Missouri Public Service Commission

Gas Incident Report

Missouri Gas Energy
Case No. GS-2008-0002

Filed on December 14, 2007

Kansas City, Missouri
May 25, 2007

Energy Department ... Utility Operations Division
December 2007… Jefferson City, Missouri

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Missouri Gas Energy Company concerning a Natural Gas Incident near the intersection of East 72nd Street and Brooklyn Avenue in Kansas City, Missouri.	)))	GS-2008-0002

AFFIDAVIT OF GREGORY A. WILLIAMS

STATE OF MISSOURI)
)ss
COUNTY OF COLE

Gregory A. Williams, employee of the Staff of the Missouri Public Service Commission, being of lawful age and after being duly sworn, states that he has participated in the preparation of the accompanying Gas Incident Report, and that the facts therein are true and correct to the best of his knowledge and belief.

Gregory A. Williams
GREGORY A. WILLIAMS

Subscribed and affirmed before me this 14th day of December, 2007. I am commissioned as a notary public within the County of Callaway, State of Missouri, and my commission expires on 9-21-10.

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

SUSAN L. SUNDERMEYER
My Commission Expires
September 21, 2010
Callaway County
Commission #06942086

Susan L. Sundermeyer
NOTARY PUBLIC

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SYNOPSIS

Missouri Gas Energy (MGE), a Division of Southern Union Company, provides natural gas service in Kansas City, Missouri. On Friday, May 25, 2007, at approximately 6:30 p.m., Central Daylight Saving Time a section of 24-inch diameter (all cast iron pipe sizes discussed in this report are the nominal pipe sizes) cast iron natural gas main ruptured near the northeast corner of the intersection of East 72nd Street and Brooklyn Avenue in Kansas City, Missouri. The cast iron main rupture occurred while Missouri Gas Energy (MGE or Company) employees were excavating above a section of the cast iron main to locate and repair a gas leak. As a result of the flying debris from the rupture, four MGE employees were injured, two of which were hospitalized. No ignition, flash fire, or explosion, occurred as a result of this natural gas incident. There were no fatalities.

The incident occurred on a section of 24-inch diameter cast iron natural gas main that was installed during May of 1948, which prior to the rupture, was operating at 53.25 pounds per square inch gauge (psig). The Missouri Public Service Commission's Energy Department - Gas Safety/Engineering Staff (Staff) has determined that the primary contributing factor and probable cause of the incident was graphitic corrosion that, over a long period of time, reduced both the wall thickness and ductile strength of the large diameter cast iron (CI) main. As a result, numerous fracture surfaces developed within the CI piping until natural gas began to escape and migrate through the soil and vented to the atmosphere via both street pavement cracks and a storm sewer catch basin located to the west. Once the compacted soil and overburden around the top of the CI main was disturbed and removed, when MGE was attempting to locate and repair a gas leak, the forces produced by the internal gas pressure caused the CI main to rupture violently and certain sections of CI piping were heaved into the air.

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.

As a result of Staff's investigation, this Report contains three (3) recommendations to MGE.

CONCLUSIONS

1. At approximately 6:30 p.m., CDST, Friday, May 25, 2007, a section of 24-inch diameter cast iron main ruptured near the northeast corner of the intersection of East 72nd Street and Brooklyn Avenue in Kansas City, Missouri.

2. As a result of the 24-inch diameter cast iron main rupture, several cast iron pipe fragments, soil debris, gravel, and asphalt were heaved out of the ground and into the air.

3. No ignition, flash fire, or explosion, occurred as a result of the 24-inch diameter cast iron main rupture. Natural gas was released from both the ruptured section of cast iron piping that remained in the ground, as well as, from a severed 2-inch diameter plastic main.

4. Four MGE employees were injured from flying debris as a direct result of the 24-inch diameter cast iron main rupture while they were attempting to locate and repair a gas leak. Two of the four MGE employees were hospitalized, while the other two were treated and released later during the evening of May 25, 2007. One of the hospitalized employees was released on May 27, while the other was released on May 30. The injuries varied, but included facial and head injuries, nose and sinus fractures, a chest puncture wound, hand and wrist fractures, an eye laceration, a broken collar bone, a back/shoulder blade contusion, and numerous scrapes and abrasions to arms and facial areas.

5. MGE personnel who were attempting to expose a section of the 24-inch diameter cast iron main were wearing personal protective gear including helmets with face shields, and fire retardant clothing.

6. The "primary contributing factor" and probable cause of the incident was graphitic corrosion which, over time, greatly reduced both the wall thickness of the 24-inch diameter cast iron pipe and the ductile strength in numerous locations. At least one location of the ruptured cast iron pipe segments had severe graphitic corrosion where it appeared that the corrosion had completely consumed an oblong shaped section of cast iron causing a gas leak.

7. Other "secondary contributing factors" that increased the likelihood of having a CI main rupture may have included one or more of the following: the removal of surrounding soil from the top portion of the cast iron main (the weight of the "undisturbed and compacted soil" directly above the cast iron pipe produced a downward compressive force/loading that appeared to have prevented the cast iron pipe from rupturing while the leak(s) caused by graphitic corrosion and fracture surfaces existed), and the gas pressure within the CI piping would have produced forces that acted upon the inside wall of the cast iron (these forces eventually exceeded the yield point of the CI pipe and created fracture surfaces).

8. The actual number of underground gas leak locations created by the numerous fracture surfaces within the CI main (prior to the rupture) was not determined, but it is likely that multiple leak locations existed over time as the gas migrated through the soil towards the storm sewer catch basin and eventually vented to the atmosphere and was detected by the public.

9. The exact cause of the graphitic corrosion was not determined, but it is likely that road salts used during the de-icing of streets may have contributed to this type of corrosion.

10. The Staff's investigation did not reveal any violations of Missouri Public Service Commission's regulations by MGE that could have contributed to the incident.

RECOMMENDATIONS

1. In response to this incident, the Company has proposed and already begun implementation of numerous proactive measures and procedures that include the accelerated replacement of certain cast iron natural gas mains. MGE's commitments of additional CI main replacements, changes to procedures, and increased leak survey frequencies exceed the Company's current long-term CI main replacement program as approved by the Commission in Case No. GO-2002-0050. The Company has committed to performing the following actions:

   - A quarterly leak survey will be performed each year on the entire 58 psig MAOP-cast iron main system, which consists of 20.51 miles of main. Prior to implementing this change, the Company was leak surveying the 58 psig MAOP system (outside of the business districts) on a 3-year schedule as required by 4 CSR 240-40.030(13)(M)2.B.

   - The Company has implemented new training procedures that require all Field Employees working on or near any section of 58 psig MAOP cast iron main to notify the Company's Pressure & Maintenance Department so that the operating pressure can be lowered prior to excavating adjacent to the pipeline.

   - During the 2007 calendar year, the Company has committed to replacing all 16-inch diameter cast iron natural gas main that operates above 25 psig.

   - The Company has proposed to replace all 24-inch diameter cast iron natural gas main that operates above 25 psig during 2008.

   - The Company's overall objective is to have all cast iron natural gas mains operating above 25 psig (includes all CI pipe sizes) replaced prior to December 31, 2011. This amounts to approximately 20.51 miles of cast iron natural gas main.

   The Staff agrees with the proposals made by the Company. However, the Staff would like to have additional discussions with the Company regarding the new training procedures for lowering the operating pressure on the 58 psig MAOP

cast iron mains when a repair or exposure is required by the Company. Missouri State Law - Underground Facility Safety and Damage Prevention statute (RSMo Chapter 319) was established in 1986 and applies to any person excavating in the state of Missouri. This statute requires that any person intending to excavate give notice to the participating utilities by contacting the Missouri One Call System, Inc. (MOCS). MGE is notified of these intended excavations by MOCS. 4 CSR 240-40.030(12)(I)1. requires MGE to pay particular attention to excavation activities in close proximity to cast iron mains and take remedial actions as required by 4 CSR 240-40.030(13)(Z). MGE already has in place procedures to identify and review notices of excavation that are near the Company's cast iron pipelines and conduct on-site visits as necessary. The Staff recommends that the Company's procedure be modified to include lowering the pressure, when possible, for any excavator MGE verifies will be excavating near the 58 psig MAOP cast iron systems.

2. Commission regulation 4 CSR 240-40.030(12)(J) requires MGE to establish and follow written procedures to minimize the hazard resulting from a gas pipeline emergency. Subparagraph (12)(J)2.B. requires MGE to train the appropriate operating personnel and conduct an annual review to assure that they are knowledgeable of the emergency procedures. The Staff recommends that, as part of the annual training and review, appropriate operating personnel be made aware of the location of the isolation valves on the 58 psig MAOP cast iron mains that would be utilized in the event of an emergency.

3. The Staff recommends MGE file a response to these recommendations in Case Number GS-2008-0002 within thirty (30) days of the filing of this Incident Report.

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 6:30 p.m., Central Daylight Saving Time (CDST)[1], on Friday, May 25, 2007, a section of 24-inch diameter[2] cast iron natural gas main ruptured near the northeast corner of the intersection of East 72nd Street and Brooklyn Avenue in Kansas City, Missouri.

No ignition, flash fire, or explosion, occurred as a result of this natural gas incident. A 2-inch diameter plastic natural gas main that crossed above the failed section of 24-inch diameter cast iron main was severed as a result of the cast iron rupture. The escaping natural gas from both the ruptured cast iron main and the damaged plastic main prompted Missouri Gas Energy (MGE or Company) to evacuate approximately 40 nearby residences in the immediate vicinity as a precaution until the area was made safe.

Personal Injuries

The rupture occurred while MGE personnel were excavating above a section of 24-inch diameter cast iron natural gas main to perform a gas leak repair. As a result of this rupture, several sections of cast iron pipe fragments, soil debris, gravel, and asphalt were heaved out of the ground and outwards into the air.

A total of four MGE employees were injured as a result of this cast iron main rupture. Two of the four MGE employees were hospitalized, while the other two were treated and released the evening of May 25, 2007. One of the hospitalized employees was released on May 27, while the other was released on May 30. There were no fatalities. MGE personnel near the excavation were wearing fire protective helmets with face shields and other safety-related equipment at the time of the incident. The injuries to the MGE employees included facial and head injuries, nose and sinus fractures, a chest puncture wound, hand and wrist fractures, an eye laceration, a broken collar bone, a back/shoulder blade contusion, and numerous scrapes and abrasions to arms and facial areas.

[1] All times in this report are Central Daylight Saving Time.

[2] All cast iron pie sizes discussed in this report are the nominal pipe sizes.

Property Damage

The residence located at 2201 East 72nd Street had some minor damage to a section of vinyl siding on the north side of this structure. Another residence located at 2200 East 72nd Street had damage to a window and a car parked in this driveway. MGE estimated the damage to the car and window at 2200 East 72nd Street at $1,500. The houses located at 1968, 1970, 2200, 2201, 2204, and 2205 East 72nd Street had varying amounts of mud and soil debris scattered on top of the roofs, driveways, and lawns. Some automobiles parked in the area also had soil debris scattered on their exterior surfaces. The car and window damages at 2200 East 72nd Street, were the only property damage claims made to MGE.

MGE had five gas-crew trucks near the intersection of East 72nd Street and Brooklyn Avenue which had varying amounts of damage. MGE estimated the damage to its gas-crew trucks as $4,838. An MGE backhoe that was near the cast iron main rupture also received damage that was estimated to be $780.

Site Description

The intersection of East 72nd Street and Brooklyn Avenue is located west of I-435, south of I-70, and southwest of the Swope Park area in Kansas City, Missouri. The area along East 72nd Street and Brooklyn Avenue is primarily a residential area with both single story and multiple-story family residences.

Meteorological Data and Conditions

The weather reporting station located at Kansas City International Airport, in Kansas City, Missouri, approximately 28 miles northwest of East 72nd Street and Brooklyn Avenue, recorded a high temperature of 67 degrees Fahrenheit (ºF), a low temperature of 53º F and a mean temperature of 60º F on May 25, 2007. Precipitation measured for the month of May, up to and including May 25, was 4.64 inches. There was a trace amount of precipitation recorded on May 25. The wind averaged 7.8 miles per hour from a northern direction on May 25. The weather is not considered to have been a factor in this incident.

Natural Gas System

Natural gas in the Kansas City, Missouri area is provided by Missouri Gas Energy, a division of Southern Union Company.

Numerous natural gas facilities are located near the intersection of East 72nd Street and Brooklyn Avenue **(see Appendix A-1, Figure 1)**. The involved 24-inch diameter cast iron natural gas main was originally installed during the time period of May 10-14, 1948, as part of a cast iron main installation project that traversed from 71st Terrace Street to East 72nd Street. This cast iron main was located parallel to and 6 feet west of the east pavement edge of Brooklyn Avenue. This 24-inch diameter cast iron main is part of a gas distribution system network that is known as the KCLS-175 system and consists of varying amounts and sizes of steel, plastic, and cast iron main segments.

At the time of the 24-inch diameter cast iron main rupture, the closest System Control And Data Acquisition (SCADA) pressure monitoring point was located at 70th Terrace and Stateline, approximately 3 miles away from the intersection of East 72nd Street and Brooklyn Avenue. This SCADA device measured the operating pressure to be 53.25 pounds per square inch gauge (psig). The established maximum allowable operating pressure (MAOP)[3] of the 24-inch diameter cast iron natural gas main was 58 psig. The KCLS-175 system in Kansas City, Missouri contains approximately 3.74 miles of 24-inch diameter cast iron main having an MAOP of 58 psig.

A 4-inch diameter plastic natural gas main was installed parallel to and east of the east pavement edge of Brooklyn Avenue **(see Appendix A-1, Figure 1)**. This 4-inch plastic pipeline supplied natural gas to a 2-inch diameter plastic main that ran parallel to and north of the north pavement edge of East 72nd Street. This 2-inch diameter plastic main primarily served the residences along East 72nd Street west of Brooklyn Avenue and just a few blocks to the east of Brooklyn Avenue. Both the 4-inch and the 2-inch diameter plastic mains were originally installed during the time period of February 17, 1998 through June 18, 1998 as part of the Company's past cast iron main replacement program. The 2-inch plastic main crossed approximately 1 foot above the failed section of 24-inch diameter cast iron main near the northeast corner of the intersection of East 72nd Street and Brooklyn Avenue.

[3] 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.

An abandoned[4] section of 6-inch diameter cast iron natural gas main was located south of the 2-inch diameter plastic main. This section of 6-inch diameter cast iron main was abandoned by the Company on June 18, 1998. The 24-inch diameter cast iron main also crossed beneath the abandoned section of 6-inch cast iron main **(see Appendix B-2, Photograph 3)**.

Previous Company Actions

Most Recent Leakage Surveys

The most recent Company mobile leak survey over the natural gas mains near the intersection of East 72nd Street and Brooklyn Avenue was conducted on October 27, 2004. No gas leaks were found within a 1-block radius of East 72nd Street and Brooklyn Avenue. The failed section of 24-inch diameter cast iron main was included in this leak survey.

The most recent residential leak survey[5] over the plastic service lines located along East 72nd Street from approximately the 1300 block to the 2400 block was conducted on July 21, 2004. No gas leaks were observed during these leakage surveys.

Odorization Records

The Company has eleven (11) odorant test points located near the incident site. The test points are used for the Company's monthly odorant concentration tests[6]. The odorant intensity tests taken on May 3, 2007 (21 days prior to the day of the incident) indicated that the natural gas was adequately odorized and readily detectable at an average

[4] An abandoned pipeline is one that is still underground but has been separated from its source of gas, purged of all natural gas and permanently removed from service.

[5] MoPSC regulation 4 CSR 240-40.030(13)(M)2.B., requires an instrument leak detection survey to be conducted outside of business districts as frequently as necessary, at least once each third calendar year not to exceed 39 months.

[6] MoPSC regulation 4 CSR 240-40.030(12)(P)6., requires at least monthly odor intensity tests of the natural gas to assure the proper concentration has been achieved.

concentration of 0.27 % gas-in-air[7]. The odorant intensity test taken on June 3, 2007 (8 days after the day of the incident) indicated that the natural gas was adequately odorized and readily detectable at an average concentration of 0.33 % gas-in-air.

MGE's Current Cast Iron Main Replacement Program

Effective December 15, 1989, the Commission adopted revised Pipeline Safety Regulations applicable to corporations, municipal gas systems, and public utilities subject to the Commission's jurisdiction. In subsection 4 CSR 240-40.030(15)(D) of the regulations, the Commission required all natural gas operators who have cast iron natural gas mains to develop a replacement program and to submit this plan for Commission review and approval. The Company's initial cast iron main replacement program was approved in Case No. GO-91-277 and resulted in the replacement of nearly 300 miles when this program ended in 2000. The Company currently has a long-term cast iron main replacement program approved by the Commission in Case No. GO-2002-0050. This program requires a minimum of 5 miles of cast iron main to be eliminated each year, and includes other components as described below.

Both past and current cast iron main fractures are tracked by the Company and, under specific criteria, trigger a required cast iron main replacement schedule for the main segment where fractures have occurred. A cast iron coupon (test sample) is collected at each cast iron main fracture location and is analyzed to determine what percentage of the pipe wall exhibits graphitic corrosion[8]. If the percentage of graphitic corrosion exceeds the applicable criterion, this cast iron main segment is then scheduled for replacement within 24 months. Special replacement priority emphasis and consideration is given to the following types of cast iron mains: (1) intermediate-pressure (2 psig to 60 psig) beneath wall-to-wall pavement or near public concentrations; (2) in areas of disturbed soil support subject to the requirements of subsection 4 CSR 240-40.030(13)(Z); (3) in areas of planned future developments; and (4) in close proximity to extensive excavation, blasting, or construction activities. The Company is also placing emphasis on segmenting its low-pressure (30 Inches Water Column) cast iron system by extending intermediate-pressure plastic mains to areas with a history of fractures, so that replacements in those areas can be more efficient and cost-effective. The Company is

[7] 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.

[8] Graphitic corrosion is defined as deterioration of gray cast iron in which the metallic constituents are selectively leached or converted to corrosion products leaving the graphite intact (definition taken from the Corrosion Source Handbook web site).

repairing a minimum of 400 leaking cast iron bell joints annually on cast iron mains until leaks of this category are eliminated. Cast iron mains within business districts are leak surveyed semi-annually and cast iron mains that are 4-inch or smaller in diameter are leak surveyed annually. The Company also conducts a semi-annual patrol of 1.5 miles of large diameter, intermediate-pressure cast iron mains beneath wall-to-wall pavement or near public concentrations.

The 24-inch diameter cast iron main involved in this incident is included within the Company's on-going long-term cast iron main replacement program. Prior to this incident, this section of 24-inch diameter cast iron main that had ruptured was not scheduled to be replaced in the near future because it did not meet the replacement criteria in the Company's, Commission-approved cast iron main replacement program.

Miles of 58 psig MAOP-CI Mains Remaining on the KCLS-175 System

The table below gives a description of the total miles of remaining cast iron natural gas mains having a 58 psig MAOP within the KCLS-175 system. The total "remaining" Company-wide miles, reported from the operating districts that have 58 psig MAOP cast iron mains, such as, Independence, Kansas City, Saint Joseph, and Excelsior Spring, is 20.51 miles.

Nominal Pipe Size (Inches)	Miles Remaining
8	0.07
12	0.15
16	0.69
20	0.11
24	3.74
	Total: 4.76

Past Leaks on the Company's Large Diameter Cast Iron Mains

As part of the plan approved by the Commission in Case GO-2002-0050, the Company submits annual replacement program updates to the Staff. These updates discuss the Company's ongoing replacement program for cast iron mains, as well as, unprotected bare steel services and yard lines. The Company-wide total number of cast iron main leaks observed on their 24-inch diameter cast iron system for the time period of January 1, 2006 thru and including December 31, 2006 was 2-Class 1 leaks[9], 2-Class 2 leaks[10], and 4 Class 3 leaks[11].

Regarding the 58 psig MAOP KCLS-175 system, the majority of the leaks reported by the Company from 1991 to present involved leaking mechanical joints where the bolts either had to be tightened or replaced due to corrosion. The most recent repaired Class 1 leak (1 from the year 2000) that was within a several block radius of the intersection of East 72nd Street and Brooklyn Avenue occurred on 16-inch diameter cast iron main. This Class 1 leak was located in front of 1822 E. 69th Street and was caused by graphitic corrosion which produced a hole located near the bottom side of the pipe. A full circle leak clamp was initially used by the Company to repair the Class 1 leak on October 3, 2000. On November 23, 2000, the Company replaced an 18-foot section of this 16-inch diameter cast iron main with steel.

MGE Actions and Observations in Response to Odor Call and the CI Main Rupture

On May 25, 2007, a MGE service person was dispatched to investigate a gas leak odor call for 2015 East 72nd Street in Kansas City, Missouri. The service person arrived at this address at 5:21 p.m. and began a leak investigation. No gas leaks were found at this

[9] MoPSC regulation 4 CSR 240-40.030(14)(C)1., defines a Class 1 leak as a gas leak which, due to its location and/or magnitude, constitutes an immediate hazard to a building and/or the general public. This type of gas leak requires immediate corrective action to provide for public safety and to protect property.

[10] MoPSC regulation 4 CSR 240-40.030(14)(C)2., defines a Class 2 leak as a gas 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. Excluding Class 2 leaks in confined areas, such as, sanitary sewers or tunnels, this type of leak is required to be rechecked every 15 days and must be eliminated within 45 days after the initial investigation.

[11] MoPSC regulation 4 CSR 240-40.030(14)(C)3., defines a Class 3 leak as a gas leak that does not constitute a hazard to property or the general public but is of a nature requiring routine actions. Class 3 leaks must be repaired within 5 years and must be rechecked twice per calendar year, not to exceed 61/2 months, until repaired or the facility is replaced.

address. During the time between when this service person was dispatched to this location and the time that he arrived, the Company's dispatch center advised that the source of the gas odor was believed to be near the intersection of East 72nd Street and Brooklyn Avenue. The dispatch center indicated that "something had been hit or was blowing". As a result, two additional MGE service crews were then dispatched to the intersection of East 72nd Street and Brooklyn Avenue.

Upon arriving at the intersection of East 72nd Street and Brooklyn Avenue, one of the MGE service people (first responding service person) observed blowing gas that was coming through a pavement crack that ran across Brooklyn Avenue on the north side of East 72nd Street. He also noticed blowing leaves and debris that appeared to be coming from a grated storm sewer catch basin that was located at the northwest corner of the intersection. The atmosphere was checked for natural gas inside of 1970 East 72nd Street (house closest to the storm sewer catch basin). No gas readings were observed in the open atmosphere inside of this residence or from the basement floor drain area.

Gas readings were found near the northwest corner of the intersection of East 72nd Street and Brooklyn Avenue. A 100% gas-in-air reading was detected inside a storm sewer catch basin (a steel grate was installed over the top) as gas was blowing from this structure. Additional 100% gas readings were discovered at various locations along a crack in the street of Brooklyn Avenue and also near the east curb line.

A short time later, another MGE service person arrived on site and began to check nearby basements while the first responding MGE service person was reviewing his gas system maps to see what natural gas mains were in the area. Meanwhile, natural gas service was shut-off to 3 adjacent houses near the leak location from about 5:34 p.m. to 5:50 p.m. At 5:52 p.m., the residence located at 2204 East 72nd Street was checked both inside and at the floor drain locations in which 0% gas was detected. A storm sewer catch basin near 7209 Brooklyn Avenue was also checked at approximately 6:00 p.m. and no gas readings were detected. At approximately 6:15 p.m., gas service to 1970, 1966, 1964, 1962, 1960, 2200, and 2201 East 72nd Street was also discontinued. During this time, a third MGE service person arrived and started drilling bar holes[12] in the pavement of Brooklyn Avenue (located north of the north curb line for East 72nd Street) in the vicinity of where gas had been previously detected in the pavement cracks.

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

As the first bar hole was made in the street, MGE personnel observed that the amount of gas venting from the storm sewer catch basin was greatly reduced as gas was now coming up through the newly created bar hole. Meanwhile, the other MGE service person returned and indicated that no gas readings were found inside the floor drains serving the houses that he had checked. A backhoe was then used to facilitate the breaking of the pavement to assist with excavating and locating the source(s) of the gas leak, as well as, to vent the escaping gas to the atmosphere.

The first responding MGE service person then left at 5:54 p.m. to investigate another leak call and later returned to East 72nd Street and Brooklyn Avenue at 6:08 p.m. When arriving, he observed the Superintendent of Engineering had arrived and an MGE crew was using a backhoe and had uncovered and exposed a section of 2-inch diameter plastic natural gas main. Since no gas readings were observed and no gas was blowing along the 2-inch diameter plastic main, efforts were focused on the nearby 24-inch diameter cast iron (CI) natural gas main to determine the source of the gas leak. The excavation was extended further to the north (north excavation) for the purpose of attempting to expose a portion of the 24-inch diameter CI main. Once the backhoe had removed surrounding soil to a depth of approximately 1 foot above the CI main, a MGE service person positioned himself on the outside of the excavation and on the west side of the excavation and used an air knife[13] to assist in exposing the top portion of the CI main. Approximately 18 inches of the top portion of the 24-inch diameter CI main was exposed using the air knife.

At approximately 6:25 p.m., MGE personnel determined that gas was blowing from underneath the cast iron piping that had just been exposed. As the Digging Machine Operator (DMO) on the backhoe was continuing to remove additional soil from above the cast iron piping (further to the north), the first responding MGE service person received a cell phone call and turned around to walk away from the excavation site. At that moment the 24-inch diameter cast iron natural gas main ruptured which heaved cast iron pipe fragments and other debris into the air. The cast iron main rupture occurred at approximately 6:30 p.m., on May 25, 2007. After getting a safe distance away, the Superintendent of Engineering verified the condition of other MGE employees, called 911 and then notified Pressure & Measurement (P&M) personnel to close valves in the area to isolate the ruptured CI main. One of the valves was located at 71st and Brooklyn Avenue and the other located at 83rd Terrace and Troost.

[13] An air knife is a tool that uses high velocity compressed air to displace and move soil away from underground structures.

P&M personnel started the process of closing two (2) essential mainline gas valves that supplied gas to the 24-inch diameter cast iron main at approximately 7:50 p.m., on May 25, 2007. Both of the essential gas valves were closed by 8:00 p.m.; however, 100% closure was not achieved. The pressure in the cast iron main was reduced from approximately 53 psig to 30 Inches Water Column[14] by 8:20 p.m. To reduce the pressure to zero, the Company later installed bypass systems with relief valves near these valves so Company personnel could work safely to extend the excavation along the northeast corner of the intersection to determine the failure cause.

After the two mainline essential valves were closed, natural gas was still venting to the atmosphere near the northeast corner of the intersection of East 72nd Street and Brooklyn Avenue from a broken 2-inch diameter plastic main that had been severed when the 24-inch cast iron main ruptured. This 2-inch diameter plastic main was squeezed-off after the flow of gas to the 24-inch diameter cast iron main was stopped.

The following residences along East 72nd Street were without natural gas service due to the 24-inch diameter cast iron main rupture: 1960, 1962, 1964, 1966, 1968, and 1970. An additional 26 homes were also without natural gas service due to the severed 2-inch diameter plastic main in the 1900 block of East 72nd Street and the 7100 block of The Paseo.

From approximately 9:40 p.m. to 11:32 p.m. on May 25, 2007, after the gas pressure in the involved section of cast iron main had been reduced to zero and the 2-inch plastic main had been squeezed-off, Company personnel continued to conduct numerous combustible gas indicator[15] (CGI) checks at subsurface locations that included 26 manholes and 11 catch basins in the approximate vicinity of the incident. No gas was detected inside any of these subsurface locations.

After verifying that the area near East 72nd Street and Brooklyn Avenue was clear of any gas, an additional excavation (south excavation) was made by the Company along the southeast corner of this intersection. Reinforced shoring boxes were then installed in this south excavation to allow safe access.

[14] Inches of water column are often used to express the pressure at which gas is delivered to residential customers. Pressure measurement in inches is usually done with an instrument called a manometer. At sea level, 1 pound per square inch gauge is equivalent to 27.7 Inches Water Column.

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

On May 26, 2007, a 3-foot length of the 24-inch diameter cast iron main (was part of the same KCLS-175 system) was removed from the south excavation to facilitate the installation of an end cap at a location remote from the cast iron main rupture. A cast iron to wrought iron mechanical coupling was then installed along with a short section of steel pipe. After the section of CI pipe was joined to the mechanical coupling, the open end of the piping was temporarily closed-off by welding on an end cap.

At approximately 3:00 p.m. on May 26, the 2-inch plastic main that had been severed during the cast iron main rupture was then repaired and purged of all air with natural gas and placed back into service and the Company started the process of turning the gas back on to the homes along East 72nd Street. The majority of the residences were restored that day and the rest were restored on May 27. The adjacent section of pipe to the north of the rupture was then cut at a location that was north of the rupture area and removed. A mechanical end cap was then utilized to close the open end of the pipe left in the ground near the north end of the north excavation. The installation of the mechanical end cap inside of the north excavation was completed at approximately 9:00 p.m. on May 26, 2007. The Company then abandoned in place approximately 80 feet of the 24-inch diameter cast iron main that existed between the north and the south excavations.

Other Company Actions

On May 26, 2007, MGE conducted an additional leak survey over manholes, catch basins, and random sections of both mains and service lines near the intersection of East 72nd Street and Brooklyn Avenue. No gas readings were detected.

On May 31, 2007, the Company assembled the various ruptured sections of the 24-inch diameter CI main that were extracted from the north excavation, as well as, the displaced sections of cast iron piping found scattered along the ground after the pipe rupture. MGE was unable to locate all of the cast iron fragments/pieces **(see Appendix B-1, Photographs 1 and 2)**.

During the period of June 8, 2007 through June 15, 2007, the Company replaced the abandoned section of 24-inch diameter CI pipe with approximately 80 feet of 24-inch diameter coated steel pipe. Graphitic corrosion was observed on the section of cast iron pipe adjacent to, and directly to the south of the section that ruptured. The cast iron pipe was tested for soundness with a brass hammer. After several strikes with the hammer two separate holes were knocked through the pipe wall.

MGE personnel returned to the intersection of East 72nd Street and Brooklyn Avenue on September 24, 2007, to inspect the storm sewer system. The storm sewer drop inlet was found along the northwest corner of the intersection near the bend radius of the curb line after Company personnel broke-up some dried mud on top of the grate. The manhole lid was also found approximately 9 feet to the south of the grate cover. MGE personnel also determined that the storm sewer drop inlet was connected directly to the manhole by a pipe that entered the manhole at a depth of approximately 4 feet.

Proactive Measures Taken by the Company as a Result of the Cast Iron Rupture

As a result of the May 25, 2007 CI pipeline rupture, the Company immediately implemented some new training procedures that relate to performing work on the 58 psig MAOP cast iron main systems. The Company instructed all Field Employees who operate on these CI piping systems to notify the Pressure & Maintenance Department to lower pressure on the operating system prior to excavating adjacent to the pipeline.

The Company has implemented an accelerated leakage survey program over their entire 58 psig MAOP cast iron mains (20.51 miles) that would include the KCLS-175 System. The leak survey will be conducted on a quarterly basis rather than the 3-year schedule required by 4 CSR 240-40.030(13)(M)2. of the Commission's pipeline safety regulations.

One of the Company's goals is to eliminate all cast iron piping that has an MAOP above 25 psig. At the present time the Company is planning to replace any 16-inch diameter cast iron main operating above 25 psig this calendar year. Additionally, the Company is in the planning process to replace any 24-inch diameter cast iron main operating above 25 psig in 2008. The overall plan is to have all the cast iron main that operates above 25 psig (approximately 20.51 miles Company-wide) replaced prior to December 31, 2011. Due to the large number of customers served by the cast iron pipelines operating above 25 psig, the replacements will likely take place during the spring and summer months of 2008-2011. Staff agrees with this plan because these CI piping systems are critical feeds into adjacent pressure systems and extreme cold weather might impact the Company's system if the CI piping was taken out of service during the winter.

Company's Actions to Meet 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 the MoPSC 24-hour answering service at 7:10 p.m. on Friday, May 25, 2007. A Staff member was later contacted by the answering service at approximately 7:22 p.m. that same evening.

2. At 10:18 p.m. on May 25, 2007, after determining the magnitude of the damage and the update of injuries to Company personnel, the Company called the United States Department of Transportation-Pipeline and Hazardous Materials Safety Administration (U.S. DOT-PHMSA) to report the natural gas incident. This incident did meet the U.S. DOT-PHMSA Federal Incident reporting requirements because there was a release of gas from a pipeline that resulted in personal injuries that necessitated in-patient hospitalization.

3. The PHMSA F 7100.1 form, as completed by the Company, was transmitted to the MoPSC on June 25, 2007. The Staff forwarded the report to the U.S. DOT-PHMSA on July 2, 2007.

Commission Staff Actions and Investigation

On the evening of May 25, 2007, the Company notified the Staff of the incident. Due to darkness and the fact that the Company was in the process of terminating the natural gas flow to the effected section of cast iron main, Staff traveled to the incident site the next morning. Two members of the Staff arrived near the intersection of East 72nd Street and Brooklyn Avenue, in Kansas City, Missouri at approximately 8:45 a.m., on Saturday, May 26, 2007.

Upon arrival at the scene, Staff met with MGE's Director of Compliance to discuss the events that had transpired, the condition of the MGE employees who were injured and the actions MGE had taken up to that point. During this discussion, the Staff observed several Company personnel on-site that were raking and removing mud and soil debris from nearby yards and driveways located east of the intersection of East 72nd Street and

Brooklyn Avenue. Members of the Kansas City, Missouri, Fire Department were also on-site to provide standby assistance to the Company.

While observing the condition of nearby homes, the Staff observed both mud and soil debris scattered along the rooftops, driveways, and sidewalks for the following addresses: 1968, 1970, 2200, 2201, 2204, and 2205 East 72nd Street. One house located at 2201 East 72nd Street had damage to a section of vinyl siding that was facing Brooklyn Avenue. Numerous spoil[16] piles from an excavation made by the Company along the northeast corner of the intersection were covering a portion of Brooklyn Avenue. A layer of packed mud was also visible on top of the streets near the intersection of East 72nd Street and Brooklyn Avenue. The Staff later learned that the mud was covering a grated storm sewer catch basin near the northwest corner of this intersection.

A large excavation was located near the northeast corner of the intersection of East 72nd Street and Brooklyn Avenue **(referred to as the north excavation, see Appendix B-2, Photograph 3)**. Within this excavation the Staff observed approximately 11 feet of an exposed section of 24-inch diameter cast iron natural gas main that was visible near the north end of this excavation. This exposed section of cast iron pipe had an open pipe end with a mechanical flange for fastening a mechanical coupling. The burial depth to the top of cast iron was measured as approximately 5 feet. Toward the south end of the same excavation a 2-inch diameter section of plastic natural gas main was visible as it crossed the excavation, approximately 1 foot above the CI pipe in approximately an east-to-west direction. This section of plastic main appeared to have been completely severed at approximately the midpoint above the cast iron main and a temporary squeeze-off tool[17] had been utilized by the Company to stop the flow of natural gas. At the far south end of this excavation, an abandoned section of 6-inch diameter cast iron natural gas main also crossed above the 24-inch diameter cast iron main in an east-to-west direction. A backhoe was later used by the Company to remove additional soil from around the remaining buried segments of 24-inch diameter cast iron piping and to also discover if any past directional bore projects may have damaged the cast iron piping. During this work, the Staff observed a long section of CI piping inside of the north excavation that appeared to have been fractured in numerous locations. The overall length of this fractured section of cast iron piping that had remained in the trench was measured as 14 feet and 11 inches. The Staff then observed the sides of the excavation in an attempt to locate any past directional bore hole locations. No bore hole locations were observed.

[16] Spoil is the refuse matter that is removed from an excavation which typically contains subsoil and rock material.
[17] A squeeze-off tool is a vise-like device that can be installed around a plastic natural gas main or service line to squeeze the plastic together so that the flow of natural gas can be restricted.

Just east of the north excavation and on the north side of East 72nd Street, several large and small fragments of cast iron main were visible on the ground at varying distances away from the north excavation. One fragment of cast iron, approximately 14 inches in length, was located 50 feet to the east from the north excavation. Upon further observation, several other fragments of cast iron were visible across the street just south of the south curb line of East 72nd Street and east of the east curb line of Brooklyn Avenue. These CI pipe fragments had been removed from the street by MGE and placed in the yard of 2201 East 72nd Street.

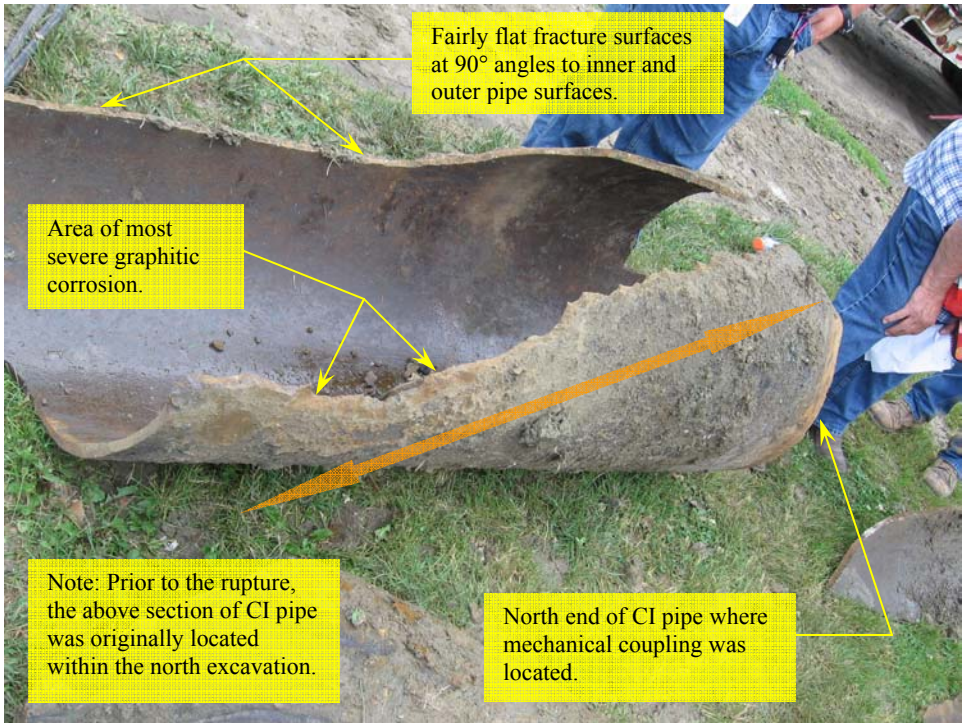
An MGE gas-crew truck was parked along the north side of East 72nd Street, located approximately 20 feet southeast from the north excavation. Staff noted the truck had a broken glass windshield, a damaged hood and damaged grille area from flying debris, such as, cast iron pipe fragments, soil and mud, gravel, and asphalt that came out of the ground when the cast iron main rupture occurred. Pieces of dirt and mud covered most of the truck. MGE personnel indicated that the truck had not been moved since the rupture occurred.

Across the street, near the southeast corner of the intersection of East 72nd Street and Brooklyn Avenue, Staff observed another excavation (the south excavation for purposes of this report). A reinforced shoring device had been placed inside this excavation and the Company was in the process of cutting and removing an approximate 3-foot long section of 24-inch diameter CI main in preparation for installing an end cap. This section of CI piping was part of the same KCLS-175 system as the ruptured section of 24-inch diameter cast iron main within the north excavation.

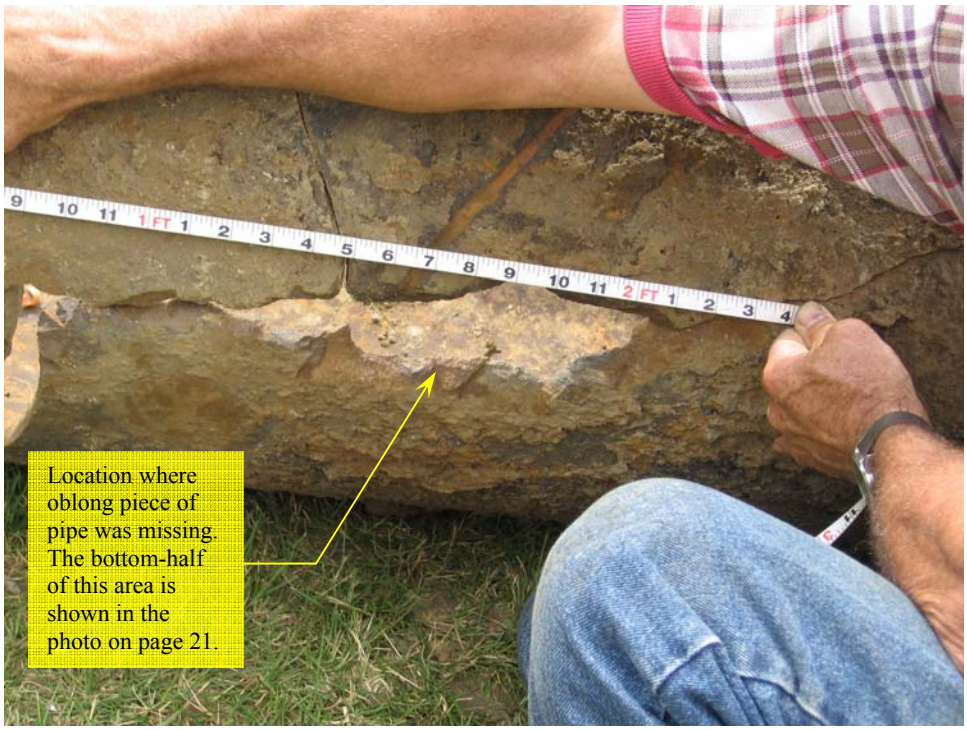
Once the 3-foot section of cast iron was removed and placed aboveground, the Staff inspected both freshly cut edges of the removed pipe segment ends of the CI piping and the exterior surface for any obvious signs of pitting and graphitic corrosion. No visible signs of deep pitting or corrosion were detected during this cursory inspection. Neither end of this CI piping appeared to have any significant or detrimental pitting. Staff only noted slight pitting which caused shallow craters on one end of the piping.

Throughout the day on May 26, the Staff and Company personnel attempted to locate and re-assemble the scattered fragments or pieces of 24-inch diameter CI piping that were heaved out of the ground when the cast iron main ruptured **(see Appendix B-2, Photograph 4)**. The Staff then made an overall length measurement of the re-assembled sections of 24-inch diameter cast iron piping. The overall length was measured as 13 feet and 3 inches (compared to 14 feet and 11 inches found remaining in the north excavation). During the process of re-assembling the pipe fragments, Staff observed

what appeared to be severe graphitic corrosion along portions of the fracture surfaces (see photograph below). The CI pipe fragment shown in this photograph has been turned approximately 180° (top to bottom) from its actual undisturbed pipe orientation prior to the rupture. The severe corrosion area appeared to penetrate the entire pipe wall at numerous locations. One area of corrosion appeared to start approximately 6 inches from the north end (at approximately the 6 o'clock position) of the section of CI pipe that ruptured and extended southward somewhat longitudinally at a slight spiral rotation for a length of approximately 4 feet to approximately the 3 o'clock position. The orange arrow in the photograph below represents the approximate span of this graphitic corrosion on this CI pipe fragment. One of the many fracture surfaces developed and propagated along this area of graphitic corrosion. Most fracture surfaces of the CI pipe resulted in a fairly flat fracture surface and the fracture surfaces were at a 90° angle relative to the inner and outer pipe surfaces. The pipe surface along most of this 4-foot long fracture surface was highly irregular and cratered in appearance and the fracture surface was at a slight angle to the inner and outer pipe surfaces. In the photograph below, the north end of the CI pipe is to the right.



At one location along the previously mentioned fracture area, a small oblong piece of pipe (see photograph below), measuring approximately 3 inches by 10 inches could not be located. Upon reassembling the pipe segments severe graphitic corrosion was observed all along the fracture surface where this small piece of pipe would have been located. The pipe fracture surfaces were highly irregular and cratered in appearance and the fracture surface was at approximately a 45° angle to the inner and outer pipe surfaces.



After observing the installation of the steel end cap in the south excavation and taking additional photographs and measurements, the Staff left the incident site at approximately 4:00 p.m. on Saturday, May 26, 2007.

ANALYSIS

Graphitic Corrosion of the 24-inch Diameter Cast Iron Natural Gas Main

Graphitic corrosion is a corrosion process that involves the removal of iron in the graphite network of the cast iron. The removal of iron from graphite flakes in the cast iron microstructure can result in a weakened and porous cast iron structure, which can compromise the strength and metallic properties of the metal.

Graphitic corrosion over time can reduce both the wall thickness of the CI material and the ductile strength properties. This graphitic corrosion would have further reduced the wall thickness (ductile strength reduction as well) of the cast iron pipe in certain locations such that cracks and fracture surfaces would have eventually developed in the wall of the pipe as a result of the forces produced by the 53.25 psig of internal gas pressure. The magnitude of these internal forces would have eventually exceeded the yield point of the weakened CI material over a period of time causing multiple fracture locations. If the graphitic corrosion is severe enough, the iron components of the cast iron may be completely consumed by this process (see photograph near bottom of page 22).

The CI main exposure to road salts over a long period of time may have caused graphitic corrosion to certain areas of the CI piping.

Fractures and Resulting Rupture of the 24-inch Diameter Cast Iron Natural Gas Main

Cast iron, which is cast in a mold, is a general name given to a wide range of alloys containing iron, carbon, silicon, and, to a lesser extent, manganese, phosphorus, and sulfur. Cast iron is a material that is cast in a mold. The methods of casting and the types of molds used have a profound effect on the structure and properties of cast iron.

Because cast iron has a low ductility characteristic (flexibility), it is generally considered to be very brittle. Pipeline materials currently installed by natural gas operators, such as, steel and polyethylene plastic, have more ductility and will deform prior to rupture. In contrast, cast iron deforms very slightly before fracture due to its inherent brittle nature. When subjected to stresses greater than the yield point, failure of the CI material is sudden and typically results in a partial or complete circumferential fracture.

The type of fracture surface observed along the 4-foot section of CI piping was not a typical circumferential fracture common to most gray cast iron piping. The resultant cracks along this fractured area traveled along a spiral rotation about the longitudinal axis of the CI pipe. Other fracture surfaces were at 90° angles to both the inside and outside walls of the CI pipe and no signs of graphitic corrosion were observed. These fracture surfaces (with 90° angles) more than likely occurred as a direct result of the CI pipe rupture in which the pipe wall burst outward and would not be attributed to graphitic corrosion.

As previously discussed in the **Natural Gas System** section of the Report on page 8, the ruptured 24-inch diameter cast iron main was part of the KCLS-175 System. Based upon the Company's past leak history of their 58 psig MAOP 24-inch diameter cast iron mains on the KCLS-175 System, the majority of the leaks were attributed to mechanical joint leaks. No leaks due to graphitic corrosion on the 24-inch diameter CI piping, or fractures (whether circumferential or longitudinal) have been reported. The type of fracture surfaces involved in this Report and the CI main rupture itself appear to be an isolated occurrence that is unique to this pipeline system.

The burial depth of the cast iron piping varied from 5 to 6 feet inside of the north excavation. The weight from this column of soil above the CI main would have resulted in downward compressive forces that were distributed along the top portion of the CI main. As long as the soil was not disturbed near the CI pipe, the pipe did not rupture or burst (even though fractures were present and leaks were occurring) because the weight of the soil provided a compressive force from above while the compacted soil supporting the pipe and along the sides also restricted the pipe from expansion or failure (rupture).

While MGE was in the process of locating the source of the gas leak, enough soil was removed so the compressive loading from the weight of the soil was reduced to a point in which the internal forces (due to the natural gas pressure inside the CI pipe) overcame this compressive force, causing the pipe to violently burst and rupture into numerous pieces.

Natural Gas Escape and Migration

Prior to the rupture of the CI main, MGE personnel observed natural gas blowing and venting from the storm sewer catch basin and natural gas readings were detected above certain cracks in the pavement of Brooklyn Avenue just north of East 72nd Street. This would indicate that natural gas was escaping from the location where the cast iron

material had been completely consumed by graphitic corrosion. Some of the CI main fracture surfaces (prior to the rupture) may have also provided a path for the escaping natural gas.

Staff did not determine the number of underground gas leak locations emanating from the numerous fracture surfaces within the buried CI piping (prior to the rupture), but it is likely that multiple leak locations existed. As the gas migrated through the soil towards the storm sewer catch basin, it eventually vented to the atmosphere (via storm sewer catch basin and pavement cracks) and was detected by the public. Although the natural gas did enter the storm sewer system, no gas entered into the storm/sewer drains for any nearby residences along East 72nd Street and no gas readings were detected in any of the nearby manholes checked.

Following the rupture, natural gas would have been emanating from the remaining underground section of CI main operating at approximately 53 psig. Since natural gas is lighter than air it tends to migrate along paths of least resistance through the soil and upwards to the atmosphere where possible. With the CI pipe opened to a full 24-inch pipe diameter, the exiting pressure of the escaping natural gas would have dropped quickly. When the CI main rupture occurred, a portion of the soil surrounding the CI pipe was dislodged and loosened, as well as, some of the asphalt that was on the street surface above. This would have allowed most of the natural gas to escape into the atmosphere. The section of 2-inch diameter plastic natural gas main that was severed as a result of the CI main rupture would have also vented to the atmosphere.

APPENDIX A
(Figure)

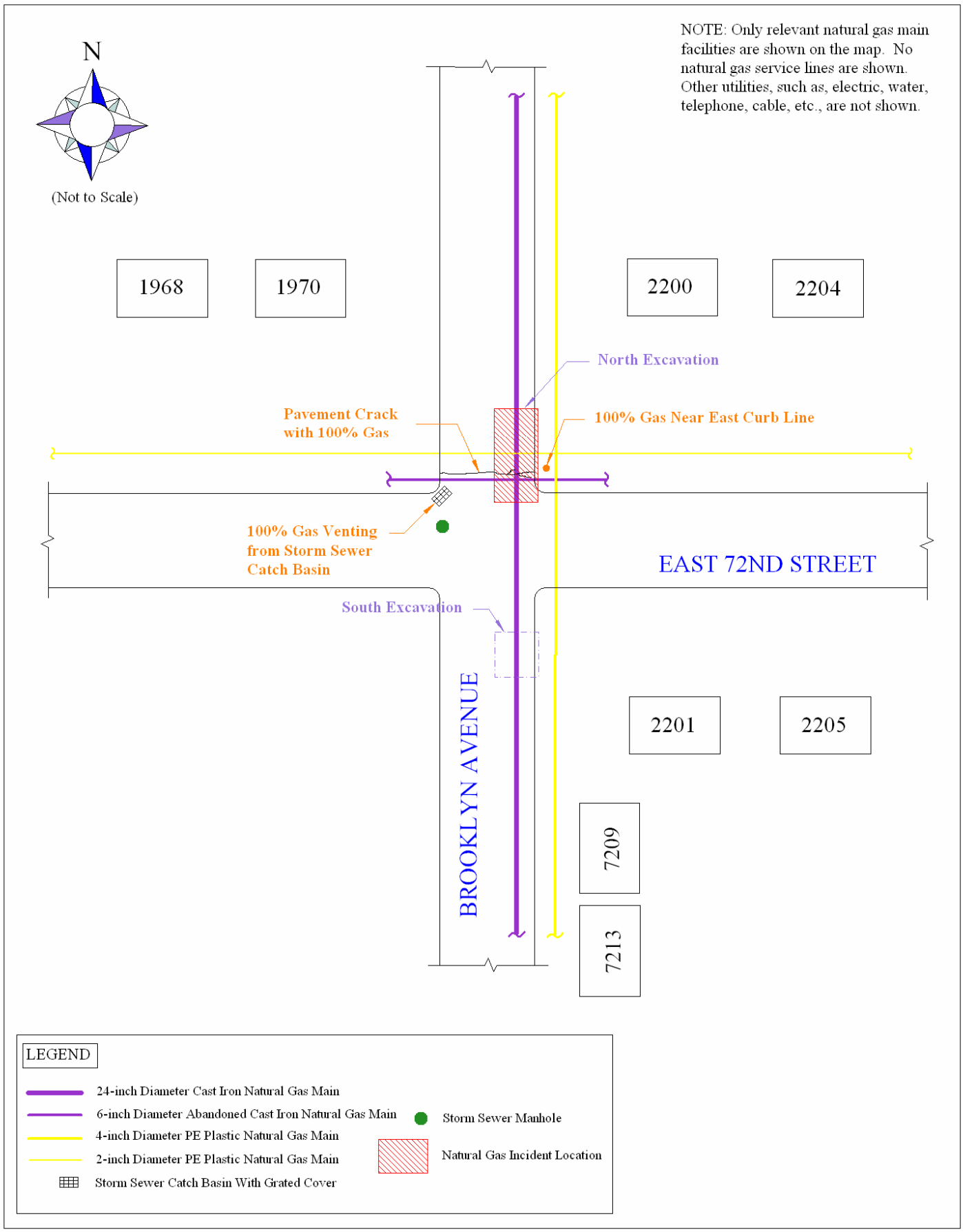


Figure 1

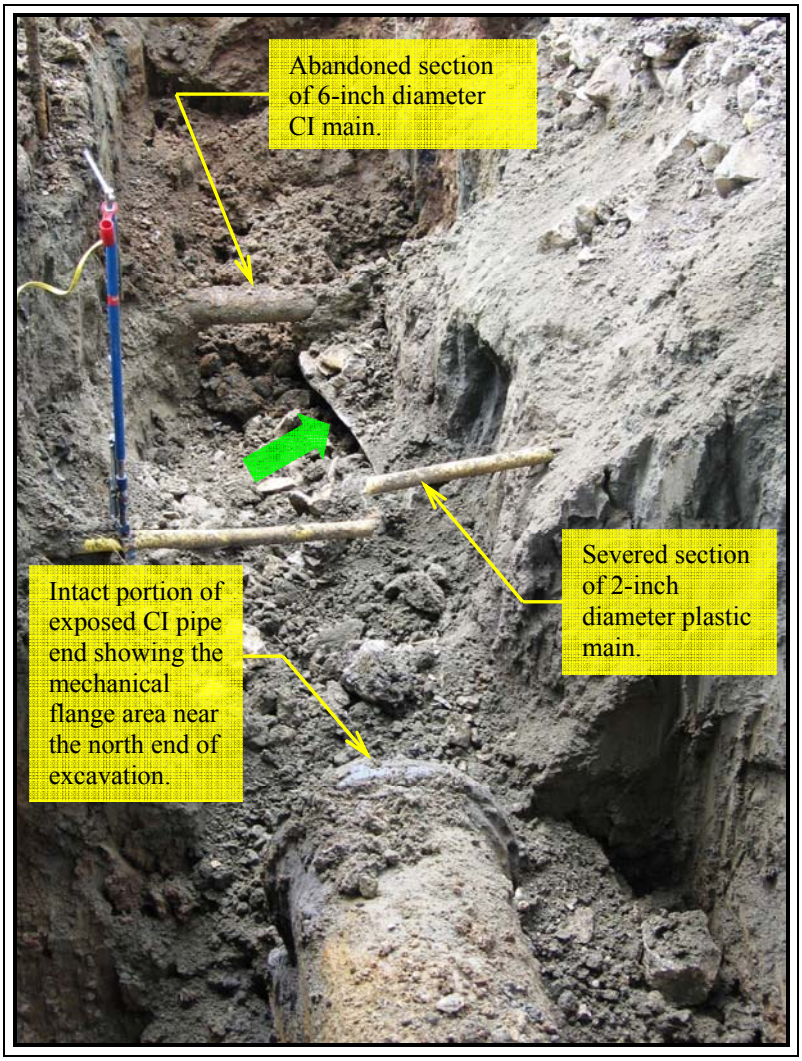
Plan View of East 72nd Street and Brooklyn Avenue-Incident Location

Appendix A-1

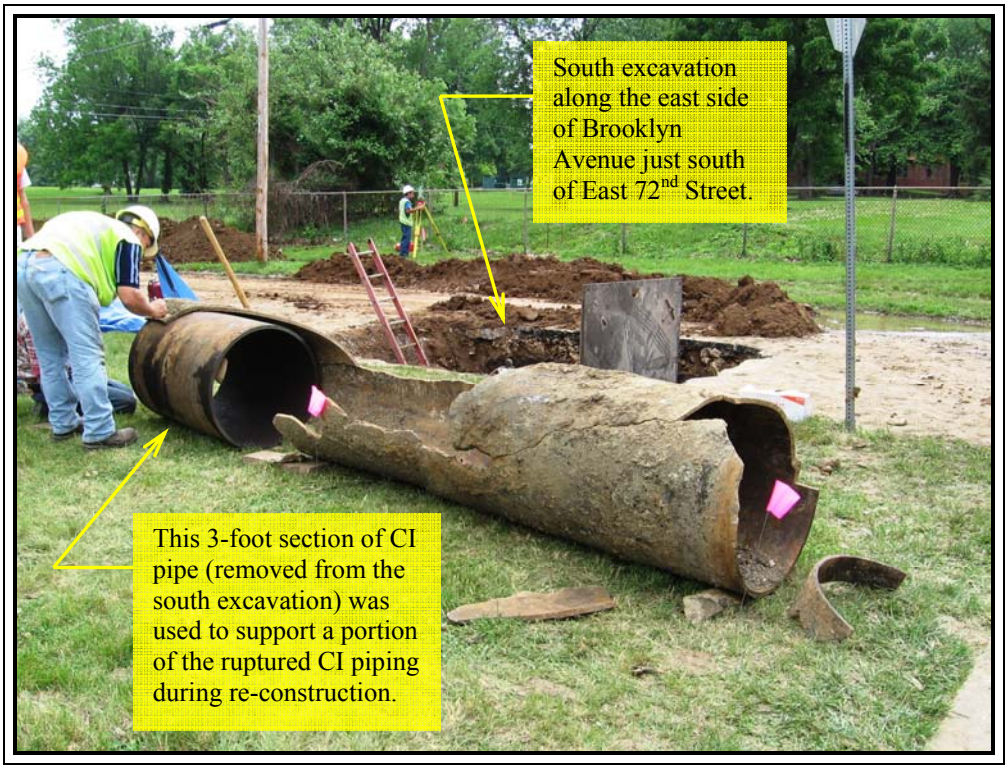
APPENDIX B
(Photographs)

Photograph 1 View of a portion of the 24-inch diameter CI pipe fragments that were pieced together by MGE at their training facility. The duct tape wrapping near the right side is approximately where the mechanical coupling would have been located at the north end of the north excavation (Photograph provided by MGE).

Photograph 2 Opposite side view of the assembled CI pipe fragments. The north end of the cast iron main is to the left in this photograph (Photograph provided by MGE).



Photograph 3 View looking approximately to the south inside of the north excavation after a Company backhoe was used to deepen and extend the excavation to expose the sections of 24-inch diameter cast iron main that had remained in the trench. The green arrow indicates a fractured section of cast iron piping that was not heaved out of the ground. The blue rod on the left side of the photo is a squeeze-off tool that has a grounding wire attached to prevent a potential build-up of static electricity along the plastic pipe surface.



Photograph 4 Looking southwest at the various pieces of 24-inch diameter CI main that the Staff and MGE personnel were assembling. After assembling the ruptured sections of CI pipe, the measured length along the pipe's longitudinal axis from the north end to the south end was approximately 13 feet and 3 inches.