Methane Emissions Project

Borough of Versailles, Pennsylvania

Attachment I

FIELD STUDY

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Prepared for

National Energy Technology Laboratory

By

Research and Development Solutions, LLC (RDS)

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Cover Photo: Versailles, PA, circa 1920 (Photo courtesy of Mrs. Josephine Cindric).

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1.0 Summary

1.1 Background

Versailles is a Borough located in southwestern Pennsylvania, in Allegheny County, and southeast of the city of Pittsburgh (Figure 1). It is bordered to the north and east by the City of McKeesport and to the south and west by the Youghiogheny River. The 2000 census reported the population of Versailles as 1724. Since the 1960's, the Borough has had problems with stray hydrocarbon gas leaking from abandoned and improperly plugged gas wells. As a result, some residents have been forced to leave their homes or businesses until the stray gas problem entering their structures was eliminated, and sometimes the structures were condemned as uninhabitable.

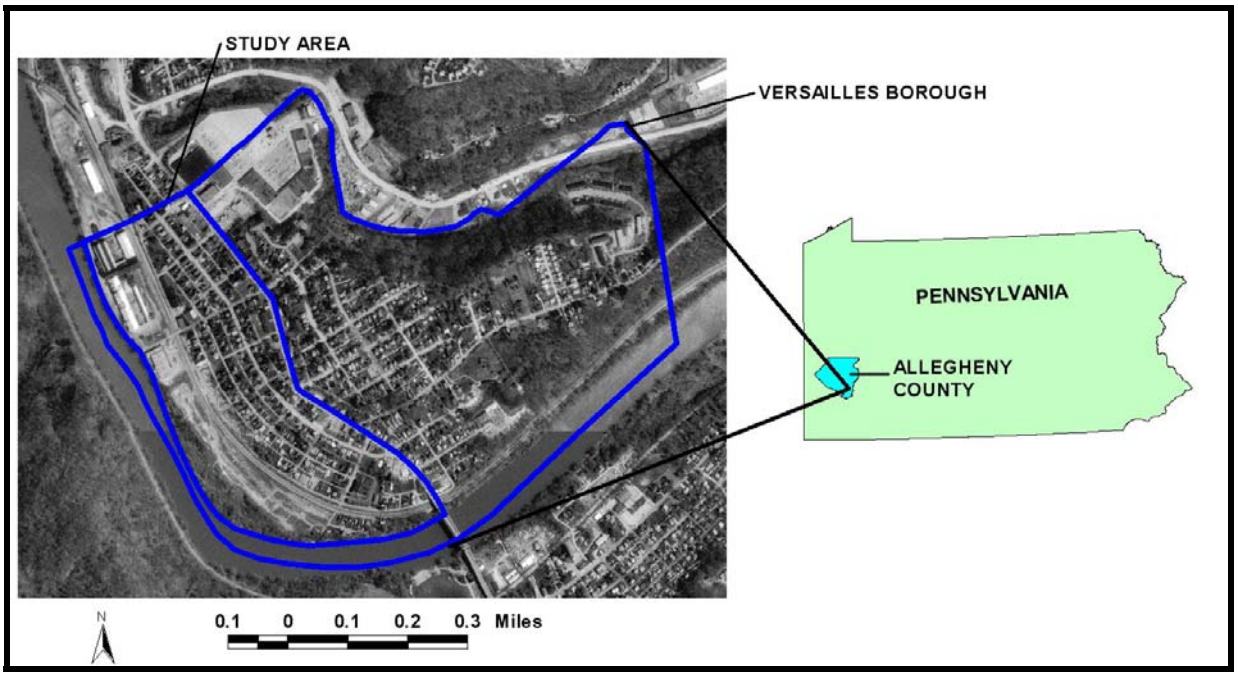

Figure 1. Location map for Versailles showing the extent of the Borough and study area.

During the period from 1919 through 1921, over 600 wells were drilled as part of the McKeesport Gas Field. The big gas boom of the time saw interests in wells being bought and sold on the street corners of Versailles Borough and neighbor pitted against neighbor as each tried to be the first to get the gas underlying their property. As a result, over 175 wells were drilled in the Borough of Versailles. Some were non-productive and were abandoned without placing casing (steel pipe) in the wells. Others produced for only a few years as over-drilling and over-production rapidly depleted the reservoir. These wells were cased, but were left abandoned and unplugged after production ceased. The call for steel as part of the war effort during World War II caused a renewed interest in the Versailles Borough wells – not in production, but in removing the portions of the abandoned steel casings that could be removed (the internal casing, rather than the surface conductors, which contact the surrounding strata, and generally could not be removed) and the wellheads (the well pipes and ground valves associated with the well).

Again the wells were left abandoned and unsealed, but this time there was often nothing left at the surface to mark the wells. This left three type of abandoned wells in Versailles Borough – wells without any casing, wells with only the surface conductor casing left, and wells with the surface conductor and some of the original production casing. Construction boomed after the war as soldiers returned to work and start families. Homes and businesses were built adjacent to or over the now uncased and open wells.

In the same area, mining of the Upper Freeport coal seam began during 1924 at the Hubbard Mine. The vertical mine shaft was located just north of Versailles Borough and mining occurred east of the Borough with the mine mains running under Long Run Road. Several explosions in the mine demonstrated the high methane gas content of the Upper Freeport coal seam. Air was circulated and water was pumped from the mine during mining operations to help degasify and dewater the mine. These operations ceased when the mine closed in the early 1960's. Shortly after the mine closed, Versailles Borough had its first reported problem with methane gas entering a structure. Since then, there have been several incidents involving methane gas entering structures. As a result, utility companies have turned off gas, electric, and telephone services due to public safety and company liability concerns. Residents and businesses have been forced to correct the situation at their own expense or move out of the structure.

In 2005, U.S. Representative Mike Doyle, Democrat, Pennsylvania's 14th District, secured federal funding for a study to determine how to potentially eliminate the threat to public safety presented by stray natural gas leakage in the Borough of Versailles. Because of its expertise in geological science, the U.S. Department of Energy's National Energy Technology Laboratory (NETL) was given the task of managing an investigation into the problem. The objective of the study was to develop a set of potential remediation options. NETL has neither the legal authority nor the capacity to conduct remediation efforts. In order to develop a set of remediation options, it was necessary to: (1**)** define the extent of the problem, (2) better understand the physical and geological setting, (3) determine the source(s) of natural gas leakage, (4) evaluate potential migration pathways, and (5) locate old gas wells within the Borough, methane gas sources, migration pathways, existence of buried wells, and potential remediation actions. This report covers the work of Research and Development Solutions (RDS) as a support contractor to NETL, and also incorporates some work that was closely integrated with the RDS efforts, done by NETL's DOE employees.

1.2 Findings

The study was limited to reported problem areas within Versailles Borough, primarily between Walnut Street and the Youghiogheny River. Twenty-eight gas samples were analyzed for hydrocarbon content from 36 vents and wells within this study area. For comparison, a sample was also taken from a well producing natural gas from the Speechley sandstone, the zone to which most wells were originally drilled. The Speechley sandstone well was located approximately 5 miles from Versailles Borough in front of the East Allegheny High School. Samples were analyzed for methane, ethane, propane, and butane (C1 – C4, respectively) content. The results showed that gas leaking from all vents known to be located over or attached to an abandoned well had 98% or higher methane content. This high methane content indicated the gas may be sourced by a coal seam, a natural gas pipeline leak, natural gas stored

underground, or possibly from a conventional Devonian age formation such as the Murrysville sandstone. Since no mercaptan, an odorant placed in pipeline natural gas to detect a leak, was detected at any of the vents and since most of the vents were not located near any pipelines, a pipeline leak was ruled out.

Stable carbon and hydrogen isotope data for stray gas samples collected at two locations by the Pennsylvania Department of Environmental Protection (PA DEP) in 2004 were most consistent with natural gas of Upper Devonian origin. Natural gas production history reveals that natural gas was produced from the Speechley sandstone in the study area, and that the shallower Elizabeth, Murrysville, and Hundred-foot sandstones were also productive. The stray hydrocarbon gases detected at the surface in Versailles Borough is likely a mixture of gases from some combination of these producing intervals of Upper Devonian origin and/or natural gas that some records indicate may have been stored underground in the area possibly beneath Versailles, although the exact location can not be found from existing publicly available records. Gas from the Upper Freeport and other stratigraphically lower coal beds may also be contributing to and further complicating the stray gas problem at the surface, though it is important to note that the study area was apparently not undermined.

Many of the vents were found to not be attached to old wells, but were placed in yards or adjacent to structures where gas “hot spots” had been located during previous studies. Gas emanating from the vents and old abandoned wells has very low surface pressure (3.5 pounds per square inch, psi) and in most cases, low production rates of less than 0.5 cubic feet per hour (ft^3/hr). The total flow rate from all existing vents and wells within the study area was found to be about 70 ft^3/hr. Of this total, one well, located on the 4800 block of Second Street, was producing 50 ft^3/hr (1.2 Mcf/day) of the total 70 ft^3/hr. Since seismic surveys had been inconclusive in determining gas migration pathways, two old wells were reopened and cleaned out (debris was removed) down through the coal intervals. One well was located at 4722 Walnut Street; the second well was located at 4822 Second Street adjacent to the Borough garage.

Gas was visibly seen emanating from a cleat at the base of the Upper Freeport coal seam in the Walnut Street well using the down-hole video camera after the well was cleaned out to below the coal seam. Gas bubbles were not present below the Upper Freeport seam in this well. Casing was installed in the well immediately above the Upper Freeport seam using an open-hole packer. Lack of gas flow or pressure in the annulus (casing exterior) after casing installation indicated the gas migration pathway in this well was limited to the Upper Freeport coal and that the gas has not migrated to any of the overlying formations. Based on the findings within this well, gas appears to be migrating from deeper formations from one or more old wells and moving laterally within the Upper Freeport coal seam. Once in the coal seam, the gas utilizes other abandoned wellbores to migrate to the surface making each a gas emanation point source.

In the lower elevation part of the Borough, in the 4700 and 4800 block area of Penn Way and Second Street, another gas migration pathway appears to exist based on down-hole video surveys from the Borough garage well at 4822 Second Street. Gas bubbles were visible in the wellbore to a depth of 65 feet. Unlike the Walnut Street well, the exact entry point could not be determined due to the amount of fine clay and coal fragments held in suspension in the wellbore water. However, the lack of gas bubbles below a depth of 65 feet means that the gas was emanating

from the shallow Buffalo sandstone. The Buffalo sandstone extends from a depth of approximately 17 feet to 65 feet within this wellbore. Casing was run on an open hole packer in the wellbore, but at every set point from the top of the Upper Freeport coal to inside the old surface conductor, gas was found on the outside of the casing (annulus), not within the casing. The inability to seal off gas from the annulus in the Borough garage well indicated that methane gas was not emanating from the Upper Freeport coal seam as seen in the Walnut Street well, but was entering from the Buffalo sandstone formation into the wellbore and through the rusted out surface conductor casing. Horizontal migration of the gas in the Buffalo sandstone close (less than 20 feet) to the surface may account for the wide spread methane gas problem in the 4700 and 4800 blocks of Penn Way and Second Street, including gas within several yards and within or adjacent to the roadways. Based on field magnetometer and gas detection surveys, the old wellbores are the primary source for the vertical migration of the stray gas to the surface in this area, especially where casing remains to the surface. However, where casing is absent at the surface, the stray gas tends to migrate away from the old wellbore into the surface soils. Local residents have reported that the gas leakage problem is worse during wet weather. During dry weather, the gas can migrate up the old wellbores, into the soil, and be dispersed into the atmosphere. During periods of wet weather or snow or ice cover, the upper pore spaces in the soil can be closed off, forcing the migrating gas to move laterally into structural foundations or back into the abandoned wells instead of continuing the vertical movement into the atmosphere. Similar conditions may exist during conditions of barometric high pressure, where the barometric pressure would tend to limit or halt the low pressure stray hydrocarbon gas from exiting the wellbore. Theoretically, methane gas may be able to be extracted from the Buffalo sandstone in the 4700 and 4800 blocks of Penn Way and Second Street through the use of vertical or horizontal wells, but may require removal and treatment of groundwater to enhance production.

The finding of H_2S was not one of the original study purposes, but it was detected during the course of this study in two wells and was also found in one of the two wells that we cleaned out for the video camera examination. The most likely H_2S source is the decomposition of organic materials in the wellbore water or organic materials dumped in the wellbores when they were open to the surface, though it is also possible that it could be associated with deeper strata. The occurrence of H_2S appears to be limited primarily to the 4700 and 4800 blocks of Second Street and Penn Way. The H_2S was only present at measurable concentrations inside the confinement of the wells themselves, not in the open air.

In the well that we cleaned out for the video camera examination, the H_2S peaked 1 to 2 months after the cleaning was done at concentrations within the wellbore that could have been problematic if the volume of the gas was not so low. The well had a low flow rate of 6.5 ft^3/hr, a low well head pressure of 3.5 psi, and was filled with water to within 17 feet of the surface, creating a well bore volume of only 7.2 ft^3 in the 10-inch surface pipe. That well was capped the same day that the high concentrations were detected and remained closed until an H_2S elimination filter was installed. Again, the H_2S was only present at measurable concentrations within the confined well bore space, not in the open atmosphere. It is likely that the drilling and cleaning process washed down organics into the high sulfate water, which encouraged the growth of sulfate-reducing bacteria and the generation of the H_2S. H_2S concentrations in that

well decreased to non-detectable levels within four months and have remained that way for the past 6 months.

A down-hole video survey was also run on the well at 4307 Third Street, although this was not one of the cleaned-out wells. This well has been a source for gas migration to nearby structures in the past, requiring residents and business owners to temporarily vacate their structures until the gas migration problem was eliminated by the installation of a power vent. Methane gas problems associated with the well appear to be related to gas coming up the back (annulus) of the smaller diameter casing left in the hole at a depth of 44 feet. At this point, the smaller casing is separated from the larger (6-inch) surface casing, allowing gas to migrate into the surrounding permeable geologic formations. The well currently has an electric blower attached to the vent, which aids the gas in moving up the well and out to the atmosphere; however, gas could still be leaking into the geologic formations below a depth of 44 feet.

Regardless of the gas origin, based on the down-hole video surveys, improper well abandonment for many of the gas wells drilled in the Borough provides a mechanism for stray hydrocarbon gas to migrate to the surface. Magnetic and sensitive methane surveys were used successfully to target many potential unmarked abandoned wells in Versailles Borough. Over 27 line miles of magnetic data were collected over an urban study area of approximately 40 acres. A combination of magnetic and methane data were acquired for over 67% of the available study area. The remainder of the study area was either occupied by structures, inaccessible due to terrain/obstacles, or inaccessible due to the landowner. A total of 52 magnetic anomalies were found in Versailles Borough (Figure 2). Based on NETL's excellent track record in finding abandoned wells using this technique at other sites, almost all of these 52 anomalies are likely unmarked abandoned wells. Excavation of one of the anomalies revealed a previously unknown abandoned well at a depth of 2-3 feet directly below the anomaly, but only excavation of each site can positively confirm the presence of an abandoned well.

An Apogee Scientific Inc. leak detection system (LDS), a highly sensitive methane and light gaseous hydrocarbon detector, was shown to be very effective at targeting methane plumes (methane gas transported by the wind from a source) while simply driving through the streets. Employing a cart-mounted implementation of the Apogee LDS instrument allowed NETL to trace the methane plumes to their sources, mainly passive gas vents, some of which were mounted on top of known abandoned gas wells. Fourteen of the 52 sites with magnetic anomalies were associated with leaking stray hydrocarbon gas. Initial reports of stray hydrocarbon gas problems in the study area had indicated only two primary areas of concern – the 4300 block of Walnut and Third Streets and the 4700 and 4800 blocks of Second Street and Penn Way. However, the 14 unmarked and apparently leaking abandoned wells were found between these two areas. Almost all of the methane found in the initial air plume study or using the cart-mounted sensor was found to be associated with storm sewers, small leaks around gas meters, locally elevated levels near vents, or the 14 magnetic indications of unmarked abandoned wells. Low levels of dispersed methane were sometimes detectable emerging through the soil at some sites. The highest measured methane concentration (13.6 ppm) in the Apogee LDS street survey was traced to a sanitary sewer vent. None of the measured concentrations came remotely close to the lower explosive limit for methane (approximately 50,000 ppm).

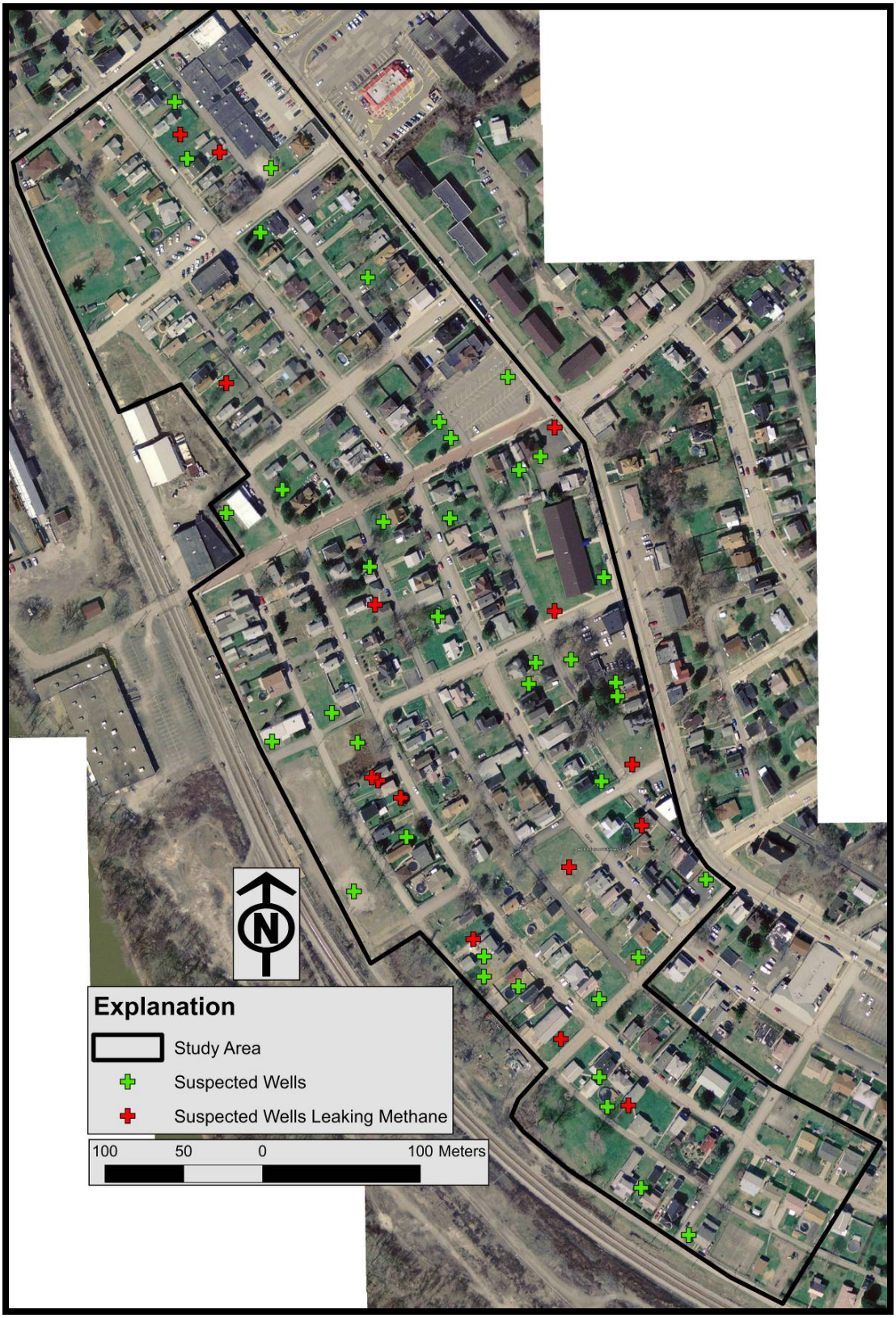

Figure 2. Suspected unmarked abandoned wells located using magnetic methods and methane detection.

Slightly more than an order of magnitude increase (10 to 120 ft^3/hr) in gas volume was noticed by reducing the hydrostatic pressure approximately 75 pounds per square inch (psi) on the Upper Freeport coal at the Walnut Street well. A commercially available device, the Methane Buster™*, was tested as a potential remedial option to eliminate the methane gas leak within the Borough by pulling a vacuum on a producing well. The Methane Buster™ is a six-cylinder gasoline engine that has been converted to run on methane gas, equipped with a blower assembly, and designed to degasify coal seams prior to mining operations. Since the Methane Buster™ runs on methane gas, it can sustain itself on the methane produced from a well or series of wells. In the tested configuration, it required approximately 180 ft^3/hr of methane. This demand could not be met by any of the wells in Versailles Borough, so for testing purposes, a propane tank was installed on the Walnut Street well. The Methane Buster™ was found to increase the volume of gas that could be extracted, but required lowering the water level in the well to reduce the hydrostatic pressure on the produced gas.

Samples were taken of the produced Walnut Street well water and water from the Youghiogheny River to determine if the produced well water could be entered into the local storm sewer without treatment. Laboratory results indicated the well water was high in sodium (Na) and chloride (Cl) ions. The high Na and Cl levels suggest that the source may be salt water from deeper formations. Salt water under artesian pressure has over the years migrated up the old boreholes and out into the shallower freshwater aquifers in Allegheny County. This was due primarily from the intense drilling for oil and gas in the past and the fact that many of the old casings have been removed or have become severely corroded. The water was also found to be relatively high in several metal ions, including aluminum (Al), barium (Ba), iron (Fe), magnesium (Mg), and strontium (Sr), possibly derived from the coal. The sample was also high in silicon (Si) apparently due to weathering of silicate minerals, including quartz from the sandstone formations and clay minerals. Because of all these factors, the water could not be placed directly into the river and was therefore collected in a portable tank and hauled away for disposal at an approved disposal site.

Costs associated with treating and/or hauling the formation water would be expensive, especially since there does not appear to be marketable amounts of gas being produced from the existing vents and wells. Gas volume decreased from 50 to 35 ft^3/hr at the 4805 Second Street well while water was being pumped and the Methane Buster™ was being tested at the Walnut Street well. This would suggest interconnectivity across the two areas and that increasing methane gas extraction from a point source may pull the gas from a larger area.

* KSD Enterprises

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2.0 Project Purpose

Versailles is a borough located in southwestern Pennsylvania, in Allegheny County, and southeast of the city of Pittsburgh (Figure 1). It is bordered to the north and east by the City of McKeesport and to the south and west by the Youghiogheny River. The 2000 census reported the population of Versailles as 1724.

Since the early 1960's, the Borough of Versailles has experienced problems with methane gas from old, improperly plugged natural gas wells leaking into homes and businesses. Over 650 wells were drilled between 1919 and 1921 in the McKeesport Gas Field (M. E. Johnson, 1929) with nearly 175 of these wells drilled in Versailles Borough. The wells were primarily drilled and completed in the Speechley sandstone, nearly 3000 feet below the surface. Casing was retrieved and recycled from many of these wells during World War II. The result was thousands of feet of exposed geologic formations that could release gas into the wellbore or act as a conduit for gas migration throughout the Borough or to the surface.

When gas emissions are detected within or near the foundation of a home or business, the standard practice for the local utility companies has been to shut off all gas and electric to the structure until the methane problem has been corrected due to the risk of a catastrophic gas explosion. Families and businesses have been displaced until the problem was eliminated. Many residents within the community are retired or on fixed incomes; as a result, several homes have been condemned as uninhabitable or torn down due to the inability to properly remove the methane from within the structures.

On May 11, 2005, U.S. Representative Mike Doyle, Democrat, 14th Congressional District in Pennsylvania announced that he had secured federal funding for a study. Because of its expertise in geological science, the U.S. Department of Energy's National Energy Technology Laboratory (NETL) was given the task of managing an investigation into the problem. The goal of the study was to develop a set of potential remediation options. To do this, NETL defined four objectives, each with its own set of questions to be answered:

- **Determine the methane gas source or sources**
  Since most of the wells were drilled to a depth of nearly 3000 feet to the Speechley sandstone reservoir, was this the primary source for the gas emissions or was it emanating from shallower formations? Were there pockets of gas that could be drained (and used or vented) to prevent the gas from seeping up in an uncontrolled manner.

- **Examine the area extent of the problem**
  Did the gas emanations extend over the entire Borough or were they limited to certain areas within the Borough? Could the old abandoned wells and surface gas concentrations be located using newer technologies that were unavailable in previous investigations?

- **Evaluate possible gas migration pathways**
  The old, uncased, and poorly plugged wells were the most likely vertical pathways for gas migration to the surface or near surface. Did other vertical pathways exist such as

faults? Was the gas also moving horizontally through permeable geologic formations or the surface soils? Was gas being concentrated in subsurface zones?

- **Develop remediation options**
  Determine, based on project findings, potential ways to mitigate the problem through proper well venting of located wells, utilization of the produced gas, or redirection of produced gas away from residential and business structures. The objective of this study was to determine the remediation options; not to put these options into place. NETL has neither the legal authority nor the capacity to conduct remediation efforts, and corrective measures would require additional funding beyond the scope of this study.

To address these objectives and answer the various questions associated with each objective, NETL compiled a team of federal, state, academic, oil industry, and contractor personnel. NETL managed the overall project and worked in conjunction with Versailles Borough council. The study area was confined to the section of Versailles Borough between Walnut Street and the Youghiogheny River, based on discussions with the Borough Council and local residents, the presence of existing vents, historic evidence of emissions, and known gas emission sites. NETL contractor personnel from Research and Development Solutions (RDS) were responsible for evaluating the existing vents and wells for production potential, and determining the methane gas source(s). Federal employees would use a magnetometry technique that they had refined and used successfully elsewhere to find abandoned wells, along with new, very sensitive gas sensing technologies to locate old buried wells within the study area. Oil and gas industry personnel would be contacted to assist as needed by supplying geologic, gas chemistry, and well data. The Pennsylvania Department of Environmental Protection (PA DEP), Oil and Gas Division would also provide technical support. All parties would assist in determining the final remediation options based on project findings.

3.0 Background

3.1 Defining the Methane Gas Problem

The methane problem in Versailles Borough stems from a sequence of events which began with the discovery of natural gas in what would become the prolific McKeesport Gas Field. The gas field was located on the northwest flank of the Murrysville anticline below the surface of Versailles, Snake Hollow, and eastern McKeesport (See Plate 1 for the location of the Field relative to Versailles). Structural folding of the previously deposited underlying rocks allowed for the accumulation of gas into pools, oftentimes along the axes of anticlines. In this region, the Murrysville anticline played an important role.

The McKeesport gas pool was discovered in 1919 during efforts to extend successful Speechley production from southeastern North Versailles Township. The Speechley sandstone, a prolific producer of both oil and natural gas, is named for a farm in Venango County where it first became productive in 1885. The Speechley is a porous, medium to fine-grained sandstone deposited in a proximal marine environment. The Speechley was deposited, along with many other important hydrocarbon-bearing reservoirs, as part of a clastic wedge which was eroded from the eastern highlands during the latter stages of the Devonian period of the Paleozoic Era. In Versailles, the Speechley is generally 20 to 50 feet thick, and lies at a depth of approximately 3,000 feet from the surface. The relationship of the Speechley sandstone to other gas producing sandstone formations (except the Buffalo sandstone) and the locally mined Upper Freeport coal is shown in Figure 3.

The discovery well of the McKeesport pool yielded an initial production of 1.5 Million cubic feet per day (MMcf/d). The second well measured 6.0 MMcf/d. A third well, completed August 23, 1919, reported an initial production of 4.0 MMcf/d. Production from this well, however, rapidly increased to nearly 25 MMcf/d. Its production rate continued to increase, and in less than a month, it had exceeded 56 MMcf/d. Within four months, well number three had surpassed five billion cubic feet (Bcf) of cumulative production. The enormous success of this well, as well as the high initial flow rates of the first two, initiated a drilling boom that resulted in the completion of 650 wells in the pool in the span of one year (M. E. Johnson, 1929). Given the size of the productive Speechley area within the McKeesport pool, 864 acres, it is estimated that 10 wells would have been sufficient to drain the entire area. As a result of the drilling frenzy, and the disregard of normal oilfield production practices, the pool was mostly depleted within two years. The only remaining Speechley production in the field after 1920 resulted from the placement of compressors on the pipelines, which pulled a vacuum on the wells in the center of the field.

Typically, a few companies would have acquired the majority of the leases and developed the gas field in a more regulated manner. However, much of the McKeesport pool was located in a developed area that had been subdivided into hundreds of town lots, many of which were in close proximity to the high producing wells that had recently been completed. The owners of these lots, many only 25 by 100 feet in size, often owned the oil and gas mineral interests under them. For this reason, hundreds of leases were available and hundreds of companies sprang up virtually overnight selling well interests to the public for a chance to strike it rich with a big well.

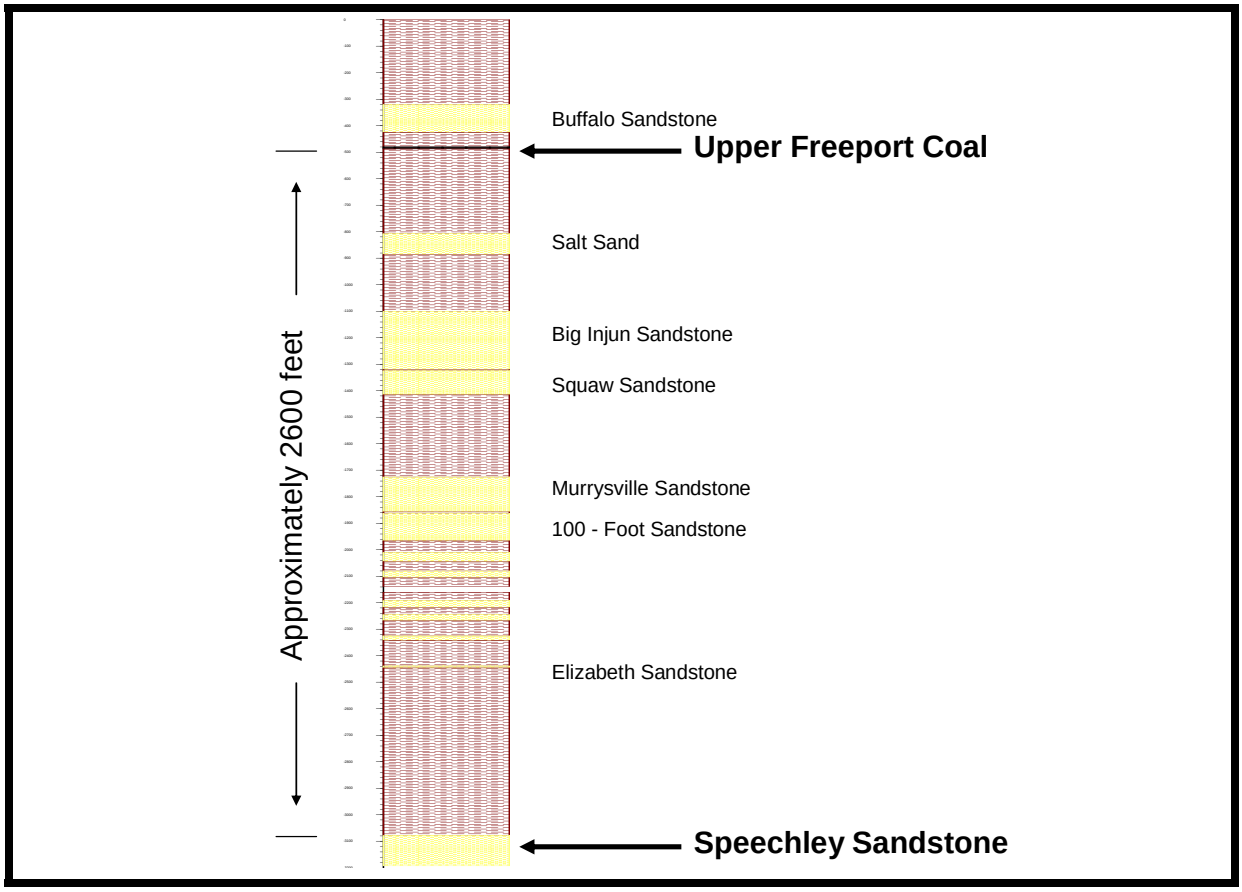

Figure 3. Relationship of Speechley sandstone to other oil and gas producing reservoirs and Upper Freeport coal seam.

Additionally, each land owner wanted at least one well drilled on his property. An exorbitant number of wells were drilled into the relatively limited area encompassed by the pool, as shown in Figure 4 and Figure 5. Because many of the lots were small, wells were often drilled in very close proximity to existing houses, either between them or in the back yard. In some cases, houses were torn down to allow well drilling.

Although most of the wells were drilled and completed by the standards of the time, most would not be acceptable under today's environmental standards. In their rush to complete a well before a rival company could complete their well on a neighboring lease, many companies failed to adequately case their wells. In addition, wells that were non-productive or found only nominal amounts of gas were abandoned, often times without regard to proper plugging and abandonment techniques.

During the 1940's, America's involvement in World War II required the use of tremendous amounts of steel for the manufacture of armaments. Campaigns to salvage steel for the war effort were launched across the country. Steel wellheads (well valves and fittings above ground) and well casings from abandoned wells were cut off at or below the surface in the McKeesport gas pool, as they were in many other old oil and gas fields throughout Appalachia. It is also possible

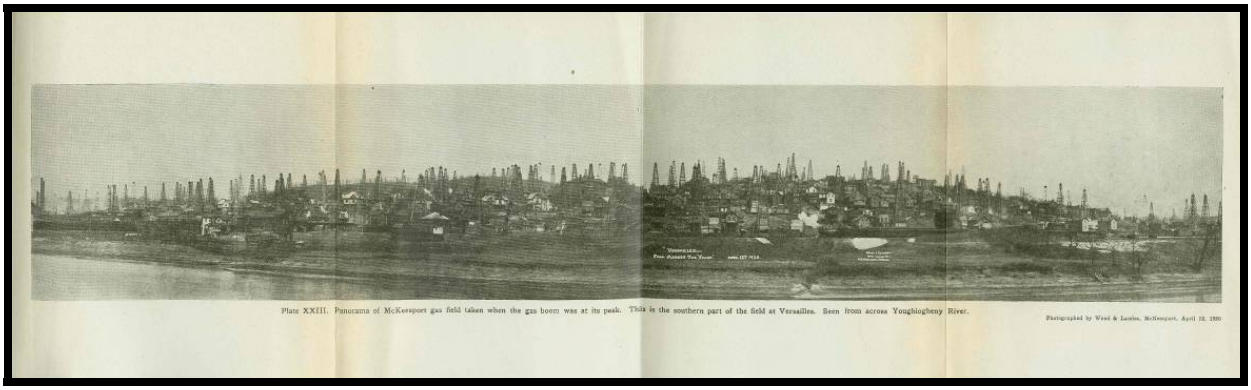

Figure 4. View of Versailles from across the Youghiogheny River during the peak drilling period (from M. E. Johnson, 1929).

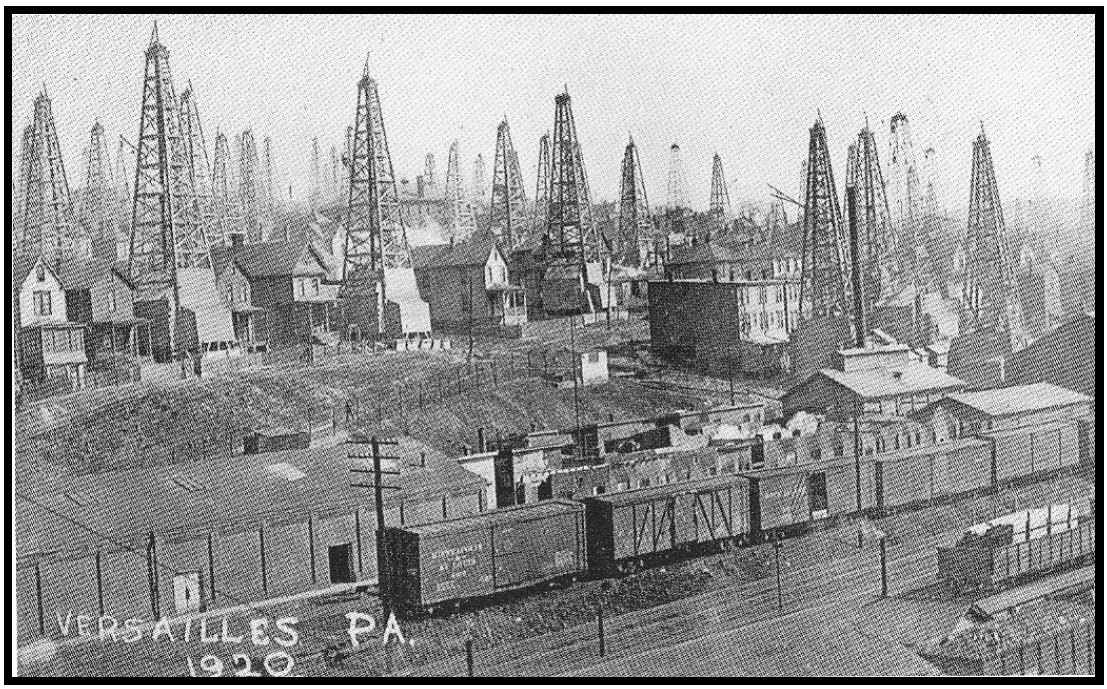

Figure 5. Scene of Versailles, PA near intersection of Grant and Second Streets, circa 1920 (photo courtesy of Josephine Cindric).

that casing in some wells in the pool may have been shot off at depth with dynamite. This would allow the collection of more casing from deeper within the well. With the surface manifestation of the well now removed, it was just a matter of time before weathering and the reestablishment of vegetation completely concealed the old well locations. In time, future homes would be built in very close proximity, and in some cases, over these old abandoned wells.

Concurrent with the well drilling, production, and eventual removal of wellheads and well casing was the operation and subsequent closure of the Hubbard coal mine. The Hubbard mine of the McKeesport Coal and Coke Company at Versailles began operations in 1924 (M. E. Johnson, 1929). It mined the Upper Freeport or “thick Freeport” coal, which underlies the entire area of

Versailles and occurs approximately 180 feet below the surface at the shaft entrance near the northwest edge of Versailles. Figure 6 shows the geologic units above the Upper Freeport coal as a stratigraphic column of a core boring taken at the Hubbard Mine hoist shaft (after M. E. Johnson, 1929). Where the coal is thick, it is often divided into an upper and lower member, the two members divided by a thin (7 to 15 inch) bone coal. In this locality, the lower member seems to occur more consistently, while the areas comprising the "thick Freeport" are limited to those areas where the upper member is present. Although the Hubbard mine covered an extensive area to the north and east, mine maps obtained from the PA DEP indicate that virtually none of the area under the town of Versailles was mined (Figure 7).

In January, 1939, a large explosion in the Hubbard mine claimed the lives of several miners from the Versailles area (Mrs. Josephine Cindric, personal communication, 2006). The explosion was an indication of the gassy nature of the Upper Freeport coal and perhaps a forerunner of future problems the township would have with methane. The Hubbard mine ceased operation and closed in the early 1960's. As a result, the ventilation fans and water pumps that had been removing methane gas and water from the mine were removed. The mine subsequently filled with water, since its elevation was below that of the nearby Youghiogheny River. In addition,

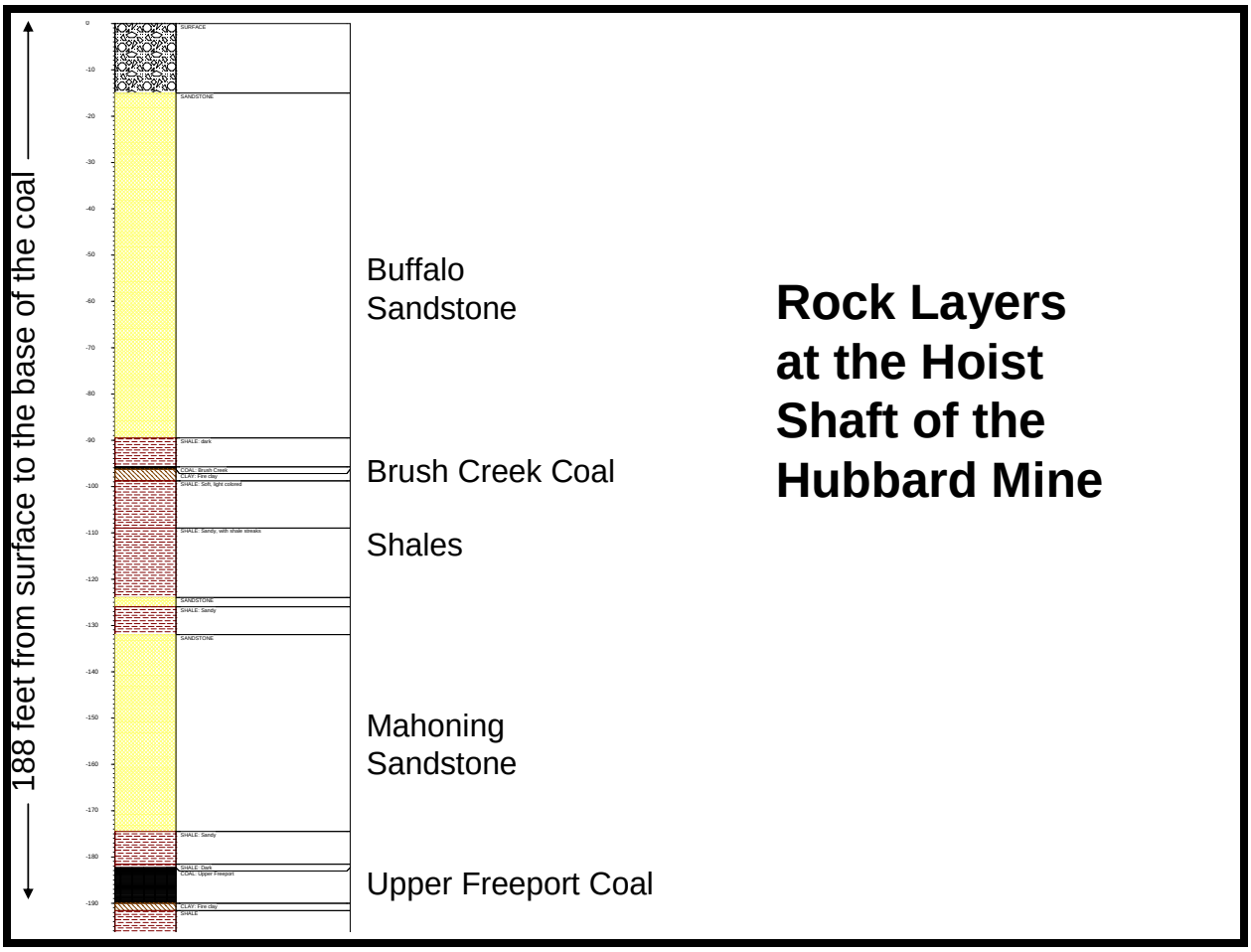

Figure 6. Geologic stratigraphy of a core boring at the Hubbard Mine hoist shaft (after M. E. Johnson, 1929).

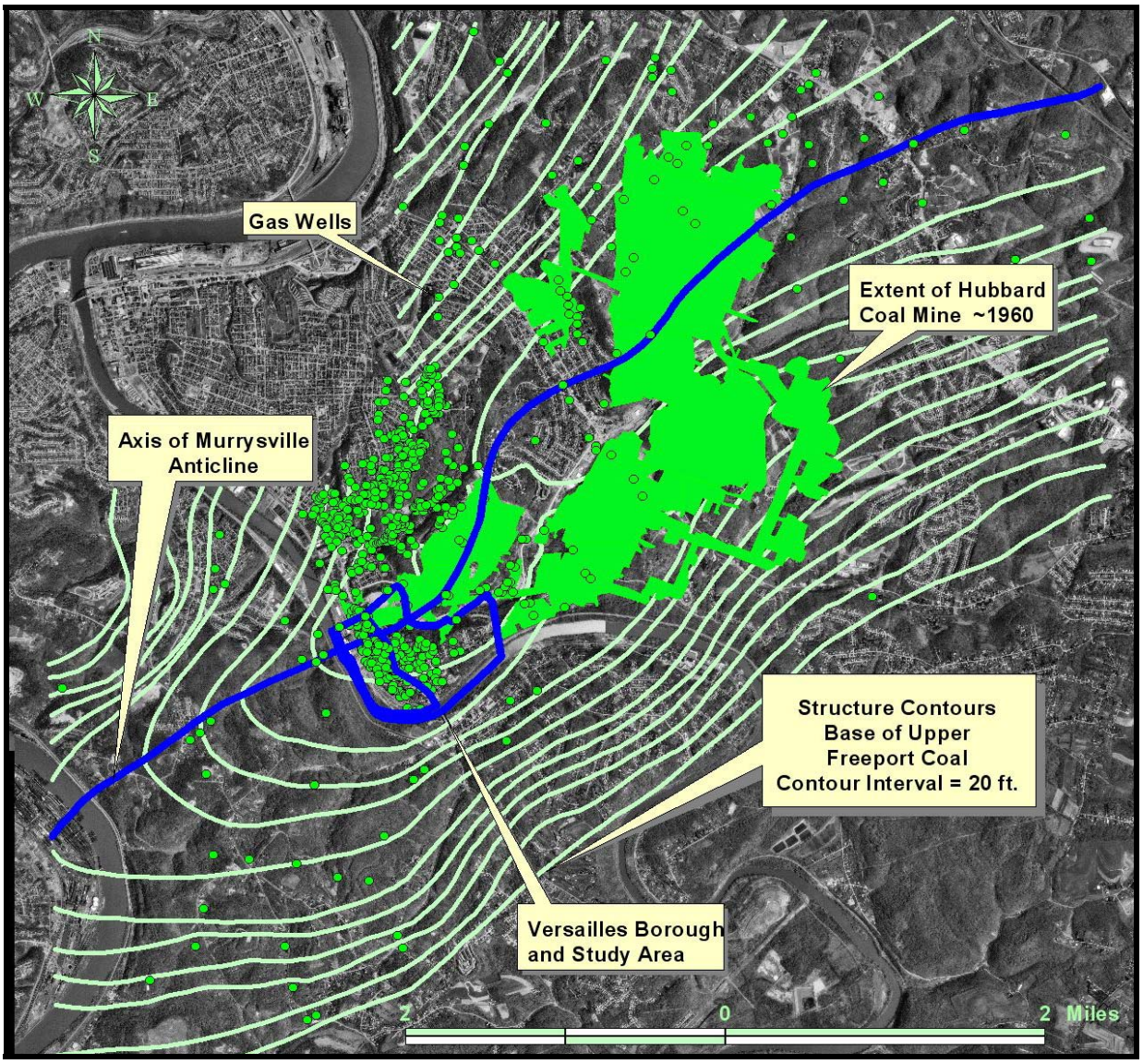

Figure 7. Relationship of Hubbard Mine to study area and Murrysville anticline.

since ventilation was terminated, methane contained within the mined and unmined areas of the Upper Freeport seam, regardless of the original source of that gas, could accumulate.

An additional potential complication is the possible placement of coke gas or natural gas underground beneath Versailles Borough. Personal communication with local residents, a line marked on one map, and a letter in the files of the PA DEP all indicate that there was some injection of natural gas for storage purposes in the Hundred-foot sandstone around 1957, but it is not possible to verify how much, if any, gas was placed underground, and whether or not such storage may have contributed to the current stray gas leakage problem. Analysis of gas samples does not appear to indicate the presence of coke gas, but the possibility that natural gas stored

underground may have leaked through the old abandoned wells and increased leakage rates from the subsurface cannot be ruled out.

In summary, a sequence of events involving the exploitation of the natural resources of the area has contributed to the methane problem being experienced by Versailles Borough since the early 1960's. It began with the overly aggressive drilling of the Speechley in the McKeesport gas field, which resulted in more than 600 holes through the gassy Upper Freeport coal. The issue of a grossly over-drilled field was exasperated by poor casing, as well as poor plugging and abandonment practices. In the haste to drill a good well, wells that may have had insufficient production to be economical were left uncased and unplugged as drillers moved on in search of more productive sites. Wells that were adequately cased through this zone likely had casing removed during World War II. Any remaining casing has almost surely been degraded, having been subjected to over 80 years of exposure to the harsh condition existing in the wellbore. This left three type of abandoned wells in Versailles Borough – wells without any casing, wells with only the surface conductor casing left (which they were unable to pull from the ground), and wells with the surface conductor and some of the original production casing. These three types of wells are shown graphically in Figure 8. Finally, the closure of the Hubbard mine in the early 1960's, and subsequent termination of ventilation activities, meant that any remaining methane in the mine (or the remaining coal seam) would stay trapped if it could not find another avenue of escape. The apparent storage of natural gas underground only complicates this picture.

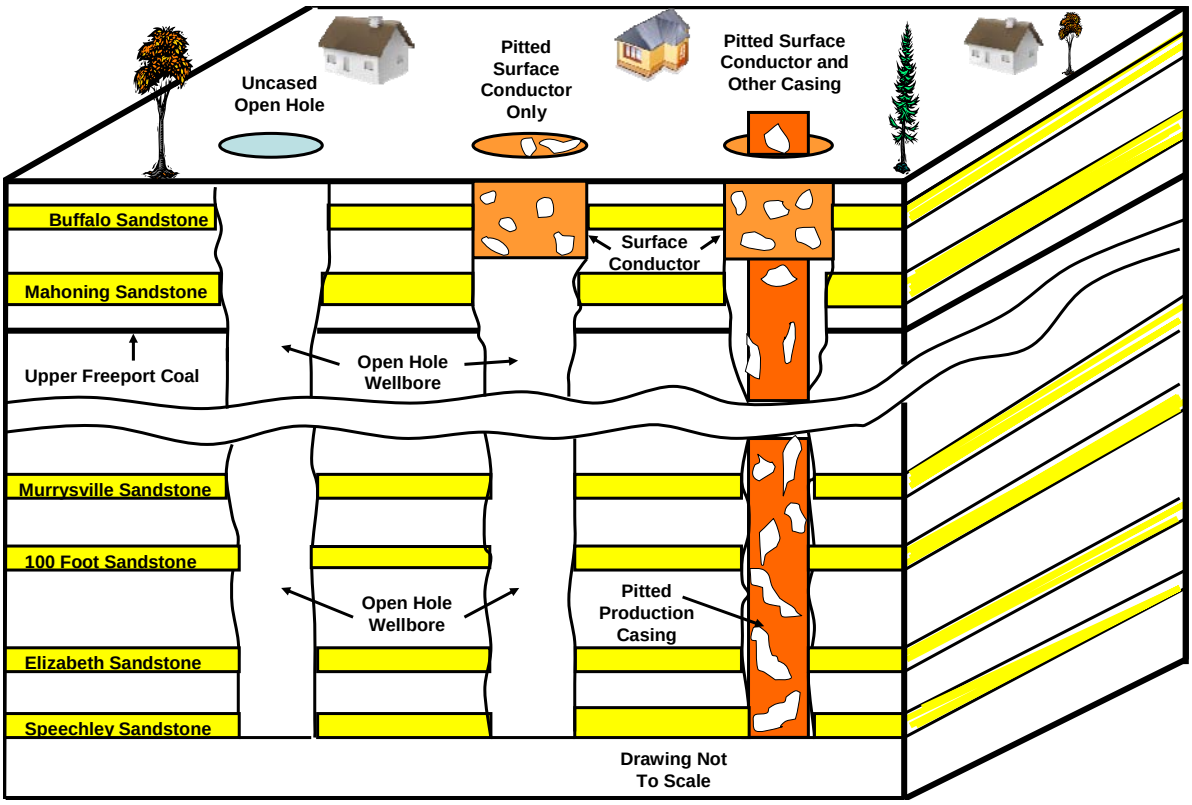

Figure 8. Three typical types of abandoned wells found in Versailles Borough and key geologic formations.

3.2 Historical Events Related to the Methane Gas Problem

In 1963, the citizens of Versailles had their first reported indication of a methane problem in the residential section of the Borough. Rose Motta, who lived in the 4400 block of Second Street, is reputed to have turned on a light switch and blown off her stockings. Later that year, a similar incident happened down the block. In the early 1960's, residents would have been aware of methane gas, as many had worked in the gaseous Hubbard Coal Mine, or remembered the large number of gas wells which had been drilled in town during 1919 to 1920, or had witnessed the ignition of gas from these old wells. Additionally, the McKeesport Daily News had periodically published stories of the gas well drilling, which showed pictures of derricks between and behind houses in Versailles.

Some of the wells were still in existence in the 1960's. The Caudill family reputedly used gas from a well located next to their house at 4709 Second Street, and an October 3, 1969 article in the McKeesport Daily News shows a photograph of them lighting a flare attached to the well. According to many Versailles residents, the well located in the yard next to 4821 Second Street was flared for years. However, most of the wells shown in the old photographs had been forgotten and their surface locations lost to time, construction, or vegetative cover.

Since the first two explosive episodes in 1963, many citizens have been severely impacted by methane leaking into their houses from unknown sources. Although the affected area is not large, mostly below Walnut Street, there have been a significant number of people who have been forced out their homes or businesses when the gas company detected methane within the structure that was not related to their utility service. Gas service would be turned off, and the electric and telephone companies notified to do the same with the power and phone services. Several houses have been condemned and torn down because the methane could not be vented sufficiently to make the houses habitable.

There have also been instances of children reportedly sickened from inhaling methane and associated gases where houses were inadvertently built over or next to old gas wells. In 1968, Mr. and Mrs. Saraka had to attach a vent to a gas well located next to an addition to their house at 4819 Second Street for this reason. A similar situation affected the Hackett family several years later at 4728 Second Street when an addition to their house was built over an old well that had been cut off and buried under the garage floor.

3.2.1 Continuing Problems after 1990

Throughout the 1990's, residents continued to fear that new gas leaks would be found and that they would be forced to perform costly corrective measures or leave their homes or businesses due to the previously discussed scenario in which the gas utility company (Equitable) doing routine leak detection along their distribution lines within the Borough would find non-utility gas adjacent to or inside buildings. As a result of this gas inspection activity, houses at 4809 and 4811 Second Street were torn down when they could not be vented adequately.

In response to such gas detections, several more vents were attached either to wells or constructed at places in a yard where high gas concentrations were detected, indicating the possible presence of a well but where no casing was discovered. Versailles Borough was

involved in installing vents on at least two of these sites, one between 4719 and 4723 Penn Way; and one in the yard at 4717 Second Street. Additional vents were also installed by homeowners in response to gas detection. In total, there are approximately 41 vents in the area of Versailles below Walnut Street; at least 15 of these are likely attached to a well or, based on the gas concentrations emerging from them, are at spots above where an uncased well might have been. The remaining vents are in places where elevated gas concentrations were found. Several of these vent house foundations or trenches along foundations.

This project was prompted by Equitable Gas Company's detection of methane leakage in several buildings and houses in the 4300 block between Walnut and Third Streets during late fall 2003. Methane had been detected at a concrete patio behind 4307 Third Street in 1990; however, it was not entering the foundations at either 4307 or 4305 Third Street at the time. This area is several blocks away from previous problems. Equitable Gas Company's discovery caused residents from two houses (4305 and 4309 Third Street), a medical center, and a welding supply company to be displaced for more than two months. Gas well casing was uncovered several feet below the surface at a former home site at 4307 Third Street. Installation of a power vent attached to the casing along with trenching and installation of a passive vent at 4309 Third Street allowed the two houses to be re-occupied. During the same time, five vents were installed around the medical center, welding supply company, and a bar in the 4300 block of Walnut Street. The vents were located over places where elevated levels of methane were detected under the asphalt parking lot or adjacent to the buildings.

3.2.2 Previous Investigations

3.2.2.1 M. E. Johnson

In 1925, Meredith E. Johnson, a geologist with the Pennsylvania Topographic and Geological Survey, visited Versailles, McKeesport, and the surrounding parts of the McKeesport Gas Field as part of his work for the report on the Geology and Mineral Resources of the Pittsburgh Quadrangle. By this time many of the gas wells in the field had already been abandoned. In spite of this, he endeavored to locate and map all of the wells in the McKeesport and Versailles areas (see Plate 1). In his report, he carefully documented the conditions leading to the rapid drilling and depletion of the field and mapped the well locations, including those in the Versailles area. He also presented a wealth of information regarding coal mining in the Pittsburgh area. His report was essential to understanding some of the conditions leading to the present methane problems.

3.2.2.2 Heath Consultants

At least two previous studies have been commissioned to find the source of the problem and attempt to remediate it, notably two by Heath Consultants Incorporated in 1986 and 1990. As a result of these efforts, many of the methane leaks were located and vents were installed to safely conduct the gas to the atmosphere, as discussed above.

In 1986, Heath Consultants Inc. was hired by the Twin Rivers Council of Governments (TRCOG) to investigate the "unknown flammable hydrocarbon" problem on Second Street in Versailles. The investigation quickly identified "significantly dangerous" conditions at 4728 Second Street and the well, which had been buried under the garage floor, was vented to the outside. These efforts allowed the residents to move back into the house. Because so many of the houses in the one block area immediately adjacent to 4728 Second Street were found to have serious methane problems by Heath, the focus of the study immediately turned to attempting to locate and remediate the problem. Vents were installed at 4728, 4806, 4808, 4809, 4811, 4813, and 4815 Second Street during the project. This allowed the gas utility service to be restored at 4728, 4806, 4813, and 4815 Second Street, and gas service was never interrupted at 4808 Second Street. The venting activities were ineffective at 4809 and 4811 Second Street and those houses were eventually torn down. Local residents indicate that at one of the houses, the gas problem was first indicated when ashes from a barbecue thrown into the backyard ignited cracks in the lawn. At the other house, the earthen floor of the crawl space was reportedly heaved up by the escaping gas. In summary, although the initial plan was to survey a larger area, the urgency to remediate the problems in the one-block area and a lack of funding severely limited the size of the 1986 investigation.

In 1990, TRCOG again contracted with Heath Consultants Incorporated to survey all of Versailles Borough for stray hydrocarbons. In order to investigate an individual property, a release form was required from the owner and their cooperation was strictly voluntary. Most (43) of the 56 leaks that Heath discovered were determined to be linked to utility lines and valves. Thirteen of the leaks were found to be non-utility related, and most of these were suspected or confirmed to be related to a well. Additional vents were installed at several houses where the methane detection was determined to be from a non-utility source. A report of each gas detection was generated, showing the location and concentration of the gas.

In addition to the gas survey, TRCOG (in conjunction with Heath) sponsored a gas monitor installation program that funded the purchase and installation of 100 explosive gas monitors. These were placed at any home where any non-utility gas had been detected, any home within 50 feet of these detections, or any home with evidence of an old gas well. As a result of this program, 74 monitors were installed.

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4.0 Investigative Methods and Findings

4.1 Investigative Methods

A number of different methods were used to investigate the nature and extent of the gas emission problem. These methods included:

- Literature and newspaper searches
- Examination of old maps and photographs
- Meetings with oil and gas industry personnel
- Personal interviews with Borough residents
- Creation of maps and databases
- Sampling and gas analyses from existing vents and wells
- Re-entering two abandoned gas wells
- Searching for hidden wells

4.1.1 Literature and Newspaper Searches / Examination of Old Maps and Photographs

A search was completed of relevant literature, newspaper articles, and old maps and photographs to provide insights into the history behind the Versailles Borough methane leaks and the extent of mining operations related to the Hubbard Mine. Most of the information was compiled and has been summarized in Section 3 of this report.

4.1.2 Oil and Gas Industry Consultation

Project personnel met with four oil and gas industry companies during the extent of this project: Huntley and Huntley, Inc.; Equitable Gas Company; DORSO, LLC; and Mifflin Energy. These meetings were held to acquire geologic information for seismic interpretations, gather information on natural gas chemistry in the area, or to acquire additional information on known areas of gas emissions within the Borough.

4.1.2.1 Huntley and Huntley, Inc.

A meeting was held in November 2005 with Huntley and Huntley, a local gas and oil producer. Over the years, the company has drilled and completed numerous wells around the Versailles area with several being completed in the Speechley sandstone. Huntley and Huntley provided the project with a Versailles – McKeesport area map of early gas well locations, more than 200 driller's logs, and a preliminary geologic cross-section of the vicinity. The hydrocarbon chemical characteristics of the various producing formations were discussed as part of this meeting. From their experience, most of the conventional reservoir gases (not coal bed methane) in this area contain predominately methane, but also significant amounts of the heavier hydrocarbons – ethane, propane, and butane. The only exception is the Murrysville sandstone, which in the local area produces almost 100 percent methane, similar to gases produced from coal seams.

4.1.2.2 Equitable Gas Company

During the same time period, a meeting was held with personnel from Equitable Gas Company. The intent was to learn more about the gas emission problems in Versailles and determine if old driller logs or well location maps existed from their acquisition of Peoples Natural Gas, a major gas production company in the area during the McKeesport field development. Unfortunately, according to company personnel, virtually all of these data have been lost or discarded as offices moved or were downsized.

As gas emission problems began to develop in the early 1960's, Equitable was summoned to determine the sources of several of these emissions. Several additional gas emission locations had been found by Equitable Gas Company during routine pipeline inspections within the Borough that were not related to their natural gas transmission or distribution lines. However, Equitable Gas Company was unwilling to provide any of these locations or any information on the chemistry of the emitted gases.

4.1.2.3 DORSO, LLC

On May 15, 2006, a meeting was held at the NETL-Pittsburgh site with George Scott of DORSO, LLC, an oil and gas exploration and development company drilling wells to the Speechley reservoir several miles from the Versailles Borough. Mr. Scott brought electric well logs to the meeting to assist in correlating the area geologic formations.

4.1.2.4 Mifflin Energy

In July 2006, a meeting was held with Robert Clay, Mifflin Energy geologist, to discuss his insights with respect to the Versailles gas emissions problem. Mr. Clay has extensive experience with several gas wells drilled and completed in the surrounding area. He provided drill records and maps for several old and new wells drilled in the region. He also noted a northwest-southeast cross-strike discontinuity crossing on the west side of the Youghiogheny River. This fractured zone may account for similar linear trends evident in the surface river segments.

4.1.3 Borough of Versailles Residents

4.1.3.1 Meeting with Borough Personnel

Project personnel attended a meeting in November, 2005, with members of the Versailles fire and police departments, city council, and citizens with detailed knowledge about the gas emission problem. Additional photographs showing the locations of old drill derricks within the Borough were obtained as well as copies of several newspaper articles. These articles described drilling activities during the boom era and explosions that occurred in the Hubbard Mine due to the Upper Freeport coal seam. It was also learned that there were no reported methane gas problems until after closure of the Hubbard Mine, that the methane gas problems seemed to be intensified during times when the soil was wet, and that no gas emission problems had been reported east of Walnut Street or in the town of McKeesport.

4.1.3.2 Town Meeting

Project personnel created posters and a PowerPoint presentation for a town meeting held in Versailles on January 5, 2006. Over 100 Borough citizens attended along with Congressman Doyle, representatives of the Pennsylvania Department of Environmental Protection, and the local news media. A questionnaire was distributed at the meeting eliciting considerable information from the residents regarding possible wells and other gas-related problems on their properties. Based on the questionnaire results and data from the Allegheny County Assessors office, a database for all of the houses in Versailles was created, including information derived from the completed questionnaires, actual street locations, and construction dates of all houses within the study area. Construction date information was used to determine the relationship of the homes to potential well locations for each property. Any wells drilled at homes completed prior to 1919 would have been located in the surrounding yard or on an adjacent lot. Homes completed after 1919 but before World War II may have been built over an old well if it was a dry hole and the casing had been removed. Homes built after the casings had been removed as part of the steel drive for World War II may or may not have been built over old well locations.

4.1.3.3 Discussions with Rich Ingram

In February, 2006, Rich Ingram, who lives at 4513 Second Street, met with researchers to provide a quick tour of Versailles Borough. Ingram, who knew the locations of several old wells, gave a description of how some of the wells had been plugged in bygone days. Plugging was completed by cutting the casing a few feet below the surface, pushing part of a tree into the remaining wellbore, adding a little dirt or other filler, followed by the addition of a bag of cement, and then covering any remaining hole with dirt. He further indicated that many of these “plugged” well locations were evident by “brown grass” areas within residential yards.

4.1.3.4 Borough Tour with Mark Jacklitch and Council Members

During April, 2006, project personnel toured the town to look for old wells, vent pipes, and vents attached to old wells with Mark Jacklitch (former Versailles Street Department supervisor), Walt Winkler (Borough Council president), and Borough Council members Linda Sheedy and Pat Brown. Mr. Jacklitch, who had installed many of the recent vent pipes within the borough, was able to distinguish vents located over actual old well casings from those located over areas of high gas concentration determined from previous gas surveys. Pat Brown supplied the project with reports completed in 1986 and 1990 by Heath Consultants detailing locations where gas concentrations were found within the borough in addition to all homes that were subsequently given methane gas detectors.

4.1.4 Geographic Information System Maps

Several maps were created throughout the project using a Geographic Information System (GIS). With GIS, one can link information (attributes) to location data such as buildings to addresses, or well information to a specific location. The information can then be layered to provide a better understanding of how differing data inputs work together. Layers are combined into maps based on what questions need to be answered.

Nine digitally scanned images of maps were registered to real-world geographic coordinates using maps of the roads and streets in the Versailles, White Oak, and McKeesport areas. The streets in lower Versailles were mapped with a high accuracy global positioning system (GPS) and roads in McKeesport and White Oak were digitized from images of the McKeesport 7½ minute topographic quadrangle map. The scanned images include:

- Four mine maps that entirely cover the extent of the Hubbard Coal Mine, including gas wells, from approximately 1960 (obtained by NETL from PA DEP).
- A 1930's Hubbard mine map which had been transferred to a McKeesport quadrangle map by the Works Progress Administration (WPA), including more than 700 gas wells (obtained by NETL from PA DEP).
- A land parcels map of Versailles Borough.
- A 1915 map showing gas wells and land parcels in the southeastern ¼ of the Pittsburgh 15 minute quadrangle, obtained from Huntley and Huntley, Inc.
- A 1925 map showing gas wells, geologic structure, and roads in the Versailles – McKeesport area from the report by M. E. Johnson.
- A high resolution tiled air photo image of Versailles from Google Earth™ (©2007 Europa Technologies, ©2007 Navteq).

From these registered images, a number of map layers were digitized including:

- More than 70 gas wells from the 1915 map.
- More than 500 gas wells from the 1925 map.
- More than 725 gas wells from 1930's mine map.
- More than 80 gas wells from 1960 mine maps.
- Upper Freeport coal seam maps
    - Geologic structure map of the base of the Upper Freeport coal.
    - Upper Freeport coal thickness.
    - Edges of no-coal areas within the Upper Freeport coal.
- Edge of the gas storage fields operated by Carnegie and People's Natural Gas (This information was on the 1960 mine map, but origin of information, storage field extent, and type of gas stored are unknown.
- Mined areas of the Hubbard Mine.
- More than 400 building outlines with addresses in the area below Walnut Street.

Metadata (documentation for GIS map layers, which includes details regarding the source, scale, accuracy, geographic projection, method of creation, author, etc.) were completed for all of the GIS coverage in the Versailles project. This documentation is important for data use by more than one person.

4.1.4.1 Well Location Maps

More than 725 gas wells drilled before the 1930's were digitized from mine maps that had been transferred to a McKeesport quadrangle map by the Works Progress Administration (WPA). Although the gas wells from this map cover a very large area, they are not particularly accurate

in Versailles Borough since there were few roads marked on that part of the map to allow us to properly register (geographically locate) the image.

The more than 500 wells digitized from the 1925 map of M. E. Johnson (Figure 9) are probably the most accurate since the maps had referencing streets, although the accuracy of the street locations was not very good in many cases. In creating the gas well location map from the 1925 image, the map was registered city block by city block to the streets locations obtained from GPS mobile surveys to ensure as high a degree of accuracy as possible for locating the wells. The map was created in an attempt to help find wells buried in backyards and between houses that could be related to methane leaks. More accurate well and vent locations are depicted on Plate 2. In spite of the methods used, the accuracy of the well locations varies. Some well locations near Walnut Street appear to be close to those found with the magnetometer; however, there are probably considerable inaccuracies in the remainder of the study area. There are several possible causes, including a time lag of five years between well drilling and the visit by Johnson, by which time the traces of abandoned wells would have disappeared. In addition, many of the houses had only just been constructed and the streets in Versailles were little more than dirt tracks, as shown in photographs. Many of the wells were completed as dry holes in 1919 - 1920,

Figure 9. Map showing wells digitized from M. E. Johnson (1929) report.

so there may have been little trace of them in 1925. It should be noted that the lack of a well spot on the map does not mean that no well was drilled. In fact, there are a number of wells that have been located on Second Street that are not shown on Johnson's map. The wells from the map should be used only as a rough guide – if a well is shown near a house, it is possible one was drilled in the vicinity. The accuracy of well spots on the map may only be ± 30 feet, with less accuracy outside of the borough due to a lack of roads and changes in road intersections over time that were used to register the images.

4.1.4.2 Hubbard Mine Map

Four map images of the Hubbard Mine, adjacent to Versailles Borough, were registered to real world coordinates using GPS points and road intersections digitized from topographic maps Figure 10 and Figure 11). The mine maps indicate that the Upper Freeport coal does underlie the Borough of Versailles, but that it was not mined there, except for a small part under Olympia Park.

4.1.4.3 Streets and Houses Location Map

More than 400 building outlines (Figure 12 and Plate 2) in the area below Walnut Street were digitized from a high resolution tiled air photo image of Versailles from Google Earth™ (©2007 Europa Technologies, ©2007 Navteq). Street addresses were field checked for accuracy and added to the building outlines to aid in determining old well locations with respect to existing structures. The address map was also used to update and refine the location and information from the 1990 gas sampling done by Heath Consultants.

4.2 Vent and Well Sampling

Several street-by-street walking reconnaissance trips were conducted of Versailles Borough between Walnut Street and the Youghiogheny River to map known gas wells, vents, and points believed to be old well locations. These points were determined by examining features within lots (existence of old casing, brown grass areas, vent pipes, or sunken areas of yards) and community questionnaire results. Attempts were then made to correlate the known and suspected wells and vents with previously mapped well locations as derived from maps in the 1929 M. E. Johnson report or reported on the WPA maps of the Hubbard Mine. By March 2006, over 80 features were noted and mapped with the GPS on or west of Walnut Street. Of these:

- Approximately 30 were known vents.
- Remaining sightings were suspected, but unverified, abandoned well locations. Many of these consisted of steel casing sticking up in yards, sometimes with a clothes line pole stuck in it, and more subtle signs, such as sunken areas or brown spots in a yard near where a well had been mapped in 1925. Although some of these were confirmed as old wells by Borough residents, future analyses would determine that many of these sightings were just what they appeared – clothes line posts.

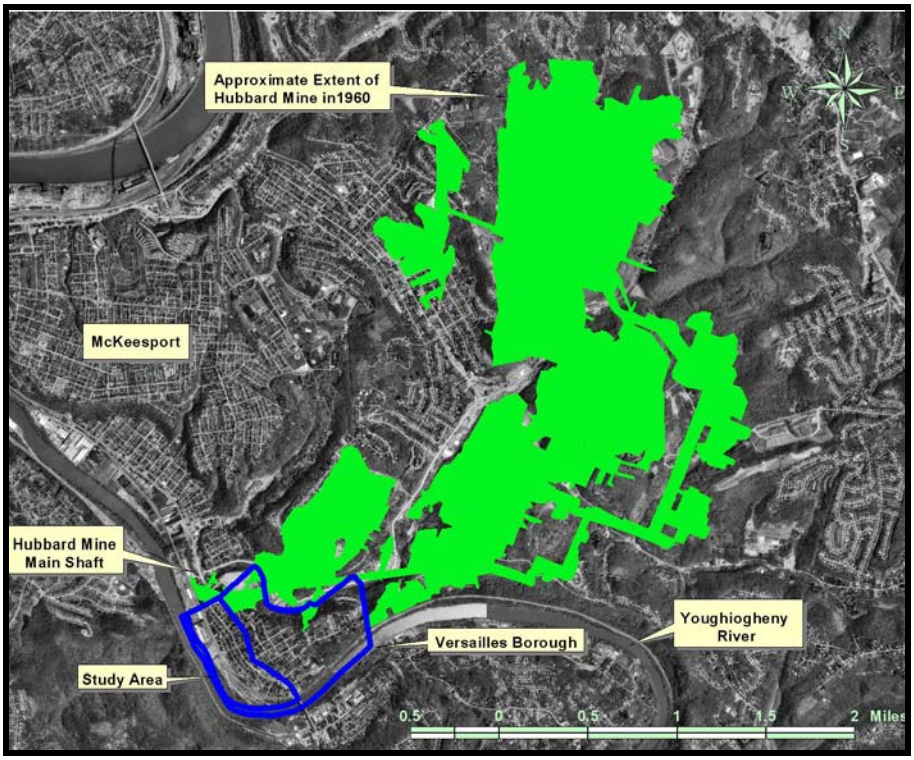

Figure 10. Composite map of the Hubbard Mine showing the extent of the mine in 1960.

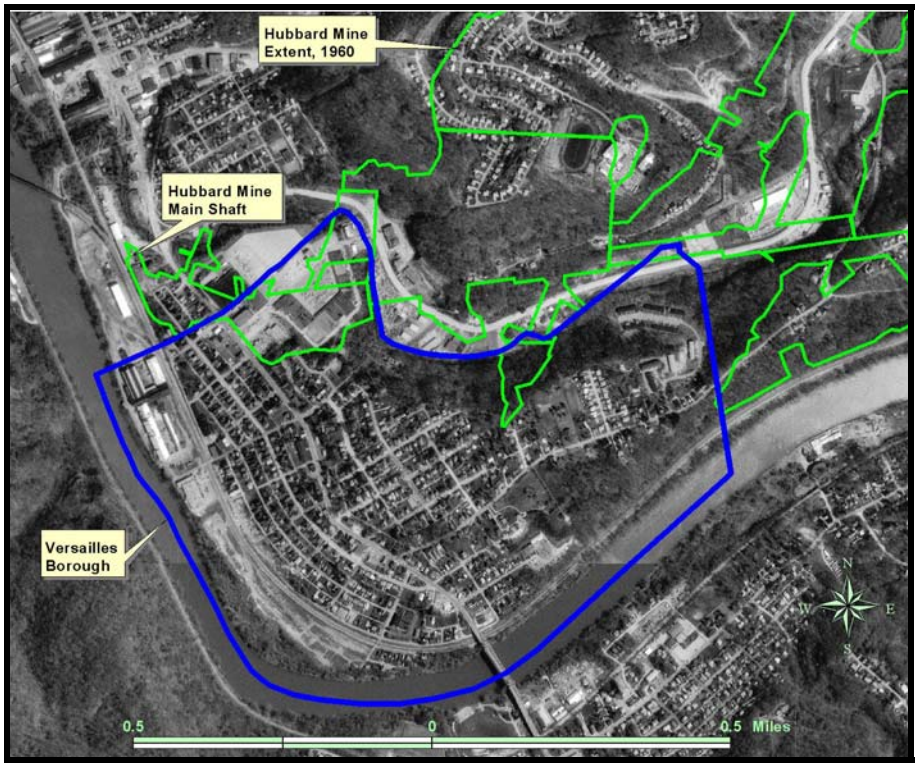

Figure 11. Relationship of the Hubbard Mine to Versailles Borough; note that only a small area near Olympia Park was undermined.

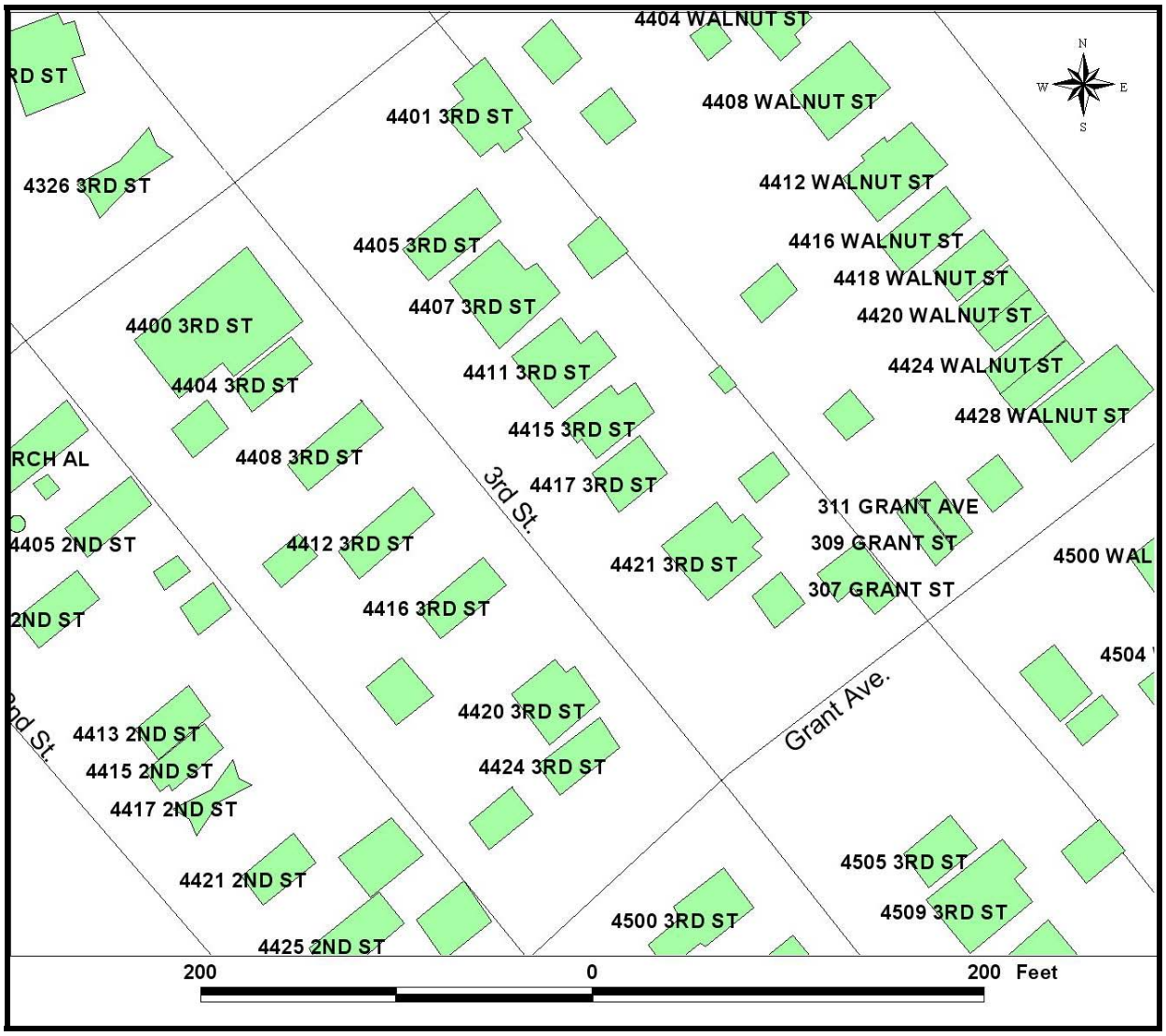

Figure 12. Partial view of the study area showing building shapes and addresses.

Once a vent or well was verified, gas chemistry sampling was conducted to "fingerprint" the gas source or sources. By comparing the hydrocarbon chemistry of the sampled gas from each vent and well to gas samples from conventional natural gas wells or coal bed methane wells, the gas source for each vent or well could be determined. Gas flow measurements were taken to determine the amount of gas being produced by each vent and well to estimate the total volume of gas being produced on a daily basis within the borough and if sufficient gas were available to be used within the borough or sold as a commodity to the local gas distribution company. Depth measurements were taken to determine if a vent was located over a well and to determine if the vent or well had sufficient depth to allow wireline-conveyed electric geophysical well logs and/or down-hole video camera surveys. However, much of this effort, including the verification of a vent or a well, was delayed by several months since the project team could not enter onto private property without permission. The property access problems and the results of the testing, once the access problems were resolved, are given in the following subsections.

4.2.1 Property Access Problems

Beginning in February 2006, Borough Council members began soliciting liability release waivers forms from property owners to allow the research team access to private property. By April, only 111 out of 397 (28%) of the property owners on or west of Walnut Street had signed the waiver forms. The lack of access to most of the properties resulted in an inability to:

- Examine and verify potential well locations and determine if they were actual wells, vents were over old wells, or vents over high gas concentrations areas.
- Access vent pipes to obtain a gas sample for analysis. Several of the vents known to actually produce methane were on properties for which a waiver had not been signed,
- Access properties held in lien by Versailles Borough. Some of these properties were held due to property condemnation from existing methane gas issues, unpaid property taxes, or in some cases, ownership was unable to be determined due to death of owner and unknown status of relatives.

On May 24, the research team addressed the potential impact on the project with the Borough Council for their consideration. At the recommendation of their Solicitor, the Borough Council voted to seek a court order forcing property owners to allow methane testing on the properties lying between Walnut Street and the Youghiogheny River.

In lieu of a time-consuming and expensive court case, the Borough Council passed an ordinance on July 20, 2006 requiring property owners to permit the Borough of Versailles, or its designee, to enter properties for purposes of detecting the presence of dangerous levels of methane gas for the health and safety of all residents within the borough. This removed a problem that had plagued the project since its start – our inability to enter private property to acquire gas samples, conduct ambient air sampling, or verify presence of old well casings. As a result of the inability to access properties, much of the field verification and sampling had been delayed almost six months.

4.2.2 Descriptions of Wells and Vents

Physically walking the streets and observing vents, depressions or brown grass areas within yards, or pipes protruding above ground level that might have been old well casing remnants had resulted in over 80 possible old well locations. A database was created to record basic vent data: address, property owner, vent or pipe size, and vent construction type (PVC or metal). In addition to the basic data, other factors were included: whether the vent top could be safely reached for gas sampling and whether the vent was of sufficient diameter to make it a potential candidate for a down-hole video camera survey. Most of the vents were constructed of 4-inch polyvinyl chloride (PVC) pipe and were usually equipped with a metal turbine ventilator, creating a vacuum effect to facilitate evacuation of methane gas. Some larger PVC vents (6 to 8-inch) were equipped with electric power blowers to facilitate gas evacuation.

Discussions with Mr. Mark Jacklitch, who had installed several of the vents, eliminated some of the questionable vent sites as only old clothes line poles or other yard fixtures. He also confirmed vents located over old wells or placed where surface gas shows were reported, but not necessarily directly related to old wells. Many additional questionable vent sites were eliminated

once property access was granted to examine the site. A listing of all vents is given in Table 1, locations are depicted in Figure 13 and Plate 2, and pictures of all known vents in the study area are included in Appendix A.

Based on these findings, known vents were divided into two groupings of candidate test sites. The first grouping contained wells known to be located over old wells that would be sampled for gas content analysis, gas flow rates, and, if accessible, down-hole video camera logging. The second group of wells would be sampled for gas flow and analysis only, since they were not accessible for down-hole video surveying due to building/landscaping limitations, vent inside diameter, or vent configuration.

Table 1. Locations of all vents and wells studied as part of this project. Addresses listed with an asterisks (*) reflect vents known or suspected to be directly associated with wells. Actual well locations are marked with a pound (#) sign.

Second Street	Third Street	Penn Way	Walnut Street
4705*	4307*	4713#	4300
4709*	4309	4723*	4304
4717*	4319*	4727	4322
4721	4625*		4324
4728*	4807		4719#
4802	4811#		4722#
4803#	4814		
4805*	4818		
4806*	4820		
4807			
4808*			
4813			
4815			
4819*			
4821*			
4822#			
4915			
4924			

4.2.3 Gas Analysis Results

Gas samples were taken from all vents that could be safely reached by ladder or from building roofs. Gas analyses were conducted to “fingerprint” the potential gas generation source or sources. Discussions were held with Microseeps Analytical Laboratory in Pittsburgh, PA regarding analyzing the gas samples from several of the vented wells in the Borough in an effort to “fingerprint” the gas source. Based on these discussions, a decision was made on sampling technique to use a gas extraction technique used by Microseeps as part of their soil sampling survey. Samples would be analyzed for C1 – C4 hydrocarbons (methane, ethane, propane, and butane) from vents known to be associated with an old abandoned well or actual old wells. For comparison, at least one sample would be taken form a known Speechley sandstone producing well in the area to help in “fingerprinting” the source formation(s).

Figure 13. Locations of all located study area vents and wells.

Sampling procedure utilized for all vents except the Borough garage well is given below.

1. A three foot piece of ¼-inch plastic tubing was attached to a 60-ml syringe equipped with a shut-off valve.
2. Plastic tubing was inserted into the vent top and extended down the inside of the vent.
3. A 50-ml sample of gas was withdrawn using the syringe, the valve was shut, tubing was removed from the syringe, and the sample discharged from the syringe to the atmosphere to purge syringe.
4. The plastic tubing was placed back on the syringe and the valve was opened.
5. A 50-ml gas sample was extracted with the syringe, the valve was closed, and tubing was withdrawn from the vent.
6. Plastic tubing on the syringe was replaced with a hypodermic needle, which was inserted through the septum of a sealed sample bottle, the valve was opened, and a 50 ml gas sample was expelled into the sample bottle.
7. The syringe valve was again closed, and the hypodermic needle was replaced with the plastic tubing.
8. Steps 4-6 were repeated for a duplicate sample for each vent.
9. Sample bottles were labeled and Chain of Custody report completed.

The Borough garage well was unique in that the well was cemented at the surface with a 1 ¼ inch pipe extruding through the cement (Figure 14). The 1 ¼ inch pipe was also filled with cement, but gas was visibly bubbling along the cement to the pipe contact where water was standing on the cement. Both the well casing and the 1 ¼ inch pipe had been cut off just above ground level, apparently so the site could be mowed without hitting the well.

Figure 14. Borough garage well at 4822 Second Street status prior to the beginning of drilling operations.

Since the Borough garage well was cut off at ground level and partially sealed with concrete, there was no way of inserting the plastic tubing to take a sample. A single-hole rubber stopper, equipped with a short piece of ¼-inch metal tubing and ¼-inch flexible inert laboratory tubing, was pushed into the cemented 1 ¼ inch piece of steel pipe where gas bubbles were emanating. The flexible laboratory tubing was attached to a Tedlar bag. Once filled, the 50-ml syringe equipped with a hypodermic needle and shut-off valve was inserted into the septum on the Tedlar bag and a sample and duplicate sample taken for analysis.

Laboratory analyses (Appendix B) were conducted on stray gas emanating from 30 existing vents and six abandoned wells within the Borough (Figure 15 and Plate 2) and from a known Speechley sandstone production well near East Allegheny High School, approximately five miles from the borough. Remaining vents were not sampled as they could not be safely reached for sampling due to height above roofs or physical inaccessibility. Analyses were run for C1 through C4 hydrocarbons (methane, ethane, propane, and butane, respectively). Based on these analyses, it was determined that gas from the 12 vents known to be attached to or associated with old wells contained 98% or higher of the hydrocarbon content was methane, based on the percentage of each of the tested hydrocarbons. Gas analysis of the Speechley well showed 96% methane with higher amounts of the C2 – C4 constituents (Figure 16 and Figure 17, and Table 2). The high methane content of the gas emanating from the vents correlated well with reports of local residents that they could not smell any gas odor, except for an occasional rotten egg sulfur smell. Pure methane gas has no odor. Gas utility companies add an odorant, mercaptan, so that gas can be detected in a home or business in case of leakage. The occasional rotten egg odor reported by some residents would suggest the presence of some sulfur dioxide or hydrogen sulfide (H_2S) in the stray gas. The H_2S could be due to anaerobic (absence of oxygen) digestion from bacterial breakdown of organic matter, but can also occur naturally in natural gas wells.

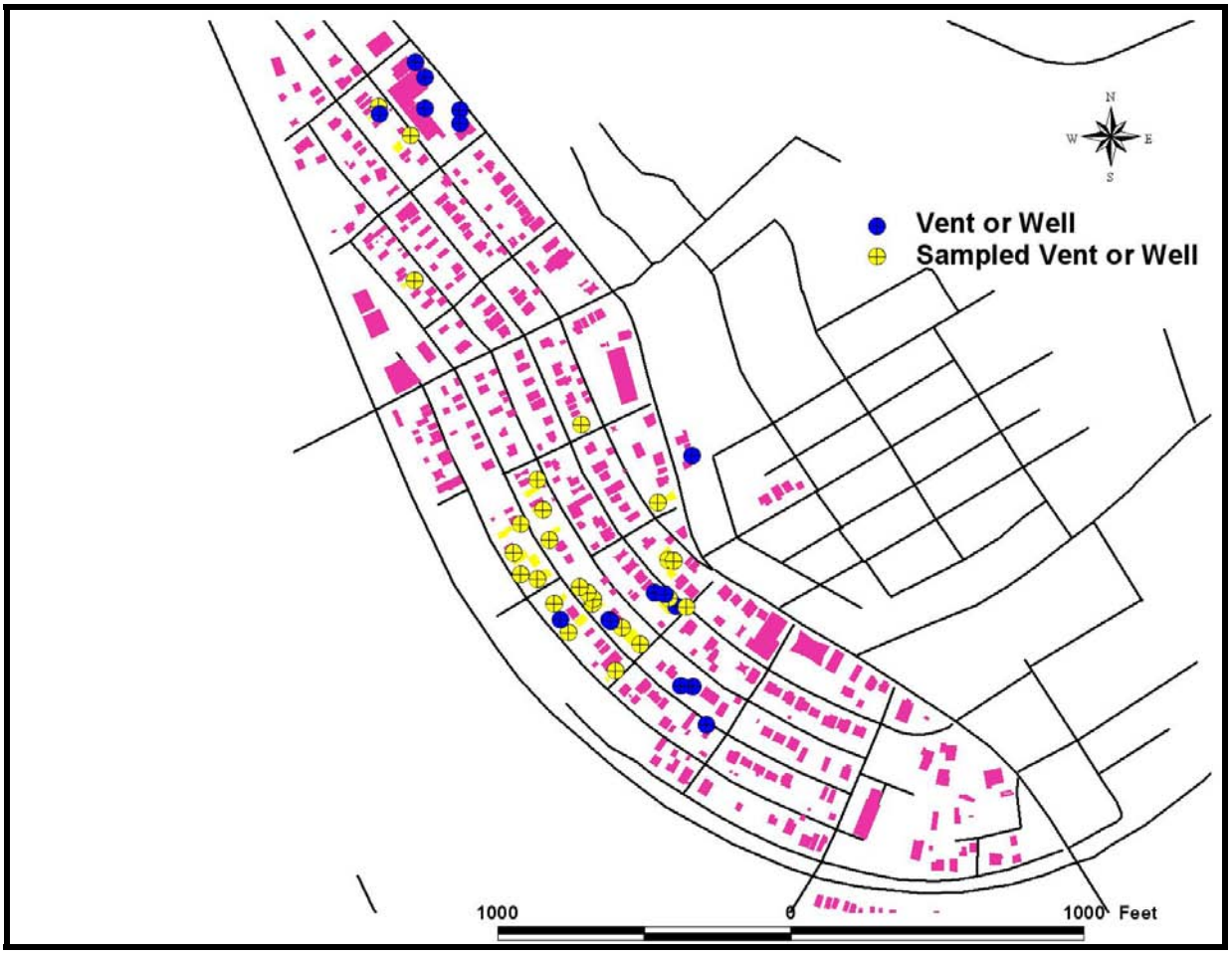

Figure 15. Map showing the locations of all vents within the study area; vents shown in yellow were sampled for gas analysis.

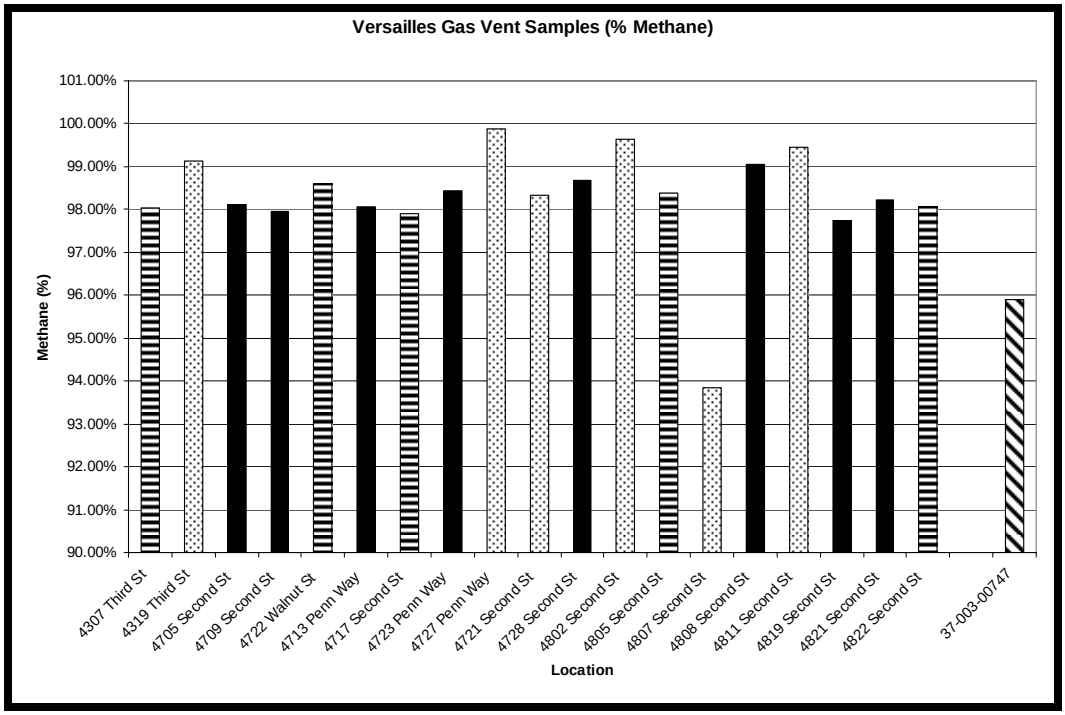

Figure 16. Percent methane in sampled Versailles vents: solid bars are vents over known or suspected wells, dotted bars are vents over areas where gas had previously been detected, bars with horizontal lines are wells/vent with measurable gas flows, and the cross-hatched bar is a known Speechley producing well at East Allegheny High School.

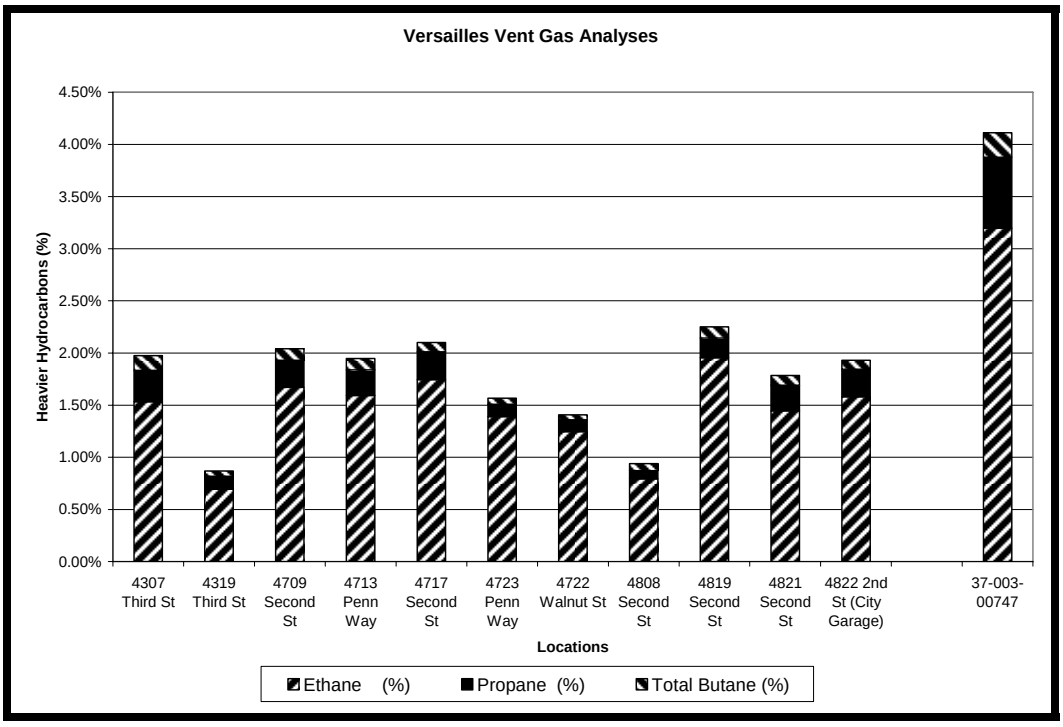

Figure 17. Distribution of non-methane hydrocarbon in select sampled vents and the Speechley gas well.

Table 2. Gas vents sample location, sample source, sample date, and each analyzed hydrocarbon percentage.

Sample Description	Sample Source	Sample Date	Methane (%)	Ethane (%)	Propane (%)	Butane (%)
4417 Second St (Tall)	Vent	11-Sep-06	93.43%	0.69%	1.73%	4.15%
4417 Second St (Hole)	Hole	11-Sep-06	91.70%	0.87%	2.18%	5.24%
4417 Second St (Short)	Hole	11-Sep-06	91.70%	0.87%	2.18%	5.24%
4705 Second St	Vent/Well	8-Sep-06	98.12%	1.61%	0.20%	0.08%
4709 Second St	Pipe/Well	24-May-06	97.96%	1.67%	0.26%	0.11%
4717 Second St	Vent	6-Jul-06	97.90%	1.74%	0.27%	0.09%
4721 Second St	Vent	18-Aug-06	98.33%	1.40%	0.19%	0.08%
4728 Second St	Vent/Well	22-Aug-06	98.69%	1.18%	0.09%	0.04%
4802 Second St	Vent	22-Aug-06	99.64%	0.20%	0.05%	0.12%
4803 Second St	Well	11-Sep-06	99.14%	0.51%	0.11%	0.25%
4805 Second St	Vent/Well	18-Aug-06	98.39%	1.33%	0.20%	0.09%
4807 Second St	Vent	18-Aug-06	93.86%	4.42%	0.95%	0.77%
4808 Second St	Vent/Well	23-May-06	99.06%	0.79%	0.08%	0.07%
4811 Second St	Vent	18-Aug-06	99.45%	0.43%	0.04%	0.08%
4819 Second St	Vent/Well	23-May-06	97.75%	1.95%	0.19%	0.11%
4821 Second St	Vent/Well	24-May-06	98.21%	1.45%	0.25%	0.09%
4822 2nd (City Garage)	Pipe/Well	23-May-06	98.07%	1.58%	0.26%	0.09%
4307 Third St	Vent/Well	6-Jul-06	98.02%	1.53%	0.30%	0.14%
4319 Third St	Vent	6-Jul-06	99.13%	0.69%	0.12%	0.05%
4625 Third St	Well	11-Sep-06	98.47%	1.48%	0.05%	0.00%
4807 Third St	Vent	11-Sep-06	99.59%	0.22%	0.06%	0.14%
4811 Third St	Well	11-Sep-06	98.95%	0.91%	0.05%	0.10%
4818 Third St (Porch)	Vent	11-Sep-06	95.68%	0.53%	1.11%	2.67%
4820 Third St (Shrub)	Vent	11-Sep-06	95.35%	0.49%	1.22%	2.93%
4713 Penn Way	Hole/Well	24-May-06	98.05%	1.59%	0.25%	0.11%
4723 Penn Way	Vent	23-May-06	98.43%	1.39%	0.12%	0.06%
4727 Penn Way	Vent	8-Sep-06	99.87%	0.01%	0.03%	0.08%
4722 Walnut St	Pipe/Well	22-Jun-06	98.59%	1.25%	0.11%	0.05%
37-003-00747	Gas Well	22-Jun-06	95.89%	3.20%	0.68%	0.23%

The high methane content in the sampled vents and wells is consistent with previous soil gas investigations of stray hydrocarbon gas conducted by the PA DEP (Baldassare and Laughrey, 1997) where heavier hydrocarbons may be stripped out by migration through the soil. Vents not attached to wells showed inconsistent results based on the amount of gas within the soil adjacent to the vent and the apparent distance the gas had to migrate from its source. Review of the hydrocarbon profile from the analytical data obtained from vents associated with known old gas wells indicated that the C-1:C2+ ratios were consistent with natural gas of Upper Devonian origin. Stable carbon and hydrogen isotope data for stray gas samples collected at two locations by the PA DEP in 2004 support this interpretation (Fred Baldassare, personal communications, 2007). Specific origin of the stray gases is unknown and was beyond the scope of this investigation. The stray hydrocarbon gases detected at the surface in Versailles Borough is likely

a mixture of gases from some combination of the gas-producing Upper Devonian sandstones. Gas from the Upper Freeport and other coal seams may also be contributing to the stray gas problem at the surface as gas moves vertically up the improperly abandoned wellbores. Improper well abandonment for many of the gas wells drilled in the borough provides a mechanism of migration for the stray gas detected at the surface.

4.2.4 Gas Flow Measurements

Gas flow measurements were taken at all vents that could be safely reached by ladder or from the building roof. Flow measurements were taken to:

- Locate vents producing measurable gas
- Examine gas variations across the study area
- Determine the accumulative amount of gas being produced
- Evaluate if produced methane gas was sufficient to have economic value

Many of the vents were found to not be attached to old wells, but were placed in yards or adjacent to structures where gas "hot spots" had been located during previous studies. Gas emanating from the vents and old abandoned wells has very low surface pressure (generally only a few pounds per square inch, psi) and in most cases low production rates, less than 0.5 cubic feet per hour (ft^3/hr). Of the sampled vents, only five vents (Table 3 and Figure 18) had measurable gas flows above the minimal detection limit of 0.5 standard cubic feet per hour (ft^3/hr). A total flow rate of 70 ft^3/hr was found from all existing vents and wells within the study area. One well, located at 4805 Second Street, was producing 50 ft^3/hr (1.2 Mcf/day) or approximately 70% of the combined total of 70 ft^3/hr. Since seismic surveys (refer to Attachment II) were inconclusive in determining gas migration pathways, two old wells were reopened and cleaned through the coal intervals. One well was located on a vacant lot at 4722 Walnut Street; the second well was located at 4822 Second Street on a vacant lot adjacent to the Borough garage. Gas flow rates after wellbore cleanout were 10.0 and 6.5 ft^3/hr, respectively. These two wells plus the well at 4307 Third Street were selected for down-hole video camera surveys and electric geophysical logging.

Table 3. Locations and flow rates of vents and old wells having measurable gas flows.

Location	**Flow Rate (ft^3/hr)**		**Type**
	Initial Rate	Post Clean-out	
4307 Third Street	20.0	not applicable	Vent over Well
4717 Second Street	3.5	not applicable	Vent
4805 Second Street	50.0	not applicable	Vent over Well
4822 Second Street	≈ 0.5	6.5	Well
4722 Walnut Street	≈ 0,5	10.0	Well

Along with gas flow measurements, a weighted tape with a water contact probe was lowered in the well to determine depth of the open wellbore and top of water depth. Total well depth was important to evaluate if down-hole video camera surveys and/or electric well logs could be run to determine methane gas entry point(s) into the wellbore. Locations, open well bore depth, depth

to top of water, and initial testing gas flow rates as well as sample date and any comments by the field team for all vents are given in Table 4 and Table 5. Vents producing gas are shown in **bold type**.

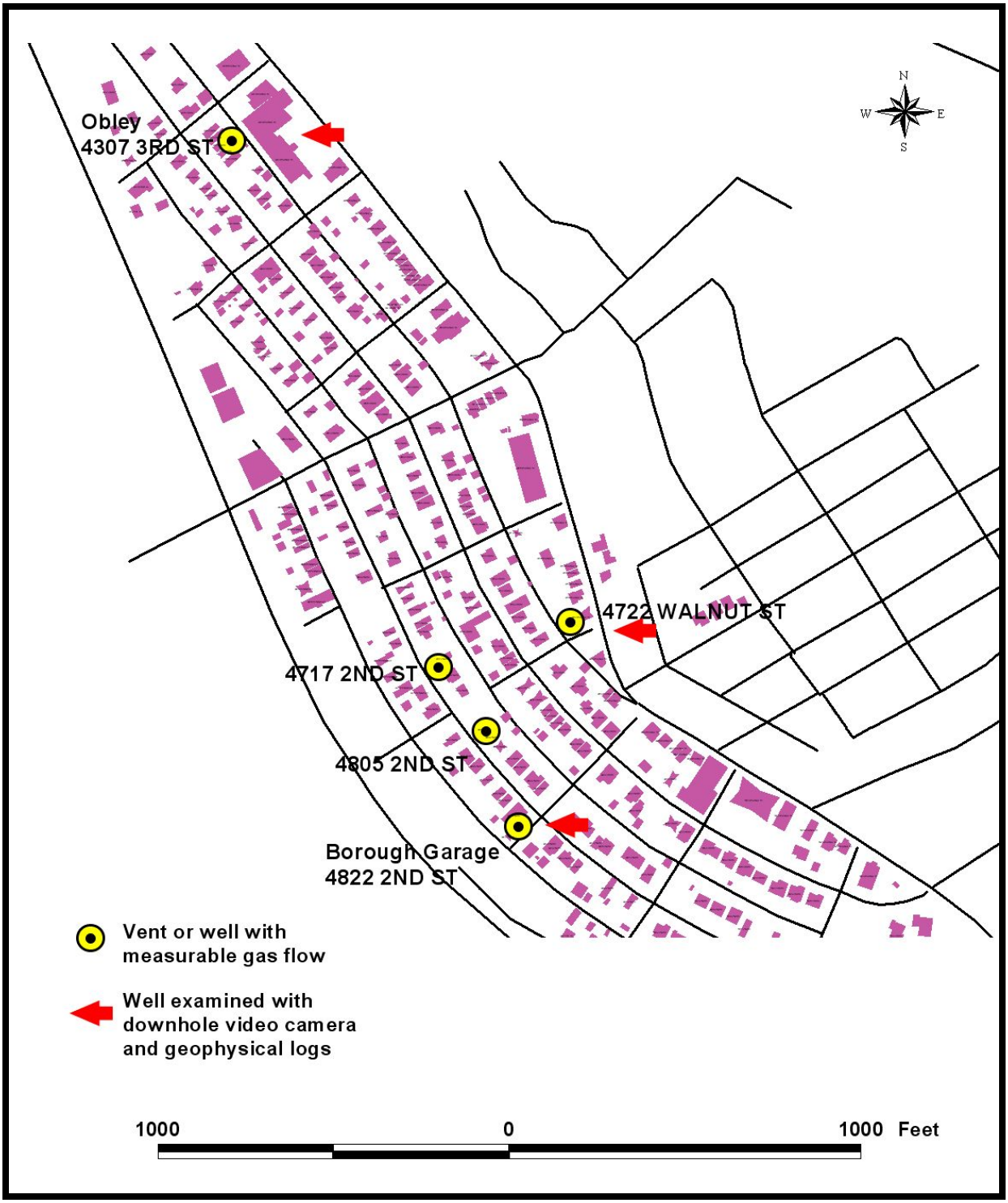

Figure 18. Locations of vents having greater than 0.5 cubic feet per hour gas flow rates. Three of these wells were examined with down-hole video camera and geophysical logs.

Table 4. Gas flow rates, well depth, and water level in vents known or suspected of being associated with a well; BOLD type reflects gas producing vents or wells.

Address	Well Depth (feet)	Top Water (feet)	Gas Flow Rate (ft^3/hr)	Sample Date	Field Team Comments
Vents attached to wells tested for gas flow rates					
4307 Second St.	99	55	20.0	10/9/2006	Next to Obley's
4705 Second St.	13	4.65		9/8/2006	Bubbling; sulfur odor
4717 Second St.	13	5	3.5	8/18/2006	Opfar rental
4805 Second St.	32.7	17.2	50.0	8/18/2006	No H_2S found
4805 Second St.	32.7		50.0	3/21/2007	
4805 Second St.	32.7		35.0	4/10/2007	During Methane Buster™ testing
4808 Second St.	0		Not measurable	8/22/2006	
4821 Second St.	0		Not measurable	9/18/2006	17 ppm H_2S; vent not open below grd level
4822 Second St. (Borough garage)			Not measurable	8/22/2006	Bubbling slightly at surface seal
4811 Third St.	64.2	38	Not measurable	9/8/2006	
4722 Walnut St.			Not measurable	8/22/2006	Vacant lot

Results of the gas flow rate testing and well total depth measurements showed:

- No vents were found with sufficient depth to allow for down-hole video camera surveys or electric well logging operations without drilling out the wells.
- All vents not directly attached to wells had no measurable flow rates at the minimal detection rate of 0.5 ft^3/hr.
- Total amount of gas produced from all productive vents prior to any well clean out or Methane Buster™ testing was 74.0 ft^3/hr, with the majority of the gas (50.0 ft^3/hr) at 4805 Second Street.

Table 5. Gas flow rates, vent depth, and water level for vents not associated with a well.

Address	Well Depth (feet)	Top Water (feet)	Gas Flow Rate (ft^3/hr)	Sample Date	Field Team Comments
Vents not directly attached to wells tested for gas flow rates					
4417 Second St	2		Not Measurable	9/8/2006	Galvanized 3-in pipe: not a well
4417 Second St	1.7		Not Measurable	9/8/2006	Hole
4417 Second St			Not Measurable	9/8/2006	Short pipe; part of old oil tank?
4709 Second St			Not measurable	9/8/2006	
4728 Second St			Not measurable	8/22/2006	
4802 Second St			Not measurable	8/22/2006	
4807 Second St			Not measurable	8/18/2006	
4811 Second St			Not measurable	8/18/2006	
4319 Third St			Not measurable	8/22/2006	
4625 Third St			Not measurable	9/19/2006	
4723 Penn Way			Not measurable	9/8/2006	
4727 Penn Way			Not measurable	9/8/2006	

4.2.5 Hydrogen Sulfide (H_2S) Problems

Three vents (two that were tested and one that could not be tested, but was reported by local residents) were found to have a sulfur (rotten egg) odor as part of the gas analysis sampling conducted during September, 2006, prior to opening the Borough garage and Walnut Street wells. The original thought was it was possibly sulfur oxide, but surveys taken with the Passport multi-gas detection unit indicated that the gas was hydrogen sulfide (H_2S). Hydrogen sulfide often results from anaerobic bacterial digestion, the bacterial breakdown of organic matter in the absence of oxygen, such as in swamps and sewers. It also occurs naturally in some coal seams, natural gas, and some well waters. Although the exact source of the hydrogen sulfide could not be determined, it is speculated that it might be coming from bacteria attacking organic material that has been thrown into the old wells in the past when the wells were open at the surface, or possibly a sewage leak in the area.

All three vents are located in the 4700 and 4800 blocks of Second Street over old wells. The vent at 4705 Second Street had a sulfur odor and showed the presence of 1 ppm H_2S using a Passport combination gas meter. The vent is constructed of 4-inch PVC pipe, equipped with a small passive turbine, and located next to an aboveground swimming pool and deck (Figure 19). The passive turbine blades and blade support mechanism are missing or badly corroded. The vent next to 4819 Second Street (Figure 20) had produced a sulfur odor and discharged water with a sulfur odor numerous times in the past as reported by local residents, but had not done so for the past few years. What appeared to be sulfate coatings were evident on the bottom and side in the nearby storm drain where water from the vent had been discharged in the past. However, this site was not tested for H_2S concentration due to safety issues, since the vent extended high above the roof of the structure. The only vent that was tested and showed a significant presence of H_2S before opening and cleaning any of the old wells was located at 4821 Second Street (Figure 21). This vent currently has a fake bird house on top of the support pipe to vent produced gas and to add aesthetic value to the vent. Gas within the vent measured 17 parts per million (ppm) H_2S with the Passport combination gas analysis meter, but dissipated to near zero within a couple feet of the open vent. Although H_2S can be lethal in higher concentrations, 17 ppm is within the safe range for humans and well below the

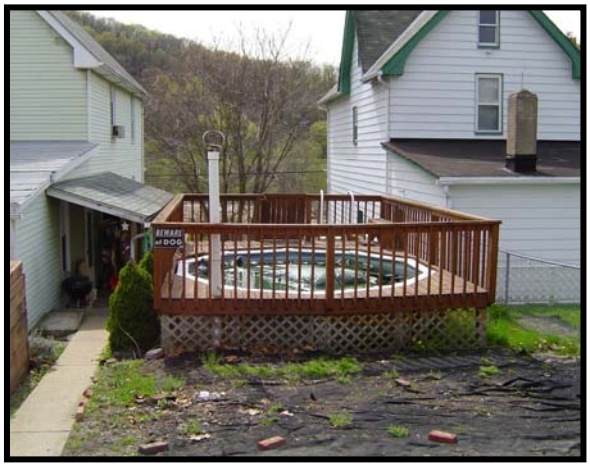

Figure 19. Vent with 1 ppm H_2S at 4705 Second Street.

Figure 20. Vent reportedly producing sulfur odor and sulfurous water at 4817 Second Street.

National Institute of Safety and Health (NIOSH) Immediately Dangerous to Life and Health (IDLH) level of 100 ppm. Hydrogen sulfide was also detected, in significantly higher levels, after drilling and cleaning the well by the Borough garage at 4822 Second Street. Details are described in Subsection 4.3.1.5 below.

4.3 Drilling and Cleaning of Existing Wells

Depth determinations of all vents known to overlie old wells showed they were partially plugged or caved-in a short distance below the surface. To determine the gas migration pathways and attempt to delineate possible stray gas sources, up to three wells (two partially cemented wells and a vented well) were to be cleaned out to below all coal seams. The first partially cemented well was located at 4822 Second Street, adjacent to the Borough garage building. The second partially cemented well was located on a vacant lot at 4722 Walnut Street. A well located at 4307 Second Street had previously been vented and was equipped with a blower system. Locations of the three wells are shown on Figure 18.

Figure 21. Vent with 17 ppm H_2S at 4821 Second Street.

After clean-out, a video camera survey would be conducted to examine the wells for points of gas entry in addition to casing integrity. Borehole geophysical logs would also be run to correlate subsurface geology. The wells were selected based on (1) accessibility, as all three were situated on properties owned by or in tax arrears to the Borough and (2) areas of known stray hydrocarbon gas problems. After the wells were cleaned out and testing completed, they would be equipped with a wellhead, valve, and vent to aid in venting the stray gas. Discussions with PA DEP personnel indicated that no permits were required to clean the wells since the procedure was not for gas production, but for testing purposes and gas entry validation. Clean-out operations for each of these wells are described in the following subsections. A detailed daily report of each operation is included as Appendix C.

4.3.1 Borough Garage Well (4822 Second Street)

4.3.1.1 Drilling Operations

Prior to drilling operations, a 13.2 kilovolt (kV) power line and transformer located along Worthington Avenue were removed and relocated in order to prevent a potential electrocution hazard. Hydrocarbon Well Services, Inc. moved their drill rig on location September 25, 2006. The well was opened and found to be filled to within three feet of the surface with old blocks of wood, bricks, and metal window trim. Hydrocarbon personnel equipped the well with a threaded 10-inch collar, flow diverter, and rotating head in preparation for drilling. A water tank and

portable drilling pit were moved on location. Water for drilling operations was supplied from a nearby fire hydrant using hoses supplied by Versailles Borough Fire Department. Amount of water usage was recorded using a water meter supplied by the Municipal Authority of Westmoreland County. Clean-out operations on the well commenced on this same day.

The well was drilled to a depth of 345 feet using a 6 5/8 inch tri-cone bit with 4 1/2 inch drill collars run on 2 3/8 inch drill string by September 28. The well was then bailed for 4 hours using an 8-inch bailer in preparation for the down-hole video survey. In spite of these efforts, well water level could not be reduced below 20 feet from the surface due to groundwater entering the well from the surrounding area. Water level in the well stabilized at 16.6 feet below ground level with visible gas bubbling through to the surface at a measured flow rate of less than 0.5 cubic feet per hour (ft^3/hr).

4.3.1.2 First Down-hole Video Survey

On September 29, 2006, a special borehole camera designed to run in explosive gaseous conditions was lowered into the well. The borehole camera had capabilities to view either the wellbore edge, using a rotating side view camera, or vertically down the wellbore with a fixed camera. Both cameras were equipped with individual lighting systems and focusing capabilities. Due to the murky condition of the well borehole water, visibility was limited and the exact depths of objects could not be determined. The bottom of the 10-inch surface conductor casing was approximately 40 feet below ground level and the hole was open below this depth. The bottom of the Upper Freeport coal seam was approximately 195 feet, and the total depth of the well was tagged by the camera at 332 feet, 13 feet higher than the driller's depth. This implied that the wellbore may be caving and causing partial or full blockage of the well. The murky water and low visibility would not allow verification of this theory. Gas bubbles appeared to be evident at this depth, but could not be verified. Gas bubbles appeared to increase in frequency as the camera rose above a depth of 180.5 feet, above the top of the Upper Freeport coal seam. Periodic gas bubbles were also evident as the camera was coming up the well bore, but it could not be ascertained if the gas was coming from geologic formations above the coal or if the gas was coming from the coal. Due to the uncertainty of gas being present below a depth of 332 feet, a decision was made to drill the well deeper to a total depth of 800 feet, thus passing through all coal measures in the area.

4.3.1.3 Continued Drilling Operations

Well deepening operations began on October 4, 2006 with the same drilling assembly. Over 5000 gallons of fire hydrant water went down the drill string in an effort to reestablish water circulation and bring drill cuttings to the surface. These efforts, however, were unsuccessful. Drilling was then continued without adding fluids and with little resistance to a depth of 380 feet where circulation was reestablished. Drilling continued without incident to a depth of 570 feet where the bit either deviated out of the original well bore or began drilling new hole. The deepening operation was terminated at a total depth of 575 feet on November 6, 2006. A 10 x 4-inch swage and 4-inch ball valve were installed on the well. The well was shut-in awaiting the down-hole video camera survey.

4.3.1.4 Second Down-hole Video Survey

A second down-hole video survey was conducted on October 9, 2006. Gas was visibly bubbling through water at an approximate depth of 17.5 feet below ground level. As with the first video survey, the water was very murky but with this run it cleared at 217 feet. No gas bubbles were visible at this depth. As the camera was pulled out of the hole, rock debris from the well bore was seen falling in the water at depths of 200 and 190 feet. There were, however no visible gas bubbles. Rock debris particles appeared to be swirling at a depth of 180 feet. What appeared to be the first gas bubbles were seen at a depth of 110 feet, more than 40 feet above the top of the Upper Freeport coal seam. The camera appears to confirm that no gas is coming from below the Upper Freeport coal seam, but gas may be entering from stratigraphically higher formations. Again the water was too murky to verify any gas entry points or actual evidence of where the gas bubbles began or ended.

4.3.1.5 Presence of Hydrogen Sulfide (H_2S) in Gas

Drilling began on the Borough garage well on September 21, 2006 and ended on October 6, 2006. On October 24, the well was producing 13 ppm H_2S. A 4-inch PVC vent pipe approximately 10 feet tall was attached to the well casing to disperse the H_2S into the atmosphere. A reading taken on November 15 of the wellbore gas indicated an H_2S reading of 118 ppm. This concentration is above the 100 ppm Immediately Dangerous to Life and Health (IDLH) level as determined by the National Institute of Safety and Health (NIOSH). The vent pipe was removed and the well was shut-in using a 2 x 4-inch swage, 2-inch ball valve, and a 2-inch bull plug with ¼-inch needle valve and pressure gauge in the end of the bull plug. The same day the well was shut-in, the Borough Street Maintenance personnel using the garage, Borough security, and Borough office personnel were notified that the wellbore contained high levels of H_2S, that the well had been shut-in to avoid any escape of H_2S to the atmosphere, and to not reopen the well. Notifications were also made that day to the PA DEP Oil and Gas Division and RDS Environmental Health and Safety (ES&H) personnel apprising them of the situation and the actions taken.

On November 21, flow was opened through the ¼ inch needle valve and the Passport combination gas meter indicated 170 ppm H_2S. A sample of the gas was taken using a Tedlar bag, analyzed by the Morgantown NETL laboratory, and determined to contain 331 ppm H_2S. The lower measurement in the field was likely a result of gas dilution caused by circulating air at the top of the 2-inch ball valve sampling point. Although the level in the wellbore was at an unsafe level, the concentration in the open atmosphere was near zero within a couple feet of the well. The well was flowing at a rate of only 6.5 ft^3/hr and had shut-in surface pressure of 3.5 psi. Due to the low flow rate, the height of the vent above ground level, and dispersion rate in the open atmosphere, area borough residents were never in jeopardy from the produced H_2S. Measurements taken at the vent at 4821 Second Street remained at 17 ppm during the increased H_2S levels in the Borough garage well.

A H_2S removal system was researched and a H_2S removal cartridge was ordered to allow the well to be safely reopened to the atmosphere. A SulfaTreat* mini-vent was ordered to eliminate

* Mark of M-I, LLC.

the H_2S emission problem. The SulfaTreat mini-vent is a commercially available 4-foot x 3-inch PVC pipe packed with granular material that removes most, if not all, H_2S. Based on wellhead pressure, gas flow rate, and measured H_2S concentrations, the mini-vent should eliminate any H_2S emanating gas from the well for at least two years. The H_2S removal cartridge was installed on the well on December 11, and the well was reopened to the atmosphere. No H_2S was detected at the output end of the cartridge. By December 13, the H_2S inside the wellbore had dropped from the high of 331 ppm to 104 ppm using the Passport multi-gas meter. By March 21, the H_2S level inside the wellbore had dropped below the detection level of the Passport multi-gas meter, and has remained at that level throughout the duration of the field project. The last H_2S wellbore reading taken as part of this project with the Passport multi-gas meter was again below the detection level of the Passport multi-gas meter on April 13, 2007. The H_2S removal cartridge was left on the wellhead in case any additional H_2S was produced in the wellbore after the project was completed. RDS ES&H personnel were on site with monitoring and safety equipment during all sampling and work on the Borough garage wellbore until the well dropped to undetectable H_2S readings in March. All H_2S readings taken during video camera surveys, geophysical well logging, and installation of wellbore casing were all in the safe range over the open wellbore and consistently dropped to nearly zero or below the detection level of the Passport multi-gas meter within a couple feet of the wellbore. Hydrogen sulfide (H_2S) measurements during this time period are shown in Table 6.

Table 6. Gas flow rates, sample dates, and field comments before, during, and after H_2S production at the Borough garage well (4822 Second Street).

Address	Well Depth (feet)	Top Water (feet)	Gas Flow Rate (ft^3/hr)	Sample Date	Field Team Comments
4822 Second St	345	16.6	Not measurable	9/29/2006	During drilling; water bubbling strongly
4822 Second St	491		6.5	10/24/2006	13 ppm H_2S detected. Installed 10 ft PVC vent
4822 Second St	491		6.5	11/15/2006	118 ppm H_2S. Well shut in (valves closed)
4822 Second St	491		Shut-in	11/17/2006	158 ppm H_2S. Shut-in pressure 3.4 psi.
4822 Second St	491		Shut-in	11/21/2006	Shut-in pressure 3.3 psi. Took garage sample # 1 @ 70 ppm H_2S & sample # 2 @ 170 ppm H_2S
4822 Second St	491		Shut-in	11/27/2006	Ordered SulfaTreat H_2S removal filter
4822 Second St	491		8.0	12/11/2006	Shut-in pressure 3.35 psi. Installed SulfaTreat H_2S removal filter (cracked during shipping)
4822 Second St	491		6.5	12/15/2006	104 ppm H_2S Replaced cracked SulfaTreat filter
4822 Second St	491		6.5	1/4/2007	132 ppm H_2S
4822 Second St	491		6.5	3/21/2007	No measurable H_2S
4822 Second St	491		6.5	4/10/2007	No measurable H_2S
4822 Second St	491		5.5	4/13/2007	No measurable H_2S

Hydrogen sulfide often results from anaerobic bacterial digestion of organic matter in the absence of oxygen, such as occurs in swamps and sewers. It also occurs naturally in natural gas, coal seams, and some well waters. The H_2S in the Borough garage well could be coming from a

multitude of sources. The wellbore when opened and drilled contained pieces of old wood and bricks that had been under water since the well had been temporarily sealed many years ago (the exact date is unknown). This debris, along with any other trash placed in the open wellbore before it was sealed and dislodged during the drilling and cleaning, may have been digested and produced some H_2S gas when exposed to the fresh water drilling fluids. The water used to drill out the rubble in the old wellbore was obtained from a nearby fire hydrant. The water in the hydrant had obviously been there for a long period of time as it contained what appeared to be a combination of mud and iron residue and may also have contained some bacteria. The steel water storage tank and portable mud pit used for drilling had lain dormant for a period of time and could have contained bacteria. Alternatively, H_2S may be occurring naturally in the stray natural gas or in the coal seams and its concentration heightened by the drilling activity and increased flow rate.

4.3.1.6 Third Down-hole Video Survey and Electric Geophysical Well Logging

Borehole video of the Borough garage well run on December 13, 2006 indicated the water level was at an approximate depth of 21 feet with some gas bubbles visible at the water surface. Gas bubbles were visible to a depth of 65 feet. The exact entry point could not be determined due to the amount of fine clay and coal fragments held in suspension in the wellbore water. However, since no gas bubbles were evident below a depth of 65 feet, this means the gas was emanating from the shallow Buffalo sandstone within this wellbore. Total depth for the well as recorded by the video camera was 491 feet.

Horizontal migration of the gas in the Buffalo sandstone close to the surface (less than 20 feet) may account for the widespread methane gas problem in the 4700 and 4800 blocks of Penn Way and Second Street, including gas within several yards and within or adjacent to the roadways. Based on field magnetometer and gas detection surveys described in Subsection 4.5, the old wellbores are the primary source for the vertical migration of the stray gas to the surface in this area, especially where part or all of the surface casing remains. However, where casing is absent at the surface, the stray gas tends to migrate away from the old wellbore into the surface soils. Soil types in the area may be a contributing factor as they were derived from weathering of the underlying sandstone and former floodplain materials of the Youghiogheny River. Local residents reported that the gas leakage problem was worse during wet weather. During dry weather, the gas would migrate up the old wellbores, through the soil, and into the atmosphere. During wet weather, water can fill the upper pore spaces within the soils, forcing the migrating gas to move laterally into structural foundations and back into the old wells instead of continuing the vertical movement into the atmosphere. The same may be true when barometric highs are in the area, since the low pressure gas in the wells and vents could be retained under such conditions.

On the same day of the video survey, Century Geophysical ran borehole geophysical logs including gamma ray, density, caliper, resistivity, temperature, collar locator, and borehole deviation. The water level was found to be 19 feet below the top of the 4-inch tee; the tee is approximately two feet above ground level. Top and base of Upper Freeport coal were 166 and 173 feet, respectively. Log total depth for the well was 479 feet, indicating additional filling or

cave-in at depth had occurred since the video survey. Noteworthy geologic formation depths determined from the geophysical logs are shown in Table 7.

Table 7. Depth of select formations at the Borough garage well located at 4822 Second Street.

Geologic Formation	Top Depth (ft)	Bottom Depth (ft)
Surface Conductor (casing)	0	41
Buffalo sandstone	<20	73
Mahoning sandstone	128	156
Upper Freeport coal	166	173
Lower Freeport coal	233	236
Upper Kittanning coal	341	345
Middle Kittanning coal	418	422

4.3.1.7 Open-hole Well Packer and Production String Installation

At the Borough garage well, an open-hole well packer was run on 7-inch, J-55, 23 lb/ft casing and set with 3,000 pounds tension at a depth of 150 feet in the base of the Mahoning sandstone, just above the Upper Freeport coal seam. Casing and packer were set above the Upper Freeport seam due to the uncertainty that stray gas might still be entering the wellbore from the coal seam. NOTE: The fact that the gas was not entering the wellbore below the Buffalo sandstone was not determined until after the video tapes had been converted from video tape to digital video disc (DVD) format and viewed on a high resolution monitor, several weeks after the casing was originally run in the wellbore. Pipe tally of the open-hole packer and 7-inch casing are provided in Table 8.

Table 8. Pipe tally for Borough garage well.

Description	Length (ft)
Packer	4.45
Casing	30.20
Casing	30.20
Casing	30.15
Casing	30.20
Casing	23.05
Casing (Pup joint)	5.00
Total	**153.25**

A 10 x 7-inch well head was installed at the surface with a solid bull plug on one side and a ¼-inch NPT tapped bull plug on other side. To monitor any annular pressure, ¼-inch tubing, ¼-inch valve, and a pressure gauge were installed to bring the test point above ground level. A 7 x 4-inch swage was installed on the 7-inch casing collar and the previously installed valve system, SulfaTreat module, and vent pipe were reinstalled.

The gas flow rate from the 7-inch well casing was tested on February 12, 2007. No measurable flow rate or pressure was found on the casing. However, the casing annulus had a pressure of 3.5

psi. This indicated that gas was present outside the casing above the Upper Freeport coal. Gas flow rates were again taken on both February 16 and 21, with similar results.

The service rig was moved back on location on March 6, 2007. The packer was released and several attempts were made to raise the casing, but the casing only moved about 12 inches and became stuck in the well bore due to debris on top of the packer. Several attempts were made to move the packer and casing assembly up and down in an attempt to dislodge the debris without success. A decision was made to lower the packer into a washed-out section of the well bore. A 5-foot pup joint was added and the packer assembly was lowered, which allowed the debris to fall from atop the packer. The packer was raised 11 feet from its original position and set with 4,000 pounds tension at a depth of 142 feet near the top of the Mahoning sandstone. Gas was still present in the well annulus with no flow through the casing. The packer was raised and set in a siltstone unit at 134 feet, but gas was still present in the well bore annulus. The packer was then raised and reset at a depth of 69 feet in the base of the Buffalo sandstone and again gas was present in the annulus but not in the casing. The packer was raised and set with 4,000 pounds tension just inside the base of the surface conductor casing, but gas flow and pressure were still evident in the annulus. Since gas was present in the annulus but not in the casing all the way up the wellbore, it appears that it is entering the well from the near-surface Buffalo sandstone via holes in the degraded surface casing and then bubbling up through the water approximately 17 feet below the ground surface. Because the gas was present in the surface conductor casing, there was no reason to have a packer or 7-inch casing in the wellbore. The casing, packer, and wellhead were removed, and a 10 x 4-in swage was installed on the well. All surface valves and the H_2S filter were reinstalled on the well.

4.3.2 Well at 4307 Third Street

The well located at 4307 Third Street was examined using a borehole video camera. On the surface, the well consisted of 6-inch steel casing inside 8-inch PVC pipe with a power vent fan located above the steel pipe to help pull methane from the well. The PVC is secured to the steel pipe approximately 2 feet below ground level with a Fernco 8 x 6-inch coupling. The well was bubbling audibly and producing visible gas at the top of the vent. The borehole video camera revealed that inside the 6-inch casing, at approximately 44 feet below ground level, the wellbore size is reduced to approximately 4 or 5-inch casing. The water level is approximately 55 feet below ground level in that casing. However, no bubbles were visible from the water surface to a depth of 99 feet where the casing is blocked by debris. After the camera was removed from the well, gas flow through the 6-inch steel casing was measured at 20 ft^3/hr. It appears gas is coming up the outside (annulus) of the 4 or 5-inch casing, at a depth of 55 feet below ground level (outside the casing) and entering the 6-inch casing at that point. The potential problems associated with sealing-off the 4 or 5-inch casing annular leakage, the probability of the gas entering the geologic strata instead going up the vent, and the proximity of the well to nearby houses resulted in the decision to abandon the plans to do additional work on this well. The vent and blower were reassembled, the yard was raked, and grass was planted. A natural gamma ray borehole geophysical logging tool was later run in the well, which showed that the top of the Buffalo sandstone was 61 feet below the ground surface.

4.3.3 Well at 4722 Walnut Street

This well is located on a vacant lot at the corner of Wampler Avenue and Sumac Alley at 4722 Walnut Street. According to accounts by residents, the well had been used by the owner to supply some of the gas to a building until the well stopped producing sufficient gas. The building has since been torn down and the lot left vacant. Prior to clean-out operations, the well had 10-inch casing sticking approximately 6-inches above ground level. A 2-inch pipe elbow was set in the 10-inch casing with concrete, and the elbow had been bent over as if hit by a dozer blade, perhaps during demolition of the pre-existing building. A slight, non-measurable flow of methane was emanating from the 2-inch elbow.

4.3.3.1 Pre-drilling Activities

Hydrocarbon Well Service dug around the 10-inch casing with a backhoe and determined that the casing was loose in the ground. After digging to a depth of 7 feet, it was revealed that the 10-inch casing had separated at a collar and was tilted at approximately 20 degrees. The 10-inch casing was straightened, the hole was filled to approximately 18-inches below ground level, and the 10-inch casing cut off approximately 15-inches below ground level. By cutting off the casing, it was found that although the 2-inch elbow and associated 2-inch pipe was cemented into the top of the 10-inch casing, the 2-inch pipe extended only about one foot below the top of the casing. Old construction materials and wire cable filled the 10-inch casing to within three feet of the surface. The depth of this debris below this level was unknown. The 10-inch casing was dug out to the original break point at seven feet below the surface and the casing was removed for proper repair. It was found that all of the debris was in the 7-foot section of broken joint. The water level was determined to be 83 feet below the broken 10-inch casing collar or approximately 90 feet below ground level using a weighted tape, with an audible sound on reaching water. Open wellbore depth was determined to be 178 feet from the top of the casing collar (185 feet from surface), as shown by the weighted tape measure.

After the broken 10-inch casing at ground level was dug out with a backhoe and a new joint added to bring the pipe above ground level, a borehole video camera was run in the well. The water level was approximately 90 feet below ground level, with gas bubbling through debris in the 10-inch casing. Due to the uncertainty of the depth and the amount of debris floating in the water, a decision was made not to run the video camera any deeper than the top of the debris. Because of the water problems experienced during drilling at the Borough garage well, a cable tool rig was moved onto this well to clean out the hole instead of using a rotary rig.

4.3.3.2 Drilling Activities

Before drilling, approximately 0.5 ft^3/hr of stray gas was flowing. After drilling to 285 feet (approximate depth of the Upper Freeport coal seam), the gas flow had increased to more than 50 ft^3/hr. Drilling below 295 feet was difficult due to wood and rock debris in the hole, probably dumped in the wellbore over time. Numerous problems were also encountered from rock ledges and rock debris falling into the hole from the wellbore sides. The well was drilled out to a total depth of 800 feet using a 4-inch mill bit and double-acting jars. At a depth of 650 feet, the well was flowing 17 ft^3/hr. The decreased gas flow may have been the result of clay and other fines

covering the face of the exposed coal seam during drilling operations, or the increased flow rate at the depth of the coal may have been trapped gas that was released due to wellbore cleaning.

4.3.3.3 Post-drilling Video Survey and Borehole Geophysical Logging

The borehole video camera survey of the Walnut Street well showed the water level at an approximately depth of 94 feet below the top of casing with numerous bubbles visible on the water surface. Three gas entry points were clearly visible, bubbling vigorously from the Upper Freeport coal seam at 248.3 feet. No bubbles were present below this depth. Well total depth, as recorded by the video camera, was 618 feet.

Century Geophysical ran borehole geophysical logs, including gamma ray, caliper, collar locator, density, resistivity, temperature, and sonic. The logs indicated the water level was 91 feet. The top and bottom of the Upper Freeport coal seam were 239 and 246 feet, respectively, below the top of 10-inch casing. Borehole video camera depth readings are apparently three feet deeper than geophysical logs. Based on this depth discrepancy, the gas entry points would be at approximately the base of the Upper Freeport coal seam. Key geologic formations depths, as determined from the geophysical logs, are given in Table 9.

Table 9. Top and bottom depth of select formations at the 4728 Walnut Street well.

Formation	Top Depth (ft)	Bottom Depth (ft)
10-inch Surface Conductor	0	48
Buffalo sandstone	91	156
Mahoning sandstone	214	227
Upper Freeport coal	239	246
Lower Freeport coal	301	303
Upper Kittanning coal	418	422
Lower Kittanning coal	556	559

A geologic cross-section (Figure 22 and Plate 3) was constructed using the gamma ray and density logs for the Borough garage and Walnut Street wells and the gamma ray log for the well at 4307 Third Street (density log was not run on this well). Key geologic formations (sandstones and coals) are correlated between the wells. A slight arch is evident on top of the Buffalo sandstone indicting the crest of the Murrysville Anticline traversing near the center of the study area. Variations in sandstone and coal thicknesses are also evident on the cross-section. The top of the water table is evident across all three wells at the top of the Buffalo sandstone.

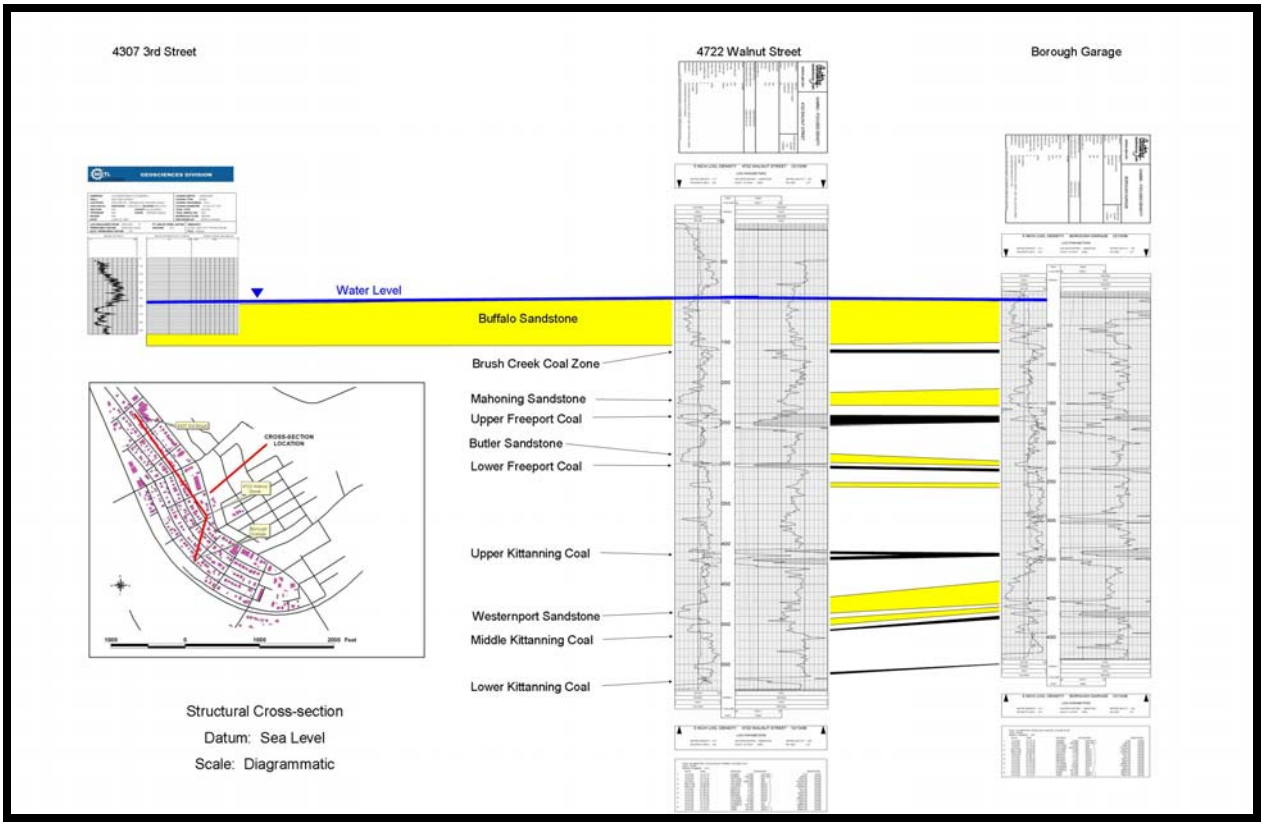

Figure 22. Geologic cross-section between the Borough garage, Walnut Street, and 4307 Third Street wells. Note depth of water table in Borough garage, Walnut Street, and 4307 Third Street wells at the top of the Buffalo sandstone.

4.3.3.4 Open-hole Well Packer and Production String Installation

At the Walnut Street well, an open-hole packer was run on 7-inch, J-55, 23 lb/ft casing and set at 222.95 feet in the middle of Mahoning sandstone with 3,000 pounds tension on February 7, 2007. Problems developed with getting the packer to set in the base of the Mahoning sandstone, so the packer was moved up the wellbore until it could be firmly set into the formation. A pipe tally of the open-hole packer and 7-inch casing are given in Table 10.

A 10 x 7-inch well head was installed at the surface with a solid bull plug on one side. The other side consisted of a ¼-inch NPT tapped bull plug equipped with a ¼-inch valve and pressure gauge to monitor the presence of annular pressure. A 7 x 4-inch swage was installed on the casing collar and the existing valve assembly and vent pipe were reinstalled.

The gas flow rate was measured on February 12, 2007, at 10.5 ft^3/hr from the 7-inch casing. The annulus showed no pressure, indicating a good packer seal with the formation and that no gas was leaking around the packer or from geologic formations above the Upper Freeport coal seam. Exactly the same results were found when gas flow rate measurements and annulus pressure readings were taken February 21, 2007. Improper well abandonment for many of the 175 gas wells drilled in the Borough provides a mechanism of migration for stray gas detected at the

surface. Based on the down-hole video surveys, the Upper Freeport coal seam appears to act as a lateral migration pathway in the Walnut Street well, while the Buffalo sandstone appears to play that role in the Borough garage well, regardless of the gas origin.

Table 10. Pipe tally for Walnut Street well.

Description	Length (ft)
Packer	4.45
Casing	31.30
Casing	31.20
Casing	31.20
Casing	31.20
Casing	31.20
Casing	31.20
Casing	31.20
Total	**222.95**

4.4 Methane Buster™ Testing

The Methane Buster™ is a six-cylinder gasoline engine that has been converted to run on methane gas, and equipped with a blower assembly (Figure 23). It was created to degas coal seams prior to mining operations. It was tested as a potential remedial option to eliminate the methane gas leak within the Borough by pulling a vacuum and drawing the methane gas to a producing well. In the tested configuration, the Methane Buster™ required approximately 180 ft^3/hr of methane. The original plans were designed to place the Methane Buster™ on one of the cleaned-out wells and conduct a test 24 hours a day for 30 days. None of the wells in Versailles Borough produced enough methane, so for testing purposes, a propane tank was installed at the Walnut Street well and the system was turned on. The Methane Buster™ was found to increase the volume of methane that could be extracted, but required lowering the water level in the well to reduce the hydrostatic head pressure on the produced gas.

Methane Buster™ testing began at the Walnut Street well on March 20, 2007. Prior to testing, the water level was 94.91 feet below the top of the 4-inch tee near the top of the wellhead. The Methane Buster™ was run at 1500 rpm for approximately one hour, generating a vacuum of 20 inches of water (approximately 0.7 psi) in the 7-inch well casing. No gas flow was indicated on the gas meter located on the output side of the Methane Buster™.

A pressure transducer was installed through the wellhead to monitor water level changes on March 21st. The Methane Buster™ was run at 1300 rpm for 20 minutes generating a vacuum of 23 inches of water (approximately 0.8 psi) on the 7-inch casing, but with no measurable gas flow through the meter. The pressure transducer indicated a water level drop of approximately 0.5 feet, equivalent to 0.2 psi of vacuum. Measured wellhead gas flow was 10 ft^3/hr, indicating gas was being lost in the Methane Buster™ plumbing or that the gas flow meter on the Methane Buster™ was not working properly.

Figure 23. Photograph of a typical Methane Buster™ used to test methane gas degasification. A similar unit was used to test methane degasification at Versailles Borough.

Samples were taken of the produced well water and water from the Youghiogheny River to determine if the produced well water could be discharged into the local storm sewer without treatment. Laboratory results (Table 11) indicated the well water was high in sodium (Na) and chloride (Cl) ions. The high Na and Cl levels suggest that the source may be water from deeper formations. Gallagher (1973) found that salt water under artesian pressure has over the years migrated up the old boreholes and into the shallower freshwater aquifers in Allegheny County. This was due primarily to the intense drilling for oil and gas in the past and the fact that many of the old casings have been removed or have become severely corroded. The water was also found to be high in several metal ions, including aluminum (Al), barium (Ba), iron (Fe), magnesium (Mg), and strontium (Sr), which were probably derived from the coal. The sample was also high in silicon (Si), due to weathering of silicate minerals, including quartz from the sandstone formations. Because of all these factors, the water could not be placed directly into the river and was therefore collected in a portable tank and hauled away for disposal at a designated disposal site.

Table 11. Analysis of Versailles water samples from the Walnut Street well. A sample was also taken from the Youghiogheny River for comparison.

Versailles Water Samples, sampled 4/18/07								
analyzed 4/19/07				*note larger units for Ca and Na*				
ICP-OES		Optima 3000						
		Versailles, FA		**Versailles A avg**		**River A avg**		***det limits***
Ag	ug/L	< DL		< DL		< DL	**Ag**	*< 5*
Al	ug/L	19.2		2928		490	**Al**	*< 15*
As	ug/L	< DL		< DL		< DL	**As**	*< 8*
B	ug/L	137		161		< DL	**B**	*< 25*
Ba	ug/L	3047		3338		41.9	**Ba**	*< 1*
Be	ug/L	< DL		0.44		0.16	**Be**	*< 0.1*
Ca	*mg/L*	*76.3*		*84.7*		*16.6*	***Ca***	*< 0.010*
Cd	ug/L	< DL		< DL		< DL	**Cd**	*< 1*
Ce	ug/L	< DL		< DL		< DL	**Ce**	*< 80*
Co	ug/L	< DL		3.8		< DL	**Co**	*< 3*
Cr	ug/L	< DL		6.4		< DL	**Cr**	*< 3*
Cu	ug/L	< DL		18.0		< DL	**Cu**	*< 4*
Fe	ug/L	3281		10460		968	**Fe**	*< 3*
K	ug/L	7578		8748		1275	**K**	*< 45*
Li	ug/L	36.6		43.4		< DL	**Li**	*< 9*
Mg	ug/L	18510		19590		4451	**Mg**	*< 3*
Mn	ug/L	78.4		123		120	**Mn**	*< 1*
Mo	ug/L	< DL		< DL		< DL	**Mo**	*< 3*
Na	*mg/L*	*1803*		*1897*		*16.3*	***Na***	*< 0.025*
Ni	ug/L	< DL		10.3		4.5	**Ni**	*< 4*
P	ug/L	< DL		58.3		35.0	**P**	*< 15*
Pb	ug/L	< DL		18.2		< DL	**Pb**	*< 5*
S	ug/L	1443		1525		10565	***S***	*< 25*
Sb	ug/L	< DL		< DL		< DL	**Sb**	*< 6*
Se	ug/L	< DL		< DL		< DL	**Se**	*< 8*
Si	ug/L	3005		6358		2065	**Si**	*< 100*
Sn	ug/L	< DL		< DL		< DL	**Sn**	*< 15*
Sr	ug/L	2032		2147		69.8	**Sr**	*< 1*
Ti	ug/L	< DL		32.8		3.8	**Ti**	*< 1*
Tl	ug/L	< DL		< DL		< DL	**Tl**	*< 12*
V	ug/L	4.3		4.9		< DL	**V**	*< 2*
Zn	ug/L	< DL		48.2		25.4	**Zn**	*< 3*

Cl	ppm	2272
pH	su	7.35
Alkalinity (as $CaCO_3$)	mg/L	570

Table 11 Notes:

- Filtered acidified sample analyzed as received for dissolved metals.
- Acidified samples were digested according to EPA Method 3005 for total metals.
- Na analyses performed on Versailles samples diluted 50x with water.
- Metal by ICP-OES and others by ICP-MS (mass spec) which has much lower detection limits.
- IC was used for chloride. pH and alkalinity measured in the lab.
- FA means filtered (0.45um) acidified and A designates samples that were just acidified without filtration.
- The pumping entrained a fair bit of gray sediment and from the analysis of filtered and unfiltered samples - it appears the sediments contain mainly Al, Fe, and Si.

An air powered purge pump (used for groundwater monitoring) was installed in the well on March 25, to determine if lowering the water level would enhance gas production by reducing the hydrostatic pressure. Gas flow rates during drilling and subsequently during Methane Buster™ testing are summarized in Table 12. After pumping for 37 minutes and lowering the water level by 1.55 feet, gas flow increased from 10 to 18 ft^3/hr. After pumping for 2 hours 13 minutes, the gas flow rate remained at 18 ft^3/hr, but the water level was down 2.4 feet. The Methane Buster™ was started and run at 1300 rpm, pulling a vacuum of 22 inches of water on the well, but no measurable flow was seen through the gas meter. A manometer attached to the Methane Buster™ outlet indicated a gas flow of 15 ft^3/hr, while simultaneously pumping water from the well and running the Methane Buster™. A maximum vacuum of 24 inches of water (approximately 0.9 psi) was generated and the water level was pulled down a maximum of 2.8 ft.

On March 26, a natural flow rate of 10 ft^3/hr was measured with the Methane Buster™ disconnected from the well. On March 27, the well was pumped at a rate of 1.1 gallons of water per minute for 4.25 hours, lowering the wellbore water level by 3.5 feet. This is the equivalent of lowering the hydrostatic pressure on the gas column by 1.5 psi. Gas flow increased to 17 ft^3/hr almost immediately, but then remained unchanged despite the additional decrease in water level.

On April 9, the previously installed air-operated pump was removed and a 1 ½ horsepower submersible pump was installed. The water level was 94.5 feet below the 4-inch tee on top of the wellhead. After pumping, the water level was down 20 feet and the gas flow was measured at 50 ft^3/hr compared to 10 ft^3/hr before pumping. When the water level was pumped down to 174.3 feet below the 4-inch tee, the gas flow was 120 ft^3/hr. Approximately 2000 gallons of water were pumped in 163 minutes (approximately 12 gallons per minute), the maximum drawdown was 80 feet, and the maximum gas flow was 134 ft^3/hr. After the pump was shut off, the water level rose approximately 40 feet in 2 minutes.

On April 10, the water level in the well was 95 feet from the 4-inch tee before pumping started. After 90 minutes of pumping at 12 gallons of water per minute, the gas flow was 120 ft^3/hr. The gas flow from the well at the Naughton property (4805 Second Street) was measured at 35 ft^3/hr (the well was surging from 30 to 40 ft^3/hr) compared to its normal stray gas flow rate of 50 ft^3/hr. Stray gas flow at the Borough garage well remained at its previous flow rate of 6.5 ft^3/hr. After 2 ½ hours of pumping, the water level at the Walnut Street well was 172.6 feet below the 4-inch tee and the gas flow was 110 ft^3/hr. The Methane Buster™ was started at 1:17 PM and the flow through a manometer connected to a side port increased from 7 to 25 ft^3/hr, while running at 1300 rpm with a vacuum of 17 ½ inches of water. As the speed of the Methane Buster™ was increased to 1400 rpm, the flow through the manometer increased to 29 ft^3/hr, with a vacuum of 20 ¾ inches of water. The flow through the Methane Buster's™ gas meter was indicated at 2 ft^3/min (120 ft^3/hr). The Methane Buster™ was increased to 1500 rpm with a vacuum of 25 inches of water, but the gas flow was still 2 ft^3/min. At 2:40 PM, the flow rates at the Naughton and Borough garage wells were unchanged from earlier in the day. At 2:55 PM, while running the Methane Buster™ at 1400 rpm with a vacuum of 20 ½ inches of water, an attempt was made to lean it off of the propane and run it on well gas. While nearly successful, the well was not yet producing enough gas to run the Methane Buster™ without supplemental fuel.

Table 12. Gas flow rates during drilling and Methane Buster™ testing on the Walnut Street well.

Address	Well Depth (feet)	Top Water (feet)	Gas Flow Rate (ft^3/hr)	Sample Date	Field Team Comments
4722 Walnut St	178	90	Not measurable	10/9/2006	Gas bubbling through
4722 Walnut St			≈ 0.5	10/13/2006	Prior to well clean out
4722 Walnut St	260		4.0	10/18/2006	
4722 Walnut St	260	95	> 50.0	10/19/2006	
4722 Walnut St	581		14.0	1/12/2007	
4722 Walnut St	581	95	10.0	3/26/2007	Began Methane Buster™ testing
4722 Walnut St	581	96.5	18.0	3/26/2007	Pumped water level down w/purge pump
4722 Walnut St	581	98.5	17.0	3/27/2006	Pumped water level down w/purge pump
4722 Walnut St	581	115	50.0	4/9/2007	Lower water level w/submergible pump
4722 Walnut St	581	174.3	120.0	4/9/2007	Lower water level w/submersible pump
4722 Walnut St	581	95		4/10/2007	Before starting pump
4722 Walnut St	581	153.6	90.0	4/10/2007	30 Minutes pumping
4722 Walnut St	581	163.0	95.0	4/10/2007	60 Minutes pumping
4722 Walnut St	581		120.0	4/10/2007	90 Minutes pumping
4722 Walnut St	581	172.6	110.0	4/10/2007	150 Minutes pumping

On April 18, 2007, the Methane Buster™ was tested to determine if it would run from gas produced solely by the wellbore if the water level and hydrostatic head were reduced. If the test was successful, the local water treatment facility would be contacted to see if the wellbore water could be placed in the local sanitary sewers for treatment, eliminating the water hauling. At the test start, the wellbore water level was 93.4 feet from the top of the 4-inch tee and the gas flow was 20 ft^3/hr at 10:35 AM. The water level in the Naughton well was 25 feet from the top of the pipe, with a gas flow of 35 ft^3/hr. These values were unchanged from April 10. The submersible pump was started at a rate of 12 gallons per minute. The following are the test events as they were reported that day:

- 12:03 PM Gas flow in the Walnut Street well had increased to 120 ft^3/hr.
- 12:05 PM Water level was 142.7 feet below the 4-inch tee, and the gas flow was 150 ft^3/hr.
- 1:20 PM Water level was 148.4 feet below the 4-inch tee, with a gas flow of 110 ft^3/hr.
- 1:44 PM Gas flow was measured at 75 ft^3/hr taken at the Methane Buster's™ side port manometer. When the Methane Buster™ was started on propane at 1200 rpm, the flow rate through the manometer increased to110 ft^3/hr.
- 1:55 PM Methane Buster™ was pulling a vacuum of 12 ½ inches water at 1200 rpm, and the well was flowing 3 ft^3/min (180 ft^3/hr) through the gas meter on the Methane Buster™.

- 2:00 PM Speed was increased to 1500 rpm, the Methane Buster™ was pulling a vacuum of 23 ½ inches of water, and the well was flowing 3.2 ft^3/min through the gas meter.
- 2:05 PM Methane Buster™ was leaned off of propane and began running completely from the methane in the wellbore alone, generating a vacuum of 25 ¼ inches water.
- 2:18 PM Methane Buster™ (still running off of the well) speed was increased to 1500 rpm pulling a vacuum of 25 inches water.
- 2:30 PM Methane Buster™ began surging slightly, pulling a vacuum of up to 26 ¼ inches of water.
- 2:45 PM Methane Buster™ required additional wellhead gas through the air cleaner intake to run smoothly.
- 2:55 PM There was insufficient gas to run the Methane Buster™ at 1500 rpm.
- 3:04 PM The Methane Buster™ blower was shut down. At this point, the motor ran at 900 rpm on gas solely from the wellbore. Shortly thereafter, the Methane Buster™ stopped completely due to a lack of sufficient fuel being produced by the well. It was apparent that the Methane Buster™ was running on stray gas stored in the gas storage capacity of the wellbore. Once the storage capacity gas was exhausted, the wellbore could not produce sufficient gas, even with reduced hydrostatic pressure, to run this size Methane Buster™. Since the Methane Buster™ tested was the only size available to the project without going to the expense of building a smaller version, Methane Buster™ testing was terminated.

Gas volume decreased from 50 to 35 ft^3/hr at the 4805 Second Street well while water was being pumped and the Methane Buster™ was being tested at the Walnut Street well. This would suggest interconnectivity across the two areas and that increasing methane gas extraction from a point source may pull the gas from a larger area. However, costs associated with treating and/or hauling the formation water would be expensive, especially since there does not appear to be marketable amounts of produced stray gas.

4.5 Search for Buried Well Casings

NOTE: This section describes work conducted by Garret Veloski and Richard Hammack, both employees of NETL, U.S. Department of Energy, with assistance provide by RDS personnel.

Magnetic and sensitive methane surveys were used successfully to target many potential unmarked abandoned wells in Versailles Borough. Using a Geometrics G-858 cesium ion magnetometer, over 27 line miles of magnetic data were collected over an urban study area of approximately 40 acres. A combination of magnetic and methane data were acquired over approximately 67% of the available study area. The remainder of this area was either occupied by structures, inaccessible due to terrain/obstacles, or inaccessible due to the wishes of the landowner. A summary of the survey statistics is given in Table 13.

Table 13. Summary of survey statistics.

Region in Study Area	Area (acres)
Versailles Borough Study Area	40.3
* Buildings	6.2
Area Available for Survey	34.1
Methane and Magnetic Survey Areas	22.9 (67.2%)

* Not all permanent structures were digitized for inclusion in area calculations

The magnetic amplitudes of the suspected well anomalies were usually in excess of the geomagnetic total field value by at least 5,000 nanoteslas (nT) and sometimes as high as 30,000 nT. Individual surveys were short in duration (less than 15 minutes); therefore, it was not necessary to compensate for the diurnal variation of the Earth's magnetic field. Position information was acquired alongside the magnetometer by employing a Trimble AG132 global positioning system (GPS) with a multi-path resistant antenna, operated in differential mode augmented by OmniSTAR® supplemental differential correction service for increased accuracy. In this configuration, the location of the suspected unmarked abandoned well could generally be mapped with an accuracy of +/- 0.9 meters (approximately 3 feet).

Numerous magnetic surveys were conducted in the residential lots of Versailles Borough (Plate 4, a portion of which is shown in Figure 24). Surveys were conducted on the individual lots by walking a serpentine course in a direction parallel to the longest dimension of each property. A priority was given to surveying the largest contiguous area within the lot that permitted the most unobstructed path. In some lots, the largest contiguous survey area would not allow the collection of more than three adjacent parallel swaths; either single line profiles were collected, or the instrument was operated in search mode, in which case no data was logged. Search mode was also used to both target and more precisely determine the position of anomalies discovered during a regular serpentine survey and in the final reconnaissance. This was accomplished by observing the magnitude of the digital total field readout in conjunction with the strip chart graphic display on the instrument consol while sweeping a small area with the magnetometer sensor above the target at a constant height.

One of the most important results from this study was that a total of 52 very strong monopole-like magnetic anomalies in excess of 5000 nT above the earth’s geomagnetic total field intensity were detected in Versailles Borough (Figure 25 and Plate 5). Although all of these anomalies are suspected unmarked abandoned wells, only excavation of a site can positively confirm this. Permission was only obtained to excavate one magnetic anomaly, which did indeed prove to be an unknown, abandoned well, 2-3 feet below the surface (Figure 26).

The Apogee Scientific leak detection system (LDS) was found to be a highly sensitive methane and light gaseous hydrocarbon detector. The LDS works on the principle of infrared absorption. The LDS is tuned to monitor an absorbance wavelength specific to methane (CH_4), but will also simultaneously monitor other light hydrocarbons and carbon dioxide (CO_2). The collective response of the higher molecular weight hydrocarbons (C2 – C6) is referred to as total hydrocarbons. The instrument is capable of measuring these species in near real time and at very

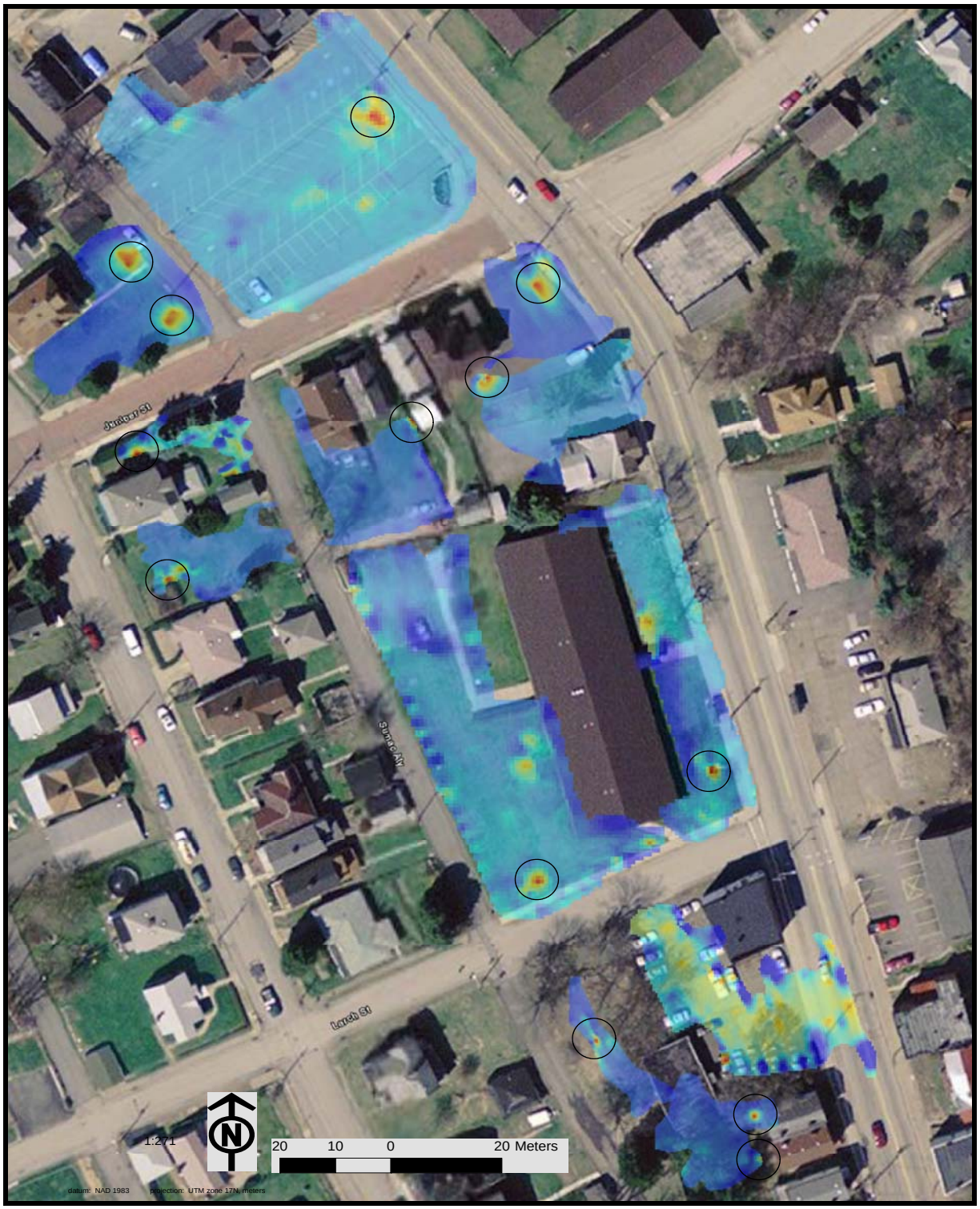

Figure 24. Total field magnetic data collected over a portion of Versailles Borough. Suspected abandoned gas wells are circled. The gridded magnetic data is presented as a semi-transparent overlay on geo-referenced Google Earth™ imagery (©2007 Europa Technologies, ©2007 Navteq).

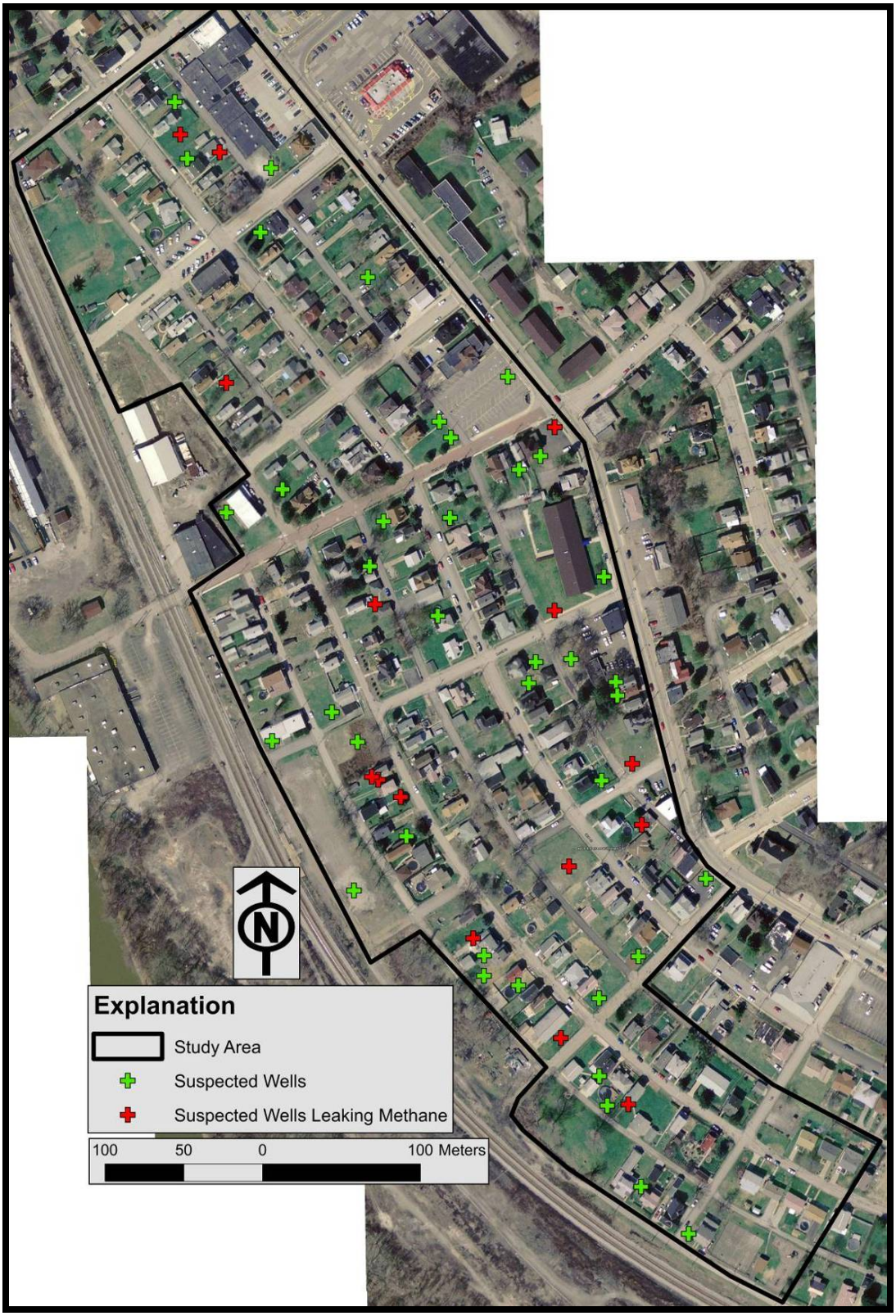

Figure 25. Suspected unmarked abandoned wells located using magnetic methods and methane detection.

Figure 26. Unmarked abandoned well excavated in Versailles Borough, PA. This well was first detected by methane measurements and subsequently by magnetometry.

low detection limits (0.2 ppm, parts per million). The GPS position of each leak can be reverse geo-coded to provide a street address.

A custom software application developed at NETL was used to extract methane peak data based on width (samples) and threshold amplitude (concentration) in a Geographical Information Systems (GIS) compatible format. The GIS database contains the imagery and other mapping data layers that were used to select leaking potential well targets from the magnetic data sets through correlation with methane concentration data based on a spatial proximity analysis.

Areas containing a high density of abandoned gas wells that were leaking could be identified simply by driving the streets, with the Apogee LDS mounted in a truck. The results of the street survey are shown in Figure 27. Upon close examination of the color-coded concentration profiles in Figure 27, evidence for methane plumes can be observed. In fact, consecutive surveys performed after a shift in wind direction reveals that certain sources persist for considerable distances. Ideal survey conditions were when the survey direction was upwind and crosswind to the source and didn't change for the duration of the survey. It soon became apparent that ideal conditions seldom occur. Wind direction can suddenly change from obstruction-induced turbulence along with eddy currents that further complicate interpretation of the methane plumes due to partitioning and dilution. Our method to target potential unmarked abandoned wells using the Apogee LDS had to be revised in order to distinguish between low volume methane sources and a transient plume intercepted from a nearby vent. The instrument would therefore have to be brought closer to the source of leaking methane.

The Apogee LDS was mounted in a lightweight folding cart constructed of aluminum (Figure 28). The air induction system was modified so that sampling would occur through a pipe mounted about 10 cm (4 inches) above the ground. To avoid contamination, the sensitive optical elements were protected by two automotive type cylindrical air filter elements mounted in series on the intake side of the induction system. Input from a mass air flow sensor was used to compensate for irregularities in induction rate due to obstructions that could otherwise affect the response. Employing the cart-mounted implementation of the Apogee LDS instrument, methane plumes could be traced to their sources, which were mainly passive gas vents, some of which were mounted on top of known abandoned gas wells. Fourteen magnetic targets interpreted as unmarked abandoned wells were associated with elevated methane levels measured using the Apogee LDS methane and light hydrocarbon detector mounted on a cart and sampling the air close to ground level (Plate 6). These suspected unmarked abandoned wells were found between the two known methane leak problem areas (Table 14). This indicates that the problem area is larger than originally believed and in essence extends across most of the area below Walnut Street.

Other sources of methane were identified as storm sewers, small leaks around gas meters, or locally elevated levels in proximity to vents. The highest measured methane concentration (13.6 ppm) in the Apogee LDS street survey was traced to a sanitary sewer vent. None of the measured concentrations exceeded the lower explosive limit for methane (approximately 50,000 ppm).

Figure 27. Results from an Apogee LDS survey of Versailles Borough. Methane concentrations along the vehicle GPS track are represented by graduated symbol and color. The magenta symbols are the GPS locations of passive vents. Some vents are associated with abandoned gas wells.

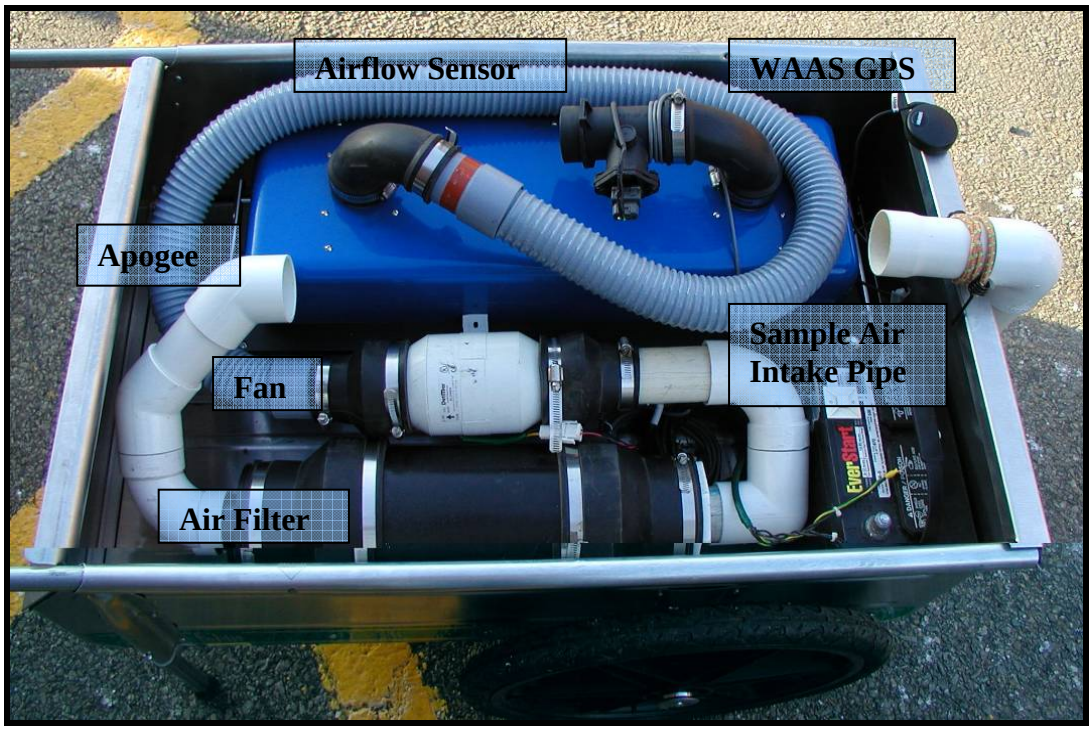

Figure 28. Apogee LDS methane and light hydrocarbon instrument mounted in a light-weight aluminum cart. The intake hose was removed for clarity as was the ruggedized tablet computer data system.

Table 14. Summary of Methane Leaks Found near Selected Magnetic Targets interpreted as Unmarked Abandoned Wells.

Magnetic Target Description	**Coordinates (WGS-84, UTM zone 17, meters)**	
	Easting	Northing
4912 2nd Street	599067	4463387
4801/4807 3rd Street	599076	4463563
4806 3rd Street (well excavated 02/01/2007)	599029	4463537
4822 2nd Street (municipal garage well excavated)	599024	4463429
4319 3rd Street (under red brick sidewalk)	598808	4463988
4909 3rd Street	598783	4463999
4415 2nd Street (methane near 4 in steel vent pipe)	598812	4463842
4708 2nd Street	598904	4463594
4626 Walnut Street (Larch & Sumac, SW of Apartment complex)	599020	4463699
318 Juniper Street (asphalt parking lot)	599020	4463814
4722 Walnut Street (reworked well, Methane Buster™ installed)	599070	4463602
4710 Penn Way	598923	4463581
4806 2nd Street (steel plate covering depression, target 9 m NE)	598969	4463492
4611 2nd Street (strong anomaly under concrete walk)	598906	4463703

5.0 Conclusions

5.1 Causes of Methane Gas Emissions in the Borough

Several causes have contributed to the natural gas emission problems in Versailles Borough. Undoubtedly, the most significant factor was the number of wells drilled during the McKeesport Field boom from 1919 to 1921. With each leaseholder or landowner trying to produce the gas underlying their property, more than 175 wells were drilled within the Borough. Many of these wells were drilled between or behind houses that were on lots only 25 feet wide. Once production diminished, these wells were abandoned and never properly plugged, creating pathways for gas migration to the surface.

Most of the wells were left virtually unattended until the onset of World War II during the 1940's. The Defense Department asked the country to provide any unused steel to assist in the war effort. Casing that could be removed was pulled from the abandoned wells, and in most cases, the hole that remained was covered with earth. At this point, the wells were left abandoned and unplugged with a virtually open well bore from the Speechley sandstone at a depth of nearly 3,000 feet to the surface. Gas from any producing horizon could now enter the well bore and saline waters from deeper aquifers could now mix with fresh groundwater.

The post-World War II era saw a sharp increase in housing and building construction as soldiers returned home to start families and businesses. Since the casings had been pulled from most of the wells, some new homes were constructed adjacent to or over the open wells. This created a direct pathway of gas migration into the foundations of the newer homes and businesses. Thus, homes built after the wells were drilled were often as vulnerable to gas problems as those built before or during the gas boom. However, no stray gas problems were reported until 1963.

The Borough sits on the crest of the Murrysville anticline, a slight arch in the subsurface geologic formations (Figure 29). Methane gas, since it is lighter than water, tends to move to the highest point within a geologic structure, in this case, the Murrysville anticline. Gas from Devonian formations and area coal seams apparently use the open wellbores as a vertical pathway to migrate into intervening strata and into the atmosphere or into the foundation of a home or business. The Upper Freeport coal seam was shown in the Walnut Street well to act as a lateral migration pathway for stray gas from nearby wells, based on down-hole video surveys. At the Borough garage well, the near-surface Buffalo sandstone was shown to be the lateral migration mechanism from other nearby wells. This lateral migration in the shallow sandstone may explain why several large surface gas anomalies are present along the 4700 and 4800 blocks of Penn Way and Second Street.

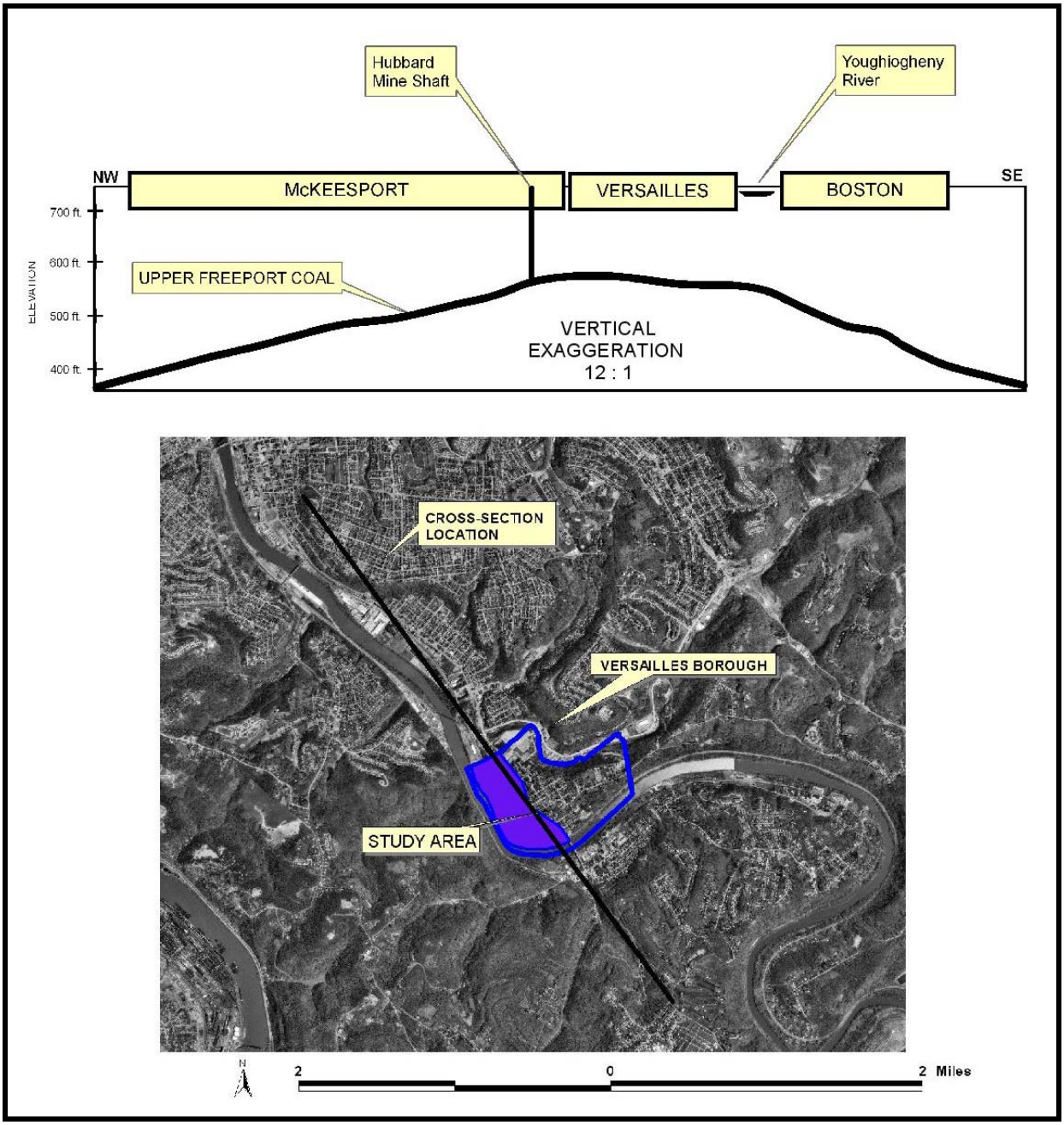

Figure 29. Geologic cross-section on the Upper Freeport coal seam through the Murrysville Anticline showing the relationship of the anticline to the Hubbard Mine portal, study area, and Versailles Borough.

Once the gas has migrated as far as possible up the old wellbore, the soil that covers it may provide another horizontal pathway for gas migration into homes and businesses. During dry weather, the soil is less saturated with water, which allows the gas to migrate vertically to the atmosphere. During wet weather, the water within the soil pores tends to restrict vertical migration, forcing the gas to migrate horizontally until it can find another outlet.

5.2 Problem Area Extent

This study confirms the opinions expressed by residents and officials that the gas problem is mostly between Walnut and First Streets, and High Street and Lincoln Avenue. Although currently installed vents are in two groups (centered on the 4300 block of Third Street and the 4700 to 4800 blocks of Second Street), evidence from the magnetometer and Apogee methane sensor surveys indicate that there are leaking wells located between these areas. By far, the largest concentrations of leaking wells and vents are in the 4700 and 4800 blocks between Birch Alley and Penn Way. In this area, there is evidence that gas has migrated into the shallower Buffalo sandstone through pathways created by the numerous open well bores. This may be the most serious problem area within the Borough and was the area where the highest vent gas flow rates were recorded.

Although wells are known to have been drilled east of Walnut Street, there were fewer of them because it was not as intensely developed and landowners had larger parcels of land. As indicated by M. E. Johnson's map, most of these wells were dry holes and may have been plugged or were never cased and the wellbore has subsequently collapsed, thus sealing the well. The water table is likely higher in this area due to the topography, thus providing a higher hydraulic head pressure on any methane contained in the coal seam.

More wells were drilled in the McKeesport area than in Versailles Borough, yet there does not appear to be a problem in McKeesport. This could be due to gas storage that apparently occurred in Versailles. Alternatively, it may be related to the fact that the Hubbard mine workings are structurally higher than the Upper Freeport coal under McKeesport, which may allow any methane to be intercepted and vented through the old mine. Another possibility may be that the Upper Freeport coal is thin or absent under McKeesport, as indicated on a map of the Upper Freeport coal extent (Figure 30) by M. E. Johnson (1929).

The apparent presence of multiple surface methane gas leaks within the 4700 and 4800 blocks of Penn Way and Second Street may be related to lateral movement of the gas within the near-surface Buffalo sandstone. The hypothesis that methane gas from the Upper Freeport coal has moved vertically up the open wellbores and is now moving laterally through the near-surface Buffalo sandstone needs to be verified. This discovery was not made until casing was run into the Borough garage well and gas was found in the Buffalo sandstone. Unfortunately, this was near the end of the project and there were not sufficient funds to drill additional wells. If funds are acquired for additional investigation, up to three test wells should be drilled on the vacant lots between First Street and Penn Way within this two block area. The first well should be drilled across from the Borough garage since this is the closest area to the known presence of the gas in the Buffalo sandstone. A second well could be located near the intersection of Penn Way and Wampler Street with the third well at the intersection of Penn Way and Larch Street. The wells should be drilled to the top of the Buffalo sandstone, casing set, and the casing grouted (cemented) in place. The well would then be drilled through the casing to slightly below the base of the Buffalo sandstone. Presence of gas in these wells would verify that the Buffalo sandstone is a lateral conduit for gas migration within this area. Gas could be produced from these wells using a smaller version of the Methane Buster™, an electric blower system, or a small gas compressor. The gas could be removed without having to pump and treat water, as was required at the Walnut Street well, since the sandstone is near the surface and the gas is not covered by a

large water column. Once gas production begins, gas vents in the area should be monitored to determine if gas flow rates decrease.

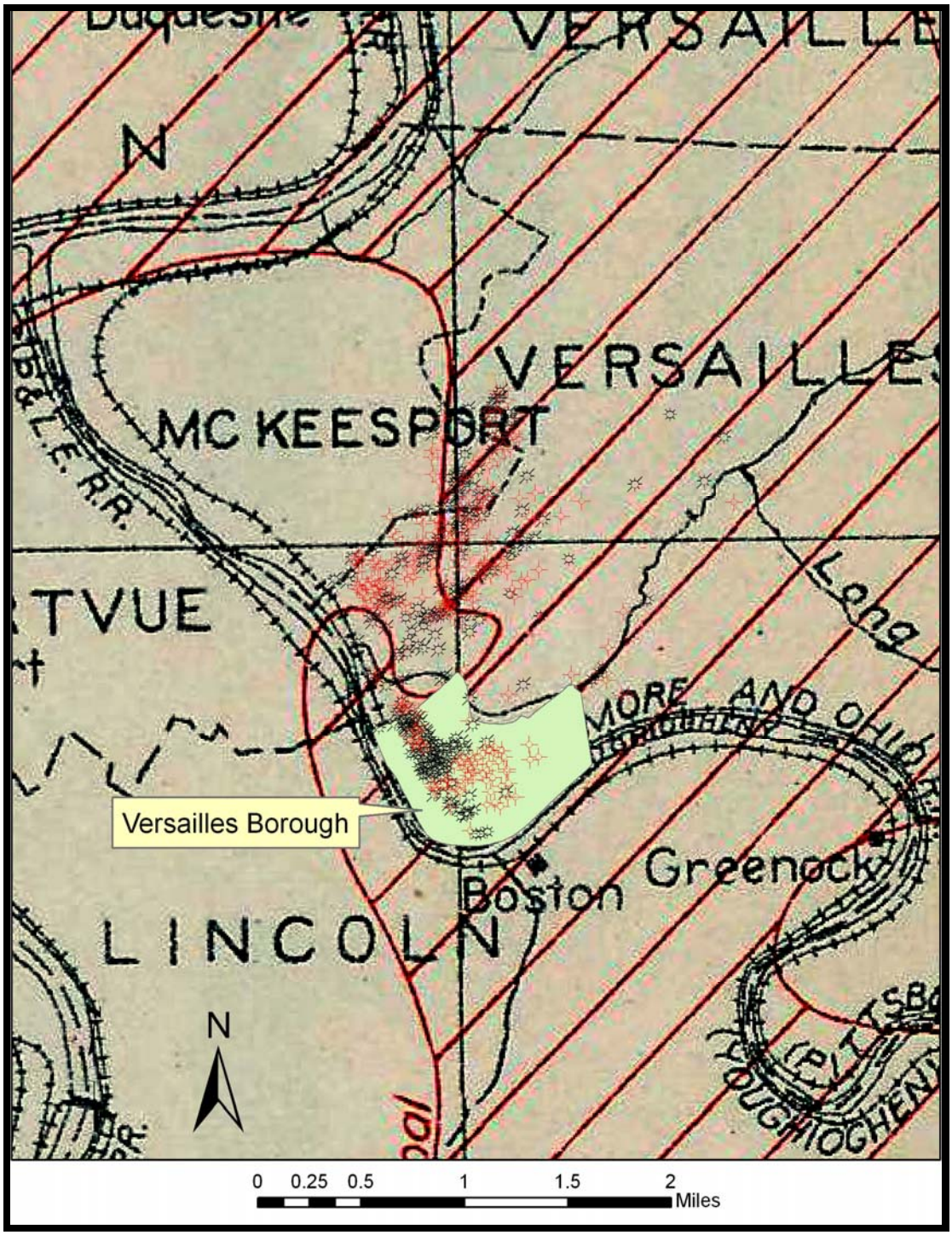

Figure 30. Map showing thickness of the Upper Freeport coal seam in the area of Versailles Borough (green area) and the City of McKeesport. Hachured area indicates coal thickness greater than 3 feet (from M. E. Johnson, 1929).

Gas migration within the Buffalo sandstone may not be limited to this two block area along Penn Way and Second Street; it may also be a contributing factor to the gas problems in the 4300 block area between Walnut and Third streets. Gas was not percolating through standing water within the wellbore at 4305 Third Street as seen by the down-hole video survey, but was present in the surface casing. This would imply the gas was entering below the surface casing, but above the current water level. Geophysical logging of the well indicated that the current water level is near the top of the Buffalo sandstone. Although this does not prove the sandstone to be the gas entry source, it does show the need for additional research.

Gas within the Buffalo sandstone has apparently not migrated to the Walnut Street well location. Gas was not present within the annulus once the Upper Freeport coal seam was isolated. Wellbore video showed conclusive evidence that the gas entering the well was entering from the Upper Freeport coal seam. This does not mean that gas will not eventually migrate through the Buffalo sandstone to the Walnut Street location. If gas in the Buffalo sandstone were to reach the Walnut Street well, it would be above the current water level within the well and easily placed on a vacuum system.

5.3 Summation

Results of the field investigations, gas sampling, Methane Buster™ testing, and subsurface unmarked abandoned well detection surveys can be summarized in the following conclusions:

1) Over 175 wells were drilled in Versailles Borough between 1919 and 1921 as part of Speechley sandstone gas drilling in the McKeesport gas field. Many of these wells were drilled in close proximity to houses. The field was over-drilled, over-produced, and rapidly went to depletion. Depleted wells and dry holes were left abandoned and unplugged. During the steel scrap drive of World War II, most of the casings were removed from the wells and the wells were left unplugged and improperly abandoned. This resulted in a complex and hazardous problem that is not going to be easily or inexpensively corrected.

2) Based on known problem areas and discussions with local residents, the study was limited to an area bounded to the north by the City of McKeesport, to the east by Walnut Street, to the south by the Boston Bridge, and to the west by the Youghiogheny River. Although the study area was defined by the borough and local residents, this does not mean that structures outside the study area are safe from stray methane problems.

3) Previous gas leak investigations installed vents over areas where gas concentrations were high at the surface. Some of these vents were over actual abandoned wells; most were not.

4) Most of the vents show no evidence of a gas flow, at least measurable at a minimum rate of 0.5 ft^3/hr. Of those connected to wells, only a couple of vents are actually producing gas flows in excess of 0.5 ft^3/hr. Total gas production from all vents and wells prior to clean-out of any well was approximately 70 ft^3/hr, with the majority of this production (50 ft^3/hr) coming from a single well on the 4700 block of Second Street.

5) Many of the vents have had little or no maintenance since installation and some have been removed. Some with top mounted rotating ventilators showed evidence of severe rust and mechanical degradation. Some wells had bird or bee nests that were inhibiting gas ventilation.

6) The Murrysville Anticline cresting under the Borough, combined with the open wellbores, appear to be a major contributor to the current gas leakage problem. Gas has migrated along the limbs of the anticline towards the structurally highest point. Normally this gas would remain in the higher permeability formations due to overlying lower permeability formations and the weight of the overlying geologic formations. However, since these formations are breached by the open well bores, the gas is allowed to migrate to the surface soils and atmosphere. During dry weather conditions, the gas can leak through the surface soil and into the atmosphere. During wet weather, the moisture fills the rock fractures and soil pores, impeding the vertical gas migration and temporarily re-directing the gas horizontally in the lower part of the soil horizon or in more permeable rock formations. This lateral migration can lead to gas entering building foundations.

7) Gas sampling indicates that the gas is primarily a combination of deeper Devonian formation gas and minor amounts of shallower coal bed methane. Gas apparently migrates vertically from these formations through the abandoned and improperly plugged wellbores.

8) Down-hole video surveys showed shallower formations are providing lateral gas migration pathways, at least in the two surveyed wells. The primary lateral migration pathway in the Walnut Street wellbore is through the Upper Freeport coal seam and then up the old wellbore to the surface, making a single point gas source on the surface. The Buffalo sandstone is the lateral migration pathway in the Borough garage wellbore. Gas in the near-surface Buffalo sandstone appears to migrate up and out of the wellbore to the surface where part of the well casing is still present, creating a single point source for stray gas at the surface. However, where the surface casing is missing, gas can migrate away from the wellbore through the surface soils.

9) Originally, two main areas of the Borough were thought to be the only problem areas for methane gas leakage – the 4300 block of Walnut Street and Third Street and the 4700 and 4800 blocks of Penn Way and Second Street. Results of magnetometer and high-sensitivity methane gas detection surveys indicated several anomalies were leaking methane between these two areas. As a result of these surveys, 52 subsurface anomalies were located that are believed to be abandoned wells. Of these 52 anomalies, 14 anomalies were found to be leaking methane during the time of sampling.

10) Historical pictures showing old drilling derrick locations, magnetometer, and Apogee methane detection surveys over the study area indicated that old wellbores are the primary gas pathway to the surface.

11) Two old wells were opened and cleaned out to determine the methane source. Both had obviously had wood, bricks, rocks, and other materials thrown into the wells over time.

Cleaning out this debris added significantly to the drilling costs and time required to clean the wells.

12) Hydrogen sulfide (H_2S) was found to be present in minor amounts in two vents along Second Street prior to opening the two old abandoned wells. H_2S levels exceeded the 100 ppm National Institute of Safety and Health (NIOSH) Immediately Dangerous to Life and Health (IDLH) level within one wellbore about a month after it had been opened and cleaned of debris. The well was shut in (all venting terminated), appropriate authorities were notified, and a H_2S removal cartridge was installed. Due to the low well flow rate (6.5 ft^3/hr) and atmospheric dilution, H_2S ambient levels were below detectable limits (near zero ppm) within a couple of feet of the well. Trained personnel with monitoring and safety equipment were on-site during all sampling and work on the well after the initial high reading. Wellbore H_2S levels dropped to 104 ppm within four days of installing the H_2S removal cartridge and reopening the well and within four months had dropped to undetectable levels in the wellbore. The ambient air H_2S levels were consistently below detectable limits (near zero ppm) within a couple of feet of the well.

13) Methane gas problems associated with the well at 4307 Third Street appear to be related to gas coming up the back (annulus) of the smaller diameter casing left in the hole at a depth of 44 feet. At this point, the smaller casing is separated from the larger (6-inch) surface casing, allowing gas to migrate into the surrounding permeable geologic formations. The well currently has an electric blower attached to the vent, which helps move gas up the well and out to the atmosphere; however, gas could still be leaking into surrounding more permeable geologic formations.

14) Gas was visibly seen emanating from the Upper Freeport coal seam in the Walnut Street well. Lack of gas flow or pressure on the annulus side of the installed casing suggests that gas migration pathway is limited solely to the Upper Freeport coal in this well and that the gas has not migrated to any of the overlying formations.

15) Slightly more than an order-of-magnitude increase (10 to 120 ft^3/hr) in gas volume was noticed by reducing the Upper Freeport coal hydrostatic head by approximately 75 psi at the Walnut Street well.

16) The Methane Buster™ was found to increase the volume of gas that could be extracted, but required lowering the water level in the well to reduce the hydrostatic head. Costs associated with treating and/or hauling the sodium-rich water would be expensive, especially since there does not appear to be marketable amounts of gas left in the coal seam. Water costs may be reduced if the water could be injected back into the formation down dip from the producing well.

17) Gas volume decreased from 50 to 35 ft^3/hr at the 4805 Second Street well while water was being pumped and the Methane Buster™ was being tested at the Walnut Street well. This would suggest interconnectivity across the two areas and that increasing methane gas extraction from a point source may pull the gas from a larger area of influence.

18) Loss of gas bubbles below the Buffalo sandstone as observed in the down-hole video survey indicated gas was migrating vertically up nearby wellbores and moving laterally in the near-surface Buffalo sandstone in the Borough garage well. The inability to seal off gas from the annulus while running tubing in the well confirmed that the gas was entering the wellbore via the Buffalo sandstone. Vertical migration via the old wellbores combined with possible horizontal stray gas migration in the porous soils during wet conditions may be contributing to the widespread methane gas problems in the 4700 and 4800 blocks of Penn Way and Second Street.

6.0 References

Baldassare, F. J., 207, Personal Communication, Pennsylvania Department of Environmental Protection.

Baldassare, F. J., and C. D. Laughrey, 1997, Identifying the Sources of Stray Methane by Using Geochemical and Isotopic Fingerprinting: Environmental Geosciences, V4, No. 2, P 85-94.

Heath Consultants, Inc., 1986, “Unidentified Flammable” Site Investigation, Versailles, Pennsylvania, Unpublished, initiated by Twin Rivers Council of Governments.

Heath Consultants, Inc., 1990, “Stray Hydrocarbons” Site Investigation, Versailles, Pennsylvania, Unpublished, initiated by Twin Rivers Council of Governments.

Johnson, Meredith E., 1929, Topographic and Geologic Atlas of Pennsylvania, Pittsburgh Quadrangle, Geology and Mineral Resources: Topographic and Geologic Survey, Commonwealth of Pennsylvania, 236 pp.

The Atlas of Major Appalachian Gas Plays, 1996, edited by Roen, J. B., and B. J. Walker: West Virginia Geological and Economic Survey, 201 pp.

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7.0 Appendices

A. Photographs of Existing Vents and Wells

B. Gas Analysis Laboratory Data

C. Daily Drilling Report

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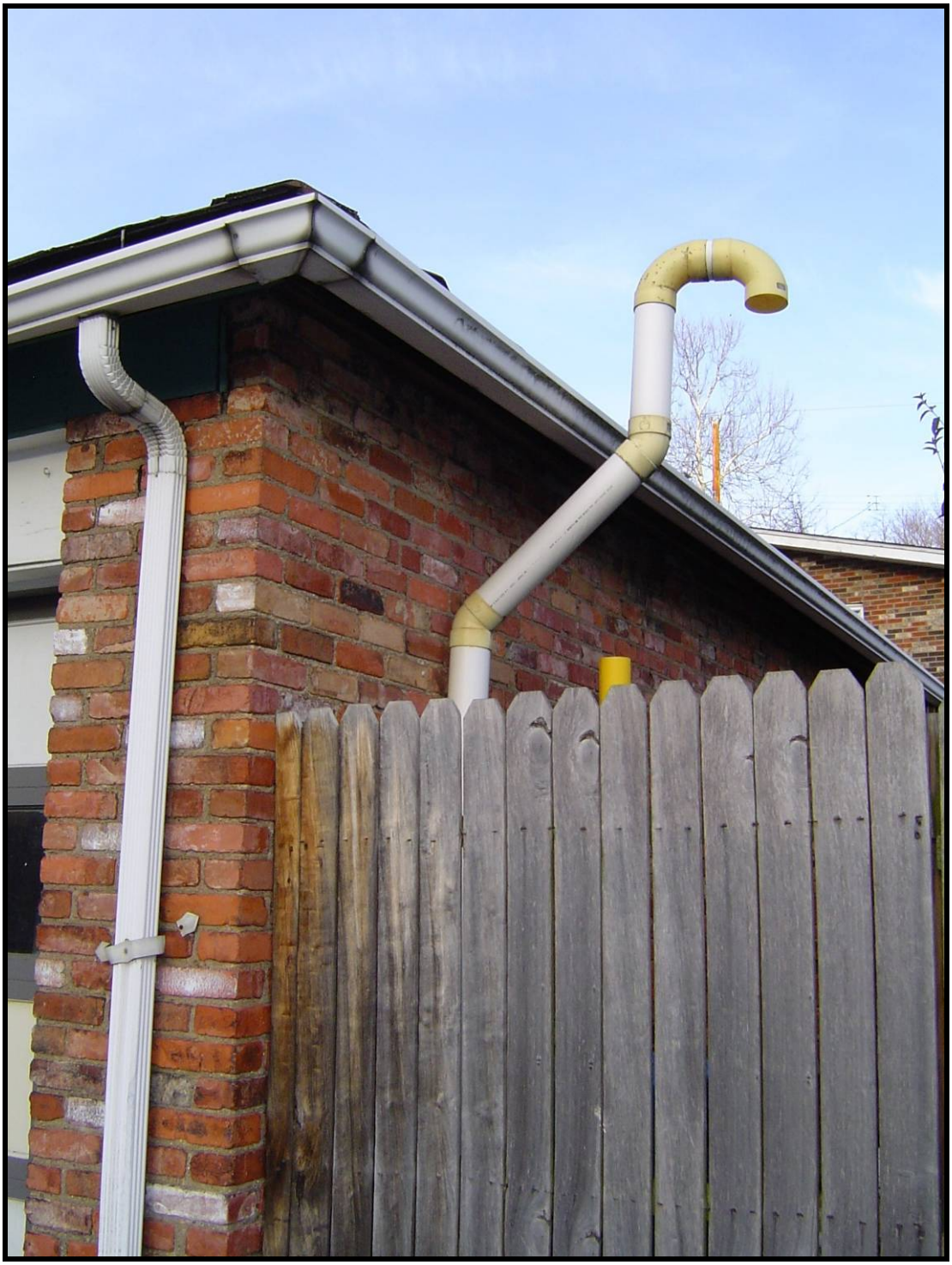
Appendix A

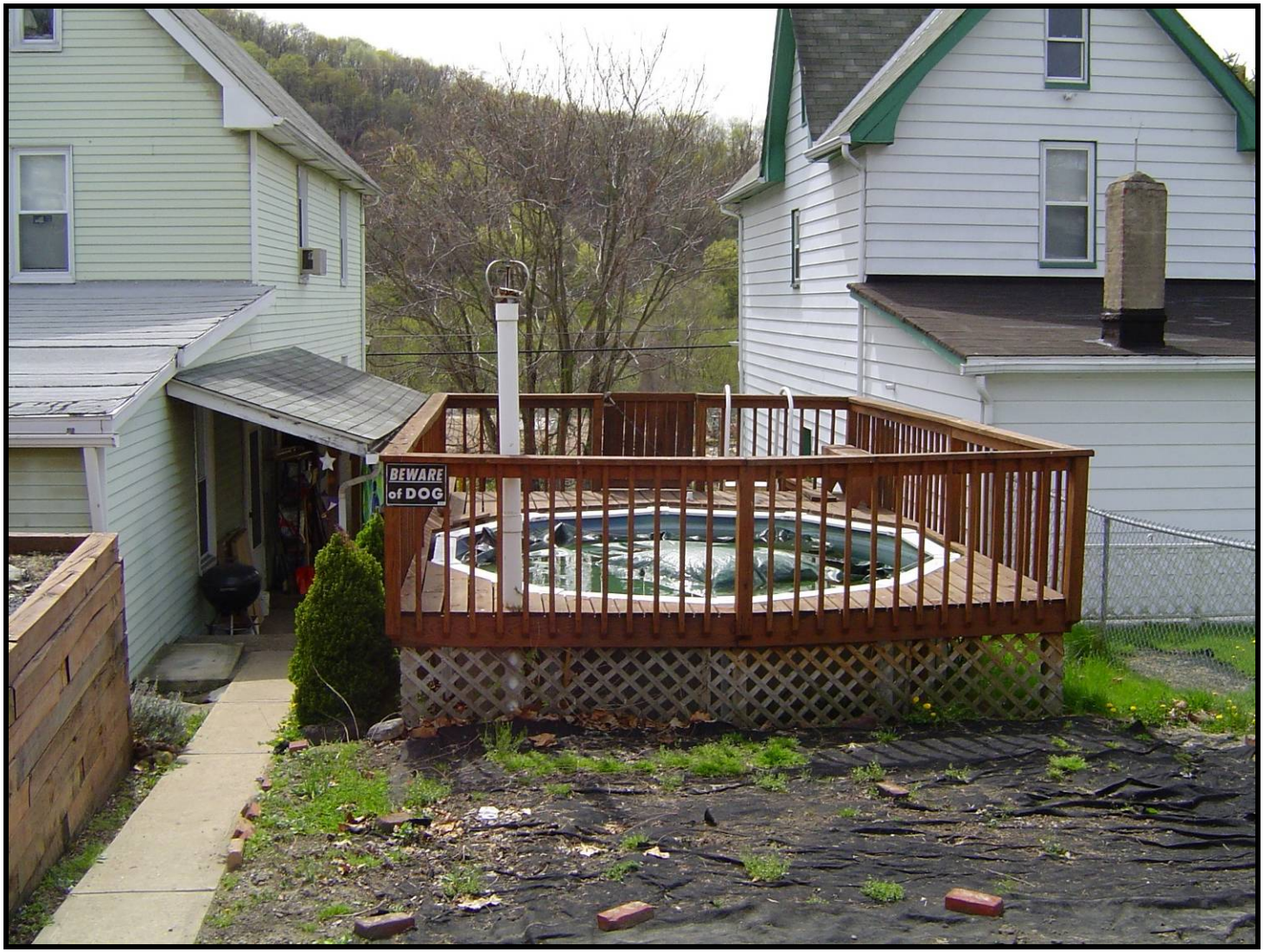
Photographs of Existing Vents and Wells

Appendix A-1. 4713 Penn Way

Appendix A-2. 4723 Penn Way



Appendix A-3. 4724 Penn Way



Appendix A-4. 4705 Second Street

Appendix A-5. 4709 Second Street

Appendix A-6. 4717 Second Street

Appendix A-7. 4721 Second Street

Appendix A-8. 4728 Second Street

Appendix A-9. 4802 Second Street

Appendix A-10. 4803 Second Street

Appendix A-11. 4805 & 4807 Second Street

Appendix A-12. 4806 Second Street

Appendix A-13. 4708 Second Street

Appendix A-14. 4813 & 4815 Second Street

Appendix A-15. 4819 Second Street

Appendix A-16. 4821 Second Street

Appendix A-17. 4822 Second Street

Appendix A-18. 4915 Second Street

Appendix A-19. 4915 Second Street

Appendix A-20. 4924 Second Street

Appendix A-21. 4307 & 4309 Third Street

Appendix A-22. 4319 Third Street

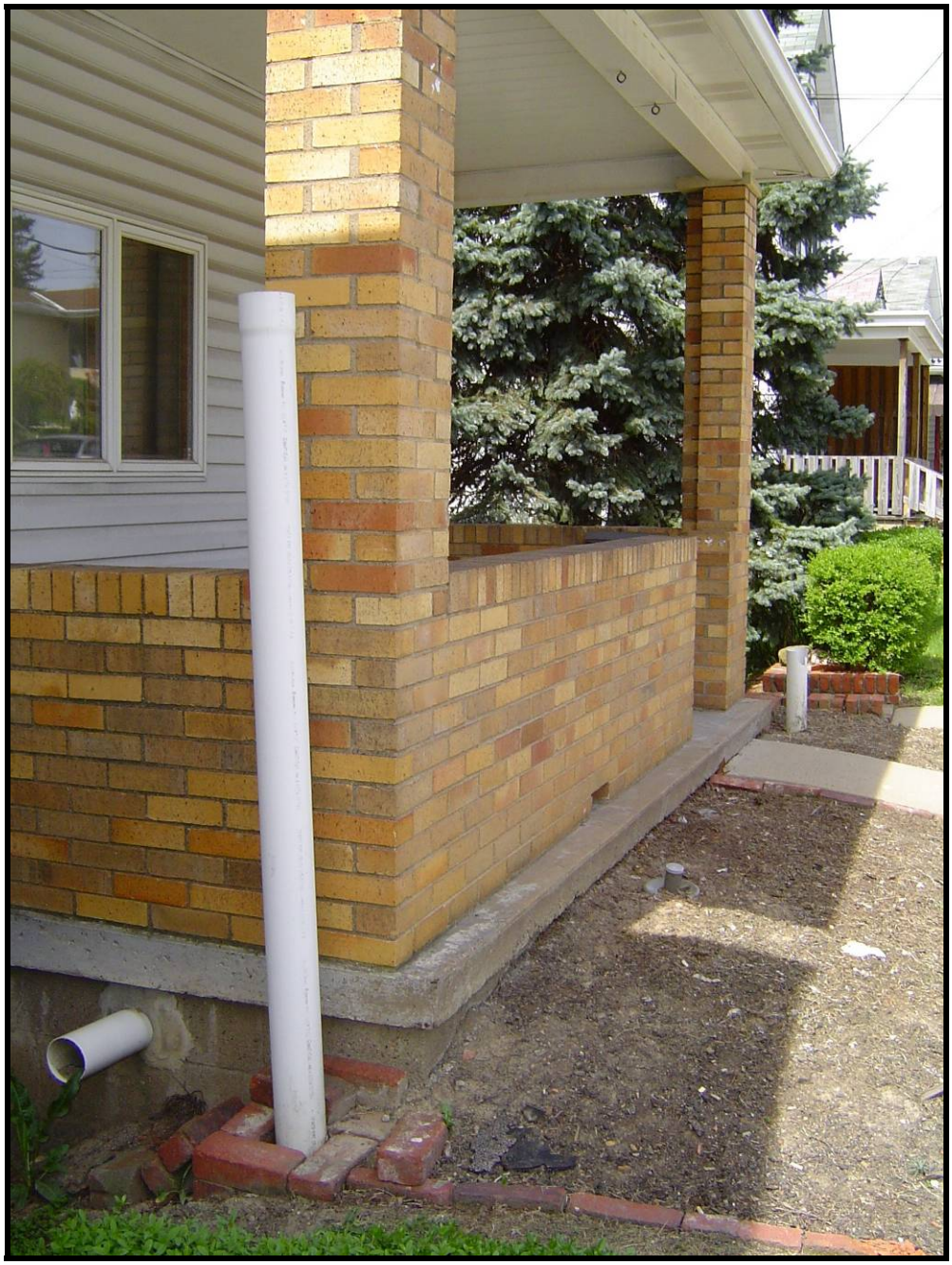
Appendix A-23. 4625 Third Street

Appendix A-24. 4804 Third Street

Appendix A-25. 4807 Third Street

Appendix A-26. 4811 Third Street

Appendix A-27. 4814 Third Street



Appendix A-28. 4818 Third Street

Appendix A-29, 4820 Third Street

Appendix A-30. 4820 Third Street

Appendix A-31. 4300, 4304, & 4322 Walnut Street

Appendix A-32. 4322 Walnut Street

Appendix A-33. 4324 Walnut Street

Appendix A-34. 4719 Walnut Street

Appendix A-35. 4722 Walnut Street

Appendix B

Gas Analysis Laboratory Data

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

Page: Page 2 of 8
Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
GARAGE	Vapor	P0605472-01	23 May. 06 13:30	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	15000.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Ethene	<1.500	1.500	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	710.000	2.500	PPMV	AM20GAX	6/9/06	mm
N Methane	930000.000	10.000	PPMV	AM20GAX	6/9/06	mm
N n-Butane	98.000	3.500	PPMV	AM20GAX	6/9/06	mm
N Propane	2500.000	2.500	PPMV	AM20GAX	6/9/06	mm
N Propene	<5.000	5.000	PPMV	AM20GAX	6/9/06	mm

Client Name: Research and Development Solutions, Inc.
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Page: Page 3 of 8
Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4808 2ND	Vapor	P0605472-02	23 May. 06 14:00	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	120.000	0.020	PPMV	AM20GAX	6/9/06	mm
N Ethene	<0.030	0.030	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	8.800	0.050	PPMV	AM20GAX	6/9/06	mm
N Methane	15000.000	0.200	PPMV	AM20GAX	6/9/06	mm
N n-Butane	1.400	0.070	PPMV	AM20GAX	6/9/06	mm
N Propane	12.000	0.050	PPMV	AM20GAX	6/9/06	mm
N Propene	<0.100	0.100	PPMV	AM20GAX	6/9/06	mm

Client Name: Research and Development Solutions, Inc.
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Morgantown, WV 36505-2353

Page: Page 4 of 8
Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4723 PENN WAY	Vapor	P0605472-03	23 May. 06 14:45	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	8900.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Ethene	<1.500	1.500	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	330.000	2.500	PPMV	AM20GAX	6/9/06	mm
N Methane	630000.000	10.000	PPMV	AM20GAX	6/9/06	mm
N n-Butane	35.000	3.500	PPMV	AM20GAX	6/9/06	mm
N Propane	760.000	2.500	PPMV	AM20GAX	6/9/06	mm
N Propene	<5.000	5.000	PPMV	AM20GAX	6/9/06	mm

Client Name: Research and Development Solutions, Inc.
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Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4819 2ND	Vapor	P0605472-04	23 May. 06 15:15	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	26.000	0.020	PPMV	AM20GAX	6/9/06	mm
N Ethene	<0.030	0.030	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	1.300	0.050	PPMV	AM20GAX	6/9/06	mm
N Methane	1400.000	0.200	PPMV	AM20GAX	6/9/06	mm
N n-Butane	0.240	0.070	PPMV	AM20GAX	6/9/06	mm
N Propane	2.700	0.050	PPMV	AM20GAX	6/9/06	mm
N Propene	<0.100	0.100	PPMV	AM20GAX	6/9/06	mm

Client Name: Research and Development Solutions, Inc.
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PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4713 PENN WAY	Vapor	P0605472-05	24 May. 06 14:00	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	3900.000	0.400	PPMV	AM20GAX	6/9/06	mm
N Ethene	<0.600	0.600	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	190.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Methane	240000.000	4.000	PPMV	AM20GAX	6/9/06	mm
N n-Butane	75.000	1.400	PPMV	AM20GAX	6/9/06	mm
N Propane	600.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Propene	<2.000	2.000	PPMV	AM20GAX	6/9/06	mm

Client Name: Research and Development Solutions, Inc.
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Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4709 2ND	Vapor	P0605472-06	24 May. 06 14:25	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	2900.000	0.400	PPMV	AM20GAX	6/9/06	mm
N Ethene	<0.600	0.600	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	140.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Methane	170000.000	4.000	PPMV	AM20GAX	6/9/06	mm
N n-Butane	52.000	1.400	PPMV	AM20GAX	6/9/06	mm
N Propane	450.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Propene	<2.000	2.000	PPMV	AM20GAX	6/9/06	mm

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Lab Proj #: P0605472
Report Date: 06/12/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4821 2ND	Vapor	P0605472-07	24 May. 06 14:55	26 May. 06 14:29

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	5300.000	0.400	PPMV	AM20GAX	6/9/06	mm
N Ethene	<0.600	0.600	PPMV	AM20GAX	6/9/06	mm
N iso-Butane	280.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Methane	360000.000	4.000	PPMV	AM20GAX	6/9/06	mm
N n-Butane	64.000	1.400	PPMV	AM20GAX	6/9/06	mm
N Propane	900.000	1.000	PPMV	AM20GAX	6/9/06	mm
N Propene	<2.000	2.000	PPMV	AM20GAX	6/9/06	mm

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0607066
Report Date: 07/20/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4722 WALNUT	Vapor	P0607066-01	22 Jun. 06 12:50	07 Jul. 06 14:59

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	11000.000	0.500	PPMV	AM20GAX	7/19/06	sl
N Ethene	<0.750	0.750	PPMV	AM20GAX	7/19/06	sl
N iso-Butane	350.000	1.200	PPMV	AM20GAX	7/19/06	sl
N Methane	870000.000	5.000	PPMV	AM20GAX	7/19/06	sl
N n-Butane	68.000	1.800	PPMV	AM20GAX	7/19/06	sl
N Propane	1000.000	1.200	PPMV	AM20GAX	7/19/06	sl
N Propene	<2.500	2.500	PPMV	AM20GAX	7/19/06	sl

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0607066
Report Date: 07/20/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
37-003-00747	Vapor	P0607066-02	22 Jun. 06 15:20	07 Jul. 06 14:59

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	23000.000	0.500	PPMV	AM20GAX	7/19/06	sl
N Ethene	<0.750	0.750	PPMV	AM20GAX	7/19/06	sl
N iso-Butane	770.000	1.200	PPMV	AM20GAX	7/19/06	sl
N Methane	690000.000	5.000	PPMV	AM20GAX	7/19/06	sl
N n-Butane	910.000	1.800	PPMV	AM20GAX	7/19/06	sl
N Propane	4900.000	1.200	PPMV	AM20GAX	7/19/06	sl
N Propene	<2.500	2.500	PPMV	AM20GAX	7/19/06	sl

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Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0607066
Report Date: 07/20/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4717 2ND	Vapor	P0607066-03	06 Jul. 06 10:30	07 Jul 06 14:59

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	980.000	0.020	PPMV	AM20GAX	7/18/06	mm
N Ethene	<0.030	0.030	PPMV	AM20GAX	7/18/06	mm
N iso-Butane	40.000	0.050	PPMV	AM20GAX	7/18/06	mm
N Methane	55000.000	0.200	PPMV	AM20GAX	7/18/06	mm
N n-Butane	11.000	0.070	PPMV	AM20GAX	7/18/06	mm
N Propane	150.000	0.050	PPMV	AM20GAX	7/18/06	mm
N Propene	<0.100	0.100	PPMV	AM20GAX	7/18/06	mm

Client Name: Research and Development Solutions, Inc.
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Morgantown, WV 36505-2353

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Lab Proj #: P0607066
Report Date: 07/20/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4307 3RD	Vapor	P0607066-04	06 Jul. 06 10:50	07 Jul. 06 14:59

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	6100.000	0.500	PPMV	AM20GAX	7/19/06	sl
N Ethene	<0.750	0.750	PPMV	AM20GAX	7/19/06	sl
N iso-Butane	340.000	1.200	PPMV	AM20GAX	7/19/06	sl
N Methane	390000.000	5.000	PPMV	AM20GAX	7/19/06	sl
N n-Butane	220.000	1.800	PPMV	AM20GAX	7/19/06	sl
N Propane	1200.000	1.200	PPMV	AM20GAX	7/19/06	sl
N Propene	<2.500	2.500	PPMV	AM20GAX	7/19/06	sl

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

Page: Page 6 of 6
Lab Proj #: P0607066
Report Date: 07/20/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4319 3RD	Vapor	P0607066-05	06 Jul. 06 11:10	07 Jul. 06 14:59

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	1400.000	0.020	PPMV	AM20GAX	7/19/06	sl
N Ethene	0.053	0.030	PPMV	AM20GAX	7/19/06	sl
N iso-Butane	81.000	0.050	PPMV	AM20GAX	7/19/06	sl
N Methane	200000.000	0.200	PPMV	AM20GAX	7/19/06	sl
N n-Butane	22.000	0.070	PPMV	AM20GAX	7/19/06	sl
N Propane	250.000	0.050	PPMV	AM20GAX	7/19/06	sl
N Propene	0.860	0.100	PPMV	AM20GAX	7/19/06	sl

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

Page: Page 2 of 9
Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4811 ~~2nd st~~ ~~3RD ST~~ 2ND ST	Vapor	P0609115-01	18 Aug 06 13:05	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	20.000	0.020	PPMV	AM20GAX	9/12/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	9/12/06	sl
N iso-Butane	3.600	0.050	PPMV	AM20GAX	9/12/06	sl
N Methane	4600.000	0.200	PPMV	AM20GAX	9/12/06	sl
N n-Butane	<0.070	0.070	PPMV	AM20GAX	9/12/06	sl
N Propane	2.000	0.050	PPMV	AM20GAX	9/12/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	9/12/06	sl

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
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Page: Page 3 of 9
Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4805 2nd st	Vapor	P0609115-02	18 Aug. 06 13:30	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	12000.000	0.200	PPMV	AM20GAX	9/13/06	sl
N Ethene	<0.300	0.300	PPMV	AM20GAX	9/13/06	sl
N iso-Butane	610.000	0.500	PPMV	AM20GAX	9/13/06	sl
N Methane	890000.000	2.000	PPMV	AM20GAX	9/13/06	sl
N n-Butane	180.000	0.700	PPMV	AM20GAX	9/13/06	sl
N Propane	1800.000	0.500	PPMV	AM20GAX	9/13/06	sl
N Propene	<1.000	1.000	PPMV	AM20GAX	9/13/06	sl

Client Name: Research and Development Solutions, Inc.
Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4807 2nd st	Vapor	P0609115-03	18 Aug. 06 13:55	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	32.000	0.020	PPMV	AM20GAX	9/12/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	9/12/06	sl
N iso-Butane	4.200	0.050	PPMV	AM20GAX	9/12/06	sl
N Methane	680.000	0.200	PPMV	AM20GAX	9/12/06	sl
N n-Butane	1.400	0.070	PPMV	AM20GAX	9/12/06	sl
N Propane	6.900	0.050	PPMV	AM20GAX	9/12/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	9/12/06	sl

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Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4721 2nd st	Vapor	P0609115-04	18 Aug. 06 14:25	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	1200.000	0.020	PPMV	AM20GAX	9/12/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	9/12/06	sl
N iso-Butane	56.000	0.050	PPMV	AM20GAX	9/12/06	sl
N Methane	84000.000	0.200	PPMV	AM20GAX	9/12/06	sl
N n-Butane	14.000	0.070	PPMV	AM20GAX	9/12/06	sl
N Propane	160.000	0.050	PPMV	AM20GAX	9/12/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	9/12/06	sl

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Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4802 2nd st	Vapor	P0609115-05	22 Aug. 06 14:35	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	0.220	0.020	PPMV	AM20GAX	9/12/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	9/12/06	sl
N iso-Butane	0.059	0.050	PPMV	AM20GAX	9/12/06	sl
N Methane	110.000	0.200	PPMV	AM20GAX	9/12/06	sl
N n-Butane	<0.070	0.070	PPMV	AM20GAX	9/12/06	sl
N Propane	<0.050	0.050	PPMV	AM20GAX	9/12/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	9/12/06	sl

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PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4728 2nd st	Vapor	P0609115-06	22 Aug. 06 15:15	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	1800.000	0.020	PPMV	AM20GAX	9/12/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	9/12/06	sl
N iso-Butane	63.000	0.050	PPMV	AM20GAX	9/12/06	sl
N Methane	150000.000	0.200	PPMV	AM20GAX	9/12/06	sl
N n-Butane	<0.070	0.070	PPMV	AM20GAX	9/12/06	sl
N Propane	130.000	0.050	PPMV	AM20GAX	9/12/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	9/12/06	sl

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Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4727 Penn Way	Vapor	P0609115-07	08 Sep. 06 12:10	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	<0.020	0.020	PPMV	AM20GAX	9/12/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	9/12/06	sl
N iso-Butane	<0.050	0.050	PPMV	AM20GAX	9/12/06	sl
N Methane	150.000	0.200	PPMV	AM20GAX	9/12/06	sl
N n-Butane	<0.070	0.070	PPMV	AM20GAX	9/12/06	sl
N Propane	<0.050	0.050	PPMV	AM20GAX	9/12/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	9/12/06	sl

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PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609115
Report Date: 09/14/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4705 2nd st	Vapor	P0609115-08	08 Sep. 06 14:15	11 Sep. 06 9:58

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	9000.000	0.200	PPMV	AM20GAX	9/13/06	sl
N Ethene	<0.300	0.300	PPMV	AM20GAX	9/13/06	sl
N iso-Butane	370.000	0.500	PPMV	AM20GAX	9/13/06	sl
N Methane	550000.000	2.000	PPMV	AM20GAX	9/13/06	sl
N n-Butane	61.000	0.700	PPMV	AM20GAX	9/13/06	sl
N Propane	1100.000	0.500	PPMV	AM20GAX	9/13/06	sl
N Propene	<1.000	1.000	PPMV	AM20GAX	9/13/06	sl

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Contact: William Schuller
Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4803 2ND ST	Vapor	P0609365-01	11 Sep. 06 10:50	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	0.240	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	47.000	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4417 2ND ST (T)	Vapor	P0609365-02	11 Sep. 06 11:10	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	<0.02	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	2.700	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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Address: 3610 Collins Ferry Road
PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4417 2ND ST (H)	Vapor	P0609365-03	11 Sep 06 11:30	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	<0.02	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	2.100	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4417 2ND ST (S)	Vapor	P0609365-04	11 Sep. 06 11:35	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	<0.02	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	2.100	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4820 3RD ST (SHRUB)	Vapor	P0609365-05	11 Sep. 06 13:50	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	<0.02	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	3.900	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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PO Box 880
Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4818 3RD ST (PORCH)	Vapor	P0609365-06	11 Sep. 06 14:50	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	0.024	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	4.300	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4811 3RD ST	Vapor	P0609365-07	11 Sep. 06 15:00	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	1.100	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	120.000	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	0.059	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4807 3RD ST	Vapor	P0609365-08	11 Sep. 06 15:30	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	0.190	0.02	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.03	0.03	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	0.054	0.05	PPMV	AM20GAX	10/2/06	sl
N Methane	88.000	0.2	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.07	0.07	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.05	0.05	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.1	0.1	PPMV	AM20GAX	10/2/06	sl

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Morgantown, WV 36505-2353

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4625 3RD ST	Vapor	P0609365-09	11 Sep 06 14:15	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	420.000	0.020	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	1.100	0.050	PPMV	AM20GAX	10/2/06	sl
N Methane	28000.000	0.200	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.070	0.070	PPMV	AM20GAX	10/2/06	sl
N Propane	14.000	0.050	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	10/2/06	sl

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Lab Proj #: P0609365
Report Date: 10/03/06
Client Proj Name: Versailles
Client Proj #: Versailles

Sample Description	Matrix	Lab Sample #	Sampled Date/Time	Received
4805-D 2ND ST	Vapor	P0609365-10	11 Sep. 06 10:45	24 Sep. 06 10:50

Analyte(s)	Result	PQL	Units	Method #	Analysis Date	By
RiskAnalysis						
N Ethane	<0.020	0.020	PPMV	AM20GAX	10/2/06	sl
N Ethene	<0.030	0.030	PPMV	AM20GAX	10/2/06	sl
N iso-Butane	<0.050	0.050	PPMV	AM20GAX	10/2/06	sl
N Methane	1.700	0.200	PPMV	AM20GAX	10/2/06	sl
N n-Butane	<0.070	0.070	PPMV	AM20GAX	10/2/06	sl
N Propane	<0.050	0.050	PPMV	AM20GAX	10/2/06	sl
N Propene	<0.100	0.100	PPMV	AM20GAX	10/2/06	sl

Appendix C

Versailles Borough Project
Drilling Report

VERSAILLES BOROUGH PROJECT
DRILLING REPORT

BOROUGH GARAGE WELL – 4822 SECOND STREET.

9/15/2006 Moved in Hydrocarbon Well Service completion rig.

9/18/2006 Hydrocarbon Well Service driller and helper dug around 10-inch casing at Borough garage well. Knocked out plug in the center of 1 ½-inch pipe, had a slight puff of gas. Passport multi-gas meter indicates 100% of lower explosive limit (LEL) below the concrete in the 10 inch casing. Borough Street Department employees used backhoe to excavate part of surface casing. Hydrocarbon personnel knocked out concrete with jackhammer, depth inside pipe to top of debris approximately 36 inches. Cut off 10-inch casing with torch one foot below ground level; wellbore appears to be filled with reduced pieces of wood, pieces of old bricks, and metal window debris. Hydrocarbon personnel moved in mud pump, covered well, and field operations were shut down for the night.

9/19/2006 Hydrocarbon personnel moved in drill pipe. Top of 10-inch surface conductor casing was cleaned with grinder and a 10-inch threaded collar was welded onto surface conductor to connect flow diverter and rotating head. Borough Street Department employees filled hole around casing with rock. Field operations were shut down for the night.

9/21/2006 Hydrocarbon personnel moved in water tank, rigged up power swivel, 6 ¼ -inch wash over shoe on 2 inch tubing, and started in hole. Power swivel hydraulic line blew; new one obtained from across Pittsburgh. Tripped in hole with tubing and wash over shoe and rotated to a depth of 10 feet. Several pieces of reduced wood, rocks, and old bricks were retrieved from the wellbore. Shut down operation for the night.

9/22/2006 Hydrocarbon personnel moved in portable mud pit to assist with drilling operations, hooked up water lines from water tank to mud pit and mud pump. Converted to drilling with a tri-cone bit and will begin drilling with tri-cone bit on Monday.

9/25/2006 Drillers delayed by mandatory drug test. Rig crew rigged up mud pump and portable mud pit. Crew tripped in hole with 6 5/8-inch tri-cone bit on 4 ½-inch drill collar. Several bricks and other debris were drilled to a depth of 30 feet 10 inches while circulating with city water from the nearby fire hydrant. Operations were shut down for the night.

9/26/2006 Rotating head was connected to the flow diverter to ease drilling operations. Drilling continued using fire hydrant water and a 4 ½-inch drill collar on 2-inch tubing. Drilled from 30 feet to 40 feet, broke through barrier, and lost water to

hole. Pieces of reduced wood were drilled from 45 to 50 feet. Bit rotated free to 60 feet, but continued to lose water to the hole. Driller's helper shut off both water valves on mud pump and blew heads off mud pump. Shut down drilling operations to repair mud pump. Resumed drilling operations and rotated free to 135 feet, drilled junk briefly, then continued to rotate free to total depth of 316 feet 10 inches. Circulated city fire hydrant water in wellbore. Terminated drilling, tripped out of hole, and lay down bit and tubing. Shut down operations for the night. Will rig up bailer to bail water from wellbore on 9/28 and run down-hole video camera on 9/29.

9/28/2006 Tripped in hole with 8-inch bailer and bailed wellbore for 4 hours with well slugging gas while bailing. Wellbore water level could not be bailed below 20 feet. Drill crew tagged well total depth of 345 feet with wireline. Shut down operations for night.

9/29/2006 Wellbore water level at 17.2 feet below top of diverter, approximately 16.6 feet below ground level. Well bubbling gas through water. Flow rate not measurable – less than 0.5 cubic feet per hour. Rigged up borehole video camera and tripped in hole. Water in wellbore was very murky making it almost impossible to determine formations. Bottom of 10-inch casing appears to be approximately 40 feet below ground level with open hole below this depth. Bottom of Upper Freeport coal appears to be at an approximate depth of 195 feet. Camera tagged wellbore bottom (total depth) with camera at 332 feet. It appears that some gas bubbles may be coming from below this depth, but verification of gas bubbles and gas entry point are not discernible. There was an apparent increase in bubbling as camera above 180.5 feet as the camera was coming up the wellbore. Decision was made to drill well deeper to below all coal seams in the area to determine gas entry locations. Rig crew will trip back in hole with bit on tubing as soon as a rotating head can be brought to control gas production while drilling. Shut down operations for night.

10/3/2006 Rigged up rotating head.

10/4/2006 Tripped in hole with 6 5/8-inch tri-cone bit and 5-inch drill collar on 2-inch tubing to 345 feet. Circulated approximately 5000 gallons of city water down drill string to try and establish circulation, but no returns to pit. Tripped out of hole with all but one string of tubing and drill collar to ensure bit was in surface conductor in case of wellbore cave-in. Shut down waiting on orders from Hydrocarbon field supervisor.

10/6/2006 Rig crew tripped in hole to 345 feet and drilled with 6 5/8-inch tri-cone bit and 5-inch drill collar on 2-inch tubing. Circulate city water, but no returns. Decision was made between Hydrocarbon field supervisor and RDS field crew to attempt drilling without circulation until circulation could be reestablished. Drilled to 380 feet with little resistance and circulation returned. Returns showed we were drilling dark gray material (possibly coal fines) then light gray shale. Rotated free

to 570 feet and drilled apparently new hole to 575 feet (either sidetracked hole or this was original well depth) in light gray shale and fine sandstone. Rig crew tripped out of hole for night.

10/9/2006 Gas bubbling through water in wellbore at approximately 17.5 feet below ground level. Borehole video camera ran in well. Water was found to be very murky at the top due to clay and coal particles suspended in the water. Water cleared at 217 feet, with no gas bubbles visible at this depth. Coal and formation particles were visible dropping through the water. Water again became murky below 275 feet, becoming dark below 375 feet with no visibility. Camera drew began running camera back out of the wellbore. Particles were visibly seen falling past the camera lens at 200 feet and 190 feet, but no bubbles were evident. At 180 feet, suspended particles were seen swirling around the camera lens. Apparent gas bubbles were first visible at a depth of 110 feet. Borehole video survey appears to confirm that the gas is not coming from below the Upper Freeport coal at an approximately depth of 190 feet.

10/24/2006 Gas bubbling out of well contains 13 parts per million hydrogen sulfide at flow rate of 6.5 ft^3/hr. This is well below the National Institute of Safety and Health (NIOSH) Immediately Dangerous to Life and Health (IDLH) of 100 ppm and less than 17 ppm occurring at 4821 Second Street prior to drilling. Installed 4-inch schedule 80 PVC pipe vent onto well with top of vent approximately 10 feet above ground level to safely disperse H_2S into atmosphere.

11/15/2006 Wellbore gas reached H_2S level of 118 parts per million using Passport multi-gas meter. Well flow rate remained at 6.5 cubic feet per hour. Spoke to Versailles maintenance, security, and office personnel of high hydrogen sulfide reading. Reported to them that well was being shut-in (all valves were being closed) due to high level of H_2S in wellbore, problem was under control with no danger to public, and to make certain nobody reopen the well. Notified by cell phone PA Department of Environmental Protection personnel and RDS Environmental Health & Safety (ES&H) personnel of high H_2S reading, and that well was being shut-in. Contacted Hydrocarbon Well Services by cell phone to acquire wrenches and valves to shut-in well. Vent pipe was removed and 2-inch x 4-inch swage, 2-inch ball valve, and - inch bull plug installed on the well. Installed ¼-inch needle valve and pressure gauge in end of bull plug, shut-in well.

11/17/2006 Gas contained in well indicates 158 parts per million hydrogen sulfide using Passport multi-gas meter. RDS ES&H personnel on site to monitor ambient H_2S levels while sampling well H_2S levels. Ambient levels were within safe working levels. Shut in pressure estimated at 6 psi on 100 psi gauge. Contacted PA DEP by cell phone to report current H_2S levels in wellbore. Contacted Hydrocarbon Well Services by cell phone about availability of gas sample cylinder. Sampled gas using pressure cylinder provided by Hydrocarbon Well Service, returned sample to Morgantown NETL laboratory for analysis.

11/20/2006 Received gas analysis from lab, hydrogen sulfide not detected due to adsorption onto stainless steel pressure bomb. Another sample will be required to be taken to determine current H_2S level.

11/21/2006 Flowed well through ¼-inch needle valve until Passport meter indicated 70 ppm H_2S, then took sample gas using Tedlar bag (Garage Sample #1). Flowed well through ¼-inch needle valve until Passport meter indicated 170 ppm H_2S and took second sample using Tedlar bag (Garage Sample #2). Wellbore H_2S samples were delivered to Morgantown NETL laboratory for analysis. Changed 100 psi pressure gauge to 15 psi pressure gauge for more accurate reading of well pressure; shut-in pressure after sampling 3.3 psi. RDS ES&H personnel were on site to monitor ambient H_2S levels; within safe working levels.

11/22/2006 Sample analysis received from Morgantown NETL laboratory for gas contained in shut-in wellbore. PA DEP was contacted by cell phone to report laboratory analysis results. SulfaTreat was contacted by cell phone to determine if their product would eliminate H_2S from vented gas once wellbore was reopened, but salesman was on vacation and would not be returning until 11/27.

Garage #1:		**Garage #2:**	
Hydrogen:	Not detectable	Hydrogen:	Not detectable
Carbon Dioxide:	1.92%	Carbon dioxide:	2.03%
Ethane:	1.24%	Ethane:	1.29%
Oxygen:	1.04%	Oxygen:	0.27%
Nitrogen:	5.76%	Nitrogen:	2.62%
Methane:	90.53%	Methane:	94.47%
Hydrogen sulfide:	271.6 ppm	Hydrogen sulfide:	331.2 ppm

11/27/2006 SulfaTreat was contacted by cell phone to discuss using their product to remove H_2S from vented gas once well was reopened. Salesman stated that based on the 331 ppm level and 6.5 cubic feet per hour flow rate, their product would remove all H_2S from the gas stream for more than two years. The SulfaTreat module is a commercially purchased PVC pipe packed with a granular material that removes all of the hydrogen sulfide from the vented gas. Purchase order was placed to acquire a SulfaTreat Minivent consisting of a 4-inch x 4-foot PVC cartridge filled with SulfaTreat H_2S removal material.

12/11/2006 Shut-in well pressure 3.4 psi. Well was opened through manometer with an initial flow rate of 380 cubic feet per hour, but blew down in less than a minute and stabilized at 8 cubic feet per hour after 5 minutes. Shut-in well and removed existing valve borrowed from Hydrocarbon. A 4-inch full-bore ball valve, 4 x 3-inch reducing nipple, SulfaTreat module, and vent stack were installed on the well. SulfaTreat module was cracked during shipping, so cartridge was taped to seal crack and new cartridge reordered. The well was opened to the atmosphere. Meter at top of SulfaTreat module indicates that no hydrogen sulfide is being vented. RDS ES&H personnel reported safe ambient H_2S working levels while

completing work on well. Informed PA DEP and Borough personnel that SulfaTreat module had been installed on well, well had been reopened, and that a zero H_2S level was being reported at the output end of the treatment module.

12/13/2006 Removed vent stack. Had safety meeting with down-hole video camera, logging, and RDS ES&H personnel to explain H_2S problems with well prior to opening well. RDS ES&H personnel monitored ambient H_2S levels around open wellbore during video taping and logging operations; levels well within safety levels. Borough Council personnel and PA DEP personnel were on site to view borehole camera survey and geophysical logging. Camera crew tripped in hole with borehole video camera. Water level was approximately 21 feet, with gas bubbles visible at surface. No bubbles were visible below a depth of 143.3 feet, however, unable to discern actual entry point of gas because of apparent intermittent bubbling at and above this depth. Well total depth was reached at 491 feet. Century Geophysical ran borehole geophysical logs including gamma ray, density, caliper, resistivity, temperature, collar locator, and borehole deviation. Wellbore water level was 19 feet below 4-inch tee, which is approximately 2 feet above ground level. Top of Upper Freeport coal was found to be 167 feet, with the base of the coal at a depth of 173 feet. Log total depth was found to be 479 feet.

12/15/2006 Well was shut in and removed SulfaTreat module, which was damaged in shipment from the manufacturer. Well was opened through the manometer and had a stabilized flow rate of 6.5 cubic feet per hour. Peak wellbore hydrogen sulfide value was 104 parts per million as determined by using the Passport multi-gas meter. Installed new SulfaTreat module on vent stack and opened well to atmosphere. H_2S reading at output end of SulfaTreat module was zero. RDS ES&H monitored operation and indicated ambient H_2S levels were well within safe working levels.

2/6/2007 RDS personnel had safety meeting with rig crew prior to running casing to explain H_2S situation in wellbore. RDS ES&H personnel on site to monitor ambient H_2S levels and found readings were well within safe working level. Ran open-hole packer on 7-inch, J-55, 23 pound/foot steel casing. Set packer at 150 feet in base of Mahoning sandstone with 3000 pounds tension. Pipe tally of open-hole packer and 7-inch casing:

Description	**Length (ft.)**
Packer	4.45
Casing	30.20
Casing	30.20
Casing	30.15
Casing	30.20
Casing	23.05
Casing (Pup joint)	5.00
Total	**153.25**

Installed 10-inch x 7-inch wellhead at surface with solid bull plug on one side and ¼-inch NPT tapped bull plug on other side. A piece of ¼-inch tubing, valve, and pressure gauge were installed on the wellhead to monitor presence of annular pressure between 7-inch and 10-inch casing. Installed 7-inch x 4-inch swage on casing collar and re-installed existing valves, SulfaTreat module, and vent pipe. Determined well assembly was too high to work with efficiently and would require cutting off part of 7-inch casing and welding on a new collar. Rig crew needed to get 7-inch casing cutter and weld-on collar from Clarksburg, WV and would install on 2/8/07.

2/8/2007 Rig crew cut off approximately 2 feet of 7-inch casing and welded on new casing collar. RDS personnel reinstalled surfaced valves, SulfaTreat module, and vent pipe. RDS ES&H personnel on site and found H_2S ambient levels within safe working levels.

2/12/2007 Tested gas flow rate from 7-inch well casing; no flow and no pressure on casing. Annulus between 7-inch and 10-inch casing had 3.5 psi pressure indicating that gas was flowing on the backside of the packer. Will re-measure flow readings later in week to determine if gas flow re-established. RDS ES&H personnel will be on site whenever wellbore is opened or sampled. Ambient air H_2S within safe levels.

2/16/2007 Tested gas flow rate from 7-inch casing; still no flow or pressure. Will bring rig back and raise open-hole packer higher in wellbore. Ambient H_2S within safe levels.

2/21/2007 Tested gas flow rate from 7-inch casing; still no flow or pressure. Pressure on annulus was 3.5 psi indicating gas still leaking around packer. Rig will move back onto well to raise casing in wellbore the week of March 5. Ambient H_2S tested within safe levels.

3/6/2007 Moved in and rigged up rig. Released packer and attempted to raise casing; casing moved about 12 inches and stuck in wellbore due to debris on top of packer. Attempted several times to move packer up and down to remove debris, but to no avail. Sent rig hand to Waynesburg, PA to get pup joint. Rig crew will try tomorrow to add pup joint and lower packer in an attempt to remove fallen debris from on top of packer. Ambient H_2S was found to be within safe levels.

3/7/2007 Rig crew was able to lower packer into larger part of wellbore with additional 5-foot pup joint and clean debris from packer top. Raised packer 11 feet and set with 4000 lbs tension at 142 feet near top of Mahoning sandstone. Gas was still present in annulus between 7-inch and 10-inch casing. Packer was raised and set at 134 feet; gas was still in annulus. Crew raised and set packer at 69 feet; still gas in annulus. Raised and set packer with 4000 lbs tension at 46 feet; still gas in annulus. Apparently stray gas has migrated to the shallow Buffalo sandstone through uncased wellbores, including corroded surface conductor casing. Since

gas has migrated into the shallow Buffalo sandstone, there is no need to have packer or 7-inch casing in the wellbore. All casing and packer were pulled from the wellbore, wellhead was removed, and a 10-inch x 4-inch swage was installed on the well. Surface valves and hydrogen sulfide filter were placed back on the well. RDS ES&H personnel monitored ambient H_2S and found it to be within safe levels.

3/21/2007 Borough garage well gas flow measured at 6.5 cubic feet per hour. Ambient H_2S levels were found to be within safe levels.

4/10/2007 Borough garage well gas flow measured at 6.5 cubic feet per hour. Ambient H_2S levels were found to be within safe levels.

4/13/2007 Borough garage well water level measured at 17.2 feet from ground level, gas flow rate was 5.5 cubic feet per hour, and no hydrogen sulfide measured in the wellbore using the Passport multi-gas meter.

OBLEY WELL – 4307 THIRD STREET

10/9/2006 Top was pulled from power vent and base of 8-inch PVC pipe was excavated with backhoe to approximately 3 feet below ground level. The 8-inch PVC casing was found to be attached to 6-inch steel casing with Fernco 8-inch x 6-inch boot approximately 2 feet below ground level. Well is audibly bubbling and producing visible gas at surface. Borehole video camera was run down 6-inch steel casing. At an approximately depth of 44 feet below ground, the hole size reduced to 4 -inch or 5-inch casing Water level was found to be approximately 55 feet below ground level in the 4-inch or 5-inch casing, with no visible bubbles. No bubbles were visible to total depth of 99 feet in 4-inch or 5-inch casing. Camera was pulled out of well and the gas measured at a flow rate of 20 cubic feet per hour. Appears the gas is coming up outside the 4-inch or 5-inch casing, bubbling at 55 feet below ground level (outside the casing) and then going into the 6-inch casing from the 4-inch or 5-inch casing above the water level. Because of possible problems in upsetting the venting of this well and so close proximity to houses, no further work will be done on this well. Vent and blower were reassembled.

10/19/2006 Restored yard: raked out rocks, spread topsoil, planted grass, and spread straw.

WALNUT STREET WELL – 4722 WALNUT STREET

10/4/2006 Original condition of the well had 10-inch casing sticking approximately 6 inches above ground level, with a 2-inch pipe elbow set in the 10-inch casing with concrete and the elbow bent over as if hit by a dozer blade. Methane gas was flowing slightly from 2-inch elbow. Hydrocarbon Well Service dug around 10-inch casing with backhoe and found the casing was loose in the ground. Dug out

casing to a depth of 7 feet and found that 10-inch casing had broken off at a collar and was tilted at approximately 20 degrees. Straightened up 10-inch casing, and filled in hole to approximately 18 inches below ground level. Cut off 10-inch casing approximately 15 inches below top with reciprocating saw. Found that the 2-inch pipe set in the top of the 10 inch with cement only went down 1 foot 10 inches. Casing below cut is filled with junk approximately 3 feet below ground level, although it may extend to 7 feet below ground. Plan to dig out hole again when a Dresser sleeve is located to tie the 10 inch together at 7 feet below ground and vent the well properly.

10/9/2006 Dug out 10-inch casing with backhoe and found that all of the debris was in the joint broken off 7 feet below ground level. Water level was measured at 83 feet below the 10-inch casing collar or approximately 90 feet below ground level. Water level tape was able to be run to 178 feet below top of casing. Borehole video camera was run in well and showed the 10-inch casing to water level, gas bubbling through water, debris (bricks and wood) at water level. The video camera was unable to go deeper due to debris in wellbore. Will add 10 inch casing back to surface and fill in hole. Due to problems found at the Borough garage well with drilling on water, a cable tool rig will be moved in to clean out hole.

10/12/2006 Move in and rig up cable tool rig and added 10-inch casing to 3 feet above surface. New casing was threaded into existing collar 7 feet below ground level..

10/18/2006 Trip in hole with 5-inch cherry picker cable tool bit (bit with vertical slot for junk) to 90 feet below ground level. Several chunks of wood were recovered. Drilled to 260 feet with the last 5 feet are in medium gray shale. Well had a gas flow rate of 4.0 ft^3/hr compared to original rate of 0.5 ft^3/hr. Shut down for night.

10/19/2006 Changed to 6 ½-inch cable tool bit. At 275 feet began drilling dark gray shale and coarse sand. Drilling line became tangled, pulled out, and cut drilling line. Rig crew drilled to a depth of 285 feet using the 6 ½ cable tool bit in dark gray shale. Current water level depth measured at 95 feet from ground level (originally 90 feet). Measured gas flow at greater than 50 ft^3/hr, which was the manometer limit. Shut down operation due to thunderstorm in area.

10/23/2006 Drilling with 6 ½-inch cable tool bit. Hole had caved to approximately 270 feet Drilled to approximately 285 feet, recovering coal fines, bit dragging on something in the hole, cavings and sticky shale not allowing progress below 285 feet Gas flow approximately same as last week. Shut down for night. Rig crew will try to run cherry picker bit into well tomorrow.

10/24/2006 Drilling with 5-inch cherry picker cable tool bit to an approximately depth of 275 feet in cavings and fill. Bit recovering gummy gray shale and wood, possibly a wooden plug used to plug the well originally. Drilling continued to a depth of 285 feet. Changed to 8-inch cherry picker bit, recovered wood fragments, and set down hard at 260 feet. Changed back to 5-inch cherry picker and was able to get

to 285 feet (total depths measured). Continue to have problems at 260 feet, appears there may be a string of 6-inch casing at 260 feet with wood inside it. Shut down for night.

10/25/2006 Drilling with 5-inch cherry picker cable tool bit. Bit recovering some wood, most likely from wooden plug used to plug the well originally. Drilling continued to a depth of 295 feet, where bit and jars were dragging on wood in side of hole. Rig crew was able to drill to a total depth of 310 feet before shutting down for night.

10/26/2006 Drilling with 5-inch cherry picker cable tool bit. Alternately drilling more freely and catching on side of hole, recovering medium gray shale. Appears to be drilling through bridges in approximately 6-inch diameter hole, may not be casing. Crew drilled to 410 feet before shutting down for the night.

10/27/2006 Drilling with 5-inch cherry picker cable tool bit. Overnight we lost 60 feet of open hole before being able to drilled back to 410 feet. Shut down for weekend.

10/30/2006 Tripped in hole with 5-inch bailer to 410 feet and recovered gray shale. Rig crew started drilling again with 5-inch cherry picker. Recovering some rock fragments mixed with wet shale and one large chunk of orange sandstone. Crew drilled back to total depth of 410 feet before shutting down for night.

10/31/2006 Changed bit to 4-inch mill bit (hollow with teeth on outside) in an attempt to break-up debris in wellbore and double-acting jars that trip on both up- and down-stroke. Tripped in hole to 410 feet, and was able to drill to 495 feet, still recovering gray shale with a few wood fragments. Drilled to a depth of 650 feet, and shut down for the night.

11/1/2006 Drilling with 4-inch mill bit and double-acting jars. Crew drilled to 725 feet before shutting down for the night.

11/2/2006 Drilling with 4-inch mill bit and double-acting jars. Crew drilled to total depth of 800 feet before shutting down for the night. This depth should put bottom of hole below the last coal seam in area.

12/13/2006 Tripped in hole with borehole video camera. Water level was approximately 94 feet below top of casing with numerous bubbles visible on surface. Three entry points for gas clearly visible at 248.3 feet bubbling vigorously from what appears to be coal cleats. No gas bubbles were present below this depth, reaching a video total depth of 618 feet with camera. Century Geophysical ran borehole geophysical logs, including gamma ray, caliper, collar locator, density, resistivity, temperature, and sonic. Logging water level was 91 feet. Top of the Upper Freeport coal was found to be 239 feet below top of 10-inch casing with the base of the coal at 246 feet. Borehole video camera depth readings are apparently 3 feet deeper than the geophysical logs, placing the gas entry points approximately in the base of the Upper Freeport coal seam.

2/7/2007 Open-hole packer was run in the wellbore on 7-inch, J-55, 23 lb/ft steel casing. Packer was set at 222.95 feet in middle of Mahoning sandstone (above Upper Freeport coal). Problems were encountered getting the packer to set in the sandstone and this was lowest place in the formation that the packer would hold. Set packer with 3000 pounds tension. Pipe tally of open-hole packer and 7-inch casing are given in the following table:

Description	Length (ft)
Packer	4.45
Casing	31.30
Casing	31.20
Casing	31.20
Casing	31.20
Casing	31.20
Casing	31.20
Casing	31.20
Total	**222.95**

Installed 10-inch x 7-inch wellhead at surface with solid bull plug on one side and ¼-inch NPT tapped bull plug on other side. A ¼-inch valve and pressure gauge were installed on the wellhead to monitor presence of any annular pressure. A 7-inch x 4-inch swage was installed on the 7-inch casing collar and valve and vent pipe were installed completing the well.

2/12/2007 Gas flow rate measured 10.5 ft^3/hr from the 7-inch casing with no pressure on annulus.

2/21/2007 Gas flow rate measured 10.5 cubic feet per hour from 7-inch casing with no pressure on annulus. Methane Buster™ will be moved onto well site the week of March 5.

3/6/2007 Versailles Borough Street Maintenance personnel leveled location with backhoe. Methane Buster™ arrived on location. After several attempts to lift the Methane Buster™ from the trailer to the ground with the Borough backhoe with no avail, C and D towing (McKeesport, PA) was called to lift and set Methane Buster™.

3/7/2007 AmeriGas set 1000 gallon propane tank on location and connected to Methane Buster™. They plan to fill tank on 3/9. Cut approximately 12 inches off of 7-inch well casing and welded on new collar to allow easier access to valves and test ports.

3/20/2007 Water level was measured at 94.91 feet below the 4-inch tee on wellhead assembly. Methane Buster™ was connected to the well and ran at 1500 rpm on propane pulling a vacuum of approximately 20 inches water on the 7-inch casing, but no gas flow was measurable from well. Methane Buster™ began surging

apparently due to problems pulling vacuum on well. Operations were shut down for the night..

3/21/2007 Measured gas flow at Naughton property well at 50 cubic feet per hour and well at Borough garage at 6.5 cubic feet per hour. Ran Methane Buster™ at 1300 rpm and pulled a vacuum of 22.5 inches water, but still no measurable gas flow from the well.

3/26/2007 Disconnected Methane Buster™ from well, measured gas flow at 10 cubic feet per hour. Installed air operated pump in well. After pumping for 17 minutes gas flow increased to 17 cubic feet per hour. After 1 hour 13 minutes water level had dropped 2.4 feet and gas flow was 18 cubic feet per hour. Reconnected Methane Buster™ and ran at 1300 rpm pulling a vacuum of 22 inches water on the well, but still no apparent effect on gas flow. Operations were shut down for the night.

3/27/2007 Pumped water from the well at a rate of 1.1 gallons per minute for 4 hours 15 minutes, resulting in a maximum water level drawdown of 3.5 feet and a maximum gas flow rate of 17 cubic feet per hour. Shut down operations for storm in the area. Apparently the air operated pump could not lower the water fast enough or create enough wellbore drawdown to significantly increase gas flow rates. A decision was made to install a larger pump in the well and retest the Methane Buster™.

4/9/2007 Removed air operated pump and installed a 1½ horsepower submersible pump. Water level was measured at 94.5 feet below 4-inch tee. The water level was pumped down 20 feet and gas flow measured 50 cubic feet per hour. The water level down was pumped down to 174.3 feet below 4-inch tee and the gas flow increased to 120 cubic feet per hour. Approximately 2000 gallons of water was pumped in 163 minutes (approximately 12 gallons per minute), reaching a maximum drawdown of 174.3 feet and a maximum gas flow rate of 134 cubic feet per hour. Operations had to be shut down because the water holding tank was full. Water could not be placed in the storm sewer system, but had to stored in tank and hauled away for disposal due to high sodium levels in the well water. Water level rose in the wellbore approximately 40 feet with in 2 minutes of shutting off the pump.

4/10/2007 Vacuum truck arrived and emptied water tank. Water level was measured in the well at 95 feet below the 4-inch tee. Water was pumped from the wellbore at a rate of 12 gallons per minute starting at 10:29 AM. After 30 minutes of pumping, the water level was measured at 153.6 feet below the 4-inch tee and the gas flow rate measured 90 cubic feet per hour. After 1 hour of pumping, the water level was 163 feet below 4-inch tee and the gas flow rate was 95 cubic feet per hour. After 90 minutes of pumping, the gas flow rate increased to 120 cubic feet per hour. To determine if the enhanced production from the Walnut Street well had any effects on other wells in the area, flow rates were tested at the Borough garage well and the vented well at 4805 Second Street. The vented well at 4805

Second Street was surging and had decreased in flow from 50 cubic feet per hour to 35 cubic feet per hour. The Borough garage well remained unchanged at its previous rate of 6.5 cubic feet per hour. After 2 ½ hours pf pumping, the water level in the well measured 172.6 feet below the 4-inch tee with a gas flow rate of 110 cubic feet per hour. The Methane Buster™ was started at 1:17 PM and the flow rate through the manometer connected to side port increased from 7 to 25 cubic feet per hour while the Methane Buster™ was running at 1300 rpm and pulling a vacuum of 17 ½ inches water. Methane Buster™ speed was increased to 1400 rpm, flow through the manometer was now 29 cubic feet per hour, and it was pulling a vacuum of 20 ¾ inches water. Flow through Methane Buster's™ gas meter located on the blower outlet indicated a rate of 2 cubic feet per minute (120 cubic feet per hour). Methane Buster™ speed was increased to 1500 rpm pulling a vacuum of 25 inches water, but the gas flow remained at 2 cubic feet per minute. At 2:40 PM the gas flow rates were again checked at the Second Street and Borough garage wells. Flow rates remained unchanged from earlier in the day. At 2:55 PM, the Methane Buster™ was running at 1400 rpm with a vacuum of 20 ½ inches water. An attempted was made to lean the Methane Buster™ off of propane and instead run it on gas from well. The test was almost successful, so will try again with help from the Methane Buster™ manufacturer. Shut down the Methane Buster™. At 3:23 PM, the water level was measured at 175.5 feet below 4-inch tee, and a gas flow rate of 75 cubic feet per hour. Since the water tank was full, the pump was shut down and operations ended for the evening.

4/13/2007 Water level was measured at 94.7 feet below 4-inch tee, with a gas flow rate of 11 cubic feet per hour. Borough garage water level was measured at 17.2 feet from ground level and a gas flow rate of 5.5 cubic feet per hour and no wellbore hydrogen sulfide indicated on the Passport meter. Water level at 4805 Second Street well was measured at 25.15 feet from the top of the pipe with an average gas flow rate of 35 cubic feet per hour as the well was slugging gas and the flow rate was varying from 25 to 45 cubic feet per hour.

4/18/2007 Water level was measured at 93.4 feet from the top of the 4-inch tee with a gas flow rate of 20 cubic feet per hour at 10:35 AM. Methane Buster™ test began by pumping water at a rate of 12 gallons per minute.

11:45 AM - Second Street well water level 25 feet from top of pipe with average gas flow rate of 35 cubic feet per hour; well surging from 30 to 40 cubic feet per hour.

12:03 PM – Walnut Street well gas flow rate measured 120 cubic feet per hour.

12:05 PM – Walnut Street well water level measured 142.7 feet below 4-inch tee and gas flow rate of 150 cubic feet per hour.

1:20 PM – Walnut Street water level measured 148.4 feet below 4-inch tee with a gas flow rate of 110 cubic feet per hour.

1:44 PM – Walnut Street well flowing at a rate of 75 cubic feet per hour as recorded by manometer on side port of Methane Buster™. Methane Buster™ started on propane at 1200 rpm. Gas flow rate increased to 110 cubic feet per hour through manometer.

1:55 PM – Methane Buster™ pulling a vacuum of 12 ½ inches water at 1200 rpm with a gas flow rate of 3 cubic feet per minute (180 cubic feet per hour) through the gas meter on the blower outlet.

2:00 PM – Methane Buster™ speed increased to 1500 rpm while pulling a vacuum of 23 ½ inches water and showing a gas flow rate of 3.2 cubic feet per minute through gas meter.

2:05 PM – Methane Buster™ running off of well gas alone and pulling a vacuum of 25 ¼ inches water.

2:18 PM – Methane Buster™ still running off of well gas at 1500 rpm and pulling a vacuum of 25 inches water.

2:30 PM - Methane Buster™ began surging slightly while pulling a vacuum of up to 26 ¼ inches of water.

2:45 PM – Methane Buster™ still running off of well gas but started to die. Additional well gas was added through the air cleaner to help the engine run smoothly.

2:55 PM – Insufficient wellbore gas for the Methane Buster™ to run at 1500 rpm.

3:04 PM – Methane Buster™ blower was shut off and the engine allowed to run at 900 rpm on gas from well alone.

3:06 PM – Methane Buster™ died while trying to run on well gas alone. Methane Buster™ testing was terminated at that point.

3:20 PM – Final water level in wellbore measured at 152.3 feet below 4-inch tee.

5/17/2007 Gamma ray and resistivity geophysical logs were run on the vents at 3805 Second Street and 4305 Third Street using NETL logging tools. An attempt was made to log the vent at 4705 Second Street, but was insufficient depth to get meaningful data.

5/30/2007 Methane Buster™ was removed from the Walnut Street well location and well was put back to pre-testing configuration.

6/6/2007 Walnut site was regraded and seeded. Field work for this project was terminated.

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South, Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

Visit the NETL website at:
www.netl.doe.gov

Customer Service:
1-800-553-7681

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