 10 to 12 hours/day as forklift operator. Made ~\$70,000 at \$25/hr. in ~2000. Also worked as a lifeguard.
Exhibit 1, pages 151-153	1969 – 2002	Vacation policy: 6 weeks after 30 years. New hires received 2 weeks. Two weeks mandatory during shutdown or model change. Took two weeks of vacation per year from 1977 to 1994.; stayed in neighborhood. Very little vacation taken after 1994; took pay instead..
Exhibit 1, pages 140	1969	On disability due to hemorrhoidectomy in 1969 for eight weeks.
Exhibit 1, pages 139	1970	On disability due to broken jaw and hemorrhoids in 1970 for eight+ wks.
Exhibit 1, pages 111-113	June 1971 to August 1971	Quit Ford and traveled to California. Moved back to 11100 Scarritt in August 1971.
Exhibit 1, pages 118, 125; Exhibit 35, page 1.	August 1971 to February 1972	Unemployed. Lived at home until 1972.
Exhibit 1, pages 117-120, 124	February 1972 to February 1975 timeframe.	Began working for Blue Ridge Village on Highway 40 and Sterling; scraped sidewalks, move appliances, repaired toilets etc. Worked three years for this company. No work with paints, chemicals or gasoline.
Exhibit 1, pages 168 to 170	February 1972 to 1975/1976	Moved to Guadalupe Center in Kansas City for six months (~2/72 to ~8/72); then moved to Alton Plaza in Independence for six months (~9/72 to ~2/73); then moved to house at 1327 South Osage in Independence for a little over a year (~3/73 to mid 1974.
Exhibit 38, pages 1	June 25, 1974	Purchased home at 10836 Scarritt by parents.
Exhibit 1, pages 112, 124	June 9, 1977	Rejoined Ford.
Exhibit 1, pages 137-138	1979	On disability due to broken leg in 1979 for eight weeks.
Exhibit 1, pages 240-241	1980	Diagnosed with cancer on January of 1980.
Exhibit 1, pages 132-135	1980 to 1983	On disability due to cancer from January 1980 to 1983.
Exhibit 1, pages 141	1985	On disability due to broken arm in 1985 for eight weeks.
Exhibit 1, pages 137-138	1986	On disability due to broken leg in 1986 for eight weeks.
Exhibit 1, pages 141-143	1994	On disability for two months (September 1994) due to heart attack.
Exhibit 1, pages 206-229	Mid to late 1990s	Noticed oil on top of his well water in 1997 to 1998. Amoco missed the well and later came out and tested it after he called city. Told not to be concerned. K-State told him not to use well water on his

DOCUMENT	DATE(S)/ TIMEFRAME	INFORMATION/COMMENTS
		garden. Took sample from the mid column and did not sample free product. Questioned why the well wasn't sampled on top or the bottom. Wells on both properties never canvassed by Amoco. Parents well on 11100 Scarritt not sampled.
Exhibit 1, page 144	2002	On disability for one year in 2001 due to heart condition.
Exhibit 1, page 31 – 32		Would fish with brother John Stanley 4 weekends/year.
Exhibit 1, page 61		"There was always an odor in Sugar Creek."
Exhibit 1, page 15-16	January 2005	Current home located at 10836 Scarritt in Sugar Creek, MO.
Exhibit 1, page 12 - 14	April 2004 to January 2005	Helped wife run garage she purchased nine months before the deposition.

A detailed work history for Paul Hedrick is summarized in Table 3:

Table 3: Summary of Paul Hedrick's Work History

Timeframe	Employer	Job/Job Function	Reference
1964/1965	Sugar Creek Pool	Lifeguard.	Exhibit 1, pgs. 77-78.
1966	A&P Grocery Store; Northern and Highway 24.	Sacked groceries. Worked for 6 months, five days per week and four hours per day.	Exhibit 1, pg. 89; Exhibit 35, pg. 1
1967	Mattie's Car Hop, Sterling and Gill	Carhop. Worked for 12 months on Friday, Saturday and Sunday evenings.	Exhibit 1, pg. 89; Exhibit 35, pg. 1.
1968 to July 8, 1969	City of Sugar Creek	Laborer - Full trash collector in summer and as need snow removal worker in the winter.	Exhibit 1, pgs. 167-168; Exhibit 35, pg. 1.
July 8, 1969 to June 1971	Ford	Motor decker – ~1 year; utility man for balance of time till he left in 1971.	Exhibit 1, pgs. 99, 99-110, 119-120 and 111-113.
June 1971 to September 1972.	Un-employed.	Left Sugar Creek in February 1972.	Exhibit 1, pgs. 111-113, 118 and 125. Exhibit 39.
Sept./Oct. 1972 to Early 1973	Blue Ridge Village Co.	Laborer – Scraped sidewalks of snow, moved appliances, repaired toilets. W-2 lists address as 1327 S. Osage, Independence, MO. Earned approximately \$600.	Exhibit 1, pgs. 117-120 and 124. Exhibit 39.
1973	Barbour Concrete Company	Laborer, helped with concrete forms. W-2 lists address as 1327 S. Osage, Independence, MO. Earned \$849.90	Exhibit 39.
1973	Advanced Industries, Inc. 301 Northeast Railroad St. Odessa, MO 64076	Machinist's Assistant. W-2 lists address as 1327 S. Osage, Independence, MO. Earned \$655.07	Exhibit 39

Timeframe	Employer	Job/Job Function	Reference
3 rd and 4 th quarter of 1973 and 1 st and 2 nd quarter of 1974	General Analine and Film (GAF)	Forklift driver. W-2 lists address as 1327 S. Osage, Independence, MO. Earned \$4,368.05 in 1973 and	Exhibit 1, pgs. 120-123; Exhibit 36 and Exhibit 39.
12-14-74 to 5-8-75	Un-employed.	Unemployment checks issued to Mr. Paul Hedrick at 10836 Scarritt, Sugar Creek, MO.	Exhibit 39.
1975 through part of 1976	General Analine and Film (GAF)	Forklift driver. W-2 lists address as as 10836 Scarritt, Sugar Creek, MO. Earned \$6,103.23 in 1975 and \$1,064.84 in 1976.	Exhibit 1, pgs. 120-123; Exhibit 36 and Exhibit 39.
4 th quarter of 1976 to June 1977	Panasonic Products Dist., Inc. 2520 Summit, Kansas City, MO.	Radio installer. W-2 wages for 1976 were \$895.61. W-2 lists address as 10836 Scarritt, Sugar Creek, MO.	Exhibit 39
June 9, 1977 to 2002.	Ford	Utility man and forklift operator.	Exhibit 1, pgs. 90, 99-110, 112, 119-120, 124, 144, 151-153.

As a teenager, Mr. Hedrick worked a variety of part-time jobs, including working in Sugar Creek as a lifeguard at the pool, as a laborer removing trash and snow, as a carhop at a drive in and as a sacker of groceries at an A&P grocery. After graduating from high school, Mr. Hedrick joined Ford as a laborer on July 8, 1969 where he worked until June 1971. He then quit and was unemployed from June 1971 until the fall of 1973. In February of 1972, he moved from his parent's home on 11100 Scaritt out of town eventually settling in at a home located at 1327 S. Osage, Independence, MO. From the fall of 1972 until early 1973, he worked briefly as a laborer for the Blue Ridge Village Company. At this company, he shoveled sidewalks and performed other laborer functions. He then worked briefly in 1973 for Barbour Concrete Company where he helped set forms and for Advanced Industries, Inc. where he worked as a machinist's assistant. Wages earned were less than \$1,000 each at all three of these companies. In late 1973 and early 1974, he worked as a forklift operator for GAF. In June of 1974, he moved back to Sugar Creek, MO retuning to a home purchased for him by his parents at 10836 Scarritt. Based on un-employment check stubs, he was un-employed from December 1974 to early May of 1975. He then returned to work at GAF for the balance of 1975 into 1976. From the fourth quarter of 1976 to June of 1977, he worked for Panasonic Products Distribution, Inc. as a radio installer. He then rejoined Ford as a laborer and forklift operator on June 9, 1977 until he retired in 2002.

Nothing in his work history suggests any significant exposure to benzene or benzene-containing compounds.

Summary of Literature on Air Monitoring Results:

Information was reviewed that was contained in Amoco documents: Sampling and Modeling (1995 RCRA Facility Investigation Report, 1999 Norledge Area Investigation Report and Exhibits 23 to 31) regarding possible data on monitoring of the air for benzene in Paul Hedrick's neighborhood from 1986 to 1997. A summary of these documents and findings is provided in Table 1:

Table 1: Air Monitoring Documents - Review

DOCUMENT	TIME FRAME	LOCATION OF AIR MONITORING	COMMENTS
1995 Amoco RCRA Facility Investigation Report (pg. 8-6).	Pre December 1995	Norledge Avenue Residence	Location and date of sampling not stated. Results were at detection limit of 0.05 ppm. Later reported that house may have been open.
1999 Amoco Norledge Area Investigation Report	Pre December 1999	—	No relevant data identified.
Exhibit 23	May – Aug. 1994	On refinery grounds	Problems with moisture and equipment; background levels higher than monitored data near removal of benzene-containing equipment. Not in neighborhood.
Exhibit 24	June 1998	Seven basements in homes	Grab samples and summa canister samples. Sampling over 10 years after the dates of interest. Residents still report odors occur.
Exhibit 25	August 1991	—	Suggests OSHA standard of 10 ppm benzene should be adequate in home's unoccupied basement.
Exhibit 26	December 1993	Fillmore residence; 215 N. Hardy	Report of odors. OVM badges reported 6 ppb; instructions suggest best day to use is when it's raining? Data taken well after the dates of interest. Also, Mr. Fillmore asked about digging his well deeper!
Exhibit 27	January 1994	Fillmore residence; 215 N. Hardy	See above comments.
Exhibit 28	October 1999	ATSDR sampling at the Chappell residence; no address provided in document.	Benzene levels from non-detect to 2 ppb. Reportedly samples taken on day when "no odors were evident." Data from tests taken over 10 years after the period of interest.
Exhibit 29	October 1999	Analytical results of air sampling at the Chappell residence.	See previous comments.
Exhibit 30	August 1991	—	Same as Exhibit 25.

DOCUMENT	TIME FRAME	LOCATION OF AIR MONITORING	COMMENTS
Exhibit 31	August 1993	Kentucky/Vermont; Kentucky/Gerber Hill; and Norledge/Northern	Used new instrument called a Scentometer to monitor odors, including samples where a resident complained of odors. Table reports no odors detected; table says results <2 thresholds. Looks like an experimental apparatus; no basis for interpretation of results provided. The following conclusion language is somewhat odd: "The results of the Scentometer monitoring shows that even when noxious odors from the bioremediation project are present, the odor levels are within the acceptable odor range and therefore are not nuisance odors." Data taken after period of interest.
Exhibit 32	1998 - 1999	Eight (8) unoccupied homes in Norledge area. – October 1999.	One sample contained 16.3 $\mu\text{g}/\text{m}^3$ benzene. Data taken over 10 years after timeframe of interest.
Exhibit 33	March 1991	Samples of air near monitoring wells.	Sample results varied from 0 to 15 ppm; most on lower end of range. Data closest to the period of interest, but still measured at least ten years after Mr. Hedrick's exposures.
Exhibit 34	Feb. – April 2001	Air monitoring near corner of Northern and Burton.	Benzene detected in 11 or 20 samples; highest value was 1.3 ppb. Data taken ~15 years after the period of interest.

As can be seen from the summary in Table 1, no airborne data was taken during the period of interest (1951 to 1980).

Interestingly, field measurements taken near monitoring wells in 1991, nearest the time of Mr. Hedrick's exposures, contained benzene values ranging from 0 to 15 ppm.

Exposure Estimates:

An inhalation exposure estimate, resulting in PPM-YRS of benzene exposure, was completed. The analysis was based on an assessment of Paul Hedrick's exposure times while at/near his homes on 11100 Scarritt and 10836 Scarritt Streets in Sugar Creek, MO.

The benzene levels in air are based on recollections of gasoline odors in air by Paul Hedrick, odor recognition levels of gasoline in air, and the benzene content of gasoline. Details on the basis of these estimates, along with results, follow.

Estimates of Exposure Times:

Based on Paul Hedrick's deposition and affidavit, and data on the time Paul Hedrick spent at both his parent's home on 11100 Scarritt and his own home on 10836 Scarritt is summarized in Table 3:

Table 3: Time at Sugar Creek Residences Prior to Diagnosis

BACKGROUND INFORMATION			
Residential History			
Living Location	Years	Units	Timeframe
11100 Scarritt	~20.2	years	7/51 – 2/72
10836 Scarritt	~5.5	years	6/74 to 1/80
TOTAL	~25.7	years	

The total calendar time spent at 11100 Scarritt was ~20.2 years. In 1975 or 1976 he purchased a home down the street from his parents at 10836 Scarritt where he and his wife live currently. The time Mr. Hedrick lived in his home prior to his diagnosis in January 1980 was estimated at 4.5 years.

A PPM-YR of inhalation exposure is traditionally based on a worker's exposure working full time. A worker PPM-YR of time, (defined as ETY) was estimated to be 120,000 minutes. This was based on the following values:

Minutes per hour	60.0
Hours per work day	8.0
Days per work week	5.0
Weeks per work year	50.0

The total minutes in one calendar year (i.e., year) was calculated to be 525,600 minutes. This was based on the following values:

Minutes per hour	60.0
Hours per day	24.0
Days per year	365

Therefore, there are 4.38 ($4.38 = 525,600/120,000$) maximum worker years (in terms of PPM-YRS of time) per calendar year

To calculate PPM-YRS, one must defined the time of exposure in equivalent YRS to with time For example, a child living at home in an exposure situation would be exposed up to 24 hours per day rather than 8 hours per day that might be used for a worker in a workplace exposure. This term (YRS), is given by the following equation:

$$\text{Eq (1)} \quad \text{YRS} = \text{Time exposed (minutes)} / \text{ETY, or}$$

$$\text{Eq (2)} \quad \text{YRS} = \text{Time exposed (minutes)} / 120,000$$

Estimated worker-years (YRS) of exposure for Paul Hedrick at each residence, with time, are summarized in Table 4. In this table, Equations (1) was used to calculate the table's net time at home entry by year:

$$\text{Eq (3)} \quad \text{Net Time at Home} = \text{Total Time /yr} - (\text{School Time/yr} + \text{Work Time/yr} + \text{Vacation \& Shut-down Time/yr} + \text{Disability Time/yr}) * 85\%.$$

Based on Mr. Hedrick's testimony (Exhibit 1), a number of factors were considered in the calculated results for the annual estimates of the tabled values of "Net Time at Home." These included:

- Excluding from the term, the time Mr. Hedrick was away from Sugar Creek while in middle and high school. Since the elementary school was located in close proximity to Mr. Hedrick's home and the refinery, the time he was in his elementary school was included in the exposure time.
- Including the times in this term when Mr. Hedrick played outdoors.
- Including the times in this term when Mr. Hedrick worked part time at the local pool, for the city of Sugar Creek and for the drive-through since these locations were near his home and in the vicinity of the refinery (see for example Exhibits 1 and 1-B).
- Excluding the time he worked at Ford, including a travel hour to/from work per day.
- Excluding the time Mr. Hedrick was in California and away from the area in the early 1970s.
- Including the exposure times for vacation, plant shutdowns and disability since he reportedly stayed at/near home at these times.
- Excluding all exposure times after Mr. Hedrick was diagnosed with his disease in January 1980.

The net time at home values were decreased by 15% to increase the conservatism of the estimate and account for any possibly miscellaneous time away from the area not accounted for in Equation 3.

The annual net exposure times (minutes and YRS) smelling gasoline were the product of net times at home multiplied by the percent time smelling gasoline.

The exposure time was calculated as follows:

$$\text{Eq (4)} \quad \text{Exposure time} = \text{Time at each location} \times \% \text{ time gasoline smelled}$$

The % time gasoline was smelled was obtained from the Affidavit of Mr. Hedrick (Appendix C). In his affidavit, Mr. Hedrick recalled smelling gasoline 100% of the time as long as he could remember. I have been more conservative, dropping the percentages to 90% from 1951 to 1970 and 75% during the 1970s to reflect a period where environmental regulations began to take hold.

The total exposure time, in PPM-based years (YRS), was 66.1 years, accounting only for the period from July 1951 to January 1980.

Table 4: Exposure Time Estimates**11100 Scarritt:**

<u>Time frame</u>	<u>Years</u>	<u>Total Minutes</u>	<u>School Min./Year*</u>	<u>Work Min./Year</u>	<u>Vac. & Shutdown Min./Year**</u>	<u>Disability - Home Min./Yr.</u>	<u>% Time @ Home</u>	<u>Net Time at Home Minutes</u>	<u>% Time Smelled Gasoline</u>	<u>Minutes @ Home Smelling Gasoline</u>	<u>Years (PPM) @ home</u>
7/51 to 1/52	0.4	219,000	0	0	0	0	90%	197,100	90%	177,390	1.5
1/52 to 1/53	1.0	525,600	0	0	0	0	90%	473,040	90%	425,736	3.5
1/54 to 1/55	1.0	525,600	0	0	0	0	90%	473,040	90%	425,736	3.5
1/55 to 1/56	1.0	525,600	0	0	0	0	90%	473,040	90%	425,736	3.5
1/56 to 9/56	0.7	350,400	0	0	0	0	90%	315,360	90%	283,824	2.4
9/56 to 1/57	0.3	175,200	0	0	0	0	90%	157,680	90%	141,912	1.2
1/57 to 6/57	0.4	219,000	0	0	0	0	90%	197,100	90%	177,390	1.5
6/57 to 9/57	0.3	131,400	0	0	0	0	90%	118,260	90%	106,434	0.9
9/57 to 1/58	0.3	175,200	0	0	0	0	90%	157,680	90%	141,912	1.2
1/58 to 1/59	1.0	525,600	0	0	0	0	90%	473,040	90%	425,736	3.5
1/59 to 1/60	1.0	525,600	0	0	0	0	90%	473,040	90%	425,736	3.5
1/60 to 1/61	1.0	525,600	0	0	0	0	85%	446,760	90%	402,084	3.4
1/61to 1/62	1.0	525,600	0	0	0	0	85%	446,760	90%	402,084	3.4
1/62 to 1/63	1.0	525,600	0	0	0	0	85%	446,760	90%	402,084	3.4
1/63 to 1/64	1.0	525,600	0	0	0	0	85%	446,760	90%	402,084	3.4
1/64 to 9/64	0.7	350,400	0	0	0	0	85%	297,840	90%	268,056	2.2
9/64 to 1/65	0.3	175,200	41,600	0	0	0	85%	113,560	90%	102,204	0.9
/65 to 1/66	1.0	525,600	93,600	0	0	0	85%	367,200	90%	330,480	2.8
1/66 to 1/67	1.0	525,600	93,600	0	0	0	85%	367,200	90%	330,480	2.8
1/67 to 1/68	1.0	525,600	93,600	31,200	0	0	85%	340,680	90%	306,612	2.6
1/68 to 1/69	1.0	525,600	93,600	0	0	0	85%	367,200	90%	330,480	2.8
1/69 to 6/69	0.4	219,000	52,000	0	0	0	85%	141,950	90%	127,755	1.1

[illegible]

* Included E.S. time in calculations since it was neighborhood school

** Vacation 2 wks./yr. and shutdown 2 wks./yr. - stayed at home, included in exposure calculations.

10836 Scarritt:

[illegible]

Estimates of the Benzene Content of Gasoline:

In documents provided to date, Amoco self-reported the benzene content of gasoline in 1963 was 0.7% (Exhibit 14) and in 1981 was 3.2% to 3.3% and 5.4% (Exhibit 13). MSDS sheets (see Appendix F) typically report the benzene content of gasoline ranging from 1% to 5%; Amoco, in their 1993 MSDS, reported the benzene content of their gasoline at 4%. Based on the time-frame of Mr. Hedrick's exposure, and availability of site specific data, an average of the 1963 (0.7%) and 1981 (4.3%) data (i.e., 2.5%) was considered to best represent the benzene content of gasoline for these exposure calculations.

Mr. Hedrick's Recollection of Gasoline Odors:

Exhibit 35: pages 1-2:

From my earliest age of memory at 5 years of age in 1956 through 1972, I remember the strong odor of gasoline at our residence and throughout greater Sugar Creek 100% of the time.

From 1974 through my date of diagnosis on approximately January 1, 1980, I remember the strong odor of gasoline at our residence and throughout greater Sugar Creek 100% of the time.

Exhibit 1: pgs 61, 79-84, 182-184:

Q. Did you notice any kind of odor when they were turning the soil over on Anderson Court?

A. There was always an odor in Sugar Creek.

Q. Did you ever play in that part of the creek?

A. Yes, we played ditch, 'em, we ranged over the whole thing. There is a lot of woods in these areas. It is an older neighborhood.

Q. Into the creek itself?

A. Yes, or jumping across it. If you got it on you you do a lot of wiping of the sludge off. I was just part of life. We just accepted it. There used to be I guess about seven houses up in here and they dismantled them or razed the homes because of the gasoline smell in the basements.

Q. Can you indicate where those seven houses were? Just draw a long rectangle there, consume the space they took up. Do you have an understanding as to when they were razed?

A. They started doing it before my memory but there was three houses there that I remember that one of them was as late as probably about '82.

Q. The water in the creek that is south of the Norledge bridge, did that also have gasoline and petroleum or sheen on it?

A. No, because the water would be going against the flow of the water.

Q. So really the place where the sheen and the gasoline began was where that tributary to the west would join the Sugar Creek?

A. Yes.

Q. And is that, in your view, was that the source of how the gasoline would get into the main body of the Sugar Creek was through that feeder creek that you described?

- A. Yes, from the Norledge bridge down, yes.
- Q. When you were a young kid did you ever talk about the gasoline in the creek or the petroleum in the creek or the sheen with any of your friends?
- A. I just figured my brothers asked the questions and I just went along. It was just an accepted part of the neighborhood. Nobody ever talked about it.
- Q. Did your folks ever tell you not to play in that area or anything?
- A. We would get our asses whooped if we came home smelling. They would have known if we would have go into that area. Most of the time we just jump over the creek and go play. We had forts build there. There is still a depression right up above this feeder creek where we had, that's the Norledge bridge, approximately right here there is still a pit and we would cover it up with boards and put earth on it and we would play Army and that was our bunker.
- Q. It was kind of like a fort or bunker?
- A. Yes.
- Q. So your folks told you to stay away form those areas in the creek where the oil was?
- A. Yes. We would get whooped so we wouldn't go there.
- Q. So you would try to avoid those areas?
- A. As much as kids listen to their parents.
- Q. Do you have an understanding about why your folks didn't want you to go into those areas?
- A. Because we would come home smelling to high heaven and they didn't like it. Then she would have to do wash or you would have to leave your clothes outside until they aired out.
- Q. Did you ever have any understanding that the substances in the creek, the gasoline in the creek was not healthy?
- A. We don't know anything about it. Nobody told us. We just accepted it. It was part of living next to a refinery. We would play up to midnight they would have 30 foot flames coming off of the derricks down there. It would be like daylight in the middle of the night.
- Q. What about outside the house there when you were living there, were there any odors that you noticed outside the house at 11100 Scarritt?
- A. There was always odors coming from Amoco or Standard Oil, whatever it is, or BP now. I noticed the older folks call it Standard still. Sometimes it would be stronger than others. Depends on what time of the year and the way the wind was blowing.
- Q. Could you tell me - - could you describe the odors that you would smell?
- A. Petroleum.
- Q. Was it a gasoline smell?
- A. At times. Sometimes it would be an oil smell, sometimes it would be a burnt smell.
- Q. The odors that you have described, did they continue pretty much from the time you were very young until - -
- A. Yes.
- Q. Until did there come a time when you stopped smelling the odors?
- A. Just when I would get used to them. But sometimes somebody, man it stinks, and I couldn't smell it because I was raised with it.
- Q. Do you still smell odors out there today?

- A. Yes.
- Q. Are they as strong today as they were back then?
- A. Not as strong, no. Usually on moist mornings you can feel it sitting in the valley.
- Q. Do you have an understanding of what the smell is from?
- A. I would think it is from the old refinery.

Estimates of Benzene Exposure from Gasoline Exposure in PPM-YRS:

In general, the PPM-YRS for inhalation exposure were calculated by multiplying the concentration of benzene in the air, $C_a(\text{benzene})$ in ppm by the effective exposure time (in standard worker-years, YRS, of time) as follows:

$$\text{Eq. (5)} \quad \text{PPM-YRS} = C_a(\text{benzene}) \bullet \text{YRS}$$

The term YRS defines the effective worker-years of exposure summarized in Table 4 for the period of interest (i.e., 1951 to 1980).

The benzene in air concentration, $C_a(\text{benzene})$, was determined by the use of gasoline odor threshold data of Drinker et al. [1943] (see Appendix E for a detailed summary of this work) couple with the work of Runion (Runion, 1975). A brief summary of odor responses, by gasoline concentration, from Drinker's data is shown below:

<u>Concentration (ppm)</u>	<u>Odor Response(s)</u>
140 - 160	Detectable odor; loss of odor beginning in as little as 1 hour; at 140 described as disinfectant by some subjects.
270	Detectable odor entire 8 hours; one subject had loss of odor after 6 hours.
500	Detectable odor by all nine subjects; described as weak by 5 of 8 and strong by 3 of 8.
900	Detectable odor by all six subjects; 4 of 6 describe as strong.
2,600	Described as "very strong" by six subjects.
10,700 - 11,200	Detectable odor, immediately.

Based on the Drinker data, the following approach was used to determine gasoline vapor concentrations by odor response in modeling Mr. Hedrick's benzene exposure:

<u>Concentration- Gasoline (ppm)</u>	<u>Odor Responses(s)</u>	<u>Physiological Responses(s)</u>
150	Weak, detectable odor	None
300	Moderate to strong odor	Slight – moderate eye irritation
600	Strong to very strong odor	Moderate eye and throat irritation

No physiological responses were noted in Mr. Hedrick's deposition (Exhibit 1), but in her Affidavit (Appendix C) he noted that the "strong odor" of gasoline in/near his neighborhood in Sugar Creek from 1956 until 1980.

Because no gasoline vapor-related physiological response was noted in his deposition or affidavit, a conservative gasoline vapor concentration of 150 ppm was used whenever Mr. Hedrick reported smelling the strong odor of gasoline.

The benzene vapor in air release rate was based on the following formula [Runion, 1975]:

$$\text{Eq. (6)} \quad C_a (\text{benzene}) = 0.4 \cdot C_a (\text{gasoline}) \cdot (\% \text{benzene}/100)$$

The Drinker odor-response data provided a method for calculating the gasoline vapor concentration, C_a (gasoline). The benzene vapor concentration (1.51 ppm) was calculated from the gasoline vapor concentration (150 ppm) using 2.5% benzene content in gasoline and Eq. (6). Results of these calculations are summarized in Table 5.

Note in Table 6 that the average total predicted benzene inhalation exposure was 102.1 PPM-YRS. This inhalation exposure estimate used reasonable values for the gasoline benzene concentrations for the time period from 1951 - 1980.

Table 5: Input and Output for Paul Hedrick's Inhalation Benzene Exposure

Location:	Time frame	Exposure Years (YRS)	Gasoline Concentration (PPM)	Benzene Gas. Conc. (%)	Benzene Air Concentration (PPM)	PPM-YRS
11100 Scarritt	7/51 to 2/72	58.5	150	2.51	1.50	88.1
10836 Scarritt	5/74 to 1/80	9.3	150	2.51	1.50	14.0
TOTAL BENZENE EXPOSURE (PPM-YRS)		67.8				102.1

Estimates of Inhalation Benzene Exposure PPM-YRS – Monte Carlo Analysis:

It is constructive to look at the effect of varying key parameters to determine their impact on results, in this case benzene exposure. To accomplish this, a Monte Carlo simulation program by Decisioning was utilized. It is an add-on program to Microsoft Excel™ and is accessed as a custom tool bar. Parameters that were allowed to vary, and the degree to which they were varied, is summarized below:

<u>Parameter:</u>	<u>Range of Values Considered:</u>
Percent Time at/near Home	Mean (85%) plus or minus 15%
Percent Time Smelled Gasoline	Mean (90% or 75%) plus or minus 10%
Gasoline Concentration	For value of 150, range used was 100 to 200
Benzene Content of Gasoline	Used values of values from 0.5% to 4.5%.

Each value for the benzene content was picked randomly. Then the simulation was run 100,000 times. Output from this simulation is summarized in Figure 1 and Table 6:

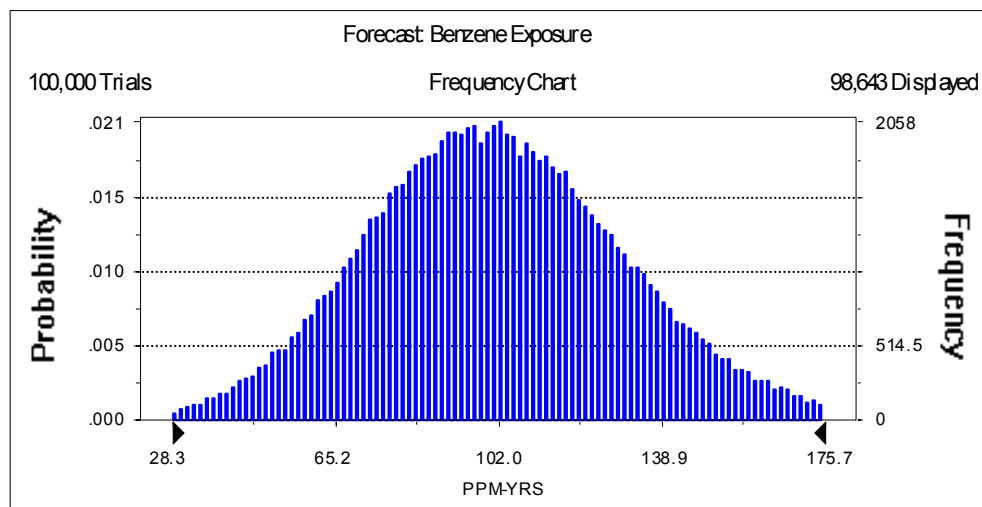


Figure 1: Simulated Benzene Exposure (PPM-YRS)

The average exposure was calculated to be 102.0 PPM-YRS. The 95% range of exposures was from 47.0 PPM-YRS – 163.5 PPM-YRS. Statistics and percentiles from the simulation are summarized in Table 6.

Table 6: Exposure Simulation Statistics and Percentiles

Statistics	Forecast values
Trials	100,000
Mean	102.0
Median	100.9
Mode	---
Standard Deviation	29.6
Variance	874.3
Skewness	0.22
Kurtosis	3.12
Coeff. of Variability	0.29
Minimum	0.1
Maximum	257.9
Range Width	257.8
Mean Std. Error	0.09
Percentiles	Forecast values
0.0%	0.1
2.5%	47.0
5.0%	55.3
50.0%	100.9
95.0%	152.6
97.5%	163.3
100.0%	257.9

Discussion:

The following factors contributed to conservative results in the overall calculated exposure:

- No quantification of dermal exposure while wading and swimming in Sugar Creek or the Norledge Tributary to Sugar Creek (see discussion below).
- No quantification of dermal exposure while playing on the banks of Sugar Creek or the Norledge Tributary to Sugar Creek (see discussion below).
- No quantification of ingestion exposure from eating crawdads or from ingestion of water from Sugar Creek or the Norledge tributary to Sugar Creek.
- The gasoline concentrations used from Drinker in the model were well below those that could have been used for a strong odor, as reported by Paul Hedrick.

- The percentage of benzene in gasoline used (2.5%) in the calculations was less than that (4%) reported in Amoco MSDS sheets or values as high as 5.4% reported by the refinery in 1981.
- The results do not reflect other fuels that were also reportedly released (Exhibit 21), some of which had benzene concentrations as high as 15%.

Also, note that none of the exposure calculations account for dermal or ingestion exposures. In his deposition (Exhibit 1), Mr. Hedrick noted that:

Ingestion Exposure:

Exhibit 1, pg. 74- 75, 84, 86, 223-224:

Q: ...Would you boys swim off the Norledge bridge as well?

A: No. We would crawdad down up into here. Me and the Wells boys, we would tie a little bucket, a little sand pail or something and tie it to our thing, we would walk through the creek, when the crawdads would jump up, instead of using bait and – we would bait and string sometimes. When they come up we would catch them. If you catch them right they wouldn't pinch you.

Q: And put them in the bucket?

A: Put them in the bucket. Go home and wash them off and eat them.

Q: This is before Sushi?

A: Yes. Poor man's shrimp.

Q. Did you ever eat crawdads from the creek that you caught north of Norledge bridge?

A. Yes. A lot of them would wash underneath the bridge because crawdads are mobile type creatures. They go lots of places.

Q. They don't say here is the Norledge bridge, we can't go past there?

A. No, because the creek was deeper down there.

Q. Now, how often would you eat crawdads out of the Sugar Creek?

A. Depends on the age group. Probably from when I was five to eight years old probably once a month through the summer, so that would be three times a year. My parents would say go catch some crawdads, all of us boys we would do down there, catch a mess of them, 20, 30.

Q. Your mom would cook them?

A. Uh-huh.

Q. Do you have an understanding as to when that well stopped being used for drinking water?

A. Probably last person to drink out of it was me when I was a child or my brothers. They were older than me so they graduated to other things.

Q. About how many glasses of water do you think you had out of that well?

A. Three, four. We would go over and pump it and get the little cup and drink out of it and then that would be it, then we would go play.

- Q. So three or four your whole life?
- A. Maybe more. But yes, it wasn't much more than that. Probably wasn't over a gallon.
- Q. But your grandfather and the Frieses do you think that was their primary source of drinking water?
- A. Yes.

Dermal Exposure:

Exhibit 1, pgs. 73, 76, 78-74:

- Q: --Show me where on the map, if you put Xs on the Sugar Creek where you think you used to play in Sugar Creek.
- A: This is Kentucky. The creek comes up this way. I guess this is probably called some other creek is why they don't have it on there. It runs over to Chris Lake. But from the stream up to 24 Highway to the bridge here at Norledge. We would play in the creek but there was no crawdads in there on down because of the petroleum products in the creek. Especially this one here it was always blue, had a sheen of gasoline on it. The Norledge creek or whatever it is.
- Q. What years do you think that was that you were swimming in the swimming hole and walking the creek?
- A. From childhood to 12. Childhood to about 14 maybe.
- Q. When you say childhood, what is the earliest memory?
- A. Ever since I was a kid I followed my brothers down there.
- Q. You think when you were two years old you went down there?
- A. From probably three, four. Probably two. I was raised by my brothers.
- Q. You don't think you would swim in the swimming hole when you were two, do you, or would you?
- A. I remember getting dumped in the creek one time when I was about five years old and I froze by the time they got me out.
- Q. You played in the creek and swam in the swimming hole until you were about 13?
- A. Yes.
- Q. During that period of time when you were crawdadding in the creek and swimming in the swimming hole south of the Norledge ridge, did you also swim and crawdad north of the Norledge bridge?
- A. We would venture to see if there was any crawdads down there but usually chances of catching them is pretty slim down in there. It was better above that feeder creek, from the Norledge bridge south.
- Q. Why do you say that?
- A. Because of gasoline in the water.
- Q. It was harder to see them or harder to catch them or harder to get them?
- A. They just weren't there.
- Q. So occasionally you would go up north of Norledge bridge and look for the crawdads up there. Would you play in the creek there as well?

A. Yes.

Q. Did you ever play in that part of the creek?

A. Yes, we played ditch, 'em, we ranged over the whole thing. There is a lot of woods in these areas. It is an older neighborhood.

Q. Into the creek itself?

A. Yes, or jumping across it. If you got it on you you do a lot of wiping of the sludge off. I was just part of life. We just accepted it. There used to be I guess about seven houses up in here and they dismantled them or razed the homes because of the gasoline smell in the basements.

Q. When you were a young kid did you ever talk about the gasoline in the creek or the petroleum in the creek or the sheen with any of your friends?

A. I just figured my brothers asked the questions and I just went along. It was just an accepted part of the neighborhood. Nobody ever talked about it.

Q. Did your folks ever tell you not to play in that area or anything?

A. We would get our asses whooped if we came home smelling. They would have known if we would have go into that area. Most of the time we just jump over the creek and go play. We had forts build there. There is still a depression right up above this feeder creek where we had, that's the Norledge bridge, approximately right here there is still a pit and we would cover it up with boards and put earth on it and we would play Army and that was our bunker.

Q. It was kind of like a fort or bunker?

A. Yes.

Q. Did you ever have any understanding that the substances in the creek, the gasoline in the creek was not healthy?

A. We don't know anything about it. Nobody told us. We just accepted it. It was part of living next to a refiner. We would play up to midnight they would have 30 foot flames coming off of the derricks down there. It would be like daylight in the middle of the night.

Given that benzene was known to be present in the creek, soils, and groundwater, and the fact that Mr. Hedrick played in/near Sugar Creek, dermal and ingestion exposures were likely yet have not been quantified in this exposure analysis.

Smoking Exposure:

Mr. Hedrick reported beginning to smoke in 1967 or 1968. He smoked a pack a day or less from this time until he quit in 1980. In 1984 he began smoking again. For the first year, his smoking level increased to about half a pack a day and then from about 1995 to 1990, he smoked about one pack per day (Exhibit 1, pgs. 153-157).

Thus, at the most, he smoked a pack a day for 13 years (1967 to 1980) prior to his diagnosis.

Based on data and calculations summarized in Tables 7-9, Mr. Hedrick's benzene exposure from smoking was calculated to be 0.55 PPM-YRS.

Table 7: Referenced Levels of Benzene in Cigarettes

Filtered/Non Filtered	Benzene (μ/cig.)	Reference
Filtered	63.7	<u>References:</u>
Non-filtered	51.5	Carletti R et al, 2002, Assessing Health Risk from Benzene in an Urban Area &
Filtered	37.3	Wallace, 1989, Major Sources of Benzene Exposure, Envir Health Persp, 82, pp 165-69
Non-filtered	25.5	
Non-filtered	40	
Filtered	36.7	
Filtered	39.9	
Filtered	<u>39.1</u>	
AVG =	41.71	
	30.0	WHO, 1987, Air Quality Criteria, WHO Regional Office for Europe, Copenhagen
	45.0	Carletti et al, Assessing Health Risk from Benzene in an Urban Area,
	<u>60.5</u>	Environmental Monitoring and Assessment, 80: pp 135 - 148, 2002
AVG =	45.17	

Table 8: Exposure From Smoking Cigarettes

INPUT VARIABLE	VALUE	DESCRIPTION/ UNITS	COMMENTS
Benzene per Cigarette (µg/cig.)	25.5	C _L = Lower Bound	See table above for benzene concentration data
	63.7	C _h = Lower Bound	
Packs Smoked/Day (P)	1.0	packs/day	Input factor
Cigarettes/Pack (CP)	20		
Intake Dose/day =	510	DI _L = Lower Bound	ug/day = (C _L = Lower Bound * packs/day * cigarettes/pack)
	1274	DI _h = Lower Bound	ug/day= (C _L Upper Bound * packs/day * cigarettes/pack)
Absorption Factor (R)	0.5		50% retained by lung; See EPA IRIS for benzene
Absorbed Dose/day =	255	DAD _L = Lower Bound	ug/day = (DI _L = Lower Bound * 0.5)
	637	DAD _h = Lower Bound	ug/day= (DI _L Upper Bound * 0.5)
No Days/yr Smoking=	365	days	Input factor
Total Abs Dose/yr=	93.08	DAY _L = Lower Bound	mg/yr. = (DAD _L = Lower Bound * days /1,000 µg/mg)
	232.51	DAY _h = Lower Bound	mg/yr. = (DAD _L = Upper Bound * days /1,000 µg/mg)
PPM-YRS/YR=	0.024313	Lower Bound	PPM-YRS/Yr (see Table 9 for basis of conversion factor)
	0.060734	Lower Bound	PPM-YRS/Yr (see Table 9 for basis of conversion factor)
AVERAGE=	0.042524	Average of above	PPM-YRS/Yr (Average of upper and lower values)
YRS =	13.0		Years smoking – Input Factor
PPM-YRS=	0.55		PPM-YRS = (AVERAGE * YRS)

Table 9: Equivalent PPM-YRS PER MG/YR – CONVERSION FACTOR

INPUT VARIABLE	DIMENSION	VALUE	COMMENTS
Conc(benz) at 1 ppm = MW/ 24.45	3.19	mg/m3	1 ppm Benzene concentration
FA-Fraction absorbed into lungs from US ATSDR (1993)=	0.5		Fraction of inhaled benzene absorbed
Avg Exposure Time (ETavg):			
hrs/day=	8		
days/wk=	5		
wks/yr=	50		
ETavg=	2,000	hrs	250 days/yr*8 hrs/day
BR-Breathing rate(adult) from EPA Exp Fact Hndbk (1995) = (Adult Male - light activity) - Table 3-21	1.2	m3/hr	
1 PPM Inhalation Abs Dose for 1 Year =	3,828	mg/ppm-yr	=BR*FA*Conc(benz)*ETavg

Closing:

EES appreciates the opportunity to provide these professional services for the Walters Law Firm, LLC. If you have any questions regarding this case, or require further information, please do not hesitate to contact our office.

Thank you,

Stephen Petty, P.E., C.I.H.
President

APPENDIX A

References

American Industrial Hygiene Association. (AIHA). 1997. Odor Thresholds for Chemicals with Established Occupational Health Standards, Fairfax, VA.

Amoco, 1999. Norledge Investigation Report - Amoco Former Refinery – Sugar Creek, Missouri, prepared by ThermoRetec Consulting Corporation (Project # AMO31-03999-310), December 22.

Amoco, 1995. Revised RCRA Facility Investigation Report – Amoco Sugar Creek Former Refinery, Vol. 1, Sections 1-16, prepared by ThermoRetec Consulting Corporation, December 18.

Amoco memorandum from Mr. Kaplan to distribution dated August 22, 1963 (Amoco # 48218 and File # SC078698)

Amoco memorandum from G.S. Van Gorp to T. E. Kupferer dated August 12, 1981 (Amoco # 48218 and File # SC078698)

ATSDR – US Agency for Toxic Substances and Disease Registry (Website: <http://www.atsdr.cdc.gov/interactionprofiles/IP-btex/ip05-a.pdf>), 1997.

Bullock, H. W., and J. S. Ignacio, *A Strategy for Assessing and Managing Occupational Exposures*, 3rd Edition, AIHA Press, 2006.

Deposition of Dr. Peter Infante, Vol. 1, January 10, 2005, Robert E. Scherer and Melanie Scherer v. S&S Automotive, et. al., No. 02L435 consolidated with 02L679.

DiNardi, R., *The Occupational Environment: Its Evaluation, Control, and Management*, 2nd Edition, AIHA Press, 2003.

Dravnieks, A. 1974. A Building-Block Model for the Characterization of Odorant Molecules and Their Odors. Ann. N.Y. Acad. Sci. 237:144-163.

Drinker, P., Yaglou, C.P., and Madeleine Field Warren, "The Threshold Toxicity of Gasoline Vapor", The Journal of Industrial Hygiene and Toxicology, Volume 25, pp.225-232, January 1943 – December 1943.

Egeghy, P.P., Tornero-Velez, R. and Rappaport, S.M., "Environmental and Biological Monitoring of Benzene during Self-Service Automobile Refueling", Environmental Health Perspectives, Vol 108, No. 12, pp. 1195 – 1202, Dec., 2000.

Federal Register, Part II, Environmental Protection Agency, Vol 71, Part 60, Proposed Rules, page 15865, March 29, 2006

May, J. 1966. Odor Thresholds of Solvents for Assessment of Solvent Odors in the Air. Staub 26: 385-389 (English translation of German article)

Mulhausen, J.R. and Damiano, J., *A Strategy for Assessing and Managing Occupational Exposures*, 2nd Edition, AIHA Press, 1998.

Proctor, N.H., Hughes, J.P., and Fischman, M.L., 1988. Chemical Hazards of the Workplace, II Ed., 92, Lippincott, Philadelphia, 1988.

Reid, R. C., J. M. Prausnitz and T. K. Sherwood. "The Properties of Gases and Liquids", Third Edition, McGraw-Hill Book Company, New York, NY, 1977.

Runion, H.E., "Benzene in Gasoline", AIHA Journal, pp. 338 – 350, May, 1975.

USEPA, *Dermal Exposure Assessment: Principals and Applications*. EPA/600/8-91/011B. Office of Health and Environmental Assessment. Washington, D.C., 1992.

Tironi, G., and D. G. Hodgkins. 1991. Compliance with OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL, Appl. Occup. Environ. Hyg., 6(10), October, pgs. 881-884.

USEPA, *Exposure Factors Handbook*, EPA/600/P-95/002A, June, 1995.

USEPA, *Risk Assessment Guidance for Superfund – Volume I – Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*, EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312, July, 2004.

W.L. Nelson. 1958. Petroleum Refinery Engineering, Fourth Edition, McGraw-Hill Book Company, New York, NY.

APPENDIX B

Material Received from The Walters Law Firm

LIST OF EXHIBITS	
Exhibit	Description
01	January 28, 2005. Deposition of Paul Hedrick, Paul Hedrick and Joyce Hedrick, Plaintiffs, vs. BP Corporation North America, Inc., and BP Products North America, Inc., Defendants.
01-A	Retex Map of Sugar Creek Area dated 1/17/05 with markings from Hedrick Deposition.
01-B	Keystone Laboratories, Inc. Analytical Report on water sample results taken on August 5, 1998.
02	March 31, 1989 Letter from James Mansell Jr. to Amoco Corporation complaining of oil leak in rock retaining wall north of his home on Norledge St. in Sugar Creek, MO.
03	Woodward-Clyde Consultants field notes regarding investigation of oil leak mentioned in Exhibit 02
04	April 11, 1989 Woodward-Clyde Consultants (WCC) field report prepared by R. Torrini, Jr., PhD titled "Norledge Street/Sugar Creek Perimeter reconnaissance". Response to Exhibit 02.
05	April 20, 1989 - Wilson laboratories report on BTX levels in samples collected by R. Torrini on April 11, 1989.
06	April 7, 1989 – Telephone Memorandum regarding phone call to WCC concerning oil leak on Norledge St (Mr. Mansell's complaint in Exhibit 02)
07	April 28, 1975 – Complaint by Mrs. Jim Mansell regarding gas fume odor in home (11007 Norledge St. Sugar Creek, MO)
08	April 28, 1975 – Handwritten version of Exhibit 07
09	September 11, 1990 – Letter from LJ Sutton regarding complaint by John Duncan of odor (house on NW corner of Willow Ave. and Norledge St)
10	January 26, 2007 Affidavit of Laurie Reed
11	May 26, 2006 Affidavit of Kim Detel
12	May 14, 1986 – Letter from J.G. Huddle of Amoco to D.A. Wagoner of U.S. EPA regarding accumulation of product in the refinery's subsurface (Walters -Exhibit 04).
13	August 12, 1981. Memo To: T. E. Kupferer, From: G.S. Van Gorop, Re: Volume % Benzene in Gasoline – Sugar Creek.
14	August 22, 1963. American Oil Company, Letter to Mr. W. Kaglan (sp?) Re Benzene Content Vol. % From P.D. Halley (sp?)
15	March 2, 2001. Agostino Deposition Exhibits, Attachment A: 2001 On-Site Investigation Scoping Document, BP Former Refinery, Sugar Creek, MO.
16	May 25, 2002. Agostino Deposition Exhibits, Attachment B: Corrective Measures Study Norledge Area Addendum-Phase 2 Area Redesign.
17	No Date. Agostino Deposition Exhibits, Figure 1: Plume.
18	No Date. Agostino Deposition Exhibits, Figure 2: Arial.
19	No Date. Agostino Deposition Exhibits, Figure 3: Topography.

LIST OF EXHIBITS	
Exhibit	Description
20	No Date. Agostino Deposition Exhibits, Figure 4: 3D-View.
21	March 21, 2005. Off-site Petroleum Hydrocarbon Contamination Resulting from Losses at the Amoco Former Refinery, Sugar Creek, Missouri, by Patrick N. Agostino, Ph.D., P.G.
22	March 18, 2005. Assessment of Contamination in the Norledge Area at the Amoco Refinery in Sugar Creek, Independence, Missouri, Summary of Expert Opinions of Philip B. Bedient, Ph.D., P.E.
23	October 1994. Air Monitoring Results for Former Amoco Refinery, Sugar Creek, MO, 1994, Prepared By David Adelman, Environmental Science Services. SC076475 – SC076512 AMO 46088 – AMO 46125
24	November 12, 1998. Basement Air Sampling Report, Amoco Oil Company, Sugar Creek, Missouri, Prepared by: ThermoRetec Consulting Corp. SC 157154 – SC 157274
25	August 21, 1991. Letter From David Adelman, Environmental Chemist, ESS, to: Mr. Lew Sutton, Field Manager, Amoco Oil Company SC133538
26	Attachment 3. January 27, 1994 – September 9, 1991. Memorandums SC073733 – SC073743 AMO41093 – AMO 41104
27	January 27, 1994. Memorandum, Air Monitoring – Basement of Mr. and Mrs. Fillmore, 215 N. Hardy, From Jim Blaise, Site Superintendent SC015499 SC125404
28	October 22, 1999. Letter from United States Environmental Protection Agency, Robert E. Aston, Corrective Actions Officer, to: Mr. and Mrs. Chappell, 10440 Norledge. SC 164473
29	October 25, 1999. Letter from Pace Analytical, Tena Tiruneh, Project Manager, to Mr. Bill Solberg, Thermoretec, Re: Pace Project Number: 6034686, Client project ID: Chaple Basement. SC 164495 – SC 164505
30	August 28, 1991. Letter from ESS, David Adelman, Environmental Chemist, to, Mr. Lew Sutton, Field Manager, Amoco. SC133538
31	August 5, 1993. Memorandum to: Raier Majewski, Amoco, from: Jay Burns, Ecova, Re: Sugar Creek Refinery Bioremediation Service Contract. SC081771 – SC081778 AMO 51221 – AMO 51228
32	January 20, 2000. Letter from Amoco, Joseph E. Casebolt, Site Manager, to, Denise Jordan-Izaauiire, ATSDR, Region VII. Re: Indoor Air Sampling Results, Amoco Oil Company, Sugar Creek, Missouri SC 167162 – SC 167167
33	March 1991. Air Monitoring Data Sheets, Direct-Reading. SC047211 – SC047238
34	February – April, 2001. Sugar Creek Air Monitoring Report, by Missouri Department of Natural Resources, Division of Environmental Quality, Environmental Services Program. SC 171458 – SC 171578
35	July 23, 2007 Affidavit of Paul Hedrick
36	August 6, 2007. Affidavit of Paul Hedrick. Page 1 - 2
37	November 29, 1974. State of Missouri Division of Employment Security, Division's Record of Wages From 07/01/73 Through 06/30/74. Page 1

LIST OF EXHIBITS	
Exhibit	Description
38	June 25, 1974. Missouri Warranty Deed. Page 1 - 3
39	Wage and Tax Statements for Mr. Hedrick – 1972 to 1977

APPENDIX C

Affidavit – Mr. Paul Hedrick

**IN THE CIRCUIT COURT OF JACKSON COUNTY, MISSOURI
AT INDEPENDENCE**

**PAUL HEDRICK and
JOYCE HEDRICK,**

Plaintiffs,

vs.

**BP CORPORATION NORTH
AMERICA, INC., et al**

Defendants.

**Case No.: 04CV-209360
Division 16**

AFFIDAVIT OF PAUL HEDRICK

STATE OF MISSOURI

)

) ss.

COUNTY OF JACKSON

)

1. My name is Paul Hedrick and I presently reside at 10836 Scarritt, Sugar Creek, Missouri. I have lived at this address from approximately July 1, 1975 to the present.
2. From my date of birth on July 8, 1951 through 1972 I lived at 11100 Scarritt, Sugar Creek, MO.
3. From my earliest age of memory at 5 years of age in 1956 through 1972 I remember the strong odor of gasoline at our residence and throughout greater Sugar Creek 100% of the time.
4. From 1975 through my date of diagnosis on approximately January 1, 1980 I remember the strong odor of gasoline at our residence and throughout greater Sugar Creek 100% of the time.

FURTHER AFFIANT SAITH NOT.


PAUL HEDRICK

STATE OF MISSOURI)
) ss.
COUNTY OF JACKSON)

Subscribed and sworn to before me this 23 day of July, 2007.


Notary Public



APPENDIX D

**August 7, 2007
Telecom With Mr. Paul Hedrick**

APPENDIX E

Summary of Drinker (1943) Study

Summary of Previous Work:

According to a study involving three subjects conducted by the Bureau of Mines in 1921, it was determined that gasoline is a very innocuous substance that will cause different effects on an individual, based on the concentration inhaled. The study results indicate that:

- 700 to 2800 ppm concentrations of gasoline vapor caused dizziness within 14 ½ minutes.
- 11300 to 22200 ppm concentrations of gasoline vapor caused great dizziness in 3 minutes.
- 22200 to 26000 ppm concentrations of gasoline vapor made a man dizzy after 10 to 12 breaths.

In 1927, these experiments were repeated with results indicating:

- 1000 ppm concentrations of gasoline vapor caused mild symptoms of dullness, unsteadiness, and giddiness within 50 minutes.
- 3000 ppm concentrations of gasoline vapor caused slight irritation of the eyes and moderate symptoms of dizziness within 30 minutes.
- 7000 ppm concentrations of gasoline vapor caused coughing, marked irritation of the eyes and nose, numbness in the legs and unsteadiness within ten minutes.

In 1922, O. M. Spencer reported on a group of workers exposed to vapors of whole gasoline while wiping off moving belts with gasoline. According to Spencer's report, complaints in order of frequency involved: eye irritation, headaches, drowsiness, heaviness in the head, and fatigue.

It was concluded by investigators from all three studies that no relation exists between the possible effects of exposure and the quality of gasoline.

Current Work:

In 1942, an experiment was conducted using two gasolines brought out in analysis from commercial colorless lead-free gasoline. The two gasolines were: Commercial Gasoline (100F to 400F cut) and a Light Fraction of Commercial Gasoline (100F to 110F Cut). The study consisted of nine experiments. Seven experiments were carried out in a specially designed room in which the temperature, humidity, and ventilation rates could be accurately controlled. Subjects within the room were exposed to different concentrations of the two gasolines to determine the health effect of exposure at different levels. The final two experiments consisted of the two gasolines being delivered steadily in specific concentrations into an air-line, where it was vaporized through a face mask held by the subject over his/her nose and face.

The following two tables present a summary of each experiment that identifies the test substance used, concentration levels, experiment duration, subject information, noted observations of odor thresholds, noted health effects of exposure and complaints made by the test subjects.

TABLE 1: COMMERCIAL GASOLINE

CONC. LEVELS	EXPOSURE DURATIONS	NOTED OBSERVATIONS	HEALTH EFFECTS
160 ppm (Subjects were exposed to commercial gasoline uniformly distributed through the test areas ventilation system).	8 hours	Detectable odor upon entering area (majority of subjects experienced a loss of odor after 1, 3 and 7 hours). Subjects included 8 women, age 17 to 32.	<u>Examination</u> ➤ Hyperemia of the conjunctiva vessels. ➤ No redness of throat was noted. <u>Complaints</u> ➤ Loss of appetite. ➤ Sickness at stomach. ➤ Headache. ➤ Cough/Throat irritation. ➤ Irritation/Itching of eyes.
270 ppm (Subjects were exposed to commercial gasoline uniformly distributed through the test areas ventilation system).	8 hours	Detectable odor entire duration upon first entering area (one subject experienced a loss of odor after 6 hours). Subjects included 13 men, age 23 to 45.	<u>Examination</u> ➤ Slight hyperemia of the conjunctiva vessels. ➤ Distinct hyperemia of the throat. <u>Complaints</u> ➤ Loss of appetite. ➤ Dizziness. ➤ Sickness at stomach. ➤ Cough/Throat irritation. ➤ Irritation/Itching of eyes.
11,200 ppm (Commercial gasoline was delivered steadily into an air-line, where it was vaporized through a face mask held by the subject over his/her nose and face).	5 to 5.5 minutes (test was terminated voluntarily)	Detectable odor immediately. Subjects included 3 men and 1 woman, age 29 to 45.	<u>Examination</u> ➤ Dizziness. ➤ Incoordination and drunkenness. ➤ Cough and sneezing. <u>Complaints</u> ➤ Severe nose and throat irritation after 20 seconds to 1 minute.

TABLE 2: LIGHT FRACTION OF COMMERCIAL GASOLINE			
CONC. LEVELS	EXPOSURE DURATIONS	NOTED ODOR OBSERVATIONS MADE BY SUBJECTS	HEALTH EFFECTS
140 ppm (Subjects were exposed to a light fraction of commercial gasoline uniformly distributed through the test areas ventilation system).	8 hours	Detectable odor upon entering area. ➤ Described as gasoline by 8 of 10 subjects. ➤ Described as some sort of disinfectant by 2 of 10 subjects. Subjects included 10 college girls, age 17 to 22.	<u>Examination</u> ➤ N/A <u>Complaints</u> ➤ Slight sickness at stomach. ➤ Slight headache. ➤ Slight cough/throat irritation. ➤ Slight drowsiness. ➤ Slight irritation/itching of eyes.
150 ppm (Subjects were exposed to a light fraction of commercial gasoline uniformly distributed through the test areas ventilation system).	8 hours	Detectable odor entire duration upon first entering area. ➤ Described as weak by 5 of 8 subjects. ➤ Described as strong by 3 of 8 subjects. (Four subjects experienced a loss of odor. Three after 2 hours and one late in the afternoon). Subjects included 8 women, age 17 to 32.	<u>Examination</u> ➤ N/A <u>Complaints</u> ➤ Loss of appetite. ➤ Sickness at stomach. ➤ Headache. ➤ Cough/Throat irritation. ➤ Very slight irritation/itching of eyes.
500 ppm (Subjects were exposed to a light fraction of commercial gasoline uniformly distributed through the test areas ventilation system).	1 hour	Detectable odor entire duration upon first entering area. ➤ Described as weak by 3 of 9 subjects. ➤ Described as strong by 2 of 9 subjects. ➤ 4 of 9 subjects made no comments. Subjects included 9 men, age 23 to 45.	<u>Examination</u> ➤ N/A <u>Complaints</u> ➤ Headache. ➤ Cough/Throat irritation. ➤ Irritation/itching of eyes.
900 ppm (Subjects were exposed to a light fraction of commercial gasoline uniformly distributed through the test areas ventilation system).	1 hour	Detectable odor within area (one subject indicated that the odor was stronger than previous day but other five subjects could not detect same). ➤ Described as strong by 4 of 6 subjects. ➤ 2 of 6 subjects made no comments.	<u>Examination</u> ➤ Dizziness and unsteadiness <u>Complaints</u> ➤ Dizziness was not experienced, however, two subjects the following morning experienced unsteadiness of gait and uncertainty in driving.

TABLE 2: LIGHT FRACTION OF COMMERCIAL GASOLINE

CONC. LEVELS	EXPOSURE DURATIONS	NOTED ODOR OBSERVATIONS MADE BY SUBJECTS	HEALTH EFFECTS
system).		Subjects included 6 men, age 23 to 45.	➤ Slight nose/throat irritation. ➤ Slight irritation/itching of eyes.
2600 ppm (Subjects were exposed to a light fraction of commercial gasoline uniformly distributed through the test areas ventilation system).	1 hour	"Very Strong" Detectable gasoline odor upon first entering area but strength could not be estimated (one subject experienced a loss of odor after 6 hours). Subjects included 5 men and 1 woman, age 23 to 45.	<u>Examination</u> ➤ Mild intoxication. ➤ Small amount of muscle incoordination. ➤ Difficulty accurately reading gauges. ➤ Light-headedness with no headaches or disagreeable sensations. ➤ No unpleasant after-effects. <u>Complaints</u> ➤ Dizziness without mark incoordination. ➤ Sickness at stomach (one subject left room due to nausea after 13 minutes). ➤ Cough/Throat irritation. ➤ Irritation/Itching of eyes (was experienced at beginning of experiment but rapidly disappeared). ➤ Two subject reported tasting and smelling gasoline the following morning.
10,700 ppm (A light fraction of commercial gasoline was delivered steadily into an air-line, where it was vaporized through a face mask held by the subject over his/her nose and face).	2 to 7.1 minutes	Detectable odor immediately.	<u>Examination</u> ➤ Dizziness and visible unsteadiness was observed within 4 minutes. ➤ In-coordination and drunkenness. ➤ Two subjects were distinctly hilarious and very active. ➤ Acute effects appeared to wear off in a short time with no objectionable after-experiences. <u>Complaints</u> ➤ Severe nose and throat

TABLE 2: LIGHT FRACTION OF COMMERCIAL GASOLINE			
CONC. LEVELS	EXPOSURE DURATIONS	NOTED ODOR OBSERVATIONS MADE BY SUBJECTS	HEALTH EFFECTS
		Subjects included 4 men, age 37 to 45	irritation after 2 minutes. ➤ Incoordination and drunkenness occurred in three subjects within 4 to 5 minutes and one subject within 7 minutes 10 seconds.

(Drinker, P., C.P. Yaglou and Madeleine Field Warren, 1943. "The Threshold Toxicity of Gasoline Vapor", The Journal of Industrial Hygiene and Toxicology, Volume 25, pp.225-232, January 1943 – December 1943.)

APPENDIX F

Benzene Content of Gasoline – Literature Values

BENZENE CONCENTRATIONS IN GASOLINE BY YEAR

YEAR	% BENZENE	REFERENCE
1974	<1	(Runion, Howard E.; "Benzene in Gasoline", American Industrial Hygiene Association Journal, Vol. 36, p.338, 1975.)
1975	<2	(Runion, Howard E.; "Benzene in Gasoline", American Industrial Hygiene Association Journal, Vol. 36, p.338, 1975.)
1976	.54 – 2.39	(Runion, Howard E.; "Benzene in Gasoline", American Industrial Hygiene Association Journal, Vol. 36, p.338, 1975.)
1977	>1	(Testimony of R.J. Comeaux, July 11, 1977, Vice President of Gulf Oil Company)
1977	1.1 - 4	(Testimony of R.S. Proctor – Chevron - before the OSHA committee reviewing the proposed revised permanent standard for occupational exposure to benzene on July 11, 1977 – OSHA Docket H-059)
1977	0.86	Mobile Premium Gasoline - (Memo from W. F. Hergrueter to P.R. Carl dated October 4, 1977. Source Monitoring of Marine Emissions of Benzene, Technical Service Laboratories, Mobil Technical Center, Princeton, N.J.)
1978	0.2 – 4.8	(McDermott, H.J. and S.E. Killiany, Jr.; "Quest for a Gasoline TLV", American Industrial Hygiene Association Journal, Vol. 39, pp. 110-117, Feb. 1978.)
1981	3.2, 3.3 and 5.4%	Amoco memorandum from G.S. Van Gorp to T. E. Kupferer dated August 12, 1981.
1988	4	AMOCO Oil Co.- AMOCO Regular Leaded Gasoline Material Safety Data Sheet, – 9130-00-264-6218, http://hazard.com/msds/f2/bgw/bgwpv.html
1988	2.7	Regular – Leaded Gasoline, (Letter from R.E. Green to C.F. Grimmer, Shell Oil Company Interoffice Memorandum, February 29, 1988, Table III, p. 6)
1988	1.30	Regular – Leaded Gasoline, (Letter from R. K. Jones to D. E. Eitel, Shell Oil Company Interoffice Memorandum, March 28, 1988, p. 1-2)
1988	3.0	RU-2000, (Letter from R.E. Green to C.F. Grimmer, Shell Oil Company Interoffice Memorandum, February 29, 1988, Table III, p. 6)
1988	1.21	RU-2000, (Letter from R. K. Jones to D. E. Eitel, Shell Oil Company Interoffice Memorandum, March 28, 1988, p. 2)
1988	2.8	SU-2000, (Letter from R.E. Green to C.F. Grimmer, Shell Oil Company Interoffice Memorandum, February 29, 1988, Table III, p. 6)
1988	1.10 – 1.58	SU-2000, (Letter from R. K. Jones to D. E. Eitel, Shell Oil Company Interoffice Memorandum, March 28, 1988, p. 1-2)

YEAR	% BENZENE	REFERENCE
1988	2.55	SU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	5.29	RU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.91	Shell Regular, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.25	SU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	5.42	RU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.84	Shell Regular, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	2.96	SU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.65	Shell Regular, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	2.96	SU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.64	Shell Regular, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.86	SU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.63	Shell Regular, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.90	SU2000, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1988	4.64	Shell Regular, (Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14)
1989	2.1	(Page, Norbert P. and Myron Mehlman; "Health Effects of Gasoline Refueling Vapors and Measured Exposures at Service Stations", Toxicology and Industrial Health, Vol. 5, No. 5, pp. 869-890, 1989.)
1989	3.2	(Air Force, Chemical and Physical Information, Table 3-3 Major Components of Gasoline, 1989)
1990	0.95	http://www.chevron.com/prodserv/fuels/bulletin/fed-refm/rfq-char.shtml
1991	1.35 – 1.70	Premium Gasoline - (Tironi, Gene and D. G. Hodgkins. 1991. <i>Compliance with the OSHA Benzene Permissible Exposure Limit</i>

YEAR	% BENZENE	REFERENCE
		(<i>PEL</i>) at the Gasoline Vapor <i>PEL</i> , Appl. Occup. Environ. Hyg., Vol. 6, No. 10., pp. 881-884, October)
1991	1.38 – 1.73	Regular Gasoline - (Tironi, Gene and D. G. Hodgkins. 1991. <i>Compliance with the OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL</i> , Appl. Occup. Environ. Hyg., Vol. 6, No. 10., pp. 881-884, October)
1991	0-5	(Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pgs. 3-8).
1991	<5	Recovered Gasoline, Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 4
1993	1 - 5	(Employee Benzene Exposure Assessment Summary Report Barge Operations, Bruce B. Crowell, Ashland Petroleum Company, April 1, 1993)
1993	4	AMOCO Oil – Regular Lead- Free Gasoline – Gasoline, Automotive Material Safety Data Sheet, http://home.att.net/~weltanco/msds/gasoline.htm
1994	1.6	http://www.ec.gc.ca/energ/fuels/reports/benz_99/benz_1999_e.pdf
1994	3.5	http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/fr309.pdf
1995	1.4	http://www.ec.gc.ca/energ/fuels/reports/benz_99/benz_1999_e.pdf
1995	2	http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/fr309.pdf
1996	1.6	http://www.ec.gc.ca/energ/fuels/reports/benz_99/benz_1999_e.pdf
1997	1.5	http://www.ec.gc.ca/energ/fuels/reports/benz_99/benz_1999_e.pdf
1998	1.6	http://www.ec.gc.ca/energ/fuels/reports/benz_99/benz_1999_e.pdf
1998	1	http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/fr309.pdf
2005	0.1 - 4	http://www.kemi.se/kemamne_eng/benzen_eng.htm
	1.2 to 4.9	http://www.prod.exxon.com/exxon_gas/conv-exxon.html