BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Laclede Gas Company Concerning a Natural Gas Incident at 7527 Michigan Avenue, St. Louis, Missouri.	))))	Case No. GS-2009-0270

STAFF'S FINAL STATUS REPORT

COMES NOW the Staff of the Missouri Public Service Commission ("Staff"), by and through counsel, and for its *Final Status Report* respectfully states as follows:

1. On January 20, 2009, Staff requested the Missouri Public Service Commission (Commission) *Establish A Case For Investigation of Gas Safety Incident* involving an incident that occurred on December 30, 2008 at 7527 Michigan Avenue, St. Louis, Missouri and for the purpose of receiving the response of Laclede Gas Company ("Laclede" or "Company").

2. On January 27, 2009 the Commission granted Staff's request and established Case No. GS-2009-0270. The Commission also ordered Staff to file either its final incident report or an interim incident report no later than May 28, 2009.

3. On May 28, 2009, Staff filed an *Interim Status Report* notifying the Commission that Staff was in still in the process of investigating the incident.

4. Attached hereto as Exhibit 1, Staff submits its investigation of this event with its recommendations.

WHEREFORE, Staff respectfully requests the Commission accept this *Status Report*, and order Laclede to comply with the recommendations in the Report and issue its Order:

A. Laclede continue its recently implemented practice of reviewing gas system maps in conjunction with Missouri One-Call locate tickets to determine if its CI mains may be adversely affected by third party excavations;

B. For situations where one or more CI main may potentially be located near or within a proposed excavation, that Laclede contact each excavator and/or visit each excavation site to further determine what portion of the pipeline may require protection or replacement due to lying within an area of affected soil[5] or by having the support beneath the pipe removed for a length of more than ten (10) times the nominal pipe diameter not to exceed six (6) feet;

C. In conjunction with the Staff's Recommendation B above, that when the excavation work near its CI mains is associated with installing new water service lines and taps to City water mains, Laclede obtain a set of drawings showing water line locations from the City and/or contact the City regarding each new installation;

D. In conjunction with the Staff's Recommendation B above that in the event that Laclede speaks with an excavator, Laclede should determine the dimensions and locations of each proposed excavation relative to each Laclede CI main;

E. In conjunction with the Staff's Recommendations A-D above, that if a determination is made that an excavation will involve the installation of one or more water main taps (for water service line connections) and that Laclede's CI gas main facilities may be adversely affected because of their proximity, an on-site investigation be made by Laclede for each of these types of excavations to determine the area of affected soil;

F. That Laclede follow the guidelines from the "Guide for Gas Transmission and Distribution Piping Systems 2009 Edition" which will be amended in Addendum 1 to include additional information that operators of CI systems should communicate to builders, designers and excavators;

G. That Laclede continue to develop and implement a program identifying all CI mains having a nominal pipe diameter of 6-inch and smaller that are in areas having a continuous covering (e.g. pavement, or concrete) from the CI main to building wall. Laclede's schedule for completing this work is August of 2009;

H. While evaluating facilities in conjunction with the soon to be finalized Integrity Management Program for Gas Distribution Pipelines (DIMP Rule), Laclede:

i. Consider increasing the total annual amount of CI main replacements; and

ii. Assign a priority to 6-inch and smaller CI mains having a continuous covering from the CI main to a building wall;

I. That Laclede record sufficient additional information when performing leak investigations (currently documented on the "Report of Street Leak F712" form) to:

i. Physically locate each significant reading so that the exact same location can be rechecked in the future; and

ii. Determine the extent of gas migration;

Laclede has indicated in past discussions with the Staff that they are developing a new leak management system that will geographically reference leak locations within its GIS mapping system. If Laclede chooses to implement this recommendation by using the "Report of Street Leak F-712" form, that at a minimum, the physical location measurements also be recorded for each significant reading to ensure that the same location will be visited during the next re-check of the leak. The extent of the leak should be investigated and documented in a format similar to that used by Laclede titled "Ongoing Leak Survey Information";

J. That Laclede inform its personnel who are involved in leak investigations of the circumstances related to this incident, with the intention of raising awareness that gas venting from an area undergoing construction is a special concern. Leak investigation personnel should

be made aware of situations such as this one where gas is venting to the atmosphere from a gravel backfill area before a sidewalk is repaired, since repairs may prevent the gas from venting;

K. Laclede has revised its Excavation Safety brochure to communicate to excavators that precautions should be taken by excavators when the soil beneath a CI main is removed. The Staff approves of this revision, and recommends that Laclede further revise its Excavation Safety brochure to address potential situations where CI pipe lies within the area of affected soil and the soil is not necessarily removed from directly beneath the pipe;

L. That Laclede be directed to file a response regarding these recommendations contained in this Case within 60 days of the filing of this report.

Respectfully submitted;

/s/ Jaime N. Ott
Jaime N. Ott
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CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing have been mailed, hand-delivered, transmitted by facsimile or electronically mailed to all counsel of record this 15th day of July, 2009.

/s/ Jaime N. Ott

Missouri Public Service Commission

Gas Incident Report

Laclede Gas Company
Case No. GS-2009-0270

Filed on July 15, 2009

7527 Michigan Avenue
St. Louis, Missouri
December 30, 2008

Energy Department ... Utility Operations Division
July 2009… Jefferson City, Missouri

Exhibit 1

TABLE OF CONTENTS

List of Acronyms and Abbreviations

%	Percent
Brochure	Excavation Safety Brochure
C&M	Construction and Maintenance
CGI	Combustible Gas Indicator
CI	Cast Iron
City	City of St. Louis
Company	Laclede Gas Company
CSR	Code of State Regulations
CST	Central Standard Time
DOT-PHMSA	United States Department of Transportation-Pipeline and Hazardous Materials Safety Administration
gravel	1-inch clean rock gravel backfill
IWC	Inches of Water Column
Laclede	Laclede Gas Company
Locate Ticket	Missouri One-Call Locate Requests
MoPSC	Missouri Public Service Commission
ºF	Degrees Fahrenheit
psig	Pounds per Square-Inch Gauge
S.A.I.D	Service and Installation Department
Sprinkler Line	6-inch Steel Water Line
St.	Saint
Staff	Commission's Energy Department-Safety/Engineering Staff

Roles of Companies and Individuals Mentioned in this Report

Fire Protection Contractor: The company contracted by the General Contractor to install the fire sprinkler system for the building renovation.

First Technician: The first Laclede S.A.I.D. Technician to respond after the incident and who took gas-in-air measurements at the incident site.

Owner of Plumbing Contractor: The owner of the Plumbing Company contracted by the General Contractor to install the water service for the building renovation and to perform excavation and backfill of the street. The owner of the Plumbing Contractor was also the individual who performed the excavation.

Plumbing Contractor: The plumbing company contracted by the General Contractor to install the water service for the building renovation and to perform excavation and backfill of the street.

Second Technician: The second Laclede S.A.I.D. Technician to respond after the incident and who took gas-in-air measurements at the incident site.

Third Technician: The third Laclede S.A.I.D. Technician to respond after the incident and who took gas-in-air measurements at the incident site.

Laclede Gas Company: The owner and operator of the natural gas distribution system in the City of St. Louis, Missouri.

1.0 SYNOPSIS

At approximately 10:56 a.m. Central Standard Time (CST; all times in this report are Central Standard Time), on Tuesday, December 30, 2008, a natural gas ignition and resulting flash fire occurred within the basement of 7527 Michigan Avenue[1] in Saint (St.) Louis, Missouri.

At the time of the incident, renovation work was in progress at the building located at 7527 Michigan Avenue, at the intersection of Michigan Avenue and Steins Street. The renovation work included installation of a new water service line and a fire sprinkler system in the building. Two excavations were made on November 19, 2008. One excavation was through the concrete sidewalk abutting the south building wall of 7527 Michigan Avenue to bring the water service and fire sprinkler lines into the basement wall; and the other was in Steins Street to access and tap into the City of St. Louis (the City) water main. The Plumbing Contractor responsible for the excavation work requested through Missouri One-Call marking of the location of facilities in the work area prior to beginning the excavation.

A section of 4-inch[2] cast iron (CI) natural gas main was located between the building wall and the water main. The CI main was properly located by Laclede Gas Company (Laclede or Company) and the excavation was performed without apparent damage to the pipe. The soil around and beneath this CI natural gas main was excavated for a length of approximately 7 linear feet so that the water piping could be installed. The water taps were installed on November 24, 2008 (for the service line) and December 18, 2008 (for the sprinkler line). The excavated area was backfilled with clean fill on December 18, 2008 and was inspected by the St. Louis Street department on December 24, 2008. The street was patched with concrete on December 24, 2008 and the sidewalk was patched on December 30, 2008 at approximately 9 a.m. CST.

Since the 4-inch CI main was not supported in the excavation prior to the gravel backfill and the poured concrete street patch, the additional weight of the concrete plus any additional weight from vehicular traffic would have resulted in downward loading forces that were distributed along the previously undermined 7-foot section of CI piping. Over a period of time, this external loading would have induced stresses that exceeded the yield point of the 4-inch CI piping until a stress-induced circumferential fracture occurred. This fracture likely

[1] The incident address is given as both 7527 and 7529 Michigan Avenue in different records and correspondences. In discussions with the City of St. Louis Recorder of Deed's office, Staff learned that the two addresses represent one combined parcel, and are noted as 7527-7529 Michigan Avenue in property records. For purposes of this report, the address "7527 Michigan Avenue" has been used.

[2] Wherever pipe sizes are given in this report, they refer to nominal pipe diameter.

occurred sometime between December 26, 2008 (when no gas was detected in the gravel backfill of the un-patched sidewalk) and December 28, 2008 (when a gas reading of 85% gas-in-air was detected in the un-patched sidewalk just north of the north curb line of Steins Street).

Laclede had investigated an odor complaint in the vicinity on December 28, 2008, and had found 85% gas-in-air in the fill that was placed in the sidewalk. It is believed that natural gas continued to vent from this area until it was patched with concrete on December 30, 2008. After the concrete was placed, gas could no longer vent from the sidewalk, but instead migrated into the basement area of 7527 Michigan Avenue. After the incident, the excavation was reopened over the CI gas main, and a circumferential fracture was discovered.

During the course of its investigation into this incident, the Commission's Energy Department-Safety/Engineering Staff (the Staff) did not discover any violations of the Missouri Public Service Commission's (MoPSC's) Pipeline Safety Regulations[3]. Twelve recommendations were made to Laclede as a result of the Staff's investigation.

[3] 4 CSR 240-40.030: Safety Standards – Transportation of Gas by Pipeline

2.0 CONCLUSIONS

1. At approximately 10:56 a.m., CST, Tuesday, December 30, 2008, a natural gas ignition and resulting flash fire occurred within the basement area of 7527 Michigan Avenue.

2. As a result of the natural gas flash fire, one plumber working inside the basement area of 7527 Michigan Avenue received medical treatment for singed eyebrows and a burning feeling in his right eye and was later released from the hospital on December 30, 2008.

3. The probable cause of the incident was a combination of sequential actions. One of those actions included the removal of soil support beneath an approximate seven-foot span of 4-inch CI natural gas main. The Plumbing Contractor undermined this section of 4-inch CI main and no temporary or permanent shoring or support was provided from November 19, 2008 until the excavation was backfilled with 1-inch clean rock gravel (hereafter referred to as gravel) on December 18, 2008. The other action involved the pouring of cement to a depth of approximately 10 inches directly above the 4-inch CI main to complete a concrete street patch. The weight from this concrete street patch would have induced downward loading stresses that were distributed along the seven-foot section of 4-inch diameter CI main. The combination of these actions along with any settlement of the loose gravel backfill eventually caused the 4-inch CI natural gas main along Steins Street (south of 7527 Michigan Avenue) to fail by circumferential fracture.

4. A secondary contributing factor to the incident may have involved additional loading stresses from any vehicular traffic that crossed over the freshly poured concrete street patch after that driving lane had been opened.

5. The exact source of the ignition was not identified but numerous devices were available. The most likely source of ignition may have involved the propane torch that was being used by the Plumber in the basement area of 7527 Michigan Avenue.

6. 4 CSR 240-40.030(13)(Z)4. requires replacement of CI pipe if the support beneath the pipe is removed for a length of more than ten (10) times the nominal pipe diameter,[4] not to exceed six (6) feet, if permanent or temporary shoring or support was not installed to protect the pipeline during excavation and backfilling. No permanent or temporary shoring or support was used in this case. Therefore, the 4-inch CI natural gas main involved in this Report should have been replaced had Laclede been aware, or had knowledge that the seven-foot section of CI main was undermined.

[4] In this case, ten times the nominal pipe diameter would be 3-feet, 4-inches.

7. The current process for preparing the "Report of Street Leak F-712" form to document leak investigations requires that the gas-in-air measurements be taken and recorded at multiple areas of concern and possible migration; however, the physical location is only recorded for one of these measurements (the measurement used to originally classify the leak). This can lead to uncertainty regarding the location of the other recorded readings, and is especially of concern when the classification is later changed based on readings taken at a different location.

3.0 RECOMMENDATIONS

1. The Staff recommends Laclede continue its recently implemented practice of reviewing gas system maps in conjunction with Missouri One-Call locate tickets to determine if its CI mains may be adversely affected by third party excavations.

2. For situations where one or more CI main may potentially be located near or within a proposed excavation, the Staff recommends that Laclede contact each excavator and/or visit each excavation site to further determine what portion of the pipeline may require protection or replacement due to lying within an area of affected soil[5] or by having the support beneath the pipe removed for a length of more than ten (10) times the nominal pipe diameter not to exceed six (6) feet.

3. In conjunction with the Staff's Recommendation 2 above, the Staff recommends that when the excavation work near its CI mains is associated with installing new water service lines and taps to City water mains, Laclede obtain a set of drawings showing water line locations from the City and/or contact the City regarding each new installation.

4. In conjunction with the Staff's Recommendation 2 above, the Staff recommends that in the event that Laclede speaks with an excavator, Laclede should determine the dimensions and locations of each proposed excavation relative to each Laclede CI main.

5. In conjunction with the Staff's Recommendations 1-4 above, the Staff recommends that, if a determination is made that an excavation will involve the installation of one or more water main taps (for water service line connections) and that Laclede's CI gas main facilities may be adversely affected because of their proximity, an on-site investigation be made by Laclede for each of these types of excavations to determine the area of affected soil.

6. The Staff recommends that Laclede follow the guidelines from the "Guide for Gas Transmission and Distribution Piping Systems 2009 Edition" which will be amended in Addendum 1 to include additional information that operators of CI systems should communicate to builders, designers and excavators.

7. The Staff recommends that Laclede continue to develop and implement a program identifying all CI mains having a nominal pipe diameter of 6-inch and smaller that are in areas having a continuous covering (e.g. pavement, or concrete) from the CI main to building wall. Laclede's schedule for completing this work is August of 2009.

[5] As "area of affected soil" is defined in 4 CSR 240-40.030(13)(Z).

8. While evaluating facilities in conjunction with the soon to be finalized Integrity Management Program for Gas Distribution Pipelines (DIMP Rule)[6], the Staff recommends Laclede:

    A. Consider increasing the total annual amount of CI main replacements; and

    B. Assign a priority to 6-inch and smaller CI mains having a continuous covering from the CI main to a building wall.

9. The Staff recommends that Laclede record sufficient additional information when performing leak investigations (currently documented on the "Report of Street Leak F-712" form) to:

    A. Physically locate each significant reading so that the exact same location can be re-checked in the future; and

    B. Determine the extent of gas migration.

    Laclede has indicated in past discussions with the Staff that they are developing a new leak management system that will geographically reference leak locations within its GIS mapping system. If Laclede chooses to implement this recommendation by using the "Report of Street Leak F-712" form, then Staff recommends that, at a minimum, the physical location measurements also be recorded for each significant reading to ensure that the same location will be visited during the next re-check of the leak. The extent of the leak should be investigated and documented in a format similar to that used by Laclede titled "Ongoing Leak Survey Information."

10. The Staff recommends that Laclede inform its personnel who are involved in leak investigations of the circumstances related to this incident, with the intention of raising awareness that gas venting from an area undergoing construction is a special concern. Leak investigation personnel should be made aware of situations such as this one where gas is venting to the atmosphere from a gravel backfill area before a sidewalk is repaired, since repairs may prevent the gas from venting.

11. Laclede has revised its Excavation Safety brochure to communicate to excavators that precautions should be taken by excavators when the soil beneath a CI main is removed. The Staff approves of this revision, and recommends that Laclede further revise its

[6] The proposed DIMP Rule was published in the June 25, 2008 Federal Register. The DIMP Rule will amend 49 CFR Part 192 to require operators of gas distribution pipelines to develop and implement integrity management programs to enhance safety by identifying and reducing pipeline integrity risks.

Excavation Safety brochure to address potential situations where CI pipe lies within the area of affected soil and the soil is not necessarily removed from directly beneath the pipe.

12. The Staff recommends that Laclede be directed to file a response regarding these recommendations contained in this Case within 60 days of the filing of this report.

4.0 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.

4.1 The Incident

At approximately 10:56 a.m. CST on Tuesday, December 30, 2008, a natural gas ignition and resulting flash fire occurred within the basement area of 7527 Michigan Avenue in St. Louis, Missouri.

4.2 Personal Injuries

As a result of the natural gas flash fire, a plumber working inside of the basement area of 7527 Michigan Avenue was injured and chose to receive medical attention on December 30, 2008. The plumber received treatment for singed eyebrows and a burning feeling in his right eye, and was released from the hospital that same day.

4.3 Property Damage

A two-story commercial brick building at 7527 Michigan Avenue was undergoing a renovation project at the time of the incident. A portion of the wooden floor joists and flooring for the 1st floor of the building, as viewed from the basement area, received extensive fire and smoke damage in the vicinity of the southern basement wall. Some of the drywall covering the southern wall of the 1st floor also received fire, smoke, and water damage. The property damage to this two-story structure was originally estimated to be approximately $100,000 by Laclede. After receiving property damage information from the insurance company for the building owner on July 1, 2009, this estimate was reduced to $33,056.45. The cost to repair the damaged 4-inch CI main was calculated by Laclede to be $4,561.34.

4.4 Site Description

The building at 7527 Michigan Avenue is located near the northwest corner of the intersection of Michigan Avenue, Ivory Avenue[7] and Steins Street (see Appendix A-1, Photograph 1[8]). The front of the building faces approximately east towards Michigan Avenue. For the purpose of this Report, Steins Street is assumed to traverse along an east-to-west direction and Michigan Avenue is assumed to traverse in a north-to-south direction. The building located at

[7] Both City Street maps and Google identify this street as "Ivory Avenue", however the actual street sign identifies the same road as "Ivory Street". For this Report, "Ivory Avenue" has been used.

[8] All Photographs used in this report were provided by Laclede.

7527 Michigan Avenue is south of I-55, east of the River des Peres and north and west of the Mississippi River in St. Louis, Missouri (see Appendix B-1, Figure 1). The building at 7527 Michigan Avenue was undergoing renovations to make it a public bar that would require a fire sprinkler system and, other than the labor contracted to make the renovations, was vacant at the time of the incident. The surrounding area along 7527 Michigan Avenue is primarily a residential area with both single and multiple-story family residences.

4.5 Meteorological Data and Conditions

The weather reporting station located at Lambert St. Louis International Airport, in St. Louis, Missouri, located approximately 18 miles northwest of 7527 Michigan Avenue, recorded a high temperature of 66 degrees Fahrenheit (ºF), a low temperature of 29 ºF and an average temperature of 48 ºF on December 30, 2008.

During the time period from when the excavation along Steins Street (located south of 7527 Michigan Avenue) was opened on November 19, 2008 until when the excavation was backfilled and patched with concrete on December 24, 2008, the temperature ranged widely, from a high of 68 ºF on December 27, 2008 to a low of 4 ºF on December 22, 2008. Snowfall of 2.4 inches on November 30, 2008 and a total of 1.5 inches total for the month of December, 2008 was also recorded.

4.6 Natural Gas System

Natural gas service in the City of St. Louis is provided by Laclede.

Numerous natural gas facilities are located along Steins Street, Michigan Avenue, Ivory Avenue and Virginia Avenue (see Appendix B-2, Figure 2). The involved 4-inch cast iron (CI) natural gas main (just south of 7527 Michigan Avenue) was located approximately 8 feet south of the north curb line of Steins Street. This segment of 4-inch CI main was approximately 400 feet in length and it connected to another section of 4-inch CI main near the intersection of Steins Street, Michigan and Ivory Avenues. The involved 4-inch CI gas main was installed during the period of November 28, 1904 through December 3, 1904.

The 4-inch CI gas main was part of a low-pressure distribution system.[9] The Company's nearest low-pressure regulator station is located at Courtois Street and Pennsylvania Avenue. The pressure chart installed on the outlet of this regulator station indicated the operating

[9] MoPSC regulation 4 CSR 240-40.030(1)(B)16., defines a "low-pressure distribution system" as a distribution system in which the gas pressure in the main is less than or equal to an equivalent of 14 inches water column.

pressure range of the 4-inch CI gas main as 8 to 8.4 inches water column[10] (IWC; approximately 1/3 pounds per square-inch gauge (psig)) the day of the incident. The highest recorded pressure at this regulator station in the 6 months preceding the incident was 8.8 IWC.

The natural gas service line for 7527 Michigan Avenue was served by the 4-inch CI gas main along Steins Street and was not active at the time of the incident. The service was renewed on April 1, 1970 with a 1¼-inch coated steel service line, but was turned off and locked at a curb valve on August 11, 2005. A natural gas meter set was located inside the basement area of 7527 Michigan Avenue and the gas meter had also been turned off since August 11, 2005.

A 30-inch CI natural gas main was installed along Steins Street and was located south of the 4-inch CI gas main. This 30-inch CI gas main was operating at approximately 12 to 16 psig during the time period of December 28-30, 2008.

Other natural gas mains in the area include a:

- 12-inch low-pressure CI main installed along Virginia Avenue;
- 4-inch low-pressure CI main installed along Michigan Avenue that transitions to a 6-inch low-pressure CI main near the intersection of Steins Street, Michigan Avenue, and Ivory Avenue (the three streets); and
- 4-inch low-pressure CI natural gas main traversed along Ivory Avenue and terminated near the three streets.

4.7 Previous Company Actions

4.7.1 Odorization Records

Laclede conducts weekly odorant concentration tests[11] at various locations on both its transmission supply take points and its gas distribution systems. These odorization tests are conducted to verify the level of odorant to assure that consumers and the public are able to smell any leaking natural gas. A review of weekly odorant intensity readings taken at the location closest to 7527 Michigan Avenue for the 6 months prior to the incident indicated that

[10] Inches water column represents a unit of pressure measurement in which approximately 27.7 inches of water column is equal to 1 pound per square-inch gauge (psig).

[11] 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.

the natural gas was adequately odorized, and was readily detectable. During this time period the odorant intensity readings ranged from 0.32 percent (%) gas-in-air to 0.48% gas-in-air[12].

4.7.2 Past Leak Repairs on the 4-inch CI Gas Main along Steins Street

Other than the leak involved in this incident, no gas leaks due to CI main breaks or fractures occurred on the involved section of 4-inch CI gas main along Steins Street from Michigan Avenue west to approximately Virginia Avenue. A past CI main fracture did occur on a different section of 4-inch CI gas main across from 7423 Michigan Avenue (approximately 1 block north of 7527 Michigan Avenue). This CI natural gas main fracture was determined to be caused by soil settlement. This fracture was detected while investigating a publicly reported odor, and was repaired on December 1, 2008.

A total of five different gas leak repairs were made to the 4-inch CI gas main along Steins Street during the dates of: July 14, 1972; July 17, 1972; May 14, 1993; May 17, 1993, and May 19, 1993, respectively. All of these gas leaks were caused by leaking CI bell joints near the intersection of Michigan Avenue and Steins Street and all were repaired. The location of the 4-inch CI main repairs ranged from 65 feet west of the centerline of Michigan Avenue to 1-foot west of the centerline of Michigan Avenue. The pipe conditions observed during these repairs ranged from good to soft & pitted[13].

4.7.3 Leak Detection, Classification, Monitoring and Repair

Laclede identifies the approximate location of gas leaks on buried piping by using leak detection equipment above ground. Potential areas of leaking gas come to Laclede's attention by several means, including:

- Laclede conducts routine scheduled leak surveys over mains and service lines using gas detection equipment;
- leaks are sometimes found by Laclede service personnel in performing other pipeline operations;
- leaks are reported by members of the public calling in to report gas odors; and

[12] 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 of 4.5% gas-in-air.

[13] MoPSC regulation 4 CSR 240-40.030(9)(F), requires that whenever an operator has knowledge that any portion of a buried metallic pipeline has been exposed, the surface of the pipe must be examined for external corrosion. If the pipe has external corrosion, then remedial action under subsections (9)(R) through (9)(U) may apply.

- leaks are reported by fire or police departments.

For each leak found, Laclede assigns a Leak Control ID.[14] It should be noted that each Leak Control ID represents a detection of gas at a specific location, rather than the location of the defect in the piping which allowed the gas to escape. A single Leak Control ID therefore does not necessarily represent a single leak. For example, leaks on two different, but nearby mains were repaired in order to clear a single Leak Control ID located at 7604 Michigan Avenue on June 6, 2008. Conversely, gas may spread over a wide area from one leak in the pipeline, thereby contributing to detections of gas at multiple locations. This can result in several Leak Control ID numbers being assigned to a single leak. For example, the repair of a leaking bell joint on a 30-inch CI gas main at the intersection of Michigan Avenue and Steins Street on January 7, 2009 closed five Leak Control IDs.

After the leak has been rechecked and the gas readings are found to be zero (0 %), the leak is "closed". In many cases, this recheck is done following a repair to the piping. In other cases, the leak is "closed" following a routine re-check of the leak vicinity in which no gas is detected.

Laclede classifies leaks by taking measurements with a Combustible Gas Indicator[15] (CGI) in the vicinity of the reported leak. The CGI measures % gas-in-air. Specifically, readings are taken at an inside wall, over the main, in any nearby manholes, at an outside wall, in any nearby curb boxes, over the service line, along the curb, and other locations that may be appropriate to the leak investigation. These readings are recorded on a form ("Report of Street Leak F-712") then evaluated to classify the leak. A measurement description of a gas leak is only recorded for the location where the gas-in-air concentration obtained is responsible for the initial leak classification.

4.7.3.1 Previous Closed Leaks in the Vicinity of 7527 Michigan Avenue

In the eight months prior to the incident, seven Leak Control IDs in the vicinity of 7527 Michigan Avenue were closed after repairs were made to leaking CI bell joints on 30-inch, 6-inch and 4-inch CI gas mains.

[14] Laclede Gas Company assigns a unique Leak Control number for gas leaks that are found during routine leak surveys and for gas leak/odor calls. The Leak Control numbers help the Company to track and evaluate gas leaks so their required rechecks can be performed and to assure that a gas leak is repaired within the required timeframe.

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

In addition, a Class 2 leak[16] was found during a service line leak survey at the incident address on February 28, 2008 with 1% gas-in-air measured at the outside wall (5 feet west of the east house line and 1-foot south of the south house line) and 11% gas-in-air in a curb box[17]. The leak was classified based on the reading at the outside wall; therefore the recorded location is for this 1% gas-in-air measurement along the outside wall. The leak was rechecked on March 7, 2008, with 75% gas-in-air over a main on Steins Street, 0% gas-in-air at the outside wall and 1% gas-in-air at the curb box. Based on these readings, the leak was downgraded to a Class 3 leak[18]. However, since the original leak classification was based on a location along the outside wall, the location of the 75% gas-in-air measurement detected over the main was not updated and recorded. During the August 5, 2008 gas leak recheck at this address, no gas readings were detected and this leak was downgraded to a "No Leak" and was closed. As there were two natural gas mains on Steins Street (the 4-inch CI gas main along the north curb later involved in the incident and a 30-inch CI gas main along the south curb), and since Laclede only recorded measurements for the gas reading along the outside wall, it is not known if the readings taken over the main refer to the 4-inch or 30-inch CI main. In addition, the location of the curb box is not identified in the leak records.

4.7.3.2 Natural Gas Leaks in the Vicinity of 7527 Michigan Avenue that were Active at the Time of the Incident

At the time of the incident, there were ten active (not closed) Leak Control IDs near the intersection of Michigan Avenue, Steins Street and Ivory Avenue. Details of these Leak Control IDs are discussed in Appendix C.

[16] 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. A Class 2 leak must be rechecked every fifteen (15) days, until repaired, to determine that no immediate hazard exists. A Class 2 leak may be properly reclassified to a lower leak classification within fifteen (15) days after the initial investigation. Class 2 leaks due to readings in sanitary sewers, tunnels, or confined areas must be repaired or properly reclassified within fifteen (15) days after the initial investigation. All other Class 2 leaks must be eliminated within forty-five (45) days after the initial investigation, unless it is definitely included and scheduled in a rehabilitation or replacement program to be completed within a period of one (1) year, in which case the leak must be rechecked every fifteen (15) days to determine that no immediate danger exists.

[17] Leak Control ID 200803208.

[18] MoPSC regulation 4 CSR 240-40.030(14)(C)3., defines a Class 3 leak as a gas leak that doesn't 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 rechecked twice per calendar year, not to exceed 6 ½ months, until the facility is replaced.

Of these ten active Leak Control IDs, one[19] was located outside of the incident address, between the 4-inch CI gas main and the building wall facing Steins Street. At 3:55 p.m. on December 28, 2008, 85% gas-in-air was measured 7 feet south of the outside wall of 7527 Michigan Avenue in the loose gravel fill where a sidewalk section had been removed to install new water service and sprinkler system lines for the renovation. The leak was classified as a Class 2 leak. This leak was closed by the repair to the 4-inch CI gas main on Steins Street immediately following the incident and is discussed in greater detail in Section 4.10 of this report.

Of these ten active Leak Control IDs, one[20] located at the intersection of Steins Street and Virginia Avenue was classified as an active Class 3 leak on December 26, 2008 and subsequently closed when no gas was detected during the recheck on February 5, 2009.

The remaining eight Leak Control IDs were closed after the incident following repairs to one 30-inch CI bell joint, one 4-inch CI bell joint and one tapping sleeve to a steel service line. The nearest repair was approximately 55 feet from the building at 7527 Michigan Avenue. All of these repairs were completed between January 7 and January 13, 2009.

4.7.4 Past Incidents Resulting from Fractures on Laclede's Low-Pressure CI Mains

During the time period of 1963 to 1977, a total of five natural gas incidents that were attributed to circumferential fracture/breaks occurred on Laclede's low pressure 6-inch CI mains. A total of seven injuries occurred during these gas incidents with no fatalities reported. Four out of five incidents involved both backfill and soil settlement issues that had contributed to the failures; and graphitic corrosion was found to play a role in one. Two out of five had some type of continuous pavement from the CI main to a building wall.

In addition to the above incidents, on February 10, 1985, gas entered the basement of a residence located at 1350 Pierce Avenue, in St. Louis, Missouri and was ignited. The incident investigation concluded that the probable cause was gas originating from a fractured natural gas main adjacent to the residence. The main was a 6-inch low-pressure CI main, installed in 1959. Natural gas leaking from the main was prevented from venting to atmosphere by the street and sidewalk, and eventually migrated 13.5 feet to the basement wall of the residence of 1350 Pierce Avenue, entering through the basement wall. This incident resulted in approximately $34,000 in damages and three injuries; however, none of the injured required hospitalization.

[19] Leak Control ID 200816330
[20] Leak Control ID 200816264

On January 17, 1991, a natural gas explosion and fire occurred at 4324 North Taylor Street, in St. Louis, Missouri. Two people were injured as a result of the incident and the residence was considered a total loss. The probable cause of this incident was natural gas leaking from a fractured 6-inch CI natural gas main installed in 1949 that had migrated through the soil into 4324 North Taylor Street, accumulated and ignited. A contributing factor that caused the CI main fracture was stresses induced by surrounding backfill conditions at a location on the pipe weakened by graphitic corrosion.

On November 5, 1997, a natural gas explosion occurred at one unit of a duplex located at 5530 Dugan Avenue, in St. Louis, Missouri. The probable cause was natural gas escaping from a fracture in a 6-inch low-pressure CI main located near the duplex. The fracture was determined to be caused by a combination of graphitic corrosion, which had reduced the pipe wall thickness, and stresses that were induced by uneven soil settlement. The incident resulted in an injury requiring hospitalization and property damage estimated at $50,000.

4.7.5 Laclede's CI Main Replacement Program

Regulation 4 CSR 240-40.030(15)(D) became effective December 15, 1989 and required all Missouri operators with CI pipe to develop and submit a systematic replacement program. This regulation specifies that the program be prioritized to identify and eliminate CI piping that presents the greatest potential for hazard. On May 1, 1990, the Company submitted its initial Proposed Replacement Program for CI piping to the Staff. At the Staff's request, Case No. GO-91-275 was established to receive and consider the Company's CI main replacement program. The Company filed a revised CI main replacement program on June 21, 1993, and the Commission approved it on August 27, 1993. The approved replacement program contained three parts: a specific priority schedule, an on-going program, and a long-term program. At the end of calendar year 1989, the Company operated 1,031 miles of CI mains. By the end of calendar year 2008, this has been reduced by 167 miles (approximately a 16% reduction) to a remaining total of 864 miles of CI mains.

The Company prioritizes the CI pipe into categories that take into account all available information considering the CI pipe's condition and environment. This information includes, but is not limited to:

- Records of circumferential breaks;
- Remaining wall thickness of coupons taken during the repair of circumferential breaks;

- Angle of repose conflicts that meet replacement criteria;[21]
- Severe graphitic corrosion;[22]
- Non-circumferential breaks;
- Pipe condition reports of "Soft & Pitted" or "Deep Pits";
- Localized graphitic corrosion repair; and
- Pipe size (events listed above are given greater value if they occur on mains less than 6-inch).

Events listed above, except for circumferential breaks, that had occurred more than 10 years ago are given a lower value or priority when considering replacement.

To develop the CI main replacement program, the Company conducted an extensive records search of all historical fractures, updated its fracture maps and established a computer database to implement the program and track all leak repair and pipe condition reports on CI mains. The Staff monitors the program on an annual basis through a Company status report of its approved replacement program. Included in the status report is the footage of CI main replaced during the previous fiscal year[23]. The total CI main footage replaced for the most recent five years were as follows:

- FY 2008: 5.7 miles
- FY 2007: 8.4 miles
- FY 2006: 6.4 miles
- FY 2005: 4.8 miles
- FY 2004: 7.3 miles

[21] Angle of repose issues arise from pipes being placed in an "Area of Affected Soil" during an excavation or due to erosion. "Area of Affected Soil" refers to the area above a line drawn from the bottom of the excavation or erosion, at the side nearest the main, at a forty-five degree (45°) angle from the horizontal. If more than half the pipe diameter lies within the area of affected soil then actions must be taken as described by 4 CSR 240-40.030(13)(Z) 1. thru 4. For example, replacement of a CI main segment is required if the support beneath the pipe is removed for a length greater than 10 times the nominal pipe diameter, or the exposed portion exceeds six feet.

[22] Graphitic corrosion is the deterioration of gray cast iron in which the metallic constituents are selectively leached or converted to corrosion products leaving the graphite intact. It is sometimes also referred to as graphitization.

[23] Laclede's Fiscal Year runs from October 1 through September 30.

No maintenance activity had been reported on the involved section of CI main since 1993; therefore the 4-inch CI gas main along Steins Street between Virginia Avenue and Michigan Avenue was not scheduled for replacement prior to this incident.

4.7.6 Laclede's Inspections of Excavations Near CI Mains

In addition, as required by 4 CSR 240-40.030 (13)(Z)[24], Laclede's process for choosing which excavation site may involve an area of affected soil issue, or could potentially disturb the CI main support, typically involves an initial review of Missouri One-Call locate request tickets. A determination is made by the Laclede Civic Improvement Inspector as to which excavations will impact a CI main, and then the Civic Improvement Inspector makes every effort to visit the site. This work is divided into three districts, Central, South and North. There is a Civic Improvement Inspector for each district. The Central district is where the incident occurred. The table below summarizes the number of such inspections performed by Laclede during November and December of 2008 in the Central district.

Month in 2008	Number of inspections					% on CI
	Total	Ongoing projects	New from locates	CI[25]	Transmission Lines	
November	117	88	29	36	2	31 %
December	119	85	34	35	17	29 %
Total	236	173	63	71	19	30 %

Of the 71 inspections of work around CI mains conducted November through December 2008, 34 inspections were at an on-going project described as Filling & Soil Sampling, at the intersection of Espenschied Street and Reilly Avenue. The remaining 37 (about 18 per month) were at other locations in the Central District.

An excavation was started by a third party along Steins Street and just south of 7527 Michigan Avenue on November 17, 2008 (see Section 4.8 Missouri One-Call Locate Tickets for 7527 Michigan Avenue) for the purpose of accessing a 12-inch CI water main that was in close proximity to a 4-inch CI natural gas main. This excavation was not identified by the Company as an excavation that would require an on-site inspection based upon the information that was available, so no inspections were conducted. Based on past experience

[24] 4 CSR 240-40.030 (13)(Z) requires that when an operator has knowledge that the support for a segment of a buried CI pipeline is disturbed or that an excavation or erosion is nearby, the operator shall determine if the support has been disturbed to an extent that requires the pipe segment to be protected and/or replaced.

[25] Includes inspections at Espenschied Street and Reilly Avenue.

and the given street address, the Civic Improvement Inspector did not believe it would be necessary to excavate near the gas main in order to install the water service line or tap into the water main.

Also, Company personnel indicated that their understanding was that a water service installation would typically require a 3-foot by 5-foot size excavation. They also indicated that this size excavation would not place CI mains in the area of affected soil that may further require protecting or replacing disturbed CI mains. (See Section 4.12.3 City of St. Louis-Water Division: Required Excavation Size for Water Main Taps for the actual excavation size requirements.)

4.7.7 Laclede's Damage Prevention Program

Laclede is a member of Missouri One-Call System and has a separate Damage Prevention Department that is solely focused on damage prevention safety efforts and excavator training. Investigations of third party damages are conducted when they occur. The Company's Damage Prevention Program is directed at reducing third party damages and includes the following primary functions:

- Receiving, recording, and responding to Missouri One-Call excavation notifications;
- Investigating, documenting, and analyzing third-party damages in an attempt to determine what happened. The details of each dig-in damage are evaluated by the Company's Damage Prevention Department in an effort to establish the root cause of each damage; and
- Public awareness activities regarding damage prevention.

When considering which excavations may require on-site visits, the Company procedures require that particular attention shall be placed:

a) During and after excavation activities, on the possibility of joint leaks and breaks due to settlement when excavation activities occur near CI, threaded coupled steel, and oxyacetylene welded steel;

b) When a transmission line within a high consequence area is known to be exposed due to excavation activities;

c) When excavation is planned in proximity to any transmission line; and

d) When boring projects are identified and notice is provided by the Damage Prevention Department of boring projects planned by known boring contractors.

4.7.8 Laclede's Public Education Program for Excavators

On an annual basis Laclede mails an Excavation Safety brochure (brochure) to excavating contractors identified in the St. Louis metropolitan area. The Excavation Safety brochure:

- Provides information on how an excavator can identify the different color code markings used by locators for various underground facilities;
- Provides information on Chapter 319-Underground Facility Safety and Damage Prevention Act;
- Identifies various website locations that relate to both Damage Prevention and Natural Gas Safety;
- Gives safety tips on what to do and not to do if a gas leak is suspected; and
- Contains a description of the type of aboveground pipeline markers that the Company uses.

The March 2008 version of this brochure discusses the need for excavators to notify the Company anytime a gas line is scratched, bumped, or disturbed as a result of an excavation so that a future potential safety hazard may be prevented. The brochure did not specifically mention precautions that should be taken when working around CI natural gas mains, such as, trying not to remove the soil support (undermining) beneath a CI gas main.

Additionally, Missouri One Call, on behalf of Laclede, conducts a semi-annual mailing of excavation education materials to the same group of excavating contractors in the St. Louis area. The list of contractors is updated annually by Laclede.

4.7.9 Laclede's Previous Communication to Plumbing Contractor

Laclede sent its public education Excavation Safety brochure (letter format prior to 2008) to the Plumbing Contractor during each of the three years prior to the incident. Laclede Gas Company also provided the Plumbing Contractor's mailing address during these three years to Missouri One Call to receive semi-annual Missouri One Call excavator educational program mailings.

4.8 Missouri One-Call Locate Tickets for 7527 Michigan Avenue

An initial Missouri One-Call locate request was made by the Plumbing Contractor on November 13, 2008, for 7529 Michigan Avenue (see Section 4.1 above, this is the same location as 7527 Michigan Avenue). The locate ticket indicated that a new water service line would be installed for the General Contractor to serve 7527 Michigan Avenue. The

excavation work was scheduled to begin November 17, 2008. The locate ticket also indicated that the excavation depth required would be 10 feet and that no tunneling, boring, or explosives would be required, just a backhoe. The location description for the excavation site asked that all underground facilities be marked from the south side of the property to and including sidewalk and street. The nearest intersecting street for the locate request was defined as Steins Street.

On November 14, 2008, another Missouri One-Call locate request was made for the same address, but with an updated location description for the excavation work. The location description indicated that the excavation site was on the southwest corner of the above intersection. The description also asked to mark/locate the entire south side of the property to and including the sidewalk and street, and to also mark the entire west side of the property to and including the sidewalk and street.

Laclede responded to the locate request on November 17, 2008 and marked the location of its 4-inch CI natural gas main along with a 30-inch CI natural gas main and the steel gas service line that had served 7527 Michigan Avenue which was not in use at the time.

4.9 Laclede's Actions to Meet MoPSC Reporting Requirements

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

1. The initial telephone notification of a possible natural gas incident was made to a MoPSC Staff Member at approximately 12:55 p.m. on December 30, 2008[26].
2. At approximately 6:32 p.m. on December 30, 2008, after estimating the magnitude of the damage and the update of injuries to contractor 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 initially met the U.S. DOT-PHMSA Federal Incident reporting requirements because there was a release of gas from a pipeline that resulted in what was estimated to be more than $50,000 damage.
3. The PHMSA F 7100.1 form, as completed by the Company, was transmitted to the MoPSC on January 29, 2009. The Staff forwarded the report to the U.S. DOT-PHMSA on February 4, 2009.

[26] MoPSC regulation 4 CSR 240-40.020(4)(A), requires the operator to notify designated commission personnel by telephone within two hours following discovery, unless efforts to protect life and property would be hindered, for each event which meets the natural gas incident reporting requirements of this section.

4. On July 8, 2009, the Company submitted a supplemental report PHMSA F 7100.1 form with revised information concerning the property damage/loss estimate. This revision stated that the total damages were $37,617.79, which does not meet the U.S. DOT-PHMSA Federal Incident reporting requirements. However, the damage amount does meet the Missouri Public Service Commission Incident reporting requirements in 4 CSR 240-40.020(4).

4.10 Laclede's Actions in Response to Leak/Odor Calls and the CI Main Fracture

A public leak/odor call was received by Laclede's Dispatch Center on December 26, 2008 at 9:15 a.m. A person that was walking along Steins Street between Ivory Avenue and Virginia Avenue reported a gas odor to a nearby Laclede crew. The leak call was dispatched at 9:45 a.m. and a Leak Control ID[27] was assigned to a Service and Installation Department (S.A.I.D.) leak technician that responded. After conducting a leak investigation, the S.A.I.D. leak technician found 100% gas-in-air in the intersection of Steins Street and Ivory Avenue from a bar hole near a 30-inch, a 6-inch, and a 4-inch CI main. A 2% gas-in-air reading was obtained in a storm manhole. The responding leak technician noted a strong odor in the air and he could hear gas blowing in the street in existing bar holes[28] over one of the mains. No gas readings were reported near building walls at this intersection. The leak was initially classified as a Class 1[29] leak due to the blowing gas. The 100% gas-in-air reading was obtained at a location that was approximately 13 feet north of the south curb line of Steins Street and 9 feet east of the east curb line of Ivory Avenue. A Laclede Construction and Maintenance (C&M) crew was dispatched to the scene and from approximately 1:00 p.m. to 3:30 p.m. placed additional bar holes over the mains near the intersection of Steins Street and Ivory Avenue. The C&M Leak Truck Foreman from this crew documented a 100% gas-in-air reading over the 30-inch CI gas main near the middle of the intersection with a slight pressure and a slight gas odor in the air. This Foreman stated in an interview with the Staff (see Section 4.13.3) that the actual sustained gas reading was approximately 65-70% after opening some additional bar holes to pinpoint the location of the leak. The leak was then downgraded to a Class 3 leak after additional bar holes were placed in the street and after opening some existing bar holes to vent the gas. This downgrade was made after determining that the

[27] Leak Control ID # 200816251.

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

[29] 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. Class 1 leaks require immediate corrective action for public safety and to protect property.

criteria for a Class 1 or Class 2 leak were not met. This Foreman also stated that at this time the excavation on Steins Street had been covered with a steel plate and the sidewalk was backfilled with gravel. He checked for gas readings in holes in the steel plate and in the gravel, but did not detect any gas.

Another public leak/odor call was received by the Dispatch Center on December 28, 2008 at 3:13 p.m. A woman reported a gas smell near the northwest corner of Michigan Avenue and Steins Street as she was walking by. The leak call was dispatched at 3:17 p.m. and a Leak Control ID[30] was assigned to the S.A.I.D. leak technician that responded. After conducting a leak investigation, the S.A.I.D. leak technician found 85% gas-in-air at a distance of approximately 7 feet from the south building wall of 7527 Michigan Avenue. This gas reading was taken in some loose rock fill just north of the north curb line of Steins Street in an area where a concrete sidewalk had been removed during an excavation project. The location of this gas leak was described as 36 feet west of the west curb line of Michigan Avenue and 1-foot north of the north curb line of Steins Street. No gas readings were found at the south building wall for 7527 Michigan Avenue and no gas was detected within 5 feet of this building wall. Upon concluding his leak investigation, the S.A.I.D. leak technician classified the gas leak as a Class 2 leak.

On December 30, 2008, at approximately 11:06 a.m., a Laclede Service Representative received a report from an employee of the Plumbing Contractor that made the excavation along Steins Street of a possible incident at the intersection of Michigan Avenue and Steins Street (Michigan and Steins). A Laclede Dispatcher then notified a S.A.I.D. General Foreman at approximately 11:08 a.m. and two S.A.I.D. Supervisors at approximately 11:09 a.m.

A second Laclede Dispatcher then dispatched a S.A.I.D. Service Technician to the reported location at 11:09 a.m. The S.A.I.D. Service Technician arrived at the intersection of Michigan and Steins at 11:10 a.m. A C&M Leak Supervisor was notified at 11:11 a.m. by the first Laclede Dispatcher. After the C&M Leak Supervisor contacted a second C&M Leak Supervisor, a Leak Truck was dispatched at 11:19 a.m. to this location. The Leak Truck-Leak Crew Foreman and two Leak crew gas members arrived at the scene at approximately 11:20 a.m. While en-route, the second C&M Leak Supervisor notified a second Leak Truck in which another Leak Crew Foreman and two additional Leak crew gas members responded. The second C&M Leak Supervisor arrived at the scene at 11:30 a.m. The second Leak Truck with Laclede employees arrived at approximately 11:45 a.m. Additional Laclede C&M and S.A.I.D. personnel responded to the incident site between 11:45 a.m. and 1:00 p.m.

[30] Leak Control ID # 200816630

Upon arrival, the first responding S.A.I.D. Service Technician (the First Technician) notified the St. Louis City Fire Department of his presence on the scene. He then found fire department personnel working the fire inside of 7527 Michigan Avenue. The First Technician could not safely gain entry into the building at that time. While outside of the building, the First Technician noticed a slight odor of gas between the south side of the building wall and Steins Street. He then found the curb cock for the natural gas service line serving this building in the "off" position. He immediately began to conduct a leak investigation in the area of 7527 Michigan with a CGI and obtained a 92% gas-in-air reading at the south outside wall of the structure facing Steins Street (located 1-foot south of the south building line and 18 feet east of the west building line). He also obtained a 75% gas-in-air reading within a newly installed water valve box in the street just south of 7527 Michigan Avenue. The gas reading observed along the 4-inch CI gas main, just south of 7527 Michigan Avenue, was 40% gas-in-air. Additional gas checks were made on the east side of 7527 Michigan Avenue where 0% gas-in-air readings were obtained. He continued to survey the area and observed that additional gas-in-air readings were present near the southeast corner of the intersection of Michigan Avenue, Steins Street, and Ivory Avenue. A sanitary sewer in Steins Street just east of Michigan Avenue was also checked for gas and was found clear. Several bar hole readings were obtained near the southeast corner of this intersection (see Appendix B-2, Figure 2).

During this time, the Leak crew from the first responding Leak Truck arrived and immediately called Missouri One-Call for "Emergency Facility" locates and began assisting in the leak investigation, and also created additional bar holes in the street at various locations. A safety zone was established at 11:35 a.m. by evacuating residents and pedestrians from 7519 Michigan Avenue through 7529 Michigan Avenue. During this time, two additional S.A.I.D. Service Technicians arrived (Second & Third Technicians) and focused their leak investigation efforts on the intersection of Michigan Avenue, Steins Street, and Ivory Avenue and to the south and east along Ivory Avenue and Steins Street (see Appendix B-2, Figure 2). A C&M Leak supervisor then called at 11:38 a.m. to request that the utilities for 7527 Michigan Avenue be disconnected. Upon arrival of the second C&M Leak Truck at 11:45 a.m., both C&M Leak Truck crews on the scene began excavating the 4-inch CI natural gas low-pressure main on Steins Street where a recent excavation had been backfilled and patched with concrete.

A Laclede Claims Supervisor arrived at 12:10 p.m., but was not able to perform an inside investigation of 7527 Michigan Avenue until the telephone and electric utilities were disconnected at approximately 1:00 p.m.

While the Technicians were conducting their leak investigations, a C&M crew excavated a section of the 4-inch CI gas main along Steins Street in an area where a fresh concrete street patch was observed (see Appendix A-1, Photograph 2). The C&M crew found the 4-inch CI gas main had a fracture that extended around the entire circumference (see Appendix A-2, Photograph 3). After cleaning the CI pipe near the fracture, Laclede C&M personnel used a stainless steel repair clamp to seal the circumferential fracture at approximately 1:30 p.m., at which time the scene was determined to be safe and the fire department was released. During the subsequent leak investigations after the CI main repair on December 30, 2008, no gas-in-air readings were detected near the south building wall of 7527 Michigan Avenue.

A gas odorant intensity reading was taken by a Laclede Laboratory person at approximately 2:39 p.m., at a natural gas range inside of 7519 Michigan Avenue, Apartment 6. A readily detectable reading of 0.39% gas-in-air was obtained.

Bar hole surveys were then conducted by S.A.I.D. personnel until approximately 3:45 p.m. The job site was closed at approximately 4:20 p.m. on December 30, 2008.

During the first week after the leak repair to the 4-inch CI natural gas main had been completed, the Claims Department of Laclede received various e-mail correspondences and a letter dated January 6, 2009 from the Project Manager of the General Contractor. The Project Manager indicated that a strong odor of gas could still be detected at the work site (7527 Michigan Avenue) and due to safety concerns for the workers; the job site would remain closed as directed by the Safety Director of the General Contractor until the source of the gas leak was repaired.

The Company also received a gas leak call for 7527 Michigan Avenue on January 5, 2009. During the responding S.A.I.D. Service Technician's leak investigation, no gas readings (0% gas-in-air) were detected either inside or outside of the walls for 7527 Michigan Avenue. However, some gas-in-air readings were observed in the street near the southeast corner of the intersection of Michigan Avenue and Steins Street.

Beginning on January 7, 2009, other gas leak repairs were also made near the southeast corner of the intersection of Michigan Avenue and Steins Street (in the vicinity of 7527 Michigan Avenue) as discussed in Section *4.7.3.2 Natural Gas Leaks in the Vicinity of 7527 Michigan Avenue that were Active at the Time of the Incident* of this report.

On January 7, 2009, Laclede also abandoned in-place the previously repaired section of 4-inch low-pressure CI natural gas main along Steins Street that had fractured. The CI main was cut and capped at a location that was 5 feet 5 inches north of the centerline of Steins

Street and 1-foot west of the centerline of Ivory Avenue. This involved the abandonment of approximately 382 feet of 4-inch natural gas CI main. There were no other natural gas services on this section of CI main. A new plastic service line for 7527 Michigan Avenue was installed on April 24, 2009 by Laclede. The tap connection for this new service line was made from another segment of 4-inch CI main that was located along Michigan Avenue.

4.11 Proactive Measures Taken by Laclede as a Result of the CI Main Fracture

On February 4, 2009, three Damage Prevention Coordinators from Laclede presented Damage Prevention training to approximately 22 Supervisors and Project Managers employed by the General Contractor. The training presentation was titled "Damage Prevention…a shared Responsibility" and lasted 1 hour and included the following information and damage prevention topics:

- Laclede background information;
- The damage problem and recent examples of damages;
- The RSMo-Chapter 319 Underground Facility Safety and Damage Prevention Act and the 2009 changes to the law;
- The Missouri One-Call notification process;
- Description of Laclede's Operating Area and Districts (Central, North, and South);
- Laclede's Damage Prevention Program and aspects of its investigations;
- Laclede's Damage Prevention Department Contact List;
- Safety tips if a gas facility is damaged; and
- Tips for safer and more effective excavation.

Additionally, on June 17, 2009, the same Damage Prevention Coordinators from Laclede met with and provided a Damage Prevention presentation to the City of St. Louis-Water Division. The meeting was given to 42 people on two separate shifts beginning at 2:30 and 3:30 pm. Each session lasted about 1 hour. The presentation provided the following information:

- Laclede Gas Company's background, distribution system size, and customer base;
- Underground Facility Damage Problem-damage frequency;

- Missouri One Call System and the notification process;
- Laclede's Damage Prevention district map and contact list;
- Laclede's on site investigations and process;
- Laclede's participation in promoting public awareness of Damage Prevention;
- Immediate Action Safety Tips in the event of a gas line damage;
- Tips for safer and more effective excavation (i.e. hand digging, communication, white lining, and calling emergencies); and
- Angle of Repose issues when working around cast iron mains and notification of Laclede.

Since the December 30, 2008 incident, Laclede has revised their March 2008 version of its Excavation Safety brochure that is given to all excavators that have been previously identified by the Company. The following paragraph contains some of the damage prevention information that has been revised especially for the CI piping (the *italicized* font depicts the new section that was added during the January 2009 revision):

> Laclede Gas should be notified anytime a gas or propane pipeline is scratched, bumped or disturbed. A future potential safety hazard may be prevented if Laclede has the opportunity to inspect at the time of the occurrence. (In most cases, Laclede will not pursue inspection/ repair costs on disturbances that do not result in a leak.) *Special care needs to be exercised when working around cast iron pipes. Cast iron is a strong but brittle material that may break if the soil beneath it is disturbed or removed. For assistance when working around cast iron gas pipes, call (314) 342-0800.*

On May 1, 2009, the Staff met with Laclede Gas Company personnel to discuss certain questions relating to the incident and to gain a better understanding of what type of information is typically reviewed by the Civic Improvement Inspectors when they determine which excavation sites require one or more on-site visits.

During this meeting, the Central District Area Civic Improvement Inspector described the process used to select excavation sites for an inspection to determine whether the excavation may impact a CI natural gas main. As he described the process, typically, the Company has an average of 48 Missouri One-Call locate requests (locate tickets) per day in the Central District. After Laclede is notified and the locate tickets are given to the applicable supervisory personnel for each District to be worked, the Civic Improvement Inspector

typically gets a copy of the locate tickets the next day. He then sorts the locate tickets to decide if a visit is needed and a daily log of the sites visited is also kept. The following factors are considered when choosing which excavation sites to visit:

- Is the proposed excavation expected to be near the CI main?
- What type of work is being performed?
- Is a high-pressure gas facility involved?
- Is a high profile facility involved (e.g. transmission line)?
- Are any locates near the downtown area?
- Are any locates near a school or church?
- Past history with the given contractor/excavator, and
- Type of equipment being used by excavator.

For locate requests in high profile areas where there is a 20-inch or greater size Intermediate Pressure CI natural gas main, the locate requests are typically flagged for the attention of the Civic Improvement Inspector(s).

The Civic Improvement Inspector also explained to the Staff that about 95% of the time, the Company's gas mains are typically located on the south and east sides of the streets while the City's water mains are typically located on the opposite sides (north and west). He also explained that, for even numbered addresses, the gas mains normally have to be crossed when a water tap connection is made; while for odd numbered addresses, the gas mains typically do not have to be crossed since the water main is closer to the address that needs the water service.

For demonstration purposes, the Civic Improvement Inspector had a stack of Missouri One-Call locates that had been received on April 29, 2009. The Civic Improvement Inspector went through all of the locate tickets with the Staff to demonstrate the thought process for each. Out of a total of 41 Missouri One-Call locate request tickets, the Civic Improvement Inspector selected/pulled two locate request tickets to conduct on-site visits.

The majority of the locate tickets were examples of locations where either no gas facilities were involved ("all clears"), repairs to a water cover for a manhole (because it would be shallow work) were required, landscaping (in a yard) was involved, tree or shrub planting was involved, and soil sampling/testing (in which the consulting firms are usually taking soil samples well away from any underground facilities that have been marked/located).

During the conversation, the Staff learned that, for cases when a CI main may be in the path of an excavation or adjacent to it, the Central Civic Improvement Inspector is now using mainline gas maps and contacting excavators directly. This allows the Central Civic Improvement inspector to get a more accurate description of the excavation location to determine if the proposed excavation may adversely impact a CI gas main that is nearby.

4.12 MoPSC Staff Investigation

At the direction of the Assistant Manager-Gas Safety/Engineering, two Staff members traveled to the incident site on December 30, 2008. The Staff arrived at the incident site located at 7527 Michigan Avenue at approximately 4:30 p.m.

Upon arrival, the Staff met with a Laclede Gas Company-Claims Supervisor and a Laclede Incident Response Engineer.

The Laclede Claims Supervisor then showed the Staff where the Plumbing Contractor had previously made an excavation in Steins Street, just south of 7527 Michigan Avenue. The Plumbing Contractor had created the excavation so that a 1½-inch copper water service line and a 6-inch steel water line (sprinkler line) could be tapped into a 12-inch CI water main. The sprinkler line was being installed for the required fire sprinkler system for 7527 Michigan Avenue. The Laclede Claims Supervisor then explained that when the C&M crew excavated the Plumbing Contractor's concrete street patch along Steins Street, they found that the 4-inch CI natural gas main had fractured around the entire circumference of the CI pipe.

When the Staff arrived, the scene in the vicinity of 7527 Michigan Avenue had already been made safe and no emergency first responders, such as the fire department were present. The Staff did observe a Laclede C&M crew that was standing by. The Staff observed the open excavation along Steins Street, but the fractured section of 4-inch CI gas main had already been repaired by Laclede with a stainless steel repair clamp and the water main and other water related facilities were not visible. Due to this reason, the Staff was not able to view the actual fracture surface of the CI pipe (see Appendix A-2, Photograph 4).

The Claims Supervisor also showed the Staff the approximate location where an 85% gas-in-air reading was obtained on December 28, 2008 near the north curb of Steins Street and approximately 7 feet from the south wall of 7527 Michigan Avenue. On December 28, the gas reading was obtained in an area that had been previously backfilled with loose gravel as part of the excavation for the two water service lines (both the 6-inch steel sprinkler line and the 1½-inch water line) serving 7527 Michigan Avenue. During the Staff's on-site

investigation, the sidewalk area between this north curb line and the south building wall for 7527 Michigan Avenue had a new section of concrete that was recently poured.

Afterwards, the Staff, along with the Laclede Claims Supervisor and Incident Response Engineer, went inside of the basement area of 7527 Michigan Avenue.

4.12.1 Interior Observation of 7527 Michigan Avenue

Along the southern wall in the basement, the Staff observed two large openings in the foundation wall where the newly installed 1½-inch water service line and the 6-inch steel sprinkler line entered the basement wall (see Appendix A-3, Photograph 5). The backfill surrounding the water service line contained some large rocks along with gravel that had created some voids around the water piping. A window that had been boarded up was also observed along the south wall. The window appeared to be installed below street grade and slight singeing and burning was observed near the top of this window.

The Staff observed some singeing of some electrical wires near the 6-inch water flange that housed what appeared to be an electronic shut-off valve. A significant amount of burning and charring of wooden ceiling joist rafters (floor joists for the first floor) in the basement area were also observed. Most of the burning appeared to be near the ceiling level and east of where the water lines entered into the basement foundation wall. A section of the wooden ceiling (flooring for the first floor) appeared to be completed consumed by the fire in a location that was east of where the water lines entered into the basement.

On the first floor, the Staff observed various building and construction supplies along with various tools. In the area where a portion of the floor was missing, sheets of drywall were stacked and lying against the south wall and some of the exterior sheets of drywall had received fire, smoke, and water damage. Also, in an area just above where a portion of the floor was missing, the Staff observed a well defined v-pattern burn[31] along the south wall (see Appendix A-3, Photograph 6).

4.12.2 Exterior Observation of 7527 Michigan Avenue

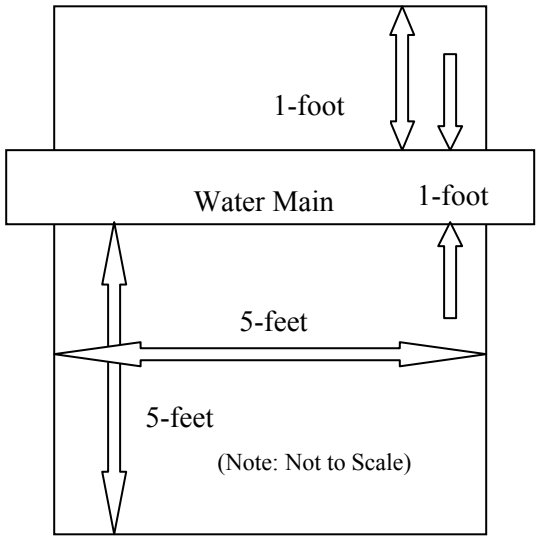
The front windows and entryway for 7527 Michigan Avenue (the side facing Michigan Avenue) were covered with wooden paneling. No evidence of explosion damage was observed for any sides of the structure. From the exterior, the Staff did not observe any obvious fire or smoke damage. The Staff did observe some broken window glass along the

[31] The v-pattern burn is a description of the up and out burning pattern of fire as it travels up and away from the point of origin. This produces a "V" pattern, hence its name.

southwest corner of the structure, but it was not known if this occurred during fire suppression activities or some other time.

4.12.3 City of St. Louis-Water Division: Required Excavation Size for Water Main Taps

The Staff reviewed some of the policies and requirements for both small and large service connections to water mains on the Water Division's web site. According to the June 2004 edition, Table 4-Size of Excavations, on page 21 requires an excavation to be 5 feet x 7 feet when a 1½-inch tap is necessary on a 12-inch water main (see the drawing below for a size description of this excavation).



5-foot x 7-foot Excavation Drawing

A 6-foot x 11-foot excavation is required for a 6-inch tap connection to a 12-inch water main. The smallest excavation required by the Water Division is for a 1-inch tap connection to a water main in the range of 6-inch to 12-inch and the size is 4-feet x 6-feet.

4.13 Witness Interviews

4.13.1 The owner of the Plumbing Contractor

The Staff interviewed the owner of the plumbing and excavation company (the Plumbing Contractor) for the project. He was also the individual who performed the excavation for the project and is hereafter referred to as the owner of the Plumbing Contractor. The Plumbing Contractor was responsible for all of the excavation and installation of the 1½-inch copper

water service line as well as backfilling of the excavated areas. The Plumbing Contractor was contracted by the General Contractor for the renovation work at 7527 Michigan Avenue. The Plumbing Contractor was also responsible for the concrete patch in the street, while the General Contractor was responsible for the concrete replacement of the sidewalk area near the south building wall of 7527 Michigan Avenue. The General Contractor contracted with a separate fire protection company (The Fire Protection Contractor) to install the 6-inch steel sprinkler line for the fire sprinkler system after the Plumbing Contractor completed the excavation.

On November 14, 2008, the owner of the Plumbing Contractor called in an updated Missouri One-Call locate request for the excavation that he was planning along Steins Street (see 4.8-Missouri One-Call Locate Tickets for 7527 Michigan Avenue, for further details). On November 19, 2008 the street to the sidewalk area located near the south wall of 7527 Michigan Avenue was excavated to access a 12-inch CI water main so that two taps could be installed. One tap was for the 1½-inch water service line and the other tap was for a 6-inch steel sprinkler line. Both water line facilities were being installed to serve the structure. As required by the City of St. Louis, Missouri, any water tap installation has to be made by the City of St. Louis Water Division, but only after certain permits and applications have been received and processed. The City of St. Louis Street Department is responsible for the review and approval of excavation permits that are required anytime a street has to be excavated. They also specify certain requirements for the type of backfill material that is used to repair a public street.

According to the owner of the Plumbing Contractor, Laclede had correctly located its 4-inch CI gas main. After saw cutting and removal of the street pavement and two sections of concrete sidewalk with a backhoe on November 19, 2008, the Plumbing Contractor used the backhoe and hand excavation techniques to open the excavation in the vicinity of both the water and natural gas mains along Steins Street. During the excavation, the CI gas line was not disturbed or damaged. The excavation included a portion of the sidewalk area, extending from the south wall of the building to the curb (approximately 10 feet) and from the curb, starting at about 2 feet from the curb and extending about 13 feet into the street. The excavation in the street was made about 7 feet wide (east-to-west direction along Steins Street) to accommodate both a 1½-inch water service line tap connection and a 6-inch steel sprinkler line tap connection for a fire sprinkler system. The Plumbing Contractor indicated that he had received a variance from the City to install both water taps in this size of excavation. The excavation was approximately 6 feet deep at the deepest point near the water main, and became shallower towards the curb. The 12-inch CI water main was 5 feet deep (from street level to top of main) and 11 feet south from the curb at the far end of the

excavation. The 4-inch CI gas main was located approximately 3 feet north of the water main and was installed at a depth of 3 feet from street level to top of main. Both water main taps and water services were installed approximately 2 feet below the CI natural gas main. The 4-inch CI gas main was excavated and totally exposed for the entire width of the ditch (approximately 7 feet) and was excavated 3 feet beneath the CI gas main

The sidewalk excavation between the south wall of the building and the curb was 10 feet wide by 10 feet long and approximately 5 feet deep. The street curb was not disturbed during the sidewalk excavation and was left in-place during the excavation process. Installation of the 1½-inch copper water service line was completed on November 24, 2008 by the Plumbing Contractor, and the Fire Protection Contractor completed the installation of its 6-inch steel sprinkler line on December 18, 2008. The reason for the time delay in completing the 6-inch steel sprinkler line was related to the Fire Protection Contractor not being able to obtain a timely permit for the installation. The Plumbing Contractor indicated that a heavy steel street plate and orange barrier signs were placed above the excavation during the time period when the Fire Protection Contractor was awaiting permit approval.

The excavation from the street to the sidewalk area was backfilled on December 18, 2008 with 1-inch clean gravel fill in accordance with the City of St. Louis Street Department regulations. On December 24, 2008, the St. Louis Street Department inspected the rock backfill in the street excavation as part of its permit approval process. After the inspection was completed and approved, the Plumbing Contractor patched the street with approximately 10 inches of concrete that same day (the sidewalk area had not been poured with concrete at this time). The Plumbing Contractor indicated that he was unaware of any problem, fracture, or damage to the 4-inch CI natural gas main when he made the excavation along Steins Street and then backfilled. He also indicated that he did not smell gas either before, or after, the excavation had been backfilled and patched with concrete.

The Plumbing Contractor indicated that at approximately 7:00 a.m. on December 26, 2008, workers arriving at the jobsite detected a strong odor of natural gas outside of 7527 Michigan Avenue. He indicated that Laclede Gas Company was notified about the gas odor and a Laclede employee was on site checking for the source of the gas odor. The responding Laclede employee spoke with another Plumbing Contractor employee as well as a Carpenter Superintendent for the General Contractor, telling them they had also received a complaint of a gas smell by a neighbor and were checking the whole block for the source.

The Plumbing Contractor indicated that he had questioned the Laclede employee on his leak findings and asked if he (the Plumbing Contractor) should be concerned about the possibility

of the gas leak being in the recent excavation in the street since it had just been backfilled and patched with concrete two days ago. The Laclede employee indicated that he was getting strong readings throughout the whole block and that he would notify the Plumbing Contractor when he found the gas source. The Plumbing Contractor also indicated that the Laclede employee told him that they have had problems with this gas line for years. He indicated that the Laclede employee also said that the gas main was very old and had been repaired numerous times in this area. As the Plumbing Contractor left the job site around noon, he talked to the Laclede employee one last time to ask if he had found the source of the gas leak. The Plumbing Contractor explained that the Laclede employee said not to worry that he was getting a stronger reading with his electronic leak detector across the intersection (approximately 100 feet away) than he was getting in the loose rock fill on the other side of the curb, in the non-concrete patched sidewalk area of our excavation.

On December 30, 2008 at approximately 9:00 a.m., the General Contractor poured a new concrete sidewalk from the north curb of Steins Street to the south building wall of 7527 Michigan Avenue.

Following the natural gas flash fire incident, the Plumbing Contractor was informed by Laclede that he was responsible for the 4-inch CI natural gas main fracture because of inadequate support while the CI pipe was undermined and then backfilled. Prior to the incident, the Plumbing Contractor indicated that he was unaware of any precautions or procedures required by Laclede for supporting CI pipe during an excavation.

4.13.2 Plumber (employed by the Plumbing Contractor)

The Staff interviewed a plumber employed by the Plumbing Contractor (the owner of the Plumbing Contractor's son) who was in the basement soldering a water valve on the 1½-inch copper water service line when the natural gas ignition and flash fire occurred.

The employee of the Plumbing Contractor indicated that he was in the basement area on the morning of December 30, 2008 with a couple of sprinkler fitters. The employee of the Plumbing Contractor was cutting a piece of copper pipe to patch the wall where the pipe had penetrated. The employee of the Plumbing Contractor had his propane torch running for about 5-6 minutes as he was "sweating off" a 90 degree elbow, then the natural gas flash fire occurred. The employee of the Plumbing Contractor also indicated that several potential ignition sources were available within the basement area and the first floor prior to the gas fire, such as, propane heaters, cigarettes used by some contractors, open flames from torches, air compressors, and electrical light switches.

The employee of the Plumbing Contractor indicated that he had not detected a strong smell of gas within the basement area, but that the smell of gas was strong outside of the building all week long. The employee of the Plumbing Contractor explained that most of the doors and windows were open that morning and that he was kneeling on the ground and did not smell gas inside of the basement area. The employee of the Plumbing Contractor had also observed that Laclede Gas Company had been out a couple of times checking for gas leaks prior to the flash fire.

4.13.3 Laclede C&M Leak Truck Foreman

The Staff interviewed the Laclede C&M Leak Truck Foreman (The C&M Foreman) involved with the leak investigation on December 26, 2008 for leak Control ID 200816251. The reading identified as "water other" 60% on the F-712 Report of Street Leak form was taken in the intersection of Steins Street and Michigan, nearer to Michigan than Ivory. The initial 100% gas-in-air value that was recorded over the main was taken over the 30-inch CI gas main. The actual sustained gas reading was closer to 65-70% gas-in-air, as opposed to the 100% value that was recorded on the form. The 5% gas-in-air reading detected "along the curb" was along the southeast curb of Steins, close to a water box. He also opened bar holes over the 4-inch CI gas main on Steins Street. He noticed the steel plate over the excavation in the street and took readings by sticking the wand of his CGI into holes in the steel plate and also into the gravel backfill in the sidewalk. He did not detect any gas in either location.

4.13.4 Laclede S.A.I.D. Service Technicians

The Staff interviewed three Laclede Service Technicians who responded to the incident and took gas-in-air readings, identified on Figure 2 of Appendix B as "First Responding S.A.I.D. Service Technician" (First Technician), "Second Responding S.A.I.D. Service Technician" (Second Technician) and "Third Responding S.A.I.D. Service Technician (Third Technician) based on arrival times at the incident. The Staff provided the Technicians with a draft drawing of Figure 2 from Appendix B, titled Plan View of the Incident Area for review.

The First Technician indicated that the 5% gas-in-air readings on Steins Street should be moved further west in the drawing and Figure 2 was revised accordingly by the Staff.

Regarding the F-712 Report of Street Leak form that the First Technician completed on December 30, 2008, he indicated that the 75% gas-in-air reading that was located at a "water stop box" actually referred to a water stop box in the street. The water stop box in the street was actually for the 6-inch steel sprinkler line that was installed to serve 7527 Michigan

Avenue. The water stop box in the sidewalk (just south of 7527 Michigan Avenue) was for the 1½-inch copper water service line.

Regarding the 40% gas-in-air over the main, the First Technician did not recall which natural gas main this referred to. The reading of 5% gas-in-air along the curb was located across the street from the alley, on the south side of Steins Street.

Questions were also asked of the Second and Third Technicians. Their responses were primarily limited to confirming/identifying the locations where bar-hole readings were taken.

4.13.5 Laclede C&M Leak Supervisor

The Staff interviewed a Laclede C&M Leak Supervisor regarding the actions taken to repair the leak on the 4-inch CI gas main. The C&M Leak Supervisor indicated that they broke out the concrete in the street just after the incident and observed a break in the CI gas main in about the middle of the excavation. The C&M Leak Supervisor indicated that the pipe was in good condition aside from the fracture.

5.0 ANALYSIS

5.1 Circumferential Fracture in the 4-inch CI Natural Gas Main

Cast iron, which is cast in a mold, is a general name given to several ferrous alloys containing about 2-4% carbon, about 1-3 % silicon, and lower concentrations of other alloying and impurity elements, e.g. manganese, phosphorus, and sulfur. Cast iron is no longer used for installation of new gas pipelines. The older cast iron pipe still in use can have variable remaining pipe wall thickness, due to factors including casting defects introduced during production and corrosion that has occurred during the time the pipe has been installed. Further, the microstructure of some cast irons (e.g. the graphite flakes in grey cast iron) contribute to an inherently low tensile strength in these materials. In addition, cast irons tend to be brittle, depending on the particular alloy. Pipeline materials currently installed by natural gas operators, such as steel and polyethylene plastic, have higher ductility and will deform plastically prior to rupture. In contrast, cast iron (CI) 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.

Some causes of stress-induced fracture of CI are: (1) vibration from a nearby source such as excavation equipment, blasting operations, traffic, demolition, or earthquakes; (2) settlement of surrounding soil due to backfill; (3) inadequate, or lack of, support for a CI main after the soil supporting the CI piping is removed (undermined) or disturbed; (4) downward forces imposed by heavy surface objects such as vehicles; (5) force from the freezing and thawing action of the soil; (6) force from the expansion and contraction of soils due to wet/dry cycles; and (7) any combination of these.

Based upon facts gathered from Section 4.13 Witness Interviews and data collected from Laclede Gas Company, approximately 7 linear feet of 4-inch CI gas main was exposed and then undermined to a depth of approximately 3 feet below the bottom of the CI main in the excavation along Steins Street just south of 7527 Michigan Avenue. On December 18, 2008 the excavation was backfilled with gravel by the Plumbing Contractor after two water taps and water service lines (one each of 6-inch steel and 1½-inch copper) had been installed to serve 7527 Michigan Avenue. Prior to the gravel backfill being poured into the excavation, no measures were taken by the Plumbing Contractor to provide support to the suspended section of 4-inch CI gas main.

On December 24, 2008, the top portion of the excavation containing both the water and natural gas facilities was poured with cement (concrete street patch after curing) by the owner of the Plumbing Contractor to a depth of approximately 10 inches.

As discussed in Section 4.13.3 of the Witness Interviews portion of the Report, a C&M Foreman was conducting a leak investigation near the intersection of Steins Street and Michigan Avenue on December 26, 2008. The C&M Foreman then opened some existing bar holes along Steins Street over a section of 4-inch CI main and no gas readings were detected. He then checked for gas beneath a steel plate covering a concrete street patch made over an excavation along Steins Street, just south of 7527 Michigan Avenue and no gas readings were observed. The C&M Foreman then checked for gas near the south building wall of 7527 Michigan Avenue where gravel had been used to backfill a previous excavation. No gas readings were detected as he sampled the atmosphere beneath the gravel.

A public reported gas leak/odor call was investigated by Laclede on December 28, 2008. A lady had reported smelling a gas odor near the northwest corner of Michigan Avenue and Steins Street while walking by. A Laclede S.A.I.D. Leak Technician responded to and investigated the leak call and obtained a reading of 85% gas-in-air located approximately 7 feet south of the south building wall of 7527 Michigan Avenue in some loose gravel fill where a sidewalk used to be located. The 85% gas-in-air reading was also located north of the north curb line of Steins Street in the vicinity of where the 6-inch steel sprinkler line and 1½-inch copper water service line had entered the south building wall of 7527 Michigan Avenue.

A fracture in the 4-inch CI gas main would have likely occurred sometime between December 26, 2008 (when no gas was detected in the gravel backfill of the un-patched sidewalk) and December 28, 2008 (when a gas reading of 85% gas-in-air was detected in the un-patched sidewalk just north of the north curb line of Steins Street). Since the 4-inch CI main was not supported in the excavation prior to the gravel backfill and the poured concrete street patch, the additional weight of the concrete (approximately a 7-foot x 10-foot x 10-inch slab) plus any additional weight from vehicular traffic would have resulted in downward loading forces that were distributed along the previously undermined 7-foot section of CI piping. Over a period of time, this external loading would have induced stresses that exceeded the yield point of the 4-inch CI piping until a stress-induced circumferential fracture occurred.

5.2 Natural Gas Escape and Migration

As previously discussed, on December 28, 2008, an 85% gas-in-air reading was obtained in the gravel area where a portion of the sidewalk had been removed. On this date, the natural

gas was venting through the gravel backfill and into the atmosphere. The gas was venting approximately 7 feet south of the south wall for 7527 Michigan Avenue in an area where both a 6-inch steel sprinkler line and 1½-inch copper water service line had been installed in an excavation to serve this building.

At approximately 9:00 a.m. on December 30, 2008, the General Contractor poured two new sections of concrete sidewalk over this excavation over the gravel backfill. Shortly afterwards (approximately 10:56 a.m.) a natural gas ignition and resulting flash fire occurred within the basement area of 7527 Michigan Avenue.

Natural gas is lighter than air and tends to migrate along paths of least resistance. Once the sidewalk was repaired by pouring the new sections of concrete, the venting of the natural gas to the atmosphere was restrained so the gas began to migrate underground. The gravel (nominally 1-inch size) that was used for the excavation near the south building wall of 7527 Michigan Avenue contains numerous voids and gaps since this material does not compact as well as soils. This would have provided an excellent path for the natural gas to migrate. The escaping natural gas would have migrated through the gravel and along any nearby underground utilities, such as, the 6-inch steel water line and the 1½-inch copper water service line that entered below grade into the south basement wall of 7527 Michigan Avenue.

The natural gas could have entered through one or both of the openings in the south basement wall of 7527 Michigan that were made for the 1½-inch copper service line and the 6-inch steel sprinkler line. Natural gas could have also entered through any available cracks or seams along the south basement wall. Natural gas may have also entered through the boarded-up window that was below grade since some burning and singeing marks were visible along the top portion of this window.

Once the natural gas entered into the basement area of 7527 Michigan Avenue, a sufficient amount of gas would have accumulated to form a flammable gas-in-air mixture that was at or above the lower-explosive limit of the natural gas. Since natural gas is lighter than air, the vast majority of the natural gas would have been near the ceiling area (beneath the first floor) of the basement for 7527 Michigan Avenue. Some of the gas would have also vented from the basement area through any openings, seams, or cracks in the first floor and along the south wall. The natural gas that accumulated inside of 7527 Michigan Avenue was then ignited by an undetermined source and a natural gas flash fire resulted.

5.3 Requirements for Protecting or Replacing Disturbed Cast Iron Pipelines

4 CSR 240-40.030(13)(Z)2. and 4. require that when an operator has knowledge that the support for a segment of the buried 8-inch or smaller CI pipeline is disturbed or that an excavation or erosion is nearby, the operator must determine how much, if any of the pipe must be replaced. This determination is to be based on the pipe diameter and the length of pipe which is unsupported. Pipe is considered to be unsupported if it is undermined (i.e. the soil beneath the pipe is removed) or if more than ½ of the pipe diameter lies within an "area of affected soil". The "area of affected soil" is generally considered the area above a line drawn from the bottom of the excavation or erosion, at the side nearest the main, at a forty-five (45º) angle from the horizontal[32].

4 CSR 240-40.030(13)(Z)4. requires that the unsupported pipe be replaced unless any of the following conditions exist:

1. The support beneath the pipe is removed for a length of less than ten times the nominal pipe diameter not to exceed six feet;

2. For parallel excavations, the pipe lies within the area of affected soil for a length of less than ten times the nominal pipe diameter not to exceed six feet;

3. The excavation is made by the operator in the course of routine maintenance, such as leak repairs to the main or service line installation, where the exposed portion of the main does not exceed six feet, and the backfill supporting the pipe is replaced and compacted by the operator; or

4. Permanent or temporary shoring was adequately installed to protect the cast iron pipeline during excavation and backfilling.

The involved 4-inch CI natural gas main was undermined for a length of 7 feet. There was no permanent or temporary shoring installed during excavation and backfilling; therefore replacement would have been required under the regulations, if the Company had knowledge that the pipeline had been disturbed or that an excavation or erosion was nearby.

As discussed in Section 4.7.6, while the Company had knowledge that there would be an excavation in the vicinity of its CI main, its past experience indicated that because the street address was an odd number, the water main should lie on the opposite side of the street and closer to the building than the gas main. The Company therefore did not expect that the

[32] A lesser angle should be used for sandy or loose soils, or a greater angle may be used for certain consolidated soils if the angle can be substantiated by the operator.

excavation would disturb or affect the supporting soil beneath its CI mains. The Staff therefore does not believe that the Company had knowledge that the support for their CI pipeline had been disturbed, or that an excavation would be made in close proximity that would place its CI main within the "area of affected soil".

5.4 Damage Prevention and Excavator Education

Missouri Revised Statutes (RSMo) Chapter 319.041 of the "Underground Facility Safety and Damage Prevention Act" requires any person making any excavation to do so in a careful and prudent manner. In this case, the excavator served notice of intent to excavate to the notification center as required by RSMo Chapter 319.036. The Company correctly located its 4-inch CI gas main. The excavator used hand excavation techniques to open the excavation in the vicinity of both the water and natural gas mains. There is no evidence to suggest that the involved 4-inch CI gas main was damaged during excavation.

When CI is disturbed, additional precautions are needed to support or replace unsupported sections as discussed above in Section 5.3. In this incident, the CI pipe was not supported by installation of temporary shoring during excavation and backfilling. The Excavator (the Plumbing Contractor) indicated during an interview with the Staff that prior to the incident; he was unaware of any precautions or procedures required by Laclede for supporting CI pipe during an excavation. (See the Witness Interview in Section 4.13.1.)

Since the incident, Laclede has revised its Excavation Safety brochure to include a precaution to excavators when working around CI gas pipes, and cautions that a CI pipe may break if the soil beneath it is disturbed or removed and provides a phone number where excavators can call for assistance as discussed in Section 4.11. The Staff believes that some additional language is needed to address potential situations where the pipe lies within the area of affected soil; however the soil is not necessarily removed from directly beneath the pipe.

5.5 Laclede's Inspection/Monitoring Program for Cast Iron Mains

Prior to this incident, the Staff believes that Laclede was relying on its past field experience to help identify which Missouri One-Call locate requests may involve an excavation for a water service line that could place its CI mains in an area of affected soil. In general, the information that is recorded on the locate request tickets can be very vague at times and doesn't necessarily define the size of an excavation, the exact location of the excavation in relation to other underground utilities, and whether one or more water taps will be installed.

For this particular incident, the initial Missouri One-Call locate request made on November 13, 2008 by the owner of the Plumbing Contractor did indicate that a new water service line

would be installed, however, the updated locate request ticket for November 14, 2008 made no mention of the need to install a second tap for a 6-inch steel sprinkler line. This updated locate request asked to mark the entire west side of the property to and including the sidewalk and street in addition to marking the south side of the property to and including the sidewalk and street.

The Civic Improvement Inspector's decision to not inspect/monitor the excavation south of 7527 Michigan Avenue was based on an assumption involving his past experience that the gas main and water main are located on opposite sides of the street and because the street address was an odd number, the water main should lie closer to the building than the gas main. The Company therefore did not expect that the excavation would disturb or affect the soil supporting its CI mains

5.6 Gas Leak Investigation and Classification Procedures

Review of the leak investigation reports in this vicinity for the time frame preceding the incident has raised two concerns.

The first concern is that, when documenting a leak on a "Report of Street Leak F-712" form, a measurement description of the gas leak is only recorded for the location where the gas-in-air concentration obtained is responsible for the initial leak classification (see Section 4.7.3). As discussed in Section 4.7.3.1, a leak was discovered during a service line leak survey at 7527 Michigan Avenue and was classified as a "Class 2" leak because of a 1% gas-in-air reading at the outside wall of the building. The leak was subsequently downgraded to a "Class 3" leak because no gas was detected at the outside wall of the building; however, a 75% gas-in-air reading was measured over a main on Steins Street. The physical location of this reading was not recorded.

This is of concern because if the reading had been within 15 feet of a building, the leak would still have been a Class 2 leak.[33] Since the leak was classified as a Class 3, we assume that the 75% gas-in-air reading "over main" was taken at a distance greater than 15 feet away from a building wall. The Staff recommends that the actual distance be measured and documented. In addition, leaks must be rechecked according to classification requirements in 4 CSR 240-40.030(14)(C). In this case, there were two natural gas mains located along Stein Street: a 30-inch and a 4-inch CI main. By not recording where the 75% gas-in-air reading was observed during the March 7, 2008 investigation, Staff could not be certain that the same location was

[33] 4 CSR 240-40.030(14)(C)2 directs that any reading over 50% gas-in-air located 5 to 15 feet from a building is a Class 2.

checked during the August 5, 2008 recheck in which the leak was downgraded from a "Class 3" to a "No Leak" and therefore closed.

The second concern is that on December 28, 2008, two days prior to the incident; a publically reported leak was investigated near the incident address by a Laclede Service Technician (see Section 4.10). At this time, the excavations in the Steins Street and the sidewalk adjacent to 7527 Michigan Avenue had been backfilled with gravel, and the street had been patched with concrete. The sidewalk had not yet been patched with concrete. The Laclede Service Technician recorded a reading of 85% gas-in-air in the gravel backfill in the sidewalk at a distance of approximately 7 feet from the south building wall of 7527 Michigan Avenue. It is believed that at this time, the 4-inch CI main had already fractured (see Section 5.1) and that the escaping gas was venting from the un-repaired sidewalk (see Section 5.2). It is possible that this incident could have been avoided if it had occurred to the investigating Service Technician that pouring the two new sections of concrete to repair the sidewalk would create a situation that could impair the venting of natural gas to the atmosphere; and if the Service Technician then notified appropriate Company personnel to further investigate and repair the leak or abandon the main before allowing the sidewalk repair work to continue.

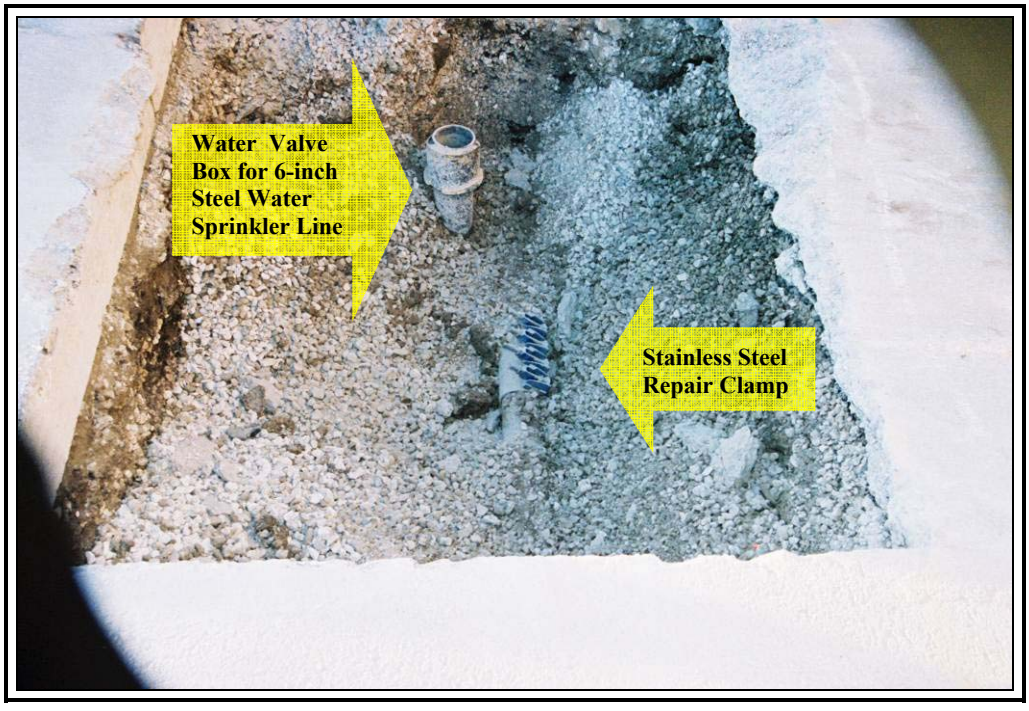
APPENDIX A

PHOTOGRAPHS
(All Photographes Provided by Laclede Gas Company)

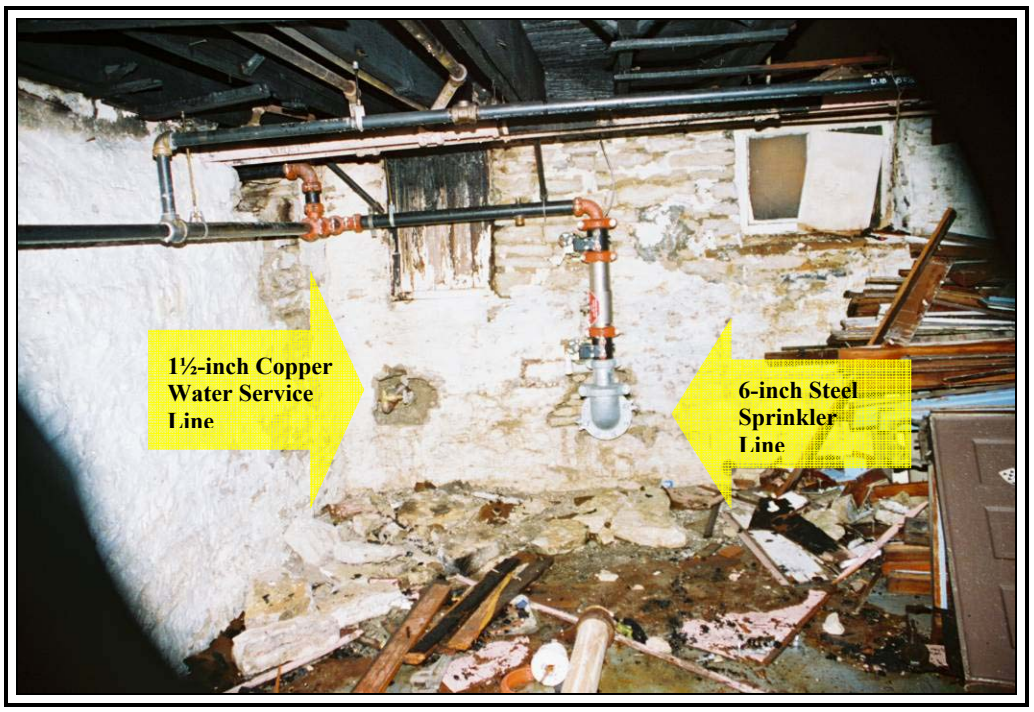
Photograph 1 View looking approximately north toward the south wall of 7527 Michigan Avenue. The structure was undergoing renovation for a public bar and the front side was boarded up.

Photograph 2 View looking approximately to the east at the south wall of 7527 Michigan Avenue. The pavement in the street along Steins Street was broken in this location to access the Company's 4-inch natural gas CI main. Observe the freshly poured concrete sidewalk in the foreground along the south wall of 7527 Michigan Avenue.

Photograph 3 View looking inside of the excavation along Steins Street after the concrete patch for the street was removed on December 30, 2008. Observe the fracture area around the circumference of the 4-inch natural gas CI main.



Photograph 4 View looking approximately to the west at the excavation in Steins Street. A stainless steel repair clamp was placed around the circumference of the 4-inch natural gas CI main to seal the leaking fracture area. The standpipe to the left of the natural gas CI main served as a valve box for a 6-inch steel water sprinkler line. A 75% gas-in-air reading was obtained at this water valve box location by the first responding S.A.I.D. Leak Technician on December 30, 2008.



Photograph 5 View looking towards the south interior basement wall of 7527 Michigan Avenue where the 1½-inch copper water service line (to the left) and 6-inch steel sprinkler line entered. Note the burn damage to the wooden floor joists and the first floor flooring above.

Photograph 6 View looking approximately to the southwest at the south wall of the first floor room inside of 7527 Michigan Avenue. A portion of the floor (located between the two stacks of sheet rock that were placed against the wall) was removed during fire suppression activities and a portion appeared to have been consumed by the fire. Observe the v-pattern burn that appears along the wall and above the opening in the floor.

APPENDIX B

FIGURES

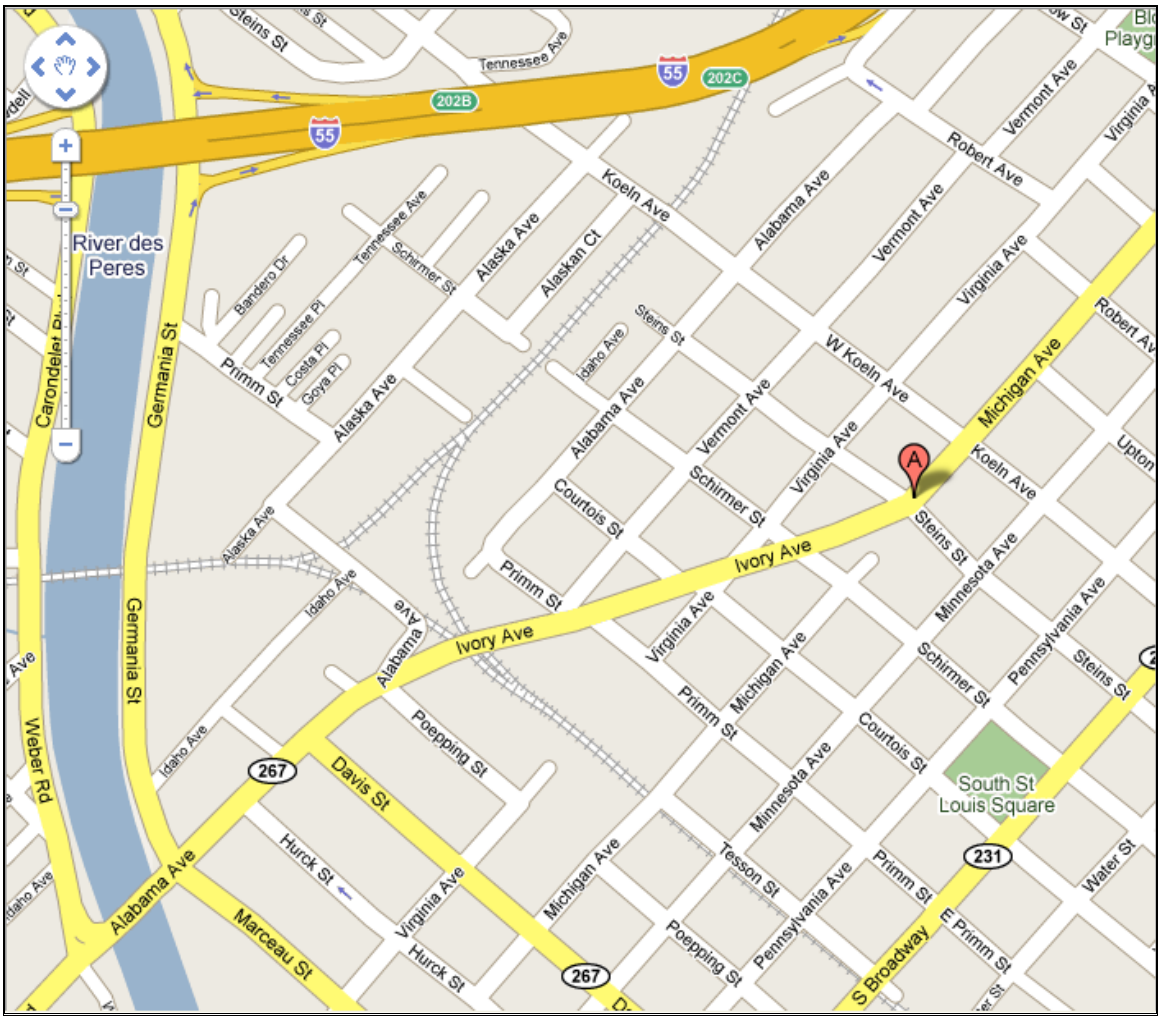


Figure 1-Plan View of Incident Site Location (Map provided by Google Maps-"A" denotes the approximate location of 7527 Michigan Avenue).

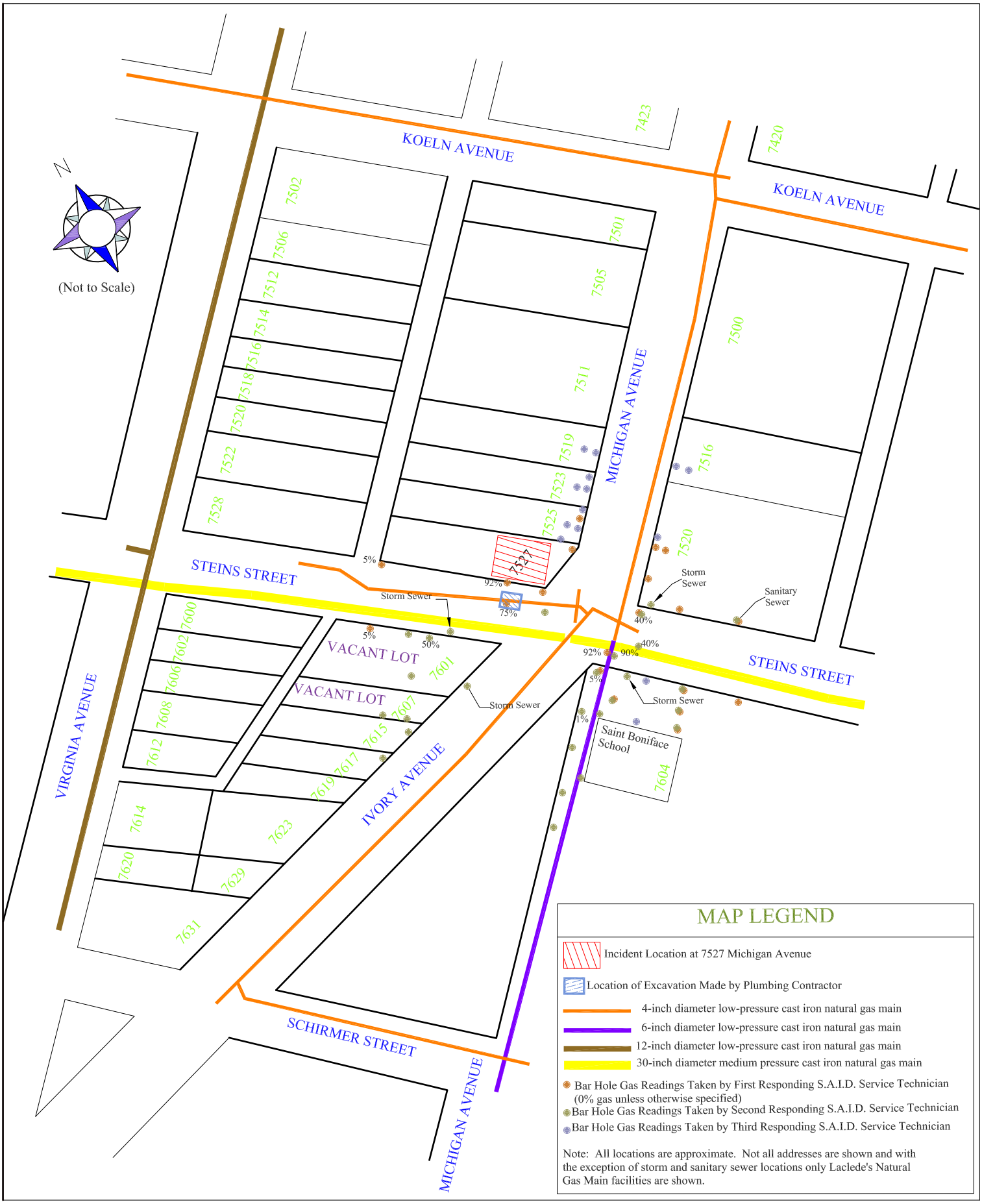


Figure 2

Plan View of the Incident Area

Appendix B-2

APPENDIX C

LEAK CONTROL ID DETAILS

Other Nearby Leaks that were Active at the Time of the Incident

- Steins & Michigan (Leak Control ID #200816330). This leak was reported by the public on December 28, 2008. At 3:55 p.m. on December 28, 2008, 85% gas-in-air was measured 7 feet from the south wall of 7527 Michigan Avenue in loose gravel fill where a section of concrete sidewalk had been removed for the installation of two different water service lines. The leak was classified as a Class 2 leak. Repair by installing a clamp over the leak on the 4-inch CI main along Steins Street immediately following the incident on December 30, 2008 closed this leak.

- Intersection of Michigan and Stein (Leak Control ID #200804491). This gas leak was found during a routine leak survey of the gas mains on March 21, 2008. It was an active Class 3 leak at the time of the incident. On March 21, 2008, gas readings of 57% gas-in-air over a main, 99% gas-in-air in a water valve box, and 3% gas-in-air along a curb were found. During the Class 3 leak recheck on August 5, 2008, 15% gas-in-air was detected over a main, 7% gas-in-air in a water valve box, and 2% gas-in-air along a curb. This leak was closed on January 7, 2009 following the incident by a repair (Leak Control ID #200802069) to a leaking bell joint on the 30-inch CI natural gas main near this intersection.

- Intersection of Michigan and Steins (Leak Control ID #200802069). This leak was reported by the public February 7, 2008. It was an active Class 3 leak at the time of the incident. The leak report for this location on February 7, 2008 recorded 35% gas-in-air over a main, 20% gas-in-air at the curb. On August 5, 2008, readings of 39% gas-in-air over a main and 4% gas-in-air at the curb were reported. The leak was repaired by installing a 30-inch bell joint clamp on January 7, 2009.

- Intersection of Michigan and Steins (Leak Control ID #200807301). This leak was reported by the public on May 14, 2008. It was an active Class 3 leak at the time of the incident. The leak report for this location on May 14, 2008 indicated no access on the inside wall, main "under street" – no reading. 91% gas-in-air along curb, 55% gas-in-air "in street". During the August 5, 2008 gas leak recheck, 15% gas-in-air was found over a main, 25% gas-in-air along the curb and 7% gas-in-air in a water box. This leak was closed out under Leak Control ID #200802069 on January 7, 2009.

- Intersection of Ivory and Steins (Leak Control ID #200816251**).** This leak was reported by the public on December 26, 2008. The leak report indicates a "yes" for "did you hear or feel gas blowing" at 9:45 a.m. on December 26, 2008, and the leak was initially classified as a Class 1. At that time, 100% gas-in-air was measured over a main, 2% gas-in-air in a storm

water manhole, 5% gas-in-air along the curb and 10% gas-in-air in a water valve box. The leak report for 3:15 p.m. that same day indicates that all bar holes in the street were closed or opened and additional bar holes were placed in the street to vent the gas. Afterwards, the gas leak was downgraded to a Class 3. This later report indicates that 100% gas-in-air was measured over a main, 5% gas-in-air along a curb and 60% gas-in-air was measured in a water manhole. This gas leak was subsequently closed out after a repair was made under Leak Control ID #200802069 on January 7, 2009.

- Intersection of Ivory and Steins (Leak Control ID #200805965). This gas leak was found during a routine leak survey of mains on April 18, 2008. It was an active Class 3 leak at the time of the incident. On April 18, 2008, a gas reading of 94% gas-in-air was obtained near this intersection in the street over a main. Additional gas readings of 77% gas-in-air along a curb and 98% gas-in-air in a water valve box were also obtained. A gas reading of 0% gas-in-air was obtained in a storm sewer manhole. A gas leak recheck was made on August 5, 2008 and 15% gas-in-air was observed over the main and 2% gas-in-air along a curb. No gas was detected in the storm sewer. This gas leak was repaired under Leak Control ID #200802069 on January 7, 2009. A 30-inch bell joint clamp was found leaking. The old clamp was removed and a new one was installed to repair the leak.

- 07615 Ivory (Leak Control ID #200804469). This gas leak was found during a service line leak survey on March 21, 2008. It was an active Class 3 leak at the time of the incident. During a leak recheck on August 5, 2008, the leak remained a Class 3, with readings of 14% gas-in-air measured along the curb. It was repaired January 12, 2009 by repairing a bell joint on a 4-inch CI main. The primary cause of the leak is listed as other, with settlement listed as a contributing cause. The pipe condition is listed as good.

- 07615 Ivory (Leak Control ID #200815443). This leak was reported by a Laclede Service Technician on December 5, 2008. It was an active Class 3 leak at the time of the incident. On December 5, 2008, 95% gas-in-air was detected over the 4-inch CI main along Ivory Avenue. On February 2, 2009, after a leak repair was made under Leak Control ID #200804469 above, residual gas readings of 3% gas-in-air were found over the 4-inch CI natural gas main and 1% gas-in-air at the curb.

- Intersection of Koeln and Michigan (Leak Control ID #200804492). This leak was found during a routine leak survey of gas mains on March 21, 2008. During a leak recheck on August 5, 2008, 8% gas-in-air was measured along the curb, 8% gas-in-air was measured in a water box and 94% gas-in-air was measured over a gas main. This gas leak was repaired on

January 13, 2009. An old tapping sleeve to a steel service line was leaking. The tapping sleeve leak was repaired using a stainless steel clamp. The primary leak cause was listed as "Other", with "Other" listed as a contributing factor. Pipe condition was listed as good.

- Intersection of Steins and Virginia (Leak Control ID #200816264). This leak was called in by police or fire department and was initially classified as a Class 3 leak on December 26, 2008. The leak was closed after a recheck on February 5, 2009 resulted in zero gas readings.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Laclede Gas Company concerning a Natural Gas Incident at 7527 Michigan Avenue in Saint Louis, Missouri.	))))	GS-2009-0270

AFFIDAVIT OF KATHLEEN A. MCNELIS

STATE OF MISSOURI)
) **ss**
COUNTY OF COLE)

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

KATHLEEN A. MCNELIS

Subscribed and affirmed before me this 15th day of July, 2009.

NOTARY PUBLIC STATE OF MISSOURI NOTARY SEAL

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

NOTARY PUBLIC

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Laclede Gas Company concerning a Natural Gas Incident at 7527 Michigan Avenue in Saint Louis, Missouri.	))))	GS-2009-0270

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 15th day of July, 2009.

NOTARY PUBLIC STATE OF MISSOURI NOTARY SEAL

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

Susan L. Sundermeyer
NOTARY PUBLIC