Missouri Public Service Commission

Gas Incident Report

City Utilities of Springfield
Case No. GS-2004-0040

Frisco Building
Ozark Empire Fairgrounds
Springfield, Missouri
June 18, 2003

Gas Safety/Engineering Section … Energy Department ... Utility Operations Division
December 2003… Jefferson City, Missouri

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SYNOPSIS

At approximately 11:47 a.m., Central Daylight Saving Time (CDST, all times in this report are Central Daylight Saving Time) on Wednesday, June 18, 2003, a natural gas ignition and explosion occurred at the Frisco Building, located within the Ozark Empire Fairgrounds in Springfield, Missouri. The explosion destroyed the Frisco Building and damaged other buildings that were up to 700 feet away. Some of the damage included broken windows, creased and impaled siding, broken light fixtures and damaged furnishings within nearby buildings. One Ozark Empire Fair maintenance employee was in the Frisco Building at the time of the explosion, and he was fatally injured. There were no other reported injuries.

City Utilities of Springfield provides natural gas service in Springfield, Missouri. The E-Plex Building located within the Ozark Empire Fairgrounds and northeast of the Frisco Building is supplied natural gas through a combination of both 2-inch and 1¼-inch diameter plastic service line (see Appendix A-2, Figure 2). The Frisco Building did not have natural gas service. City Utilities' records indicated the 12-inch diameter coated steel natural gas main and plastic service line for the E-Plex Building were operating at 56.5 pounds per square inch gauge (psig) at the time of the natural gas ignition and explosion.

The Missouri Public Service Commission's Energy Department - Gas Safety/Engineering Staff (Staff) has determined that the probable cause of the incident was the escape of natural gas from a damaged portion of the 2-inch diameter Dupont Aldyl® "A" plastic pipe providing natural gas service to the E-Plex Building.

The damage resulted from the effects of improper backfill surrounding the pipe that allowed rocks to come in direct contact with the pipe wall. Over time the rock contact with the pipe induced high-localized stress on the pipe wall causing it to crack. It was not determined how or when the improper backfill (rock) came in contact with the service line, or who placed the backfill at the location.

During the course of its investigation into this incident, the Staff did not discover any violations of the Missouri Public Service Commission (Commission or MoPSC) pipeline safety regulations that may have contributed to the incident.

The Staff incident report contains four recommendations to City Utilities as a result of Staff's investigation. Based on the evidence collected during this investigation, a separate natural gas ignition at 3050 North Kentwood, and other instances of plastic pipe failures due to rock

impingement, the Staff has recommended that a separate case be opened to allow the Staff to evaluate City Utilities' plastic main and service line piping failures. Establishment of a separate case will enable the Staff to conduct an on-going in-depth examination and analysis of City Utilities' plastic piping system, methods of leak surveys over this system, installation and backfill procedures, the adequacy of their current program replacement activities, and recommend changes if necessary.

FACTS

NOTE: Except for the information gathered during the on-site investigation and/or interviews, the information used to compile this portion of the report was obtained in record and/or statement form.

The Incident

At approximately 11:47 a.m., CDST on Wednesday, June 18, 2003, a natural gas ignition and subsequent explosion occurred within the Frisco Building located at the Ozark Empire Fairgrounds in Springfield, Missouri.

Personal Injuries

An Ozark Empire Fairgrounds maintenance employee was in the basement of the Frisco Building at the time of the explosion. He was fatally injured. There were no other injuries reported.

Property Damage

The Frisco Building and its contents were destroyed as a result of the explosion. Several buildings in the vicinity of the Frisco Building received extensive structural damage and subsequently had to be demolished. Other buildings up to 700 feet away from the Frisco Building were damaged as well. Some of these damages included broken windows, doors, lights, creased and impaled siding, as well as damaged furnishings within the buildings.

Ozark Empire Fairgrounds officials estimated the damage to the E-Plex building to be $80,000 and the damage to the Safety Services Building to exceed $50,000. The Safety Services Building will be demolished. No damage estimate was provided for the loss of the Frisco Building and the contents. Numerous other buildings owned by different entities and individuals received varying levels of damage to roofing, overhead doors, ceiling tiles, electrical and plumbing, light fixtures, as well as, broken windows. The total damage amounts for these buildings were not known at the time of this report.

Site Description

The Frisco Building was located in the southwest portion of the Ozark Empire Fairgrounds. The Ozark Empire Fairgrounds is located north of Interstate 44 (I-44), east of Highway 13 (also known as Kansas Expressway), and west of North Grant Avenue in the northwest part of Springfield (See Appendix A-1, Figure 1). Wooden ticket booths and a portable wooden structure were located on a concrete pad adjacent to and south of the Frisco Building. Various other exhibit buildings and concession stands for food and beverages were located to the north, east, and south of the Frisco Building. A large asphalt parking lot is located both west and north of the Frisco Building (See Appendix A-2, Figure 2).

The Frisco Building consisted of sandstone block walls erected on a poured concrete foundation and floor. The roof consisted of wooden trusses and a two-tier flat roof assembly. There was a basement located under the west one-third portion of the building that was used as a storage facility. The upper portion of the Frisco Building was used to house and exhibit historic memorabilia. A retaining wall consisting of multiple layers of terra cotta decorative brick was constructed along the west side of the Frisco Building. Excluding the concrete pad adjacent to the south side of the Frisco Building and the small grass area between the terra cotta brick retaining wall, the Frisco Building was surrounded by an asphalt paved surface that extended west and north to the Ozark Empire Fairground's parking lot area.

Meteorological Data and Conditions

The Midwestern Climate Center reported the following conditions for the weather reporting station located at the Springfield/Branson Regional Airport, located approximately 8 miles west of the Ozark Empire Fairgrounds. On June 18, 2003, a high temperature of 84.0 degrees Fahrenheit (ºF), a low temperature of 64.0º F, with no precipitation occurring for that day. The hourly reporting condition for 11:53 a.m. on that same day, indicated a temperature of 80.6° F, 48 percent (%) relative humidity, a barometric pressure of 29.95 inches of mercury, and a wind speed of approximately 7 miles per hour predominantly from the east.

Natural Gas System

Natural gas in Springfield, Missouri, is provided by City Utilities of Springfield. At the time of the ignition and subsequent explosion, the E-Plex Building within the Ozark Empire Fairgrounds was supplied natural gas through a combination of both 2-inch and 1¼-inch diameter plastic service line from a 12-inch diameter, coated steel natural gas main (See Appendix A-2, Figure 2). The plastic natural gas service line was approximately 50 feet west of the Frisco Building and consisted of Dupont Aldyl® "A" plastic material that was manufactured on April 28, 1970. It was installed on May 7, 1971, at a depth of approximately 30 inches. The Frisco Building itself did not have natural gas service. The 2-inch diameter section of plastic service line was reduced to 1¼- inch diameter plastic at a location northeast of Island #2 (See Appendix A-2, Figure 2). The 1¼-inch diameter section of plastic service line consisted of Aldyl® "A" plastic material that was installed on February 20, 1997, to serve the E-Plex Building.

At the time of the natural gas incident, the 12-inch diameter coated steel natural gas main and the various sections of plastic service line that served the E-Plex Building were operating at 56.5 pounds per square inch gauge (psig). The established maximum allowable operating pressure[1] (MAOP) for the 12-inch diameter coated steel natural gas main and the various sections of plastic natural gas service line that served the E-Plex Building was 60 psig. The 12-inch diameter steel natural gas main was installed on August 6, 1996, and was placed into service on October 29, 1996, after a required relocation for a street widening project along West Norton Road.

Susceptibility of Older Plastic Pipe To Premature Brittle-Like Cracking

On April 23, 1998, the National Safety Transportation Board (NTSB) issued a Special Investigation Report entitled *Brittle-like Cracking in Plastic Pipe for Gas Service,* that describes how plastic piping installed in natural gas distribution systems from the 1960s through the early 1980s may be vulnerable to brittle-like cracking resulting in gas leakage and potential hazards to the public and property. A NTSB survey of the accident history of plastic pipe suggested that the material may be susceptible to premature brittle-like cracking under conditions of local stress intensification because of improper joining or installation procedures. NTSB believed that any vulnerability of this material to premature cracking could represent a potentially serious hazard to public safety.

[1] MoPSC regulation 4 CSR 240-40.030(1)(B)16., defines the "maximum allowable operating pressure (MAOP)" as the maximum pressure at which a pipeline or segment of a pipeline may be operated.

The Office of Pipeline Safety (OPS) of the U.S. Department of Transportation (DOT) has issued three advisory bulletins on this issue. The first advisory bulletin **ADB-99-01**, which was published in the Federal Register on March 11, 1999, advised natural gas distribution system operators of the potential poor resistance to brittle-like cracking of certain polyethylene pipe manufactured by Century Utility Products, Inc. (Century pipe). The second advisory bulletin **ADB-99-02,** also published in the Federal Register on March 11, 1999, advised natural gas distribution system operators of the potential brittle-like cracking vulnerability of plastic pipe installed between the 1960s and early 1980s.

The NTSB Report indicates that brittle-like cracking in plastic pipe relates to a part-through crack initiation in the pipe wall followed by stable crack growth at stress levels much lower than the stress required for yielding, resulting in very tight slit-like openings and gas leaks. The report relates that although significant cracking may occur at points of stress concentration and near improperly designed or installed fittings, small brittle-like cracking requires relatively high localized stress intensification that may be a result from geometrical discontinuities, excessive bending, improper installation, and dents and gouges. The report also documents that older polyethylene pipe, manufactured from the 1960s through the early 1980s, may fail at lower stresses and after less time than was originally projected. The DOT-OPS advisory bulletin, **ADB-99-02,** also recommended that all owners and operators of natural gas distribution systems identify all pre-1982 plastic pipe installations, analyze leak histories, and evaluate any conditions that may impose high stresses on the pipe. In addition, the bulletin indicated that appropriate remedial action, including replacement, should be taken to mitigate any risks to public safety.

In 1998, the NTSB Special Investigation Report made several recommendations to trade organizations and to DOT-OPS on the need for a better understanding of the susceptibility of plastic pipe to brittle-like cracking. This prompted DOT-OPS to examine the extent of the susceptibility to premature brittle-like cracking of older plastic piping that remains in use for gas service nationwide. The purpose was also to inform gas system operators of the findings and require them to closely monitor the performance of the older plastic piping and to identify and replace, in a timely manner, any of the piping that indicates poor performance based upon such evaluation factors as: installation; operating and environmental conditions; piping failure characteristics; and, leak history.

In order to obtain the most complete information on the extent of the susceptibility to premature brittle-like cracking of older plastic pipe, a meeting was convened in May of 1999 with all stakeholders to determine how information on older plastic pipe could be assembled. As a result of this meeting, a pipe study committee was formed to address the NTSB recommendations. In-

turn a Plastic Pipe Database Committee was formed to gather data on plastic pipe failures. This committee started gathering data in January of 2001 on the extent of plastic pipe performance problems and to mitigate risks to safety.

DOT-OPS issued a third advisory bulletin regarding plastic pipe, **ADB-02-07**, which was published in the Federal Register on November 26, 2002. **ADB-02-07** identifies "known susceptible material" as Century pipe, low-ductile inner wall Aldyl® "A" piping manufactured before 1973, and PE 3306 pipe. Part of the background for this ADB indicated that the environment, installation, and service conditions under which the piping is used are factors that could lead to premature brittle-like cracking of these older materials. These conditions included, but were not limited to inadequate support and backfill during installation and rock impingement. In general, DOT-OPS recommended that all operators implement practices for all PE piping systems to identify brittle-like cracking problems and take appropriate action, up to and including replacement. The first recommended practice was to review system records to determine if any known susceptible materials have been installed. Then, review engineering and purchasing records to identify the location of any susceptible materials. Additionally, increasing the frequency of inspections and leak surveys on systems that have exhibited brittle-like cracking failures on known susceptible materials. Another recommended practice was to establish a process to identify brittle-like cracking failures. Identification of these failure types and site installation conditions should be used in predicting the performance of the natural gas system.

In summary, three DOT-OPS advisory bulletins have been issued regarding the susceptibility of certain older plastic piping to brittle-like cracking. This plastic piping included low-ductile inner wall Aldyl® "A" piping manufactured before 1973. The advisory bulletins also indicate that brittle-like cracking can be caused by high localized stress intensification that may be a result from geometrical discontinuities, excessive bending, improper installation, and dents and gouges. Other factors that can lead to premature brittle-like cracking are the pipe's environment and service conditions under which the piping is used. These conditions include, but are not limited to, inadequate support and backfill during installation and rock impingement.

City Utilities' Experience With Plastic Natural Gas Mains and Replacements

On May 14, 1997, the Staff mailed a letter to all the Missouri natural gas distribution system operators that included a questionnaire survey concerning older plastic pipe. The survey asked if natural gas operators had any Century pipe or Flying "W" piping and requested information regarding any plastic pipe installed prior to 1980. No operators responded to having any Century or Flying "W" piping within their Missouri gas systems. However, several operators provided information about plastic pipe that was installed prior to 1980, including City Utilities, who had installed Aldyl® "A" pipe. City Utilities' June 19, 1997 response to Staff's survey indicated that, in the 28 years they have been using Aldyl® "A" pipe, they have not experienced a high incidence of brittle-like failures or high leak rate. City Utilities indicated there was some pipe installed in the early 1970's that experienced "low-ductile inner-wall" failures. City Utilities also indicated that, in general, they have had good experience with plastic piping installed before and after 1980, but the post-1980 piping performed better. City Utilities thought this might be the results of, in part, better installation techniques.

In March of 1999, **ADB-99-02** recommended that all operators review their systems to determine the susceptibility of pre-1982 plastic piping to failures and to take the appropriate remedial action. Included in the advisory bulletin, for all operators of natural gas distribution systems, was the recommendation to identify all pre-1982 plastic pipe installations, analyze leak histories, and evaluate any conditions that may impose high stresses on the pipe. Also included, was the recommendation for the operator to take appropriate remedial action, including replacement, to mitigate any risk to public safety. City Utilities issued a report in April of 2000 detailing the City's plastic piping system and the actions to be taken based upon their analysis.

City Utilities' report indicated at that time there were approximately 640 miles of plastic main piping in their system of which 275 miles were installed prior to 1982. The report identified belowground main leaks on plastic pipe that had a leak cause designation of "material failure". These leaks were then further classified as: leaks on pipe, service tee, socket coupling, flange, and other. The leaks that had "pipe" listed as the leaking component were analyzed. City Utilities did not track the leaks on plastic service lines.

City Utilities' analysis indicated that there is not any specific year of pipe manufacture or years that have an abnormally high incidence of failure and concluded that other factors should be taken into account, such as installation, working pressure, and environmental conditions. City Utilities also reviewed leak records to determine main segments that had a higher than normal leak rate. Ten main segments, installed between 1972 and 1993, were identified as having an

above normal leak rate. These main segments were annually leak surveyed and replaced in the next two budget years. Other plastic mains that became higher priority were also to be replaced. City Utilities concluded that it had not experienced a significant problem with pre-1982 plastic pipe. However, the report also indicated that there were some brittle-like failures of this piping. City Utilities also established a tracking system for its plastic mains to identify future problem areas.

Previous City Utilities' Actions

Odorization Records

City Utilities conducts monthly odorant concentration tests at various locations throughout the natural gas system to verify the level of odorant to assure that consumers and the public are able to smell any leaking natural gas. Some of the test locations chosen randomly for odorant concentration tests include 3319 North Grant (Hillcrest High School, see Appendix A-1, Figure 1) and 2000 North Broadway (Broadway Laundry). Both of these locations are near the Ozark Empire Fairgrounds and were monitored during the months of February, April, and May of 2003, prior to the incident. A review of these odorant intensity test readings indicated that the natural gas was adequately odorized and readily detectable at an average concentration of 0.21 percent (%) gas-in-air[2].

Leakage Surveys and Leaks

The natural gas facilities owned by City Utilities within the Ozark Empire Fairgrounds are typically leak surveyed with a Flame Ionization (FI)[3] unit on a 3-year schedule. Excluding the day of the incident, the most recent City Utilities' leak survey[4] of the natural gas facilities (that included the plastic service line serving the E-Plex Building) was conducted in May of 2001. No natural gas leaks were discovered within the Ozark Empire Fairgrounds as a result of this leak survey.

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[2] MoPSC regulation 4 CSR 240-40.030(12)(P)1., requires the odorant in natural gas to be readily detectable at a concentration of less than 0.90% gas-in-air, based upon a lower explosive limit at 4.5% gas-in-air.

[3] An FI unit is a leak detection instrument used to measure gas concentrations, in parts per million, in an air sample. The FI unit has a built-in pump, which is able to draw in an air sample above the ground.

[4] MoPSC regulation 4 CSR 240-40.030(13)(M)2.B., requires leakage surveys to be conducted outside principal business districts using a leak detection instrument at intervals not exceeding 39 months, but at least once each third calendar year for all pipelines other than unprotected steel pipelines and yardlines.

The 12-inch diameter coated steel natural gas main (See Appendix A-2, Figure 2) along the 800 to 1200 block of West Norton Road was leak surveyed on August 8, 2001, by City Utilities with a mobile FI unit. The section of natural gas main along the 700 to 1200 blocks of West Smith Street was leak surveyed on August 9, 2001. Additionally, the section of main along North Grant Avenue on the east side of the fairgrounds was most recently leak surveyed on October 31, 2002. No natural gas leaks were discovered during these leak surveys.

City Utilities received a leak call on September 3, 2000 for "1000 West Smith Street" (caller was from the Missouri Department of Conservation Building) in which an outside leak was reported. A Class 2 leak[5] was discovered along the southern portion of the 2-inch diameter plastic natural gas service line (See Appendix A-2, Figure 2) and was repaired on September 6, 2000.

Past Leak Repairs to the Plastic Natural Gas Service Line Serving the E-Plex Building

On October 16, 1999, a third party damage occurred to a section of 1¼-inch diameter plastic natural gas service line (installed on February 20, 1997) that served the E-Plex Building (See Appendix A-2, Figure 2). Contractors working for the Ozark Empire Fairgrounds severed the plastic service line while constructing a ticket booth office for the E-Plex Building. City Utilities responded and squeezed[6] the plastic line off to terminate the flow of gas. City Utilities repaired the plastic service line that same day.

The Class 2 leak, repaired on September 6, 2000, on the 2-inch diameter plastic natural gas service line, was on piping installed on May 7, 1971 (See Appendix A-3, Figure 3, "Location of 9/6/00 Leak Repair"). The leak was 234 feet north of the centerline of West Norton Road, just north of the entrance to Gate 5. City Utilities repaired the leak by replacing a 2-foot portion of the leaking plastic service line. City Utilities recorded the primary cause of this leak as an "aged/worn component." According to City Utilities personnel, the "aged/worn component" leak cause description is typically used whenever several types of failures occur. A crack failure that has occurred due to rock impingement is one of these types.

[5] MoPSC regulation 4 CSR 240-40.030(14)(C)2., defines a Class 2 leak as a leak that does not constitute an immediate hazard to a building or to the general public, but is of a nature requiring action as soon as possible. Class 2 leaks must be rechecked every 15 days until repaired. Class 2 leaks due to readings in a sanitary sewer must be repaired within 15 days. All other Class 2 leaks must be eliminated within 45 days.

[6] A process where a vise-like device is installed over the main and the device is used to squeeze the plastic together so that the flow of natural gas can be restricted.

Plastic Pipe Installation Regulations and Procedures

Regulations For Plastic Pipe Installations

December 12, 1968 to March 12, 1971 – Plastic Piping Installations

The Missouri Public Service Commission adopted General Order No. 45 for gas companies under its jurisdiction, effective March 14, 1968. The U.S. Department of Transportation – Office of Pipeline Safety (DOT-OPS) adopted General Order No. 45 for all gas pipeline facilities in Missouri, effective December 12, 1968 (49 CFR part 190). Section 842.43(c) in General Order No. 45 stated, "Plastic piping shall be installed in such a way that shear or tensile stresses resulting from construction, backfill, thermal contraction or external loading are minimized." In Section 843.431 titled *Direct Burial*, paragraphs (b) and (e) stated:

> (b) Plastic pipe shall be laid on undisturbed or well compacted soil. If plastic piping is laid in soils which may damage it, the pipe shall be protected by suitable rock free materials before backfilling is completed. Plastic pipe shall not be supported by blocking. Well tamped earth or other continuous support shall be provided.
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> …
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> (e) Backfilling shall be performed in a manner to provide firm support around the piping. The material used for backfilling shall be free of large rocks or pieces of pavement, or any other materials that might cause damage to the pipe.

March 12, 1971 to Present – Main and Service Line Installations

In 1970, DOT-OPS adopted 49 CFR part 192 and prescribed in §192.13(a) that the regulations regarding installation applied to pipeline segments "readied for service after March 12, 1971". In §192.319 titled *Installation of Pipe in a Ditch,* paragraph (b) stated:

> (b) Each ditch for a transmission line or main must be backfilled in a manner that
>
> (1) Provides firm support under the pipe; and
> (2) Prevents damage to the pipe and pipe coating from equipment or from the backfill material.

In §192.361 titled *Service lines: installation,* paragraphs (b) and (d) stated:

> (b) *Support and backfill.* Each service line must be properly supported on undisturbed or well-compacted soil, and material used for backfill must be free of materials that could damage the pipe or its coating.
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> …
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> (d) *Protection against piping strain and external loading.* Each service line must be installed so as to minimize anticipated piping strain and external loading.

The Missouri Public Service Commission adopted 49 CFR part 192 after it was issued by DOT-OPS. The Commission then promulgated new pipeline safety regulations effective December 15, 1989, and the requirements of §192.319(b), §192.361(b), and §192.361(d) are now found at 4 CSR 240-40.030(8)(J)2., (8)(G)2., and (8)(G)4., respectively.

City Utilities' Installation Procedures

City Utilities was unable to provide any formal installation procedures that would have been in effect during the time period of the installation of the 2-inch diameter Dupont Aldyl® "A" plastic natural gas service line (See Appendix A-2, Figure 2) at the Ozark Empire Fairgrounds.

City Utilities indicated that procedures similar to the installation standards from the 1977 Gas Department Standards & Procedures Manual (1/28/77-version) were likely used during the plastic service line installation. This manual contains, under the Gas Department Specifications Covering Installation of Gas Mains and Services, Laying and Backfilling of Coated Steel and Plastic Pipe, the following information on installing pipe:

> "Backfilling shall be done in such manner as not to injure the pipe or coating. No rock shall be allowed to fall on the pipe. In rocky areas the pipe will be covered by AG Limestone or protected by flexible rock shield with a cover of select dirt to a depth of 6-inches over the pipe… Both the top and the sides of the pipe shall be protected in this manner. Backfill shall be tamped in lifts or layers in such manner as may be satisfactory. Rock will not be used for backfilling until a cushion of AG Limestone or dirt has been placed on the top and around the sides of the pipe by hand so that damage to the pipe may be avoided."

City Utilities' Notification, Actions and Observations

Initial Notification and Response

City Utilities received a telephonic notification from a 911 dispatcher at 12:10 p.m. on Wednesday, June 18, 2003, indicating a "possible gas explosion". The location was reported as the Frisco Building on the Ozark Empire Fairgrounds property. Various Gas Department emergency crews, including construction crews, gas leak investigation, pressure control personnel, and various City Utilities' supervisory and engineering personnel were dispatched and began arriving at the incident site at approximately 12:20 p.m. Numerous other City Utilities' Gas Department personnel responded to the incident site throughout the day of the incident and in the days following the incident up to and including June 21, 2003.

Upon initial arrival at the incident site, City Utilities' leak surveyors and leak investigators consulted a map of the location of the natural gas lines in the incident area. At approximately 12:35 p.m., leak surveyors and leak investigators began to leak survey in the immediate area of the incident site to check for any indications of migrating natural gas. FI units were used to sample the atmosphere above the ground near the Frisco Building and over existing natural gas mains and service lines. During this initial leak survey, two indications of gas were detected near the retaining wall flowerbed just west of the restroom building (BH-3), and in the flowerbed around a utility pole and tree (Island #1, BH-1) located approximately 40 feet west of the west foundation wall of the Frisco Building (See Appendix A-3, Figure 3).

City Utilities' leak surveyors and leak investigators also began to make a series of bar holes[7] along the 2-inch diameter, PE service line west of the Frisco Building and in the asphalt pavement between the service line and the Frisco Building (See Appendix A-3, Figure 3). A combustible gas indicator (CGI)[8] was used to sample the atmosphere in these bar holes. "Sustained readings"[9] of 0% to 60% gas-in-air were obtained in these bar holes. The highest sustained readings of 50% and 60% gas-in-air respectively were obtained adjacent and near the flowerbed (Island #1) west of the Frisco Building, and in a bar hole just north of the Frisco Building (See Appendix A-3, Figure 3, BH-1 & 2). Also, the atmosphere in the restroom sewer

[7] Bar holes are small diameter holes made in the ground by a steel rod to facilitate sampling of the subsurface atmosphere for natural gas with a combustible gas indicator.

[8] A CGI is an instrument used to draw a sample of the atmosphere and measure the percentage of natural gas in the sample.

[9] "Sustained Reading" means the reading taken on a combustible gas indicator after adequately venting the test hole or opening.

(adjacent and north of the Frisco Building) was sampled with a CGI and no presence of gas was detected. Other leak surveyors began to leak survey all of the other buildings on the fairgrounds property and also the other two natural gas service lines, which served a burger stand and the Guest Services building. The leak surveys were performed using an FI unit. No indications of natural gas were detected during these surveys.

Gas Department crews also began to turn off all of the natural gas meters on the fairgrounds property. The crews had all of the natural gas meters shut off at 12:50 p.m. During the time that leak surveys and investigations were being conducted, City Utilities' Gas Department personnel determined, that, in order to terminate the flow of natural gas in the 2-inch diameter, PE service line, a valve located near Gate 5 and West Norton Road (See Appendix A-3, Figure 3) would need to be shut off. A City Utilities' Gas Department Gas Pressure Control crew shut off this valve at approximately 1:00 p.m., which terminated the flow of natural gas in the service line.

Between 1:14 p.m. and 3:30 p.m., samples of the subsurface atmosphere were collected from bar holes in the flowerbed (Island #1) west of the Frisco Building, the retaining wall west of the restrooms, and near the west basement wall of the Frisco Building. These samples were transported to a local laboratory for gas chromatographic testing. The test results indicated that all four samples "contained all the components of natural gas."

To ensure the required concentration of odorant was in the natural gas, from approximately 1:15 p.m. through 2:40 p.m., City Utilities' Gas Department personnel performed odorant intensity tests at the Dickerson Park Zoo, the E-Plex Building meter set, 1116 West Norton Road (apartment building directly across from Gate 5), and at the incident site. The tests were conducted using an odorometer, and the natural gas was readily detectable at concentrations of 0.05%, 0.02%, 0.05%, and 0.04% gas-in-air, respectively.

At approximately 4:00 p.m., City Utilities' personnel determined, that, in order to facilitate their investigation of the incident, they would contract with a consultant specializing in fire and explosion investigation to assist with the investigation. The consultant was contacted and was scheduled to arrive at the site on June 20, 2003.

Around 5:00 p.m., the Springfield Fire Department determined that, in order to facilitate their investigation of the incident, heavy equipment would be required to remove debris from the basement area of the Frisco Building. After the debris had been removed from the basement area, fire department personnel discovered a floor drain in the northwest corner of the basement.

At approximately 8:30 p.m., the Springfield Fire Department closed the incident site for the day because of darkness. Investigation activities were scheduled to resume the next day at 8:00 a.m.

Further City Utilities' Response

On June 19, 2003, at approximately 8:00 a.m., City Utilities' Gas Department personnel resumed their investigation activities.

Leak surveyors and leak investigators performed CGI checks in the same locations where checks were made on June 18, 2003. These bar holes were located along the 2-inch diameter, PE service line west of the Frisco Building and in the asphalt pavement between the service line and the Frisco Building. Sustained readings of 0% to 73% gas-in-air were obtained in these bar holes. The highest sustained readings of 73% and 38% gas-in-air were obtained in two separate bar holes northwest of the Frisco Building (See Appendix A-3, Figure 3, BH- 2 & 4). A CGI reading of 50% gas-in-air was also obtained in the floor drain located in the northwest corner of the basement in the Frisco Building. The natural gas had been turned off over night and the June 19th readings were obtained after the gas was turned back on for investigation and testing.

At approximately 9:30 a.m., a sample of the atmosphere in the basement floor drain was obtained and transported to a local laboratory for testing. The test results indicated that the sample "contained all the components of natural gas."

To determine if natural gas had migrated beneath the basement floor of the Frisco Building, Gas Department personnel began to drill bar holes in the basement floor of the Frisco Building, at approximately 11:30 a.m., to sample the atmosphere under the basement floor. Eight separate bar holes were drilled in the basement floor, three bar holes were located in the approximate center of the floor, four bar holes were located along the west wall of the basement, and one was located at the northwest corner of the basement floor. No indications of gas were detected in any of these bar holes.

At approximately 12:25 p.m. and 12:52 p.m., respectively, Gas Department personnel collected samples of earth from an excavation located approximately 30 feet north of Island #1 (west of the Frisco Building) and at another location approximately 40 feet south of Island #1. These earth samples were transported to a local laboratory for testing and the test results indicated that the samples contained traces of methane (a component of natural gas).

At 1:45 p.m. and 1:55 p.m. respectively, CGI readings were taken along the top of the southwest basement wall within the Frisco Building. A FI leak survey was also conducted east of the east basement wall of the Frisco Building. No gas was detected during these investigations.
In order to determine the location of a possible leak on the 2-inch diameter, PE service line, City Utilities' Gas Department crews made several excavations to expose the service line, during the morning and early afternoon of June 19th (See Appendix A-3, Figure 3). These locations were determined by the sustained gas-in-air readings obtained with a CGI in bar holes that had been placed over the service line. These excavations were later used to conduct pressure tests on different segments of the service line. Crews cut the service line into 3 separate sections. Each segment was later capped and subjected to a pressure test. The pressure test for the pipe segment between Excavations #1 and #4 began at 1:29 p.m. at a pressure of 60 psig and ended at 1:46 p.m. at a pressure of 38 psig, indicating a pressure loss of 22 psig. The pipe segment between Excavations #1 and #3 was pressure tested beginning at 2:07 p.m. at a pressure of 60 psig and ending at 2:17 p.m. at a pressure of 20 psig, indicating a pressure loss of 40 psig. The pipe segment between Excavation #4 and the E-Plex Building was pressure tested beginning at 3:43 p.m. at a pressure of 56 psig and ending at 3:56 p.m. at a pressure of 56 psig, indicating no pressure loss. City Utilities determined, based upon these pressure tests, that there was a possible leak on the service line somewhere between Excavations #1 and #4.

At approximately 6:00 p.m., the Springfield Fire Marshal cleaned out the floor drain located in the northwest corner of the basement floor in the Frisco Building and found an opening in the bottom. A decision was made to perform a smoke test[10] of the drain to try and determine where the drain ran. The smoke test was scheduled for 8:30 a.m. the following day (June 20th). At approximately 8:30 p.m., the Fire Department closed the incident site for the day because of nightfall.

On June 20, 2003, at approximately 8:30 a.m., City Utilities' Gas Department personnel arrived at the incident site to resume their investigation activities. The smoke test of the basement floor drain began at 8:30 a.m. and was conducted by the City of Springfield Sewer Department. The smoke test ended at 9:00 a.m. and no observations of smoke were noted emanating aboveground or from any sanitary sewer and storm sewer in the vicinity of the Frisco Building.

At approximately 9:30 a.m., the fire and explosion investigator hired by City Utilities arrived and met with City Utilities' personnel to plan a course of action on how to proceed with the investigation. The fire and explosion investigator and City Utilities personnel made plans to

[10] A smoke test is a process in which smoke is injected into a pipe, such as a drain or sewer, by a motor driven fan. The smoke then would be forced out of unrestricted available openings in the piping and observed at the surface.

make a series of closely spaced bar holes over the 2-inch diameter, PE service line and in the asphalt pavement between the service line and the Frisco Building. Based upon the findings obtained from CGI gas-in-air readings in these bar holes, the investigator would later determine the pipe sections that needed to be pressure tested.

Gas Department crews began drilling bar holes in the asphalt pavement over the service line and between the service line and the Frisco Building around 9:45 a.m. Based upon the previous day's pressure tests with air on segments of the service line, the crews concentrated on a section of pipe approximately 240 feet in length between Excavations #1 and #4 (See Appendix A-3, Figure 3). The service line was reconnected to provide a source of natural gas. After the bar holes had been drilled in the pavement, Gas Department leak surveyors and leak investigators began sampling the atmosphere in these bar holes with CGI's. The natural gas in the 2-inch diameter service line was cycled on and off at different pressures so some natural gas would be introduced into the bar holes to facilitate using the CGI's. Considering the gas-in-air readings obtained in the bar holes, Gas Department crews began to pressure test segments of the service line.

The service line piping between Excavations #3 and #4 was pressure tested beginning at 1:25 p.m. at a pressure of 56 psig and ending at 1:35 p.m. at a pressure of 56 psig, indicating there was not a leak on this segment of pipe. Subsequently, the service line was cut and capped in Excavation #4. Then the process of introducing natural gas into the service line and taking CGI readings in the bar holes was repeated on the remaining service line between Excavations #1 and #3. Based upon these bar hole readings, the service line was pressure tested between Excavations #1 and #2. The pressure test began at 3:45 p.m. at 56 psig and ended at 4:00 p.m. at a pressure of 56 psig, indicating there was not a leak on this segment of pipe. Then bar hole and pressure testing was conducted on the service line segment between Excavations #2 and #3. This pressure test began at 6:24 p.m. at 50 psig and ended at 6:35 p.m. at a pressure of 20 psig, indicating a leak on this segment (approximately 40 feet) of service line. Gas Department crews used a saw and a jack hammer to cut the asphalt pavement above the service line between Excavations #2 and #3 in anticipation of excavating and exposing the service line to determine the location of the leak.

At approximately 9:00 p.m., the incident site was closed down for the night, to be resumed the next morning.

On June 21, 2003, at approximately 7:50 a.m., City Utilities' Gas Department crews continued with the investigation activities. Gas Department crews continued cutting the asphalt pavement

above and on the west side of the 2-inch diameter, PE service line between Excavations #2 and #3 to allow a strip of asphalt pavement approximately 40 feet long and 4 feet wide on the west side of the service line to be removed. Gas Department crews then made a series of bar holes where the strip of asphalt had been removed. The bar holes were placed every two feet for approximately 32 feet. CGI readings were then taken with and without gas pressure in the service line. This cycle of CGI readings with the gas on and off continued until the leak location could reasonably be determined. Gas Department crews used hand tools to expose the 2-inch diameter, PE service line. At approximately 1:30 p.m., a crack was found on the bottom of the service line at a location that was in contact with a rock.

At approximately 3:30 p.m., the plastic service line was further exposed and an 18-foot section, containing the crack, was removed and transported to the City Utilities' Gas Engineering Laboratory for safekeeping until June 23, 2003 when it would be sent to an independent laboratory for testing and analysis. After the section of pipe was removed, Gas Department crews backfilled all of the excavations along the natural gas service line. All crews left the site at approximately 5:30 p.m. on June 21.

Other City Utilities Actions

Pressure Testing and Abandonment of Service Line

On June 23, 2003, Gas Department crews excavated and exposed the location where the 2-inch diameter, PE service line was connected to the 12-inch diameter, coated steel main on the north side of West Norton Road at the Gate 5 entry into the fairgrounds (See Appendix A-3, Figure 3). The service line was disconnected from the main at a steel valve and then was pressure tested between this point and Excavation #1 (See Appendix A-3, Figure 3). The pressure test began at 1:46 p.m. at a pressure of 56 psig and ended at 2:16 p.m. at a pressure of 56 psig, indicating no leak on the segment of service line. The service line was permanently abandoned by welding a steel enclosure over the valve assembly. At the same time, a 70-inch section of the 2-inch diameter, PE service line, which could not be pressure tested on-site, was removed and transported to the City Utilities' Gas Engineering laboratory for pressure testing. This section of pipe was pressure tested on August 1, 2003 at a pressure of 60 psig. The test indicated no pressure loss for the duration of the test.

Post-Incident Leak Survey

On June 23, 2003, City Utilities' leak surveyors completed a FI leak survey around the perimeter of and inside the fairgrounds. The leak survey area included the natural gas mains and service lines along West Norton Road, between North Grant Avenue and approximately at the entrance to Dickerson Park Zoo, Smith Street, between North Grant Avenue and the Zoo, and North Grant Avenue, between West Norton Road and Smith Street (See Appendix A-1, Figure 1). The leak survey also included the natural gas service lines on the fairgrounds property. Several small leaks were found on aboveground meter set piping. Three Class 3 leaks[11] were found in valve box enclosures during this leak survey and were scheduled for repair.

Installation of New Service Line to the E-Plex Building

On August 18, 2003, City Utilities installed a new 2-inch diameter, PE service line to the E-Plex Building on the fairgrounds property. This service line replaced the existing service line, which had been abandoned on June 23, 2003.

Excavation of Abandoned E-Plex Building Service Line

On September 17, 2003, at the request of Staff, City Utilities excavated and exposed the abandoned 2-inch diameter, PE, natural gas service line to the E-Plex Building at three different locations between West Norton Road and the Frisco Building. Gas Department crews exposed the service line on the north and south side of a September 6, 2000 leak repair site (See Appendix A-2, Figure 2). These excavations indicated that sand surrounded the piping. The crews also excavated and exposed the service line at a point just south of Excavation #1. Sand also surrounded the pipe at this location.

[11] MoPSC regulation 4 CSR 240-40.030(14)(C)3., defines a Class 3 leak as a leak that does not constitute a hazard to property or to the general public, but is of a nature requiring routine actions. These leaks must be repaired within 5 years and be rechecked twice per calendar year, not to exceed 6½ months.

MoPSC Reporting Requirements

The Missouri Public Service Commission incident reporting requirements were completed as follows:

1. The initial telephone notification of a possible natural gas incident was made to a Staff member at 12:55 p.m. on June 18, 2003. Staff directed City Utilities personnel to wait to contact the DOT-OPS until further developments gave evidence of natural gas involvement.

2. City Utilities' Gas Department personnel notified to the United States Department of Transportation (DOT-OPS) of a natural gas incident at 10:40 a.m. on June 19, 2003. This incident did meet the DOT-OPS Federal Incident reporting requirements because there was a release of gas from a pipeline that resulted in a death and property damage in excess of $50,000.

3. D.O.T. form RSPA F 7100.1, was completed by City Utilities' Gas Department, and transmitted to the MoPSC on July 15, 2003. The Staff forwarded the report to the DOT-OPS on July 18, 2003.

MoPSC Staff Investigation – June 18-23, 2003

Two members of the Commission's Energy Department – Safety/Engineering Staff arrived at the incident site at approximately 4:30 p.m. on June 18, 2003. Upon arrival, the Staff met with the City Utilities' Gas Compliance Administrator. He gave a brief description of the events that had taken place up to that point and the security conditions at the incident site. Upon examination of the Frisco Building, the Staff detected a strong odor that was similar to a chemical solvent.

Staff, along with City Utilities' personnel found several sustained gas readings in the area around the Frisco Building. A high sustained gas-in-air reading of 60% was found in a drilled-out bar hole north of the Frisco Building (See Appendix A-3, Figure 3, BH-2). A natural gas service line serving the E-Plex Building, the building that is north of the Frisco Building, was valved-off near the main at approximately 1:00 pm. There was no natural gas service line serving the Frisco Building.

Staff's initial observations at the site of the explosion found no indication of burning and a vast amount of debris from the explosion was scattered in the vicinity of the Frisco Building. There

was noticeably more debris scattered to the west than any other direction. To illustrate the magnitude of the explosion, the Staff observed a doorframe piece approximately 444 feet north of the Frisco Building. There were also sheets of metal siding that were scattered up to 220 feet north of the Frisco Building. Among the other explosion remnants were splintered wood, broken glass, and other debris. The entire basement level of the Frisco Building was filled with debris from the explosion. Some of the contents left in the basement area included numerous paint cans, paint thinners, a drum of liquid concrete sealer, and other chemical solvents. At approximately 5:00 p.m., heavy equipment began removing debris from the basement of the Frisco Building. The Staff left the incident site at approximately 8:10 p.m.

The Staff returned to the incident site on June 19, 2003. When the Staff arrived, a good portion of the debris was cleared from the basement and the concrete floor was exposed (mainly at the northern-most corner of the building). A floor drain was located at the northwest corner of the basement and City Utilities' personnel informed the Staff that a 50% gas-in-air reading was obtained in the drain. By early afternoon, three excavations had been made to expose the natural gas service line. Immediately after the top layers of asphalt were removed from Excavation #3 (See Appendix A-2, Figure 2), the Staff observed the gas readings within the floor drain dramatically decreased from 50% to 0% gas-in-air. Afterwards, the Staff detected the smell of natural gas odorant in the air and a City Utilities' leak investigator obtained a sustained 2.0% gas-in-air reading in the open air approximately 30 feet south of Excavation #3.
Table 1 describes the pressure tests that were performed throughout the day. Air was used as the pressurizing medium for each test. Two of the tests indicated one or more leaks on the natural gas service line adjacent to the Frisco Building. During the series of tests, the pipeline segment between Excavation #4 and the E-Plex Building was determined not to be leaking.

Table 1: Pressure tests on E-Plex service line for June 19, 2003.

EXCAVATION #/ LOCATION	LENGTH OF PIPE TESTED (FT)	INITIAL PRESSURE (PSI)	FINAL PRESSURE (PSI)	START TIME	TEST DURATION (MIN)
1-4	239	60	38	1:29 p.m.	17
1-3	142	60	20	2:07 p.m.	10
E-Plex Bldg.	222	56	56	3:43 p.m.	13

At 3:00 p.m. Staff members, representatives from City Utilities, and the Springfield Fire Department conducted an interview with the General Manager of the Ozark Empire Fairgrounds and two Fair Maintenance employees who were working at the fairgrounds at the time of the incident. It was explained that one of the Fair Maintenance employees had been in the basement

of the Frisco Building two weeks prior to the incident and they did not smell any natural gas at that time. Upon hearing the explosion, one of the maintenance employees present at the interview rushed to the site, found the victim's body and extinguished a small fire. The layout of the Frisco Building, as it was prior to the explosion, was also explained during the interview. There were two light switches in the basement area. One switch was inside of the only door to the basement and the other was further inside the basement on a circuit breaker that controlled the lights to the paint room (See Appendix A-3, Figure 3).

At approximately 4:00 p.m. the Springfield Fire Marshal reported to the Staff that a disposable lighter had been found in the basement of the Frisco Building in close proximity to where the victim's body had been found. The Staff left that evening at approximately 6:00 p.m.

The Staff returned to the incident site Friday, June 20, 2003 at approximately 7:15 a.m. A smoke test of the floor drain was scheduled for 8:30 a.m. The purpose of the smoke test was to locate any other openings in the drain that would provide a migration path for the natural gas. The smoke testing unit was configured with a mechanical fan and a smoking stick attachment. The sealing section of the smoke testing unit was circular in shape so that it could be placed on top of a round sewer manhole. However, the opening of the floor drain was a 1-foot square. Consequently, when the smoke test began the majority of the smoke was blown out of the annular space between the smoke unit and the opening in the floor drain. No smoke was observed from the excavations along the service line, or from any of the sanitary sewer or storm sewer manholes in the area. Due to the amount of smoke in the air it would have been difficult to differentiate between the smoke in the air and smoke that may have been coming from any other opening in the drain system that may have provided a migration path for the natural gas.

At 9:30 a.m. the consultant hired by City Utilities to assist in the investigation arrived at the incident site. Upon arrival, he surveyed the incident site looking in the basement of the Frisco Building and the excavations along the natural gas service line. He began his investigation by trying to pinpoint the leak on the natural gas service line. The gas on the service line was turned on and a series of bar holes were made in the asphalt along the service line. These bar holes were made in order to determine the highest percentage of gas readings as obtained with CGI equipment. Following this, a series of pressure tests were conducted on the service line section between Excavations #2 and #4 (See Appendix A-3, Figure3).

Table 2 on the following page describes the pressure tests that were performed during the day. The pressurizing medium was air for each test. By performing these tests, it was concluded that there was no leak between Excavations #3 and #4, but there was a significant leak between

Excavations #2 and #3. This segment was primarily the area of interest for the following day's investigation.

Table 2: Pressure tests on E-Plex service line for June 20, 2003.

EXCAVATION #	LENGTH OF PIPE TESTED (FT)	INITIAL PRESSURE (PSI)	FINAL PRESSURE (PSI)	START TIME	TEST DURATION (MIN)
3-4	97	56	56	1:25 p.m.	10
2-3	72	50	20	6:24 p.m.	11

On Saturday June 21, 2003, the Staff returned to the incident site at approximately 7:40 a.m. Shortly thereafter, City Utilities began cutting out a segment of asphalt west of the service line location between Excavations #2 and #3. As illustrated in Appendix A-3, Figure 3, footage markings were spray painted every two feet along the cut out section of asphalt. Bar holes were made at these marks, and the atmosphere in each bar hole was sampled with a CGI to further pinpoint the leak location between Excavations #2 and #3. While continuing the excavation of this segment of service line, foreign debris, such as, a short broken segment of clay drain tile, a short section of galvanized piping, a piece of 2-inch diameter threaded steel pipe, and large rocks were observed in the trench. Once the approximate depth of the service line was reached, a lateral excavation was made to the east to expose the 2-inch diameter, PE, natural gas service line. This provided the opportunity to see the type of backfill surrounding the pipe (See Appendix B-3, Photograph 5). Some of the backfill in this area included rocks and pieces of asphalt paving. During the time City Utilities' personnel were uncovering the pipe, approximately 56 psig of natural gas pressure was in the main and the valve was slightly opened to establish the sound of the escaping gas in the service line, which was used to determine the leak location.

Upon identifying and exposing the leak source, the Staff observed the plastic service line was laying on a large rock. The pipe in this area was egg-shaped and contorted in an upside down U-shape fashion (See Appendix B-4, Photograph 7). The leak was found on the plastic service line at a depth of approximately 30 inches, at the 24-foot mark (See Appendix A-3, Figure 3) between Excavations #2 and #3. The Staff also observed rocks and pieces of asphalt paving in the immediate vicinity of the leak. Some of the rocks that were removed near the leak location had a white mold matter on their surface (See Appendix B-4, Photograph 8). The Staff's understanding is that the mold may have been anaerobic bacteria, which sometimes occurs in the vicinity of leaking natural gas. The leak was approximately 13 feet north and 48 feet west of the

northwest corner of the Frisco Building (See Appendix A-3, Figure 3). After the leak was located, a section of the service line (approximately 18 feet long) containing the leak was removed. Upon further observation of the removed plastic pipe, a longitudinal crack was identified at the location where the rock was in contact with the pipe wall. The Staff observed sand backfill material around the plastic service line that was exposed in the excavations on either side of the removed 18-foot section of service line (Excavations #2 and #3).

A pressure test was conducted on the portion of pipe from the southern end of the removed section to Excavation #1. The test was conducted at 3:43 p.m. with air at a pressure of approximately 56 psig. The test held at 56 psig and concluded there were no leaks in the section. The Staff left the site at 5:30 p.m.

On Monday, September 23, 2003, two Staff members arrived at the City Utilities' Calhoun Street office at 7:30 a.m. City Utilities conducted a meeting with the Springfield Fire Department and the consultant hired by City Utilities from 8:30 to 10:30 am. While at the Calhoun Street office, the Staff had planned to view the pressure test of the 18-foot section of service line containing the longitudinal crack. However, City Utilities decided during the meeting to have an independent consultant examine and test the removed section of pipe. Subsequently, plans were made then to proceed to the incident site and pressure test the remaining untested portion of service line between the gas main adjacent to West Norton Road and Excavation #1. Both Staff members were at the incident site at 11:00 a.m. to witness the excavation for the pressure test. City Utilities uncovered the service line valve near the 12-inch steel main at approximately 10:30 a.m. The Staff requested that the pressure test be conducted as close to the main as possible, but during the excavation, earth and debris fell on the portion of the service line at the service line tap to the main and the pressure test had to be conducted on the portion of the service line parallel to the main (See Appendix A-3, Figure3). The pressure test began at 1:44 pm at 56 psig for a 17-minute duration. There was no pressure loss during the test indicating no leaks on the natural gas service line between the main and Excavation #1. The Staff left the site at 2:30 p.m.

Other Staff Investigations and Actions

On Wednesday September 17, 2003, three Staff members returned to the incident site to investigate the fill conditions along the 2-inch diameter service line that were not uncovered previously when the Staff was at the incident site in June. The Staff arrived at the Ozark Empire Fairgrounds at approximately 9:00 a.m. on Wednesday, September 17.

An area of interest was the backfill condition around the pipe where a September 6, 2000 leak repair had occurred (See Appendix A-3, Figure 3). The pavement repair in the asphalt from the leak repair was located 234 feet north of the north curb line of West Norton Road. The Staff requested to examine the backfill conditions around the pipe north and south of the previous repair. City Utilities began unearthing the south portion first in an excavation roughly 3 ½ x 5 feet. There was roughly a 3-inch layer of asphalt removed from the excavation followed by 6 to 8 inches of base rock beneath that. Native material consisting of clay and rock was then exposed. The pipe was located and the Staff observed a bedding of gray sand encompassing it. Following this City Utilities began a similar excavation to the north of the previous leak site. Its backfill conditions were almost identical to the first excavation, including the sand bedding surrounding the pipe. The last excavation to be spot-checked was made along the west side of the pavement edge in a grass area just south of Excavation #1 (See Appendix A-3, Figure 3). As was the case with the first two sites, the backfill conditions were similar and there was a bedding of sand around the pipe.

Testing of the Removed Natural Gas Piping

City Utilities chose to use an outside contractor to test the portion of service line that was removed from the Fairgrounds. The information in the section that follows was obtained from their report analysis on the pipe sent to City Utilities.[12]

An approximate 18-foot section of 2-inch IPS SDR 11 Dupont Aldyl® "A" was the test specimen in the lab analysis. The lab determined the pipe was manufactured on April 28, 1970 based on the production lot number of 0428E31 displayed in the pipe's print line. According to City Utilities it was installed in 1971. Various tests were performed on the pipe to determine its condition and the mechanism of failure.

The laboratory plugged both ends of the pipe, pressurized it and sprayed a soap solution over its entire length. Only one leak was found on the specimen approximately two feet from one end. Nondestructive testing performed by the lab determined the specimen dimensions met the ASTM dimensional requirements.

According to the laboratory's report, in the late 1960's and early 1970's the Dupont Company produced a line of polyethylene pipe called Aldyl® "A". A percentage of this pipe was produced with a layer of oxidized material on the pipes inner wall, which compromised the pipes material

[12] Engineering Systems Incorporated. 3851 Exchange Avenue, Aurora, Illinois 605504. "City Utilities of Springfield Gas Pipe Leak Investigation". Client P.O. No.: E6268. ESI File No.: 14670A.

properties. A carbonyl index and bend back test were conducted on the pipe to conclude whether oxidative degradation was a contributing factor in the pipe failure. The results of theses tests concluded oxidative degradation was not a contributing factor in the failure of the pipe.

The laboratory empirically estimated 90% of the pipe specimen's useful life had been consumed due to the conditions of backfill surrounding it. However, this estimation of the pipe's remaining life does not necessarily represent the life span of the other Aldyl® "A" pipe in service by City Utilities.

The laboratory concluded from it's examinations and tests that the pipe ultimately failed due to a "large rock or other hard object upon the wall of the pipe as it was in the ground."

Staff Investigation of Natural Gas Ignition at 3050 North Kentwood, Springfield

Although the event at 3050 North Kentwood was not directly related to the incident that occurred at the Fairgrounds, a discussion about it is included since it involves a failure of Aldyl® "A" pipe due to rock impingement.

At approximately 4:30 p.m. on July 10, 2003, a natural gas ignition occurred in a wall in the ballroom at 3050 North Kentwood (3050 North Kentwood is a motel). The natural gas ignition occurred while a maintenance worker was vacuuming the ballroom carpet. The electric cord to the vacuum cleaner was apparently pulled out of the electrical wall receptacle while the vacuum was running, which caused a spark, igniting accumulated natural gas in the wall. Motel management notified City Utilities about the natural gas ignition on July 11, 2003.

In the afternoon of July 11, 2003, during a telephone conversation between Staff and City Utilities personnel, the Staff was informed of a natural gas leak and ignition at 3050 North Kentwood. This information was considered a courtesy notification since the natural gas ignition was, by MoPSC incident definition, non-reportable.[13] However, the Staff decided to

[13] MoPSC regulation 4 CSR 240-40.020(4)(A), defines a reportable incident as:

1. An event that involves a release of gas involving the operator's actions or facilities, or where there is a suspicion by the operator that the event may involve a release of gas involving the operator's actions or facilities, and involves –
    A. A death
    B. A personal injury involving medical care administered in an emergency room or health care facility, whether inpatient or outpatient, beyond initial treatment and prompt release after evaluation by a health care professional; or
    C. Estimated property damage, including cost of gas lost, to the gas operator or others, or both, of $10,000 or more; or
2. An event that is significant, in the judgment of the operator, even though it did not meet the criteria of paragraph (4)(A)1.

personally visit the site and meet with City Utilities personnel, considering the close proximity of 3050 North Kentwood to the Frisco Building incident and that both incidents involved the same brand and type of plastic pipe.

The Staff met with City Utilities personnel on July 15, 2003, at their 1321 W. Calhoun Street office. While at the Calhoun office, the Staff observed a pipe segment that had been removed from the 3050 North Kentwood leak site, reviewed photographs of the leak site taken by City Utilities personnel on the day of the repair and reviewed maps of the natural gas system at and around 3050 North Kentwood. The Staff observed a longitudinal crack in the pipe specimen. The Staff, along with City Utilities' personnel, then traveled to the 3050 North Kentwood. The Staff observed the site where the leak was found and the construction area where the service line to 3050 North Kentwood was renewed on July 11, 2003. At the time of Staff's investigation, the new service line installation for 3050 North Kentwood had been completed, backfilled, and the area was restored to its original condition. The Staff then proceeded into the ballroom area of 3050 North Kentwood and observed where a plate for an electrical box had been blown out of the wall by the force of the natural gas ignition. The Staff also went into the mechanical room of the building where several leaks had been found on the customer's natural gas fuel lines. During Staff's investigation a plumber was working on the customer's natural gas fuel lines and connected equipment. The following text was prepared from Staff's investigation and information obtained from City Utilities.

City Utilities was notified of a gas leak in the building at 3050 North Kentwood at approximately 10:10 a.m. on July 11, 2003. Upon arrival at the site, at approximately 10:30 a.m., City Utilities began a leak investigation. Responding City Utilities' crews also became aware of the gas ignition that had occurred in the building on July 10, 2003. 100% gas-in-air readings were obtained in the sewer manhole located approximately 20 feet west of the building; readings of 100% gas-in air were also obtained over the service line approximately 80 feet west of the building, 85% and 86% gas-in-air readings were found underground at the meter riser, which was located adjacent to the building's west wall. In addition, high gas readings were found in the building. City Utilities' crews shut off the natural gas service line to 3050 North Kentwood at approximately 11:35 p.m. on July 11, 2003.

During City Utilities' leak investigation, it was determined that there was a leak on the 2-inch, diameter Aldyl® "A" plastic natural gas service line to 3050 North Kentwood. They decided to replace the service line that same day. Gas leaks were also discovered on the customer's inside fuel lines. The owner of the building at 3050 North Kentwood was notified of these leaks who

in-turn notified a plumber to pressure test the inside fuel lines. One of these fuel lines failed a pressure test.

When the 2-inch, diameter plastic service line was exposed at the leak site, it was determined that the piping exhibited a crack along its top longitudinal axis. This crack was caused by a large rock in contact (rock impingement) with the top surface of the pipe (See Appendix B-6, Photograph 12). A contractor working for City Utilities had installed this service line on September 20, 1977. On October 22, 1998, City Utilities repaired a leak on this same service line. City Utilities' repair records indicated that the leak cause was "aged/worn component". City Utilities' personnel have suggested that the term "aged/worn component" could refer to a variety of material failures including "rock impingement". During this leak repair, City Utilities' crews abandoned 133 feet of the plastic service line containing the leak and installed new plastic piping, routing it around an asphalt parking lot. This new line was tied into the existing 2-inch diameter Aldyl® "A" service line serving 3050 North Kentwood. It was on this segment of service line that was not replaced that the July 11, 2003, leak occurred. No leak call was reported to City Utilities prior to July 11, 2003 at 3050 North Kentwood.

ANALYSIS

Structural Damage

As noted in the Commission Staff Investigation section of this report, debris of the Frisco Building was strewn a great distance from the force of the blast. The debris was located mainly to the west of the Frisco Building.

The ignition most likely occurred when the mixture of gas and air was near the point where complete combustion of fuel occurred very quickly. This mixture produces the most efficient combustion and subsequently the highest explosion velocities, pressure gradients and consequently the most damage. Post-explosion fires are rare because the majority of fuel available is consumed in the explosion. The explosive range of natural gas is between 4.5% to 14.5% gas-in-air by volume. An optimum mixture of natural gas and air (approximately 10% gas-in-air) would, when ignited, produce a violent explosion splintering wood members and hurling debris great distances over a large area. These types of explosions cause walls, roofs, and structural members to splinter, shatter, or be completely demolished producing high order damage.[14] The majority of the debris consisted of pieces and was scattered over a large area, support the conclusion the explosion occurred near the optimum mixture of natural gas.

In addition, this type of explosion produces gases that expand rapidly and move outward from the point of origin at a high velocity (blast pressure wave), which is responsible for most of the damage associated with explosions. The Staff believes the damage to the other structures in the area were the direct result of the blast pressure wave.

Damage to Plastic Natural Gas Service Line

The damage to the 2-inch diameter plastic pipe resulted from the effects of improper backfill surrounding the pipe that allowed rocks to come in direct contact with the pipe wall. The rock impingement, over time, induced a high-localized stress on the bottom of the pipe and the external loading from the asphalt surface and vehicular traffic above also produced bending stresses that, in combination, ultimately exceeded the plastic pipe's long-term elastic strength.

[14]The National Fire Protection Association (NFPA) 921 Guide describes high order explosion as "a high rate of pressure rise or high force explosion characterized by small, pulverized pieces of debris thrown great distances."

The combination of these conditions ultimately produced a premature brittle-like crack failure in the wall of the plastic pipe.

Backfill Conditions Surrounding The Failed Plastic Pipe

When the leaking section of pipe was exposed, the Staff observed a majority of the backfill surrounding the removed service line (18-foot section) was composed primarily of rocks and construction debris (i.e. chunks of asphalt) with a base material of red clay. Other locations in the same vicinity had asphalt or rocks lying against the pipe, both above and below it. However, sand backfill was observed around the plastic pipe at both Excavations #2 and #3 (See Appendix A-3, Figure 3). Sand material is commonly used to backfill around plastic pipe during installation to protect the pipe from environmental conditions, such as rocks and other material that may damage the pipe.

In the **Testing of the Removed Natural Gas Piping** section of this report, the laboratory analysis performed on the removed 18-foot section of pipe indicated an estimated 90% of its useful life had been used due to the fill conditions surrounding it. However, no evidence of oxidative degradation on the test specimen's inner surface, which if present would have made it more susceptible to failure from rock impingement. The Laboratory's ultimate conclusion was the pipe failed due to a "large rock or other hard object upon the wall of the pipe as it was in the ground", which is consistent with the Staff's analysis of the failure.

When the Staff returned to the incident site on September 17, 2003 the main objective was to observe the backfill conditions along certain remaining portions of the service line, which could indicate the original backfill conditions. The Staff observed three separate locations of trench containing portions of the remaining abandoned service line. All three locations contained sand in the vicinity of the pipe, which encompassed it in a radius of approximately 3 to 4 inches protecting the pipe from damage due to rock impingement.

During the incident investigation, the Staff was unable to determine how the improper backfill material was placed in the natural gas service line trench, when it was placed there, or who put it there.

Natural Gas Escape and Migration

As noted in the **Staff Investigation** portion of the Report, while uncovering the service line at the leak location, the Staff observed rocks and debris that had a white mold matter on their surface in close proximity to the leak. The Staff believes the mold was an anaerobic bacterium that lives in an oxygen-deprived environment, such as an environment where the oxygen was displaced by escaping natural gas. The growth of the anaerobic bacterium indicated the leak on the pipe had existed for a period of time.

Once the 2-inch diameter PE natural gas service line adjacent to the Frisco Building failed, the longitudinal crack would have released natural gas at a pressure of approximately 56 psig (estimated operating pressure by City Utilities). Natural gas escaping from an underground pipe will tend to migrate along paths of least resistance through the soil and since natural gas is lighter than air (natural gas has a specific gravity of 0.6 while air has a specific gravity of 1.0), it will tend to migrate upward, to the atmosphere where possible. However, the asphalt parking lot covering the service line would have limited the upward migration of the natural gas into the atmosphere.

With the upward migration of the natural gas restricted, the natural gas would migrate laterally through the soil. Natural gas emanating from the cracked service line apparently migrated towards the Frisco Building, as indicated by the gas-in-air readings obtained in bar holes just west of and northwest of the Frisco Building. The landscape gradually slopes uphill between the service line and the Frisco Building.

Natural Gas Entrance, Accumulation and Ignition

While the exact entrance is unknown, the Staff believes that the natural gas most likely entered the Frisco Building through the floor drain located in the northwest corner of the basement, as indicated by the 50% gas-in-air reading obtained inside the drain in the morning of Thursday, June 19, 2003. It was not determined how or where the natural gas entered into the drain. Negative gas-in-air readings obtained in bar holes drilled in the basement floor indicate the natural gas had not migrated under the basement floor. In addition, no gas-in-air readings were obtained in bar holes located in several locations at the juncture of the basement floor with the basement walls, indicating that the natural gas probably did not enter the Frisco Building in this manner.

Natural gas entering the structure of the Frisco Building would have accumulated to an explosive mixture and could have been ignited by several different means, such as an arc from the operation of an electrical switch, static electricity, or a lighter. According to reports from coworkers, the Fairground maintenance employee who was in the building at the time of the explosion was a smoker. The Springfield Fire Department informed the Staff on Thursday afternoon (June 19, 2003) that a disposable lighter was found near the body.

City Utilities' Plastic Piping System

As summarized in the **Susceptibility of Older Plastic Pipe To Premature Brittle-like Cracking** section of this report, there have been several advisory bulletins issued regarding the susceptibility of certain older plastic pipe to brittle-like cracking, including low-ductile inner wall Aldyl® "A" piping manufactured before 1973. These advisories also indicate that brittle-like cracking can be caused by high-localized stress intensification that may be the result of, among other things, improper installation and dents and gouges. In addition, other factors that can lead to premature brittle-like cracking are the pipe's environment and service conditions, including inadequate support and backfill during installation and rock impingement.

Because of concerns regarding brittle-like cracking of older plastic pipe, on May 14, 1997, the Staff mailed a questionnaire survey concerning older plastic pipe to all operators in Missouri. One of the advisory bulletins in 1999 recommended that all operators review their systems to determine the susceptibility of pre-1982 plastic piping to failures and to take the appropriate remedial action, including replacement. City Utilities' responses to Staff's questionnaire and the advisory bulletin were discussed in detail in the **City Utilities' Experience With Plastic Natural Gas Mains and Replacements** section of this report. However, based upon their review, City Utilities identified certain main segments to be leak surveyed on an annual basis and segments scheduled for replacement. City Utilities' review did not include plastic natural gas service lines.

The failure mechanism of the plastic service line near the Frisco Building and the service line to 3050 North Kentwood was a crack at a localized stress area that was induced by rock impingement. In both cases, a portion of the service line near the Frisco Building and to 3050 North Kentwood had previously been replaced. City Utilities' records indicated that both replacements were due to a crack that was induced by rock impingement. In both instances, a portion of the plastic service line containing the leak was replaced, so the remaining segment of plastic service line may still have been exposed to areas of rock impingement. With a portion of the plastic service line already leaking because of rock impingement, it would seem likely that

rock impingement could occur at some point on the remaining portion of any plastic service line or main.

This incident and the natural gas ignition that occurred at 3050 North Kentwood, Springfield, Missouri on July 10, 2003, both involved brittle-like cracking of Aldyl® "A" plastic pipe. Both failures were the result of high localized stress concentration on the pipe wall due to rock impingement. In addition, records provided by City Utilities indicate other instances of brittle-like cracking failures on plastic pipe due to rock impingement. These records include failures on pre-1983 pipe installations and post-1983 pipe installations. The investigation of this incident and the natural gas ignition at 3050 North Kentwood, as well as, the records of other plastic pipe failures due to rock impingement, indicate to the Staff that an evaluation of City Utilities plastic main and service line piping failures should be conducted. Any evaluation or examination should consider and contain, at a minimum; (1) the identification of plastic mains and service lines that may be susceptible to brittle-like cracking because of rock impingement; (2) the criteria that would be used to identify plastic mains and service lines as potential risks for brittle-like failure due to rock impingement (such as installation, operating and environmental conditions, and piping failure characteristics); (3) an increase, expansion, and evaluation of the effectiveness of leak surveys over the identified plastic mains and service lines (such as making bar holes over piping under continuous pavement, etc.); (4) replacement of plastic mains and service lines that have been identified as needing remedial action; (5) complete replacement of identified plastic service lines (main to meter), in lieu of partial replacements when leaks are found, that have been identified as needing remedial action, or when exposed for other reasons.

The Staff believes that addressing these issues involves a broad examination and evaluation of City Utilities' plastic piping system and the method of leak surveys over this system. This examination and evaluation would consider information beyond the scope of this single incident report. Therefore, the Staff believes an expanded investigation of the plastic piping failures, leak survey methods, and replacements warrant the creation of a specific case for that purpose. Staff Recommendation number 4 recommends the establishment of a separate case to conduct the examination, analyze the data, examine installation and backfill procedures, and evaluate the consideration for a replacement program for certain plastic mains and service lines. The Staff would file a report detailing its findings, and make recommendations, as appropriate. The investigation will involve examination and analysis of over 25 years of records, including hundreds of leak reports and leak repair records.

CONCLUSIONS

1. At approximately 11:47 a.m. CDST, Wednesday, June 18, 2003 an explosion involving natural gas occurred at the Frisco Building within the Ozark Empire Fairgrounds at 1001 West Norton Road in Springfield, Missouri.

2. One fatality resulted from the explosion. An Ozark Empire Fairgrounds maintenance employee was in the basement of the Frisco Building and died from injuries caused by the explosion. There were no other reported injuries.

3. The Frisco Building was destroyed and the explosion damaged numerous other fairground buildings.

4. The probable cause of the incident was the ignition of natural gas that had accumulated in the basement of the Frisco Building. The natural gas originated from a crack in a 2-inch diameter plastic service line located approximately 48 feet west of the Frisco Building. The leaking natural gas migrated by an undetermined route (or routes) into the basement of the Frisco Building. The probable source of ignition was not determined, but could have been one of several electrical sources available within the structure or a disposable lighter.

5. The crack in the 2-inch diameter plastic natural gas service line was determined to have resulted from localized stresses induced on the pipe wall by a rock in contact with the bottom of the pipe. Over time, the rock's contact with the pipe created a stress in the pipe wall that caused the pipe to fail.

6. A laboratory report on the examination and testing of the cracked area of the plastic service line stated that the leak in the service line occurred due to rock impingement. The material surrounding the service line in the area of the crack consisted of rock and pieces of asphalt pavement.

7. The same 2-inch diameter plastic service line had previously been repaired on September 6, 2000, due to rock impingement. A short section containing the leaking portion of the service line was replaced during this repair. It was on the remaining portion of service line where the leak occurred that caused the incident at the Frisco Building on June 18, 2003.

8. There have been three advisory bulletins issued on the susceptibility of certain older plastic piping to brittle-like cracking. The advisory bulletins indicate that brittle-like cracking can be caused by high localized stress intensification that, among other things, may be the result of improper installation and dents and gouges. Other factors contributing to brittle-like cracking of plastic pipe include inadequate support and backfill during installation and rock impingement.

9. City Utilities had previously developed a program to leak survey, identify belowground main leaks on plastic pipe and replace certain plastic natural gas mains. Under the program's criteria, main segments experiencing an above normal leak rate were identified, monitored and systematically replaced. City Utilities also concluded that installation practices and environmental conditions need to be taken into account when analyzing plastic main failures. However, the program only addressed plastic natural gas mains and failures on natural gas service lines may not have been monitored.

10. Through the course of Staff's investigation of the incident, no determination was made regarding who was responsible for the improper backfill material surrounding the plastic service line in the vicinity of the leak location. Other locations along the service line observed by Staff were properly bedded in sand. Additionally, it was not determined when the improper backfill material was used.

11. The Staff's investigation did not reveal any violations of Missouri Public Service Commission pipeline safety regulations that caused or contributed to the incident.

RECOMMENDATIONS

1. The Staff recommends that all underground leaks attributed to rock impingement on plastic service lines should result in replacement of the service line main-to-meter, regardless of the underground leak's location on the service line.

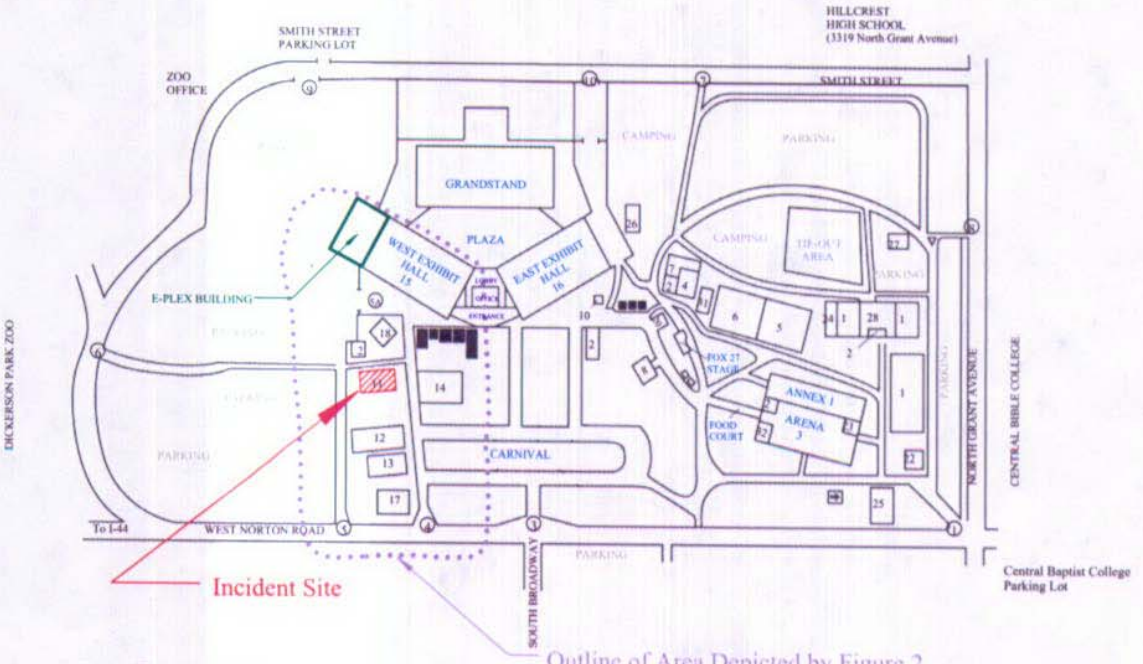
2. The Staff recommends that all underground leaks attributed to rock impingement on plastic mains should be replaced for the entire length of main that may be in an environment conducive to causing stress cracking.

3. The Staff recommends that City Utilities file a response to these recommendations in Case No. GS-2004-0040 within 30 days after the filing of this report for review by the Commission. Also, the Staff recommends that this case remain open for a period of at least 30 days following the filing date to receive City Utilities' response and any other comments.

4. The Staff recommends, based upon the analysis and investigation pertaining to the failure mechanism on the service lines near the Frisco Building and for 3050 North Kentwood, that the Office of General Counsel file a request to establish a separate case for the purpose of examining and evaluating City Utilities' plastic pipe failures, leak survey techniques, installation and backfill procedures, replacement criteria, and adequacy of their program activities. Staff would file a report detailing its findings, determine if changes are necessary, and make appropriate recommendations.

APPENDIX A
(Figures)

(Highway map provided by MapQuest)



Outline of Area Depicted by Figure 2

- (1) Public - Auto
- (3) Public - Pedestrian
- (4) Emergency - Service
- (5) Public - Auto
- (5a) Public - Pedestrian
- (6) Exit
- (7) Public - Auto/Service/Livestock
- (8) Exit
- (9) Exit
- (10) Service
- Buildings (Fair Use)
- Building Involved in Natural Gas Incident

1. Livestock
2. Rest Rooms
3. Arena
4. 4-H Building
5. Livestock
6. Dairy Goats/Swine/Sheep
7. Birthing Center
8. Guest Services
10. My Country Star Stage
11. Frisco Building/Museum
12. Mo. Dept. of Conservation
13. O'Reilly's Automania
14. First Aid
15. Commercial Exhibits
16. Competitive Exhibits
17. KTTS Country Theater
18. KWTO Stage
20. Police Dept.
22. KTTS Milking Parlor
23. Livestock Office
24. MFA Feed Barn
25. FFA Building
26. Maintenance Center
27. Brush Arbor
28. Wells Arena
31. Lester Building (Poultry/Rabbits)
32. Balanced Care Hospitality House

(Fairgrounds map obtained from http://www.ozarkempirefair.com/)

Figure 1
Overall View of the Ozark Empire Fairgrounds
Appendix A-1

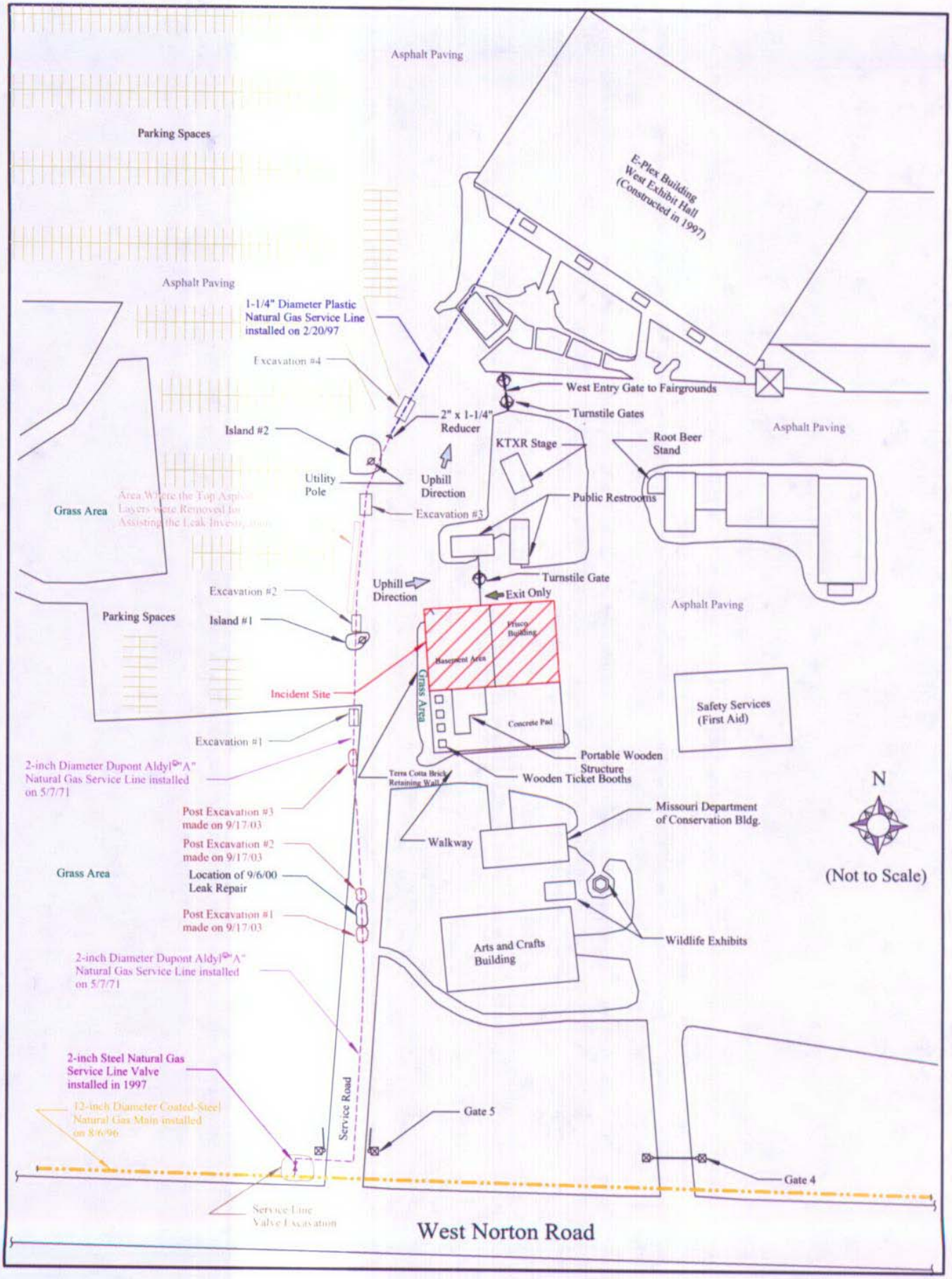


Figure 2
Plan View of 1001 W. Norton Road-Frisco Building Incident Location
Appendix A-2

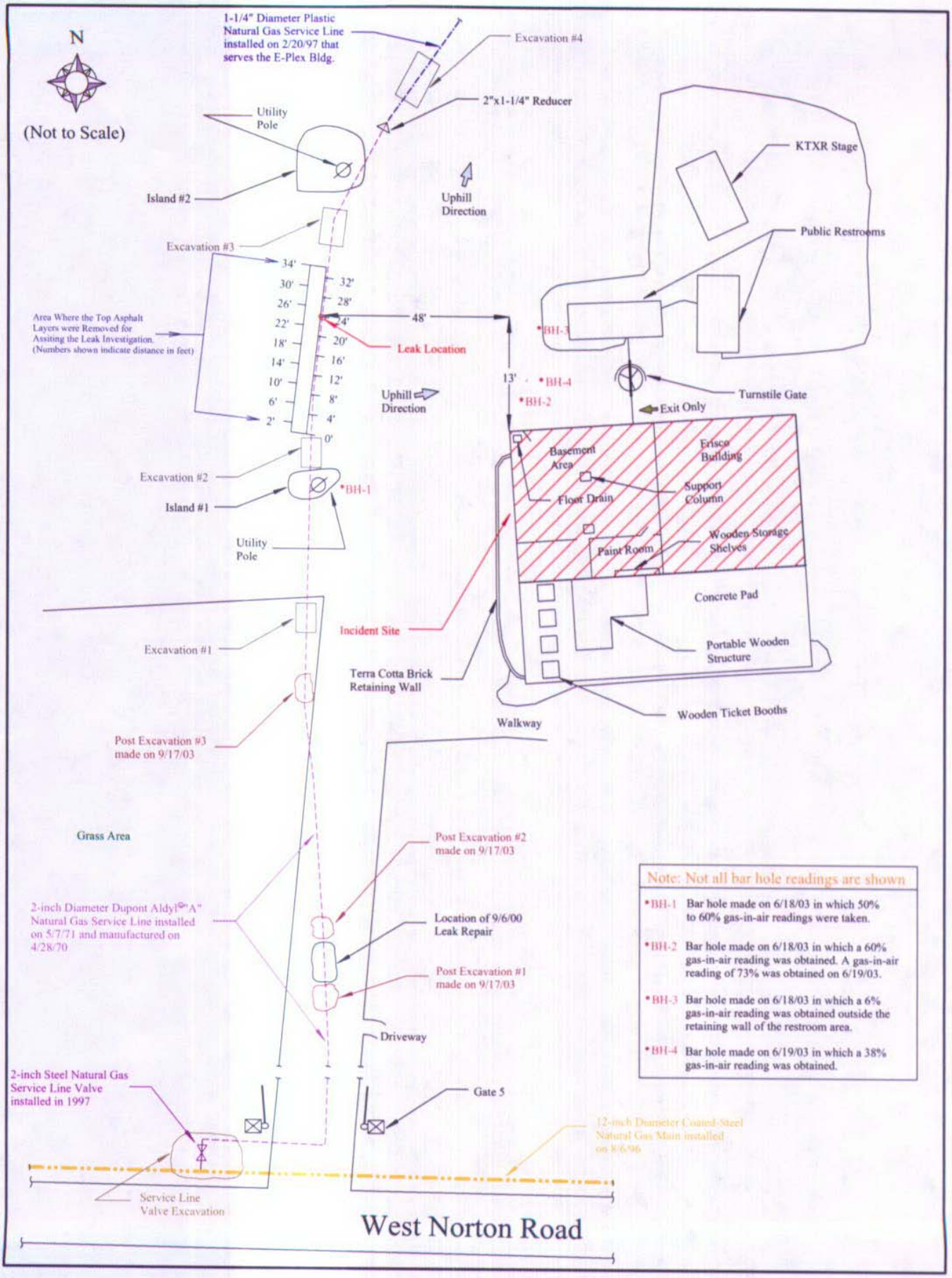


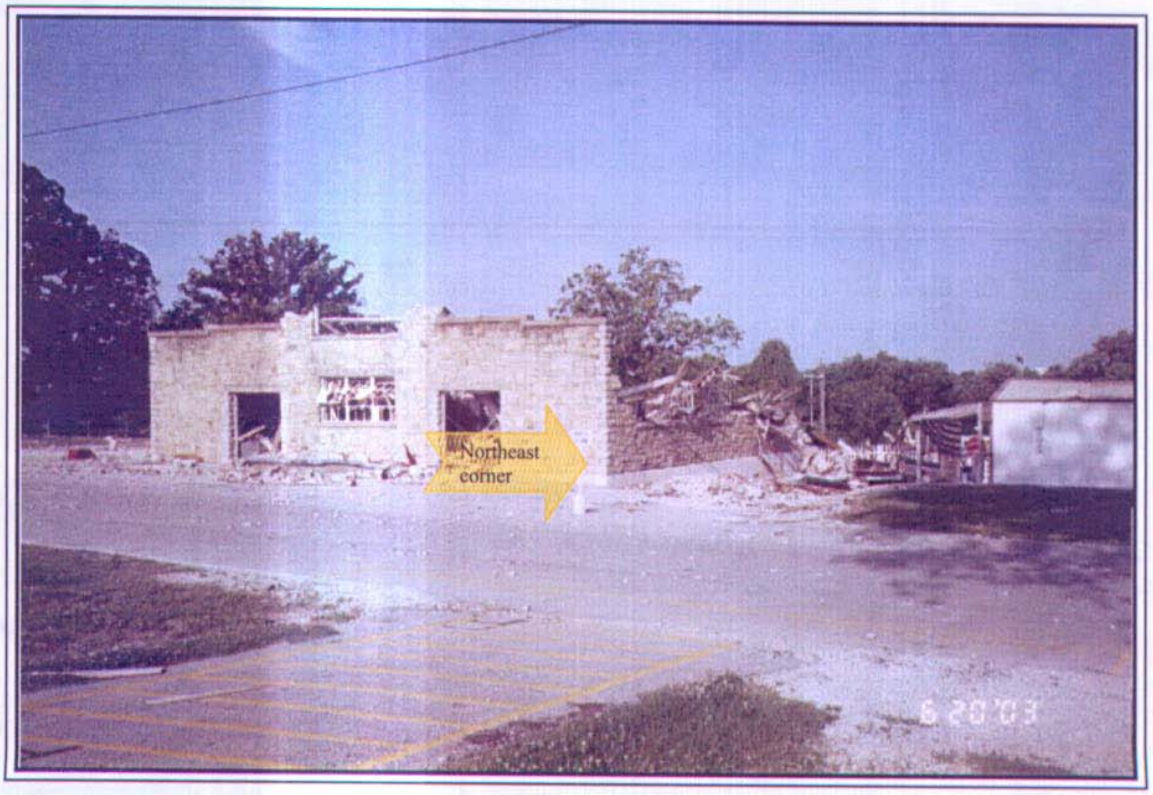
Figure 3
Detail View of 1001 W. Norton Road-Frisco Building Incident Location
Appendix A-3

APPENDIX B
(Photographs)

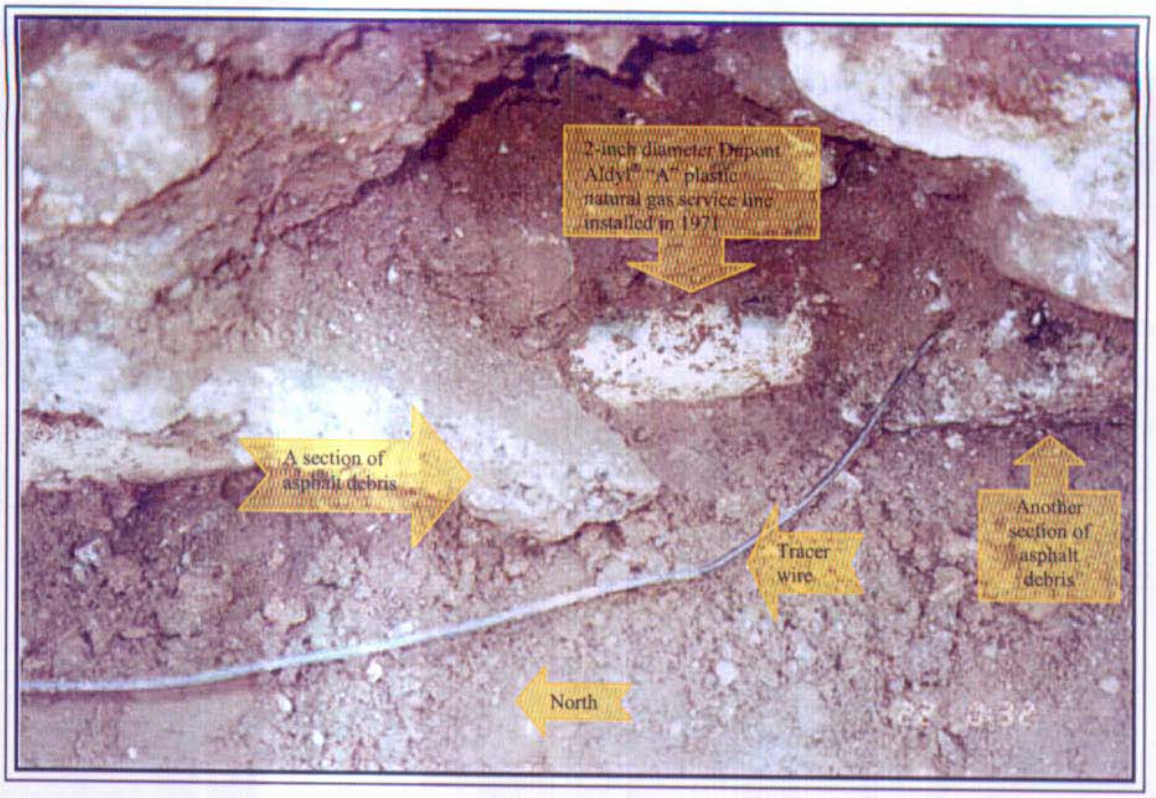
Photograph 1 View looking approximately east towards the northwest corner of the destroyed Frisco Building within the Ozark Empire Fairgrounds. Excluding the basement walls, only a portion of the north and east walls on the main level remain. This photograph was taken a short time after the incident. (Photograph was provided by City Utilities of Springfield)

Photograph 2 Looking at a portion of the remaining contents of the basement area of the Frisco Building. Observe various pieces of wood that were believed to have been part of a lattice structure suspended from the ceiling in the basement area, that received minor burn damage. This was the only evidence of burning that was observed within the Frisco Building.

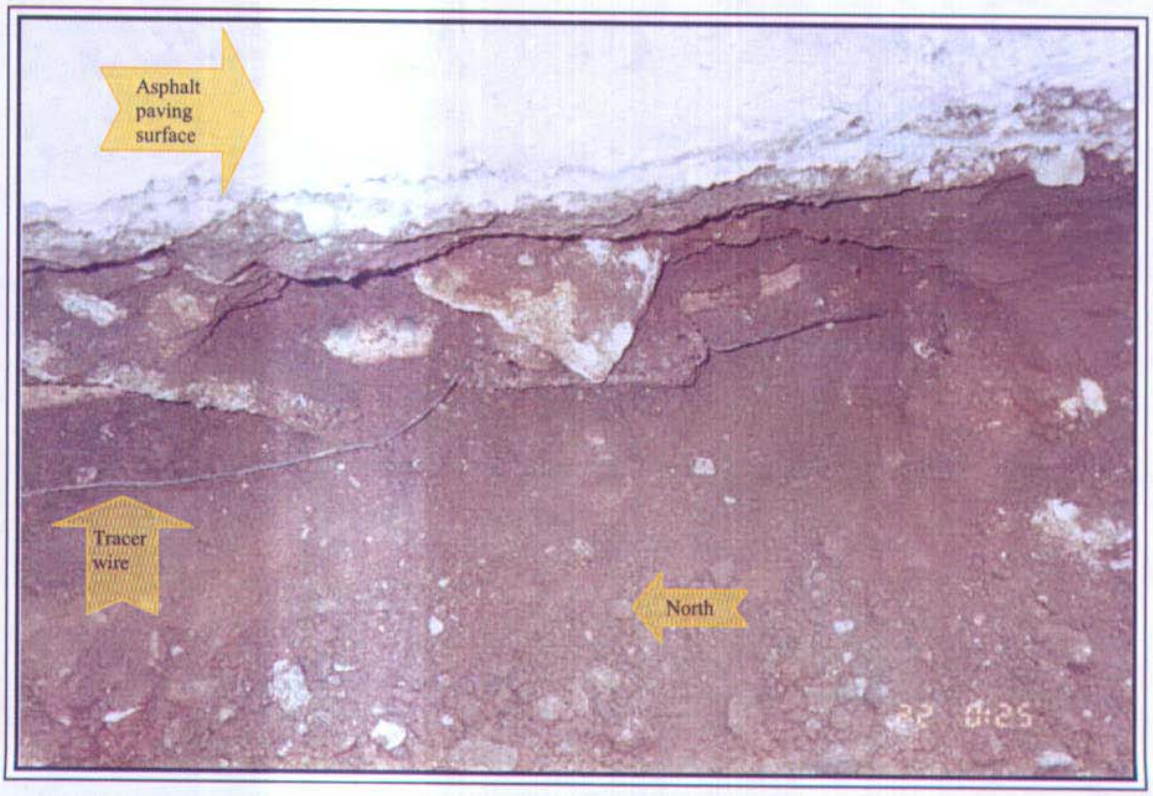
Photograph 3 View looking approximately east at the east interior wall of the basement area within the Frisco Building. The east interior wall was severely damaged and was leaning to the inside of the structure. The majority of the north basement wall was also destroyed. Several sections of the east basement wall were dislodged from the structure. Note the two support columns that remained. This photograph was taken after most of the debris had been removed from the basement area.



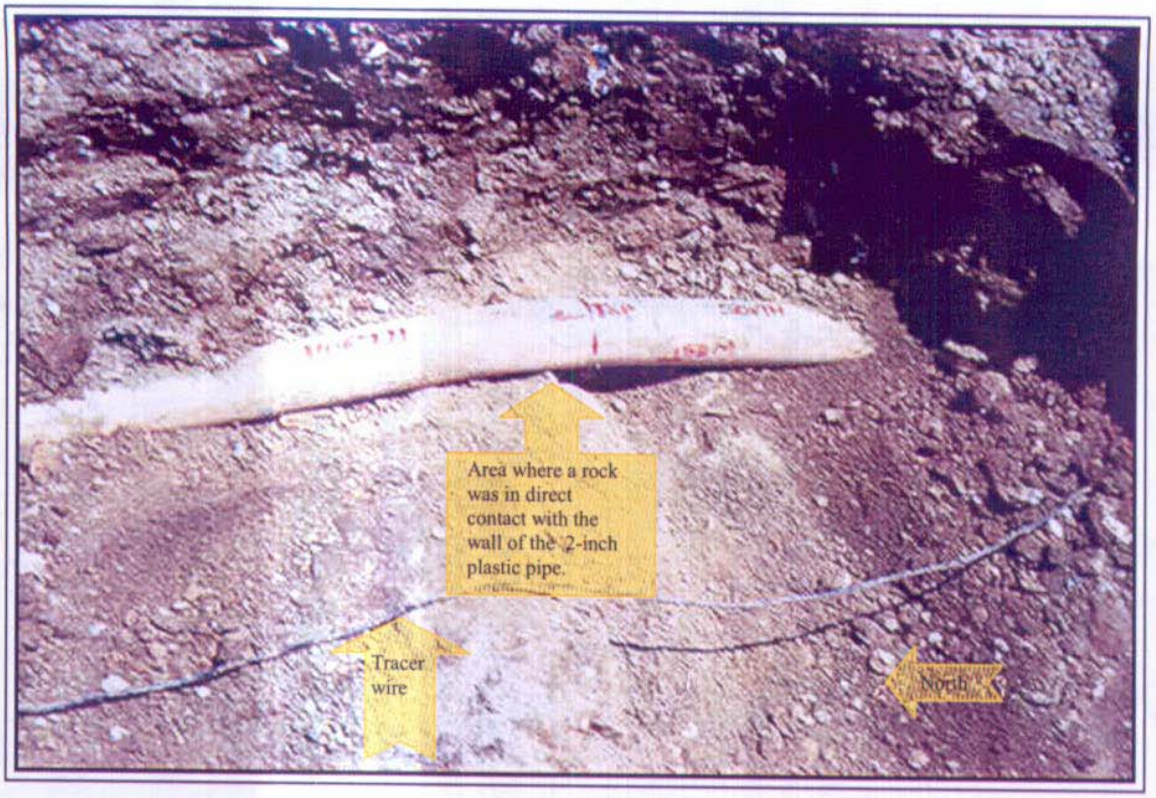
Photograph 4 View looking towards the northeast corner of the Frisco Building. Excluding the upper portion of the roof structure, most of the vertical section of the east wall remained intact. Excluding glass breakage, most of the debris field was displaced in a west to northwest direction as far away as 400 feet.



Photograph 5 A view of an excavation that was made along the west side of the 2-inch diameter plastic natural gas service line. Observe the various layers of asphalt and rock that were surrounding the pipe wall in this area. The black wire in the foreground is a tracer wire that is typically used to assist with locating underground facilities that are non-metallic. No proper bedding material was observed in this area to protect the wall of the plastic pipe.

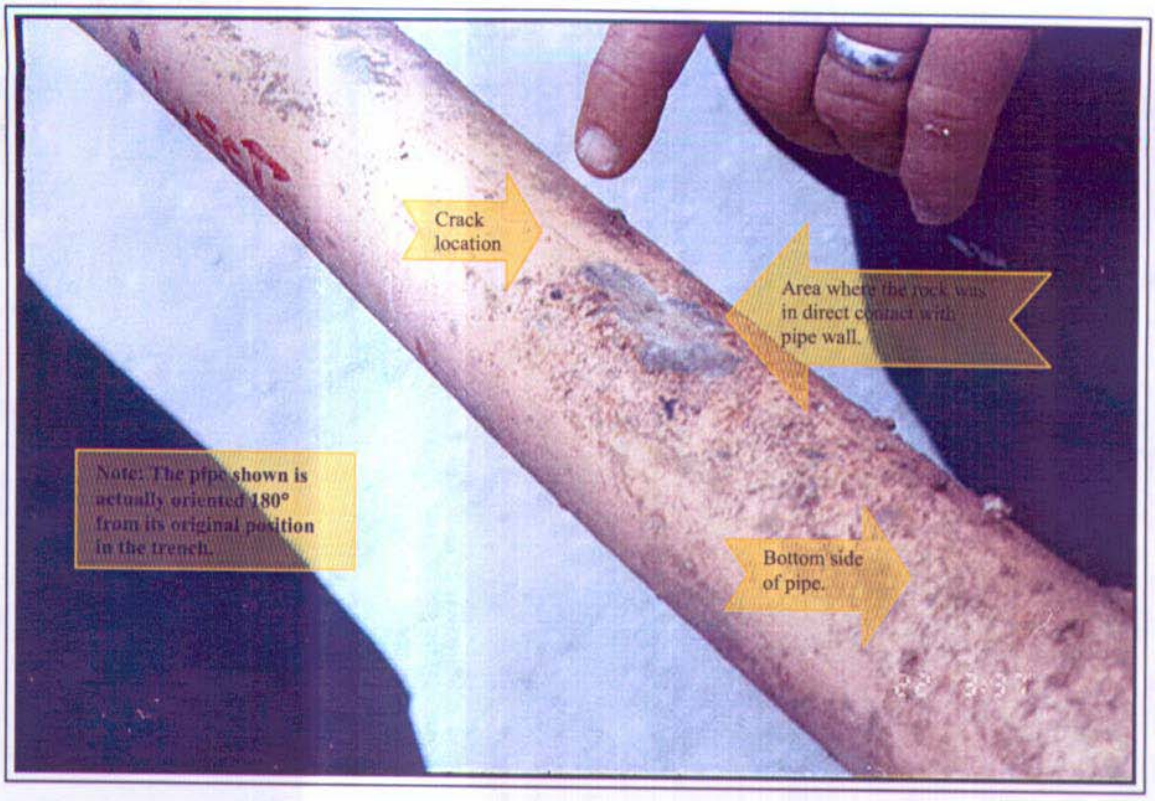


Photograph 6 Another view looking down into the same excavation that was made along the west side of the plastic pipe. The depth of the pipe installation in this area was approximately 30 inches.



Photograph 7 Looking towards the east wall of the excavation that was made to uncover the leaking section of 2-inch plastic piping. Observe how the pipe has an upside down u-shaped appearance and also notice the portion of rock that is in direct contact with the plastic pipe. The plastic pipe also had an egg-shaped or oblong appearance over the circumference of the pipe both north and south of the rock location until the sun had heated the pipe back to its original circular shape.

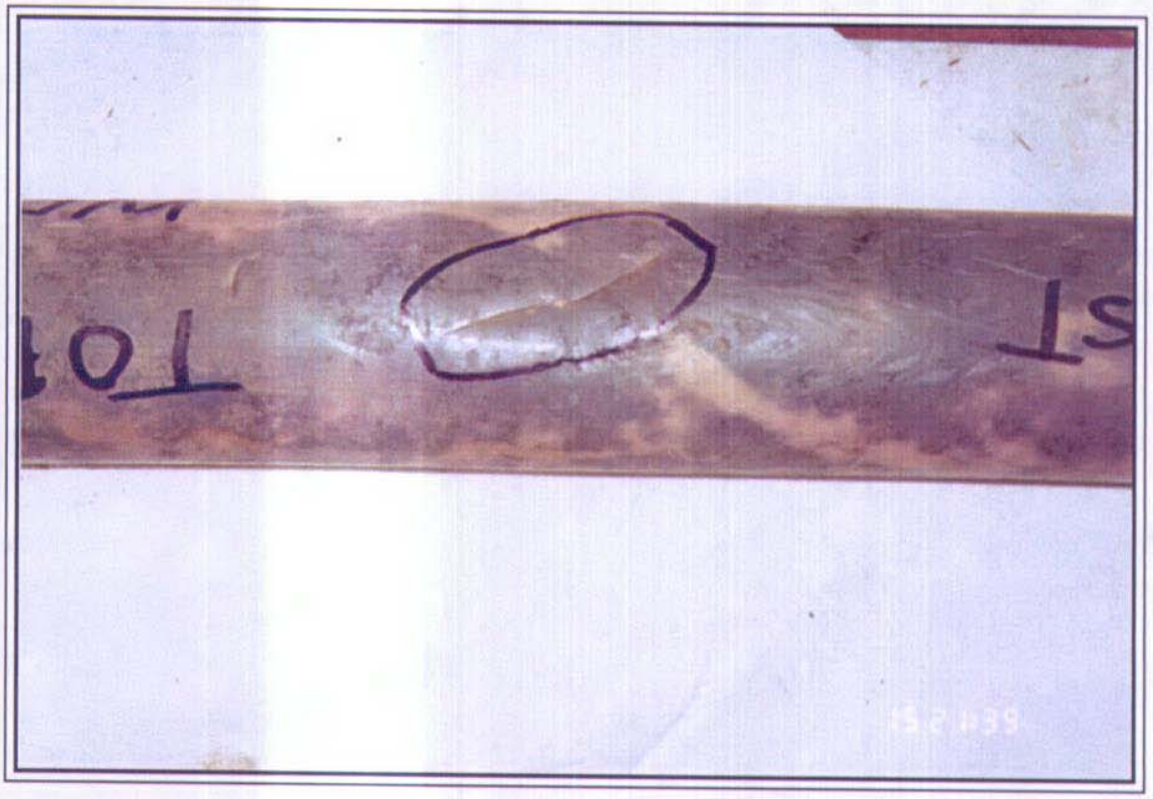
Photograph 8 View of a rock that was removed in close proximity to the leaking section of 2-inch diameter plastic natural gas service line. Note the white residue on the rock.



Photograph 9
View of the removed section of 2-inch Dupont Aldyl® "A" plastic service line piping that contained the leak location. Observe the crack that was along the longitudinal axis of the plastic pipe. The crack was located on the bottom of the pipe where a rock that was in direct contact with the pipe wall. This leak was found approximately 13 feet north and 48 feet west of the NW corner of the Frisco Building.

Photograph 10 View looking at the floor drain in the northwest corner of the basement area after debris removal. This particular view is looking south along the west wall. A sustained reading of 50% gas-in-air was obtained in the floor drain on June 19, 2003 after the incident. Samples of air drawn from this floor drain tested positive for natural gas.

Photograph 11 Looking at the exposed section of 2-inch Dupont Aldyl® "A" natural gas service line piping that served the motel at 3050 North Kentwood. Observe the large rock that is directly contacting the top portion of the plastic pipe wall. The backfill material used was native soil that contained rocks and no bedding material (e.g.-AG limestone, sand, or mine screenings) was placed around the pipe for protection from rock impingement.



Photograph 12 Close-up view of the section of 2-inch diameter plastic piping that was removed from 3050 North Kentwood. The plastic piping contains a crack location where a large rock (as seen in Photograph 11) was in direct contact with the top portion of the plastic pipe wall. The orientation of the plastic pipe in this photograph is similar to the position observed within the trench in Photograph 11.