

OUTLINES OF OPINIONS

Amoco Sugar Creek Refinery Cases

By

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Plaintiffs: Lon Walter's Sugar Creek Plaintiffs

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

Scope of Work:

Energy and Environmental Solutions, Inc. (EES) appreciates the opportunity to review this interesting case.

My evaluations and opinions are focused on:

1. The extent to which the refinery knew about migrations of hazardous chemicals produced or processed at the refinery off their property into the surrounding community.
2. The extent to which the refinery was operated without due regard for control of environmental hazards, which were known, or should have been known, to exist as a result of operation of the facility.
3. History of resistance to, and non-compliance with, environmental regulations.
4. The extent to which the refinery knew, or should have known, about the environmental health hazards of benzene.
5. Assessment of Risk Assessment (RA) results provided to this expert.

Introduction:

The Sugar Creek, MO neighborhoods, where the plaintiffs lived, were located primarily to the south 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, is located at 1000 North Sterling Road, in the City of Sugar Creek, Missouri, and was opened in 1904. The refinery occupied approximately 500 acres on both sides of Sugar Creek, along the Missouri River. The refinery closed in 1982. Dismantling began in 1986 and was completed in 1991. Storage tanks in Gerber Tank Farm are still used as a product storage and transfer facility. 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 has a population of 3,982 in 1990; is located in Jackson County on the Missouri river, is located east/northeast of Kansas City, Mo., and is located at 39°08'N 94°24'W

As early as 1908, City of Independence, Missouri, a water plant official 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 early as March 6, 1950,

internal American Oil Company (later Amoco and now BP-Amoco) correspondence notes 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 that residents were 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. A considerable amount of oil apparently remains in the ground. 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.

In forming these opinions, I have reviewed Exhibits received to date from the offices of Mr. Lon Walters (Appendix A). 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 center on the following five major areas:

1. Amoco was aware that these hazardous products, including benzene containing gasoline, were present in the Sugar Creek neighborhoods, where the plaintiffs lived and played for over 50 years. In fact, based on a 1920 court case, officials at the refinery have been aware for over 85 years that their discharges to Sugar Creek were negatively impacting nearby communities. Based on company documents, little was done to effectively mitigate the exposure until the Clean Water Act (CWA) was promulgated in 1972 and the Resource Conservation and Recovery Act (RCRA) was promulgated in 1980.
2. The oil releases were the result of poor design, maintenance, and training policies and procedures practiced by the Sugar Creek refinery.
3. Amoco continuously violated environmental regulations, which exposed residents to hazardous chemicals.
4. The Amoco Sugar Creek facility continuously discharged hazardous chemicals, including human carcinogens, such as benzene, to the environment. As a result of these discharges, AMOCO knew, or should have known, that they were exposing their workers and the general public to the hazards associated with these products. The presence of these hazardous products in creeks, ditches and seeps, for at least 50 years, resulted in significant contamination of waters (surface and ground) and soils.
5. Benzene and lead levels, associated with the released oil, were quite high, since the oil was likely premium leaded gasoline. As a result of their inaction to these releases, Amoco seriously impacted the local community by polluting their land, water and air. This posed significant risks to children and adults playing in, and living near, these releases of oils, such as gasoline.

Support for Opinions #1:

As summarized in Table 1, AMOCO has a long recorded history in the 1900s, 1910s 1920s, 1950s, 1960s, 1970s, 1980s and 1990s of significant releases of petroleum into the neighborhood waters and soils, where the plaintiffs lived and played. Specific opinions regarding certain documents are opined as italicized comments within brackets (*opine*).

Table 1: Information Supporting Position the Amoco Knew, or Should Have Known of Oil Releases From the Sugar Creek Refinery was Impacting Sugar Creek Residents

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
1908 to 1920	January 23, 1920. Affidavit of H. A. Gallagher.	From deposition by H. A. Gallagher...and since in the year 1908, has been continuously the superintendent and manager the Independence Waterworks Company's operations: "Affiant further states that he is familiar with...and for a large part of the time since 1908, several times weekly, observed and seen the locations and topography above mentioned on and along the Missouri River and the small tributary thereof known as Sugar Creek, and the Standard Oil Company's Oil Refinery plant at and about the mouth of Sugar Creek and the operations thereof; that for several years the waste products from such Oil Refinery plant have been cast and discharged into the waters of the Missouri River directly and also through Sugar Creek so as at times to cause the water thereof at and near the mouth of Sugar Creek, and especially recently at low stages and in frozen condition of the River, to show and exhibit smell and taste of oil and other substances and to be unpalatable..." Affiant further says that recently said discharges of and from said Oil Refinery appear to have been increased and to be in larger quantities, but whether so increased or not lately, within the last two months, and especially during the severe cold weather occurring in December, 1919, and since at times, and frequently, such water has not responded to treatment and was at times incapable of being rendered free of the disagreeable taste and smell caused by reason of such oil waste and disagreeable by-products from the Standard Oil Refinery cast and discharged into such river by way of Sugar Creek, as stated in such other affidavits; and herein stated...."	181
	January 21, 1920. Affidavit of R. E. Duffy.	"Affiant states at both such times he observed flowing from Sugar Creek in the waters thereof an oily discharge on the surface of the water and on January 7, 1920 a milky substance disseminated through the water, such milky substance appearing principally at the mouth of Sugar Creek and a short distance towards the sewer outlet therein, and in the river channels below the mouth of Sugar Creek, and observed on the banks the discolorations and deposition of oily substances. Affiant further states that the samples taken on January 7 and 20, 1920, from Sugar Creek at and below the sewer outlet into the same and in the channels at and around the bars, above mentioned, including that at the intake pipe, had a disagreeable oily odor, and the samples taken at the pier above the mouth of Sugar Creek did not have such odor. Affiant further states that as a result of his said examinations of the ground and the topography of the locations mentioned and of the water samples above mentioned that he, this affiant, is decidedly of the opinion that the disagreeable odor and taste of the water taken from the river by the Independence Waterworks Company at its pumping station and intake pipe is caused by the discharge into Sugar Creek, and thence into the river, of waste products and substances from the aforesaid oil refinery and especially by the discharge from the appliances or structures known as the agitators, which to all appearances are large and permanent metal tanks or structures holding each thousands of gallons of oil and used for treatment of oil therein".	180
	January 22, 1920. Affidavit of Roy Cross.	"...and took a sample of such Sugar Creek water at the point of sewer discharge into it from such oil refinery plant of the waste products there from, especially the waste products from the part of such plant known as the agitators, which are large tanks in which oil is treated for the	179

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	January 21, 1920. Defendant's Affidavit, Moffett January 17, 1920. Jackson County Circuit Court, Independence Waterworks Co., V. Standard Oil Co., et al	separation and manufacture of gasoline, kerosene and other merchantable parts thereof, and affiant found such sample to contain such large and observable quantities of noxious and disagreeable substances, being principally sulphonated oil, the same but in less diluted form as found in the Missouri River waters flowing in the channels aforesaid and contained in the samples tested and examined as aforesaid. Affiant further states that in his opinion, as a chemist of experience, the condition of the Missouri River waters at the intake pipe of the Waterworks Company pumping station and the disagreeable and obnoxious features thereof, above mentioned, are caused wholly by the discharge of waste products, above mentioned, into Sugar Creek at and near the mouth, thereof, as aforesaid. ...But that recently, as above stated, owing the formation of the bars and lessening of the volume of water flowing to and by such intake pipe, the pollution of the Missouri River waters by such substances, discharged by and from the oil refinery, has frequently polluted and rendered disagreeable the waters, as aforesaid, with substances of that character not practically removable by water companies, and especially is this true in cold weather such as occurred in the month of December, 1919..." "George H. Moffett...says that he is one of the defendants in the above entitled cause and is the manager of the Standard Oil Company at Sugar Creek Missouri in charge of the properties involved in this controversy..." That it is not true that the Standard Oil Company, in the operation of its said Plant, is contaminating the water of the Missouri River." "Wherefore, plaintiff prays that by the judgment and orders of this Court the defendants and each of them, and their servants, agents and employees be enjoined and restrained, both temporarily and permanently, from further continuing to discharge or cast or put into the waters of the Missouri River any deleterious or obnoxious wastage and discharge from said refining plant..." <i>(Testimony details fact that the refinery was contaminating Sugar Creek since 1908 and that the refinery denied, despite the evidence, responsibility for contaminating such waters).</i>	178 177
March 6, 1950	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I Erickson, March 20 1966 - American Oil Company, Letter from I Erickson to Mr. J.N. Roper. Subject: Oil Leak South of the Refinery	The first note of an oil release impacting the Norledge area is a historical reference indicating the refinery's Engineering Division was requested to investigate "oil noted in a spring on Burton Street, approximately 300 feet south of Norledge Street" on March 6, 1950. Amoco's initial conclusion was that the oil was "coming from an unknown source outside the refinery." "Usually when a leak was found and repaired the oil flow would be curtailed until another leak occurred."	131 132
1950s to 1970s	J. Studer, interview with Dr. Lenard Sorg on December 4,	According to Dr. Sorg the strip of ground between the aerated lagoon and the Missouri River was used (from the start up until the lagoon was constructed) as the dump site for all wastes	30

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	1986	generated. Dr. Sorg remembers most clearly the asphalt-tar residuals. It is reported that four pits of shallow construction (five feet depth or so) were located between the river water intake bay and the approximately two-thirds section (beginning on the west end) of the then nonexistent lagoon (see map A). These pits were filled with all process wastes from the facility. Dr. Sorg remembers the soil being saturated with the asphalt tar and sludges. The soil was reported to be hardened by the waste materials, possibly providing some resistance to downward migration of wastes dumped on top. In fact Dr. Sorg remembers two floods occurring over the period which washed away much of the waste dumped in the pits, leaving the hardened soils exposed. The Lower Refinery Separator Box, dismantled in the 1950s, was located where the No. 1 Pipe Still is located. Actually, Dr. Sorg noted that two boxes were connected together by piping (see map B). The construction was wood, it was an original structure according to Dr. Sorg. He reported that this separator leaked heavily and continuously. The ground was always saturated causing what he believed were large underground pools of oil. Some soil beneath the separator was excavated and replaced with sand for the foundation of the No.1. Pipe Still. The Crawford Plant Separator Box, decommissioned in 1950 when the fluid Catalytic Cracker Unit (FCU Plant) was constructed, was also of wood construction. This unit was reported to have leaked heavily and constantly; the ground was always saturated. He remembers oil always leaking into the Sugar Creek as it issued from the banks of the creek. This box was replaced when the West Plant Separator Box was installed in 1950. The West Plant Separator Box did not leak according to Dr. Sorg. The Agitator Treating Plant was located on the east side of the refinery just southeast of the No. 1 Pipe Still but across the north-south trending road. This was reported to have been an area where spillage and leakage was especially severe. The soil was always soaked. The agitator tanks were tall with conical shape bottoms which were often opened by workers allowing streams of product to escape and run down the hill towards the pit area. The agitators treated for mercaptans. Dr. Sorg mentioned the use of leaded pipe with sulfuric acid. Acids were used for "additional" treatment. Dr. Sorg felt that the soil at this location would be highly contaminated with oil and lead. Dr. Sorg believes that each tank began leaking within two or three years of being installed. The bottoms apparently developed cracks. It was reported that common practice was to put water in the tank as well as product. The product would float on top of the water layer. At certain times caustic would be put in the tanks. <i>(Misses point that dissolved chemicals such as benzene would leak out with the water.)</i> Dr. Sorg stated that all pipes, fixtures, etc. leaked somewhat sometime. The only accidental spill that Dr. Sorg remembered was the Tank 131 spill. He said this was the major spill over the 40 year period 1940 to 1970. The incident occurred 1962-1965. A workman opened up the drain valve to tank 131 which at the time contained caustic with a sodium mercaptan compound. He was uncertain as to whether petroleum product was in the tank at the time of spill. The spill containment dike drain valve was open as well. Three feet of caustic flowed over the ground to Sugar Creek, according to Dr. Sorg.	

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		The No. 2 Pipe Still (Asphalt P.S.), once located just west of the Crawford tract separator box (refer to map A), had some spillage, yet the asphalt stayed at or near the ground surface. The Norledge recover ditch was installed in the 1950s or 1960. Dr. Sorg felt that this ditch was not very effective. Their main concern, however, was leakage off the bluffs. The built a ditch to carry seep oil and water from the base of the bluff near the railroad to the Sugar Creek. It is reported that three water supply test wells were drilled near the No. 1 Pipe Still in the 1960s. The sought after water would have been primarily used by the power plant. These wells would have been primarily used by the power plant. These wells are reported to be capped. It is reported that these wells were drilled to approximately 1100 feet, to the same approximate water bearing horizon as that used by the city of Atherton, located across the river from the refinery. Water samples were tested, and it is reported that the quality was not adequate for its intended purpose." <i>(Very good insights into practices and situations at the refinery during the 1950s through the 1960s)</i>	
1950 to April 13, 1964	Unknown Amoco memo dated April 13, 1964	Investigations in connection with oil seepage into the drainage ditch south of Norledge Avenue outside of the refinery were started by the company in 1950. During the next seven years extensive work was carried on to locate the source and to control the oil seepage. During 1957 a geologist was employed to review the exterior exploration work that had been done and to make an independent investigation of the oil seepage problems...Two deep sumps, equipped with float operated (not legible), were installed (not legible) the refinery along the south property line to trap and remove underground oil before it reached outside property. In 1960 an interceptor cover was built about 10 feet outside of the south line of the plant along Norledge Avenue. This perforated tile cover, about 20 feet deep located at the rock ledge line, collects ground water and oil and directs the flow to a 30ft deep sump. All flow into this sump is received and transferred to the plant sewer system by an automatically operated sump pump. This arrangement corrected the oil seepage problem until early this year. This February, after oil was found trapped at various points in the drainage ditch, immediate stops were taken to remove the oil by water flushing the ditch. A 36 inch culvert under Norledge was extended 110 feet to enable refinery water to be used as a reliable source of water for flushing under refinery control. Daily water flushing has kept the creek free of oil accumulation. At this time further investigation was started to find the source of the seepage. A piping leak was found which may have been the source of the oil seeping in the ground. A flowing spring at the bend of one of the branches of the rain drainage ditch is the point where most of the oil seepage has recently been apparent....In the past six weeks there has been a steady reduction of oil in the spring flow and at present the water samples taken show less than 10 ppm of oil.	54 135
1950 to April 6, 1964	"Petition to the Missouri Health Department" April 6, 1964 [petition].	"We the undersigned would like for you to look into a matter which is of great concern to us. The seepage of gas and oil is from the American Oil Company at the Sugar Creek Refinery. The seepage is along the South boundary of the refinery along Norledge Street. This seepage is coming through underground springs and out into a natural drainage ditch along Burton St. We have seen this seepage for 10 – 14 years. The last time the Refinery attempted to do something about it was in 1959 and 1960. The smell from this seepage at times is unbearable.	81

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		We consider this to be a fire and health hazard and nuisance to the neighborhood." <i>(Problem recognized by residents back as far as 1950; health concerns at that time.)</i>	
1950 to July 20, 1965	B.T. Allison, Amoco memo to N.T. Robey, July 20, 1965	Since 1950 we have had a recurring problem at Sugar Creek with oil contamination of a natural spring which flows from the bank of a drainage ditch at a point about 300 feet south of the refinery. The spring flow and other oil and water seepage from this north back in this area drain into the ditch which empties into Sugar Creek outside of the refinery. The spring flow and adjacent seepage varies from 2 to 6 g.p.m. and the oil content from 0 to 25 per cent. Maximum oil flow has been .88 g.p.m. During five periods since 1950 the residents in the immediate area and workers of the Sugar Creek City Council have complained about the strong gasoline odor, gasoline fumes in basement drains, and fire hazard from the oil collecting in the ditch and creek. The present series of neighborhood and city complaints, which began early this year, have not stopped as in other years when we were able to eliminate the oil leakage to the spring by various repairs and the construction of intercepting systems within the refinery. The attached drawing SB-11137 shows the location of the spring, intercepting facilities, and the gasoline tanks and their associated piping which are involved in the problem. A geological survey made by Pan American in 1957 indicates various rock formations from 20 to 25 feet below the surface which transmit ground water and oil leakage flowing from the tankage area south the spring and drainage ditch. The rock formations contain cavities or solution channels which, according to the geological report, trap and create underground reservoirs of oil. Each time that oil shows in the spring flow we have attempted to find the source by testing tanks and lines and in a few cases have found insignificant tank leaks and several significant line leaks. Early this year, despite oil recovery by the intercepting facilities, the spring showed oil again, reaching the maximum of 25 per cent or .86 g.p.m. in February. Extensive borings to rock were made along the south fence line to obtain data for locating several 6 inch cased wells. Three wells have been in operation for several months pumping a total of 20-30 g.p.m. of water containing approximately 4-5 per cent oil. <i>(Note that oil is likely gasoline.)</i> The oil content of the spring has receded to about 7 per cent or .15 g.p.m. Even this amount of oil still produces a fairly strong gasoline odor at the spring. In 1960 when we installed the interceptor sewer we also acquired 34 lots south of the refinery as shown on the drawing. Other lots were considered, but because of price or other reasons, they were not purchased. You will note that the spring and other seeps are on lots 337, 338, 339, 340 and 341, which we do not own. ... Even though our efforts may again be successful in stopping the oil flow to the spring we believe the problem will recur as in the past. It is essential that we have the facilities outside the refinery to handle the spring flow and collect any oil that may escape underground from the refinery. The present complaints have not subsided and there have been threats of legal action against the company if the situation isn't corrected. Regardless of the success of any future efforts to reduce leakage within the plant, we believe that we should acquire 6 lots 337 – 342. May we have your approval to start negotiations for the purchase of this property.	31

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1951 to 1958	Deposition of John C. O'Renack, Volume 1 August 7, 1996	Q: To your knowledge, have there been spills, leaks, discharges or releases of oil into the environment at or around the Amoco property? A: Yeah. Q: When did those occur? A: Well, in my employment down there from September of '51 through just prior to the strike in '58, I worked in many different capacities. I worked in the engineering department down there,...That pump station pumped crude product to 12 towers which was a complex of 12 stills, it pumped crude to 16 towers which was a complex of 16 stills, 8 of the crude variety and 8 of the continuous operation, to the pipe still that was located in the bottoms and to receiver tanks down there that received the crude and then went from the tanks to the refining units. A: ...That whole area down in through there where the piping was had leaked for years. The pipe gang maintenance people were in there almost constantly repairing broken lines, putting clamps on them. Later on in the time they finally got tired of repairing the leads so they just – in fact, when I worked I the engineering department, I prepared some blueprints to sent to Chicago one time with that entire manifold on it because they were studying what to do to replace that leaky system that existed there. The receiver tanks that were there had water product in them. Q: We're still talking about the northeast part of the refinery? A: Yeah, down close to the railroad tracks. And these tanks had water on the bottom of them and they had some men that they called water drawers and they'd take a long stick or a pin and go along and open and crack the valve on the bottom and allow the water to drain out because it was at the bottom of the tank. And sometimes if they didn't bet back in time, why, oil would also come out into the drainage ditch on the ground. A:...Having worked in there, there were a number of locations throughout the refinery where product was on the ground, specifically in some tank rings which was a confinement or impoundment around the tank to try to hold portions of contents of it. Worked in about every phase of operation that they had at the refinery, but, yes, there have been spills and leaks. Q: The leaks that you were initially referring to that I think you said were being repaired, is that right? A: As the pipes would leak into the ground, after so long a period of time when the ground was saturated, then they would come along and they'd put a clamp on it to try to stop it, but it got to where some of those lines were just one series of clamps, and when it gets that far, I mean there was no – easiest and quickest way for repair. Like I said, they eventually abandoned all of those underground lines and moved that piping system above ground. Q: The clamp was the patch? A: Yeah. When the line cracked, there was a clamp, and it came in two pieces and it had a hinge like at the bottom...It was kind of a Band-Aid approach is what it really boiled down to. Q: Was there any other way in which you, when you were mayor, obtained direct knowledge about the condition of the Amoco property? A: I think one notification that we got from them was the Norledge Street location where Amoco had went beyond their refinery limits and put in a pump to intercept what was evidently leaking	108

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		out of the refinery area. At that time they notified us that it was there as a precautionary measure, if anything went out, that this pump would send it back, that they really weren't getting anything but water. And so basically the only information we had was what Amoco gave us. He notes that the community is being "snowed" by Amoco: A: ...after '84 when I started working in it, yeah, things are fine, things are fine. It's '96 and we're still in that mode, so that's why I'm telling you that we don't have all the information, we – as far as extent is concerned with this whole thing, we don't have all the information available on what it's going to take to finish the cleanup, but we're ready to move forward, you know.	
September 1953 to 1964	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I Erickson, March 20	"Again asked to determine the source of the oil that appeared on the surface of the branch south of the refinery at the spring." Drilled 54 holes to rock in the areas east and around Tanks 158, 159, 160, 176 and 177. No recoverable oil found, but subsurface oil was found in a low area sump. Drilled another 43 holes, smelled a "gaseous odor" but could not locate the fault. Several lines severely pitted and corroded and repaired in the area near Tank 152 over this period. Tanks 158, 159 and 160 taken out of service, inspected and tested for leaks. Only "minor" leaks in tank connections were found and repaired.	131
September 1953 to October 27, 1989	AMOCO-RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9. Tables October 27, 1989	Table 2.4-2 documents spill obtained from various records searches over this period. Accumulation of oil on water and oil seeps in the Norledge tributary of Sugar Creek were reported "due to subsurface migration from West Hills leakage" beginning in September 1953. The title page disclaimer notes that the records are likely incomplete.	41
1955 -1975	9/29/75 – Amoco Memorandum from RJ Ferm; Improved Recovery of Norledge Sump Gasoline	Gasoline sump just south of Norledge Street removes gasoline from groundwater at a depth of 25 feet bgs. Memo notes that the groundwater flows beneath the West Plant bluff where processing units and tank farms are located. The memo notes that for 20 years piping and tank leaks have been found and repaired, but "the leakages have persisted." The 1975 sump recovery rate varies from 50 to 200 bls/day. It is recommended that further efforts be made to locate the source of the leakages. The most likely sources are gasoline tanks 158, 159 and 160.	133
March 1957	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I Erickson, March 20	Mr. John F. Harris, geologist of Pan American Corp. hired to investigate oil leaks to Sugar Creeks and concludes that "Oil leakage in this area apparently flow through one or more of these channels (Bethany Falls limestone) to a lower ground water level and emerges in springs along the north bank of the west branch of Sugar Creek." He recommends that several large diameter collecting sumps be dug inside the refinery for the recovery of oil.	131
1962 - 1978	G.R. Helffrich, information (Sugar Creek press release), 1978	Sixteen years ago they built a lagoon to provide secondary treatment for process water returned to the Missouri river. Improved in 1968, it now represents an investment of more than a million dollars. The company is currently (1978) engaged in a multi-million dollar project to improve handling of storm water and to further improve the quality of water returned to the Missouri river. <i>(No secondary treatment of wastes till 1962; knew it was undesirable to discharge oily wastes.</i>	2

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		<i>reported to contain 5 to 15% benzene by volume (Ref. 116, pg. 2-2). Ref. 182 also supports this position that large amounts of vapors were known to have been released into the air by the refinery.)</i>	
1966	1966 Telephone Logs from J.N. Roper	February 17, 1966: "Mayor Randy Roper called me.... Mentioned the creek pollution problem ..gasoline seepage to the spring, etc." March 7, 1966: "Erickson says no change in condition of seepage from spring for several months. Still significant, but we don't feel odor is very bad." March 30, 1966: "Tom McJaynt (?) called to see if there had been any new developments....Told Tom we are "getting by" with no more recent complaints – would let him know if we do – odor." July 5, 1966: Erickson reports oil seepage is low in the dry season after the water table drops, but "there may be more oil released again." August 15, 1966: "Erickson reports we had about four to six weeks essentially oil free (not measurable). However, oil began to appear again about 2 weeks ago and was up to 6% on last check.... Visually, problems continuing indefinitely on intermittent basis." October 26, 1966: "HAS and I agreed that we might try to "hold out" for a little longer to see if oil seepage to spring may taper off." October 31, 1966: " Fire in gully and oil on surface of spring water attracted a lot of attention. Bad publicity!" <i>(Amoco was clearly aware of issue, avoided addressing it and was most concerned with negative publicity.)</i>	164
February 22, 1966	T.J. McJoynt, Manager Real Estate, Field Trip Report, February 22, 1966	Mr. Almann and Mr. Hall had been retained previously by this Company to negotiate for the purchase of certain residential lots and property immediately south of our property in an effort to obtain a buffer zone. In recent years an oil leak has developed on certain of these lots and said leak flows into a ditch which, in turn, flows into Sugar Creek and into the Missouri River. During the course of our meeting Mr. Roper indicated that considerable time and money has been spent by our own people, as well as geological exploration concerns in an effort to locate the seepage leak on the refinery and stop it at its source; however, all such attempts have failed to date. Wells have been drilled near our refinery boundaries on the south side to pump the product out of the ground and a 15 foot perforated sewer has been laid in along the boundary of our property in a further attempt to collect this oil seepage. All of these attempts have not stopped the seepage flow into the drainage ditch on the Fonck property immediately south of the refinery. Analysis of the product seepage indicates that the base is gasoline, and probably premium gasoline. The seepage occurs primarily at low water table and creates considerable odor in the area, as well as an extreme fire hazard. It is my opinion that the ravine which goes to a depth from the street to approximately 15 or 20 feet is, in itself, an attractive nuisance for children playing in the area since the ravine is not fenced off and, with the seepage of gasoline,, further hazards are presented due to the possibility of small children playing in the ravine and possibly starting a bonfire, or striking a match. To reduce the possibility of any extreme catastrophe, the refinery has taken steps to water down the entire seepage area with a spray of water through a pipe system lain on the surface of the ground. There have been several complaints registered by property owners downstream along the creek concerning odors and the dangerous condition resulting from the seepage of the product into the creek. To date, no formal letter has been issued by the city to the company demanding that	32

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		they clear up the situation; however, such a letter may come at any time if the nuisance continues.	
May 12, 1966	May 12, 1966 Letter from L.V. Sorg to I. Erickson regarding oil leaks – West Hill.	Mr. Sorg implies that the refinery is the source of oil found in the spring (Burton spring) and the sump when he writes: “After studying these data, we have concluded that the source of oil feeding the spring is most likely HVN (Ultraformer feed) and is not contaminated with any other stock. The oil feeding the sump appears to come from more than one source. We believe that at least a portion of it is HVN.”	138
October 10, 1966	1966. American Oil Company, Letter from I Erickson to Mr. J.N. Roper. Subject: Oil Leak South of the Refinery	In 1964, the oil content of the spring water reached 25%. “At no time during 1965 was the spring completely free of oil.” Its oil content ranged from 1% to 25%. In October, 1966, the oil content of the spring reached 12%. During the past two years, five product tanks, and their piping, along Willow Avenue have been tested. “Some leaks have been found and repaired. The author notes that installing a line of sheet piling along the south fence of the refinery would “seal the portion of the south side of the refinery which feeds the spring and prevent ground water and any oil it is carrying from leaving the refinery.” Author notes that “oil collects in pools along the branch creating a fire hazard” and that the current solution is to “flush the stream with water. <i>(Again, this would result in strong odors of gasoline reported by residents – See Appendix D for estimates of vapor concentrations above pools of gasoline – Amoco officials knew product was moving offsite, methods to prevent movement offsite were not working and that “sheet piling” should be placed on the southern boundary to prevent such movement offsite.)</i>	132 136
January 6, 1967	January 6, 1967. Letter from J.N. Roper to Mayor Roper regarding installation of ground water collection system along Burton Street.	Amoco requests permission to access City of Sugar Creek property to install a ground water collection system. The attached figure illustrates the location of the seepage areas, the spring, Amoco purchased property and the layout of the proposed system.	145
September 22, 1967 and September 26, 1967	N. Roper memo to R.S. Holcolmb, Facilities for Oil Recovery from West Hill Drainage, September 22, 1967	Last April a pond formed along the Santa Fe tracks when the culvert became partially blocked. The oil which accumulated on top of this pond was ignited from some unknown source and blazed into a fire that attracted wide public attention. This is the main line of the Santa Fe and rail traffic was affected. For a distance of approximately 100 yards, trees were burned, rails bent and signal lines and poles destroyed. Since the fire, this area is inspected regularly for oil accumulation and culvert condition. The present operation presents a potential hazard to Santa Fe trackage and allows oil to get to the Missouri River. The proposed facilities will assure that oil flow from tank drains will be confined within the refinery sewer system. Requisition purpose is to “prevent pollution of the Missouri River.” Remarks point out design problems related to distance between valves and tanks. Note on last page from Mr. Roper to Mr. Holcomb dated 9-26-67 states: “I assume you are aware of the serious situation we propose to alleviate via this appropriation request.” <i>(This note suggests that the refinery is aware of the environmental problems at the refinery.)</i>	33 64

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
November 1, 1967	J.C. Lamkin, Minutes of Conservation Committee, November 1, 1967	The fourth meeting of the Conservation Committee was held on October 25, 1967. Three complaints were received since the last meeting. They are: (A) Complaint of odor of gasoline in basements by residents along Burton Street, 6/28/67. On June 29, Mr. Pete Saxton, City Engineer, City of Sugar Creek, Missouri, asked the refinery to check the sewers along Burton Street. Representatives from the Engineering and Technical Service Division investigated the sewers and found that there was a very slight odor of gasoline but no apparent hydrocarbons in manholes along the street. <i>(How would one know without testing.)</i> Apparently the situation causing the odor problem had cleared up by the time of the investigation. No recurrent complaints were received. This area should be rechecked occasionally to determine that the problem does not exist or reoccur. (B) Odor complaint from 117 S. Chrysler, 10/20/67. The complainant claimed that a gassy refinery-type of odor was entering her kitchen. Because she lives several miles from the refinery, the prevailing winds at the time would have made it unlikely that refinery odors could have reached her residence and there were no other accompanying complaints. It is assumed that the complainant erroneously blamed the refinery. No other action was taken or is required. A seep was found at the east end of the lagoon along the north edge of the settling basin. Although at the moment this seep is of little concern, careful observation of the area should be made in case the seep becomes more serious.” <i>(In general, the language used in the responses seem dismissive...one must question the effectiveness of the committee)</i>	35
August 12, 1968	Letter from L.V. Sorg to H.A. Smith dated Aug. 12, 1968 Norledge Street Oil Recovery	At your request, we investigated the oil recovered in the sump south of Norledge Street. 1. The oil content of the water in the sump was 9 ppm. 3. The water flow was 28 gpm.	88
September 24, 1968	File Memorandum Sept. 24, 1968: Oil Content of Water From Sump South of Norledge	<u>Oil Content of Water From Sump South of Norledge</u> Except for one sample, the oil content was insignificant (<15 ppm)...The volume of water into the sump ranged from about 40,000 gals./day to about 60,000 gals./day. <i>(Except the one sample value was 131 ppm. Demonstrates internal knowledge of oil content in waters from this area and provides an example of understating the problem.)</i>	90
November 5, 1969	November 5, 1969. American Oil Company Memorandum – Details on Our Refinery Loss Prevention Work.	4. Underground Line Leaks Line leaks detected during the quarter were handled as follows: A sizeable gasoline leak was detected and repairs made where a line passes through the firewall of Tank 334. Tank 115...In inspecting the tank while it was out of service, a quarter-inch hole was found in a bottom plate. A Leak was detected in the crude lining entering the refinery in front of Tank 167.” <i>(Significant leaks known and documented at this time.)</i>	182

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #								
		"We are continuing to use our computer program to determine the amount of vapor losses from gasoline storage tanks. September showed a loss of 7,664 barrels of light hydrocarbons into the atmosphere. This confirms the assumed loss from tankage of 0.3 wt. %/ Eighty percent of these losses are indicated to be filling losses, which are eliminated with floating roofs." <i>[Amoco was releasing large volumes (322,000 gallons/month equivalent of vapor) from this area. Assuming this were gasoline, this is equivalent to 184.4 CFM of gasoline vapor and upwards of 9.2 CFM of benzene vapor per minute – a very large number).</i>									
1972 to 1980s	Deposition of John F. Horner, 25 th Day of July 1996	Recalls problems complying with water pollution regulations, including NPDES permit requirements. Noted that "there were some creeks in the area that served as rain water run off for areas probably in the refinery but including outside the refinery and that ended up creating problems for the refinery in handling their pollution permitting problems." (<i>Odd language, appears to almost blame the creek for being present as the cause of the pollution.</i>) Recalls during site visits discussing the fact that leaking product was moving offsite into surrounding areas.	118								
September 12, 1973 to July 17, 1996	Note to LM, with attached list of Amoco Sugar Creek Refinery Oil Spills, July 17, 1996	Comment from Helffrich that "Doesn't look good to someone in agencies" noting the list of over 57 spills from 9/12/73 to 10/2/82 and fines totaling \$21,000. (<i>Recognized spills occurring back to 1973.</i>)	13								
September 11, 1974	C.H. Carver memo, Survey of Oil Leaks on Perimeter of the Sugar Creek Refinery, September 11, 1974	Oil leaks within the refinery from underground lines and tanks gravitate down to the water table level and have appeared at the periphery of the refinery in springs and with the ground water. <u>Bluff North of Refinery</u> Oil seeps out with water from several springs on the side of the bluff north of the West Plant area above the railroad tracks. Via ditches the oil and water are accumulated in a 9-ft. diameter sump north of the road alongside the railroad tracks. Water is continuously drawn from the bottom of the sump and periodically the oil is removed using the vacuum truck. On August 14 and 15 the rate of accumulation of oil in the sump was found to be 73 gallons per day....By simulated distillation the heavy gravity oil appears to be FCU LCCO. The oil is also a source of pollution as the sump overflows during heavy rains and any oil in the sump and runoff frequently goes to the river. <u>Norledge Avenue Sump</u> A sump approximately 25 ft. deep with a French drain is installed on the south side of Norledge Avenue south of the refinery...Laboratory inspection of a sample of oil taken from the sump on September 4 is given in Table II. This sample indicates the leak is finished leaded gasoline, probably regular. The rate of accumulation of gasoline in the sump on September 4 was found to be 157 B/D. Measurements taken during September, October, and November, 1973 gave accumulation rates from a trace to 650 B/D." <table> <tr> <td><u>Leak Source</u></td><td><u>Norledge Sump</u></td><td><u>North Bluff</u></td><td><u>West Skimming</u></td></tr> <tr> <td>Volume of Leak, B/Yr.</td><td>57,300</td><td>634</td><td>1,040</td></tr> </table>	<u>Leak Source</u>	<u>Norledge Sump</u>	<u>North Bluff</u>	<u>West Skimming</u>	Volume of Leak, B/Yr.	57,300	634	1,040	36 60
<u>Leak Source</u>	<u>Norledge Sump</u>	<u>North Bluff</u>	<u>West Skimming</u>								
Volume of Leak, B/Yr.	57,300	634	1,040								

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		Last page of Ref. 60 contains log of oil and water collected in Norledge sump in late 1973. Tank map in back of Ref. 60. <i>(This rate of collection of gasoline at the Norledge sump is huge, approximately 2.4 million gallons of gasoline per year or 4.6 gallons of gasoline per minute. At times this rate was as high as 19 gallons of gasoline per minute)</i>	
April 22-29, 1975	J. Lamkin, EPA, Compliance Monitoring Field Survey, Summary Report, Sugar Creek Refinery, April 22-29, 1975	During rainfall periods, the company procedure is to pump all process and stormwater flows collected in the plant sumps to the lagoons up to the capacity of the pumps. As shown in figure 1, this practice increases lagoon flows to nearly 30 mgd and essentially flushes partially treated and untreated waters out of the treatment system. The visual observations of the EPA professional staff recorded during the April survey indicate substantial amounts of oil were discharged to the Missouri River during the survey period as listed below: 1. Free globules of oil (odor of diesel fuel) were observed to cover a major portion of the surface of the intake embayment at 0410 hours on May 27, 1975. 2. Free globules of a dark brown heavy oil residue were observed infrequently on Old Sugar Creek during most of the survey period. The non-permitted gravity oil separation west of the Old Sugar Creek discharge was flushed out completely of accumulated oil during the precipitation events of April 24 and 25, 1975, due to a poor design of the discharge structure which is only 15 percent of the area of the influent pipe for the separator."	37
1975 to June 12, 1980	J. F. Horner, memo (plus attachments) to Management Committee, Appropriation Request – Water Quality at Sugar Creek Refinery, June 12, 1980	"Management Committee (June 16) Item – Appropriation Requests – Sugar Creek Refinery <u>Environmental Control – Water Quality</u> "More stringent water-quality standards instituted in 1977, equipment deficiencies, failures, and operating problems have all contributed to an unacceptable environmental situation at Sugar Creek. Many violations, including a major oil spill for tank overflow has sensitized the Missouri and regional EPA officials. To date we have been cited for 28 oil spill or stain violations and have been in nearly continuous violation of our NPES permit for the past <u>five</u> years. Failures and violations have occurred in three distinct and unrelated areas. They are 1) creek bank stains and oil sheens from leaking underground oil lines, 2) deficiencies in the refinery effluent collection and treating system for handling storm water volume and sour water segregation that have caused the NPDES violations, and 3) oil spills caused by tank gauging system failures...Only the new tank gauging system has a quantifiable PI (18 – based on reduced manpower) although the replacement of leaking underground lines probably has a reasonable PI based on reducing hydrocarbon loss."	7
March 12, 1976	Letter dated March 12, 1976 from R. C. Miller to Mr. J.P Egan Regarding Sugar Creek Refinery Miscellaneous Oil Seepage Collection Including	<u>Sugar Creek Dam:</u> The basic problem is frequent overtopping of the present floating skimmer and failure of the skimmer to respond to rising water levels. I. WATER POLLUTION CONTROL	89

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #															
September 1979	1979; 2) Varec Transmitter; 3) June 4, 1979 Memorandum; FCU Particulates Control at Sugar Creek Refinery	19788 1979 (September)16 Began reporting spills and seeps to Sugar Creek in 1979 at EPA's insistence. TYPE OF SPILLS <table><tr><td></td><td>Sewer Overload</td><td>Other Equipment Deficiencies</td><td>Operator Error</td><td>“Seeps”</td></tr><tr><td>Number</td><td>6</td><td>15</td><td>4</td><td>4</td></tr><tr><td>%</td><td>21</td><td>51</td><td>14</td><td>14</td></tr></table> (Amoco only reporting spills at EPAs insistence after 1979; lots of design and operations issues implied in the table.)		Sewer Overload	Other Equipment Deficiencies	Operator Error	“Seeps”	Number	6	15	4	4	%	21	51	14	14	
	Sewer Overload	Other Equipment Deficiencies	Operator Error	“Seeps”														
Number	6	15	4	4														
%	21	51	14	14														
1977 to June 22, 1987	B.A. Esslinger, Woodward- Clyde Consultants, letter to R. Ginson, Site Reconnaissance Adjacent to Sugar Creek Former Refinery, June 22, 1987	The reconnaissance was in response to a telephone call received by Mr. John Huddle on May 15, 1987 from Mrs. John (Betty) McCord. Mrs. McCord expressed concern about the possibility of oil seepage on the McCord property (they had observed oil in the past on their property). The purpose of the reconnaissance was to look for hydrocarbon seeps on or near the McCord property. Past oil spills and releases of oil to the ground have been documented in the vicinity. In 1977, overfilling of tank 164 resulted in a spill of approximately 25,000 bbl of crude from an outfall in the stream channel southeast of tank 179. The spill ultimately reached the Missouri River. In August, 1978, free gas oil from the fluid catalytic cracking unit was documented to be within the bermed/area at tank 179, soaking the ground. Other documented, non-dated, spills or releases have occurred at or south of tanks 179 and 211. An accumulation of oil was documented in the past (no date available) outside the property fence south of tank 211. No oil seeps were observed during the reconnaissance. However, black stained soils and hydrocarbon odors observed could be evidence of past seepage in the area of the stream bed. Within the stream valleys, hydrocarbon odors were common the day of the reconnaissance (no quantitative air monitoring was conducted). Near points A and D, black soil and tree trunks on the north stream bank were observed.”	23															
1977 to June 12, 1980	S.R. Slovenko memo to J.F. Horner dated June 12, 1980 entitled “Appropriation Request – Sugar Creek Refinery Water Quality Control – Phase II.” Amoco memo dated May 21, 1980 entitled “Sugar Creek Refinery Line Raising Phase III.	The Line Raising – Phase III appropriation for \$9.1 M will complete the program of eliminating leaking underground OSBL lines that was begun in 1976 under two previous appropriations. The oil from these leaky lines filters down from the hillsides that the refinery is built on and oozes out at lower levels into the banks of the Sugar and Rock creeks causing stains and intermittent oil sheens. ...The project involves installation of a separate storm water collection system and a sour water holding tank to eliminate the lagoon shocks from these streams that have resulted in long periods of violations in the recent past. Reduce Oil Spillage to the Missouri River and Its Tributaries	8															

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
	G.R. Helffrich, memo to S.R. Slovenko, Appropriation Request – Water Quality at Sugar Creek Refinery, October 22, 1979	A summary of oil spill incidents at Sugar Creek since 1977 as a result of process sewer overload during heavy rains. Two oil spills into Sugar Creek via a “clean” storm water sewer system have occurred since 1977. The sewer system serves West Plant OSBL areas and part of the hillside west of Sugar Creek. The water discharges via an underflow dam installation at the creek. Memorandum: <u>Sugar Creek Refinery Line Raising Phase III</u> The Sugar Creek Refinery has four major tankage areas, the Lower Refinery, Middle Refinery, East Hill and West Hill. The Lower Refinery and Middle Refinery tankfarms are approximately 30-45 years old. The West Hill farm was built 20-30 years ago, while the East Hill was built 10-20 years ago. As originally constructed the piping in these tankfields was almost entirely underground. The terrain of the Sugar Creek Refinery led to burying pipe to eliminate “pockets” in piping and allow gravity flow from tankage. Some underground piping sections are up to 30 feet below grade. Furthermore, the tankfields as originally constructed were piped to allow maximum flexibility of storage (for instance, gas oil is piped to 10 of 15 tanks in the West Hill farm). This means there is a great deal of little-used pipe underground that is live and subject to leakage. Oil seepage into Sugar Creek has been a major problem for a number of years. The problem was handled by routine pumping of the entire creek flow until 1977. Oil seepage from other areas of the plant continues to be a problem, and the refinery is actively engaged in determining and eliminating the sources. Leaking lines in the West Hill tank farm is causing seepage to the north and west of the tankfarm. The area to the north of the tankfield drops off to large limestone bluffs. The bluffs are severely stained from oil seepage, and pools of oil collect below the bluffs. The area to the west of this farm is bordered by a large, natural spring which flows into Rock Creek, and the Missouri River. This spring has been dammed to create a retention pond, where oil is collected and removed daily. Samples of the oil seepage from both these locations indicate it is from the West Hill tankfarm. The Lower Refinery underground lines are also a major oil seepage problem. This is the lowest area in the plant, and the water table is near grade. Oil rapidly accumulates whenever a hole is dug. Oil seepage into drain tiles of other effluent water sources has reached Sugar Creek and the Missouri River. Attached for your handling is an appropriation request in the amount of \$5,900,000 to cover the cost of sugar Creek refinery water control and quality improvement projects. These projects reflect our appraisal of current needs to accomplish the following objectives: I. <u>Reduce</u> oil spillage to the Missouri River and its tributaries. II. <u>Reduce</u> process sewer water volume. III. <u>Improve</u> quality of effluent water to meet current NPDES limits. In addition to the projects shown in the Table I, a further major project may be required to cope with oil seepage into Sugar Creek, subject to EPA's willingness to allow us to eliminate this seepage by raising lines aboveground, and repair of leaking tank bottoms. Major sewer repair and replacement may also be required to cope with oil seepage.	

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		Total....\$5,900,000."	
September 21, 1977	G.R. Helffrich, letter to Environmental Protection Agency, Spill Report No. 77-250, September 21, 1977	This letter is in reply to your letter of September 15, 1977 concerning a slop oil spill which occurred sometime prior to 7:00 a.m., September 13, 1977. 1. The spill resulted from oil overflowing an API oil-water separator (West Plant Separator Box). An estimated 5-10 barrels of slop oil overflowed. The spill occurred sometime prior to 7:00 a.m. on September 13, 1977. A heavy rainstorm occurred in the Kansas City area the evening of September 12 and in the early hours of September 13. ... This rain overloaded the refinery sewer system, causing the box to overflow, because of high load and reduced drainage capability to the refinery effluent treating system. Further, the dam across Sugar Creek, which is used to retain oil prior to pumping to the effluent treating system, overflowed because of the rainstorm. Booms in place downstream of the dam were broken loose and rendered ineffective by tremendous volume of storm water in Sugar Creek.	12
November 23, 1977	Sugar Creek Refinery, Nov. 23, 1977; Memorandum Sugar Creek Refinery Oil Spill to the Missouri River	Memorandum: <u>Sugar Creek Refinery Oil Spill to the Missouri River</u> On October 30, 1977, a tank receiving crude oil overflowed about 25 MB due to operator error. Part of the oil (about 750 barrels) reached the Missouri River via the firewall drain system and a faulty valve.	56
November 23, 1977	G.R. Helffrich memo to J.F. Horner, Oil Spill to the Missouri River, November 23, 1977 with backup memo.	On October 30, about 25,000 barrels of crude oil were overflowed from Tank 164 in the west field due to operator error. About 750 barrels of the oil escaped to the Missouri River via the firewall drain system and Rock Creek. Leakage to the creek and river was discovered early on October 31. We are also intensifying our efforts to reduce ground oil seeps from the north bluff, water intake basin, Norledge property, and the banks of Sugar Creek. Each of these are potential if not periodic actual sources of oil flow into public waters.	16
June 9, 1978	Amoco memorandum dated June 9, 1978 by J.D. Sellers	Memo summarized meeting to discuss oil leaks known and recorded at/near the refinery. Under item 7 Mr. Sellers notes that: "A review of the line testing results show that a number of lines in the lower refinery were found to be leakers." The oil leak volumes from various sources were listed for the week of June 5, 1978. The total appears to exceed 2,100 gallons per day. The estimated Norledge sump volumes were estimated at 1,500 gallons per day. <i>(This memo illustrates that the refinery was aware of the oil leaks, quantified them and listed leak sources in detail.)</i>	148
September 6, 1978	G.R. Helffrich memo to J.F. Horner, 1979 One-Time Expense Budget Requests, September 6, 1978	For some time it has been recognized that we have a severe problem with oil seepage into the ground. This oil finds its way to outside private land as well as to Sugar Creek and the Missouri River. Last year it became apparent our efforts to reduce seepage via the on-going program for replacing old underground field piping with new revamped above-ground systems (Appn. 1778) was not sufficient. These pressures prompted us to look more closely at refinery tankage as another source of oil	11

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		seepage. A review initiated last year showed that tankage in general is in relatively poor condition and not only from the standpoint of potential leakage. Therefore, a program was developed late last year for testing, inspection, and repair.	
September 6, 1978	Amoco memorandum from RJM/GRH	Memorandum notes the refinery is the source of offsite contamination and equipment is in poor condition. Specifically it begins by stating: "For some time it has been recognized that we have a severe problem with oil seepage into the ground. This oil finds its way to outside private land as well as to Sugar Creek and the Missouri River. Last year it became apparent our efforts to reduce seepage via the on-going program for replacing old underground field piping with new revamped above-ground systems was not sufficient." The memo then goes on to propose a 10-year tank testing, inspection and repair program. 138 of 208 tanks have not leak tested or inspected in over five years. Eighty-five have not been inspected in 10 years. <i>(Amoco clearly was aware that offsite contamination was occurring and that it was a result of their equipment in poor condition).</i>	149
November 19, 1978	Sugar Creek Refinery memorandum dated November 29, 1978 to R.W. Ginson from Mr. G. J. Wurtz.	Related discussion with USEPA's Mr. Bill Keffer that the catch pan for separating oil for the North Bluffs run-off was an un-permitted discharge and that the refinery was "vulnerable to legal enforcement." He further noted that another area of non-compliance was the sanitary sewers from the main gatehouse, gasoline blender, transport loading rack and fire station that still discharge into Sugar Creek. <i>(The refinery recognized they were likely out of compliance at this time.)</i>	123
March 15, 1979 to March 6, 1981	April 10, 1981. Sugar Creek Oil Spill Incidents – 1979 to Date.	This document summarizes 32 spill incidents, by cause, over the subject time interval. Causes were listed as (A) sewer overload, (B) Equipment malfunction, (C) Seep or leakage or (D) Operator error. 50% of the spills were reported as being caused by seep or leakage.	159
June 22, 1979	June 22, 1979. Memo from J.G. Huddle Regarding Hazardous Waste Situation at Amoco Refineries	MEMORANDUM Hazardous Waste Situation at AMOCO Refineries A Survey of Amoco refineries indicates the similar burial practices, and oil leakage from equipment and sewers, have caused potential problems at most locations. The problem is most frequently characterized by the accumulation of large quantities of oil on the underground water table, and/or seepage of underground oil into surface streams. With the exception of Baltimore, all refineries appear to have some problems... Refineries with Highest Vulnerability, Requiring Prompt Remedial Action Problems with oil at the Casper, Sugar Creek, and Whiting Refineries have recently come to the attention of the Environmental Protection Agency and the U.S. Coast Guard. Sugar Creek – The water table under the refinery is contaminated with oil, which leaks from the ground at numerous locations, causing repetitive violations of oil spill regulations. Underground oil seeps into the Sugar Creek and the Missouri River constitute the most serious immediate problem. J.G. Huddle <i>(Amoco documented problems with leaks to Sugar Creek and the underground water table.)</i>	169

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
July 3, 1979	J.F. Horner memo to H.L. Fuller, Water Disposal – Amoco Oil Refineries, July 3, 1979	<u>Waste Disposal – Amoco Oil Refineries</u> (2) The most prevalent problem is oil in the underground water table, for which there is no quick fix. We are attacking it, short-term through using well points and pumping out to create in-flow ...and longer term through eliminating potential sources of leakage in the refineries.	3
July 10, 1979	R.J. McGillivray, memo to J. G. Huddle, Proposed “Spill” Prevention Plan for Sugar Creek, July 10, 1979	<u>PROPOSED</u> <u>“Spill” Prevention Plan for Sugar Creek</u> Systematically monitor water shed areas for leaks and drips. Provide temporary catch pans. Make permanent repairs. Continue testing tanks for leaks. Maintain a water bottom pending permanent repairs. Identify and remove all lines at process units and tanks which can put oil directly into water shed areas leading to the creek. Install a well point system in selected areas along the creek. Install a barrier between the well point system and the creek in selected areas. Assign a foreman permanently (and crew as required) to: a. Clean up creek surfaces so <u>no</u> oil layer or sheen remains on it even for a few hours. b. Operate and maintain the well point system. c. Monitor the creek to detect new seeps, and report them to the EPA and refinery management. d. Contain new seeps and try to identify and stop sources. e. Remove all oily dirt from the banks of the creek and replace with clean dirt. Establish the <u>new line position</u> of Environmental Superintendent and have the two Reclamation Foremen and “fact finder” report to him. <i>(Given the solubility of benzene in water, use of water bottoms at this late date, when the tanks bottoms were known to leak, would not be an effective spill prevention mechanism.)</i>	15
August 21, 1979	G.R. Helffrich, letter to J.F. Adler, EPA, Spill Report, August 21, 1979	This letter is in reply to your letter concerning an oil spill that occurred in April 30, 1979. Oil seepage from refinery via banks of Sugar Creek. An on-going program has been instituted to clean up seepages of oil into Sugar Creek. Oil accumulations and oil-soaked dirt have been removed, and the Creek is policed daily by a responsible supervisor. Where point sources of oil entering the Creek have been identified, such as leaking line plugs, etc., corrective action has been taken to eliminate the source. <i>(Tied to refinery by Amoco and state source will be eliminated.)</i>	25
October 22, 1979	G.R. Helffrich letter to S.R. Slovenko. Sugar Creek Refinery, Oct. 22, 1979; Appropriation Request – Water Quality Control Projects, Phase I	Attached for your handling is an appropriation request in the amount of \$5,900,000 to cover the cost of Sugar Creek refinery water control and quality improvement projects. These projects reflect our appraisal of current needs to accomplish the following objectives: I. <u>Reduce</u> oil spillage to the Missouri River and its tributaries. II. <u>Reduce</u> process sewer water volume. III. <u>Improve</u> quality of effluent water to meet current NPDES limits.	68

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #																		
		This project is part of the refinery's five-year Environmental Plan to upgrade facilities and achieve compliance with existing and future EPA and Missouri regulations. <u>I. Reduce Oil Spillage to the Missouri River and Its Tributaries</u> Six oil spills have been reported to the coast Guard since 1977 as a result of process sewer overload during heavy rains. The refinery's tank gauging system was obtained used from Texas City in the early 1960's and installed in 1968. A summary of operating problems with the present Varec system is enclosed as Exhibit 2. The system is to be fully replaced. Aged, exposed cables are to be replaced with conduit. Major oil spill risks (such as the October 31, 1977 crude tank overflow) will be reduced by increasing system operating factor. <u>II. Reduce Process Sewer Volume</u> The following benefits will be obtained: (1) reduced sewer overload and thereby reduced oil spills – complementing projects in category I above, (2) reduced shock loading to present water treating plant, thereby reducing the number of NPDES permit violations, (3) reduced volume to present and future water treating plants – 0.25 M Gal/Day of normally oily storm water will be removed from the effluent treating system on a year-round basis. <u>III. Improve Quality of Effluent Water</u> Oil entering the process sewer system and waste water treating system as a result of pump failures has been a major problem. <i>(Suggest all issues related to NPDES permit can be solved in 5 years.)</i>																			
March 4, 1980	AMOCO Certified Mail, "Spill Report No. 79-433", March 4, 1980; Spill Report No. 79-433. To: Mr.Ronnae Coleman, Legal Branch, Enforcement Div.; From G.R. Helffrich	4. The seepage was general ground oil, suspected of leaking from underground lines and tank bottoms. 10. ...Where point sources of oil entering the creek have been identified, such as leaking lines, tank bottoms, etc., corrective action has been taken to eliminate the source. Major capital expenditures are being made and planned, such as raising pipe lines above ground to eliminate seepages. RECORD OF ACCIDENTAL SPILLS AND OTHER POLLUTION CAUSING EPISODES FOR 1967 <table><tr><th>Date</th><th>Location</th><th>Description</th><th>Responsibility</th><th>Damage</th><th>Clean-up</th><th>Agencies Investigating</th><th>Legal Action</th><th>Publicity</th></tr><tr><td>4-67</td><td>Sugar Creek Refinery</td><td>Oil accumulated in drainage ditch along Santa Fe right-of-way, ignited and caused damage to Santa Fe equipment.</td><td>Refinery</td><td>Nominal damage to tracks and signal equipment.</td><td>Facilities designed to prevent recurrence, approval pending.</td><td>None</td><td>None</td><td>Extensive local press, radio and TV.</td></tr></table> <i>(Message to the Agencies is that the leaks and seepages have been "eliminated" despite the fact they continue to be seen. Language appears to have been selected to understate the situation.)</i>	Date	Location	Description	Responsibility	Damage	Clean-up	Agencies Investigating	Legal Action	Publicity	4-67	Sugar Creek Refinery	Oil accumulated in drainage ditch along Santa Fe right-of-way, ignited and caused damage to Santa Fe equipment.	Refinery	Nominal damage to tracks and signal equipment.	Facilities designed to prevent recurrence, approval pending.	None	None	Extensive local press, radio and TV.	55
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September 23, 1980	J.P. Corbett, Quarterly Report on Oil Movements and Utilities: Third Quarter – 1980, September 23, 1980	...a large spill of diesel oil to Sugar Creek occurred on August 5, due to a combination of operator negligence and equipment deficiencies. Finally, the refinery was issued notice in September of court action by EPA charging repeated violations of our NPDES permit stretching back over the past four year period. Storm and process water control projects were designed, issued for bids, and bond financing achieved. The new tank gauge system design was completed and contract work begun. New separator box covers were completed on the lower refinery box. Installation began on the West Plant box. Tank repairs and firewall grading continued on schedule. <u>Technical Services</u> Gasoline benzene problems analyzed and tracked to DLVN cut point and Ultraformer tower operations. Gathered background analytical data and correspondence for defense in EPA effluent water violations charge. Worked with City personnel to define total refinery water treatment program.	19
October 20, 1980 to January 13, 1981 and February 4, 1981	G.R. Helffrich, letter to U.S. Coast Guard, Water Pollution, February 4, 1981	<u>Water Pollution Case 2P07432</u> ...a great deal of time and effort has been and continues to be directed toward solution of problems resulting from oil seepage and sewer overload. Please refer to your letter of October 20, 1980 regarding water pollution cases. The Sugar Creek Refinery is a 76 year old plant that was designed under concepts of the past, many of which are not consistent with today's environmental needs. Extensive underground piping networks have developed leaks that cause oil seepage along bluffs and bankings. Under-sized sewer systems overflow during periods of heavy use. These problems are further complicated by the unique location of the refinery --- on a hillside by the Missouri River with two creeks that pass through the refinery before discharging into the river.	10
February 9, 1982	February 9, 1982. Trip Report by T. Gogel regarding Meeting with Sugar Creek Refinery Management – Results of Hydrologic Investigation and Recommendations for Subsurface Hydrocarbon Abatement.	Mr. Gogel notes that: "Seepage of hydrocarbons into the tributary of Sugar Creek continues in the Norledge Avenue area. Most of the seepage is emitting from a backfilled excavation trench which contains the sanitary sewer line. It was recommended that the possibility of extending an existing French drain about 100 feet to the east and tying into the trench be investigated." The third area of hydrocarbon seepage is into Sugar Creek along both banks. The area of seepage extends about 700 feet northward from the pipeline station. French drains were recommended along both banks in this area. Cost of installation would be significant, particularly along the west bank. However, no other abatement method appears feasible." Earlier, he notes that a pool of liquid hydrocarbons in excess of 9 feet below the north salvage yard contains an estimated 195,000 barrels. <i>(Memo recognizes that remedial efforts to date in the area of Sugar Creek have not been effective.)</i>	134

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
July 16, 1982	R.W. Ginson, Environmental Newsletter for the Period June 25, 1982 – July 26, 1982, July 26, 1982	<u>Environmental Newsletter for the Period June 25, 1982 – July 26, 1982</u> Two oil spills were reported during the period. Mr. Tony Gogel was in the refinery on July 6 and 7 to supervise the installation of nine additional monitor wells. The recovery well which started pumping on June 23 has recovered 84,700 gallons of liquid hydrocarbon (average of 2567 gallons per day).	29
September 14, 1984	C.G. Hill, U.S. Coast Guard, letter to J.G. Huddle, Water Pollution, September 24, 1984	Absent any further substantive information regarding this violation, I am compelled to stay with my preliminary determination. The instant discharge was aggravated by the fact that it was the eighth discharge, involving your sugar Creek facility during the period from May 1982 through April 1983.	21
September 28, 1982 to May 14, 1986	J.G. Huddle, letter to the U.S. Environmental Protection Agency, May 14, 1986	As you are aware, there is an accumulation of oil in the refinery's subsurface. The accumulation has resulted primarily from leakage from product tanks, underground lines, etc., during the seventy eight years the refinery was in operation. A discussion of the hydrocarbon situation is contained in a memorandum by Mr. T. Gogel of Amoco, entitled "Geohydrology of Sugar Creek Refinery, Sugar Creek, Missouri, September 28, 1982."	4
September 28, 1982	T. Gogel, "Geohydrology of Sugar Creek Refinery, Sugar Creek, Missouri". September 28, 1982	A major product of the study was the determination that approximately 196,000 barrels of hydrocarbons have accumulated on the shallow water table beneath the north salvage yard. Concerted efforts should be made to recover as much of the accumulated hydrocarbons as possible.	42
April 12, 1985	D.R. Tripp, U.S. EPA, letter to Amoco Oil Co., Spill Report, April 12, 1985	On January 19, 1985, the Environmental Protection Agency received a report that the Sugar Creek Amoco Terminal experienced a discharge of JP-4 jet fuel from a storage tank over-flow.	22
February 6, 1987	February 6, 1987. Letter from Gene W. Schmidt to R.W. Ginson Regarding Benzene In Florida Groundwater and Cost Model for Selected Technologies for Removal of Gasoline Components from Groundwater.	To: R.W. Ginson, M/C 1203, Chicago Subject: Benzene in Florida Groundwater and Cost Model for Selected Technologies for Removal of Gasoline Components from Groundwater Per our telephone conversation on 1-28-87, attached are two publications you will find very interesting... 1. Liquid hydrocarbons must be removed from the groundwater table to minimize the spread of the dissolved contaminant plume. 2. Dissolved contaminant plume intercept technology can cleanup the groundwater to low concentrations, but once the dissolved hydrocarbon concentration reaches about 100 ppb, continued use of this cleanup action will not yield a substantial improvement over natural processes. Gene W. Schmidt cc: J.C. Huddle, Chicago	165
May 18, 1987	Telephone Memorandum – Call from Mrs. John McCord, Concerning Presence of Oil of	<u>Telephone Memorandum – Call from Mrs. John McCord Concerning Presence of Oil on their Property Adjacent to Amoco's Sugar Creek Refinery</u> On Friday, May 15, 1987 John Huddle received a telephone call from Mrs. John (Betty) McCord,	53

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
	their Property, May 18, 1987	1300 Oak Hollow Drive, Friendswood, Texas, 77456. (tel. 713-482-4510) concerning the above subject. The McCords had received a notice of Amoco's forthcoming cleanup/closure activities at the Sugar Creek, Missouri refinery, from the Missouri Department of Natural Resources, as they own property West of Ash Ave., between Park View Road and the Refinery. Mrs. McCord wanted to know how soon Amoco was going to complete the cleanup, as her son planned to build three fourplex apartments on their property, and they had observed oil on the property in the past. Huddle indicated that our planned cleanup wasn't related to the area of her property, but we would investigate her problem. <i>Figure on last page of sump design and findings on 6-22-87 near Tank 179 record 8" of oil in the bottom of the sump 22 feet bgs. Excellent design details.</i> <i>(No results of investigation provided in memo.)</i>	
October 27, 1987	Letter, October 27, 1987; Mr. Ron Ginson: Preliminary Report of Water Well Survey Near Former Amoco Refinery Sugar Creek, Missouri	The information from the City of Sugar Creek indicates that 55 private water wells have been recorded within Sugar Creek City limits and that, likely, more wells have existed which were not recorded. It is recommended that Amoco conduct further investigations to verify the existence, location, use and water quality of the private wells in the immediate refinery area. We understand this program may be the first time since the Norledge Street trench installation (during refinery operation) that Amoco or its representatives will be performing work related to ground water outside the refinery boundaries. Initially, it is recommended that a house to house survey be conducted in areas within about one-quarter mile of the former refinery to confirm the existence of private wells. A listing dated October 6, 1987 suggests that a well at 10617 Norledge may be contaminated. <i>(Five years after the refinery has closed, Amoco still doesn't know who may be using the groundwater.)</i>	94
March 4, 1988	Well and Norledge Sump Location Map by Woodward-Clyde Consultants	Map shows location of creek, buried lines and lots immediately south of refinery.	88
May 16, 1988	Letter Mr. Ron Ginson, May 16, 1988: Transmittal of the Ground Oil Analysis for the Amoco Sugar Creek Former Refinery Sugar Creek, Missouri	Sample NS-2 was reported to contain the highest concentration of lead, 0.18 gm/gal. The relatively high reported lead content of NS-2 indicates that leaded gasoline is likely a major hydrocarbon constituent in ground oil recovered from the Norledge sumps." "The ground oil sample analyzed from Norledge Sump Number 2 (NS-2, the eastern-most hydrocarbon recovery sump located south of North edge street) contains a significant amount of BTX and light-end hydrocarbons (Figure 3). Based on the <i>(not legible hand writing)</i>, the major hydrocarbon products contained in sample NS-2 are within the gasoline and kerosene boiling point ranges. Sample NS-2 was also reported to contain the highest lead content of the six samples analyzed (0.18gm/gal) which indicates that the gasoline contained in the sample is probably leaded gasoline. <i>(Analysis defines released products produced by the refinery.)</i>	92

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May 27, 1988	May 27, 1988. Letter from Brad A. Esslinger and Donald S. Trelease (Woodward-Clyde) to Ron Ginson (Amoco) regarding the Interim Summary Report – Phase I Hydrocarbon Assessment, Round Two Sampling Data, Norledge Street Vicinity.	Woodward-Clyde Consultants summarizing sampling of Norledge area sumps for flowrate and BTX. They note: "Results of both sampling events indicate that the Norledge recovery sumps are acting as an overall effective barrier to hydrocarbon migration in this area. Detections of low levels (12.9 to 54.8 ug/l) of benzene, toluene and xylols were observed in one of six wells (MW-33) in the second round." <i>(Woodward-Clyde staff less certain about the effectiveness of the interceptor trench than Amoco staff were in the 1995 RFI; benzene levels in MW-33 still exceed drinking water standards.)</i>	156 157
July 28, 1989	J.G. Huddle, memo to A.T. Keith, Engineering Assistance, Sugar Creek – Norledge Ave Sump Project, July 28, 1989	<u>Sugar Creek – Norledge Avenue Sump Project</u> An area at the former Sugar Creek refinery may require remediation because hydrocarbon is seeping into Sugar Creek. This was brought to our attention on March 31, 1989 by Mr. Manseil, a resident living on Norledge Avenue (see attachment). A temporary corrective action (plugging the area with cement) was done on April 19, 1989. A permanent solution must be implemented by the end of September. <i>(Note that leakage noted seven years after the refinery closed.)</i>	24
January 31, 1990	L.P. Coen, Missouri Dept. of Natural Resources, letter to J.G. Huddle, Underground Storage Tank at Amoco (former) Sugar Creek Refinery, January 31, 1990	In addition to these concerns, an EPA report of January 16, 1990, indicates that an oil release is occurring along the face of the bluff overlooking the railroad tracks along Sugar Creek, just north of the refinery. This situation should also be investigated and addressed as well as the tank closure.	26
February 12, 1991	Letter, Mr. Arthur Daigh February 12, 1991: Installation of a Monitoring Well on His Property	During 1991, Amoco Oil Company plans to install groundwater monitoring wells and conduct a groundwater quality assessment on property adjacent to our Sugar Creek refinery site. Please remember that this is a precautionary measure. We have no reason at present to believe there is contamination on your property, but are required to install the wells for reporting the data to the USEPA. <i>(At best, the information to the homeowner is speculation, tends to blame the USEPA for the need to install the well and continues a pattern of understating the issue.)</i>	93
March 15, 1991	Amoco Well Survey Results March 15, 1991	Tables quite difficult to read, but it appears that a survey was conducted to determine if private wells were located on residential properties. It appears that approximately 18 wells or cisterns were identified. Historical use patterns and whether or not they were/are contaminated not determined.	96
September 1992 (?)	Groundwater Use Survey – 9-11-92 (?)	Sample plan for various wells proposed. Handwritten note for the southeast area indicates benzene groundwater concentrations are 1,700 ppb. <i>(No indication plan was ever executed.)</i>	95
May 1995	Deposition Exhibit 6 of Odah: Analytical Report, 803 North Sterling, Sugar Creek. 5/15/95	P03 – 10314 Norledge Street, Independence MO P04 – 10314 Chicago Street, Independence, MO P05 – 10400 Norledge Street, Independence, MO P03 benzene water sample results were: 6,052 µg/l and P04 benzene water sample results were: 164 µg/l. The P04 sample was apparently taken outside of the plume area identified in	106C

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		the RFI. <i>(Results strongly support the position that the plume size was understated.)</i>																																																								
December 18, 1995	AMOCO Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9 Revision December 18, 1995. Results of Subsurface Gas Sampling and Analysis	<u>Off-Site Locations</u> Thirty-two of 35 subsurface gas locations sampled off site contained no detectable concentrations of benzene at analytical detection limits ranging from 0.017 µg/L to 0.1 µg/L. Samples collected from off-site locations G-10, G-18, and G-19 in the Norledge Area contained benzene concentrations ranging from 31.6 µg/L to 33.2 µg/L (Figure 8-3). These concentrations exceed the RBC of 0.2 µg/L (200 µg/m ³) for benzene in subsurface gas. At least four residences are located near or adjacent to this area. SUMMARY OF SUBSURFACE GAS SAMPLING ANALYTICAL RESULTS <table><tr><th>SAMPLE LOCATION</th><th>SAMPLE DATE</th><th>BENZENE (µg/L)</th></tr><tr><td>G-10</td><td>3/14/95</td><td>31.6⁵</td></tr><tr><td>G-18</td><td>3/14/95</td><td>32.8⁵</td></tr><tr><td>G-19</td><td>3/14/95</td><td>33.2⁵</td></tr></table> Value exceeds RBC of 0.2 µg/L. Although areas of free product and dissolved hydrocarbons are present at the Former Refinery, ground water is not used on site and direct exposure to ground water by on-site receptors does not occur. Seepage of benzene in ground water to Sugar Creek, the West Bluffs Tributary, and the Missouri River results in surface water concentrations below the RBC and does not pose a potential health threat. <i>(Ignored exposure pathway of children playing in creek and spring.)</i>	SAMPLE LOCATION	SAMPLE DATE	BENZENE (µg/L)	G-10	3/14/95	31.6 ⁵	G-18	3/14/95	32.8 ⁵	G-19	3/14/95	33.2 ⁵	45 51 84 122																																											
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July 1996	Parker Expert Report from Environmental Technologies, Inc., "Practices which Contributed to Environmental Pollution", July 1996	EVIDENCE OF ENVIRONMENTAL CONTAMINATION Reports of hydrocarbon spills at the refinery are sketchy and only a few records are available from 1950 to the present. A list of reported spills was prepared by AMOCO in 1995.(1) <table><tr><th>Refinery Area</th><th>71-75</th><th>76-80</th><th>81-85</th><th>Total</th></tr><tr><td>Lower Refinery Area</td><td>1</td><td>15</td><td>8</td><td>25</td></tr><tr><td>Crawford Area</td><td>0</td><td>0</td><td>9</td><td>11</td></tr><tr><td>Norgaard Tank Area</td><td>0</td><td>10</td><td>12</td><td>30</td></tr><tr><td>West Plant Process Area</td><td>0</td><td>0</td><td>3</td><td>4</td></tr><tr><td>West Hills Tank Area</td><td>0</td><td>1</td><td>6</td><td>17</td></tr><tr><td>West Tank Area</td><td>0</td><td>13</td><td>0</td><td>21</td></tr><tr><td>Gerber Tank Area</td><td>0</td><td>0</td><td>1</td><td>2</td></tr><tr><td>Riverfront Area</td><td>5</td><td>17</td><td>5</td><td>29</td></tr><tr><td>Sugar Creek & Norledge Tributaries</td><td>3</td><td>11</td><td>4</td><td>25</td></tr><tr><td>TOTAL</td><td>10</td><td>67</td><td>48</td><td>164</td></tr></table>	Refinery Area	71-75	76-80	81-85	Total	Lower Refinery Area	1	15	8	25	Crawford Area	0	0	9	11	Norgaard Tank Area	0	10	12	30	West Plant Process Area	0	0	3	4	West Hills Tank Area	0	1	6	17	West Tank Area	0	13	0	21	Gerber Tank Area	0	0	1	2	Riverfront Area	5	17	5	29	Sugar Creek & Norledge Tributaries	3	11	4	25	TOTAL	10	67	48	164	40
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December 16, 1998	Deposition of G.M. Zemansky, Ph.D., Volume III December 16, 1998	Dr. Zemansky testified on additional sampling done in the Sugar Creek area in December 1998. He commented that they took samples on three different sites (Slayton, Chapell and Fillmore properties). In general, the smell hydrocarbon odors in soils near/within the saturated soil zone and observed staining of the soils.	113
December 16, 1998	Exhibit 19 of Deposition of G.M. Zemansky, Ph.D., Volume III December 16, 1998	Detailed history of oil contamination of the Norledge area, beginning in 1950, prepared by Zemansky.	113A
June 5, 2002	West Hills Tank Area Investigation Work Plan by The RETEC Group, Inc.	This report acknowledges benzene contamination and singles out LUF gasoline as the source of benzene seen in groundwater: Products stored in the West Hills Tank Area include unleaded and leaded gasoline, heavy and light ultraformer feed (HUF and LUF) gasoline, debutanized absorber naphtha (DAN) gasoline, alkylate, heavy stabilized naphtha, heavy virgin naphtha, furnace oil, asphalt, and heavy and light slop oil... Of these products, LUF is the most likely to contain benzene greater than 3 percent.... LUF gasoline may contain C-6 hydrocarbons including benzene, at concentrations up to 5 to 15 percent by volume. No other petroleum products stored in the West Hills Tank Area contained enough benzene by percentage to result in the elevated dissolved benzene concentration observed in the former tank dike 157. Therefore, the most likely source of the elevated benzene concentrations in groundwater is a release from a LUF gasoline tank or associated pipe. LUF was historically stored in Tank 151. <i>(While the authors may be correct, several of these materials, including naphtha, likely contained significant amounts of benzene. Modeling of the likely local exposures to benzene vapors by products such as gasoline and light ultraformer feed (LUF) containing 5% to 15% benzene are shown in Appendix D. Results predict local exposures of 18.3 to 54.5 ppm)</i>	116

The story painted on oil releases by the Sugar Creek refinery by these references and documents is that Amoco:

1. Was aware that the Sugar Creek Refinery had piping and tank systems with serious leaks and ineffective water treatment systems that would negatively impact the environment for at least 75 to 85 years. Amoco staff knew tanks would leak within three years and yet over 60% of the tanks were tested on a five year or greater basis. A tank known to leak was repaired and placed back in service despite an internal recommendation that it be leak-tested before it was returned to service.
2. Probably knew in the 1920s, and knew by the 1960s, that oil releases from their facility was the source of oil found in off-site waters and neighborhoods.

Support for Opinion #2 on Poor Design, Maintenance, and Training Practices by the Defendant:

As summarized in Table 2, AMOCO has a long recorded history in the 1950s, 1960s, 1970s, 1980s and 1990s of poor facility designs (e.g., water treatment systems), maintenance and training. Specific opinions regarding certain documents are opined as italicized comments within brackets (*opine*).

Table 2: Information Supporting Position the Amoco Operated the Refinery in a Manner that Would Result in Releases of Oil from the Sugar Creek Refinery

DATE	DOCUMENT	INFORMATION (<i>OBSERVATIONS & COMMENTS</i>)	EES REF. #
1950s to 1970s	J. Studer, interview with Dr. Lenard Sorg on December 4, 1986	The Lower Refinery Separator Box, dismantled in the 1950s, was located where the No. 1 Pipe Still is located. Actually, Dr. Sorg noted that two boxes were connected together by piping (see map B). The construction was wood, it was an original structure according to Dr. Sorg. He reported that this separator leaked heavily and continuously. The ground was always saturated causing what he believed were large underground pools of oil. Some soil beneath the separator was excavated and replaced with sand for the foundation of the No.1. Pipe Still. The Crawford Plant Separator Box, decommissioned in 1950 when the fluid Catalytic Cracker Unit (FCU Plant) was constructed, was also of wood construction. This unit was reported to have leaked heavily and constantly; the ground was always saturated. He remembers oil always leaking into the Sugar Creek as it issued from the banks of the creek. This box was replaced when the West Plant Separator Box was installed in 1950. The West Plant Separator Box did not leak according to Dr. Sorg. The Agitator Treating Plant was located on the east side of the refinery just southeast of the No. 1 Pipe Still but across the north-south trending road. This was reported to have been an area where spillage and leakage was especially severe. The soil was always soaked. The agitator tanks were tall with conical shape bottoms which were often opened by workers allowing streams of product to escape and run down the hill towards the pit area. The agitators treated for mercaptans. Dr. Sorg mentioned the use of leaded pipe with sulfuric acid. Acids were used for "additional" treatment. Dr. Sorg felt that the soil at this location would be highly contaminated with oil and lead. Dr. Sorg believes that each tank began leaking within two or three years of being installed. The bottoms apparently developed cracks. It was reported that common practice was to put water in the tank as well as product. The product would float on top of the water layer. At certain times caustic would be put in the tanks. Dr. Sorg stated that all pipes, fixtures, etc. leaked somewhat sometime. The only accidental spill that Dr. Sorg remembered was the Tank 131 spill. He said this was the major spill over the 40 year period 1940 to 1970. The incident occurred 1962-1965. A workman opened up the drain valve to tank 131 which at the time contained caustic with a sodium mercaptan compound. He was uncertain as to whether petroleum product was in the tank at the time of spill. The spill containment dike drain valve was open as well. Three feet of caustic	30

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		flowed over the ground to Sugar Creek, according to Dr. Sorg. The No. 2 Pipe Still (Asphalt P.S.), once located just west of the Crawford tract separator box (refer to map A), had some spillage, yet the asphalt stayed at or near the ground surface. The Norledge recover ditch was installed in the 1950s or 1960. Dr. Sorg felt that this ditch was not very effective. Their main concern, however, was leakage off the bluffs. They built a ditch to carry seep oil and water from the base of the bluff near the railroad to the Sugar Creek.	
1950 to July 20, 1965	B.T. Allison, Amoco memo to N.T. Robey, July 20, 1965	Since 1950 we have had a recurring problem at Sugar Creek with oil contamination of a natural spring which flows from the bank of a drainage ditch at a point about 300 feet south of the refinery. The spring flow and other oil and water seepage from this north back in this area drain into the ditch which empties into Sugar Creek outside of the refinery. The spring flow and adjacent seepage varies from 2 to 6 g.p.m. and the oil content from 0 to 25 per cent. Maximum oil flow has been .88 g.p.m. During five periods since 1950 the residents in the immediate area and workers of the Sugar Creek City Council have complained about the strong gasoline odor, gasoline fumes in basement drains, and fire hazard from the oil collecting in the ditch and creek. The present series of neighborhood and city complaints, which began early this year, have not stopped as in other years when we were able to eliminate the oil leakage to the spring by various repairs and the construction of intercepting systems within the refinery. The attached drawing SB-11137 shows the location of the spring, intercepting facilities, and the gasoline tanks and their associated piping which are involved in the problem. Each time that oil shows in the spring flow we have attempted to find the source by testing tanks and lines and in a few cases have found insignificant tank leaks and several significant line leaks. Early this year, despite oil recovery by the intercepting facilities, the spring showed oil again, reaching the maximum of 25 per cent or .86 g.p.m. in February. Extensive borings to rock were made along the south fence line to obtain data for locating several 6 inch cased wells. Three wells have been in operation for several months pumping a total of 20-30 g.p.m. of water containing approximately 4-5 per cent oil. <i>(Note that oil is likely gasoline.)</i> The oil content of the spring has receded to about 7 per cent or .15 g.p.m. Even this amount of oil still produces a fairly strong gasoline odor at the spring. In 1960 when we installed the interceptor sewer we also acquired 34 lots south of the refinery as shown on the drawing. Other lots were considered, but because of price or other reasons, they were not purchased. You will note that the spring and other seeps are on lots 337, 338, 339, 340 and 341, which we do not own. ... Even though our efforts may again be successful in stopping the oil flow to the spring we believe the problem will recur as in the past. It is essential	31

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		that we have the facilities outside the refinery to handle the spring flow and collect any oil that may escape underground from the refinery. <i>(As of 1965, still can't stop leaks from the refinery onto adjacent properties and recognized that the leaks will continue.)</i>	
1952, 1953 and 1964	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I Erickson, March 20	Tanks 176 and 177 erected in 1952 with used steel. Hydrostatic testing showed both tank bottoms to be leaking in the pitted and seam weld areas. Leaks repaired and tanks placed in service. In 1953, Tank 176 was down for repair and several leaks noticed. Despite a recommendation that it be water tested before it was returned to service. It was returned to service without being water tested. In 1964, Amoco recommended both Tanks 176 and 177 be taken out of service.	131
1955	Water Pollution Abatement Manual – Oils and Tars. 1955. Manual Sheet W-4, Manufacturing Chemists' Association, Inc., Washington, D.C.	Oily discharges are primarily a problem of petroleum refineries, petrochemical plants and metal working plants, although many other types of plants may develop oily discharges because of specific processes. A film 0.000003 inches thick has a silvery sheen while the first trace of color appears in the film when its thickness increases to 0.000006 inches. Oil films are unattractive and should be avoided. PERMISSIBLE CONCENTRATIONS In effect, no oils which can be collected should knowingly be discharged to a stream. DRAINAGE AND COLLECTION SYSTEM In general, it is easier to remove oils and tars from individual sources than to do the job on the composite waste. Separate drainage systems for cooling waters, process waters, storm waters and sanitary wastes may greatly simplify the task of removing and disposing of oils and tars. If oil contamination of storm flows is unavoidable, the storm water should not be allowed to drain onto adjoining properties or into surface waters prior to treatment. 3. Burial: If the oil and tar wastes have no commercial value, and present a difficult combustion problem, the concentrated waste may be buried....It is important that the possibility of contaminating water formations, stock ponds, streams, etc. in the vicinity of the burial place be thoroughly investigated. 4. Ponding: Again, precaution should be taken against an escape of the wastes through flooding or porosity of the bottom and sides of the ponds which would contaminate surrounding property or water formations. Lagoons should not be built in a location that, in the event of heavy rain, would drain into adjacent property or flow into a nearby stream. 5. Injection Into Underground Formations: In certain instances, wastes containing oils or tars may be safely disposed of by injection into underground formations. However, unless the formation is far below any potential sources of water supplies, and can be well sealed to prevent migration, the practice has	76

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		inherent danger.” <i>(It is clear that by 1955 industry understood no oil should be knowingly discharged to a stream, that sewer systems should be segregated and that burial sites, impoundment ponds and the underground injection oil and tar wastes should be protective of all waters and surrounding properties, including waters that could serve as water supplies.)</i>	
1959	Manual on Disposal of Refinery Wastes; Volume I: Waste Water Containing Oil, Sixth Edition 1959	Refinery drainage systems should be constructed so that no storm water, or other waste water subject to contamination by oil, will drain directly onto adjoining properties or into adjacent surface waters. The sewer systems in old refineries usually are inadequate and may not provide for optimum segregation of the different types of waste waters. <i>(Clear knowledge by 1959 that storm water and process water streams should be segregated.)</i>	67
1962 - 1978	G.R. Helffrich, information (Sugar Creek press release), 1978	Along with the production of petroleum products, officials at the plant have been concerned with water conservation for over 40 years, conscious that oil wastes can be undesirable contaminants in streams. Sixteen years ago they built a lagoon to provide secondary treatment for process water returned to the Missouri river. Improved in 1968, it now represents an investment of more than a million dollars. There is negligible economic recovery from the reprocessed oil wastes. This is not a profit undertaking, but is accepted by the company as a simple matter of responsibility to protect a vital natural resource and to be a good industrial neighbor on the river. The company is currently (1978) engaged in a multi-million dollar project to improve handling of storm water and to further improve the quality of water returned to the Missouri river. <i>(No secondary treatment of wastes till 1962; Amoco apparently knew it was undesirable to discharge oily wastes.)</i>	2
Pre- 1964 to February 5, 1964	American Oil Company memorandum from J.C. Lumpkin to Distribution List dated March 5, 1964. Chromatographic Method for Identification of West Hill Oil Leak Source by Relative Concentrations of Closely Boiling Hydrocarbons.	In further attempts to locate the leak, several test holes were drilled inside the firewalls of Tanks 176, 177, 158, 159, and 160....It appears that the vapors in holes near Tanks 177, 158, and 159 came from a leak which was later found in the filling line which contained premium gasoline at the time of the sampling. The vapors in the holes near Tanks 160 and 176 could have come from small leaks around the tanks or could have been the remains of gasoline leaked from the filling line when it was carrying regular gasoline. <i>(Recognition that tanks and/or lines were leaking gasoline.)</i>	80
February 3, 1964	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I. Erickson, March 20	Recommendation: “Take Tanks 176 and 177 out of service for inspection and testing” and “Run the new line above ground” since the old line was severely pitted. “Sugar Creek now has the policy of installing all lines above grade.”	131

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1966 (February to November)	1966 Telephone Logs from J.N. Roper	February 17, 1966: "Mayor Randy Roper called me.... Mentioned the creek pollution problem ..gasoline seepage to the spring, etc." March 7, 1966: "Erickson says no change in condition of seepage from spring for several months. Still significant, but we don't feel odor is very bad." March 30, 1966: "Tom McJaynt (?) called to see if there had been any new developments....Told Tom we are "getting by" with no more recent complaints – would let him know if we do – odor." July 5, 1966: Erickson reports oil seepage is low in the dry season after the water table drops, but "there may be more oil released again." August 15, 1966: "Erickson reports we had about four to six weeks essentially oil free (not measurable). However, oil began to appear again about 2 weeks ago and was up to 6% on last check.... Visually, problems continuing indefinitely on intermittent basis." October 26, 1966: "HAS and I agreed that we might try to "hold out" for a little longer to see if oil seepage to spring may taper off." October 31, 1966: " Fire in gully and oil on surface of spring water attracted a lot of attention. Bad publicity!" <i>(Amoco was clearly aware of issue that their operation was leaking oil into adjacent properties.)</i>	164
February 22, 1966	T.J. McJoynt, Manager Real Estate, Field Trip Report, February 22, 1966	During the course of our meeting Mr. Roper indicated that considerable time and money has been spent by our own people, as well as geological exploration concerns in an effort to locate the seepage leak on the refinery and stop it at its source; however, all such attempts have failed to date. Wells have been drilled near our refinery boundaries on the south side to pump the product out of the ground and a 15 foot perforated sewer has been laid in along the boundary of our property in a further attempt to collect this oil seepage. All of these attempts have not stopped the seepage flow into the drainage ditch on the Fonck property immediately south of the refinery. To reduce the possibility of any extreme catastrophe, the refinery has taken steps to water down the entire seepage area with a spray of water through a pipe system lain on the surface of the ground.	32
October 10, 1966	1966 American Oil Company, Letter from I. Erickson to Mr. J.N. Roper. Subject: Oil Leak South of the Refinery	Memorandum discusses plans to purchase properties and install a collection system to collect flow from the spring and related seepage and pump it into the refinery sewer system. The cost for this selected option was listed at "\$28,000 plus the cost of the lease." Two more expensive alternatives (Installation of an interceptor trench on the southern boundary at a cost of \$65,000 and "Elimination of all possible sources of leakage in the area of the refinery that feeds the spring" by lining storage tanks and relocating lines above ground at an unknown cost), were discussed but not selected. <i>(This memo clearly recognizes the source of the leaks and their solution listed in order of cost. However, cost is apparently the primary driver for the alternative (least cost) selected/recommended for approval. It is clear that only the last alternative – not selected – would eliminate all sources of leakage feeding the spring)</i>	132

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September 22, 1967 and September 26, 1967	N. Roper memo to R.S. Holcolmb, Facilities for Oil Recovery from West Hill Drainage, September 22, 1967	Last April a pond formed along the Santa Fe tracks when the culvert became partially blocked. The oil which accumulated on top of this pond was ignited from some unknown source and blazed into a fire that attracted wide public attention. This is the main line of the Santa Fe and rail traffic was affected. For a distance of approximately 100 yards, trees were burned, rails bent and signal lines and poles destroyed. Since the fire, this area is inspected regularly for oil accumulation and culvert condition. <i>(Suggests unmonitored accumulation of oil was an issue.)</i> "The present operation presents a potential hazard to Santa Fe trackage and allows oil to get to the Missouri River. The proposed facilities will assure that oil flow from tank drains will be confined within the refinery sewer system." "Requisition purpose is to "prevent pollution of the Missouri River." Remarks point out design problems related to distance between valves and tanks.	33
September 22, 1967 to September 1993	Memorandum Sugar Creek Refinery: Instructions for Filling Out Complaint Forms	Memorandum on process to fill out, and respond to, complaints about the refinery by residents. A table describing odors and completed complaint forms and responses (April 6, 1976 to September 23, 1993) are attached. <i>(Many of the complaints are related to odors and were tied to malfunctioning equipment in the refinery.)</i>	83
1969	Manual on Disposal of Refinery Wastes, Volume on Liquid Wastes, First Edition-1969; American Petroleum Institute	In designing water collection systems, this API publication states that: "Refinery collection or drainage systems should be constructed so that water subject to contamination by oil will not drain directly onto adjoining properties or into adjacent surface waters." Figure 3-1 illustrates how to lay out a refinery waste water system and explicitly shows segregation of waste water streams. <i>(The practice of how to properly handle oily waters understood in the 1960s.)</i>	119
1972 to 1980s	Deposition of John F. Horner, 25 th Day of July 1996	He agreed that top management recognized that Sugar Creek had an environmental problem and essentially gave the refinery permission to submit non-profit budget items to correct some of these problems. Agrees that training and procedures to eliminate spills and leaks was inadequate. But then accepts refinery budget that places this 5th on the priority list, one below the four top items to receive focus for a given budget year.	118
September 12, 1973 to July 17, 1996	Note to LM, with attached list of Amoco Sugar Creek Refinery Oil Spills, July 17, 1996	Comment from Helffrich that "Doesn't look good to someone in agencies" noting the list of over 57 spills from 9/12/73 to 10/2/82 and fines totaling \$21,000.	13
November 13, 1975	R.C. Mallatt, memo to J.F. Horner with attached report, CEP Report – Cracking Down: Oil Refining and Pollution Control, November 13, 1975	Amoco's fair overall performance in water pollution control is the result of poor performances at the Texas City, Yorktown, and Sugar Creek refineries. Amoco has promoted itself as a leader in pollution control. An Amoco booklet states, "Conservation of air and water resources in our company is noted in decades of operating experience..." This may have been true years ago, but other companies have surpassed Amoco.	38

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		The Sugar Creek refinery also has a poor water pollution control performance record. This is because of poor lagoon maintenance and perhaps because the refinery increased in capacity and complexity without corresponding increases in treatment plant efficiency. Sugar Creek has been in violation of its March 1973 NPDES permit, but the US EPA and the Missouri Clean Water commission have yet to take any action. The Sugar Creek FCC completed a run of more than six years in early 1974. This unit had not been shut down completely for maintenance since 1967 (33). The run was rejected for the entire refining industry: the usual interval for an FCC turnaround is once every three years. (<i>Suggests poor environmental record among peers.</i>)	
April 22-29, 1975	J. Lamkin, EPA, Compliance Monitoring Field Survey, Summary Report, Sugar Creek Refinery, April 22-29, 1975	There are several other areas where violations are evident resulting primarily from inadequate preparation of the original permit application by the discharger and failure to optimize treatment of process wastewaters through sound segregation of groundwater seepage and storm water flows from normal process wastewaters. During rainfall periods, the company procedure is to pump all process and storm water flows collected in the plant sumps to the lagoons up to the capacity of the pumps. As shown in figure 1, this practice increases lagoon flows to nearly 30 mgd and essentially flushes partially treated and untreated waters out of the treatment system. The non-permitted gravity oil separation west of the Old Sugar Creek discharge was flushed out completely of accumulated oil during the precipitation events of April 24 and 25, 1975, due to a poor design of the discharge structure which is only 15 percent of the area of the influent pipe for the separator. Verbal discussions with the laboratory superintendent, Mr. Lamkin, indicate the company is concerned with storm water handling and oil discharges but does not have a formal proposal or rigid implementation schedule for minimizing the effect of oil seepages and storm water discharges on overall plant wastewater handling. (<i>Even in 1975, the storm water and process water systems have not been separated.</i>)	37
1975 to June 12, 1980	J. F. Horner, memo (plus attachments) to Management Committee, Appropriation Request – Water Quality at Sugar Creek Refinery, June 12, 1980	Management Committee (June 16) Item – Appropriation Requests – Sugar Creek Refinery <u>Environmental Control – Water Quality</u> More stringent water-quality standards instituted in 1977, equipment deficiencies, failures, and operating problems have all contributed to an unacceptable environmental situation at Sugar Creek. Failures and violations have occurred in three distinct and unrelated areas... They are 2) deficiencies in the refinery effluent collection and treating system for handling storm water volume and sour water segregation that have caused the NPDES violations, and 3) oil spills caused by tank gauging system failures...Only the	7

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		new tank gauging system has a quantifiable PI (18 – based on reduced manpower) although the replacement of leaking underground lines probably has a reasonable PI based on reducing hydrocarbon loss.	
March 6, 1976	March 16, 1976. Letter from Michael K. Stenstrom to J. G. Huddle regarding the Visit to the Sugar Creek Refinery – March 8-10, 1976.	Mr. Stenstrom notes to Mr. Huddle seven oil leak areas/situations, several of which did/could impact Sugar Creek. He specifically notes that the old Crawford separator box is in poor condition and should be bypassed to avoid polluting Sugar Creek. However, he notes that the bypass is leaking and should be fixed.	146
March 12, 1976	Letter dated March 12, 1976 from R. C. Miller to Mr. J.P. Egan Regarding Sugar Creek Refinery Miscellaneous Oil Seepage Collection Including Attachment.	<u>Sugar Creek Dam:</u> The basic problem is frequent overtopping of the present floating skimmer and failure of the skimmer to respond to rising water levels. I. WATER POLLUTION CONTROL <u>Problems:</u> 1. Storm runoff overloads process sewer and separators causing oil spills into Sugar Creek and excessive oil discharge to the aerated lagoon causing oil and grease violations. 3. Oil seeps from bluffs, creek banks, and river bank cause: (1) Oil spills 4. Rainwater runoff from oily sludge land farm does not receive treatment. (<i>Demonstrates improper designs of pollution control systems recognized internally.</i>)	89
October 7, 1976	Letter dated October 7, 1976 from G.H. Watson to J. Victor (Chief Engineer) entitled "Hydrocarbon Spills at Sugar Creek Refinery."	Corporate staff visited the refinery and find four spill areas. Two spill area discussions are reproduced below: <u>Hydrocarbon Spills at Sugar Creek Refinery, Project 4001</u> On September 2, 1976, I visited the Sugar Creek refinery and accompanied by several of the refinery engineering staff, we inspected several areas where hydrocarbon spills had been observed. Four of these areas require immediate attention. There is a major leak in the area of tanks 144, 145, and 146. (1) Tanks 144, 145, and 146—A large hole had been excavated to the east of tank 144, and northwest of tank 145 to a depth of approximately 10 feet. Large amounts of contaminant are seeping into this hole. Sample analysis of the contaminant has shown that the seepage is the same as the feedstock stored in tanks 144, 145, and 146. (4) Northledge Lower Dam—Your proposal of using a cut-off ditch and a separator to prevent hydrocarbons from reaching the existing creek will provide the most economical solution at this location. The present leakage could come from any of the tanks on top of the hill to the north and although this contaminant could be traced and eliminated, any future leakage from one of the other tanks would probably end up in the creek.	91

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		(It was obvious to outside Amoco staff that significant leaks were occurring from tanks at the refinery.)																
1977	Deposition of George R. Helffrich, 17 th Day of July 1996	Mr. Helffrich was the Sugar Creek refinery manager beginning in 1977. When starting his new job, the previous manager (Mr. Evans) noted that they were having problems with seeps across from Sugar Creek, effluent water treatment and complying with environmental regulations. Decisions to move lines above ground were driven by discovery of leaking lines and scheduling to not upset refinery operations. Recalls on-going problems meeting NPDES permit requirements. When asked if he did anything to correct the overloaded sewer problem he responded “no”. He agrees that a lack deficiencies in training and procedures, including a lack of updating procedures and enforcing them were major factors associated with spill events. He agreed with the statement that when he was the manager that he “was aware that oil wastes can be undesirable contaminants in streams.”	117															
January 1977 to September 1979	“Exhibits”: 1) Summary of Oil Spills Reported to Coast Guard Jan., 1977 – Sept. 1979; 2) Varec Transmitter; 3) June 4, 1979 Memorandum; FCU Particulates Control at Sugar Creek Refinery	<u>TYPE OF SPILLS</u> <table><tr><th></th><th>Sewer Overload</th><th>Other Equipment Deficiencies</th><th>Operator Error</th><th>“Seeps”</th></tr><tr><td>Number</td><td>6</td><td>15</td><td>4</td><td>4</td></tr><tr><td>%</td><td>21</td><td>51</td><td>14</td><td>14</td></tr></table> (Amoco only reporting spills at EPAs insistence after 1979; lots of design and operations issues implied in the table.) <u>VAREC SYSTEM</u> During the early part of the 1960’s, sugar Creek’s Varec system was dismantled at Texas City Refinery and shipped to Sugar Creek. In 1968 this system was installed, using some existing telemetering wiring and some new telemetering cable. The reasons for Texas City’s discontinuance of this system is unknown to me. However, this system was not new when Sugar Creek received it, and has been in service at Sugar Creek for approximately eleven years. Consequently, this system has been well used. Telemetering cable has a life expectancy of approximately twelve to fifteen years.* Sugar Creek’s Varec tank gauging system’s supporting telemetering cable system has been in service for eleven to twenty years (depending on whether it was installed with the Varec system or pre-existent). Based on the above life expectancy estimation, it would appear that this system is in its senior years. The cross box east of 179 tank is damaged beyond repair. Cross Box 1123		Sewer Overload	Other Equipment Deficiencies	Operator Error	“Seeps”	Number	6	15	4	4	%	21	51	14	14	69
	Sewer Overload	Other Equipment Deficiencies	Operator Error	“Seeps”														
Number	6	15	4	4														
%	21	51	14	14														

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		(west of West Plant-Cooling Tower) should have been relocated five years ago. Cross Box 1303 (east of 270 tank) will probably require replacement within the next five years. <i>(It is clear that equipment was being used well beyond its normal life and contributed to spills and leakage.)</i>	
September 21, 1977	G.R. Helffrich, letter to Environmental Protection Agency, Spill Report No. 77-250, September 21, 1977	This letter is in reply to your letter of September 15, 1977 concerning a slop oil spill which occurred sometime prior to 7:00 a.m., September 13, 1977. 2. The spill resulted from oil overflowing an API oil-water separator (West Plant Separator Box). A heavy rainstorm occurred in the Kansas City area the evening of September 12 and in the early hours of September 13. ... This rain overloaded the refinery sewer system, causing the box to overflow, because of high load and reduced drainage capability to the refinery effluent treating system.	12
November 23, 1977	Sugar Creek Refinery, Nov. 23, 1977; Memorandum: Sugar Creek Refinery Oil Spill to the Missouri River	Memorandum: <u>Sugar Creek Refinery Oil Spill to the Missouri River</u> On October 30, 1977, a tank receiving crude oil overflowed about 25 MB due to operator error. Part of the oil (about 750 barrels) reached the Missouri River via the firewall drain system and a faulty valve. <i>(Detailed chronology of October 30, 1977 spill event, including conclusions and recommendations regarding quality of equipment and training.)</i>	56
November 23, 1977	G.R. Helffrich memo to J.F. Horner, Oil Spill to the Missouri River, November 23, 1977 with backup memo.	On October 30, about 25,000 barrels of crude oil were overflowed from Tank 164 in the west field due to operator error. About 750 barrels of the oil escaped to the Missouri River via the firewall drain system and Rock Creek. Leakage to the creek and river was discovered early on October 31. <u>Procedures</u> 1. Oil Movements personnel lined-up crude oil delivery from the pipeline to the wrong tank. In spite of remote gauging equipment with printout, the error was not discovered for about 12 hours during a 16-hour shift being worked by the same crew. Obviously they were not following proper pumphouse procedures for checking and balancing oil receipts and transfers. Although the main reason for the spill is human error and disregard for procedures, evidence indicates laxity in updating and enforcing procedures in general. 2. Contrary to accepted practice, incomplete pipeline construction, in effect, interconnected three tank firewall areas (including that for Tank 164). The line itself was open and firewall sleeves were unsealed. Evidence indicates pumphouse personnel were not aware of this, which contributed to the general confusion and spread of the spill in the diked areas. 4. Personnel training and discipline is marginal with insufficient attention to minor leaks and spills.	16

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		<u>Facilities</u> 1. Maintenance of the firewall drain system is marginal in that valves are known to leak. 2. Facilities for draining surface water-oil mixtures from firewall areas via an unattended pumped sump are prone to malfunction and misoperation due to questionable design and large differences in base elevation among tanks in the west field. Excluding oil lost and fines, the cost of the spill was about \$350,000. <u>OIL SPILL</u> The oil spill began when an operator sent incoming crude to the wrong crude tank. The error was not discovered for 12 hours, and during that time oil had overflowed the tank into the firewall area. The oil entered the firewall drain system for the west tank field, partially opened during the intermittent rain, and reached Rock Creek and the Missouri River via a faulty valve. There were a number of factors contributing to the delay in correcting the initial error and failure to contain the tank overflow, including: 1. Neither the chief operator nor the operator followed good pumphouse procedures. Levels in crude tanks were not checked, either physically or by Varec to verify proper operations. 2. Standard operating orders covering pumphouse procedures are not updated, nor is performance actively monitored. 3. No physical check of the tanks was made during the five hours the tank was overflowing, in spite of the fact the firewall drains were open during the intermittent rain. 4. Contrary to good practice, incomplete construction had left an open line and sleeves which interconnected firewall areas for three tanks. 5. The firewall drain collection system is poorly designed and allowed crude oil to move from one firewall to another. 6. A valve in an emergency firewall drain line to a surface water drainage ditch, thought to be closed, was not. <i>(Clearly training and equipment needs not met to prevent incidents)</i>	
1977 to June 12, 1980	S.R. Slovenko memo to J.F. Horner dated June 12, 1980 entitled "Appropriation Request – Sugar Creek Refinery Water Quality Control – Phase II." Amoco memo dated May 21, 1980 entitled "Sugar Creek Refinery Line Raising Phase III." G.R. Helffrich, memo to S.R.	The Line Raising – Phase III appropriation for \$9.1 M will complete the program of eliminating leaking underground OSBL lines that was begun in 1976 under two previous appropriations. The oil from these leaky lines filters down from the hillsides that the refinery is built on and oozes out at lower levels into the banks of the Sugar and Rock creeks causing stains and intermittent oil sheens. To date we have 28 violations with fines pending on 22 of these. The last fine paid involving about 1 quart of oil was for \$500. In addition, each violation carries a clean up cost of at least this amount. Future fines are expected to be \$1,000 or higher.	8

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	Slovenko, Appropriation Request – Water Quality at Sugar Creek Refinery, October 22, 1979	The Water Quality – Phase II appropriation for \$6.25M is aimed at eliminating NPDES effluent water quality violations and meeting expected tightening of NPDES emission restrictions. The project involves installation of a separate storm water collection system and a sour water holding tank to eliminate the lagoon shocks from these streams that have resulted in long periods of violations in the recent past. The New Tank Gauging System appropriation for \$1.25 M involves replacement of an old system that was originally installed at Texas City then transplanted at Sugar Creek in the 1960's. The system has become very unreliable resulting in overfilled tanks and spills. S.R. Slovenko <u>Reduce Oil Spillage to the Missouri River and Its Tributaries</u> A summary of oil spill incidents at Sugar Creek since 1977 as a result of process sewer overload during heavy rains. Two oil spills into Sugar Creek via a “clean” storm water sewer system have occurred since 1977. The sewer system serves West Plant OSBL areas and part of the hillside west of Sugar Creek. The water discharges via an underflow dam installation at the creek. <u>II. Reduce Process Sewer Volume</u> Oil entering the process sewer system and waste water treating system as a result of pump failures has been a major problem. Spare slop oil pumps are to be provided at the FCU, CRU, Coker, and at the refinery oil-water separators. G.R. Helffrich Appropriation Request 5/15/80 Sugar Creek Refinery Line Raising Phase III Raise Retaining Underground Tankfield Lines Above Grade Meet Environmental Restrictions Prohibiting Spillage of Oil to Waterways or Contamination of Underground Water Supplies. Effect of Delay in Approval: Continuing costs of cleaning up oil seepage possible legal action by the U.S. E.P.A. Description of Base Case Against Which PI is Calculated: Continued Loss of Some Underground Oil Memorandum: <u>Sugar Creek Refinery Line Raising Phase III</u> The Sugar Creek Refinery has four major tankage areas, the Lower Refinery, Middle Refinery, East Hill and West Hill. The Lower Refinery and Middle Refinery tankfarms are approximately 30-45 years old. The West Hill farm was built 20-30 years ago, while the East Hill was built 10-20 years ago. As originally constructed the piping in these tankfields was almost entirely underground. The terrain of the Sugar Creek Refinery led to burying pipe to eliminate “pockets” in piping and allow gravity flow from tankage. Some	

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		underground piping sections are up to 30 feet below grade. Furthermore, the tankfields as originally constructed were piped to allow maximum flexibility of storage (for instance, gas oil is piped to 10 of 15 tanks in the West Hill farm). This means there is a great deal of little-used pipe underground that is live and subject to leakage. Oil seepage into Sugar Creek has been a major problem for a number of years. The problem was handled by routine pumping of the entire creek flow until 1977. At that time, the USEPA began strict interpretation of the federal water pollution laws prohibiting discharge of oil into "navigable waters" of the United States. At that time, the EPA mandated efforts to eliminate sources of oil to Sugar Creek, rather than routine removal of oil having already reached Sugar Creek. In an effort to solve or reduce the problem of oil seepage into Sugar Creek, the refinery was granted two appropriations in 1976 to raise lines above grade. To date, the refinery has spent \$3,040,000, and expect to work on these appropriations to be completed by year end. With these funds, the refinery has raised all piping in the Middle Refinery and East Hill tankfarms above grade. Oil seepage from other areas of the plant continues to be a problem, and the refinery is actively engaged in determining and eliminating the sources. Leaking lines in the West Hill tankfarm is causing seepage to the north and west of the tankfarm. The area to the north of the tankfield drops off to large limestone bluffs. The bluffs are severely stained from oil seepage, and pools of oil collect below the bluffs. The area to the west of this farm is bordered by a large, natural spring which flows into Rock Creek, and the Missouri River. This spring has been dammed to create a retention pond, where oil is collected and removed daily. Samples of the oil seepage from both these locations indicate it is from the West Hill tankfarm. The Lower Refinery underground lines are also a major oil seepage problem. This is the lowest area in the plant, and the water table is near grade. Oil rapidly accumulates whenever a hole is dug. Oil seepage into drain tiles of other effluent water sources has reached Sugar Creek and the Missouri River. In order to eliminate the source of the oil responsible for these seeps, the refinery is seeking an appropriation in the amount of \$9,100,000 to complete the final phase of the line raising program. This appropriation would allow above grade installation of all lines in the West Hill and Lower Refinery tankfarms. Coupled with ongoing tankage testing and repair, this appropriation will greatly reduce and eventually eliminate oil seepage problems. The Refinery is being pressed by environmental officials to eliminate the problem and are expecting an attempt to eliminate the problem by raising leaking lines. Attached for your handling is an appropriation request in the amount of \$5,900,000 to cover the cost of sugar Creek refinery water control and quality improvement projects. These projects reflect our appraisal of current needs to	

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		accomplish the following objectives: IV. <u>Reduce</u> oil spillage to the Missouri River and its tributaries. V. <u>Reduce</u> process sewer water volume. VI. <u>Improve</u> quality of effluent water to meet current NPDES limits. In addition to the projects shown in the Table I, a further major project may be required to cope with oil seepage into Sugar Creek, subject to EPA's willingness to allow us to eliminate this seepage by raising lines aboveground, and repair of leaking tank bottoms. Major sewer repair and replacement may also be required to cope with oil seepage. Total....\$5,900,000.																	
September 6, 1978	G.R. Helffrich memo to J.F. Horner, 1979 One-Time Expense Budget Requests, September 6, 1978	Last year it became apparent our efforts to reduce seepage via the on-going program for replacing old underground field piping with new revamped above-ground systems (Appn. 1778) was not sufficient. <table><tr><th>Condition</th><th>Tanks</th></tr><tr><td>Acceptable</td><td>43</td></tr><tr><td>Leaking and/or needing major repair</td><td>11</td></tr><tr><td>Unknown (Leak-test and/or inspection scheduled):</td><td></td></tr><tr><td>5-10 yrs. since inspection</td><td>53</td></tr><tr><td>Over 10 yrs. since inspection</td><td>85</td></tr><tr><td>Anticipate dismantling</td><td>16</td></tr><tr><td>TOTAL</td><td>208</td></tr></table> A review initiated last year showed that tankage in general is in relatively poor condition and not only from the standpoint of potential leakage. Therefore, a program was developed late last year for testing, inspection, and repair. Experience has shown that we can handle contract repair of 10-20 tanks a year, depending on size, type of stock, and extent of work. On this basis it will take about 10 years to complete the upgrading program. <i>(Illustrates a lack of commitment to tank maintenance.)</i>	Condition	Tanks	Acceptable	43	Leaking and/or needing major repair	11	Unknown (Leak-test and/or inspection scheduled):		5-10 yrs. since inspection	53	Over 10 yrs. since inspection	85	Anticipate dismantling	16	TOTAL	208	11 149
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June 9, 1978	Amoco memorandum dated June 9, 1978 by J.D. Sellers	Memo summarized meeting to discuss oil leaks known and recorded at/near the refinery. Under item 7 Mr. Sellers notes that: "A review of the line testing results show that a number of lines in the lower refinery were found to be leakers." He recommended that two leaks in line 94 be clamped immediately. <i>(This memo illustrates problems with maintaining the lines and their casual attitude toward repairing leakers.)</i>	148																
November 29, 1978	Sugar Creek Refinery, Nov. 29, 1978;	<u>NPDES Permit Modifications</u>	65																

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
	NPDES Permit Modifications	The EPA regulations on discharge of storm water allow NMT 15 mg/1 oil and grease or 35 mg/1 total organic carbon. A sample of effluent water from Evans Dam on November 30, 1977 contained 137 ppm oil and grease. In general, if storm water mingles with much volume of oil, it will not meet the limits. This action may result in additional violations to our NPDES permit from discharging storm water containing more than 15 mg/1 oil and grease, until the oil leak elimination projects are completed and existing ground oil is displaced. However, it is more expedient to violate a permit temporarily than to operate unpermitted discharges. <i>(Clear recognition that the equipment doesn't perform at level needed to meet regulatory limits.)</i>	
1979	Draft Manual on Disposal of Refinery Wastes, Volume VI Solid Wastes 1979	Contamination of surface water by storm water runoff from a land farm site must be prevented. The runoff can be controlled by providing berms around the perimeter of the land farm and by use to control any runoff which must be routed to a water treatment system. <i>(A copy of this manual was received by Amoco's J.G. Huddle on May 2, 1980 and may have been held by staff earlier according to handwritten notes on the cover page of this manual.)</i>	100
March 15, 1979 to March 6, 1981	April 10, 1981. Sugar Creek Oil Spill Incidents – 1979 to Date.	This document summarizes 32 spill incidents, by cause, over the subject time interval. Causes were listed as (A) sewer overload, (B) Equipment malfunction, (C) Seep or leakage or (D) Operator error. 25% of the spills were reported as being caused by operator error.	159
March 20-22, 1979	March 2- 22, 1979. Industrial Hygiene Survey Report, Industrial Hygiene and Toxicology Environmental Conservation and Toxicology Dept., Amoco Oil Company, Sugar Creek Refinery, Sugar Creek, Missouri.	VRU Pump Room Area samples were taken in the VRU pump room to verify the previous high results of aromatics obtained during a benzene survey. These samples (SC145-79-010, 011, 013, and 014) showed benzene concentrations in excess of 10 ppm. All the windows in the pump room were removed to afford better ventilation, but nevertheless, the excessive leakage at the pumps called the abnormally high level of aromatics. The pump seals should be repaired to minimize the leakage of hydrocarbons into the pump room. Arthur A. Marozas Staff Industrial Hygienist <i>(Documents leaks in pump room and lack of repairs to pumps)</i>	170
June 4, 1979	J.F. Horner memo to G.R. Helffrich, Elimination of NPDES Permit Violations, June 4, 1979	<u>Elimination of NPDES Permit Violations</u> <u>A continuation of this situations not acceptable.</u> An informal survey of other refiners indicates that NPDES violations at Sugar Creek exceed those reported by other refiners by 10 to 100 fold. The EPA considers that NPDES discharge limits are an absolute maximum, rarely, if ever to be exceeded.	17

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
July 2, 1979	G.R. Helffrich memo to J. F. Horner, Elimination of NPDES Permit Violations, July 2, 1979	You correctly pointed out in your letter of June 4, that violations of our NPDES permit have reached an intolerable level. You also suggested that violations stem from a lack of dedication to environmental requirements and a tough enforcement program. Our candid appraisal indicates this is largely the case although some facilities are inadequate. <u>Operating factors, operability and practices</u> are problems.	18
July 3, 1979	J.F. Horner memo to H.L. Fuller, Water Disposal – Amoco Oil Refineries, July 3, 1979	However, I should note that our current waste disposal practices fall substantially short of satisfying the recently proposed regulations covering the disposal of hazardous wastes. In their present form, these regulations would force us to discontinue practices we have considered environmentally acceptable, such as land farming and deep well disposal.	3
July 10, 1979	R.J. McGillivray, memo to J. G. Huddle, Proposed “Spill” Prevention Plan for Sugar Creek, July 10, 1979	<u>PROPOSED</u> <u>“Spill” Prevention Plan for Sugar Creek</u> Systematically monitor water shed areas for leaks and drips. Provide temporary catch pans. Make permanent repairs. Continue testing tanks for leaks. Maintain a water bottom pending permanent repairs. Identify and remove all lines at process units and tanks which can put oil directly into water shed areas leading to the creek.	15
October 22, 1979	G.R. Helffrich letter to S.R. Slovenko. Sugar Creek Refinery, Oct. 22, 1979; Appropriation Request – Water Quality Control Projects, Phase I	Attached for your handling is an appropriation request in the amount of \$5,900,000 to cover the cost of Sugar Creek refinery water control and quality improvement projects. These projects reflect our appraisal of current needs to accomplish the following objectives: I. <u>Reduce</u> oil spillage to the Missouri River and its tributaries. II. <u>Reduce</u> process sewer water volume. III. <u>Improve</u> quality of effluent water to meet current NPDES limits. This project is part of the refinery’s five-year Environmental Plan to upgrade facilities and achieve compliance with existing and future EPA and Missouri regulations. <u>I. Reduce Oil Spillage to the Missouri River and Its Tributaries</u> Six oil spills have been reported to the coast Guard since 1977 as a result of process sewer overload during heavy rains. The refinery’s tank gauging system was obtained used from Texas City in the early 1960’s and installed in 1968. A summary of operating problems with the present Varec system is enclosed as Exhibit 2. The system is to be fully replaced. Aged, exposed cables are to be replaced with conduit. <u>III. Improve Quality of Effluent Water</u> Oil entering the process sewer system and waste water treating system as a	68

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		result of pump failures has been a major problem. (<i>Evident that maintenance of facilities was poor and contributed to continued oil releases.</i>)	
September 23, 1980	J.P. Corbett, Quarterly Report on Oil Movements and Utilities: Third Quarter – 1980, September 23, 1980	...a large spill of diesel oil to Sugar Creek occurred on August 5, due to a combination of operator negligence and equipment deficiencies. Finally, the refinery was issued notice in September of court action by EPA charging repeated violations of our NPDES permit stretching back over the past four year period.	19
October 31, 1980	G.R. Helffrich, memo to J.F. Horner, 1981 Objectives, October 31, 1980	In proposing the above goals, the need to emphasize training and development of supervisory and hourly personnel was given serious consideration... This recognizes we cannot make significant and sustained progress in any (environmental compliance) areas unless we continue with the program to upgrade our personnel.	20
January 13, 1981 and February 4, 1981	G.R. Helffrich, letter to U.S. Coast Guard, Water Pollution, February 4, 1981	<u>Water Pollution Case 2P07432</u> ...a great deal of time and effort has been and continues to be directed toward solution of problems resulting from oil seepage and sewer overload. Please refer to your letter of October 20, 1980 regarding water pollution cases. Extensive underground piping networks have developed leaks that cause oil seepage along bluffs and bankings. Under-sized sewer systems overflow during periods of heavy use. Beginning in 1976, a three phase program was started to replace literally miles of underground piping with above ground piping to stop existing leaks and to facilitate future inspections. At this date, the first two phases have been completed at a cost of \$6 million. The final phase is in progress at an additional cost of \$7 million for completion by 1982. All of this work is currently in progress. Much of it will be finished by the end of this year, and all of it will be done by mid-1982. In addition to the foregoing work, a program of testing and repair of oil storage tanks has been underway since 1977 to detect and eliminate oil spills from that source. By October 1980, all tanks in the program had been tested, and all leaking tanks had either been repaired, or removed from active service. (<i>This last statement is in conflict with later requests for resources and conflicts with a 10-year time frame required to campaign all tanks seen in Ref. 11.</i>)	10
October 13, 1981 To January 8, 1982	G. R. Helffrich, memo to J.G. Huddle, SEC Quarterly Report October – December 1981, January 8, 1982	List of 12 spill events over two months in late 1981. (<i>Documents pattern that was occurring for some time.</i>)	13
September 1985	Practical Guide for Ground-Water Sampling, September 1985	PRACTICAL GUIDE FOR GROUND-WATER SAMPLING by Michael J. Barcelona, James P. Gibb, John A. Helffrich and Edward E. Garske. EPA-600/15. The report concludes by stating that "the emphasis should be to collect	106E

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		hydrologic and chemical data that accurately represent in-situ hydrologic and chemical conditions." <i>(Guidance on how to properly sample groundwater. This conflicts with reported statement by Huddle to only sample wells with an accumulation of hydrocarbons - - telephone memo between Huddle and Woodward-Clyde Consultant T. Gogel, May Quarterly Sampling, May 6, 1986.)</i>	
February 1990	EPA Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, February 1990	Monitoring wells designed to detect or assess low density immiscible contaminants should be screened in the upper part of the aquifer. In many instances the screen should span the vadose zone and the upper portion of the aquifer to allow the floating contaminant to enter the well. Many immiscible contaminants depress the water table in the well and create an apparent free liquid thickness that is greater than the thickness of the floating contaminant within the aquifer."	106F
November 15, 1990	Interceptor Trench Extension NS-5 and NS-6 Post-Construction Report, Amoco Sugar Creek Former Refinery, Nov. 15, 1990	The objective of the Norledge Street hydrocarbon recovery network (Norledge Network) of interceptor drains, cut-off wall and sumps is to collect and <i>properly handle</i> separate phase hydrocarbon and associated ground water migrating from the former refinery toward a tributary, which will be referred to as the Norledge Tributary of Sugar Creek. This report describes the most recent extension of the Norledge Network which consisted of the installation of two new interceptor trench drains (NS-5 and NS-6). These trenches were installed to provide a continuous trench barrier along the southern perimeter of the former refinery to reduce the potential for migration of ground water containing separate and dissolved hydrocarbon around or through the recovery network. The trench construction activities were begun on August 6, 1990. The submersible pumps to be installed in sumps NS-5 and NS-6 should be in place and operational by late November, 1990. For construction of the vertical sump casings, approximately 19 feet of 36 inch diameter corrugated galvanized steel (16 gauge) pipe was installed in NS-6 and 24 feet in NS-5....The 4 inch pipe for both trenches totaled approximately 1,500 lineal feet. <i>(Provides some details on modified interceptor trench; trench installed 25 years or more after Amoco indicated that the 1960 version was not effective.)</i>	61

A poor story is painted regarding the Defendant's design, maintenance, and training policies and procedures at the Sugar Creek refinery by these references. Amoco:

1. Utilized used equipment, such as control systems, which were well beyond their normal life expectancies. The failure rate of this equipment was such that staff could not keep it in good repair. This was at least partially responsible for many leaks and spills.
2. Utilized salvaged pitted plate in fabricating tanks. It was recognized that the tanks would leak within three years. Complicating the situation, even in the 1970s, 138 of 200 tanks had not been inspected or tested in five (5) years. Eighty-five had not been tested in ten (10) years. In one case, a repaired tank was placed back in service without undergoing a recommended water leak test. Given a known leak period of three years, the inspection and testing interval, averaging over five years would not be sufficient to uncover leaking tanks.
3. The 1975 CEP Report – Cracking Down: Oil Refining and Pollution Control, November 13, 1975, states that the Amoco Sugar Creek refinery has a poor maintenance record for FCCs among peers.
4. Viewed repair of leaks, resulting in environmental contamination, as a non-economic investment to only be undertaken when the situation became “intolerable”. Intolerable situations were defined as those receiving negative PR or pressure from regulators. This documented that little was done to protect the environment from oil releases, until the 1970s, when regulations began to be promulgated. This position is supported by the number of documents addressing releases after issuance of the CWA in 1972 and the refinery's need to meet its NPDES permit issued in 1973.
5. Did not follow industry recommended practices in the area of segregation of process and storm water streams, and in minimizing contact between solid/hazardous wastes and storm water, as recommended in documents of the era (e.g. 1955 MCA and 1959, 1969 and 1979 API documents). For example, they continued to use combined process and storm water sewer systems despite the fact that industry-recommended practice, by 1959, was to separate these systems.
6. Delayed elevating buried pipelines above grade, even though it was recognized by internal correspondence in 1966 that above grade pipelines were the preferred design practice.
7. Sugar Creek staff was not properly trained to prevent and/or respond to spill events as documented in memorandum and depositions by the refinery manager (G.R. Helffrich) and his supervisor (J.F. Horner).
8. Sugar Creek refinery equipment, including controls valves, were known to be in poor condition and to be contributing to many oil releases and spills as documented in memorandum and depositions by the refinery manager (G.R. Helffrich) and his supervisor (J.F. Horner).

9. Amoco Sugar Creek refinery had problems with operating factors and operability practices as documented in memorandum and depositions by the refinery manager (G.R. Helffrich) and his supervisor (J.F. Horner).
10. Sugar Creek staff recognized as early as the 1950s that release of oils to water bodies was not acceptable.

Support for Opinion #3 on Violations of Environmental Laws by the Defendant:

As summarized in Table 3, AMOCO has a recorded history in the 1970s, 1980s and 1990s of violating environmental regulations, especially water regulations such as its NPDES permit issued in 1973. A list of the promulgation date of several of these regulations is presented in Appendix B. Specific opinions regarding certain documents are opined as italicized comments within brackets (*opine*).

Table 3: History of Resistance to, and Non-Compliance with, Environmental Regulations

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
1950 to July 20, 1965	B.T. Allison, Amoco memo to N.T. Robey, July 20, 1965	Since 1950 we have had a recurring problem at Sugar Creek with oil contamination of a natural spring which flows from the bank of a drainage ditch at a point about 300 feet south of the refinery. The present complaints have not subsided and there have been threats of legal action against the company if the situation isn't corrected. Regardless of the success of any future efforts to reduce leakage within the plant, we believe that we should acquire 6 lots 337 – 342. May we have your approval to start negotiations for the purchase of this property. <i>(Documents that the threat of legal action is a motivator for correcting leakage of oils from the plant to spring and creek waters.)</i>	31
February 22, 1966	T.J. McJoynt, Manager Real Estate, Field Trip Report, February 22, 1966	On February 17, the writer met with Mr. Elmer Almann, an attorney from Independence, Missouri, and Mr. Ed Hall, a real estate broker, together with Mr. Jim Roper, the Refinery Manager. Mr. Almann and Mr. Hall had been retained previously by this Company to negotiate for the purchase of certain residential lots and property immediately south of our property in an effort to obtain a buffer zone. During the course of our meeting Mr. Roper indicated that considerable time and money has been spent by our own people, as well as geological exploration concerns in an effort to locate the seepage leak on the refinery and stop it at its source; however, all such attempts have failed to date. Wells have been drilled near our refinery boundaries on the south side to pump the product out of the ground and a 15 foot perforated sewer has been laid in along the boundary of our property in a further attempt to collect this oil seepage. All of these attempts have not stopped the seepage flow into the drainage ditch on the Fonck property immediately south of the refinery. Analysis of the product seepage indicates that the base is gasoline, and probably premium gasoline. The seepage occurs primarily at low water table and creates considerable odor in the area, as well as an extreme fire hazard. It is my opinion that the ravine which goes to a depth from the street to approximately 15 or 20 feet is, in itself, an attractive nuisance for children playing in the area since the ravine is not fenced off and, with the seepage of gasoline, further hazards are presented due to the possibility of small children playing in the ravine and possibly starting a bonfire, or striking a match. To reduce the possibility of any extreme catastrophe, the refinery has taken steps to water down the entire seepage area with a spray of water through a pipe system lain on the surface of the ground. There have been several complaints registered by property owners downstream along the creek concerning odors and the dangerous condition resulting from the seepage of the product into the creek. To date, no formal letter has been issued by the city to the company demanding that they clear up the situation; however, such a letter may come at any time if the nuisance continues. Our community relations in Sugar Creek are of the utmost importance and must be preserved.	32

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		However, it is the writer's further opinion that acquiring the property would be the least expensive method of controlling this problem and cementing our fine community relations.	
1969 to June 4, 1979	Memo from "JES", Amoco Refining Planning, memo on FCU Particulates Control at Sugar Creek Refinery, June 4, 1979	<u>FCU Particulates Control at Sugar Creek Refinery</u> The Sugar Creek refinery's FCU has never been in compliance with the opacity rule. In early 1976, the DNR, following an on-site inspection, issued a notice of violation and requested a compliance schedule. Three tests were made during 1977 and 1978, but because of a variety of equipment malfunctions, the stack test program was not completed. In the first two test, emissions were above the weight limit; in the third, emissions were equal to the limit. ...in December 1978, the DNR proposed a limit of 10 lb/hr. Our position was that the limit should be no lower than the federal new source standard of 30lb/hr.We have proposed a compliance schedule that would place the control equipment in service by June 30, 1982.	6
1972 to 1980s	Deposition of John F. Horner, 25 th Day of July 1996	Recalls problems complying with water pollution regulations, including NPDES permit requirements. Noted that "there were some creeks in the area that served as rain water run off for areas probably in the refinery but including outside the refinery and that ended up creating problems for the refinery in handling their pollution permitting problems." (<i>Odd language, appears to almost blame the creek for being present as the cause of the pollution.</i>) In describing how they address environmental problems, he notes that this is done when the situation become "intolerable". His definition of intolerable is: "where we begin to have major problems with public relations, major problems with governmental agencies, state and federal, et. cetera." (<i>The driver for environmental compliance appears to be public pressure.</i>) He agrees that the refinery had a poor water pollution control performance record. He agreed that top management recognized that Sugar Creek had an environmental problem and essentially gave the refinery permission to submit non-profit budget items to correct some of these problems. Recalls during site visits discussing the fact that leaking product was moving offsite into surrounding areas. Agrees that training and procedures to eliminate spills and leaks was inadequate. But then accepts refinery budget that places this 5 th on the priority list, one below the four top items to receive focus for a given budget year.	118
March 16, 1973	NPDES Permits	NPDES permit allowed for discharge of an average discharge of 367 #/D of oil and grease up to a maximum of 550 #/D.	78
September 12, 1973 to July 17, 1996	Note to LM, with attached list of Amoco Sugar Creek Refinery Oil Spills, July 17, 1996	Comment from Helffrich that "Doesn't look good to someone in agencies" noting the list of over 57 spills from 9/12/73 to 10/2/82 and fines totaling \$21,000.	13
April 22-29, 1975	J. Lamkin, EPA, Compliance Monitoring Field Survey,	In order to fulfill the Environmental Protection Agency's (EPA) obligations under the National Pollutant Discharge Elimination System (NPDES) program, and inspection with sampling was	37

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
	Summary Report, Sugar Creek Refinery, April 22-29, 1975	carried out at the Amoco Oil Company, Sugar Creek Refinery during the period of April 22-29, 1975. Wastewater samples were collected at four points over the seven-day period and all samples were split with company personnel. There are several other areas where violations are evident resulting primarily from inadequate preparation of the original permit application by the discharger and failure to optimize treatment of process wastewaters through sound segregation of groundwater seepage and stormwater flows from normal process wastewaters. <u>Conclusions</u> 1. Absence of a sound stormwater handling and disposal policy resulted in present permit condition violations at Outfall #001 and #002. 2. Discharge #002. Flow rate measurements at the Old Sugar Creek discharge are inadequate. 3. Due to the volume of oil waste in the ground on the company property, the permit should be revised to include provisions for collection methods and regular inspection of these waste discharges. During rainfall periods, the company procedure is to pump all process and stormwater flows collected in the plant sumps to the lagoons up to the capacity of the pumps. As shown in figure 1, this practice increases lagoon flows to nearly 30 mgd and essentially flushes partially treated and untreated waters out of the treatment system. The Sugar Creek Refinery occupies an area of approximately 500 acres...The refinery has been in operation since 1903 and in its 70 plus year history has had numerous spills up to and including recent ones and there are considerable oil materials in the ground which are flushed out or leaked out during precipitation periods. The company has several oil trap areas on the grounds but the apparent servicing process is less than ideal. The visual observations of the EPA professional staff recorded during the April survey indicate substantial amounts of oil were discharged to the Missouri River during the survey period as listed below: 3. Free globules of oil (odor of diesel fuel) were observed to cover a major portion of the surface of the intake embayment at 0410 hours on May 27, 1975 4. Free globules of a dark brown heavy oil residue were observed infrequently on Old Sugar Creek during most of the survey period. The non-permitted gravity oil separation west of the Old Sugar Creek discharge was flushed out completely of accumulated oil during the precipitation events of April 24 and 25, 1975, due to a poor design of the discharge structure which is only 15 percent of the area of the influent pipe for the separator. Verbal discussions with the laboratory superintendent, Mr. Lamkin, indicate the company is concerned with stormwater handling and oil discharges but does not have a formal proposal or rigid implementation schedule for minimizing the effect of oil seepages and stormwater discharges on overall plant wastewater handling.	
November 13,	R.C. Mallatt, memo to J.F.	Amoco may be meeting most state regulations, but it is still the study's worst particulate and	38

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
1975	Horner with attached report, CEP Report – Cracking Down: Oil Refining and Pollution Control, November 13, 1975	second worst CO, hydrocarbon, and SO_x polluter. Until recently, most Amoco refineries had few, if any, air pollution control devices. For instance, most of its fluid catalytic crackers had only internal cyclones to remove particulates, and Amoco only recently installed or began to construct electrostatic precipitators at Winn River, Illinois, and at Texas City, the study's largest particulate polluter. Amoco's fair overall performance in water pollution control is the result of poor performances at the Texas City, Yorktown, and Sugar Creek refineries. Amoco has promoted itself as a leader in pollution control. An Amoco booklet states, "Conservation of air and water resources in our company is noted in decades of operating experience..." This may have been true years ago, but other companies have surpassed Amoco. The Sugar Creek refinery also has a poor water pollution control performance record. This is because of poor lagoon maintenance and perhaps because the refinery increased in capacity and complexity without corresponding increases in treatment plant efficiency. Sugar Creek has been in violation of its March 1973 NPDES permit, but the US EPA and the Missouri Clean Water commission have yet to take any action. The refinery violated its permit discharge limitations from the date of issuance, March 1973, through the end of 1975. Amoco told regulatory agencies that one reason for the refinery's poor performance and unusual violation record is that it increased capacity by roughly 25,000 barrels a day since its permit application was submitted, and that additionally, it began to manufacture petrochemicals in 1972. The Sugar Creek FCC completed a run of more than six years in early 1974. This unit had not been shut down completely for maintenance since 1967. The usual interval for an FCC turnaround is once every three years." <i>(Demonstrates poor environmental and maintenance record among peers.)</i>	
1975 to June 12, 1980	J. F. Horner, memo (plus attachments) to Management Committee, Appropriation Request – Water Quality at Sugar Creek Refinery, June 12, 1980	Management Committee (June 16) Item – Appropriation Requests – Sugar Creek Refinery <u>Environmental Control – Water Quality</u> Three appropriations are requested totaling \$16.6 M to construct projects at the Sugar Creek Refinery to improve effluent water quality and reduce oil contamination of natural water systems from sources other than refinery effluent. The accompanying initial expense is \$1.429 M. More stringent water-quality standards instituted in 1977, equipment deficiencies, failures, and operating problems have all contributed to an unacceptable environmental situation at Sugar Creek. Many violations, including a major oil spill for tank overflow has sensitized the Missouri and regional EPA officials. To date we have been cited for 28 oil spill or stain violations and have been in nearly continuous violation of our NPES permit for the past five years. ...the EPA is preparing a suit in excess of \$10 M that is expected this fall. Failures and violations have occurred in three distinct and unrelated areas. They are 1) creek	7

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		bank stains and oil sheens from leaking underground oil lines, 2) deficiencies in the refinery effluent collection and treating system for handling storm water volume and sour water segregation that have caused the NPDES violations, and 3) oil spills caused by tank gauging system failures...Only the new tank gauging system has a quantifiable PI (18 – based on reduced manpower) although the replacement of leaking underground lines probably has a reasonable PI based on reducing hydrocarbon loss.	
March 6, 1976	March 16, 1976. Letter from Michael K. Stenstrom to J. G. Huddle regarding the Visit to the Sugar Creek Refinery – March 8-10, 1976.	Mr. Stenstrom notes to Mr. Huddle seven oil leak areas/situations, several of which did/could impact Sugar Creek. Finally, he is aware that these seven issues could violate their NPDES permit when he closes by stating: "As you can tell, there are numerous small problems at the refinery, any one of which could cause a violation of the NPDES permit."	146
March 8, 1976	March 8, 1976. Memo from G.R. Helffrich to J.G. Huddle with note and copy of U.S. vs. Kennecott Copper.	Refinery Managers This decision emphasizes the importance of promptly reporting all oil spills. J.G. Huddle cc: JPG-RD, G. R. Helffrich Section 1321(b)(5) in pertinent part provides: "Any person in charge of ...an onshore facility...shall, as soon as he has knowledge of any discharge of oil ...from...such facility in violation of paragraph (3) of this subsection immediately notify the appropriate agency of the United States Government of such discharge. Any such person who fails to notify immediately such agency of such discharge shall upon conviction be fined...." The pertinent provisions of paragraph (3) provide: "The discharge of oil ... into or upon the navigable waters of the United States...in harmful quantities as determined by the President under paragraph (4) of this subsection is prohibited.... The evidence was sufficient to sustain the verdict. In Boyd, we upheld the conviction of a ship captain who failed promptly to report the discharge of about 30 gallons of diesel oil from his vessel to a waterway." <i>(Amoco aware of definition of a spill from this decision and need to report all spills)</i>	171
March 12, 1976	Letter dated March 12, 1976 from R. C. Miller to Mr. J.P. Egan Regarding Sugar Creek Refinery Miscellaneous Oil Seepage Collection Including Attachment.	<u>Sugar Creek Dam:</u> The basic problem is frequent overtopping of the present floating skimmer and failure of the skimmer to respond to rising water levels. I. WATER POLLUTION CONTROL <u>Problems:</u> 1. Storm runoff overloads process sewer and separators causing oil spills into Sugar Creek and excessive oil discharge to the aerated lagoon causing oil and grease violations. <i>(Demonstrates internal knowledge of NPDES permit violations)</i>	89

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #															
1977	Deposition of George R. Helffrich, 17 th Day of July 1996	Mr. Helffrich was the Sugar Creek refinery manager beginning in 1977. When starting his new job, the previous manager (Mr. Evans) noted that they were having problems with seeps across from Sugar Creek, effluent water treatment and complying with environmental regulations. Mr. Evans mentioned that they had: "had some prior difficulty with oil migration onto neighboring property, ground water, ground water containing oil migration onto neighboring properties." Recalls on-going problems meeting NPDES permit requirements. When asked if he did anything to correct the overloaded sewer problem he responded "no". He had no recollection of being sued for NPDES violations and Amoco paying a \$500,000 fine in 1983. He agreed with the statement that when he was the manager that he "was aware that oil wastes can be undesirable contaminants in streams."	117															
January 1977 to September 1979	"Exhibits": 1) Summary of Oil Spills Reported to Coast Guard Jan. 1977 – Sept. 1979; 2) Varec Transmitter; 3) June 4, 1979 Memorandum: FCU Particulates Control at Sugar Creek Refinery	TOTAL REPORTED, ALL TYPES 1977 3 - 1 major 1978 8 1979 (September) 16 Began reporting spills and seeps to Sugar Creek in 1979 at EPA's insistence. <u>TYPE OF SPILLS</u> <table border="1"><tr><td></td><td>Sewer Overload</td><td>Other Equipment Deficiencies</td><td>Operator Error</td><td>"Seeps"</td></tr><tr><td>Number</td><td>6</td><td>15</td><td>4</td><td>4</td></tr><tr><td>%</td><td>21</td><td>51</td><td>14</td><td>14</td></tr></table> (Amoco only reporting spills at EPAs insistence after 1979; lots of design and operations issues implied in the table.)		Sewer Overload	Other Equipment Deficiencies	Operator Error	"Seeps"	Number	6	15	4	4	%	21	51	14	14	69
	Sewer Overload	Other Equipment Deficiencies	Operator Error	"Seeps"														
Number	6	15	4	4														
%	21	51	14	14														
September 21, 1977	G.R. Helffrich, letter to Environmental Protection Agency, Spill Report No. 77-250, September 21, 1977	This letter is in reply to your letter of September 15, 1977 concerning a slop oil spill which occurred sometime prior to 7:00 a.m., September 13, 1977. 3. The spill resulted from oil overflowing an API oil-water separator (West Plant Separator Box). An estimated 5-10 barrels of slop oil overflowed. The spill occurred sometime prior to 7:00 a.m. on September 13, 1977. Further, the dam across Sugar Creek, which is used to retain oil prior to pumping to the effluent treating system, overflowed because of the rainstorm. Booms in place downstream of the dam were broken loose and rendered ineffective by tremendous volume of storm water in Sugar Creek.	12															
May 15, 1978	J.G. Huddle note to G.R. Helffrich, May 15, 1978	R.C. Mallatt and J.P. Traylor recommends that only oil discharges into Sugar Creek downstream of the off recovery dam be reported to the Coast Guard as spills: However, both advise that spills to the creek above the dam and oil seepage into the water intake bay (continued with	9															

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		bands) constitute technical violations of oil spill regulations, and could result in legal action if detected. Any oil discharge that reaches the Missouri River should definitely be reported. I would further suggest that that any large spill of oil into Sugar Creek be reported; if, anything other than the ground oil seeps from the banks of the creek, etc. In view of last fall's crude oil spill, Sugar Creek Refinery personnel could be more susceptible to legal action. <i>(Amoco clearly knew and was concerned about the legal implications of their oil releases.)</i>	
June 9, 1978	Amoco memorandum dated June 9, 1978 by J.D. Sellers	Memo summarized meeting to discuss oil leaks known and recorded at/near the refinery. The oil leak volumes from various sources were listed for the week of June 5, 1978. The total appears to exceed 2,100 gallons per day. The estimated Norledge sump volumes were estimated at 1,500 gallons per day. <i>(This memo illustrates violation of their NPDES oil and grease permit limits which were on the order of 367 to 550 pounds per day.)</i>	148
November 19, 1978	Sugar Creek Refinery memorandum dated November 29, 1978 to R.W. Ginson from Mr. G. J. Wurtz.	Related discussion with USEPA's Mr. Bill Keffer that the catch pan for separating oil for the North Bluffs run-off was an un-permitted discharge and that the refinery was "vulnerable to legal enforcement." He further noted that another area of non-compliance was the sanitary sewers from the main gatehouse, gasoline blender, transport loading rack and fire station that still discharge into Sugar Creek. <i>(The refinery recognized they were likely out of compliance at this time.)</i>	123
November 29, 1978	Sugar Creek Refinery, Nov. 29, 1978; NPDES Permit Modifications	<u>NPDES Permit Modifications</u> Before this could be done, the project to replace the overflow line from the Pipe Still once-through cooling water pumping station must be completed (Phase I of the proposed water and spill compliance program). The line must be replaced, since it is broken and allows ground oil to seep in and be flushed out by the cooling water when the sump overflows. In discussions with Mr. Bill Keffer of EPA during his NPDES permit compliance inspection on November 16, 1978, he expressed his opinion that the catch-pan for separating oil for the North Bluffs run-off was an un-permitted discharge. Mr. Keffer's comment is that we may be vulnerable to legal enforcement. Since his visit I have realized that we also may need a permit for the Evans Dam discharge, the Lower Refinery Separator Box bypass/storm water discharge and from the West Plant drainage dam. Although MDNR is aware of the existence of the West Plant drainage dam and did not require a permit for it, we do not have any written permission from them to operate it without a permit. The EPA regulations on discharge of storm water allow NMT 15 mg/1 oil and grease or 35 mg/1 total organic carbon. A sample of effluent water from Evans Dam on November 30, 1977 contained 137 ppm oil and grease. In general, if storm water mingles with much volume of oil, it will not meet the limits. This action may result in additional violations to our NPDES permit from discharging storm water containing more than 15 mg/1 oil and grease, until the oil leak elimination projects are completed and existing ground oil is displaced. However, it is more expedient to violate a permit temporarily than to operate unpermitted discharges. <i>(Clear recognition by facility staff that they are violating the permit.)</i>	65

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March 20-22, 1979	March 2- 22, 1979. Industrial Hygiene Survey Report, Industrial Hygiene and Toxicology Environmental Conservation and Toxicology Dept., Amoco Oil Company, Sugar Creek Refinery, Sugar Creek, Missouri.	VRU Pump Room	170
		Area samples were taken in the VRU pump room to verify the previous high results of aromatics obtained during a benzene survey. These samples (SC145-79-010, 011, 013, and 014) showed benzene concentrations in excess of 10 ppm. All the windows in the pump room were removed to afford better ventilation, but nevertheless, the excessive leakage at the pumps called the abnormally high level of aromatics. The pump seals should be repaired to minimize the leakage of hydrocarbons into the pump room.	
		Arthur A. Marozas Staff Industrial Hygienist VRU Pump Room	

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	June 4, 1979	those reported by other refiners by 10 to 100 fold. The EPA considers that NPDES discharge limits are an absolute maximum, rarely, if ever to be exceeded. A comprehensive in-plant waste management program and a tough in-plant enforcement program appear to be necessary parts of any plan adequate to meet the stringent EPA requirements. Table in Ref. 79 shows clear violations of NPDES permit in early 1979 on a daily basis. (<i>Internal recognition of level of violations relative to other Amoco refineries.</i>)	
June 22, 1979	June 22, 1979. Memo from J.G. Huddle Regarding Hazardous Waste Situation at Amoco Refineries	MEMORANDUM Hazardous Waste Situation at AMOCO Refineries A Survey of Amoco refineries indicates the similar burial practices, and oil leakage from equipment and sewers, have caused potential problems at most locations. The problem is most frequently characterized by the accumulation of large quantities of oil on the underground water table, and/or seepage of underground oil into surface streams. With the exception of Baltimore, all refineries appear to have some problems... Refineries with Highest Vulnerability, Requiring Prompt Remedial Action Problems with oil at the Casper, Sugar Creek, and Whiting Refineries have recently come to the attention of the Environmental Protection Agency and the U.S. Coast Guard. Sugar Creek – The water table under the refinery is contaminated with oil, which leaks from the ground at numerous locations, causing repetitive violations of oil spill regulations. Underground oil seeps into the Sugar Creek and the Missouri River constitute the most serious immediate problem. J.G. Huddle (<i>Amoco documented problems with regulatory agencies regarding oil leakage from the refinery.</i>)	169
July 3, 1979	J.F. Horner, memo to H.L. Fuller, Water Disposal – Amoco Oil Refineries, July 3, 1979	However, I should note that our current waste disposal practices fall substantially short of satisfying the recently proposed regulations covering the disposal of hazardous wastes. In their present form, these regulations would force us to discontinue practices we have considered environmentally acceptable, such as land farming and deep well disposal.	3
August 21, 1979	G.R. Helffrich, letter to J.F. Adler, EPA, Spill Report, August 21, 1979	This letter is in reply to your letter concerning an oil spill that occurred in April 30, 1979. Oil seepage from refinery via banks of Sugar Creek. An on-going program has been instituted to clean up seepages of oil into Sugar Creek. Oil accumulations and oil-soaked dirt have been removed, and the Creek is policed daily by a responsible supervisor. Where point sources of oil entering the Creek have been identified, such as leaking line plugs, etc., corrective action has been taken to eliminate the source. (<i>Oil source tied to refinery by Amoco; they state source will be eliminated.</i>)	25
October 22, 1979	G.R. Helffrich letter to S.R. Slovenko. Sugar Creek Refinery, Oct. 22, 1979; Appropriation Request –	Attached for your handling is an appropriation request in the amount of \$5,900,000 to cover the cost of Sugar Creek refinery water control and quality improvement projects. These projects reflect our appraisal of current needs to accomplish the following objectives:	

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	Water Quality Control Projects, Phase I	I. <u>Reduce</u> oil spillage to the Missouri River and its tributaries. II. <u>Reduce</u> process sewer water volume. III. <u>Improve</u> quality of effluent water to meet current NPDES limits. This project is part of the refinery's five-year Environmental Plan to upgrade facilities and achieve compliance with existing and future EPA and Missouri regulations. <u>I. Reduce Oil Spillage to the Missouri River and Its Tributaries</u> Six oil spills have been reported to the coast Guard since 1977 as a result of process sewer overload during heavy rains. <u>II. Reduce Process Sewer Volume</u> The following benefits will be obtained: (1) reduced sewer overload and thereby reduced oil spills – complementing projects in category I above, (2) reduced shock loading to present water treating plant, thereby reducing the number of NPDES permit violations, (3) reduced volume to present and future water treating plants – 0.25 M Gal/Day of normally oily storm water will be removed from the effluent treating system on a year-round basis. <i>(Suggest all issues related to NPDES permit can be solved in 5 years.)</i>																			
March 4, 1980	AMOCO Certified Mail, "Spill Report No. 79-433", March 4, 1980; Spill Report No. 79-433. To: Mr.Ronnae Coleman, Legal Branch, Enforcement Div.; From G.R. Helffrich	4. The seepage was general ground oil, suspected of leaking from underground lines and tank bottoms. 10. ...Where point sources of oil entering the creek have been identified, such as leaking lines, tank bottoms, etc., corrective action has been taken to eliminate the source. Major capital expenditures are being made and planned, such as raising pipe lines above ground to eliminate seepages. RECORD OF ACCIDENTAL SPILLS AND OTHER POLLUTION CAUSING EPISODES FOR 1967 <table><tr><th>Date</th><th>Location</th><th>Description</th><th>Responsibility</th><th>Damage</th><th>Clean-up</th><th>Agencies Investigating</th><th>Legal Action</th><th>Publicity</th></tr><tr><td>4-67</td><td>Sugar Creek Refinery</td><td>Oil accumulated in drainage ditch along Santa Fe right-of-way, ignited and caused damage to Santa Fe equipment.</td><td>Refinery</td><td>Nominal damage to tracks and signal equipment.</td><td>Facilities designed to prevent recurrence, approval pending.</td><td>None</td><td>None</td><td>Extensive local press, radio and TV.</td></tr></table> <i>(Message to the Agencies is that the leaks and seepages have been "eliminated" despite the fact they continue to be seen. Language selected to understate the situation.)</i>	Date	Location	Description	Responsibility	Damage	Clean-up	Agencies Investigating	Legal Action	Publicity	4-67	Sugar Creek Refinery	Oil accumulated in drainage ditch along Santa Fe right-of-way, ignited and caused damage to Santa Fe equipment.	Refinery	Nominal damage to tracks and signal equipment.	Facilities designed to prevent recurrence, approval pending.	None	None	Extensive local press, radio and TV.	55
Date	Location	Description	Responsibility	Damage	Clean-up	Agencies Investigating	Legal Action	Publicity													
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June 12, 1980	S.R. Slovenko memo to J.F. Horner dated June 12, 1980 entitled "Appropriation Request – Sugar Creek Refinery Water Quality	To date we have 28 violations with fines pending on 22 of these. The last fine paid involving about 1 quart of oil was for \$500. In addition, each violation carries a clean top cost of at least this amount. Future fines are expected to be \$1,000 or higher. The Water Quality – Phase II appropriation for \$6.25M is aimed at eliminating NPDES effluent water quality violations and meeting expected tightening of NPDES emission restrictions. The	8																		

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	Control – Phase II.” Amoco memo dated May 21, 1980 entitled “Sugar Creek Refinery Line Raising Phase III. G.R. Helffrich, memo to S.R. Slovenko, Appropriation Request – Water Quality at Sugar Creek Refinery, October 22, 1979	project involves installation of a separate storm water collection system and a sour water holding tank to eliminate the lagoon shocks from these streams that have resulted in long periods of violations in the recent past. Appropriation Request 5/15/80 Sugar Creek Refinery Line Raising Phase III Raise Retaining Underground Tankfield Lines Above Grade Meet Environmental Restrictions Prohibiting Spillage of Oil to Waterways or Contamination of Underground Water Supplies. Effect of Delay in Approval: Continuing costs of cleaning up oil seepage possible legal action by the U.S. E.P.A. Description of Base Case Against Which PI is Calculated: Continued Loss of Some Underground Oil Oil seepage into Sugar Creek has been a major problem for a number of years. The problem was handled by routine pumping of the entire creek flow until 1977. At that time, the USEPA began strict interpretation of the federal water pollution laws prohibiting discharge of oil into “navigable waters” of the United States. At that time, the EPA mandated efforts to eliminate sources of oil to Sugar Creek, rather than routine removal of oil having already reached Sugar Creek. The Refinery is being pressed by environmental officials to eliminate the problem and are expecting an attempt to eliminate the problem by raising leaking lines. Attached for your handling is an appropriation request in the amount of \$5,900,000 to cover the cost of sugar Creek refinery water control and quality improvement projects. These projects reflect our appraisal of current needs to accomplish the following objectives: VII. <u>Reduce</u> oil spillage to the Missouri River and its tributaries. VIII. <u>Reduce</u> process sewer water volume. IX. <u>Improve</u> quality of effluent water to meet current NPDES limits. In addition to the projects shown in the Table I, a further major project may be required to cope with oil seepage into Sugar Creek, subject to EPA’s willingness to allow us to eliminate this seepage by raising lines aboveground, and repair of leaking tank bottoms. Major sewer repair and replacement may also be required to cope with oil seepage. Total....\$5,900,000.	
August 11, 1980	G.R. Helffrich, letter to Senator Allan G. Mueller, August 11, 1980	“The hazardous waste regulations will have a significant adverse economic impact on the refinery; major capital and operating expense will result.” <i>(Memo to Senator Mueller strongly suggests a resistance to pending hazardous waste regulations)</i>	5
September 23, 1980	J.P. Corbett, Quarterly Report on Oil Movements and Utilities: Third Quarter – 1980, September 23, 1980	...a large spill of diesel oil to Sugar Creek occurred on August 5, due to a combination of operator negligence and equipment deficiencies. Finally, the refinery was issued notice in September of court action by EPA charging repeated violations of our NPDES permit stretching back over the past four year period.	19

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		Gathered background analytical data and correspondence for defense in EPA effluent water violations charge. Worked with City personnel to define total refinery water treatment program.	
January 13, 1981 and February 4, 1981	G.R. Helffrich, letter to U.S. Coast Guard, Water Pollution, February 4, 1981	<u>Water Pollution Case 2P07432</u> ...a great deal of time and effort has been and continues to be directed toward solution of problems resulting from oil seepage and sewer overload. Please refer to your letter of October 20, 1980 regarding water pollution cases. The Sugar Creek Refinery is a 76 year old plant that was designed under concepts of the past, many of which are not consistent with today's environmental needs. Extensive underground piping networks have developed leaks that cause oil seepage along bluffs and bankings. Under-sized sewer systems overflow during periods of heavy use. These problems are further complicated by the unique location of the refinery --- on a hillside by the Missouri River with two creeks that pass through the refinery before discharging into the river. Beginning in 1976, a three phase program was started to replace literally miles of underground piping with above ground piping to stop existing leaks and to facilitate future inspections. At this date, the first two phases have been completed at a cost of \$6 million. The final phase is in progress at an additional cost of \$7 million for completion by 1982. All of this work is currently in progress. Much of it will be finished by the end of this year, and all of it will be done by mid-1982. In addition to the foregoing work, a program of testing and repair of oil storage tanks has been underway since 1977 to detect and eliminate oil spills from that source. By October 1980, all tanks in the program had been tested, and all leaking tanks had either been repaired, or removed from active service.	10
January 13, 1981	January 13, 1981. Memo from R.J. McGillivray Regarding Sugar Creek Refinery Coping with Hydrocarbon Leaks, Vapors and Odors.	Sugar Creek Refinery January 13, 1981 Coping with Hydrocarbon Leaks, Vapors and Odors Leaks and diversions (whether deliberate or accidental) of hydrocarbons onto the ground, within firewalls, into sewers, to blowdown stacks or vents require immediate and constant attention until (1) the source is discovered and stopped, and (2) the hydrocarbons are removed and disposed of safely. Standing instructions 1. Routes by which hydrocarbons can escape or be diverted should be removed, blinded or plugged at all times. 3. Each unit must have a checklist to aid in the discovery of the source of hydrocarbons entering sewers, relief valve drums or blowdown stacks. 5. When even moderate amounts of hydrocarbon are discovered in unwanted places, the operating area of the foreman must be notified immediately by the Chief Operator. Implementation	168

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		Operating Superintendents are responsible for putting these practices into effect today. R. J. McGullivray cc: G. R. Helffrich <i>(Policy and procedure addressing hydrocarbon leaks finally issued in 198, one year before the facility closed.).</i>																					
July 20, 1981	July 20, 1981. Industrial Hygiene Survey Report, Industrial Hygiene and Toxicology Environmental Conservation and Toxicology Dept., Amoco Oil Company, Sugar Creek Refinery.	<table> <tr> <td>Sample</td><td>Employee & Sample Date</td><td>Description</td><td>A</td></tr> <tr> <td>81-085</td><td>Area</td><td>Separation Box – Middle of Separator</td><td>2.4</td></tr> <tr> <td>81-086</td><td>Area</td><td>On south end of separator box</td><td>1.3</td></tr> <tr> <td>81-084</td><td>Hill J</td><td>Sampling naphtha at pipestill</td><td>5.2</td></tr> <tr> <td>81-105</td><td>Moreira P</td><td>#5 Bottom – Remove Hatch</td><td>4.2</td></tr> </table> A - Air Benzene Concentration Results (ppm).	Sample	Employee & Sample Date	Description	A	81-085	Area	Separation Box – Middle of Separator	2.4	81-086	Area	On south end of separator box	1.3	81-084	Hill J	Sampling naphtha at pipestill	5.2	81-105	Moreira P	#5 Bottom – Remove Hatch	4.2	167
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October 13, 1981 to January 8, 1982	G. R. Helffrich, memo to J.G. Huddle, SEC Quarterly Report October – December 1981, January 8, 1982	List of 12 spill events over two months in late 1981.	13																				
March 29, 1984	Chicago Tribune 3-29-84; Amoco settles EPA lawsuit for \$500,000	Refinery fined \$500,000 for NPDES violations.	124																				
September 14, 1984	C.G. Hill, U.S. Coast Guard, letter to J.G. Huddle, Water Pollution, September 24, 1984	I have reviewed the case file together with the matters presented in your letter of 10 September 1984. Absent any further substantive information regarding this violation, I am compelled to stay with my preliminary determination. The instant discharge was aggravated by the fact that it was the eighth discharge, involving your sugar Creek facility during the period from May 1982 through April 1983.	21																				
April 12, 1985	D.R. Tripp, U.S. EPA, letter to Amoco Oil Co., Spill Report, April 12, 1985	On January 19, 1985, the Environmental Protection Agency received a report that the Sugar Creek Amoco Terminal experienced a discharge of JP-4 jet fuel from a storage tank over-flow.	22																				
May 6, 1986	Telephone memo between Huddle and Woodward-Clyde Consultant T. Gogel, May Quarterly Sampling, May 6, 1986	He (Huddle) "Doesn't want us to sample wells that have an accumulation of hydrocarbons, in wells that have a sheen of oil, take sample at a depth well below water surface. Adapt sampling procedures as necessary to limit amount of oil in samples." <i>(Memo clearly demonstrates that Amoco is directing how and where certain samples are taken. Process is not consistent with 1985 sampling protocols)</i>	28																				
July 19, 1988	D.W. Abshear, memo (plus attachments) to R. Ginson, If-Asked Statements – Sugar Creek Refinery, July 19,	What is the amount of hazardous waste – including acids, PCB waste oils, and sludge – remaining in pit ponds and/or lagoons? We do have approximately 225,000 tons of oily wastes that we plan to dispose of in an	27																				

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	1988	environmentally-sound manner. By current EPA definition, about 80,000 tons of this waste are hazardous because they contain trace amounts of chromium and lead. We expect that it could take as long as 10 years to completely treat the oily wastes. Yes, this is a revision. Will groundwater contamination from the refinery affect area drinking supplies? No. Our monitoring confirms this. What will be done to the groundwater by Amoco following all product recovery? We will continue to monitor the groundwater and do whatever is necessary to protect health and the environment. As I said before, our monitoring activities indicate that drinking water has not been affected. State reports filed in 1985 indicate your groundwater monitoring wells are tainted with oil. Has this situation been remedied? Out of 15 monitoring wells, only a few have shown trace quantities of oil. The presence of this oil is to be expected, - as the wells which have shown the trace amounts are in the area where we are pumping oil from the subsurface. This oil is in a localized pool. Again, the drinking water supply of Sugar Creek is not in danger. <i>(Responses dodge issue of groundwater contamination since Amoco knew resident's drinking water was from a municipal supply; but no indication that they completed survey to ensure no local wells were either present and/or being used. The use of the word "trace" is misleading giving the amounts of free product found at times.)</i>	
December 20, 1988	December 20, 1988. Letter from Arthur H. Groner (MDNR) to J. G. Huddle (Amoco) regarding penalties for violations.	Letter from MDNR outlining NPDES permit violations and proposed fines.	155
January 31, 1990	L.P. Coen, Missouri Dept. of Natural Resources, letter to J.G. Huddle, Underground Storage Tank at Amoco (former) Sugar Creek Refinery, January 31, 1990	RE: Underground Storage Tank at Amoco (former) Sugar Creek Refinery BTEX analysis was not done, and we see no reason why it should not have been done; In addition to these concerns, an EPA report of January 16, 1990, indicates that an oil release is occurring along the face of the bluff overlooking the railroad tracks along Sugar Creek, just north of the refinery. This situation should also be investigated and addressed as well as the tank closure.	26
May 29, 1990	May 30, 1990. Memo from D.J. Murphy Regarding Early Draft Version of a Speech by Steve Grossman.	In parallel with and preparatory to critical negotiations...much effort is focused on developing and maintaining excellent relations with the regulators and with the local community and its elected officials. Slide 10. I would now like to discuss in depth, one project, which is an example of the flexibility which can be tapped by effective negotiations. That project is the Sugar Creek RCRA Impoundment closure. This slide is an overhead photograph of the impoundments. RCRA regulations required the	176

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		closure of the three impoundments...the Sludge Pit, Sludge Pond, and Lagoon. The technology for closure initially chosen by Amoco and committed to in a plan filed with the State of Missouri was Incineration. The closure plan also specified various cleanup levels for metal and organic contaminants. The most critical clean up level was established by an Amoco commitment to incinerate all sludges and soils that were contaminated at levels above 1,000 ppm Total Petroleum Hydrocarbons (TPH). The volume to be incinerated was not known when the closure plan was committed. When the results of the first borings and analyses of soils under the impoundments became available...the requirement to incinerate soils above 1,000 ppm TPH was found to require an excavation up to 19 feet deep...850 thousand cubic yards of soil required incineration. Incineration of that volume would cost more than \$250 million. At that time we launched an intensive year-and-a-half effort to turn the project around. There were three milestones in the turnaround. In an atmosphere of considerable antipathy towards Amoco by the State's regulatory staff, the first milestone was reached when we persuaded the State regulatory management to allow an year-and-a-half project delay to restudy cleanup levels and technology. The second milestone was reached when new cleanup levels were established. During the delay period...we engaged the regulators in an intensive dialogue to establish credibility for a scientific risk assessment process. The results of this process allowed us to negotiate cleanup levels which are fully protective of human health and the environment, yet 30 times less stringent than the original levels proposed by Amoco. Less stringent cleanup levels reduced the volume of "contaminated" material by 800 thousand cubic yards. The third milestone was reached in early 1989 when we negotiated an agreement to change the technology from incineration to bioremediation. We also were able to relax the schedule and have up to three more years to do the work...The bottom line to all these negotiations was a reduction of about \$250 million in projected cost for this project. <i>(Comments suggest that the process of delaying remedial work was intentional and resulted in significant savings to Amoco.)</i>	
February 12, 1991	Letter, Mr. Arthur Daigh February 12, 1991: Installation of a Monitoring Well on His Property	During 1991, Amoco Oil Company plans to install groundwater monitoring wells and conduct a groundwater quality assessment on property adjacent to our Sugar Creek refinery site. Please remember that this is a precautionary measure. We have no reason at present to believe there is contamination on your property, but are required to install the wells for reporting the data to the USEPA. <i>(At best, the information to the homeowner is speculation, tends to blame the USEPA for the need to install the well and continues a pattern of understating the issue.)</i>	93
September 7, 1994	Memorandum September 7, 1994: Review of EPA's comments regarding Risk	Amoco has confirmed there is no ground water use as drinking water in the Norledge Area through the water well survey. The Norledge Area is the only area off-site with previous detections of hazardous constituents in ground water." <i>(Analysis based on current groundwater</i>	99

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	Assessment Risk Based Concentrations Amoco Former Refinery, Sugar Creek, Missouri	<i>usage rather than past and potential future usage; not a conservative approach in performing risk assessments. Further, the elimination is flawed since it was found a resident was using groundwater to water his garden. Pathway should not have been eliminated. My position is consistent with USEPA's comments and concerns.)</i> This point is amplified in AMOCO's response to Specific Comment 1: Amoco representatives have meeting notes that following the lunch break during the meeting with EPA and PRC representatives on February 18, 1994, Amoco informed EPA of the detection of product in well MW-62. Alan Hancock of EPA expressed concern over this development, specifically relating to whether nearby residents were being exposed to ground water through water supplied by domestic wells.	
December 18, 1995	AMOCO Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9 Revision December 18, 1995. Results of Subsurface Gas Sampling and Analysis	Statement on page 14-45 that: "Ground water in the on-site and off-site free product plumes and areas of ground water containing benzene above the RBC located in the Norledge Area is <i>completely</i> captured by the Interceptor Trench." (<i>Is a strong statement, appears to be unsupported and is unlikely to be accurate.</i>)	122
January 7, 1997	Deposition of Jonas Kalnas, M.D., January 7, 1997	Regarding attitude towards regulators, Mr. Kalnas, after an extensive review of the Amoco Sugar Creek files concludes that Amoco officials misled officials. This is illustrated in his testimony as follows: Q: In that second full paragraph on page eight of your report, you say: "It is unclear why Mr. Helffrich told the Coast Guard that the program" – and you're referring to a test and repair program for tanks – "had been underway since 1977." You do not, in fact, know whether or not such a program was underway in 1977, do you? A: All I know is what Mr. Helffrich told the Coast Guard. All I know is that there's other correspondence later on that indicates that this program was going to take – if he was saying that the program was underway since 1977 and if, in fact, only in 1978 funds were being requested to institute such a program, then either Mr. Helffrich miswrote, misstated or misrepresented what he was telling to the Coast Guard. That's the only point that I'm making Q: I'm going to refer you to the second page of that letter, the sort of first full indented paragraph which you have quoted where Mr. Helffrich says: "A program of testing and repair of oil storage tanks has been underway since 1977 to detect and eliminate oil spills from that source. By October 1980, all tanks in the program had been tested, and all leaking tanks had either been repaired or removed from active service," correct? A: Correct. Q: That is the statement that you are calling into question by your reference to attachment ten; is that not correct? A: Yes.	110

DATE	DOCUMENT	INFORMATION (<i>OBSERVATIONS & COMMENTS</i>)	EES REF. #
		Q: Now, attachment ten refers to more tank related issues than Mr. Helffrich was discussing in his attachment nine that I just read, does it not? A: Basically what Mr. Helffrich is saying in his memo to the Coast Guard was, first of all, that the program has been underway since 1977. What attachment ten, which was written in late 1978, indicates to me is that it's only in 1978 when they're making a request to look at and to initiate a tank repair program. So a year – approximately a year after he told the Coast Guard this was being done is when he's asking for funding. So it raises a question in my mind that really the program didn't start until sometime after he made the request for it. He also estimates that it's going to take 10 years to get this program – to complete the upgrade program and yet he's telling the Coast Guard that by October of 1980 all the tanks have been tested and repaired or removed from active service. They have a large number of tanks that had not been tested and it just appears to me that these two statements do not jive. Q: As of 1978, you're saying a large number of tanks had not been tested and Mr. Helffrich's statement is made in 1981, correct? A: It's made in 1981. He's saying that by 1980 all the tanks were tested, all leaking tanks had either been repaired or removed from active service. If he started sometime in late 1978, that means that he had at least two years to complete the program. Whereas in 1978, he was estimating 10 years to complete the program. Now, if it's going to take ten years to complete the program, how could you do it in two years? Q: You don't have any factual basis for saying that his statement is not true, do you? A: I'm only comparing documents. If you have inconsistent documents within the company from the people who are looking at the same documents and have these kinds of inconsistencies over and over and over again, it overwhelmingly raises the questions in my mind that I've articulated in my report.	
December 10, 1998	Exhibit 10 of Zemansky Deposition Dec. 9, 1989. Table GW and Soil Cleanup Criteria.	Cites Missouri and USEPA criteria for cleanup of groundwater and soils. Benzene groundwater cleanup levels for benzene were 5 micrograms/liter for USEPA Missouri DWS and Missouri GW, Cleanup Levels for Missouri (CALM) and UST potable standards. UST non-potable water standards were 50 micrograms/liter. UST soil cleanup levels were a minimum of <0.5 mg/kg to a maximum of 4 mg/kg. The CALM level for benzene in groundwater remained unchanged as of February 2005.	112E
December 16, 1998	Deposition of G.M. Zemansky, Ph.D., Volume III December 16, 1998	Dr. Zemansky generally questioned the pace at which the remedial activities were proceeding. This is illustrated below: Q: My original question a few minutes ago is about any opinion you are planning to give on Amoco's efforts after the closure of the refinery to investigate the site. What opinion do you plan to give on the subject? A: Well, it seems to have been a very slow process. Sixteen years after the refinery closed we still haven't done the assessment necessary to be able to make some of those decisions.	113

DATE	DOCUMENT	INFORMATION (<i>OBSERVATIONS & COMMENTS</i>)	EES REF. #
November 29, 2000	Public Health Assessment by ATSDR for Amoco Oil Company – Sugar Creek, November 29, 2000	ATSDR concludes that “no direct exposures to groundwater or soil gas were identified in the Norledge area.” This conclusion seems flawed in light of known use of groundwater to water one resident’s garden – Mr. Fillmore – January 27, 1994 memo) combined with the apparent lack of knowledge on use of private wells in the 1950s, 1960s, 1970s and 1980s.	115

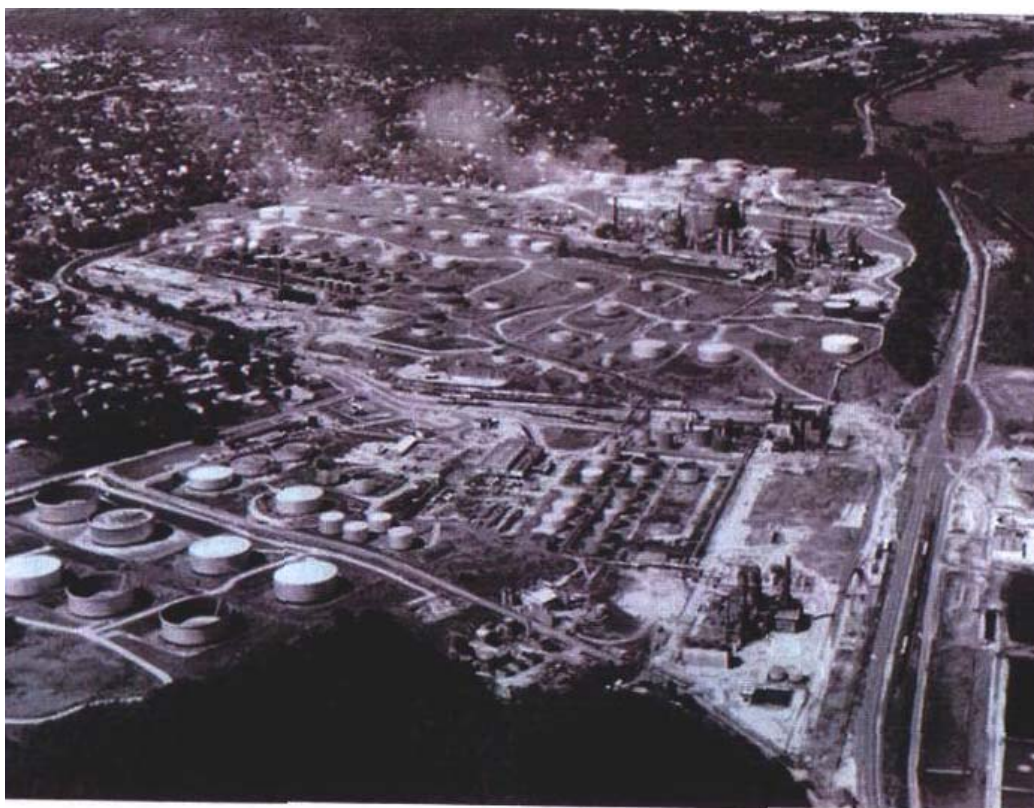
The environmental compliance record for the Amoco Sugar Creek refinery painted by these documents is also poor:

1. Amoco had dozens of violations and fines related to its NPDES permit issued in 1973. One fine was \$500,000.
2. The 1975 CEP Report – Cracking Down: Oil Refining and Pollution Control, November 13, 1975, states that the Amoco Sugar Creek refinery has a poor environmental record among peers. Its water oil and grease record is rated a “D”.
3. Both the Amoco Sugar Creek refinery manager (G.R. Helffrich), and his supervisor (J.F. Horner), admitted that the Amoco Sugar Creek refinery had problems complying with environmental regulations. Mr. Horner suggested that this refineries’ record was 10 to 100 times worse than the industry average.
4. Amoco viewed the repair of leaks, that resulted in environmental contamination, as a non-economic investment to only be undertaken when the situation became “intolerable”. Intolerable situations were defined as those receiving negative PR or pressure from regulators. This demonstrated little was done to protect the environment from oil releases until the 1970s, when regulations began to be promulgated. This position is supported by the number of documents addressing releases after issuance of the CWA in 1972 and the refinery’s need to meet its NPDES permit issued in 1973.
5. Amoco had a pattern of trying to minimize the extent and degree of contamination of the environment from local residents and regulators. This appears to have included a pattern of encouraging consultants not to sample wells with high levels of free product, to not always drill in areas most likely to contain contaminated groundwater (low vs high elevations) and to sample the air in a home after it was ventilated. Reports and memorandum often used misleading terms such as “small” or “low” to describe oil releases or contaminant levels. In another example, in their 1995 RFI they state that: ground water containing benzene above the RBC located in the Norledge Area is *completely* captured by the Interceptor Trench. This statement is likely not true; their consultant, Woodward-Clyde uses the word “effective” to describe the capture efficiency of the trench.
6. Even when it was clear that the source of oil was from the Amoco Sugar Creek refinery, Amoco delayed, and arguably haven’t completed, delineation of the groundwater plumes to determine the extent of contamination, 16 years after the refinery closed.
7. Amoco only appeared to modify their environmental positions under the threat of, potential, or actual litigation (e.g., responses to USEPA regarding NPDES permit violations).
8. Amoco, in a 1990 presentation, indicated that delaying tactics were part of a strategy that reduced environmental costs by \$250 million.

Support for Opinion #4 that Benzene and Lead in Products Released by the Defendant Contaminated the Water, Land and Air and for Opinion #5 that These Contaminated Media Posed a Serious Health Risk to Residents of Sugar Creek:

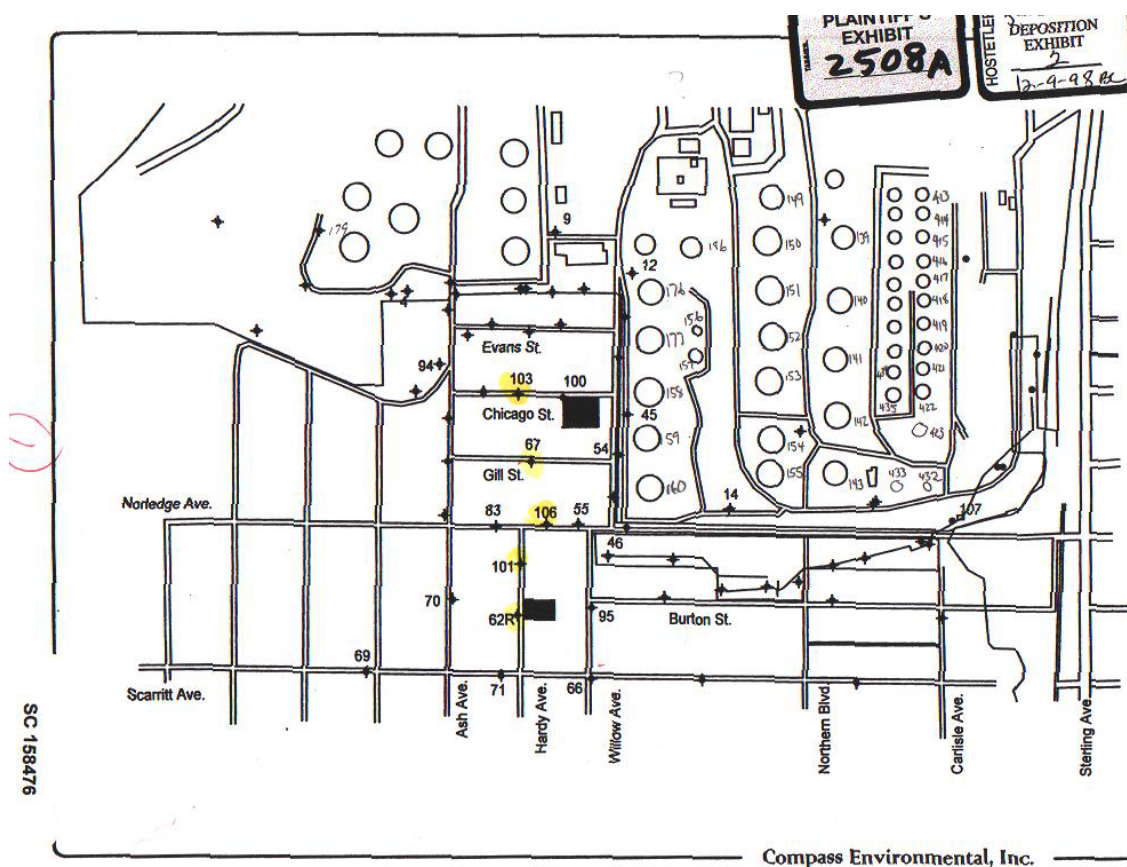
As outlined in many of the documents contained in Table 4, the land, waters and air were impacted by hazardous chemicals released by Amoco. Historical photographs and numerous complaints about sulfur and gasoline odors suggest that fugitive emissions from the refinery (Figure 1) were blown across the Sugar Creek neighborhood.

Figure 1: Historic Photo – Refinery Emissions Blowing South



SC 171634

Considerable evidence, centering on the amount of free-product, ultimately either extracted from ground waters, or reported to be in ground waters, suggests that residents of this neighborhood had the potential for significant exposures to the hazardous chemicals contained in released products, such as gasoline. Many of the reported leaking product lines and tanks were adjacent to the City of Sugar Creek (see Figure 2). The oil (gasoline) content of collected water ranged from 0 to 25% in the 1960s, with the most common value likely to be in the range of 4 to 12%.

Figure 2: Location of Amoco Tanks North of City of Sugar Creek

Documents reviewed to date suggest that premium leaded gasoline was one of the main products released into the Sugar Creek neighborhood. The composition of gasoline, especially before 1980, typically contained upwards of 5% benzene and was leaded. Other products, including naphtha, or other gasoline feedstocks, were also reported to contain up to 15% benzene (See Appendix C). Recent work by Zemansky and others (Figure 3) suggests that the hydrocarbon plume was more extensive than stated in the 1995 RFI and reached deeper into the Sugar Creek neighborhood.

Hazardous chemicals, such as gasoline, gasoline feedstocks, and naphthas, contained significant amounts of benzene, especially prior to the benzene standard issuing in the late 1980s. The hazards of chemicals, such as benzene, are well documented. Examples of this documentation are included in Table 5.

Figure 3: Estimate of Location of Hydrocarbon Plume

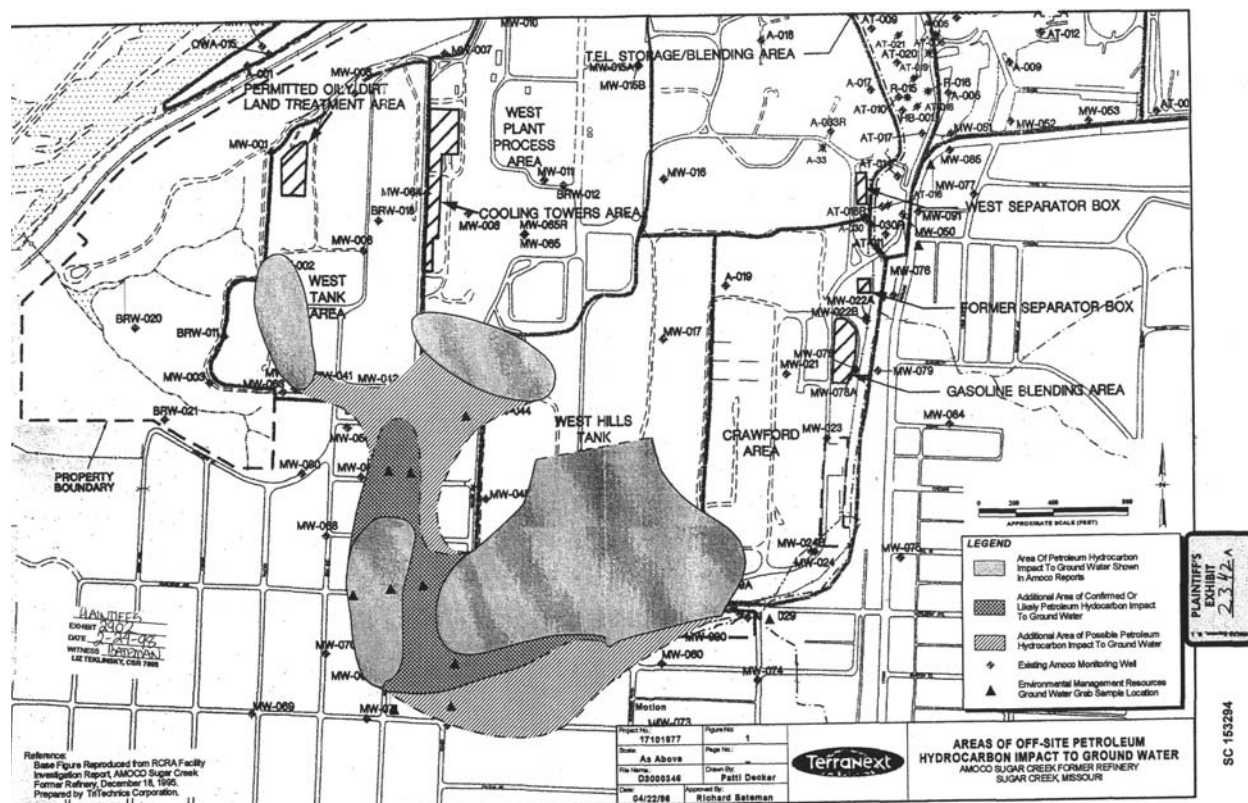


Table 4: Information Supporting Position that Amoco Knew, or Should Have Known, Oil Releases Contained Hazardous Chemicals and that These Chemicals Posed a Risk to Residents

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
March 6, 1950	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I. Erickson, March 20 1966 - American Oil Company, Letter from I. Erickson to Mr. J.N. Roper. Subject: Oil Leak South of the Refinery	The first note of an oil release impacting the Norledge area is a historical reference indicating the refinery's Engineering Division was requested to investigate "oil noted in a spring on Burton Street, approximately 300 feet south of Norledge Street" on March 6, 1950. Amoco's initial conclusion was that the oil was "coming from an unknown source outside the refinery."	131
		Note that during the 1950s considerable money was spent trying to locate the source of the leak to the Burton spring. "Usually when a leak was found and repaired the oil flow would be curtailed until another leak occurred."	132
1950s to 1970s	J. Studer, interview with Dr. Lenard Sorg on December 4, 1986	Dr. Sorg believes that each tank began leaking within two or three years of being installed. The bottoms apparently developed cracks. It was reported that common practice was to put water in the tank as well as product. The product would float on top of the water layer. At certain times caustic would be put in the tanks. <i>(Misses point that dissolved chemicals such as benzene would leak out with the water.)</i> Dr. Sorg stated that all pipes, fixtures, etc. leaked somewhat sometime. The only accidental spill that Dr. Sorg remembered was the Tank 131 spill. He said this was the major spill over the 40 year period 1940 to 1970. The incident occurred 1962-1965. A workman opened up the drain valve to tank 131 which at the time contained caustic with a sodium mercaptan compound. He was uncertain as to whether petroleum product was in the tank at the time of spill. The spill containment dike drain valve was open as well. Three feet of caustic flowed over the ground to Sugar Creek, according to Dr. Sorg.	30
1950 to April 13, 1964	Unknown Amoco memo dated April 13, 1964	Investigations in connection with oil seepage into the drainage ditch south of Norledge Avenue outside of the refinery were started by the company in 1950. During the next seven years extensive work was carried on to locate the source and to control the oil seepage. In 1960 an interceptor cover was built about 10 feet outside of the south line of the plant along Norledge Avenue. This perforated tile cover, about 20 feet deep located at the rock ledge line, collects ground water and oil and directs the flow to a 30ft deep sump. All flow into this sump is received and transferred to the plant sewer system by an automatically operated sump pump. This arrangement corrected the oil seepage problem until early this year. This February, after oil was found trapped at various points in the drainage ditch, immediate steps were taken to remove the oil by water flushing the ditch. A flowing spring at the bend of one of the branches of the rain drainage ditch is the point where most of the oil seepage has recently been apparent....In the past six weeks there has been a steady reduction of oil in the spring flow and at present the water samples taken show less than 10 ppm of oil.	54 135
1950	"Petition to the Missouri Health	We the undersigned would like for you to look into a matter which is of great concern to us. The	81

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
to April 6, 1964	Department" April 6, 1964 [petition].	seepage of gas and oil is from the American Oil Company at the Sugar Creek Refinery. The seepage is along the South boundary of the refinery along Norledge Street. This seepage is coming through underground springs and out into a natural drainage ditch along Burton St. We have seen this seepage for 10 – 14 years. The last time the Refinery attempted to do something about it was in 1959 and 1960. The smell from this seepage at times is unbearable. We consider this to be a fire and health hazard and nuisance to the neighborhood. <i>(Problem recognized by residents back as far as 1950; health concerns at that time.)</i>	
1950 to July 20, 1965	B.T. Allison, Amoco memo to N.T. Robey, July 20, 1965	Since 1950 we have had a recurring problem at Sugar Creek with oil contamination of a natural spring which flows from the bank of a drainage ditch at a point about 300 feet south of the refinery. The spring flow and other oil and water seepage from this north back in this area drain into the ditch which empties into Sugar Creek outside of the refinery. The spring flow and adjacent seepage varies from 2 to 6 g.p.m. and the oil content from 0 to 25 per cent. Maximum oil flow has been .88 g.p.m. During five periods since 1950 the residents in the immediate area and workers of the Sugar Creek City Council have complained about the strong gasoline odor, gasoline fumes in basement drains, and fire hazard from the oil collecting in the ditch and creek. The present series of neighborhood and city complaints, which began early this year, have not stopped as in other years when we were able to eliminate the oil leakage to the spring by various repairs and the construction of intercepting systems within the refinery. The attached drawing SB-11137 shows the location of the spring, intercepting facilities, and the gasoline tanks and their associated piping which are involved in the problem. Early this year, despite oil recovery by the intercepting facilities, the spring showed oil again, reaching the maximum of 25 per cent or .86 g.p.m. in February. Extensive borings to rock were made along the south fence line to obtain data for locating several 6 inch cased wells. Three wells have been in operation for several months pumping a total of 20-30 g.p.m. of water containing approximately 4-5 per cent oil. <i>(Note that oil is likely gasoline.)</i> The oil content of the spring has receded to about 7 per cent or .15 g.p.m. Even this amount of oil still produces a fairly strong gasoline odor at the spring. In 1960 when we installed the interceptor sewer we also acquired 34 lots south of the refinery as shown on the drawing. Other lots were considered, but because of price or other reasons, they were not purchased. You will note that the spring and other seeps are on lots 337, 338, 339, 340 and 341, which we do not own. ... Even though our efforts may again be successful in stopping the oil flow to the spring we believe the problem will recur as in the past. It is essential that we have the facilities outside the refinery to handle the spring flow and collect any oil that may escape underground from the refinery. The present complaints have not subsided and there have been threats of legal action against the company if the situation isn't corrected. Regardless of the success of any future efforts to reduce leakage within the plant, we believe that we should acquire 6 lots 337 – 342.	31
1951 to 1958	Deposition of John C. O'Renck, Volume 1 August 7, 1996	Q: Was there any other way in which you, when you were mayor, obtained direct knowledge about the condition of the Amoco property? A: I think one notification that we got from them was the Norledge Street location where Amoco had went beyond their refinery limits and put in a pump to intercept what was evidently leaking	108

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		out of the refinery area. At that time they notified us that it was there as a precautionary measure, if anything went out, that this pump would send it back, that they really weren't getting anything but water. And so basically the only information we had was what Amoco gave us. He notes that the community is being "snowed" by Amoco: A: ...after '84 when I started working in it, yeah, things are fine, things are fine. It's '96 and we're still in that mode, so that's why I'm telling you that we don't have all the information, we – as far as extent is concerned with this whole thing, we don't have all the information available on what it's going to take to finish the cleanup, but we're ready to move forward, you know.	
September 1953 to 1964	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I. Erickson, March 20	"Again asked to determine the source of the oil that appeared on the surface of the branch south of the refinery at the spring."	131
September 1953 to October 27, 1989	AMOCO-RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9. Tables October 27, 1989	Table 2.4-2 documents spill obtained from various records searches over this period. Accumulation of oil on water and oil seeps in the Norledge tributary of Sugar Creek were reported "due to subsurface migration from West Hills leakage" beginning in September 1953. The title page disclaimer notes that the records are likely incomplete.	41
1955 -1975	9/29/75 – Amoco Memorandum from RJ Ferm; Improved Recovery of Norledge Sump Gasoline	Gasoline sump just south of Norledge Street removes gasoline from groundwater at a depth of 25 feet bgs. Memo notes that the groundwater flows beneath the West Plant bluff where processing units and tank farms are located. The memo notes that for 20 years piping and tank leaks have been found and repaired, but "the leakages have persisted". The 1975 sump recovery rate varies from 50 to 200 bls/day. It is recommended that further efforts be made to locate the source of the leakages. The most likely sources are gasoline tanks 158, 159 and 160. (<i>Clearly identifies the "oil" as gasoline.</i>)	133
March 1957	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I. Erickson, March 20	Mr. John F. Harris, geologist of Pan American Corp. hired to investigate oil leaks to Sugar Creeks and concludes that "Oil leakage in this area apparently flow through one or more of these channels (Bethany Falls limestone) to a lower ground water level and emerges in springs along the north bank of the west branch of Sugar Creek."	131
Pre- 1964 to February 5, 1964	American Oil Company memorandum from J.C. Lumpkin to Distribution List dated March 5, 1964. Chromatographic Method for Identification of West Hill Oil Leak Source by Relative Concentrations of Closely Boiling Hydrocarbons.	Liquid and vapor samples taken for several points on the West Hill indicate premium gasoline was the main contributor to the leak." "In further attempts to locate the leak, several test holes were drilled inside the firewalls of Tanks 176, 177, 158, 159, and 160....It appears that the vapors in holes near Tanks 177, 158, and 159 came from a leak which was later found in the filling line which contained premium gasoline at the time of the sampling. The vapors in the holes near Tanks 160 and 176 could have come from small leaks around the tanks or could have been the remains of gasoline leaked from the filling line when it was carrying regular gasoline."	80
February 3, 1964	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I Erickson,	The Engineering Division was asked to review its investigation to determine the source of oil leaking from the west plant into the west branch of Sugar Creek south of Norledge Avenue.	131

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
	March 20	Recommendation: "Flush water into the branch from the spring location. " Measurement from the spring on March 16, 1964 indicated the flow to be 2 GPM with an oil content of 2.5% by volume of 3 GPH or oil.	
February 11, 1964	Amoco Memorandum, 1964. Oil Leak Investigation from L.J. Sutton and I Erickson, March 20	Samples taken from the spring and interceptor sewer indicate a premium gasoline.	131
March 5, 1964	March 5, 1964 memo from J.C Lamkin regarding the Chromatographic Method for Identification of West Hill Oil Leak Source by Relative Concentrations of Closely Boiling Hydrocarbons (A Preliminary Report).	Author notes that: "for several years oil leaks from finished gasoline storage tanks or underground lines have occurred in the West Hill part of the refinery along Willow Avenue." Using an analytical method to account for weathering, the author concludes that oil found in the firewall of Tanks 158-177 and from the interceptor sewer and a spring were all premium gasoline. He concludes that premium gasoline vapors found in holes drilled near Tanks 177, 158 and 159 came from a leak in a filling line (later replaced). He closes by stating that: "This type of work should continue until the source of all leaks is definitely established and <i>all</i> oil lost into the interceptor sewer and spring become insignificant." <i>(This last statement implies that the source of the oil is the refinery and that he knew releases to offsite waters was not acceptable.)</i>	137
February 22, 1966	T.J. McJoynt, Manager Real Estate, Field Trip Report, February 22, 1966	Mr. Almann and Mr. Hall had been retained previously by this Company to negotiate for the purchase of certain residential lots and property immediately south of our property in an effort to obtain a buffer zone. In recent years an oil leak has developed on certain of these lots and said leak flows into a ditch which, in turn, flows into Sugar Creek and into the Missouri River. During the course of our meeting Mr. Roper indicated that considerable time and money has been spent by our own people, as well as geological exploration concerns in an effort to locate the seepage leak on the refinery and stop it at its source; however, all such attempts have failed to date. Wells have been drilled near our refinery boundaries on the south side to pump the product out of the ground and a 15 foot perforated sewer has been laid in along the boundary of our property in a further attempt to collect this oil seepage. All of these attempts have not stopped the seepage flow into the drainage ditch on the Fonck property immediately south of the refinery. Analysis of the product seepage indicates that the base is gasoline, and probably premium gasoline. The seepage occurs primarily at low water table and creates considerable odor in the area, as well as an extreme fire hazard. It is my opinion that the ravine which goes to a depth from the street to approximately 15 or 20 feet is, in itself, an attractive nuisance for children playing in the area since the ravine is not fenced off and, with the seepage of gasoline,, further hazards are presented due to the possibility of small children playing in the ravine and possibly starting a bonfire, or striking a match. To reduce the possibility of any extreme catastrophe, the refinery has taken steps to water down the entire seepage area with a spray of water through a pipe system lain on the surface of the ground. There have been several complaints registered by property owners downstream along the creek concerning odors and the dangerous condition resulting from the seepage of the product into the creek. To date, no formal letter has been issued by the city to the company demanding that	32

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #																
		they clear up the situation; however, such a letter may come at any time if the nuisance continues.																	
1966	11/17/66 – American Oil Co. Handwritten Notes of I. Erickson and J.N. Roper	Description – Oil Leak Investigation (Burton Street) <table> <tr> <th>Date</th><th>Spring Flow</th><th>% Oil</th><th>Sump % Oil</th></tr> <tr> <td>11/4/66</td><td>1.6 gpm</td><td>18.5%</td><td>30%</td></tr> <tr> <td>11/8/66</td><td>1.25 gpm</td><td>12.5%</td><td>31.5%</td></tr> <tr> <td>11/17/66</td><td>1.25 gpm</td><td>11.1</td><td>28.6%</td></tr> </table> <i>(This oil is likely gasoline with a benzene content of up to 5%)</i>	Date	Spring Flow	% Oil	Sump % Oil	11/4/66	1.6 gpm	18.5%	30%	11/8/66	1.25 gpm	12.5%	31.5%	11/17/66	1.25 gpm	11.1	28.6%	163
Date	Spring Flow	% Oil	Sump % Oil																
11/4/66	1.6 gpm	18.5%	30%																
11/8/66	1.25 gpm	12.5%	31.5%																
11/17/66	1.25 gpm	11.1	28.6%																
May 12, 1966	May 12, 1966 letter from L.V. Sorg to I. Erickson regarding oil leaks – West Hill.	Mr. Sorg implies that the refinery is the source of oil found in the spring (Burton spring) and the sump when he writes: “After studying these data, we have concluded that the source of oil feeding the spring is most likely HVN (Ultraformer feed) and is not contaminated with any other stock. The oil feeding the sump appears to come from more than one source. We believe that at least a portion of it is HVN.”	138																
October 10, 1966	1966. American Oil Company, Letter from I Erickson to Mr. J.N. Roper. Subject: Oil Leak South of the Refinery	In 1964, the oil content of the spring water reached 25%. “At no time during 1965 was the spring completely free of oil.” Its oil content ranged from 1% to 25%. In October, 1966, the oil content of the spring reached 12%. During the past two years, five product tanks, and their piping, along Willow Avenue have been tested. “Some leaks have been found and repaired.” The author notes that installing a line of sheet piling along the south fence of the refinery would “seal the portion of the south side of the refinery which feeds the spring and prevent ground water and any oil it is carrying from leaving the refinery. Author notes that “oil collects in pools along the branch creating a fire hazard” and that the current solution is to “flush the stream with water.”	132 136																
January 6, 1967	January 6, 1967. letter from J.N. Roper to Mayor Roper regarding installation of ground water collection system along Burton Street.	Amoco requests permission to access City of Sugar Creek property to install a ground water collection system. The attached figure illustrates the location of the seepage areas, the spring, Amoco purchased property and the layout of the proposed system.	145																
September 22, 1967 to September 1993	Memorandum Sugar Creek Refinery: Instructions for Filling Out Complaint Forms	Memorandum on process to fill out, and respond to, complaints about the refinery by residents. A table describing odors and completed complaint forms and responses (April 6, 1976 to September 23, 1993) are attached. Many of the complaints are related to odors and appear to be tied to malfunctioning equipment in the refinery. <i>(Note that this procedure began after a relatively large spill event.)</i>	83																
November 1, 1967	J.C. Lamkin, Minutes of Conservation Committee, November 1, 1967	The fourth meeting of the Conservation Committee was held on October 25, 1967. Three complaints were received since the last meeting. They are: (C) Complaint of odor of gasoline in basements by residents along Burton Street, 6/28/67. On June 29, Mr. Pete Saxton, City Engineer, City of Sugar Creek, Missouri, asked the refinery to check the sewers along Burton Street. Representatives from the Engineering and Technical Service Division investigated the sewers and found that	35																

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		there was a very slight odor of gasoline but no apparent hydrocarbons in manholes along the street. <i>(How would one know without testing?)</i> Apparently the situation causing the odor problem had cleared up by the time of the investigation. No recurrent complaints were received. This area should be rechecked occasionally to determine that the problem does not exist or reoccur. (D) Odor complain from 117 S. Crysler, 10/20/67. The complainant claimed that a gassy refinery-type of odor was entering her kitchen. Because she lives several miles from the refinery, the prevailing winds at the time would have made it unlikely that refinery odors could have reached her residence and there were no other accompanying complaints. It is assumed that the complainant erroneously blamed the refinery. No other action was taken or is required.	
August 12, 1968	Letter from L.V. Sorg to H.A. Smith dated Aug. 12, 1968 Norledge Street Oil Recovery	At your request, we investigated the oil recovered in the sump south of Norledge Street. 1. The oil content of the water in the sump was 9 ppm. 3. The water flow was 28 gpm	88
September 24, 1968	File Memorandum Sept. 24, 1968: Oil Content of Water From Sump South of Norledge	<u>Oil Content of Water From Sump South of Norledge</u> Except for one sample, the oil content was insignificant (<15 ppm)....The volume of water into the sump ranged from about 40,000 gals./day to about 60,000 gals./day. <i>(Except the one sample value was 131 ppm. Demonstrates internal knowledge of oil content in waters from this area and provides an example of understating the problem.)</i>	90
Pre – 1970s (?)	AOC Historic Photos	Photo labeled SC 171634 shows smoke drifting to the south toward the Sugar Creek neighborhood. <i>(Location likely received exposure to fugitive emissions.)</i>	97
1972 to 1980s	Deposition of John F. Horner, 25 th Day of July 1996	Recalls problems complying with water pollution regulations, including NPDES permit requirements. Noted that “there were some creeks in the area that served as rain water run off for areas probably in the refinery but including outside the refinery and that ended up creating problems for the refinery in handling their pollution permitting problems.” <i>(Odd language, appears to almost blame the creek for being present as the cause of the pollution.)</i> Recalls during site visits discussing the fact that leaking product was moving offsite into surrounding areas.	118
September 11, 1974	C.H. Carver memo, Survey of Oil Leaks on Perimeter of the Sugar Creek Refinery, September 11, 1974	Oil leaks within the refinery from underground lines and tanks gravitate down to the water table level and have appeared at the periphery of the refinery in springs and with the ground water. <u>Norledge Avenue Sump</u> A sump approximately 25 ft. deep with a French drain is installed on the south side of Norledge Avenue south of the refinery...Laboratory inspection of a sample of oil taken from the sump on September 4 is given in Table II. This sample indicates the leak is finished leaded gasoline, probably regular. The rate of accumulation of gasoline in the sump on September 4 was found to be 157 B/O. Measurements taken during September, October, and November, 1973 gave accumulation rates from a trace to 650 B/D. <u>Leak Source Norledge Sump North Bluff West Skimming</u>	36 60

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		Volume of Leak, B/Yr. 57,300 634 1,040 Last page of Ref. 60 contains log of oil and water collected in Norledge sump in late 1973. Tank map in back of Ref. 60.	
April 22-29, 1975	J. Lamkin, EPA, Compliance Monitoring Field Survey, Summary Report, Sugar Creek Refinery, April 22-29, 1975	The visual observations of the EPA professional staff recorded during the April survey indicate substantial amounts of oil were discharged to the Missouri River during the survey period as listed below: - Free globules of oil (odor of diesel fuel) were observed to cover a major portion of the surface of the intake embayment at 0410 hours on May 27, 1975 - Free globules of a dark brown heavy oil residue were observed infrequently on Old Sugar Creek during most of the survey period. The non-permitted gravity oil separation west of the Old Sugar Creek discharge was flushed out completely of accumulated oil during the precipitation events of April 25 and 25, 1975, due to a poor design of the discharge structure which is only 15 percent of the area of the influent pipe for the separator.	37
1975 to June 12, 1980	J. F. Horner, memo (plus attachments) to Management Committee, Appropriation Request – Water Quality at Sugar Creek Refinery, June 12, 1980	Management Committee (June 16) Item – Appropriation Requests – Sugar Creek Refinery <u>Environmental Control – Water Quality</u> More stringent water-quality standards instituted in 1977, equipment deficiencies, failures, and operating problems have all contributed to an unacceptable environmental situation at Sugar Creek.	7
March 12, 1976	Letter dated March 12, 1976 from R. C. Miller to Mr. J.P. Egan Regarding Sugar Creek Refinery Miscellaneous Oil Seepage Collection Including Attachment.	I. WATER POLLUTION CONTROL <u>Problems:</u> - Storm runoff overloads process sewer and separators causing oil spills into Sugar Creek and excessive oil discharge to the aerated lagoon causing oil and grease violations. - Oil seeps from bluffs, creek banks, and river bank cause: (1) Oil spills - Rainwater runoff from oily sludge land farm does not receive treatment.” <i>(Internal recognition of sources of oil contamination to Sugar Creek.)</i>	89
October 7, 1976	Letter dated October 7, 1976 from G.H. Watson to J. Victor (Chief Engineer) entitled “Hydrocarbon Spills at Sugar Creek Refinery.”	(4) Northledge Lower Dam—Your proposal of using a cut-off ditch and a separator to prevent hydrocarbons from reaching the existing creek will provide the most economical solution at this location. The present leakage could come from any of the tanks on top of the hill to the north and although this contaminant could be traced and eliminated, any future leakage from one of the other tanks would probably end up in the creek.” <i>(It was obvious to outside Amoco staff that significant leaks were occurring at the refinery and that some of these would end up in the creek.)</i>	91 147
1977	Deposition of George R. Helffrich, 17 th Day of July 1996	Mr. Helffrich was the Sugar Creek refinery manager beginning in 1977. When starting his new job, the previous manager (Mr. Evans) noted that they were having problems with seeps across from Sugar Creek, effluent water treatment and complying with environmental regulations. Mr.	117

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		Evans mentioned that they had: "had some prior difficulty with oil migration onto neighboring property, ground water, ground water containing oil migration onto neighboring properties."	
1977 to June 22, 1987	B.A. Esslinger, Woodward-Clyde Consultants, letter to R. Ginson, Site Reconnaissance adjacent to Sugar Creek Former Refinery, June 22, 1987	The reconnaissance was in response to a telephone call received by Mr. John Huddle on May 15, 1987 from Mrs. John (Betty) McCord. Mrs. McCord expressed concern about the possibility of oil seepage on the McCord property (they had observed oil in the past on their property). The purpose of the reconnaissance was to look for hydrocarbon seeps on or near the McCord property. Past oil spills and releases of oil to the ground have been documented in the vicinity. In 1977, overfilling of tank 164 resulted in a spill of approximately 25,000 bbl of crude from an outfall in the stream channel southeast of tank 179. The spill ultimately reached the Missouri River. In August, 1978, free gas oil from the fluid catalytic cracking unit was documented to be within the bermed/area at tank 179, soaking the ground. Other documented, non-dated, spills or releases have occurred at or south of tanks 179 and 211. An accumulation of oil was documented in the past (no date available) outside the property fence south of tank 211. No oil seeps were observed during the reconnaissance. However, black stained soils and hydrocarbon odors observed could be evidence of past seepage in the area of the stream bed. Within the stream valleys, hydrocarbon odors were common the day of the reconnaissance (no quantitative air monitoring was conducted). Near points A and D, black soil and tree trunks on the north stream bank were observed.	23
1977 to June 12, 1980	S.R. Slovenko memo to J.F. Horner dated June 12, 1980 entitled "Appropriation Request – Sugar Creek Refinery Water Quality Control – Phase II." Amoco memo dated May 21, 1980 entitled "Sugar Creek Refinery Line Raising Phase III." G.R. Helffrich, memo to S.R. Slovenko, Appropriation Request – Water Quality at Sugar Creek Refinery, October 22, 1979	The oil from these leaky lines filters down from the hillsides that the refinery is built on and oozes out at lower levels into the banks of the Sugar and Rock creeks causing stains and intermittent oil sheens. Two oil spills into Sugar Creek via a "clean" storm water sewer system have occurred since 1977. The sewer system serves West Plant OSBL areas and part of the hillside west of Sugar Creek. The water discharges via an underflow dam installation at the creek. Memorandum: <u>Sugar Creek Refinery Line Raising Phase III</u> The Sugar Creek Refinery has four major tankage areas, the Lower Refinery, Middle Refinery, East Hill and West Hill. The Lower Refinery and Middle Refinery tankfarms are approximately 30-45 years old. The West Hill farm was built 20-30 years ago, while the East Hill was built 10-20 years ago. Oil seepage into Sugar Creek has been a major problem for a number of years. The problem was handled by routine pumping of the entire creek flow until 1977. Oil seepage from other areas of the plant continues to be a problem, and the refinery is actively engaged in determining and eliminating the sources. Leaking lines in the West Hill tank farm is causing seepage to the north and west of the tank farm. The area to the north of the tank field drops off to large limestone bluffs. The bluffs are severely stained from oil seepage, and pools of oil collect below the bluffs. The area to the west of this farm is bordered by a large, natural spring which flows into Rock Creek, and the Missouri River. This spring has been dammed to create a retention pond, where oil is collected and removed daily. Samples of the oil seepage from both these locations indicate it is from the West Hill tank farm.	8

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
		The Lower Refinery underground lines are also a major oil seepage problem. This is the lowest area in the plant, and the water table is near grade. Oil rapidly accumulates whenever a hole is dug. Oil seepage into drain tiles of other effluent water sources has reached Sugar Creek and the Missouri River.	
September 21, 1977	G.R. Helffrich, letter to Environmental Protection Agency, Spill Report No. 77-250, September 21, 1977	Further, the dam across Sugar Creek, which is used to retain oil prior to pumping to the effluent treating system, overflowed because of the rainstorm. Booms in place downstream of the dam were broken loose and rendered ineffective by tremendous volume of storm water in Sugar Creek.	12
November 23, 1977	G.R. Helffrich memo to J.F. Horner, Oil Spill to the Missouri River, November 23, 1977 with backup memo.	"We are also intensifying our efforts to reduce ground oil seeps from the north bluff, water intake basin, Norledge property, and the banks of Sugar Creek. Each of these are potential if not periodic actual sources of oil flow into public waters."	16
June 9, 1978	Amoco memorandum dated June 9, 1978 by J.D. Sellers	The oil leak volumes from various sources were listed for the week of June 5, 1978. The total appears to exceed 2,100 gallons per day. The estimated Norledge sump volumes were estimated at 1,500 gallons per day. <i>(This memo illustrates that the refinery was aware of the oil leaks, quantified them and listed leak sources in detail.)</i>	148
September 6, 1978	Amoco memorandum from RJM/GRH	Memorandum notes the refinery is the source of offsite contamination and equipment is in poor condition. Specifically it begins by stating: "For some time it has been recognized that we have a severe problem with oil seepage into the ground. This oil finds its way to outside private land as well as to Sugar Creek and the Missouri River. Last year it became apparent our efforts to reduce seepage via the on-going program for replacing old underground field piping with new revamped above-ground systems was not sufficient."	149
September 6, 1978	G.R. Helffrich memo to J.F. Horner, 1979 One-Time Expense Budget Requests, September 6, 1978	For some time it has been recognized that we have a severe problem with oil seepage into the ground. This oil finds its way to outside private land as well as to Sugar Creek and the Missouri River. Last year it became apparent our efforts to reduce seepage via the on-going program for replacing old underground field piping with new revamped above-ground systems (Appn. 1778) was not sufficient. These pressures prompted us to look more closely at refinery tankage as another source of oil seepage. A review initiated last year showed another source of oil seepage. A review initiated last year showed that tankage in general is in relatively poor condition and not only from the standpoint of potential leakage.	11
November 19, 1978	Sugar Creek Refinery memorandum dated November 29, 1978 to R.W. Ginson from Mr. G. J. Wurtz.	USEPA's Mr. Bill Keffer noted that another area of non-compliance was the sanitary sewers from the main gatehouse, gasoline blender, transport loading rack and fire station that still discharge into Sugar Creek. <i>(The refinery recognized they were likely out of compliance at this time.)</i>	123
July 3, 1979	J.F. Horner memo to H.L. Fuller, Water Disposal – Amoco Oil Refineries, July 3, 1979	<u>Waste Disposal – Amoco Oil Refineries</u> (2) The most prevalent problem is oil in the underground water table, for which there is no quick fix. We are attacking it, short-term through using well points and pumping out to crate in-flow ...and longer term through eliminating potential sources of leakage in the refineries.	3

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August 21, 1979	G.R. Helffrich, letter to J.F. Adler, EPA, Spill Report, August 21, 1979	This letter is in reply to your letter concerning an oil spill that occurred in April 30, 1979. Oil seepage from refinery via banks of Sugar Creek. An on-going program has been instituted to clean up seepages of oil into Sugar Creek. Oil accumulations and oil-soaked dirt have been removed, and the Creek is policed daily by a responsible supervisor. Where point sources of oil entering the Creek have been identified, such as leaking line plugs, etc., corrective action has been taken to eliminate the source. <i>(Source tied to refinery by Amoco; Amoco states that the source will be eliminated.)</i>	25
September 23, 1980	J.P. Corbett, Quarterly Report on Oil Movements and Utilities: Third Quarter – 1980, September 23, 1980	...a large spill of diesel oil to Sugar Creek occurred on August 5, due to a combination of operator negligence and equipment deficiencies. Finally, the refinery was issued notice in September of court action by EPA charging repeated violations of our NPDES permit stretching back over the past four year period. <u>Technical Services</u> Gasoline benzene problems analyzed and tracked to DLVN cut point and Ultraformer tower operations.	19
February 9, 1982	February 9, 1982. Trip Report by T. Gogel regarding Meeting with Sugar Creek Refinery Management – Results of Hydrologic Investigation and Recommendations for Subsurface Hydrocarbon Abatement.	Mr. Gogel notes that: "Seepage of hydrocarbons into the tributary of Sugar Creek continues in the Norledge Avenue area. Most of the seepage is emitting from a backfilled excavation trench which contains the sanitary sewer line. It was recommended that the possibility of extending an existing French drain about 100 feet to the east and tying into the trench be investigated." The third area of hydrocarbon seepage is into Sugar Creek along both banks. The area of seepage extends about 700 feet northward from the pipeline station. French drains were recommended along both banks in this area. Cost of installation would be significant, particularly along the west bank. However, no other abatement method appears feasible." Earlier, he notes that a pool of liquid hydrocarbons in excess of 9 feet below the north salvage yard contains an estimated 195,000 barrels. <i>(Memo recognizes that remedial efforts to date in the area of Sugar Creek have not been effective.)</i>	134
circa 1983	April 6, 1988. Meeting Notes, Meeting to View and Discuss Sewer Line Video Tapes of Sewers Near to and on AMOCO Property Between Norledge and Burton Streets and Willow and Carlisle Avenues	Mr. Martinovich, City of Sugar Creek, indicates that several homeowners made complaints circa 1983 of gasoline odors in their homes. "These houses are located at Lot numbers 346 and 146 on Burton Street close to Willow Avenue and Lot numbers 128 and 129 at the corner of Norledge Street and Willow Avenue (Attachment 1). Mr. Martinovich indicated that he believed the odors were coming from seepage through basement walls and not from floor drains since all floor drains had water in them."	153
May 18, 1987	Telephone Memorandum – Call from Mrs. John McCord, Concerning Presence of Oil of their Property, May 18, 1987	<u>Telephone Memorandum – Call from Mrs. John McCord Concerning Presence of Oil on their Property Adjacent to Amoco's Sugar Creek Refinery</u> On Friday, May 15, 1987 John Huddle received a telephone call from Mrs. John (Betty) McCord, 1300 Oak Hollow Drive, Friendswood, Texas, 77456. (tel. 713-482-4510) concerning the above subject.	53

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		The McCords had received a notice of Amoco's forthcoming cleanup/closure activities at the Sugar Creek, Missouri refinery, from the Missouri Department of Natural Resources, as they own property West of Ash Ave., between Park View Road and the Refinery. Mrs. McCord wanted to know how soon Amoco was going to complete the cleanup, as her son planned to build three fourplex apartments on their property, and they had observed oil on the property in the past. Huddle indicated that our planned cleanup wasn't related to the area of her property, but we would investigate her problem. <i>Figure on last page of sump design and findings on 6-22-87 near Tank 179 record 8" of oil in the bottom of the sump 22 feet bgs. Excellent design details.</i> <i>(No results of investigation provided in memo.)</i>	
October 27, 1987	Letter, October 27, 1987; Mr. Ron Ginson: Preliminary Report of Water Well Survey Near Former Amoco Refinery Sugar Creek, Missouri	The information from the City of Sugar Creek indicates that 55 private water wells have been recorded within Sugar Creek City limits and that, likely, more wells have existed which were not recorded. It is recommended that Amoco conduct further investigations to verify the existence, location, use and water quality of the private wells in the immediate refinery area. We understand this program may be the first time since the Norledge Street trench installation (during refinery operation) that Amoco or its representatives will be performing work related to ground water outside the refinery boundaries. Initially, it is recommended that a house to house survey be conducted in areas within about one-quarter mile of the former refinery to confirm the existence of private wells." A listing dated October 6, 1987 suggests that a well at 10617 Norledge may be contaminated. <i>(Five years after the refinery has closed, Amoco still doesn't know who may be using the groundwater.)</i>	94
March 4, 1988	Well and Norledge Sump Location Map by Woodward-Clyde Consultants	Map shows location of creek, buried lines and lots immediately south of refinery.	88
May 16, 1988	Letter Mr. Ron Ginson, May 16, 1988: Transmittal of the Ground Oil Analysis for the Amoco Sugar Creek Former Refinery Sugar Creek, Missouri	Sample NS-2 was reported to contain the highest concentration of lead, 0.18 gm/gal. The relatively high reported lead content of NS-2 indicates that leaded gasoline is likely a major hydrocarbon constituent in ground oil recovered from the Norledge sumps. The ground oil sample analyzed from Norledge Sump Number 2 (NS-2, the eastern-most hydrocarbon recovery sump located south of North edge street) contains a significant amount of BTX and light-end hydrocarbons (Figure 3). Based on the <i>(not legible hand writing)</i>, major hydrocarbon products contained in sample NS-2 are within the gasoline and kerosene boiling point ranges. Sample NS-2 was also reported to contain the highest lead content of the six samples analyzed (0.18gm/gal) which indicates that the gasoline contained in the sample is probably leaded gasoline. <i>(Analysis suggests leaded gasoline and kerosene from the refinery are being found in the sumps.)</i>	92
May 27, 1988	May 27, 1988. Letter from	Woodward-Clyde Consultants summarizing sampling of Norledge area sumps for flowrate and	156

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	Brad A. Esslinger and Donald S. Trelease (Woodward-Clyde) to Ron Ginson (Amoco) regarding the Interim Summary Report – Phase I Hydrocarbon Assessment, Round Two Sampling Data, Norledge Street Vicinity.	BTX. They note: “Results of both sampling events indicate that the Norledge recovery sumps are acting as an overall effective barrier to hydrocarbon migration in this area. Detections of low levels (12.9 to 54.8 ug/l) of benzene, toluene and xylols were observed in one of six wells (MW-33) in the second round.” <i>(Woodward-Clyde staff less certain about the effectiveness of the interceptor trench than Amoco staff in the 1995 RFI; benzene levels in MW-33 still exceed drinking water standards.)</i>	157
June 14, 1988	June 14, 1988. Letter from Brad A. Esslinger and Donald S. Trelease to Ron Ginson regarding Suggested Areas of Investigation at the AMOCO Sugar Creek Former Refinery, Sugar Creek, Missouri.	Letter outlines areas for additional delineation activities and suggests the need for off-site delineation activities. <i>(This memo would have informed Amoco that the plumes were not delineated six years after the refinery closed.)</i>	158
July 28, 1989	J.G. Huddle, memo to A.T. Keith, Engineering Assistance, Sugar Creek – Norledge Ave Sump Project, July 28, 1989	<u>Sugar Creek – Norledge Avenue Sump Project</u> An area at the former Sugar Creek refinery require remediation because hydrocarbon is seeping into Sugar Creek. This was brought to our attention on March 31, 1989 by Mr. Manseil, a resident living on Norledge Avenue (see attachment). A temporary corrective action (plugging the area with cement) was done on April 19, 1989. A permanent solution must be implemented by the end of September. <i>(Note that leakage noted seven years after the refinery closed.)</i>	24
January 31, 1990	L.P. Coen, Missouri Dept. of Natural Resources, letter to J.G. Huddle, Underground Storage Tank at Amoco (firmer) Sugar Creek Refinery, January 31, 1990	In addition to these concerns, an EPA report of January 16, 1990, indicates that an oil release is occurring along the face of the bluff overlooking the railroad tracks along Sugar Creek, just north of the refinery. This situation should also be investigated and addressed as well as the tank closure.	26
March 15, 1991	Amoco Well Survey Results March 15, 1991	Tables quite difficult to read, but it appears that a survey was conducted to determine if private wells were located on residential properties. It appears that approximately 18 wells or cisterns were identified. Historical use patterns and whether or not they were/are contaminated not determined.	96
September 1992 (?)	Groundwater Use Survey – 9-11-92 (?)	Sample plan for various wells proposed. Handwritten note for the southeast area indicates benzene groundwater concentrations are 1,700 ppb. <i>(No indication plan was ever executed.)</i>	95
January 27, 1994	Memorandum from Jim Blaise, Site Superintendent, regarding the Fillmore Residence.	“Mr. Fillmore asked about the possibility of drilling his well in the back year deeper. He used this well to water his garden in the past years. I recommended he not use the well or do any modifications to it as this time.” <i>(This statement raises several issues and questions. Has anyone, even at this late date of 1994, determined the number of contaminated wells in potentially contaminated areas – obviously the survey recommended in 1987 by Woodward Clyde was not started until 1991. Moreover, it is clear that the groundwater is an exposure pathway since it was used to water his</i>	85

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		<i>garden – perhaps for many years – and could have contaminated the soil and food supply. Everyone to date seems to have ruled out the groundwater pathway – this appears to be a mistake.)</i>													
September 7, 1994	Memorandum September 7, 1994: Review of EPA's comments regarding Risk Assessment Risk Based Concentrations Amoco Former Refinery, Sugar Creek, Missouri	Amoco has confirmed there is no ground water use as drinking water in the Norledge Area through the water well survey. The Norledge Area is the only area off-site with previous detections of hazardous constituents in ground water. <i>(Analysis based on current groundwater sage rather than past and potential future usage; not a conservative approach in performing risk assessments. Further, the elimination is flawed since it was found a resident was using groundwater to water his garden. Pathway should not have been eliminated. My position is consistent with USEPAs comments and concerns.)</i>	99												
May 1995	Deposition Exhibit 6 of Odah: Analytical Report, 803 North Sterling, Sugar Creek. 5/15/95	P03 – 10314 Norledge Street, Independence MO P04 – 10314 Chicago Street, Independence, MO P05 – 10400 Norledge Street, Independence, MO P03 benzene water sample results were: 6,052 µg/l and P04 benzene water sample results were: 164 µg/l. The PO4 sample was apparently taken outside of the plume area identified in the RFI. <i>(Results strongly support the position that the plume size was understated.)</i>	106C												
December 18, 1995	AMOCO Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9 Revision December 18, 1995. Results of Subsurface Gas Sampling and Analysis	<u>Off-Site Locations</u> Thirty-two of 35 subsurface gas locations sampled off site contained no detectable concentrations of benzene at analytical detection limits ranging from 0.017 µg/L to 0.1 µg/L. Samples collected from off-site locations G-10, G-18, and G-19 in the Norledge Area contained benzene concentrations ranging from 31.6 µg/L to 33.2 µg/L (Figure 8-3). These concentrations exceed the RBC of 0.2 µg/L (200 µg/m ³) for benzene in subsurface gas. At least four residences are located near or adjacent to this area. SUMMARY OF SUBSURFACE GAS SAMPLING ANALYTICAL RESULTS <table><tr><th>SAMPLE LOCATION</th><th>SAMPLE DATE</th><th>BENZENE (µg/L)</th></tr><tr><td>G-10</td><td>3/14/95</td><td>31.6⁵</td></tr><tr><td>G-18</td><td>3/14/95</td><td>32.8⁵</td></tr><tr><td>G-19</td><td>3/14/95</td><td>33.2⁵</td></tr></table> Value exceeds RBC of 0.2 µg/L. Although areas of free product and dissolved hydrocarbons are present at the Former Refinery, ground water is not used on site and direct exposure to ground water by on-site receptors does not occur. Seepage of benzene in ground water to Sugar Creek, the West Bluffs Tributary, and the Missouri River results in surface water concentrations below the RBC and does not pose a potential health threat.” <i>(Ignored exposure pathway of children playing in creek and spring.)</i>	SAMPLE LOCATION	SAMPLE DATE	BENZENE (µg/L)	G-10	3/14/95	31.6 ⁵	G-18	3/14/95	32.8 ⁵	G-19	3/14/95	33.2 ⁵	45 51 84 122
SAMPLE LOCATION	SAMPLE DATE	BENZENE (µg/L)													
G-10	3/14/95	31.6 ⁵													
G-18	3/14/95	32.8 ⁵													
G-19	3/14/95	33.2 ⁵													
April 9, 1996	Deposition Exhibit 3 of Odah: KDPS Analytical Laboratory Report 04/09/96	Laboratory results shown soil benzene contamination in excess of 1 mg/kg. BTEX compounds found in water sample.	106C												

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June 26, 1996	Affidavit of Mohammed Aboudah, P.E. (Known as Marco Odah, P.E.) Prepared for: Humphrey, Farrington & McClain, P.C. by EnviroRemedy International, Inc., June 26, 1996 Amoco Sugar Creek Extended Plume Map Suspected Contaminant Boundary	Mr. Odah suggests a much larger area of groundwater contamination than shown in the RFI. This area extends much deeper into residential neighborhoods and is more continuous than that shown by Amoco. Observations taken during sampling near Sugar Creek are reproduced below: "The inspection of the Sugar Creek revealed the migration of gasoline and other petroleum related liquids in the creek channel. Heavy petroleum fluids were observed seeping from openings near the bottom of a retaining wall at numerous locations. This partially deteriorated retaining wall is located near the southern portion of the refinery adjacent to the former Amoco fire station. Additionally, extensive soil contamination was observed further to the north on the refinery side of the creek. These contaminated soils are located at or near the water level in the creek. This indicates that the contaminated soils are in contact with water in the creek, and that contaminants from these soils are migrating into the creek. Sheens of petroleum products were observed in the creek at several locations. Furthermore, numerous seeps of gasoline-like constituents were observed in the creek near the intersection of Norledge Avenue and Carlisle Street." "Surface soil samples were collected from the stained area in the sediment wall. A hand auger was used to core into the side of the west bank at a 45 degree angle to a depth of approximately eight inches. The soil sample was collected directly from the auger hold. PID readings indicated concentrations of organic vapors of 114 ppm near the auger hold. While collecting the sample, a brown liquid was observed pooling at the base of the auger hole and the odor became strong. Mike Meyer and I backed off several times before completing the sampling at this location. ... The sample was labeled, C3-S-025(8). The soil was a silty clay, greenish black in color, with a very strong pungent hydrocarbon odor. I observed that the latex gloves I was wearing had started to deteriorate from handling the soil. I removed the gloves I was wearing and proceeded with my work wearing two layers through the duration of this sampling event." Mr. Odah also, claims, and later develops data which show a more extensive area of contamination than reported in the RFI. Mr. Odah believes several of the areas of contamination shown in the RFI as discontinuous are likely connected. He is critical of Amoco drilling at high points rather than low points where contamination would more likely be found. He concludes by stating: "It is my opinion that Amoco has not implemented adequate measures to fully characterize the site or to minimize adverse effects to human health and the environment posed by conditions at the site." <i>(As late as 1996, 14 years after the refinery closed, offsite releases continue to be reported.)</i>	48 62 106A
February 24, 1998	Videotaped Deposition of Richard L. Bateman, February 24, 1998	Indicates that the off-site area of groundwater contamination is likely greater than that presented in the RFI.	130 127
December 10, 1998	Exhibit 6 of Zemansky Deposition Dec. 9, 1989. Table of Well Data in Norledge Area.	Detailed table of groundwater BTEX levels from 1995 to 1998. Data often incomplete but in many wells concentrations dropped, and then rise with time. Significant amounts of benzene present at many locations in July 1998. Variations likely due to changes in groundwater levels intercepting the smear zone.	112C

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December 10, 1998	Exhibit 8 of Zemansky Deposition Dec. 9, 1989. Table of Well Data in Norledge Area.	Detailed table of groundwater BTEX, benzene, GRO and DRO levels from 1990 to 1997. Data often incomplete but in many wells concentrations dropped with time and in others they did not. Data suggests concentrations were likely much higher in the past.	112C
December 10, 1998	Exhibit 9 of Zemansky Deposition Dec. 9, 1989. Table of Soil and Water Data in Norledge Area.	This table is a summary of HydroLOGIC 1998 sampling results. Most interesting is the Fillmore well data which indicate a benzene concentration of 0.617 mg/L. Groundwater at location P2 shows a benzene concentration of 2.56 mg/L and at P1 a concentration of 0.173 mg/L.	112D
December 16, 1998	Deposition of G.M. Zemansky, Ph.D., Volume III December 16, 1998	Dr. Zemansky testified on additional sampling done in the Sugar Creek area in December 1998. He commented that they took samples on three different sites (Slayton, Chapell and Fillmore properties). In general, he smelled hydrocarbon odors in soils near/within the saturated soil zone and observed staining of the soils.	113
December 16, 1998	Exhibit 19 of Deposition of G.M. Zemansky, Ph.D., Volume III December 16, 1998	Detailed history of oil contamination of the Norledge area, beginning in 1950, prepared by Zemansky.	113A
June 5, 2002	West Hills Tank Area Investigation Work Plan by The RETEC Group, Inc.	This report acknowledges benzene contamination and singles out LUF gasoline as the source of benzene seen in groundwater: "Products stored in the West Hills Tank Area include unleaded and leaded gasoline, heavy and light ultraformer feed (HUF and LUF) gasoline, debutanized absorber naphtha (DAN) gasoline, alkylate, heavy stabilized naphtha, heavy virgin naphtha, furnace oil, asphalt, and heavy and light slop oil... Of these products, LUF is the most likely to contain benzene greater than 3 percent.... LUF gasoline may contain C-6 hydrocarbons including benzene, at concentrations up to 5 to 15 percent by volume. No other petroleum products stored in the West Hills Tank Area contained enough benzene by percentage to result in the elevated dissolved benzene concentration observed in the former tank dike 157. Therefore, the most likely source of the elevated benzene concentrations in groundwater is a release from a LUF gasoline tank or associated pipe. LUF was historically stored in Tank 151." While the authors may be correct, several of these materials, including naphtha, likely contained significant amounts of benzene.	116

Table 5: Information Supplied by Plaintiff's Attorney's Supporting Position the Amoco Knew, Or Should Have Known, that Benzene was an Health Hazard

DATE	DOCUMENT	INFORMATION (OBSERVATIONS & COMMENTS)	EES REF. #
October 1939	Manfred Bowditch and Harvey B. Elkins. 1939. "Chronic Exposure to Benzene (Benzol)," The Journal of Industrial Hygiene and Toxicology, Volume 21; October, 1939, Number 8.	Paper outlining effects of chronic exposure of workers to benzene. The authors concluded disease may be occurring at much lower levels than deemed to be harmful.	72
October 1939	Francis T Hunter. 1939. "Chronic Exposure to Benzene (Benzol). II The Clinical Effects," Vol. 21, No. 8, pgs. 331-354. October.	Paper looking at the clinical effects of chronic benzene exposure. The authors conclude that: "It is doubtful whether any concentration of benzene greater than zero is safe over a long period of time."	73
October 1939	Tracy B. Mallory, E. A. Gall and W. J. Bricklet. 1939. "Chronic Exposure to Benzene (Benzol). III The Pathologic Results," Vol. 21, No. 8, pgs. 354-377. October.	The authors note that: "The evidence that chronic exposure to benzene produces leukemia in human beings is still incomplete but it is accumulating at a rate and to a volume which command serious consideration."	74
April 27, 1944	April 27, 1944. TB MED 35, War Department Technical Bulletin, Health Hazards From Industrial Solvents.	General Information 1. Industrial solvents are widely used by military personnel in many operations such as degreasing, spray painting, dry cleaning, paint removing, rustproofing, and impregnating. 2. The principal mode of entry into the body is by inhalation; however, many of these solvents can be absorbed through the skin in amounts sufficient to cause intoxication. 4. ...In other instances where blood forming organs are particularly affected, aplastic anemia develops and purpuric manifestations are observed. In women menorrhagia may occur. b. Chronic intoxication (2) Benzol (benzene – not benzine) – This affects particularly the blood-forming organs with resulting anemia of the aplastic type, together with resulting complications. The clinical picture is frequently confused with pernicious anemia. It is possible that toluene and xylene may produce the same effects. Preventative Measures 6. Eliminate the hazard by substituting less toxic solvents where possible. 7. The degree of exposure should be determined, as well as the concentration of solvent vapors in the air. 8. Skin contact should be prevented as much as possible by the use of impervious gloves, sleeves, and aprons. 9. Inhalation of solvent vapors should be prevented. The most effective method	174

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		of preventing inhalation of vapors is by the use of local exhaust ventilation wherever practical...Personal protection devices, such as proper respirators, may be used for intermittent exposures. Cartridge-type respirators approved by the United States Bureau of Mines may be used only for short exposures to low concentration, and cartridge changes should be frequent and according to manufacturers' instructions. Supplied air respirators are preferable. 10. The time of exposures should be reduced. 12. Preplacement medical examination should be made, and persons who have a history of previous anemia, hepatic and gall bladder diseases, syphilis, diabetes or chronic cardiac, and renal disease should not be employed to handle solvents. This rule applies also to obese individuals and alcoholics. 13. Workers should be instructed about the hazards associated with exposures to solvents and the precautionary measures from the prevention of intoxication. G. C. Marshall Chief of Staff	
December 16, 1944	December 16, 1944. Army Service Forces Office of the Chief of Ordnance, Safety and Security Division, Subject: Health Hazards from Solvents and Their Control.	Subject: Health Hazards from Solvents and Their Control Attn: Medical and Engineering Departments 1. A recent series of acute poisonings with one fatality at one of the establishments on the Production Security Inspection Responsibility List of this office re-emphasizes the ever present danger associated with the use of solvents or thinners. 2. ...Solvents, thinners, and "cleaners" as a rule contain a variety of ingredients, all of which are toxic to a greater or lesser extent, -- the only non-toxic solvent is water. The products are frequently sold under a trade name which gives little or no indication of the contents. In fact the manufacturers of some solvents employ ingredients which are supplied by other manufacturers under a trade name. As a result the user does not know what a trade name solvent or thinner contains unless he analyzes it and he has no assurance from shipment to shipment that the ingredients remain the same or in the same proportion. Even some of the solvents and thinners supplied on Government Specifications which limit the amount of more toxic ingredients have been found by analysis to contain high proportions of very toxic chemicals. Other trade name solvents not bearing poison labels have been found to contain much higher percentages of very toxic chemicals. Other trade name solvents not bearing poison labels have been found to contain much higher percentages of very toxic chemicals than agreed upon between the U.S. Public Health Service and the Association of Manufacturers. 3. Under ideal conditions of supervision and control of materials, many solvents can be used safely for intermittent cleaning operations or even for routine production work in large buildings with good natural ventilation. However,	173

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		operating conditions today are far from ideal... ...production is speeded by heating the object, by heating the solvent, by blowing heated air over the finished parts...Consequently, the usually satisfactory precautions fail utterly to control the problem under conditions existing at present and it is necessary to provide "foolproof" protection, proper ventilation, at all operations involving the use of solvents or thinners. 6. Cleaning. Operations such as type cleaning and equipment or machine cleaning and equipment or machine cleaning may subject the operator to high concentrations of vapor for short periods even in well ventilated bays or buildings...The minimum required general ventilation rate for spot cleaning operations may be computed by means of the following equation: $Q = 1.2 \times 10^6 \times S \times \frac{m_0 w_0}{m_0 a_0 c_0}$ in which Q represents the ventilation rate in cubic feet per minute. S represents the amount of solvent used per minute in grams (obtained by multiplying volume in cc by specific gravity) $m_0 w_0$ represents molecular weight of solvent. $m_0 a_0 c_0$ represents the maximum allowable concentration for the solvent. b. Routine production cleaning operations as a rule require local exhaust ventilation to control the health hazard adequately...Air is drawn through the grilles at the minimum rate of 150 cfm per square foot of grill area. 7. Spray painting. a. All production spray painting and if practical, all other spray painting should be done in properly ventilated booths. The minimum exhaust ventilation rate should be 150 cfm per square foot of opening for large booths (over 50 sq. ft.) and 200 cfm per square foot of opening for small booths...Maintenance and repair painting require good general ventilation and respirators. b. For some reason the health hazard produced by the drying of the painted articles has either been overlooked or neglected. In fact, not infrequently, warmed air is blown over the painted articles to dry them more rapidly, thus creating even higher concentrations of the thinner vapors in the drying area. 8. Local exhaust and general ventilating systems for controlling solvent and thinner vapors are not expensive nor need they be complicated...In general low hood and duct velocities (about 1000 feet per minute) can be used... 9. The foregoing is not intended to belittle the good that may be accomplished by substitution of less toxic solvents or thinners. The use of relatively non-toxic chemicals consistent with good results remains one of the fundamental methods of atmospheric sanitation and should always receive first consideration. However, as shown earlier, the composition of many trade name products changes from shipment to shipment, and no solvents or thinners are harmless.	

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		Consequently, it is safer to use the best solvent available even if toxic, and to control the health hazard by relatively foolproof means such as proper local exhaust ventilation than to use a relatively non-toxic material which may change in composition without notice, and under conditions which change without notice.	
September 1948	API Toxicological Review – Benzene. 1948. American Petroleum Institute, New York, NY. September.	Comments regarding exposure to benzene under the subtitle of Safe Limits: "Inasmuch as the body develops no tolerance to benzene, and as there is a wide variation in individual susceptibility, it is generally considered that the only absolutely safe concentration for benzene is zero. The inadequacy of a limit of 100 ppm is indicated by well authenticated reports of at least 2 cases of benzene poisoning following exposure to only 75 ppm. A limit of 50 ppm or less is strongly recommended, particularly where exposures are recurrent. Skin contact should be avoided." <i>(Continued position that benzene may not have safe concentrations and the observation that recommended allowable limits continue, and continued, to fall.)</i>	75
1960	Manufacturing Chemists Association, Data Sheet [SD-2] Benzene (1960)	Provides detailed information on the toxicology, PPE and recommended handling practices for benzene. <i>(Industry-based document.)</i>	161
1960	American Petroleum Institute, Toxicological Review: Benzene (1960)	Reviews toxicological history of benzene. <i>(Industry based document.)</i>	162
January 6, 1961	January 6, 1961. TB MED 35 Department of the Army Technical Bulletin, Health Hazards from Industrial Solvents	TB MED 35 Department of the Army Technical Bulletin Health Hazards from Industrial Solvents Headquarters, Department of the Army, Washington 25, D.C. 6 January 1961 3. Important Considerations. All solvents have toxic properties to a greater or lesser extent. The problem of toxicity is further complicated in that many of the industrial solvents are not single or pure compounds, but are frequently mixtures. Health Hazards For example under proper controls a highly toxic solvent can be used in such a manner and under such conditions as to present a serious health hazard. Benzene (benzol) is an example of a solvent having both acute and chronic effects. As an acute poison it is a narcotic...A characteristic chronic toxic effect is one of injury to the bone-marrow with the salient picture that of aplastic anemia. c. Chronic Intoxication. In chronic poisoning, the blood, blood forming tissues, liver, kidney, nervous system, or other internal tissues or systems may be affected. Unfortunately, the earliest symptoms are often vague and nonspecific...Many solvents affect primarily the liver, kidneys, and/or blood-forming tissues...Benzol may produce aplastic anemia.	172

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		Preventative Measures 12. Engineering and Procedure Methods. a. Substitutes for Highly Toxic Solvents. To minimize health hazards, less toxic solvents should be substituted where possible. Appendix C provides a list of substitutes which experience has shown can be effectively utilized without loss of efficiency in the operations indicated. They should always be used instead of the more toxic solvents, such as carbon tetrachloride or benzene. b. Ventilation. Local-exhaust ventilation is the most effective method of maintaining a safe operating environment. The local-exhaust ventilating system should be designed so that the contaminants are removed from the breathing zone of the operator. 13. Personal Protective Measures. a. Respiratory Protection. Respirators of the proper type may be used for intermittent exposure or for supplementing other control measures. The dangerous practice of washing hands in solvents to remove grease should be eliminated by education and appropriate supervision of the workers, and by the use of suitable skin cleaners. <i>(Very reflective of current IH guidance regarding solvent such as benzene.)</i>	
February 22, 1966	T.J. McJoynt, Manager Real Estate, Field Trip Report, February 22, 1966	In recent years an oil leak has developed on certain of these lots and said leak flows into a ditch which, in turn, flows into Sugar Creek and into the Missouri River. During the course of our meeting Mr. Roper indicated that considerable time and money has been spent by our own people, as well as geological exploration concerns in an effort to locate the seepage leak on the refinery and stop it at its source; however, all such attempts have failed to date. Wells have been drilled near our refinery boundaries on the south side to pump the product out of the ground and a 15 foot perforated sewer has been laid in along the boundary of our property in a further attempt to collect this oil seepage. All of these attempts have not stopped the seepage flow into the drainage ditch on the Fonck property immediately south of the refinery. Analysis of the product seepage indicates that the base is gasoline, and probably premium gasoline. The seepage occurs primarily at low water table and creates considerable odor in the area, as well as an extreme fire hazard. It is my opinion that the ravine which goes to a depth from the street to approximately 15 or 20 feet is, in itself, an attractive nuisance for children playing in the area since the ravine is not fenced off and, with the seepage of gasoline, further hazards are presented due to the possibility of small children playing in the ravine and possibly starting a bonfire, or striking a match. To reduce the possibility of any extreme catastrophe, the refinery has taken steps to water down the entire seepage area with a spray of water through a pipe system lain on the surface of the ground.	32

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		There have been several complaints registered by property owners downstream along the creek concerning odors and the dangerous condition resulting from the seepage of the product into the creek. To date, no formal letter has been issued by the city to the company demanding that they clear up the situation; however, such a letter may come at any time if the nuisance continues.	
September 23, 1980	J.P. Corbett, Quarterly Report on Oil Movements and Utilities: Third Quarter – 1980, September 23, 1980	<u>Technical Services</u> Gasoline <i>benzene</i> problems analyzed and tracked to DLVN cut point and Ultraformer tower operations. (Recognized benzene content as an issue.)	19

Considerable data exists to show that free product was to be found in seeps, springs, ditches and the creek itself in the neighborhood where many of the plaintiffs played as children. The following 1966 internal AMOCO correspondence from T.J. McJoint illustrates the magnitude of the release and its hazards:

The seepage occurs primarily at low water table and creates considerable odor in the area, as well as an extreme fire hazard. It is in my opinion that the ravine which goes to a depth from the street to approximately 15 to 20 feet is, in itself, an attractive nuisance for children playing in the area since the ravine is not fenced off and, with the seepage of gasoline, further hazards are prevented due to the possibility of small children playing in the ravine and possibly starting a bonfire, or striking a match. There have been several complaints registered by property owners downstream along the creek concerning odors and the dangerous condition resulting from the seepage of the product into the creek. To date, no formal letter has been issued by the City to the Company demanding that they clear up the situation; however, such a letter may come at any time if the nuisance continues.

The impact of children playing in surface waters in the neighborhood is illustrated by the following comments made by Ms. Ann Neill in her witness affidavits of October 14, 2003:

During the time I lived on Gill Street, I played outside almost everyday. Around Burton Spring, there was a strong smell of gasoline and the water was often covered with a rainbow-colored film. The ground around this area was stained and had a sweet smell, like gasoline. There was rainbow-colored water in Sugar Creek as well. I often waded in the water of Burton Spring and Sugar Creek and made mud pies on the banks.

During the time we lived on Gill, we could always smell the refinery. Sometimes the smell was overpowering. When it rained, we saw rainbow-colored water in puddles around the yard.

These conditions, along with possible dermal health effects, were verified in the witness affidavits (September 17, 2003) of Shelly Gray (daughter of Sherri Bond), Dennis Allen (brother of Sherri Bond), and Yvonna Lea Smith:

Shelly Gray: The next day at the hospital, I shared the article with my mom. In that conversation, she told me that she lived on Ash Street near the refinery from 1959 to 1966. She told me about the hives and rashes she experienced while living there and how her childhood doctor could not tell her what caused them.

Yvonna Lea Smith: Sherri and I were "Tom Boys"; we spent most of our time in the creeks and woods near Norledge, Burton, Northern and Carlisle. I recall the strong smell of the refinery during the time I lived on Ash Street. In the vicinity of the creeks near Burton, Northern and Carlisle, just south of the refinery, there was a strong smell of gasoline. I also remember orangey mud and rainbow-colored water. Sherri often developed a rash during the time we played together. Sherri's mom often put calamine lotion on Sherri's rashes. On my visits to Sherri's house, we spent the vast majority of our time outside, playing in the woods and creeks near the refinery.

Dennis Allen: Shelly told us of her earlier conversation with Sherri in which Sherri recounted playing near the Amoco Refinery and catching frogs and crawdads in the creeks near the refinery. It was common for the neighborhood children, including Sherri and me, to spend entire days in these areas catching frogs, climbing trees, making hideouts, and exploring. I noticed on many occasions in the woods north of Kentucky playing with my friends the color of the ground around the streams and creeks was glowing orange and rainbow colored and the strong odor of sulfur-like smell permeating the air frequently. I also remember the strong smell of gasoline just south of the refinery around Burton, Northern and Carlisle. I remember very often, my sister coming home from playing in the creeks and woods just south of the refinery and the rashes and hives on my sister's arms and legs.

These children likely experienced significant dermal and ingestion exposure while playing in the creek.

Oil, likely gasoline, was present at concentrations from 11% to nearly 32% (see below):

Description – Oil Leak Investigation (Burton Street)

<u>Date</u>	<u>Spring Flow</u>	<u>% Oil</u>	<u>Sump % Oil</u>
11/4/66	1.6 gpm	18.5%	30%
11/8/66	1.25 gpm	12.5%	31.5%
11/17/66	1.25 gpm	11.1	28.6%

Assuming these oils contained 5% benzene, benzene levels from 5,550 ppm to 16,000 ppm could have existed in these waters.

Regarding dermal and ingestion exposures, it is also of interest to note that Mr. Fillmore was apparently using a private well as late as January 27, 1994, when he asked “about the possibility of drilling his well in the back yard deeper. He used this well to water his garden in the past years. I recommended he not use the well or do any modifications to it as this time.” He could have had dermal and ingestion exposure from the use of this groundwater.

This statement raises several issues and questions. Had anyone, even at this late date of 1994, determined the number of contaminated wells in potentially contaminated areas? Data suggests that such a survey was recommended in 1987 by Woodward Clyde, but was not started until 1991. This survey, completed in 1992 identified nearly 20 wells and cisterns. While many were not functional, they may have been in the past. And it appears Mr. Fillmore’s well might have been used as late as 1994. No information on the time of usage of these wells, nor a determination of the concentration of the contaminants in these ground waters appears to have been completed. Moreover, it is clear that the groundwater is an exposure pathway, since it was used to water his garden – perhaps for many years. This water could have contaminated the soil and his food supply.

The 1995 RFI states that the groundwater does not pose a hazard because it is not used as drinking water. This statement ignores all the other water exposure pathways, such as those just discussed, and appears to be looking forward rather than backwards in time.

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 call our office.

Thank you,

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

APPENDIX A

List of Exhibits Received and Reviewed to Date

The Walters Law Firm, LLC Detel v. BP Corporation et al LAW-2004-012	
Exhibit	Description
01	October 25, 1996. Affidavit of Jonas Kalnas, M.D., with CV & Report "Review of Practices and Operation at the Amoco Sugar Creek Refinery Which Contributed to Environmental Pollution. Oct. 25, 1996
02	1978. G.R. Helffrich, information (Sugar Creek press release)
03	July 3, 1979. Memo from J.F. Horner, to H.L. Fuller, Water Disposal – Amoco Oil Refineries
04	May 14, 1986. Letter from J.G. Huddle, to David A. Wagoner, United States Environmental Protection Agency,
05	August 11, 1980. Letter from G.R. Helffrich, to Senator Allan G. Mueller
06	June 4, 1979. Letter from Refining Planning, JES/sk Regarding FCU Particulates Control at Sugar Creek Refinery,
07	June 12, 1980. J. F. Horner, memo to Management Committee, Appropriation Requests – Water Quality at Sugar Creek Refinery, Environmental Control – Water Quality
08	June 12, 1980. Memo from S.R. Slovenko to J.F. Horner; Appropriation Request – Sugar Creek Refinery, Water Quality Control – Phase II. October 22, 1979 Appropriation Request – Water Quality Control Projects, Phase I. May 21, 1980 Sugar Creek Refinery, Memo: Sugar Creek Refinery Line Raising Phase III. October 22, 1979. Letter from Helffrich to S.R. Slovenko regarding Appropriation Request – Water Quality Control Projects, Phase I
09	May 15, 1978. Note from J.G. Huddle, note to G.R. Helffrich,
010	February 4, 1981. Letter from G.R. Helffrich to T.R. Grant, U.S. Coast Guard regarding Water Pollution Case 2P07432
011	September 6, 1978. Letter from G.R. Helffrich, memo to J.F. Horner regarding 1979 One-Time Expense Budget Requests
012	September 21, 1977. Letter from G.R. Helffrich to Earl J. Stephenson, Environmental Protection Agency regarding Spill Report No. 77-250,
013	July 17, 1996. Note to LM, with attached list of Amoco Sugar Creek Refinery Oil Spills,
014	January 8, 1982. Letter from G. R. Helffrich, to J.G. Huddle regarding SEC Quarterly Report October – December 1981
015	July 10, 1979. Memo from R.J. McGillivray to J. G. Huddle regarding Proposed "Spill" Prevention Plan for Sugar Creek

The Walters Law Firm, LLC Detel v. BP Corporation et al LAW-2004-012	
Exhibit	Description
016	November 23, 1977. Memo from G.R. Helffrich to J.F. Horner regarding Oil Spill to the Missouri River. November 23, 1977. Memo Prepared by J.P. Marum, J.D. Sellers, F. Thomas regarding Sugar Creek Refinery Oil Spill to the Missouri River
017	June 4, 1979. Memo from J.F. Horner to G.R. Helffrich regarding Elimination of NPDES Permit Violations,
018	July 2, 1979. Memo from G.R. Helffrich to J. F. Horner regarding Elimination of NPDES Permit Violations
019	September 23, 1980. Memo from J.P. Corbett regarding Quarterly report on Oil Movements and Utilities: Third Quarter – 1980
020	October 31, 1980. Memo from G.R. Helffrich to J.F. Horner regarding 1981 Objectives
021	September 24, 1984. Letter from C.G. Hill, U.S. Coast Guard to J.G. Huddle regarding Water Pollution Case 2P37429 In the Matter of Amoco Oil Company, Party.
022	April 12, 1985. Letter from D.R. Tripp, U.S. EPA to Amoco Oil Co. regarding Spill Report,
023	June 22, 1987. Letter from B.A. Esslinger to Ron Ginson regarding Site Reconnaissance – Adjacent McCord Property West of Ash Ave. Amoco Oil Company, Sugar Creek Former Refinery
024	July 28, 1989. Memo from J.G. Huddle to A.T. Keith regarding Engineering Assistance Sugar Creek – Norledge Ave. Sump Project,
025	August 21, 1979. Letter from G.R. Helffrich to J.F. Adler regarding Spill Report
026	January 31, 1990. Letter from L.P. Coen, Missouri Dept. of Natural Resources to J.G. Huddle regarding Underground Storage Tank at Amoco (firmer) Sugar Creek Refinery
027	July 19, 1988. Memo from D.W. Abshear to R. Ginson regarding If-Asked Statements – Sugar Creek Refinery
028	May 6, 1986. Telephone memo at Woodward-Clyde Consultants from T. Gogel regarding May Quarterly Sampling
029	July 26, 1982. From R.W. Ginson, Environmental Newsletter for the Period June 25, 1982 – July 26, 1982,
030	December 4, 1986. From J. Studer, interview with Dr, Lenard Sorg
031	July 20, 1965. Memo from B.T. Allison to N.T. Robey regarding recurring problems at Sugar Creek

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Exhibit	Description
032	February 22, 1966. Memo from T.J. McJoynt, Manager Real Estate regarding Field Trip Report Sugar Creek Refinery
033	September 22, 1967. Memo from J.N. Roper to R.S. Holcolmb regarding Facilities for Oil Recovery from West Hill Drainage,
034	August 23, 1996. J.D. Campbell, Ph.D., P.E., Report of Expert Witness
035	November 1, 1967. Memo from J.C. Lamkin, Minutes of Conservation Committee
036	September 11, 1974. Memo from C.H. Carver regarding Survey of Oil Leaks on Perimeter of the Sugar Creek Refinery
037	April 22-29, 1975. Report from J. Lamkin, EPA, Compliance Monitoring Field Survey, Summary Report, Sugar Creek Refinery
038	November 13, 1975. Memo from R.C. Mallatt to J.F. Horner regarding CEP Report – Cracking Down: Oil Refining and Pollution Control
039	August 22, 1996. J.R. Doshier, Affidavit of (expert witness)
040	July 1996. Report from Environmental Technologies, Inc., “Practices which Contributed to Environmental Pollution,
041	December 18, 1995. Revision AMOCO-RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9. Tables
042	September 28, 1982. T. Gogel, “Geohydrology of Sugar Creek Refinery, Sugar Creek, Missouri”.
043	Same as Exhibit 031
044	Same as Exhibit 035
045	December 18, 1995. Revision AMOCO Facility Investigation Report AMOCO Sugar Creek Former Refinery; Volume 1: Sections 1-9. Results of Subsurface Gas Sampling and Analysis
046	December 18, 1995. Revision RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery, Volume 1: Sections 1-9 16.7.1 Investigation and Migration Pathway Conclusions
047	Same as Exhibit 032
048	June 26, 1996. Affidavit of Mohammed Aboudah, P.E. (Known as Marco Odah, P.E.) Prepared for: Humphrey, Farrington & McClain, P.C. by EnviroRemedy International, Inc., Amoco Sugar Creek Extended Plume Map Suspected Contaminant Boundary
049	Same as Exhibit 07
050	Same as Exhibit 08

The Walters Law Firm, LLC Detel v. BP Corporation et al LAW-2004-012	
Exhibit	Description
051	December 18, 1995. Revision RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery Volume 1: Sections 1-9: , 16.5.2 Recovery Wells
052	Same as Exhibit 023
053	May 18, 1987. Telephone Memorandum – Call from Mrs. John McCord, Concerning Presence of Oil of their Property,
054	April 13, 1964. Memo from C.H. Carver (Duplicate?)
055	March 4, 1980. Memo from G.R. Helffrich to Mr. Ronnae Coleman regarding Spill Report No. 79-433
056	November 23, 1977. Sugar Creek Refinery Oil Spill to the Missouri River
057	December 18, 1995. Revision RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery Volume 1: Sections 1-9, 16.5.2 Recovery Wells, Table 2.4.2C Spills and Discharges
058	Same as Exhibit 016
059	December 18, 1995. Revision <i>RCRA Facility Investigation Report AMOCO Sugar Creek Former Refinery Volume 1: Sections 1-9, Table 2.4.2E Spills and Discharges</i>
060	September 11, 1974. Engineering-Technical Service Sugar Creek Missouri, Memorandum; Subject: "Survey of Oil Leaks on Perimeter of the Sugar Creek Refinery"
061	November 15, 1990. Interceptor Trench Extension NS-5 and NS-6 Post-Construction Report, Amoco Sugar Creek Former Refinery,
062	June 26, 1996. Affidavit of Mohammed Aboudah, P.E. (aka Marco Odah, P.E.) EnviroRemedy International, Inc. Extended Plume Map
063	April 1978. Test Holes for Oil Leak Detection West Plant Unit, Sugar Creek Refinery, Sugar Creek, Missouri, by Layne-Western Co., Inc,
064	Same as Exhibit 33
065	Nov. 29, 1978. Sugar Creek Refinery, NPDES Permit Modifications
066	Same as Exhibit 37
067	1959. Manual on Disposal of Refinery Wastes; Volume I: Waste Water Containing Oil, Sixth Edition 1959
068	Oct. 22, 1979. Letter from G.R. Helffrich to S.R. Slovenko. Sugar Creek Refinery, Appropriation Request – Water Quality Control Projects, Phase I

The Walters Law Firm, LLC Detel v. BP Corporation et al LAW-2004-012	
Exhibit	Description
069	"Exhibits": 1) Summary of Oil Spills Reported to Coast Guard January 1977 – September 1979; 2) Varec Transmitter; 3) June 4, 1979 Memorandum; FCU Particulates Control at Sugar Creek Refinery
070	1989. Odor Thresholds for Chemicals with Established Occupational Health Standards, Copyright 1989; American Industrial Hygiene Assoc.
071	June 1994. Environmental Technologies, Inc. NIOSH Pocket Guide to Chemical Hazards; U.S. Department of Health and Human Services
072	October 1939. Manfred Bowditch and Harvey B. Elkins. "Chronic Exposure to Benzene (Benzol)," October 1939, The Journal of Industrial Hygiene and Toxicology, Volume 21; Number 8.
073	October 1939. Francis T Hunter. "Chronic Exposure to Benzene (Benzol). II The Clinical Effects," Vol. 21, No. 8, pgs. 331-354.
074	October 1939. Tracy B. Mallory, E. A. Gall and W. J. Bricklet. "Chronic Exposure to Benzene (Benzol). III The Pathologic Results," Vol. 21, No. 8, pgs. 354-377.
075	1948. API Toxicological Review – Benzene. American Petroleum Institute, New York, NY. September.
076	1955. Water Pollution Abatement Manual – Oils and Tars. Manual Sheet W-4, Manufacturing Chemists' Association, Inc., Washington, D.C.
077	1959. Manual on Disposal of Refinery Wastes; Volume I, Waste Water Containing Oil, Sixth Edition, American Petroleum Institute
078	March 16, 1973. NPDES Permits, to Amoco Oil Co., From Jack K. Smith P.E.
079	June 4, 1979. Memo from G.R. Helffrich regarding Sugar Creek Refinery; Elimination of NPDES Permit Violations
080	March 5, 1964. Memo from J.C. Lumpkin to Distribution List. Chromatographic Method for Identification of West Hill Oil Leak Source by Relative Concentrations of Closely Boiling Hydrocarbons
081	April 6, 1964. "Petition to the Missouri Health Department" [petition].
082	1969. Thomas J. Haley. <i>Air Quality Monograph #69-7, A Review of the Toxicology of Lead.</i>
083	September 22, 1967. J.N. Roper. <u>Instructions for Filling Out Reports Covering Complaints About Refinery Odors, Water Contamination, Oil Spills, Etc., Complaint Reports.</u>
084	December 18, 1995. Subsurface Gas Investigation Sugar Creek Refinery. Revised RFI Report.

The Walters Law Firm, LLC Detel v. BP Corporation et al LAW-2004-012	
Exhibit	Description
085	January 27, 1994. Air Monitoring – Basement of Mr. and Mrs. H. Fillmore.
086	September 9, 1991. Air Monitoring – Basement of Mr. and Mrs. B.J. Chappell.
087	May 27, 1988. Norledge Trench Map.
088	Aug. 12, 1968. Norledge Street Oil Recovery
089	March 12, 1976. Letter: Mr. J.P Egan regarding Sugar Creek Refinery Miscellaneous Oil Seepage Collection
090	Sept. 24, 1968. File Memo regarding Oil Content of Water From Sump South of Norledge.
091	October 7, 1976. Letter J. Victor regarding Hydrocarbon Spills at Sugar Creek Refinery.
092	May 16, 1988. Letter Mr. Ron Ginson regarding the Transmittal of the Ground Oil Analysis for the Amoco Sugar Creek Former Refinery Sugar Creek, Missouri
093	February 12, 1991. Letter, Mr. Arthur Daigh regarding the Installation of a Monitoring Well on His Property.
094	October 27, 1987. Letter, Mr. Ron Ginson regarding Preliminary Report of Water Well Survey Near Former Amoco Refinery Sugar Creek, Missouri
095	September 11, 1992 (?). Groundwater Use Survey.
096	March 15, 1991. Amoco Well Survey Results.
097	AOC Historic Photos
098	Amoco Postcard
099	September 7, 1994. Memo regarding the Review of EPA's comments regarding Risk Assessment Risk Based Concentrations Amoco Former Refinery, Sugar Creek, Missouri.
100	1979. Draft Manual on Disposal of Refinery Wastes, Volume VI Solid Wastes.
101	April 27, 2000. Sugar Creek Cancer Inquiry Report Level Three Investigation, Missouri Department of Health.
102	MS Prevalence Baseline Rates in Sugar Creek
103	July 30, 1996. Deposition of Marco Odah Volume I.
104	July 31, 1996. Deposition of Marco Odah Volume II.
105	January 21, 1997. Supplemental Deposition of Marco M. Odah.
106	February 20, 1998. Deposition of Marco Odah.

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Exhibit	Description
106A	Deposition Exhibit 1 of Marco Odah: Affidavit Prepared for: Humphrey, Farrington & McClain, P.C. EnviroRemedy International, Inc. Includes CV, Statement of Opinion and EnviroRemedy Report (started at Environmental Management Resources (EMR))
106B	April 9, 1996. Deposition Exhibit 3 of Odah: KDPS Analytical Laboratory Report.
106C	May 15, 1996. Deposition Exhibit 6 of Odah: Analytical Report, 803 North Sterling, Sugar Creek.
106D	July 31, 1996. Deposition Exhibit 8 of Odah: Building Map.
106E	September 1985. Deposition Exhibit 4 of Odah: Practical Guide for Ground-Water Sampling.
106F	February 1990. Deposition Exhibit 5 of Odah: EPA Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.
106G	Deposition Exhibit 7 of Odah: Interceptor Trench and Recovery Sump Location.
106H	August 1, 1975. Deposition Exhibit 8 of Odah: Sewers Map.
106I	October 31, 1996. Rebuttal Affidavit of Marco M. Odah.
106J	February 18, 1998. Deposition Exhibit 20 of Odah: Cost Estimates for remediating the individual properties by Marco Odah.
107	September 5, 1996. Deposition of Charles E. Dumsky.
108	August 7, 1996. Deposition of John C. O'Renck, Volume 1.
109	August 15, 1996. Deposition of Mark A. O'Renck.
110	January 7, 1997. Deposition of Jonas Kalnas, M.D.
111	December 9, 1998. Deposition of G.M. Zemansky, Ph.D., Volume 1.
111A	Dec. 9, 1989. Exhibit 2 of Zemansky Deposition Map with Seven Overlays.
111B	Dec. 9, 1989. Exhibit 4 of Zemansky Deposition. MW-62 Sampling Results.
111C	Dec. 9, 1989. Exhibit 5 of Zemansky Deposition. Excel Spreadsheet – Bates 156995 and 156996
112	December 10, 1998. Deposition of G.M. Zemansky, Ph.D., Volume II.
112A	Dec. 9, 1989. Exhibit 6 of Zemansky Deposition. Summary of Monitoring Results by Amoco.
112B	Dec. 9, 1989. Exhibit 7 of Zemansky Deposition. USGS Topographic Map

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Exhibit	Description
112C	Dec. 9, 1989. Exhibit 8 of Zemansky Deposition. Table of Wells in Norledge Area.
112D	December 9, 1989. Exhibit 9 of Zemansky Deposition. Hydro-LOGIC Report (1998).
112E	Dec. 9, 1989. Exhibit 10 of Zemansky Deposition. GW and Soil Cleanup Criteria.
112F	Dec. 9, 1989. Exhibit 11 of Zemansky Deposition. Residential Air Sampling Plan.
112G	Dec. 9, 1989. Exhibit 12 of Zemansky Deposition. Draft Acceptable Ambient Levels for Missouri.
112H	Dec. 9, 1989. Exhibit 13 of Zemansky Deposition. Document sent from ATSDR.
112I	Dec. 9, 1989. Exhibit 14 of Zemansky Deposition. Document Sent from ATSDR.
112J	Dec. 9, 1989. Exhibit 15 of Zemansky Deposition. Resume of Zemansky.
113	December 16, 1998. Deposition of G.M. Zemansky, Ph.D., Volume III (Requested copy from Attorney 1-12-2004 ah).
113A	Dec. 9, 1989. Exhibit 19 of Zemansky Deposition. Amoco History Relevant to Oil Contamination of the Norledge Area.
114	December 23, 1998. Deposition of G.M. Zemansky, Ph.D., Volume IV.
115	November 29, 2000. Public Health Assessment for Amoco Oil Company – Sugar Creek.
116	June 5, 2002. West Hills Tank Area Investigation Work Plan, Amoco Former Refinery, Sugar Creek Missouri.
117	July 17, 1996. Deposition of George R. Helffrich.
118	July 25, 1996. Deposition of John F. Horner.
119	1969. Manual on Disposal of Refinery Wastes, Volume on Liquid Wastes, First Edition; American Petroleum Institute
120	August 20, 1996. Affidavit of Michael W. McLaughlin.
	October 25, 1996. Affidavit of Jonas Kalnas, M.D., with CV & Report "Review of Practices and Operation at the Amoco Sugar Creek Refinery Which Contributed to Environmental Pollution.
121	April 2004. EPA. Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action for Facilities Subject to Corrective Action Under Subtitle C of the Resource Conservation and Recovery Act.

The Walters Law Firm, LLC Detel v. BP Corporation et al LAW-2004-012	
Exhibit	Description
122	December 18, 1995. RFI Reference Sections 1, 4, 8, 10, 11, & 14.
123	November 29, 1978. Memorandum R.W. Ginson.
124	March 29, 1984. Chicago Tribune; Amoco settles EPA lawsuit for \$500,000
125	July 1996; ETI #96060; Frank M. Parker, III: Amoco Refinery Sugar Creek, Missouri Practices Which Contributed to Environmental Pollution
126	July 11, 1996. Terranext, Mr. Ralph K. Phalen, Blackwell Sanders Matheny Weary & Lonbardi, L.C. Re: Assessment of Present Off-Site Hydrocarbon Impact to Ground Water and Estimate of Cost and Time Required to Remediate Refinery and Off-Site Area at Time of Refinery Closure
127	April 22, 1996. Terranext Map: Areas of Off-Site Petroleum Hydrocarbon Impact to Ground Water Amoco Sugar Creek Former Refinery Sugar Creek, Missouri.
128	July 25, 1996. Deposition of Richard L. Bateman.
129	December 12, 1996. Deposition of Richard L. Bateman.
130	February 24, 1998. Videotaped Deposition of Richard L. Bateman.
131	March 20, 1964. Memorandum regarding the Oil Leak Investigation from L.J. Sutton and I Erickson.
132	1966. American Oil Company, Letter from I. Erickson to Mr. J.N. Roper. Subject: Oil Leak South of the Refinery
133	September 29, 1975. Memorandum from R.J. Ferm regarding Improved Recovery of Norledge Sump Gasoline.
134	February 9, 1982. Trip Report by T. Gogel regarding Meeting with Sugar Creek Refinery Management – Results of Hydrologic Investigation and Recommendations for Subsurface Hydrocarbon Abatement.
135	April 13, 1964 (?). Memorandum – Sugar Creek Refinery.
136	October 10, 1966. Letter from I. Erickson to J.N. Roper regarding oil leak south of refinery.
137	March 5, 1964. Memo from J.C Lamkin regarding the Chromatographic Method for Identification of West Hill Oil Leak Source by Relative Concentrations of Closely Boiling Hydrocarbons (A Preliminary Report).
138	May 12, 1966. Letter from L.V. Sorg to I. Erickson regarding oil leaks – West Hill.

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Exhibit	Description
139	August 13, 1980. Letter from J. P. Corbett to R.E. Boening, et al regarding the refinery SO2 emissions control including copies of the petition for injunction and penalties and the stipulation agreement between AMOCO and the State of Missouri (August 11, 1980).
140	September 2, 1980. Letter from G. R. Helffrich to W. W. Sanders regarding Refinery SO2 Emissions.
141	September 2, 1980. Letter from J. P. Corbett regarding Standing Operating Instruction, Refinery SO2 Emissions Control.
142	Chronology of Events Relating to Abatement of Odors at Sugar Creek, 2-10-72 to 11-16-73.
143	Chronology of Events Relating to Odor Abatement Order, 10-15-75 to 11/28/77.
144	October 16, 1980. Informational Note from R. L. Arnett and R. W. Ginson regarding the <u>Missouri Air Pollution Control Program (APCP)</u> .
145	January 6, 1967. Letter from J.N. Roper to Mayor Roper regarding ground water collection system along Burton Street.
146	March 16, 1976. Letter from Michael K. Stenstrom to J. G. Huddle regarding the <u>Visit to the Sugar Creek Refinery – March 8-10, 1976</u> .
147	October 7, 1976. Letter from G. H. Watson to J. Victor regarding <u>Hydrocarbon Spills at Sugar Creek Refinery, Project 4001</u> .
148	June 9, 1978. J. D. Sellers, Notes on Leak Action Meeting.
149	September 6, 1978. Memo, <u>Tank Repair Program</u> .
150	April 23, 1979. Letter from William Rice to Ron Ginson regarding a telephone conversation with Mr. Dennis Bell and Mr. Jim Adler of the EPA.
151	Letter from Dennis Bell regarding routine check of clean up operations at AMOCO refinery.
152	Prepared PIR Instructions from Bill McCollum – Oil Spills
153	April 6, 1988. Meeting Notes, Meeting to View and Discuss Sewer Line Video Tapes of Sewers Near to and on AMOCO Property Between Norledge and Burton Streets and Willow and Carlisle Avenues.
154	Sugar Creek Refinery SO2 Emissions Control – Logic Diagram.
155	December 20, 1988. Letter from Arthur H. Groner to J. G. Huddle regarding penalties for violations.

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Exhibit	Description
156	May 27, 1988. Letter from Brad A. Esslinger and Donald S. Trelease to Ron Ginson regarding the Interim Summary Report – Phase I Hydrocarbon Assessment, Round Two Sampling Data, Norledge Street Vicinity.
157	Tables 1-6, concerning well data and water quality analysis of the monitoring wells and sumps south of Norledge Street.
158	June 14, 1988. Letter from Brad A. Esslinger and Donald S. Trelease to Ron Ginson regarding Suggested Areas of Investigation at the AMOCO Sugar Creek Former Refinery, Sugar Creek, Missouri.
159	April 10, 1981. Sugar Creek Oil Spill Incidents – 1979 to Date.
160	May 26, 1983. Questions Posed by Art Masse on Visit to Refinery.
161	Manufacturing Chemists Association, Data Sheet [SD-2] Benzene (1960)
162	American Petroleum Institute, Toxicological Review: Benzene (1948)
163	November 17, 1966 Handwritten Notes of I. Erickson and J.N. Roper
164	1966 Telephone Logs of J.N. Roper
165	February 6, 1987. Letter from Gene W. Schmidt to R.W. Ginson Regarding Benzene In Florida Groundwater and Cost Model for Selected Technologies for Removal of Gasoline Components from Groundwater.
166	April 22, 1986. Letter from J.G. Huddle to Mr. and Mrs. Owen Brown Regarding Response to Concerns about the Possible Presence of Hydrocarbon Odors.
167	July 20, 1981. Industrial Hygiene Survey Report, Industrial Hygiene and Toxicology Environmental Conservation and Toxicology Dept., Amoco Oil Company, Sugar Creek Refinery.
168	January 13, 1981. Memo from R.J. McGillivray Regarding Sugar Creek Refinery Coping with Hydrocarbon Leaks, Vapors and Odors.
169	June 22, 1979. Memo from J.G. Huddle Regarding Hazardous Waste Situation at Amoco Refineries.
170	March 2- 22, 1979. Industrial Hygiene Survey Report, Industrial Hygiene and Toxicology Environmental Conservation and Toxicology Dept., Amoco Oil Company, Sugar Creek Refinery, Sugar Creek, Missouri.
171	March 8, 1976. Memo from G.R. Helffrich to J.G. Huddle Regarding U.S. V. Kennecott Copper.
172	January 6, 1961. TB MED 35 Department of the Army Technical Bulletin, Health Hazards from Industrial Solvents

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Exhibit	Description
173	December 16, 1944. Army Service Forces Office of the Chief of Ordnance, Safety and Security Division, Subject: Health Hazards from Solvents and Their Control.
174	April 27, 1944. TB MED 35, War Department Technical Bulletin, Health Hazards From Industrial Solvents.
175	May 30, 1990. Memo from D.J. Murphy Regarding Early Draft Version of a Speech by Steve Grossman.
176	May 29, 2005. Preliminary Draft Presentation by D.J. Murphy and S.J. Grossman Regarding Amoco Oil Company Environmental Remediation Review.
177	January 17, 1920. Jackson County Circuit Court, Independence Waterworks Co., V. Standard Oil Co., et al
178	January 21, 1920. Defendant's Affidavit, Moffett
179	January 22, 1920. Affidavit of Roy Cross.
180	January 21, 1920. Affidavit of R. E. Duffy.
181	January 23, 1920. Affidavit of H. A. Gallagher.
182	November 5, 1969. American Oil Company Memorandum – <u>Details on Our Refinery Loss Prevention Work.</u>

APPENDIX B

Key Environmental Regulations and Dates

Key Federal Environmental Laws and Initial Promulgation Dates

- Solid Waste Act - 1965
- National Environmental Policy Act (NEPA) - 1969
- Clean Water Act (CWA) - 1972
- Toxic Substances Control Act (TSCA) – 1977
- Resource Conservation and Recovery Act (RCRA) - 1980 and 1984 (Hazardous and Solid Waste Amendments)
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) - 1980
- “Superfund” - Superfund Amendments and Reauthorization Acts (SARA) - 1983 and 1986
- RCRA UST Rules – 1984, 1986 and 1988
- The Clean Air Act (CAA) - 1990
- Clean Air Act Amendments (CAAA) – 1997.

APPENDIX C

Benzene Content of Gasoline, Gasoline Feedstocks and Naphtha

Gasoline:

Figure I.1: Average benzene content of Canadian gasoline 1994-1999

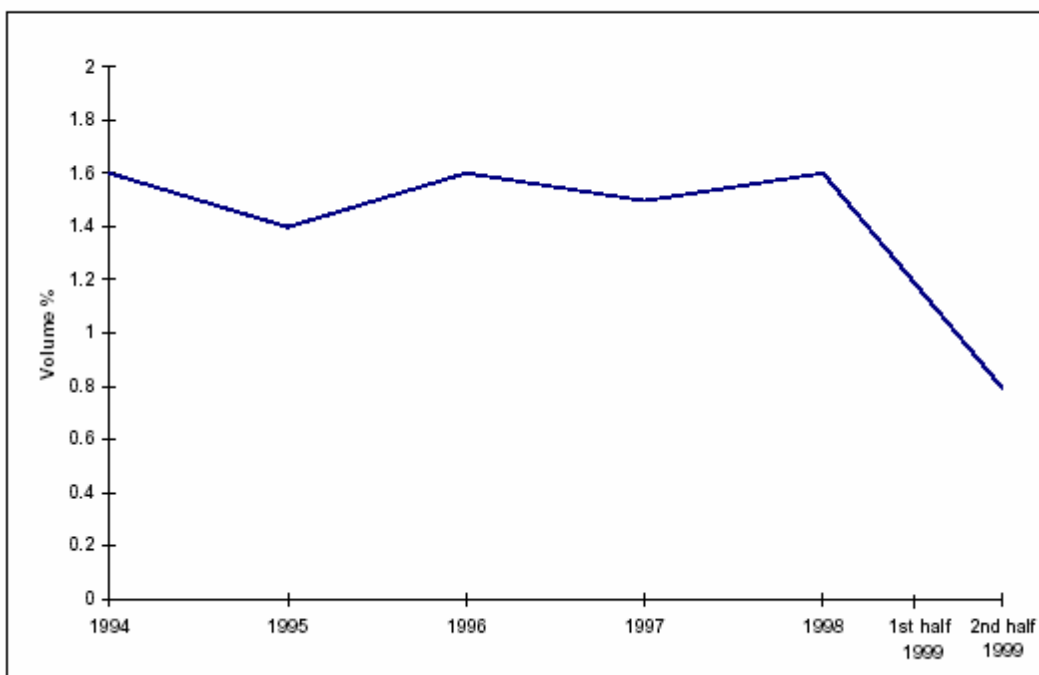


Table A5.1 : Reported Data for Benzene: Maximum, Minimum and Yearly Pool Averages (% by volume)

Region	Quarter 1 and 2				Quarter 3 and 4			
	Volume, m ³	Maximum	Minimum	Volume Weighted Average	Volume, m ³	Maximum	Minimum	Volume Weighted Average
Atlantic	1,332,607	6.68	0.94	2.14	1,837,040	1.16	0.40	0.67
Quebec	4,541,431	4.57	2.59	1.40	5,218,092	4.18	0.59	1.05
Ontario	5,873,115	3.25	1.12	1.28	6,355,940	3.89	0.50	0.81
West	6,547,421	4.40	0.88	0.75	7,201,916	3.60	0.09	0.63
National	18,294,574	6.68	0.88	1.18	20,612,988	4.18	0.09	0.80

http://www.ec.gc.ca/energ/fuels/reports/benz_99/benz_1999_e.pdf

Benzene and Total Aromatics Content - Benzene is a natural component of gasoline. Because it is a toxic pollutant, its presence in RFG is limited to 0.95% by volume, average; 1/3% by volume, maximum. This range is approximately one-third lower than the 1990 U.S. industry average. However, since benzene content is the most effective factor in controlling total toxic air pollutants, some refiners may choose to reduce its content well below this limit.

Benzene is a member of a class of hydrocarbons called "aromatics." Aromatics are natural components of most petroleum crudes and they are also manufactured by refiners to increase the octane of gasoline. The Simple Model limits the total aromatics content to the level which achieves the mandated reduction in toxic emissions. The limit is influenced by the other variables in the model, especially benzene. For a benzene content of 1% by volume, the maximum total aromatics that RFG may contain is approximately 27% by volume. The total aromatics content of 1990 U.S. industry average gasoline ranged from 26% by volume in the winter to 32% by volume in the summer.

<http://www.chevron.com/prodserv/fuels/bulletin/fed-refm/rfg-char.shtml>

MSDS sheets: See files – Ranges from 0 to 5%.

The benzene content of gasoline is nowadays kept below 5% and is usually between 0.1 - 4%.

http://www.kemi.se/kemamne_eng/benzen_eng.htm

Exxon Data Sheets: Benzene content ranged from 1.2 to 4.9% max.

http://www.prod.exxon.com/exxon_gas/conv-exxon.html

Crude petrol samples from the two Danish refineries, Shell in Fredericia and Statoil in Kalundborg, which deliver petrol to most of the petrol companies in Denmark West and East of the Great Belt respectively, have been analyzed. Retail petrol from different petrol companies in Roskilde were also analyzed. Samples were collected twice a year in the period August 1997 to July 1999. The results were also compared with earlier data. The benzene content was before 1995 approx. 3.5% for 95 RON. Statoil reduced the benzene content to approx. 2 % in 1995 and further to approx. 1 % in 1998. Shell reduced the benzene content from approx. 3.5% to approx. 1 % in 1998.

http://www.dmu.dk/1_viden/2_Publikationer/3_fagrappporter/rapporter/fr309.pdf

Shell Data Sheets:

Light Straight Run Gasoline, Natural Gasoline, Olefin Lt. Feed – Lt. St. Run Gasoline, Reformulated Unleaded Mid-Grade Unbranded without Detergent, Regular Gasoline Unbranded Oxygenated without Detergent, Regular Gasoline Unbranded Oxygenated with Detergent, Regular Grade Gasoline (Unbranded) with Detergent, Regular Grade Gasoline (Unbranded) without Detergent, RU 200(R) (Regular Unleaded Gasoline), and RU 2000 (R) Mandatory Oxygenated Gasoline, Shell Regular Gasoline, Shell Regular Gasoline Mandatory Oxygenated, Shell 100 LL Aviation Gasoline, Specification Gasoline – Regular Grade, Specification Unleaded Gasoline – Premium Grade, Specification Unleaded Gasoline – Regular Grade, Specification Unleaded Gasoline – Super Regular Grade, SR 2000(R) (Super Regular Unleaded Gasoline), SR 2000(R) Mandatory Oxygenated Gasoline, Unleaded Premium Grade Gasoline (Unbranded)

without detergent, Unleaded Premium Grade Gasoline (Unbranded) with Detergent, Unleaded Premium Grade Gasoline (93 Octane) (Unbranded) without Detergent, Unleaded Premium Grade Gasoline (93 Octane) (Unbranded) with Detergent, Unleaded Premium Unbranded Oxygenated with Detergent, Unleaded Premium Unbranded Oxygenated without Detergent, Unleaded Regular Grade (Unbranded) with Detergent, Unleaded Regular Grade (Unbranded) without Detergent, Unleaded Regular Unbranded Oxygenated with Detergent, Unleaded Regular Unbranded Oxygenated without Detergent, Unleaded Super Regular Grade Gasoline (Unbranded) with Detergent, Unleaded Super Regular Grade Gasoline (Unbranded) without Detergent, Unleaded Super Regular Unbranded Oxygenated without Detergent, and Unleaded Super Regular Unbranded Oxygenated without Detergent all contained 0-5% benzene

(Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pgs. 3-8).

Additionally, Shell also claims the following gasoline products contain the following levels of benzene:

Cat Cracker Gas (Treated):

Contains 1-5% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 1).

Heavy Cat Cracked Gasoline:

Contains 1-2% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 2).

Light Cat Cracked Gasoline:

Contains 1.0-2.0% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 3).

Light Hydrocracked Gasoline:

Contains 0.5-1.0% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 3).

Pyrolysis Gas Blend:

Contains 10-50% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 4).

Pyrolysis Gasoline:

Contains 15-25% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 4).

Pyrolysis Gasoline:

Contains: 15-25% benzene (Shell Products Letter to Keystone Shipping Co. January 15m 1980; pg. 2)

Recovered Gasoline:

Contains <5% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 4).

Regular-Leaded:

Contains 2.7% benzene (Letter from R.E. Green to C.F. Grimmer, Shell Oil Company Interoffice Memorandum, February 29, 1988, Table III, p. 6). In later literature, Regular-Leaded gasoline reportedly contained 1.42% benzene. In the same letter, the benzene level in Regular-Leaded gasoline was 1.30% (Letter from R. K. Jones to D. E. Eitel, Shell Oil Company Interoffice Memorandum, March 28, 1988, p. 1-2).

RU-2000:

Contains 3.0% benzene (Letter from R.E. Green to C.F. Grimmer, Shell Oil Company Interoffice Memorandum, February 29, 1988, Table III, p. 6). In later literature, RU-2000 gasoline contained 1.21% benzene (Letter from R. K. Jones to D. E. Eitel, Shell Oil Company Interoffice Memorandum, March 28, 1988, p. 2).

SU-2000:

Contains 2.8% benzene (Letter from R.E. Green to C.F. Grimmer, Shell Oil Company Interoffice Memorandum, February 29, 1988, Table III, p. 6). In later literature, SU-2000 gasoline reportedly contained 1.10% benzene. In the same letter, levels of benzene in SU-2000 were 1.58%. (Letter from R. K. Jones to D. E. Eitel, Shell Oil Company Interoffice Memorandum, March 28, 1988, p. 1-2).

Thermocracked Gas:

Contains 1-25% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 7).

The following information was recorded in 1988 interoffice correspondence:

Hawaii Plants
Benzene Content of Gasoline Bulk Samples

Date	Grade of Gasoline	Benzene (% volume)
1/13/88	SU2000	2.55
1/13/88	RU2000	5.29
1/13/88	Shell Regular	4.91
1/15/88	SU2000	4.25
1/15/88	RU2000	5.42
1/15/88	Shell Regular	4.84
1/18/88	SU2000	2.96
1/18/88	Shell Regular	4.65
1/19/88	SU2000	2.96
1/19/88	Shell Regular	4.64
1/19/88	SU2000	4.86
1/19/88	Shell Regular	4.63
1/19/88	SU2000	4.90
1/19/88	Shell Regular	4.64

(Letter from T. A. Colangelo to C. F. Grimmer, Shell Oil Company Interoffice Memorandum, April 4, 1988, p. 14).

According to the U.S. Coast Guard, various types of gasoline, including aromatic (GAR) gasoline, automotive (GAT) gasoline, aviation (GAV) gasoline, pyrolysis (greater than 58 benzene) (GPY) gasoline, and straight run (GSR) gasoline contain moderate levels of benzene (U.S. Coast Guard, Marine Safety Manual, Volume1, Chapter 10, Appendix C and E, pg. 1-2).

The concentrations of benzene in gasoline have been reported in literature. (Runion 1976; McDermott 1978; Weaver 1988) Runion reviewed the available data on commercial gasoline in the United States and reported that benzene concentration was generally less than 2 lv% (liquid volume percent). He reported that his earlier study from 1974 indicated benzene concentrations below 1 lv%. Gulf Refineries averaged 1.25 lv% benzene in gasoline during October of 1976, ranging from 0.54 lv% to 2.39 lv%. (Runion, Howard E.; "Benzene in Gasoline", American Industrial Hygiene Association Journal, Vol. 36, p.338, 1975.)

McDermott and Killiany, Jr. (1978) reported samples from Shell's marketing research containing an average benzene concentration of 1% by weight with 5% containing less than 0.2% and 5% containing greater than 2.5%, with a maximum of 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.)

ACGIH has listed gasoline as a confirmed animal carcinogen with unknown relevance to humans as epidemiological evidence does not confirm and increased risk of cancer in exposed humans...with the exception of possibly unlikely routes of exposure or concentrations. (American Conference of Governmental Industrial Hygienists; "Documentation of the Threshold Limit Values and Biological Exposure Indices", for Naphtha, 2001.)

McDermott (1978) indicated that the airborne vapor concentration of benzene as a component of gasoline was 0.7% (mean volume percent) with a standard deviation of 0.4 of the total gasoline by volume. (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.)

Likewise, Page (1989) reported an airborne benzene concentration of 0.9% of refueling vapors generators from dispensed liquid gasoline containing 2.1% benzene. (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.)

Tironi (1991) reported benzene exposures for gasoline refueling attendants, noting that the gasoline vapor results varied from 0.79 to 734 ppm, while the associated benzene vapor levels ranged from 0.01 to 2.88 ppm during the winter. Monitoring conducted in the summer yielded results of 1.08 to 266 ppm for gasoline and associated benzene vapor concentrations ranged from 0.01 to 2.3 ppm. (Tironi, Gene and Hodgkins, Douglas G.; "Compliance with the OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL", App. Occup Envir Hyg, Vol. 6, pp.881-884, 1991.)

In addition, Rappaport (1985) reported his findings of exposure to benzene in the petroleum industry to the American Petroleum Institute in 1985. He found that service station attendants were exposed to benzene as a component of gasoline, ranging from 0.012 to 3.428 mg/m³, with a mean concentration of 0.646 mg/m³. (Rappaport, S., Selvin, S., and Waters, M.; "Gasoline Exposures in the Petroleum Industry, Final Report", for the American Petroleum Institute, Contract IH-37-SMR-592-5, Jan 24, 1985.)

Further, Phillips (1978) reported exposure to gasoline and benzene vapors during bulk handling operations. Maximum time-weighted average concentrations were reported to rarely exceed 240 ppm for gasoline and 1.5 to 2.5 ppm for benzene contained in the gasoline. (Phillips, Carolyn F. and Jones, Robert K.; "Gasoline Vapor exposure During Bulk Handling Operations", American Industrial Hygiene Association Journal, Vol. 39, pp. 118-128, Feb. 1978.)

For a benzene in gasoline volumetric percentage of 2.64 to 2.66% vapor levels of benzene were measured. "The winter gasoline vapor results varied from 0.79 to 734 ppm, while the associated benzene vapor concentrations varied from 0.01 to 2.88 ppm. The summer results for gasoline vapor varied from 1.08 to 266 ppm, and the associated benzene vapor results varied from 0.01 to 2.30 ppm. Benzene vapor concentrations associated with a 300-ppm gasoline vapor level were 1.3 and 2.7 ppm for winter and summer, respectively. This study's results strongly suggest that the "new" gasoline

vapor PEL does not provide adequate protection against exposure to benzene exceeding the PEL.”

$C_{bs} = 0.00905 \cdot C_{gv} - 0.0116$ Summer benzene airborne level given gasoline vapor level

$C_{bw} = 0.00417 \cdot C_{gv} + 0.0207$ Winter benzene airborne level given gasoline vapor level

(Tironi, Gene and D. G. Hodgkins. 1991. *Compliance with the OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL*, Appl. Occup. Environ. Hyg., Vol. 6, No. 10., pp. 881-884, October).

ATSDR:

GASOLINE

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CHEMICAL AND PHYSICAL INFORMATION

TABLE 3-3. Major Components of Gasoline^a

Component	Percentage Composition ^b	Component
<i>n</i> -alkanes		<u>Other possible components</u>
C ₅	3.0	octane enhancers
C ₆	11.6	methyl t-butyl ether (MTBE)
C ₇	1.2	t-butyl alcohol (TBA)
C ₉	0.7	ethanol
C ₁₀ -C ₁₃	0.8	methanol
total of <i>n</i> -alkanes	17.3	antioxidants
branched alkanes		<i>N,N'</i> -dialkylphenylenediamines
C ₄	2.2	2,6-dialkyl and 2,4,6-trialkylphenols
C ₅	15.1	butylated methyl, ethyl and dimethyl phenols
C ₆	8.0	triethylene tetramine di(monononylphenolate)
C ₇	1.9	metal deactivators
C ₈	1.8	<i>N,N'</i> -disalicylidene-1,2-ethanediamine
C ₉	2.1	<i>N,N'</i> -disalicylidene-propanediamine
C ₁₀ -C ₁₃	1.0	<i>N,N'</i> -disalicylidene-cyclohexanediamine
total of branched	32.0	disalicylidene- <i>N</i> -methyl-dipropylene-triamine
cycloalkanes		ignition controllers
C ₆	3.0	tri- <i>o</i> -cresylphosphate (TOCP)
C ₇	1.4	icing inhibitors
C ₈	0.6	isopropyl alcohol
total of cycloalkanes	5.0	detergents/dispersants
olefins		alkylamine phosphates
C ₆	1.8	poly-isobutene amines
total of olefins	1.8	long chain alkyl phenols
aromatics		long chain alcohols
benzene	3.2	long chain carboxylic acids
toluene	4.8	long chain amines
xylene	6.6	corrosion inhibitors
ethylbenzene	1.4	carboxylic acids
C ₃ -benzenes	4.2	phosphoric acids
C ₄ -benzenes	7.6	sulfonic acids
others	2.7	
total aromatics	30.5	

^aAdapted from Air Force 1989^bPercent by weight

Benzene content: 1% - 5% and 3% - 5%. (Employee Benzene Exposure Assessment Summary Report Barge Operations, Bruce B. Crowell, Ashland Petroleum Company, April 1, 1993)

The benzene content of motor and aviation gasoline may exceed 1% (Testimony of R.J. Comeaux, July 11, 1977, Vice President of Gulf Oil Company).

Benzene levels (late 1970s and early 1980s) typically average 1.1% benzene but occasionally may reach 4% on individual samples. (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).

Benzene content of premium gasoline ranged from a mean of 1.35 vol.% to 1.70 vol.% from 1987 to 1990. Benzene content of regular gasoline ranged from a mean of 1.38 vol.% to 1.73 vol.% from 1987 to 1990. (Tironi, Gene and D. G. Hodgkins. 1991. *Compliance with the OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL*, Appl. Occup. Environ. Hyg., Vol. 6, No. 10., pp. 881-884, October).

The benzene content of Mobil premium gasoline was 0.86 vol.% (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.)

The concentrations of benzene in gasoline have been reported in literature. (Runion 1976; McDermott 1978; Weaver 1988) Runion reviewed the available data on commercial gasoline in the United States and reported that benzene concentration was generally less than 2 lv% (liquid volume percent). He reported that his earlier study from 1974 indicated benzene concentrations below 1 lv%. Gulf Refineries averaged 1.25 lv% benzene in gasoline during October of 1976, ranging from 0.54 lv% to 2.39 lv%. (Runion, Howard E.; "Benzene in Gasoline", American Industrial Hygiene Association Journal, Vol. 36, p.338, 1975.)

McDermott (1978) indicated that the airborne vapor concentration of benzene as a component of gasoline was 0.7% (mean volume percent) with a standard deviation of 0.4 of the total gasoline by volume. (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.)

Likewise, Page (1989) reported an airborne benzene concentration of 0.9% of refueling vapors generators from dispensed liquid gasoline containing 2.1% benzene. (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.)

Tironi (1991) reported benzene exposures for gasoline refueling attendants, noting that the gasoline vapor results varied from 0.79 to 734 ppm, while the associated benzene vapor levels ranged from 0.01 to 2.88 ppm during the winter. Monitoring conducted in the summer yielded results of 1.08 to 266 ppm for gasoline and associated benzene vapor concentrations ranged from 0.01 to 2.3 ppm. (Tironi, Gene and Hodgkins,

Douglas G.; "Compliance with the OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL", App. Occup Envir Hyg, Vol. 6, pp.881-884, 1991.)

In addition, Rappaport (1985) reported his findings of exposure to benzene in the petroleum industry to the American Petroleum Institute in 1985. He found that service station attendants were exposed to benzene as a component of gasoline, ranging from 0.012 to 3.428 mg/m³, with a mean concentration of 0.646 mg/m³. (Rappaport, S., Selvin, S., and Waters, M.; "Gasoline Exposures in the Petroleum Industry, Final Report", for the American Petroleum Institute, Contract IH-37-SMR-592-5, Jan 24, 1985.)

Further, Phillips (1978) reported exposure to gasoline and benzene vapors during bulk handling operations. Maximum time-weighted average concentrations were reported to rarely exceed 240 ppm for gasoline and 1.5 to 2.5 ppm for benzene contained in the gasoline. (Phillips, Carolyn F. and Jones, Robert K.; "Gasoline Vapor exposure During Bulk Handling Operations", American Industrial Hygiene Association Journal, Vol. 39, pp. 118-128, Feb. 1978.)

Benzene content in TX unleaded regular RFG 2.7 OXY RVP (8.1) gasoline from Equilon Enterprises, LLC reported to be 0.1 to 0.99% (wgt) benzene (MSDSs dated January 4, 1999 from Equilon Enterprises, LLC – Hartley-O'Brien Cutlip legal case)

Light Reformate:

Contains 10-20% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 3).

Gasoline Blending Stock Reformates (GRF):

According to the U.S. Coast Guard, such reformates contain high levels of benzene (typically 10% or greater) (U.S. Coast Guard, Marine Safety Manual, Volume 1, Chapter 10, Appendix C and E, pg. 1).

Naphtha:

The benzene content of specialty naphtha solvents and naphtha-based (type B) jet fuels may exceed 1%. The residual benzene content of kerosene and light fuel oils sometimes exceed 0.1%. (Testimony of R.J. Comeaux, July 11, 1977, Vice President of Gulf Oil Company).

The benzene content of naphtha can be up to 9.3% by weight – early 1960s (Pagnotto, Leonard, D., et. al., 1961. "Industrial Benzene Exposure from Petroleum Naphtha: I. Rubber Coating Industry", American Industrial Hygiene Journal, Vol. 22, pp. 417-421, Dec.)

Benzene content reported to be 3.7% by volume and 4.6% by weight in textile spirits (Elkins, Hervey, B., et. al., 1963. "Industrial Benzene Exposure from Petroleum Naphtha", American Industrial Hygiene Journal, pp. 99-102, Mar-Apr.)

Major Component	% Benzene in Major Component	Airborne Benzene Conc. (ppm)	% Benzene in Major Component to meet 1 ppm Airborne Level - Theoretical
Naptha	1.6	35 and 31	-
Naptha	2.8	18, 6, 23	-

Source: Elkins, H.B., et.al. 1963. Industrial Benzene Exposure from Petroleum Naptha, Industrial Hygiene Journal, pp. 99-102, March-April.

Naphtha – Algerian:

Contains 1-18% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 1)

Naphtha – Cutback Diluent:

Contains 1-5% benzene Contains (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 3).

Naphtha – Distilling Light:

Contains <5% benzene (Shell Products Containing Benzene or Benzene Compounds, November 13, 1991, pg. 1).

APPENDIX D

**Predicted Vapor Levels Above Gasoline and LUF Containing
5%, 10% and 15% Benzene**

And

**Monte Carlo Simulation Results for Product
Containing Benzene Ranging from 5% to 15% and
Use of Monthly Average Temperatures for Kansas City, MO**

5% Gasoline Results

GASOLINE BENZENE EXPOSURE MODEL

Concentration of Benzene in Breathing Zone - Volitization from a Mixture								
Nicas, Mark, "Using Mathematical Models to Estimate Exposure to Workplace Air Contaminants," <i>Chemical Health & Safety</i> , January/February 2003, pgs. 14-21								
Equations:								
$C_b = G/H$	Steady State Benzene Concentration in Breathing Zone (mg/m ³)							
$H = 0.5*FSA*s$	Hemispherical near field flow of air into and out of breathing zone (m ³ /min)							
$G = C_{HS}*Q$	Emission rate of benzene (mg/min)							
$C_{HS} = X_b*P_b*MW_b*1,000/(0.0623 T_b)$	Benzene Concentration (mg/m ³)							
$P_b = \exp(H_{vp}/(Z_b*R*T_b))*[(1-(3-2T_{pb}))^{**}m/T_{pb})-2m(3-2T_{pb}))^{**}(m-1*\ln T_{pb})]$ $H_{vp} = K_b*(8.75+R*\ln T_b)$	Benzene vapor pressure (mmHg)	From Chemical Properties Estimation Handbook pg 14-14.						
$X_b = (x_b*p_b)/MW_b/[((x_b*p_b)/MW_b) + (((1-x_b)*p_g)/MW_g))]:$	Mole Fraction of Benzene							
MW _b - Molecular weight of benzene	78.1	grams/mole						
MW _g - Molecular weight of gasoline	72	grams/mole						
p _b - density of benzene	0.88	grams/mL						
p _g - density of gasoline	0.74	grams/mL						
x _b - volume percent benzene in gasoline	5.0%	percent	From West Hills Tank Area Investigation Work Area Plan (5% to 15% benzene)					
T _b - benzene temp. in kelvin - assume ambient	283.75	K						
T - Temperature in headspace in degrees C	10.6		Range of temperatures: -5.5 C to 24.5 C - Kansas City - www.worldclimate.com					
Q - fill rate (equivalent to 50 GPM)	0.183	m ³ /min						
FSA - Free surface area of breathing zone (hemisphere of radius = 2.5 feet)	3.65	m ²						
s - air speed through free surface	20	m/min	25	fpm				
m	0.19							
K _b	1.00							
R	1.987							
H _{vp} /T _b = K _b *(8.75+R*lnT _b)	20.41	cal/mole-K						
T _{pb} = T _b /353.1	0.804							
$X_b = (x_b*p_b)/MW_b/[((x_b*p_b)/MW_b) + (((1-x_b)*p_g)/MW_g))]:$	0.0546							
$P_b = \exp(H_{vp}/(Z_b*R*T_b))*[(1-(3-2T_{pb}))^{**}m/T_{pb})-2m(3-2T_{pb}))^{**}(m-1*\ln T_{pb})]$	47.57	mmHg			Term 1 10.588	Term 2 -0.3253	Term 3 0.06353	
							Term 4 -2.771173666	
$C_{HS} = X_b*P_b*MW_b*1,000/(0.0623 T_b)$	11,464	mg/m ³						
$G = C_{HS}*Q$	2,167	m ³ /min						
$H = 0.5*FSA*s$	36.5	m ³ /min						
$C_b = G/H$	53.4	mg/m ³ benzene						
	18.3	ppm benzene						

10% Gasoline Results

GASOLINE BENZENE EXPOSURE MODEL

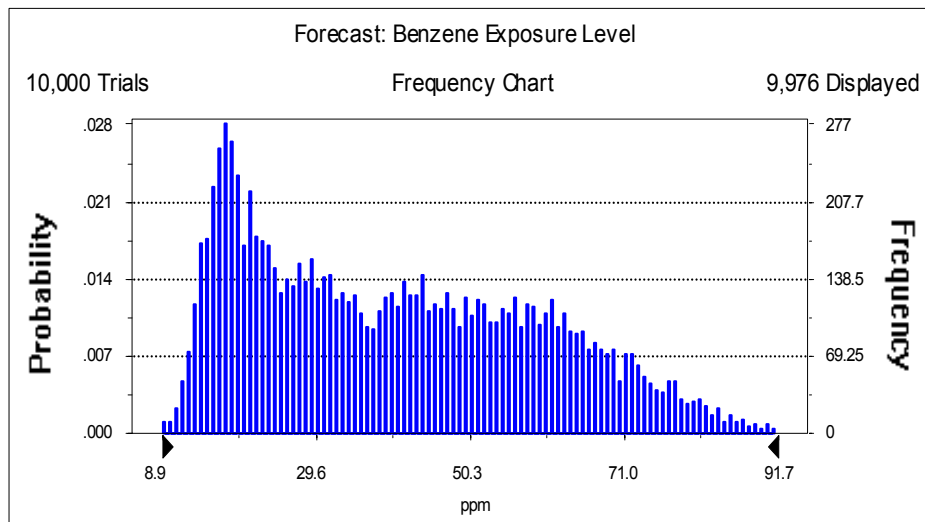
GASOLINE BENZENE EXPOSURE MODEL							
Concentration of Benzene in Breathing Zone - Volitization from a Mixture							
Nicas, Mark, "Using Mathematical Models to Estimate Exposure to Workplace Air Contaminants," <i>Chemical Health & Safety, January/February 2003, pgs. 14-21</i>							
Equations:							
$C_b = G/H$	Steady State Benzene Concentration in Breathing Zone (mg/m ³)						
$H = 0.5 * FSA * s$	Hemispherical near field flow of air into and out of breathing zone (m ³ /min)						
$G = C_{HS} * Q$	Emission rate of benzene (mg/min)						
$C_{HS} = X_b * P_b * MW_b * 1,000 / (0.0623 T_b)$	Benzene Concentration (mg/m ³)						
$P_b = \exp(H_{vp} / (Z_b * R * T_b)) * [(1 - (3 - 2T_{pb})^{**}m / T_{pb}) - 2m(3 - 2T_{pb})^{**}(m - 1 * \ln T_{pb})]$	Benzene vapor pressure (mmHg)	From Chemical Properties Estimation Handbook pg 14-14.					
$H_{vp} = K_p * (8.75 * R * \ln T_b)$	Heat of Vaporization						
$X_b = (x_b * p_b) / MW_b / [(x_b * p_b) / MW_b + ((1 - x_b) * p_g) / MW_g]$	Mole Fraction of Benzene						
MW _b - Molecular weight of benzene	78.1	grams/mole					
MW _g - Molecular weight of gasoline	72	grams/mole					
p _b - density of benzene	0.88	grams/mL					
p _g - density of gasoline	0.74	grams/mL					
x _b - volume percent benzene in gasoline	10.0%	percent	From West Hills Tank Area Investigation Work Area Plan (5% to 15% benzene)				
T _b - benzene temp. in kelvin - assume ambient	283.75	K					
T - Temperature in headspace in degrees C	10.6		Range of temperatures: -5.5 C to 24.5 C - Kansas City - www.worldclimate.com				
Q - fill rate (equivalent to 50 GPM)	0.183	m ³ /min					
FSA - Free surface area of breathing zone (hemisphere of radius = 2.5 feet)	3.65	m ²					
s - air speed through free surface	20	m/min	25	fpm			
m	0.19						
K _p	1.00						
R	1.387						
$H_{vp} / T_b = K_p * (8.75 * R * \ln T_b)$	20.41	cal/mole-K					
$T_{pb} = T_b / 353.1$	0.804						
$X_b = (x_b * p_b) / MW_b / [(x_b * p_b) / MW_b + ((1 - x_b) * p_g) / MW_g]$	0.1086						
$P_b = \exp(H_{vp} / (Z_b * R * T_b)) * [(1 - (3 - 2T_{pb})^{**}m / T_{pb}) - 2m(3 - 2T_{pb})^{**}(m - 1 * \ln T_{pb})]$	47.57	mmHg		Term 1 10.588	Term 2 -0.3253	Term 3 0.06353	Term 4 -2.771173666
$C_{HS} = X_b * P_b * MW_b * 1,000 / (0.0623 T_b)$	22,819	mg/m ³					
$G = C_{HS} * Q$	4,313	m ³ /min					
$H = 0.5 * FSA * s$	36.5	m ³ /min					
$C_b = G/H$	118.2	mg/m ³ benzene					
	36.5	ppm benzene					

15% Gasoline Results

GASOLINE BENZENE EXPOSURE MODEL									
Concentration of Benzene in Breathing Zone - Volitization from a Mixture									
Niclas, Mark, "Using Mathematical Models to Estimate Exposure to Workplace Air Contaminants," <i>Chemical Health & Safety</i> , January/February 2003, pgs. 14-21									
Equations:									
$C_b = G/B$	Steady State Benzene Concentration in Breathing Zone (mg/m ³)								
$B = 0.5 \cdot FSA \cdot s$	Hemispherical near field flow of air into and out of breathing zone (m ³ /min)								
$G = C_{HS} \cdot Q$	Emission rate of benzene (mg/min)								
$C_{HS} = X_m \cdot P_m \cdot MW_b \cdot 1,000 / (0.0623 T_b)$	Benzene Concentration (mg/m ³)								
$P_m = \exp(H_{vp} / (Z_b \cdot R \cdot T_b)) \cdot [(1 - (3 - 2T_{b,i}) \cdot m / T_{b,i}) - 2m(3 - 2T_{b,i}) \cdot (m - 1) \ln T_{b,i})]$	Benzene vapor pressure (mmHg)		From Chemical Properties Estimation Handbook pg 14-14.						
$H_{vp} = K_p \cdot (8.75 + R \cdot \ln T_b)$	Heat of Vaporization								
$X_m = (x_b \cdot p_b) / MW_b / [(x_b \cdot p_b) / MW_b + ((1 - x_b) \cdot p_g / MW_g)]$	Mole Fraction of Benzene								
MW _b - Molecular weight of benzene	78.1	grams/mole							
MW _g - Molecular weight of gasoline	72	grams/mole							
p _b - density of benzene	0.88	grams/mL							
p _g - density of gasoline	0.74	grams/mL							
x _b - volume percent benzene in gasoline	15.0%	percent	From West Hills Tank Area Investigation Work Area Plan (5% to 15% benzene)						
T _b - benzene temp. in kelvin - assume ambient	293.75	K							
T - Temperature in headspace in degrees C	10.6		Range of temperatures: -5.5 C to 24.5 C - Kansas City - www.worldclimate.com						
Q - fill rate (equivalent to 50 GPM)	0.183	m ³ /min							
FSA - Free surface area of breathing zone (hemisphere of radius = 2.5 feet)	3.65	m ²							
s - air speed through free surface	20	m/min	25	fpm					
m	0.19								
K _p	1.00								
R	1.987								
H _{vp} /T _b = K _p *(8.75+R*lnT _b)	20.41	cal/mole-K							
T _{b,i} = T _b /353.1	0.804								
$X_m = (x_b \cdot p_b) / MW_b / [(x_b \cdot p_b) / MW_b + ((1 - x_b) \cdot p_g / MW_g)]$	0.1621								
$P_m = \exp(H_{vp} / (Z_b \cdot R \cdot T_b)) \cdot [(1 - (3 - 2T_{b,i}) \cdot m / T_{b,i}) - 2m(3 - 2T_{b,i}) \cdot (m - 1) \ln T_{b,i})]$	47.57	mmHg	Term 1	Term 2	Term 3	Term 4			
			10.588	-0.3253	0.06353	-2.771173666			
$C_{HS} = X_m \cdot P_m \cdot MW_b \cdot 1,000 / (0.0623 T_b)$	34,067	mg/m ³							
$G = C_{HS} \cdot Q$	6,433	m ³ /min							
$B = 0.5 \cdot FSA \cdot s$	36.5	m ³ /min							
$C_b = G/B$	176.4	mg/m ³ benzene							
	54.5	ppm benzene							

Monte Carlo Simulation Results

**(Assumed Benzene Concentration of Product Ranges from 5% to 15%
And Use of Monthly Average Temperatures for Kansas City, MO)**



Benzene Exposure Levels in PPM (Median is 38 ppm)

Forecast: Benzene Exposure Level

Summary:

Display Range is from 8.9 to 91.7 ppm

Entire Range is from 7.7 to 102.3 ppm

After 10,000 Trials, the Std. Error of the Mean is 0.2

Statistics:

	<u>Value</u>
Trials	10000
Mean	40.3
Median	38.0
Mode	---
Standard Deviation	19.6
Variance	383.0
Skewness	0.43
Kurtosis	2.16
Coeff. of Variability	0.49
Range Minimum	7.7
Range Maximum	102.3
Range Width	94.6
Mean Std. Error	0.20

Simulation Statistics

Benzene Concentrations - Percentiles

Forecast: Benzene Exposure Level (cont'd)

Cell:
C62

Percentiles:

<u>Percentile</u>	<u>ppm</u>
0%	7.7
10%	16.9
20%	20.3
30%	25.1
40%	31.0
50%	38.0
60%	44.7
70%	51.9
80%	59.5
90%	68.1
100%	102.3

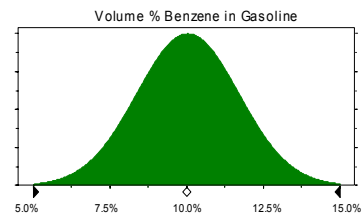
End of Forecast

Assumptions**Assumption: Volume % Benzene in Gasoline**

Normal distribution with parameters:

Mean	10.0%
Standard Dev.	1.7%

Results in Range of 5% to 15% Using Normal Distribution



Assumption: Temperature (C) by Month in KC

Temperature by Month:	C	<u>Relative</u> <u>Prob.</u>
January	-5.50	0.083333
February	-2.80	0.083333
March	-2.30	0.083333
April	4.60	0.083333
May	4.70	0.083333
June	11.10	0.083333
July	12.60	0.083333
August	17.00	0.083333
Sept.	18.60	0.083333
October	21.80	0.083333
Nov.	23.20	0.083333
Dec.	24.50	<u>0.083333</u>
Total Relative Probability		1.000000

