Applying the Case Study Method to Measure Possible Impact of Proximity to Fracking Transmission Line Facilities on Home Prices

by Richard J. Roddewig, MAI, Michael J. Samuels, MAI, Anne S. Baxendale, and Joseph R. De Marinis, MAI

Abstract

There have been many studies analyzing the effect of environmental concerns related to fracking on home prices. There have also been many studies of the generalized effect of proximity to oil and gas pipelines on nearby home prices and studies of the effect of pipeline spills on home prices and values. Residential appraisers have an obligation to consider and analyze any neighborhood environmental issues that may affect prices and values. This study looks at home prices in proximity to compressor stations and dehydration facilities related to pipelines that transmit fracked oil and gas to refineries. These facilities generate noise and can experience failures that raise environmental concerns different from the marketplace concerns associated generally with oil and gas transmission pipelines. This article applies the case study method and paired data analysis—two generally recognized methods for analyzing a detrimental condition—to analyze the effect on home prices, if any, of fracking-related facilities. Three of the case studies involve analysis of sales before and after a date when environmental incidents occurred.

Introduction: The Fracking Boom and Home Price Impact Studies

The oil shale boom in the United States has generated dozens of studies over the past twenty years analyzing the effect of fracking on prices and values of adjacent and nearby homes.[1] Most of those studies involve environmental concerns and issues related to fracking, including methane emissions from the well sites, groundwater contamination by methane and fracking chemicals, leaks from frack wastewater containment lagoons, and spills of fracking chemicals at the well sites or along the roads and highways over which the chemical trucks travel to and from well sites. A number of studies have looked at claims that the

1. See, for example, Lucija Muehlenbachs, Elisheba Spiller, and Christopher Timmins, "Shale Gas Development and Property Values: Differences across Drinking Water Sources," National Bureau of Economic Research, Working Paper 18390 (September 2012), www.nber.org/papers/w18390; Lucija Muehlenbachs, Elisheba Spiller, and Christopher Timmins, "The Housing Market Impacts of Shale Gas Development," National Bureau of Economic Research, Working Paper 19796 (January 2014), www.nber.org/papers/w19796; H. Allen Klaiber and Sathya Gopalakrishnan, "The Impact of Shale Exploration on Housing Values in Pennsylvania," Working Paper, 2012; Elisabeth N. Radow, "At the Intersection of Wall Street and Main: Impacts of Hydraulic Fracturing on Residential Property Interests, Risk Allocation, and Implications for the Secondary Mortgage Market," *Albany Law Review* 77, no. 2 (2014): 673–704, https://bit.ly/3B5vTPS; Richard J. Roddewig and Rebel A. Cole, "Real Estate Value Impacts from Fracking: Industry Response and Proper Analytical Technique," *Real Estate Issues* 39, no. 3 (2014): 6–20; and Randall Bell and Michael P. Bell, "Hydraulic Fracturing and Real Estate Issues," *The Appraisal Journal* 85, no. 1 (Winter 2017): 9–17.

fracking process itself or the injection of fracking wastes into deep abandoned wells or salt domes can cause earthquakes.[2]

One topic that has not generated significant research to date, however, is the effect on nearby home prices from the compressor stations and dehydration facilities constructed on the connector pipelines that in turn transmit the fracked oil and gas to refineries and processing facilities. The lack of studies specifically related to fracking transmission line facilities may be due to the long history of published studies dealing broadly with the price effect of gas transmission pipelines on home prices. Those pipeline impact studies generally look at the impact of proximity to pipelines on home prices,[3] and the impact of pipeline spills on home prices and values.[4]

While local connector lines are pipelines, and therefore raise the same types of home price and value impact concerns as pipelines generally, the compressor stations and dehydration facilities associated with those lines generate noise and can experience failures that raise environmental concerns that may be different from the marketplace concerns associated with gas and oil transmission pipelines in general. Residential appraisers completing form reports to support mortgage loans have an obligation to conduct a visual inspection of the neighborhood and report on and analyze any environmental issues in the neighborhood that may affect prices and values.[5] This article studies home prices around four compressor stations on fracking gas pipelines in New Jersey and Pennsylvania to demonstrate how case study analysis using paired data analysis can be applied to understand whether compressor station concerns are associated with home price and value impacts.

Compressor Stations and Dehydration Facilities: Description and Purpose

Compressor stations are pipeline facilities that maintain the flow rate and pressure in a natural gas transmission pipeline. They are necessary to overcome the distance, friction, and elevation changes that can slow the transmission process and also to cool the gas as its pressure is increased.[6] On large interstate transmission lines, they may be constructed at regular intervals varying from 40 to 100 miles—depending on terrain and flow

2. See, for example, William L. Ellsworth, "Injection-Induced Earthquakes," *Science* 341 (July 12, 2013): 1225942-1 to 1225942-4242, https://bit.ly/3NKbDL8; Katie M. Keranen, Heather M. Savage, Geoffrey A. Abers, and Elizabeth S. Cochran, "Potentially Induced Earthquakes in Oklahoma, USA: Links between Wastewater Injection and the 2011 mw 5.7 Earthquake Sequence," *Geology* 41, no. 6 (2013) 4:699–702. https://bit.ly/42eJgsL; K. M. Keranen, M. Weingarten, G. A. Abers, B. A. Bekins, and S. Ge, "Sharp Increase in Central Oklahoma Seismicity since 2008 Induced by Massive Wastewater Injection," *Science* (2014) 345:448–51, https://bit.ly/42acsB5; Patrick J. Kiger, "Scientists Warn of Quake Risk from Fracking Operations: Tremors Induced by Wastewater Disposal Are Larger and Harder to Predict than Previously Thought," *National Geographic* (May 2, 2014), https://bit.ly/3LZlwTE; Pamela King. "Uncertainty Is a Challenge in Linking Quakes with Drilling Activity." *EnergyWire*, December 17, 2014, available at *E&ENews*, https://bit.ly/3VAVKbw.

3. See, for example, William N. Kinnard Jr., Sue Ann Dickey, and Mary Beth Geckler, "Natural Gas Pipeline Impact on Residential Property Values: An Empirical Study of Two Market Areas," *Right of Way* (June/July 1994): 26–32; Allen, Williford & Seale Inc., "Natural Gas Pipeline Impact Study," Interstate Natural Gas Association of America Foundation (INGAA Foundation), Houston, TX, 2001; Eric Fruits, "The Impact of the Presence of a Natural Gas Pipeline on Residential Property Values," Portland State University and Economics International Corp., November 4, 2008, available at https://bit.ly/3p9cScl; Barry A. Diskin, Jack R. Friedman, Spero C. Peppas, and Stephanie R. Peppas, "The Effect of Natural Gas Pipelines on Residential Value," *Right of Way* (January/February 2011): 24–27; and Louis Wilde, Jack Williamson, and Christopher Loos, "A Long-Term Study of the Effect of a Natural Gas Pipeline on Residential Property Values," *Journal of Real Estate Literature* 22, no. 1 (2014): 47–65.

4. See, for example, Robert A. Simons, "The Effect of Pipeline Ruptures on Noncontaminated Residential Easement-Holding Property in Fairfax County," *The Appraisal Journal* (July 1999): 255–263; Robert A. Simons, Kimberly Winson-Geideman, and Brian A. Milkelbank, "The Effects of an Oil Pipeline Rupture on Single-Family Home Prices," *The Appraisal Journal* (October 2001): 410–418; Julia L. Hansen, Earl D. Benson, and Daniel A. Hagen, "Environmental Hazards and Residential Property Values: Evidence from a Major Pipeline Event," *Land Economics* 82, no. 4 (November 2006): 529–541; and Richard J. Roddewig, Charles T. Brigden, and Anne S. Baxendale, "A Pipeline Spill Revisited: How Long Do Impacts on Home Prices Last?" *The Appraisal Journal* (Winter 2018): 23–47.

5. See, for example, Fannie Mae, *Selling Guide: Fannie Mae Single Family* (February 1, 2023), which requires that as part of the neighborhood analysis, the appraiser consider "factors that affect the value and marketability of properties in the neighborhood," including "adverse environmental influences" (page 554), https://bit.ly/41kl1qG.

6. Penn State Extension, *Understanding Natural Gas Compressor Stations* (updated March 26, 2015), https://bit.ly/3NPC1mW.

capacity—and are necessary to repressurize the gas and keep it flowing.

But compressor stations are also necessary on the smaller gathering lines that collect the natural gas from the fracking wells and then connect to the larger transmission lines. A Pennsylvania State University article about compressor stations on these smaller gathering lines offers the following explanation:

> Natural gas within a gathering system can arrive at a compressor station at a variety of pressures depending on the pressure of the wells feeding the system and the distance gas travels from the wellhead to the compressor. Regardless of the incoming pressure, the gas must be regulated or compressed to transmission pressures (generally 800 to 1,200 psi) before it can enter an interstate transmission system. Because compression requirements can be significant within the gathering system, these compressor systems are generally large facilities consisting of 6 to 12 compressors in several buildings. Many of these gathering system compressor stations are scaled up in size as more wells are drilled in an area, increasing the demand for compression. The permanent land requirements of a gathering system compressor are generally 5 to 15 acres, but they can exceed this, considering slope of land and other factors.[7]

Fueled by diesel, gas, or electric engines, compressor stations can create significant noise levels; experience failures that cause explosions, fires, and emissions of natural gas; and be subject to federal, state, or local noise and environmental regulations, depending upon the type of pipeline and where the compressor is located.[8]

Glycol dehydration facilities are another type of fracking-related transmission line facility. The Society of Petroleum Engineers provides the following description of the purpose of a glycol dehydration facility:

> All raw natural gas is fully saturated with water vapor when produced from an underground reservoir. Because most of the water vapor has to be removed from natural gas before it can be commercially marketed, all natural gas is subjected to a dehydration process. One of the most common methods for removing the water from produced gas is glycol.[9]

The water in the natural gas, if not removed, can create problems. It can freeze in the pipelines, corrode the pipelines, or form hydrates with CO_2 and methane and clog equipment and piping.

Like compressor stations, with which they are often co-located, glycol dehydration facilities emit noise and vibration and can be subject to failures. They are a source of emissions as well. Both types of facilities are aboveground industrial installations that are not typically visually compatible with nearby homes and seldom buffered or screened entirely by natural topography or landscaping. Exhibit 1 shows the layout of the components in a typical glycol dehydration unit.[10]

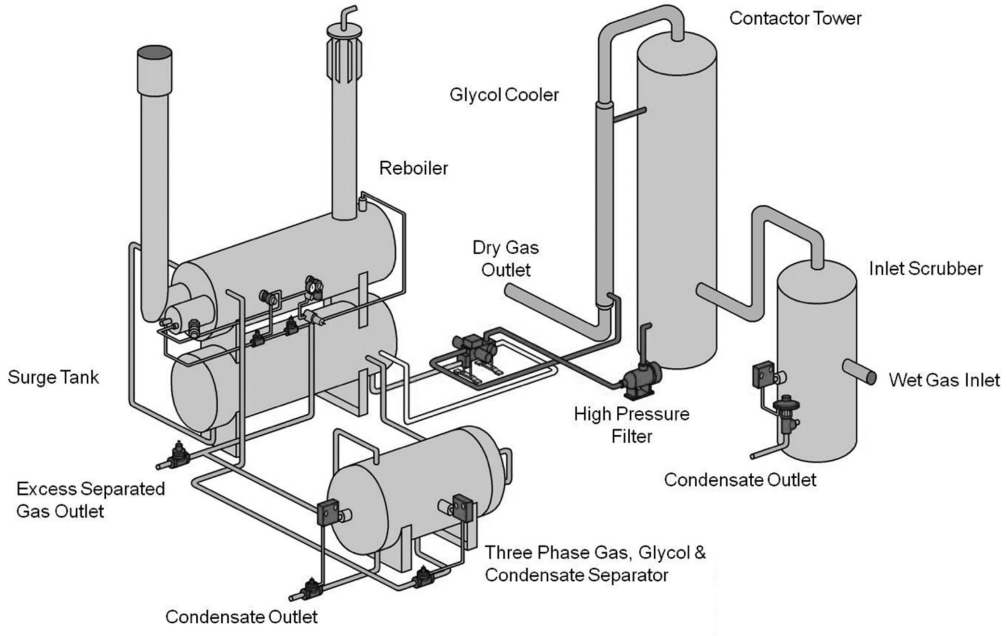
7. Penn State Extension, *Understanding Natural Gas Compressor Stations*.

8. For a photo of a gas compressor station, see "Wantage Opposes Gas Compressor Stations," *Advertiser-News North*, February 15, 2021, https://bit.ly/3HNYPiZ.

9. Society of Petroleum Engineers, "Dehydration with Glycol," PetroWiki, https://bit.ly/3B3Np6L.

10. Industrial manufacturers use various gas dehydration methods to eliminate unwanted moisture from recovered natural gas, including triethylene glycol processes. For a description of this process, see NiGen, "TEG Dehydration Process, Gas Dehydration System," https://bit.ly/3M5IBUV. For a photo of a glycol system installation in operation, see Oswal Infrastructure Limited, "Glycol Dehydration Unit," https://bit.ly/3nGzK2A.

Exhibit 1 Components of Glycol Dehydration Unit



Source: Kimray Inc., "What Is Glycol Foaming?," https://bit.ly/44Hhzu8.

Case Study 1: Transco Compressor Station 505 Explosion and Fire, Branchburg, New Jersey (2013)

The Pipeline, the Compressor Location, and the Incident

The Williams Gas Transco pipeline running from the Gulf Coast to the northeast is shown in the Exhibit 2 map.

Transco Compressor Station 505 is the origination point for Transco's Leidy Line, which extends west for 200 miles to Wharton, Pennsylvania, in Potter County.[11] The Leidy Line reportedly contains four gas pipelines: pipeline "A" constructed in 1958; pipeline "B" constructed in 1971; and pipelines "C" and "D" constructed in segments beginning in 1971 and still under construction as of 2013.[12] A 30-mile, 42-inch pipeline addition to the Leidy Line was announced in 2012 and was added to the original Leidy right-of-way between 2013 and 2016 as part of the Leidy Southeast Extension Project.

Transco Compressor Station 505, operated by Williams Gas,[13] is located south of Case Road and west of South Branch Road (Highway 567) in Branchburg, New Jersey, as shown on the location map (Exhibit 3).

In 2009 and 2012, various alterations were made to the Branchburg, New Jersey, compressor station. In 2015, other alterations (that did not include added compression) were made to Compressor Station 505.

A Pipeline Safety Trust report claiming to list all gas transmission pipeline incidents between 1986 and 2009, including incidents in New Jersey, was reviewed, but it did not show any incidents

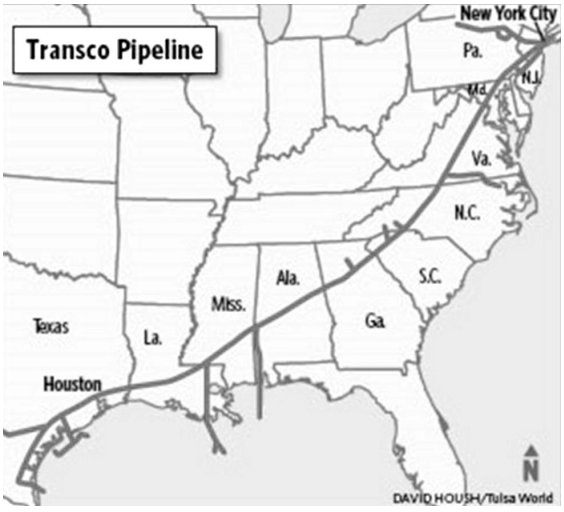
11. An August 1985 petition by Transco for an increase in pressure in its Caldwell Lateral references Compressor Station 505 and mentions that the pipeline dates to 1959.

12. Transcontinental Gas Pipe Line Company LLC, *Resource Report No. 2: Water Use and Quality, Leidy Southeast Expansion Project* (July 2013), page 2-1, available at https://bit.ly/42jmno4.

13. Transco is a subsidiary of Williams Gas Pipe Line Company.

related to Transco Compressor Station 505 during that period.[14] However, there was a significant incident at the facility in 2013. A minor explosion and fire on the night of May 30, 2013, injured 13 workers and required two to be admitted to a hospital. According to an investigation report by the US Department of Transportation Pipeline and Hazardous Materials Safety Administration,[15] workers installing a new valve were welding a 30-inch diameter cap onto a section of pipe when vapor accumulating inside the pipe due to a faulty valve ignited and blew the bolts holding the cap on the pipe. The Williams Company was fined $167,000 as a result of the accident.

Exhibit 2 Transco Pipeline



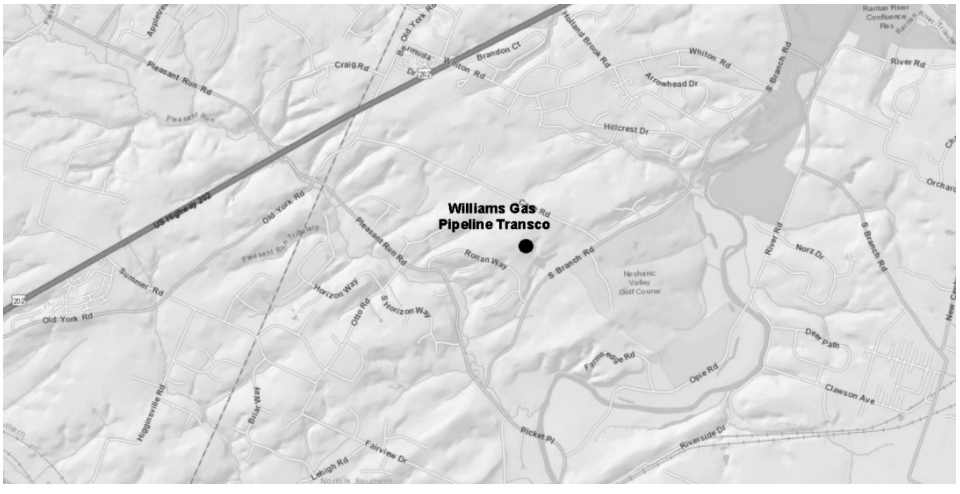
Media Coverage of the Incident

The explosion and fire were covered in some detail by the local press and other media. The accident was also the subject of comment at various public hearings related to the Leidy Southeast Expansion Project in the months following the incident. The hearings involved approvals for various additional loops in its pipeline system and upgrades to some of its facilities in New Jersey and Pennsylvania.

Case Study Home Price Sales Data Research

To understand the effect of the compressor station on home prices, home prices between 2000 and 2017 at various distances within one mile of the Transco Compressor Station 505 in Branchburg were collected and analyzed. Only sales of homes south of the compressor station facility were selected for analysis because the homes built immediately adjacent to the north side of the compressor facility are older and of a different

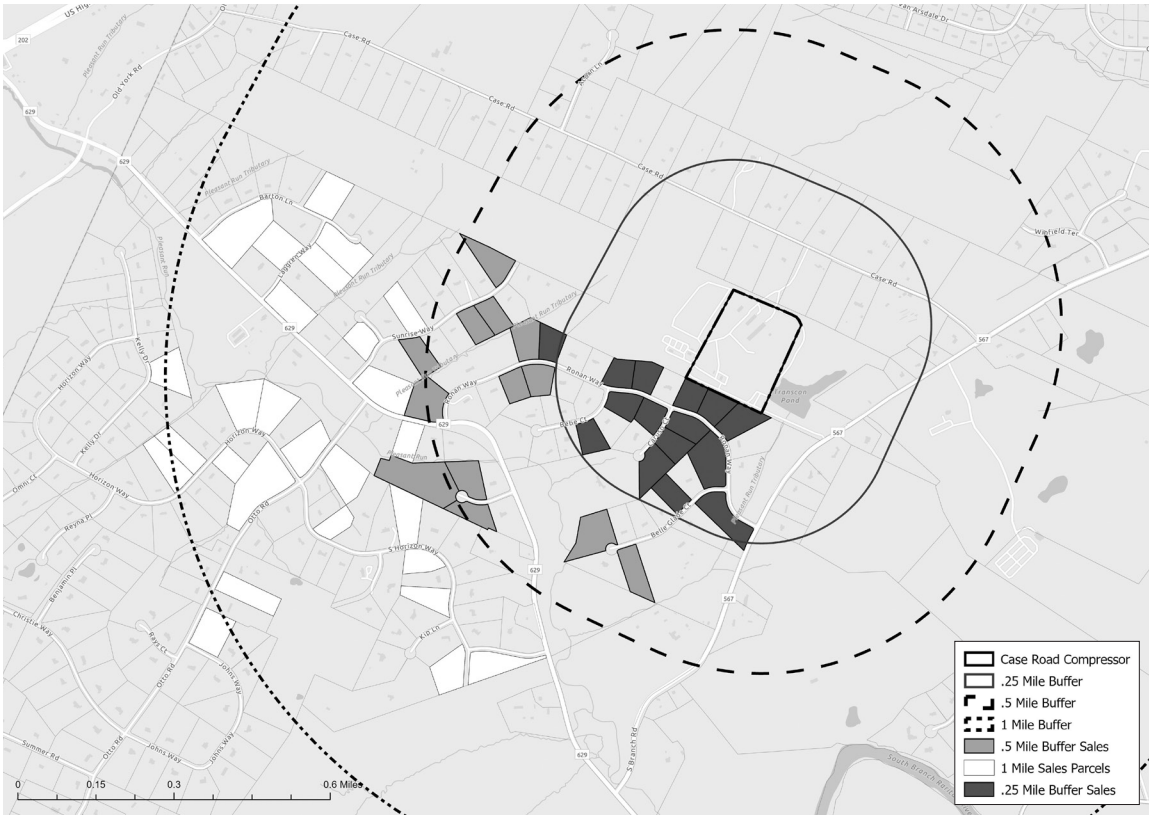
Exhibit 3 Transco Compressor Station 505 Location, Branchburg, New Jersey



14. The document is available at https://bit.ly/3VIjyKF. The Pipeline Safety Trust describes itself as an organization that "promotes pipeline safety through education and advocacy, increased access to information, and partnerships with residents, safety advocates, government, and industry, resulting in safer communities and a healthier environment," https://pstrust.org/about/mission/.

15. US Department of Transportation, "Notice of Probable Violation and Proposed Civil Penalty," March 6, 2014, https://bit.ly/44GaPgb.

Exhibit 4 Locations of Home Sales, Branchburg, New Jersey



character than the subdivisions located to the south.[16] The map in Exhibit 4 shows the locations of the sales as derived from the Garden State Multiple Listing Service for Branchburg.

Lots that were significantly larger than others were identified, and size difference adjustments were made to sale prices of lots in excess of 2.75 acres. The adjustments were based on an analysis and comparison of prices in the study area. Prices paid for homes on lots between 2.75 and 3.5 acres in size were adjusted down by $50,000, and prices for homes on lots larger than 3.5 acres were adjusted down by $75,000. The Exhibit 5 map shows the lots larger than 2.75 acres that required the downward adjustments for lot size.

A scatter plot trend line analysis of prices paid per square foot[17] at various distances from the compressor station was then undertaken. The standard deviation for each of the distance-based sales grouping was calculated and the need to remove outliers considered.[18] *The Dictionary of Real Estate Appraisal*, seventh edition, defines an *outlier* as a data point (observation) "with an extreme value (outside of the typical range)."[19] *Real Estate Damages*, third edition, on

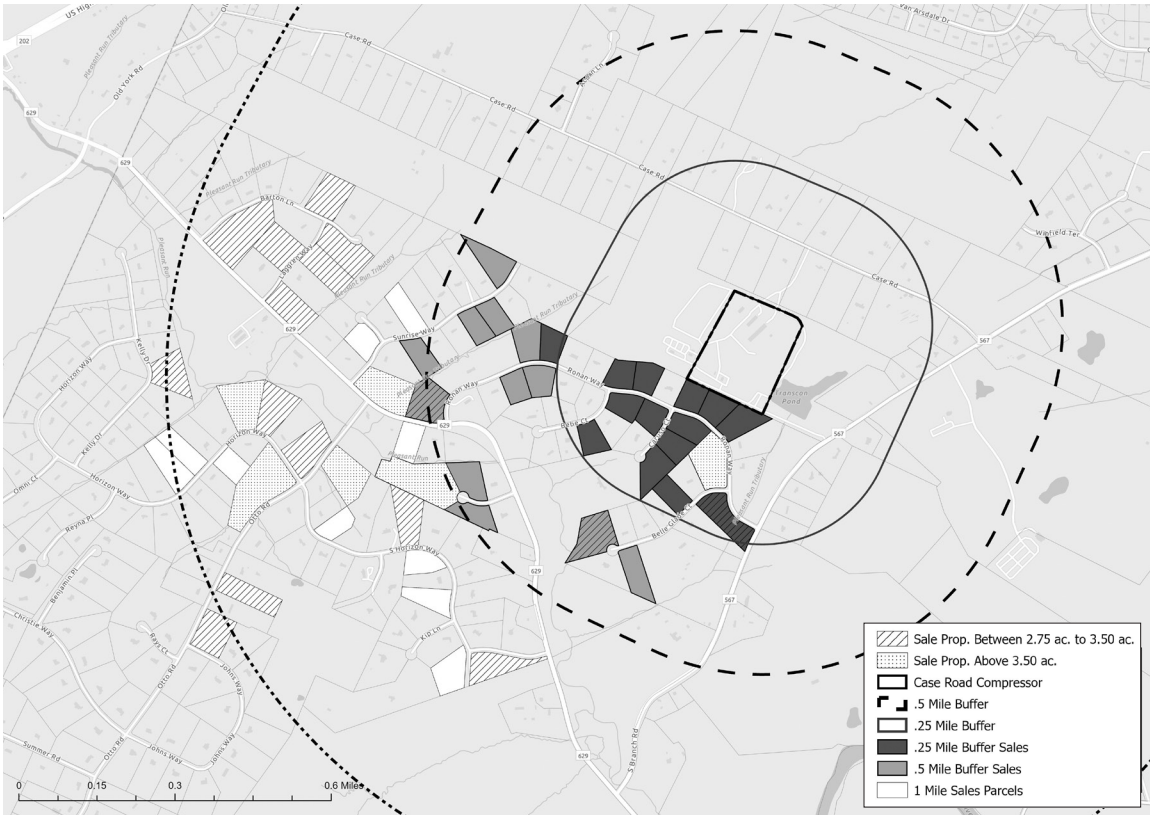
16. Two sales involving properties substantially larger in acreage than the other sales were also excluded. Both sales were located within 0.25 miles of the facility. One sale involved a 35.6-acre parcel located on Caruso Court that sold in July 2008 for $2 million. The other sale was located on the west side of South Branch Road and the east side of Ronan Way contained 9.31 acres that sold for $549,900 in 2002.

17. Price per square foot rather than nominal price is used in all the case studies reported in this article to eliminate some of the variability due to differences in size of homes that are reflected in the nominal prices.

18. In a *Daubert* challenge proceeding in a federal district court case in Florida involving trend line analysis, the court ruled that outliers that significantly affect a trend line analysis should be eliminated from a linear regression model. See *John Navelski, et al. v. International Paper Company*, US District Court for the Northern District of Florida, Pensacola Division, Case No. 3:14cv445/MCR/CJK, Document 93, Filed March 17, 2017.

19. Appraisal Institute, *The Dictionary of Real Estate Appraisal*, 7th ed. (Chicago: Appraisal Institute, 2016), s.v. "outlier."

Exhibit 5 Locations of Home Sales with Lot Adjustments, Branchburg, New Jersey



analysis of the impact of detrimental conditions states as follows:

> It is important to consider the inclusion or exclusion of outliers, since a small number of extreme values can impact some statistical analyses. However, the basis for excluding any outliers should be clearly demonstrated. Outliers should normally be excluded using a decision rule (i.e., more than two standard deviations from the mean, 10% above or below the next highest or lowest value, etc.) to minimize bias in the data selection and refinement process. At a minimum, outliers should be investigated to determine why these values differ significantly from the rest of the data.[20]

To identify outliers, a straight-line, simple linear regression trend line model was run for each of the distance-based data sets to determine its standard deviation. Those trend lines were then graphed as scatter plots as shown in Exhibit 6.

When the two data points in excess of two standard deviations from the linear trend lines are removed, and then the data plotted as both a straight-line and a polynomial trend line,[21] the reflection points and changing relationships between the prices over time can be seen as shown in the graphic comparisons in Exhibit 7 and Exhibit 8.

20. Randall Bell, *Real Estate Damages*, 3rd ed. (Chicago: Appraisal Institute, 2016), 43–44.

21. Karen Grace-Martin, "Regression Models: How Do You Know You Need a Polynomial?," The Analysis Factor (bit.ly/42y7Pkf), notes that a polynomial term—a quadratic (squared) or cubic (cubed) term—transforms a linear regression model into a curved line. This is useful when the real estate sale price scatter plot indicates that there is more than a simple straight-line relationship between the sale prices over the period analyzed. As Grace-Martin states, "There are some relationships that a researcher will hypothesize is curvilinear. …Clearly, if this is the case, include a polynomial term." A good example of such a situation is the performance of the US housing market during 2004–2015. Home prices rose rapidly between 2004 and 2007, then suffered a significant downturn in the recession, then experienced another upward price swing during the recovery. The relationship between the data points in the scatter plot for the Compressor Station 505 analysis reflects that obvious pricing pattern. For more information on polynomial linear regression modeling, see The Analysis Factor website, www.theanalysisfactor.com/resources/.

Exhibit 6 Linear Trend Line Model of Distance-Based Data Sets

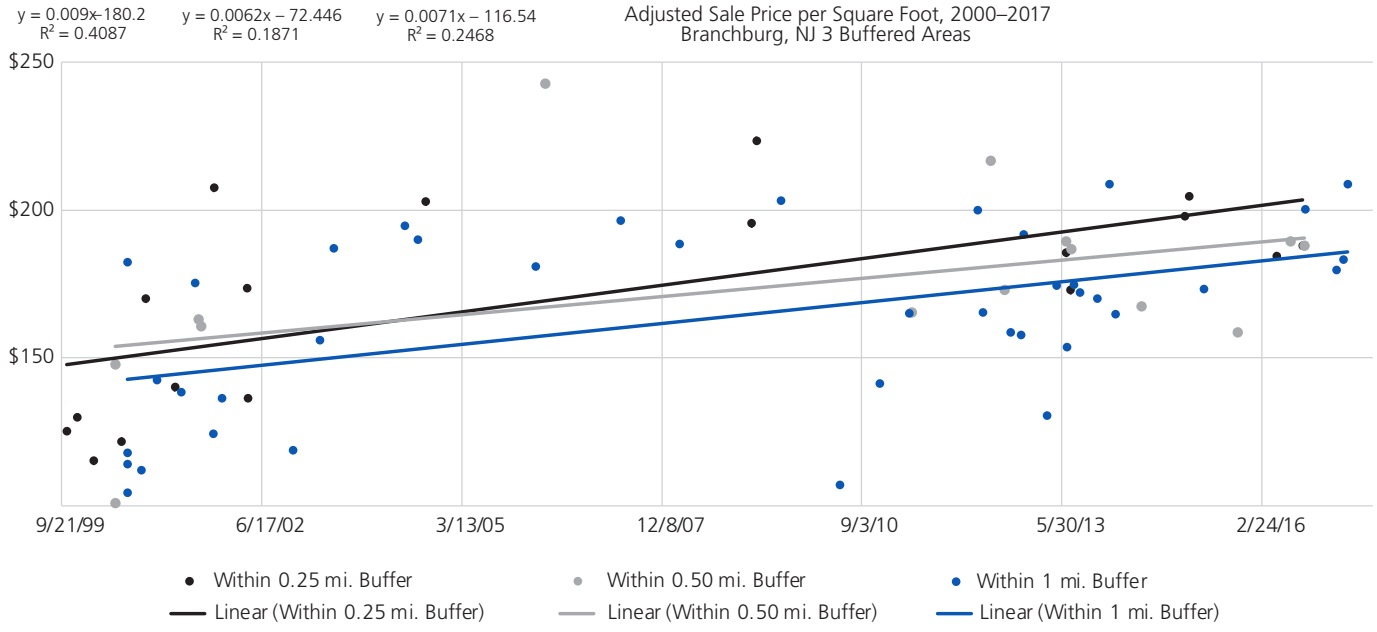


Exhibit 7 Straight-Line Trend, Outliers Removed

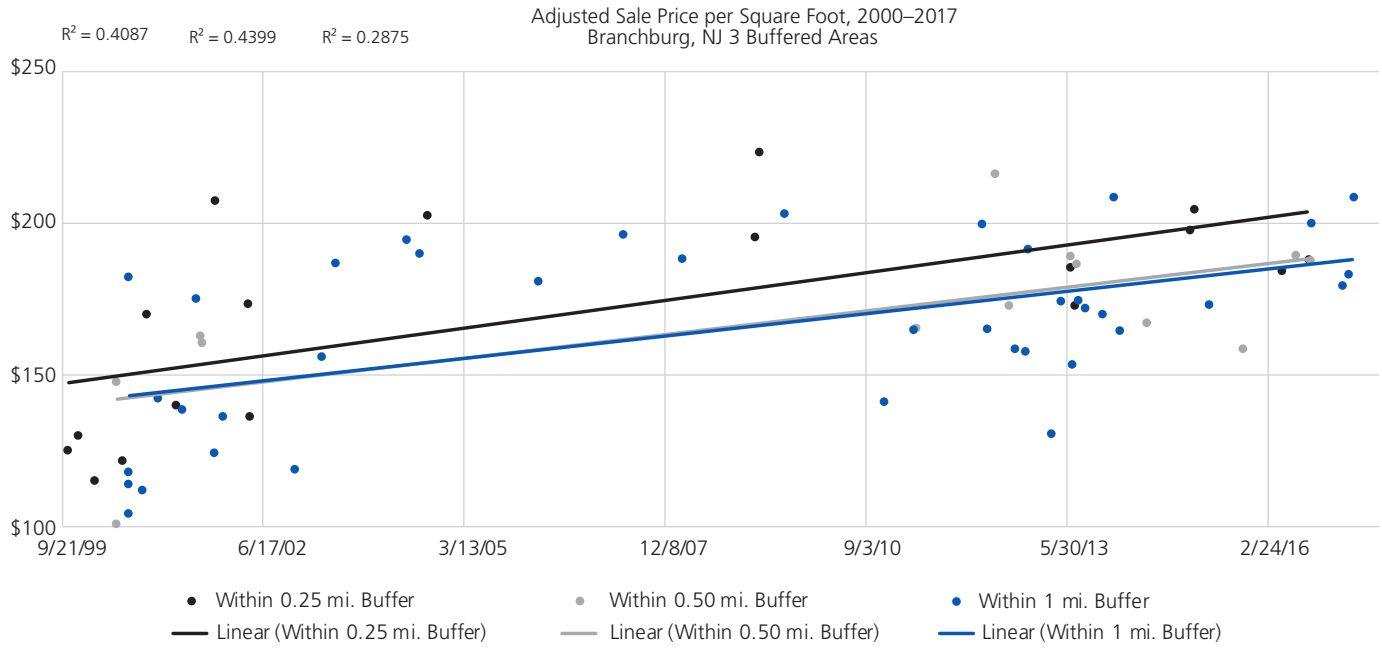
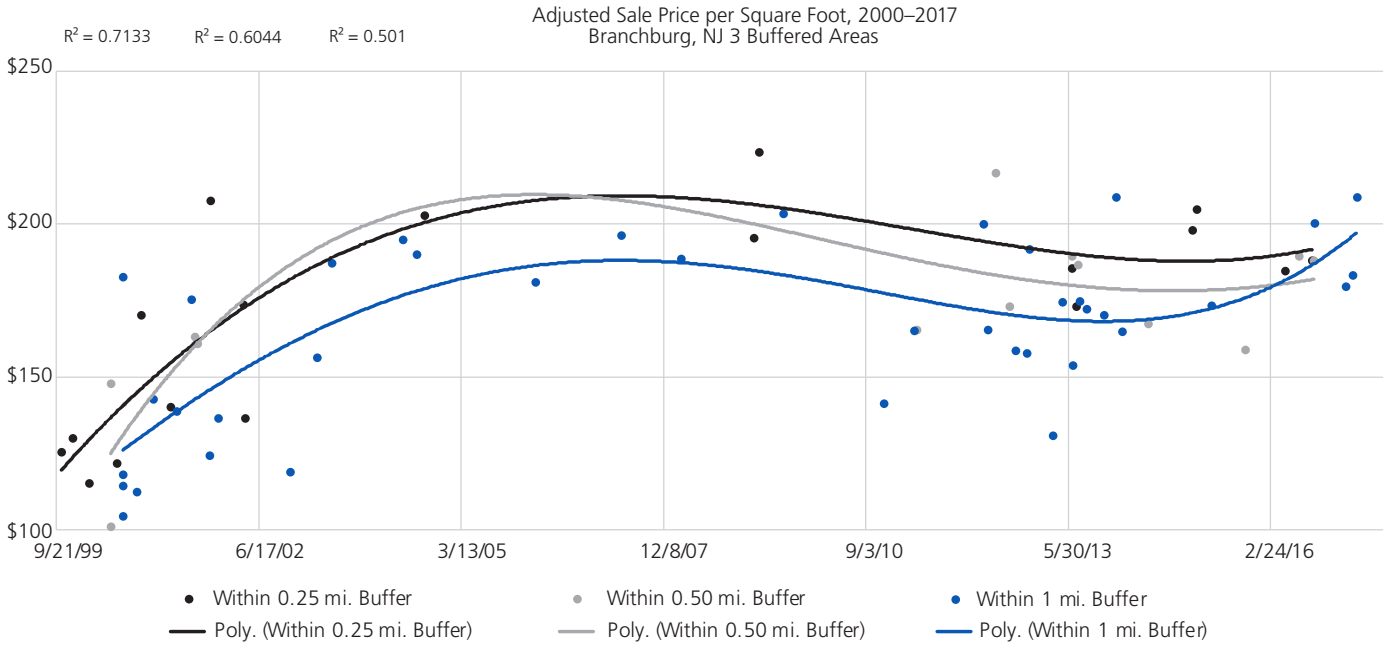


Exhibit 8 Polynomial Trend Line, Outliers Removed



The R^2 (or *R*-squared) value[22] for the 0.5-mile and 1.0-mile polynomial trend lines are 0.6044 and 0.501 respectively. The *R*-squared value for the 0.25-mile trend line is significantly higher at 0.7133. The *R*-squared value is an indicator of the degree to which there is a relationship between the variables that the trend line is attempting to show.[23] A value of 1.0 would indicate a perfect correlation between the variables; a value of 0.00 would indicate there is no correlation. All three of those *R*-squared values are relatively low compared to the *R*-squared value that might emerge in a regression model with more variables, such as one that might be constructed to predict prices or values.[24] However, all three of those *R*-squared values are higher than in the straight-line scatter plot, indicating that a polynomial model better reflects the changes in the marketplace over time and is superior to straight-line trend lines for the purpose of comparing price trends before and after the fire and explosion incident.

Results of the Trend Line Analysis and Conclusion from the Compressor Station 505 Incident Case Study

Despite the less-than-optimal *R*-squared values, the scatter plot and polynomial linear regression model indicate that proximity to Transco Compressor Station 505 was not adversely impacting home prices. The housing market within a quarter mile of the compressor consistently outperformed the 1.0-mile market and in all but a few years in the early 2000s outperformed the 0.5-mile market as well.

If the reported May 2013 accident had an adverse impact on home prices, prices for homes

22. The R^2 value is also sometimes referred to as the *R*-squared value, the r^2 indication, or the coefficient of determination (COD). The Appraisal Institute defines it as follows: "a mathematical representation of the proportion of the variation in *y* [the dependent variable] accounted for by the multiple linear regression equation." Appraisal Institute, *Quantitative Analysis* (Version PC502GDCH-D) (2012), Part 10-286.

23. Other factors, such as lot size, date of construction, condition, etc., would also be affecting the prices paid and account for another significant portion of the variation between prices.

24. *The Appraisal of Real Estate*, fifteenth edition, contains an example of a multiple linear regression model with four independent variables; the example has an *R*-squared value of 0.830. See "Regression Analysis and Statistical Applications," Appendix B, 8, bit.ly/3wxsZll.

closest to the compressor within a quarter mile would be expected to drop by comparison to those located between a quarter and a half mile from the compressor. However, that did not happen—the pre-May 2013 relationship between the 0.25-mile and 0.5-mile trend lines stayed constant in the post-May 2013 period.

However, as shown in the Exhibit 8 trend line comparisons, prices for homes located between a half mile and a mile from the compressor station began to rise faster than prices for homes located closer to the compressor station in 2015. There were no new accidents or incidents at Transco Compressor Station 505 between May 2013 and 2015 that might explain this change in the pricing trend line relationship. The change in the relationship between the lines in late 2015 and early 2016 is likely due to the limited number of sales within a quarter mile (one sale) and in the 0.25- to 0.5-mile zone (two sales) compared to the 0.5- to 1.0-mile zone (four sales) after February 2016.

Case Study 2: Eagle Compressor Station, Chester, Pennsylvania, Incidents (2001 to 2015)

The Pipeline, the Compressor Location, and the Incidents

The Eagle Compressor Station is located on part of a pipeline system formed by the merger of TransCanada Corporation with the Columbia Pipeline Group Inc. in July 2016. The Columbia Pipeline Group portion of that combined system is shown in Exhibit 9. The Eagle Compressor Station has been in operation since at least the 1960s; it is located in Chester Springs, Pennsylvania, about forty miles west of Center City Philadelphia, as shown in Exhibit 10.

Over the years, as part of the Columbia Pipeline Group's Delaware Valley Energy Expansion Project to provide natural gas to the Mantua Creek Power Plant in Gloucester County, New Jersey, various changes and upgrades were made to the pipelines utilizing the Eagle Compressor Station. These changes included replacing the 10-inch diameter Line 1856 pipeline in Chester County running from Downingtown to the Eagle Compressor Station with a 20-inch diameter line; replacing the 14-inch diameter Line 1556 with a 24-inch line beginning at the Eagle Compressor Station and running west; and adding an additional 6,000-horsepower electric compressor unit as an addition to an existing compressor building at the facility.[25]

Exhibit 9 Columbia Pipeline Group Map

Source: Dennis Fandrich, "TransCanada Locked in Negotiations for Reported Purchase of Columbia Pipeline Group," *Pipeline Technology Journal*, March 14, 2016, https://bit.ly/3HOlL1z.

Exhibit 10 Eagle Compressor Station Location

25. 66 FR 239, pages 64242–64244, December 6, 2001.

The Pipeline Safety Trust report describes three Chester County pipeline incidents between 1986 and 2009.[26] The first was a reported "significant" incident in Lionville on March 30, 2001, described as "corrosion" to a "body of pipe" installed in 1965. This incident caused $104,733 in property damage but did not cause injuries. The second incident was another reported "significant" incident on September 10, 2003, described as "incorrect operation" to a piece of equipment installed in 1967; this incident caused one injury but no property damage. The third incident was a reported "insignificant" incident on July 12, 2009, described as "malfunction of control relief equipment" that caused no injuries but resulted in $115,050 in property damage.

The US Department of Transportation (USDOT) reported on an emergency shutdown of the Eagle Compressor Station in August 2015 due to a fire. During the incident, material was released out of the blowdown stack. There were no injuries or fatalities as a result of this incident, and no reported evacuations. The Pipeline and Hazardous Materials Safety Administration (PHMSA) and USDOT investigated the incident, and USDOT issued a report.[27]

Media Coverage of the Incidents

There were three incidents between 2001 and 2009 at the Eagle Compressor Station; it is not clear whether these caused any local publicity. However, the August 2015 fire and compressor shutdown incident was reported in the *Daily Local News* as follows:

> An emergency shutdown system at the Columbia Gas facility in Chester Springs activated Tuesday morning, officials said. According to officials, the emergency shutdown system at Columbia Gas Transmission Eagle Compressor Station in Chester Springs activated, releasing gas into the atmosphere. [A] statement released by Columbia Pipeline Group … stressed this was not a gas leak, adding that the emergency shutdown system is designed to release the gas in the station when activated. No injuries were reported, and there was no evacuation. …Nearby residents smelled mercaptan, a colorless, flammable, invisible gas that smells like rotten cabbage. Mercaptan is often added to pipelines to make gas leaks more noticeable.[28]

Case Study Home Price Sales Data Research

To understand the potential impact of the Eagle Compressor Station on prices for nearby properties, sales data involving single-family homes in the immediate surrounding area were collected and analyzed. The Exhibit 11 map shows single-family detached home sales[29] between 2002 and 2017 in the Byers Station and the Reserve at Eagle Village subdivisions to the south and southwest of the Eagle Compressor Station and in the Windsor Ridge subdivision to the west across Fellowship Road.[30] All of the sales shown on the map are within approximately one mile of the Eagle Compressor Station and are denoted by distance from the facility.

A scatter plot trend line analysis was undertaken to compare prices paid per square foot for homes within the various concentric rings between 1,000 feet and slightly more than one mile from the compressor station. As in Case Study 1, the straight-line regression for each data set was modeled to identify the standard deviation and potential outliers. That scatter plot is shown in Exhibit 12.

As in Case Study 1, outliers were then excluded and the polynomial linear regression for each data set modeled and compared graphically as shown in the Exhibit 13 scatter plot diagram.

If proximity to the Eagle Compressor Station was always adversely impacting home prices, the sale price trend line for homes located closest to the facility would be expected to be consistently below the trend lines for homes located at greater distances. Instead, as shown in Exhibit 13, the trend line for homes located closest to the compressor station was higher between 2005 and 2008, lower between 2008 or 2009 and 2014, and then trended higher again from 2014 into 2017.

26. Incident data available at pstrust.org/docs/gt1986to2009.xls.

27. For details on the incident, see Report of the US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Failure Investigation Report, January 14, 2016, Columbia Gas Transmission Eagle Compressor Station Engine Fire, https://bit.ly/3B2J0kN.

28. Adam Farence, "Gas Released into Atmosphere by Emergency System," Daily Local News, August 26, 2015, https://bit.ly/3LEW04S.

29. The outer two rings in both Byers Station and Windsor Ridge contain attached townhouses as well, and those have been excluded from the analysis to ensure an apples-to-apples comparison of prices paid in the four concentric rings.

30. These subdivisions were selected for their similarity in lot size, home sizes, and dates of construction.

Exhibit 11 Home Sales near Eagle Compressor Station, 2002–2017

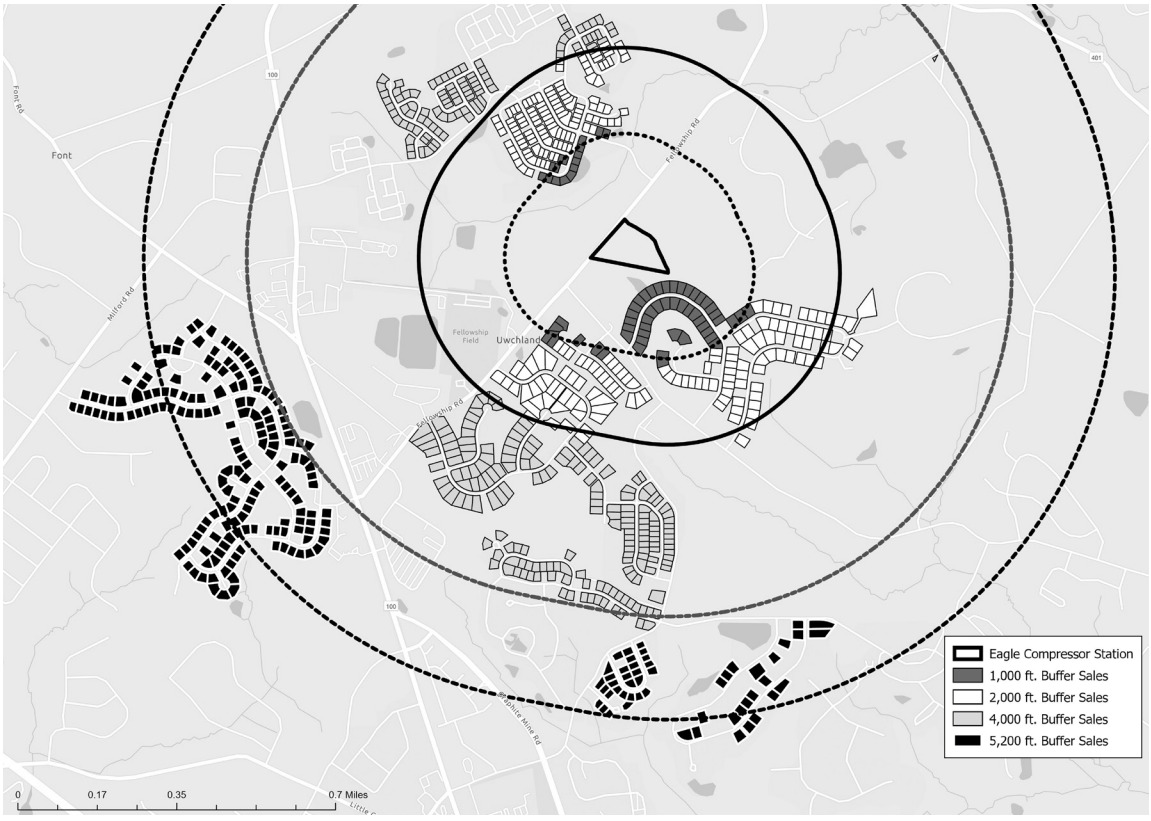


Exhibit 12 Sale Price per Square Foot Scatter Plot Trend Line Analysis

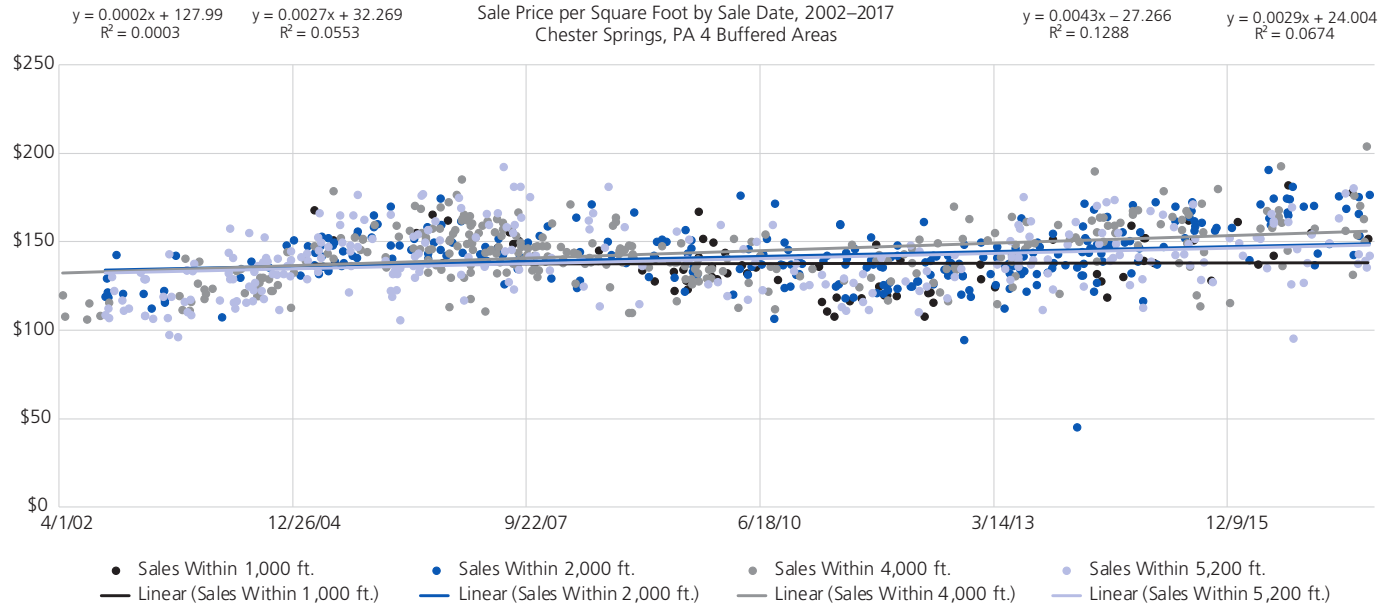
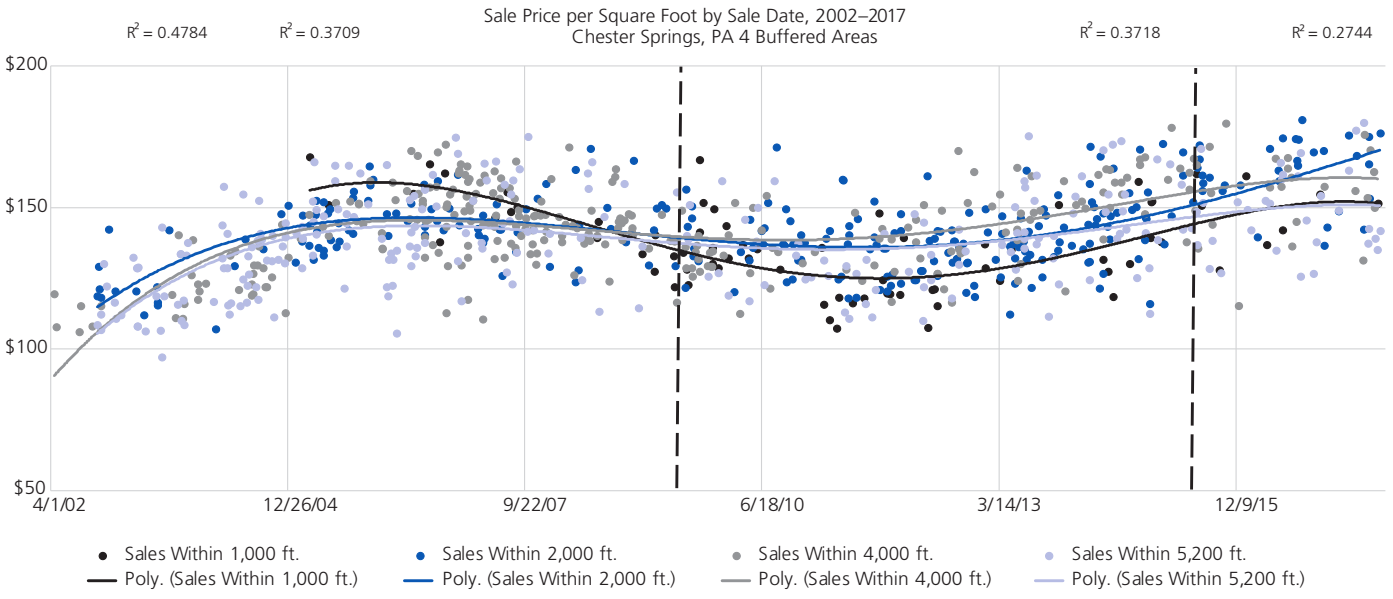


Exhibit 13 Sale Price per Square Foot, Outliers Excluded, Polynomial Linear Regression



The compressor station has been in operation since at least the 1960s. The Pipeline Safety Trust and USDOT information report no significant operational changes at the facility that might account for the steeper decline in relative sale prices for homes within 1,000 feet compared to homes at greater distances that began in 2006 and lasted till about 2011. Although there was an incident at the compressor station in July 2009 (shown with a vertical dashed line in Exhibit 13), the decline in home prices within 1,000 feet began before that date. That decline also started at least two to three years before the September 2003 incident at the facility that caused no property damage. Also, starting in 2012 or early 2013, homes located closest to the compressor at distances of less than 1,000 feet and less than 2,000 feet began increasing in value at a rate that exceeded the rate of increase for homes located at distances of 4,000 feet and a mile or more from the facility.

If the more serious August 2015 incident at the facility (that date is also shown with a vertical dashed line in Exhibit 13) was affecting home prices, it would be expected that homes located within 1,000 feet and within 2,000 feet would show a change in their pricing relationship to homes at greater distances. That did not happen. The homes closest to the Eagle Compressor Station continued to appreciate in price at a rate that exceeded that of homes farther away.

Note, however, that the *R*-squared values as shown in Exhibit 13 are relatively low and are the lowest for the distance grouping for 5,200 feet. That suggests there are other variables affecting the prices that are not explained by the simple polynomial trend lines using sale price per square foot and date of sale as the two variables. On-site physical inspection of the neighborhood indicated that in the Byers Station development, variations in model type, dates of construction, views and topography, as well as variations in lot size also were likely factors affecting sale prices. If a residential appraiser experienced in this marketplace was appraising a particular home in the Byers Station development as of a particular valuation date, adjustments to the sale prices could be made to account for those other differences and then the adjusted prices used in the scatter plot to more precisely focus on the potential effect of proximity to the compressor station.

In the Windsor Ridge subdivision located across Fellowship Road, there are fewer variations in home size, lot size, views, topography, and dates of construction. As a result, a separate analysis was undertaken of the Windsor Ridge development comparing prices paid inside and outside the

Exhibit 14 Windsor Ridge Sales by Distance from Eagle Compressor Station, 2,000 feet

2,000 feet distance from the compressor station.[31] The Exhibit 14 map shows those sales.

Once again, the standard deviation and outliers were identified and removed through a straight-line regression model and a polynomial regression line model plotted as shown in Exhibit 15.

The scatter plot trend line analysis for Windsor Ridge indicates that there was no effect on home prices from proximity to the Eagle Compressor Station during the years of analysis in one subdivision located across a busy road from the compressor station. The polynomial regression lines track each other well. There is also no indication that either the insignificant incident in July 2009 or the more serious August 2015 incident (both dates shown in vertical dashed lines on the scatter plot in Exhibit 15) had any measurable effects on home prices. In fact, if anything, home prices within 2,000 feet appear to have slightly outperformed prices in the portion of Windsor Ridge located at a distance greater than 2,000 feet from the compressor station.

Average prices per square foot each year in Windsor Ridge were also analyzed, comparing the average price paid per square foot within 1,500 feet of the Eagle Compressor Station to the average sale price per square foot for homes located at a distance greater than 1,500 feet. Again, the home price trend lines track closely to each other; as shown in the Exhibit 16 graph, there appears to be no measurable correlation between the average price differential and proximity to the compressor station in response to either the July 2009 or the August 2015 incidents.

Eagle Compressor Station Case Study Trend Line Analysis Results and Conclusion

The trend line and sale price analysis indicate no reasonably probable evidence of an impact of the compressor station generally or the incidents at

31. The number of homes within 1,000 feet at Windsor Ridge is limited. Therefore, the number of sales each year is small and insufficient to provide much statistical support to an analysis of impact from less than 1,000 feet distance from the Eagle Compressor Station for homes at Windsor Ridge only.

Exhibit 15 Windsor Ridge Sales by Distance from Eagle Compressor Station, Outliers Excluded, 2,000 feet

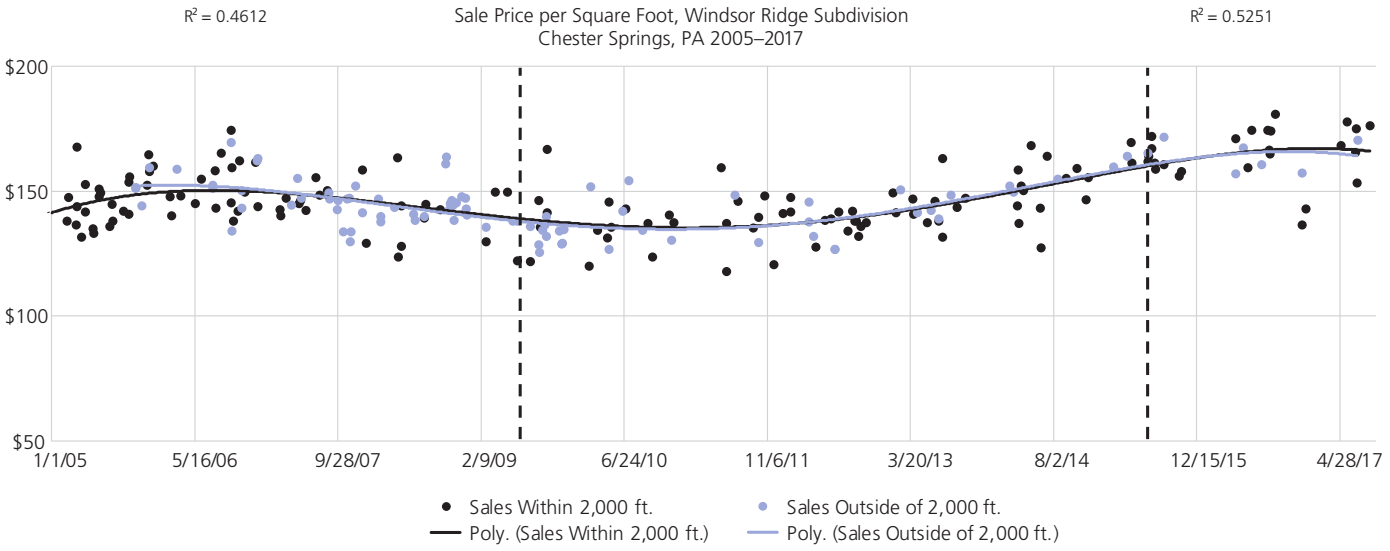
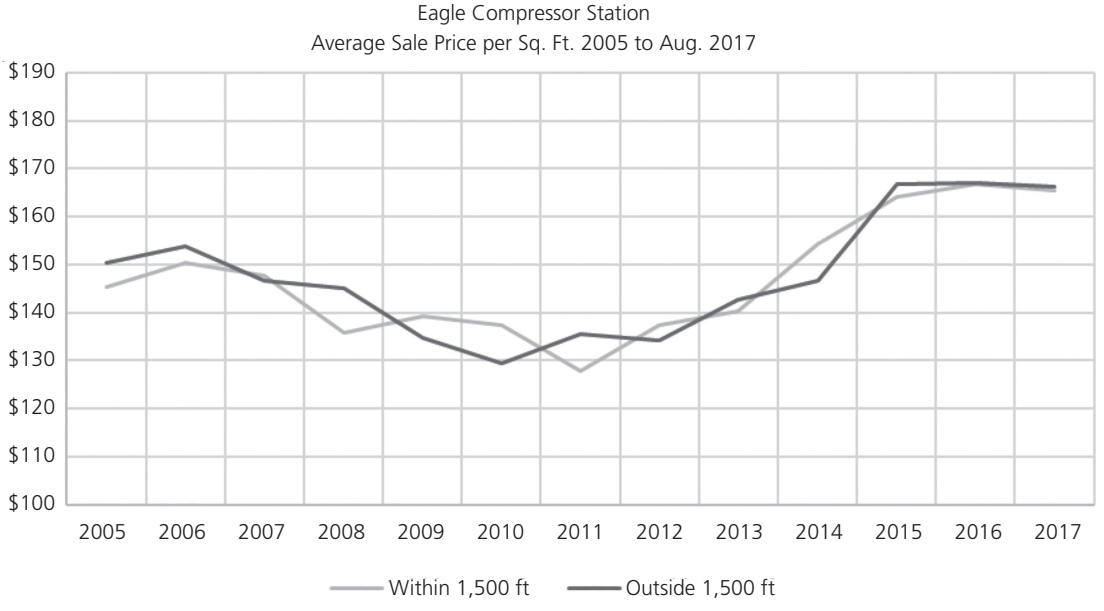


Exhibit 16 Windsor Ridge Average Sale Price per Square Foot, 1,500 Feet



the compressor station on adjacent or nearby home prices. While there is some evidence of a decline in price for homes located closest to the compressor station at the time of the 2009 incident, the trend line in Exhibit 13 shows that the decline began earlier than the date of the incident, then prices recovered, and were not affected later by the more serious 2015 event. It is likely that in the Byers Station development located closest to the pipeline, variations in home model type, dates of construction, views, and topography as well as variations in lot size were factors affecting prices as evidenced by the trend line and sale price analysis at the Windsor Ridge development where there are fewer variations in home size, lot size, views, topography, and dates of construction.

Case Study 3: Downingtown Compressor Station, West Bradford Township, Pennsylvania (2001 to 2015)

The Pipeline and the Compressor Location

Like the Eagle Compressor Station, the Downingtown Compressor Station is located west of Philadelphia and is operated by TransCanada Corporation (formerly Columbia Gas Pipeline Group). West Bradford Township, in which Downingtown is located, is about five miles southwest of Chester Springs where the Eagle Compressor Station is located.

The Downingtown Compressor Station reportedly was constructed in 1960 and is part of the Columbia Midstream natural gas network. According to the Federal Energy Regulatory Commission (FERC), the facility was modified by the addition of two motor-driven compressor units installed in April 2004 and modified in 2015.

Exhibit 17 shows the location of the compressor station in relation to the adjacent Highlands neighborhood. Homes in the Highlands are between approximately 400 feet and 2,150 feet from the compressor station. The homes range in size from 1,700 to 4,400 square feet on lots varying in size from 0.35 to 0.65 acres. The oldest homes in the Highlands neighborhood date to 1987, more than twenty-five years after the reported construction of the compressor station.

Unlike the Transco Compressor Station 505 and the Eagle Compressor Station, there were no reported compressor station incidents during the period of this case study analysis.

Exhibit 17 Highlands Neighborhood Proximity to Downingtown Compressor Station

Exhibit 18 Highlands Home Sales by Distance from Downingtown Compressor

Case Study Home Sale Price Data Research

Highlands home sale prices between 1989 and 2017 were collected and analyzed. Exhibit 18 shows the location of the sales differentiated between those inside or outside a distance of 1,000 feet from the compressor station. There is an electrical transmission line running through the neighborhood, and in order to exclude some of the potential impact on prices from proximity to the power line, sales of homes that abut the power line were excluded from the analysis. Average sale price paid per square foot of above-grade finished space each year between 1989 and 2017 for homes within and outside a distance of 1,000 feet from the facility is shown in Exhibit 19.

To investigate whether differences in house size contributed to the differential in nominal prices, sales were also analyzed on a price paid per square foot basis. Exhibit 19 shows the average price per square foot (above-grade finished space) for the proximate sales and the control set sales.

In seven of the nine years in which a comparison can be made, homes located closest to the compressor station sold at a lower price per square foot. On average, the homes located within 1,000 feet of the compressor station sold for prices that were approximately −3.2% lower than homes in the Highlands located farther from the facility. The median price differential was −6.5% lower. The consistency of lower proximate sale prices per square foot indicates that proximity to the compressor station creates a small negative impact on residential property values.

However, there were differences between the sold homes as to age, total square footage, number of baths, number of garage spaces, and presence of a finished basement. Adjustments were made for those differences in physical characteristics,[32] and the adjusted price comparisons are shown in Exhibit 20.

32. Age adjustments were as follows: 0 to 5 years (no adjustment); 6 to 10 years (+5.0%); 11 to 20 years (+10%); and 20 to 30 years (+15%). The garage adjustment was $10,000 per space and the full bath adjustment was $10,000. Homes with finished basements were adjusted downward by $10,000 when comparing them to homes without a finished basement.

Exhibit 19 Average Resale Price per Square Foot: Unadjusted for Differences in Physical Characteristics

	Proximate (<1,000 ft.) ($)	Control (>1,000 ft.) ($)	Difference (%)
1989		102.26	
1990		92.23	
1991		102.85	
1992	78.66	88.71	–11.33
1993	81.62	85.34	–4.36
1994	87.12	66.54	+30.93
1995	85.21	95.45	–10.73
1996	96.90		
1997	85.47	88.85	–3.80
1998		83.99	
1999	98.88	98.77	+0.12
2000		95.85	
2001		112.29	
2002	122.50	137.27	–10.76
2003		167.75	
2004	157.77*		
2005		174.36	
2006	182.30	195.02	–6.52
2007	161.13	183.62	–12.25
2 008			
2009	196.37		
2010	171.92		
2011			
2012		102.34	
2013			
2014	167.67		
2015		171.88	
2016		202.67	
2017			
Average			–3.19
Median			–6.52

*In 2004, there was only one sale, so that year does not indicate an average price.

Exhibit 20 Average Resale Price per Square Foot: Adjusted for Differences in Physical Characteristics

	Proximate (<1,000 ft.) ($)	Control (>1,000 ft.) ($)	Difference (%)
1989		96.61	
1990		87.05	
1991		102.85	
1992	78.66	88.71	–11.33
1993	82.88	88.54	–6.39
1994	91.48	76.86	+15.98
1995	85.21	102.79	–17.10
1996	96.90		
1997	87.56	93.29	–6.14
1998		93.30	
1999	103.83	105.38	–1.47
2000		105.43	
2001		120.92	
2002	131.49	151.00	–12.92
2003		184.53	
2004	160.80		
2005		191.79	
2006	200.53	214.52	–6.52
2007	177.24	196.33	–9.72
2008			
2009	225.83		
2010	189.11		
2011			
2012		129.96	
2013			
2014	192.82		
2015		200.91	
2016		230.49	
2017			
Average			–6.17
Median			–6.52

Exhibit 21 Average Distance of Resales to Downingtown in Feet

	Proximate	Control Set	Indicated Price Differential (%)
1989		1,515	
1990		1,267	
1991		1,143	
1992	802	1,340	–11.33
1993	755	1,470	–6.39
1994	792	1,331	+15.98
1995	596	1,380	–17.10
1996	842		
1997	725	1,668	–6.14
1998		1,339	
1999	827	1,594	–1.47
2000		2,140	
2001		1,367	
2002	539	1,234	–12.92
2003		1,618	
2004	428		
2005		1,143	
2006	727	1,415	–6.52
2007	394	1,515	–9.72
2008			
2009	600		
2010	960		
2011			
2012		2,019	
2013			
2014	649		
2015		1,436	
2016		1,442	
2017			
Average	**688**	**1,469**	**–6.17**

In seven of the nine years in which a comparison can be made, the adjusted price per square foot for homes located closest to the compressor station was measurably lower than for those located farther away. In one year (1999), the price differential (−1.47%) was so close as to indicate no difference. The average and median differentials were −6.2% and −6.5%. Again, the consistency of lower adjusted sale prices per square foot for homes located within 1,000 feet of the compressor facility tends to indicate that there is a correlation between proximity to the compressor station and an impact on value of less than −10%.

The proximate sales were substantially closer to the Downingtown facility than the control set. The average distance from the Downingtown facility for proximate resales was approximately 690 feet while the control set distance averaged approximately 1,470 feet as shown in Exhibit 21.

To better understand the relationship, if any, between distance from the Downingtown Compressor Station and prices, a "best fit" linear regression model was also run (Exhibit 22). This shows the relationship between each "proximate" impact percentage and the average price per square foot for the control sales in the same year. The graph in Exhibit 22 indicates that as distance from the Downingtown facility increases, the effect of proximity on price decreases.

When the three outliers are removed according to the criteria discussed earlier, the relationship between impact on price and distance from the Downingtown Compressor Station can be seen, as presented in the models in Exhibit 23 (straight-line model) and Exhibit 24 (polynomial model).

The removal of the three outliers significantly improves the *R*-squared values of the model, but even so the *R*-squared values are relatively low at 0.3423 and 0.3895. The polynomial trend line analysis has a slightly higher *R*-squared and is therefore the best-fit regression line given the data points.

The trend line regression model explains less than 40% of the variation in price impact, implying that there is either some better equation to explain the data or that the relationship between distance and impact is not that strong. There are likely additional factors other than distance to the Downingtown Compressor Station that determine the remaining 60% of the single-family home price variation not explained by the adjustments included in the model. The relatively low *R*-squared values are probably

Exhibit 22 Downingtown Linear Regression: Distance vs. Percentage Impact, Straight Line

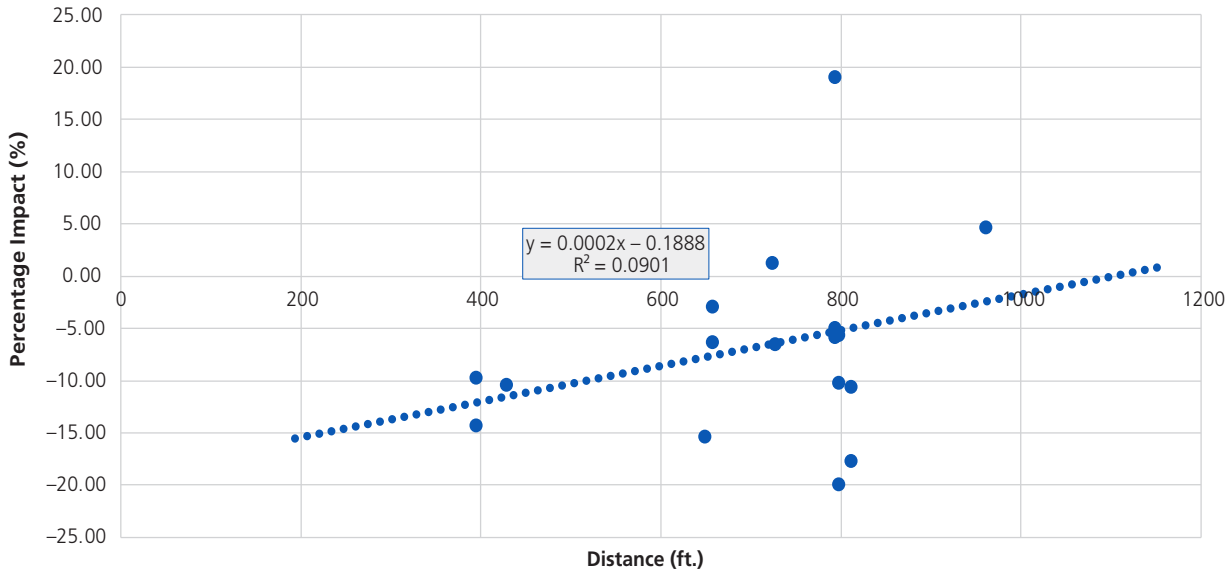


Exhibit 23 Downingtown Linear Regression: Distance vs. Percentage Impact, Outliers Removed

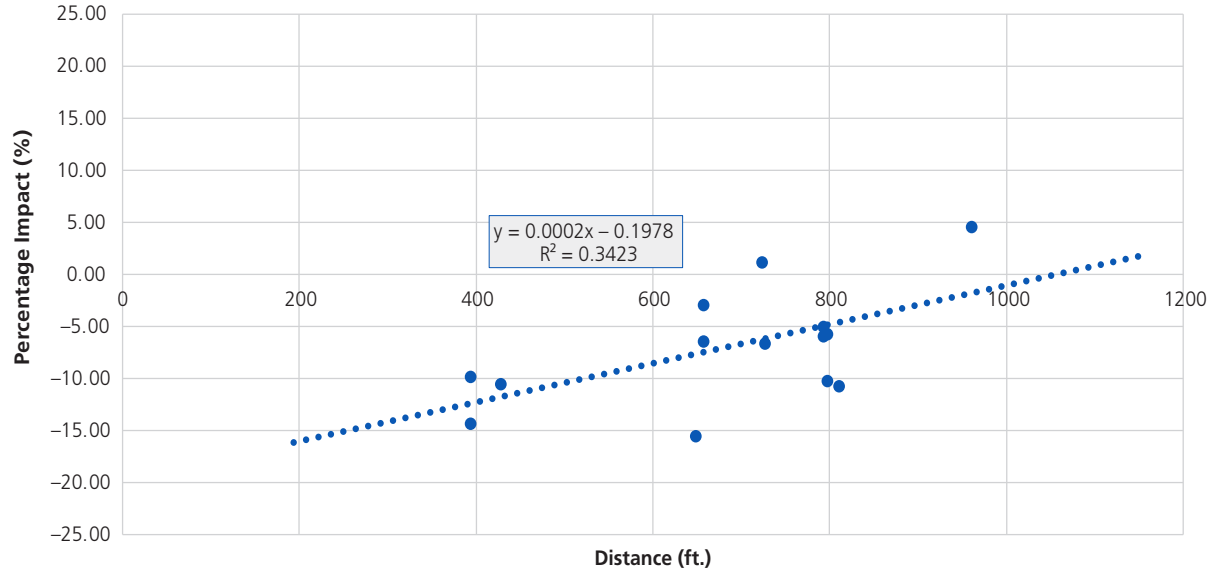
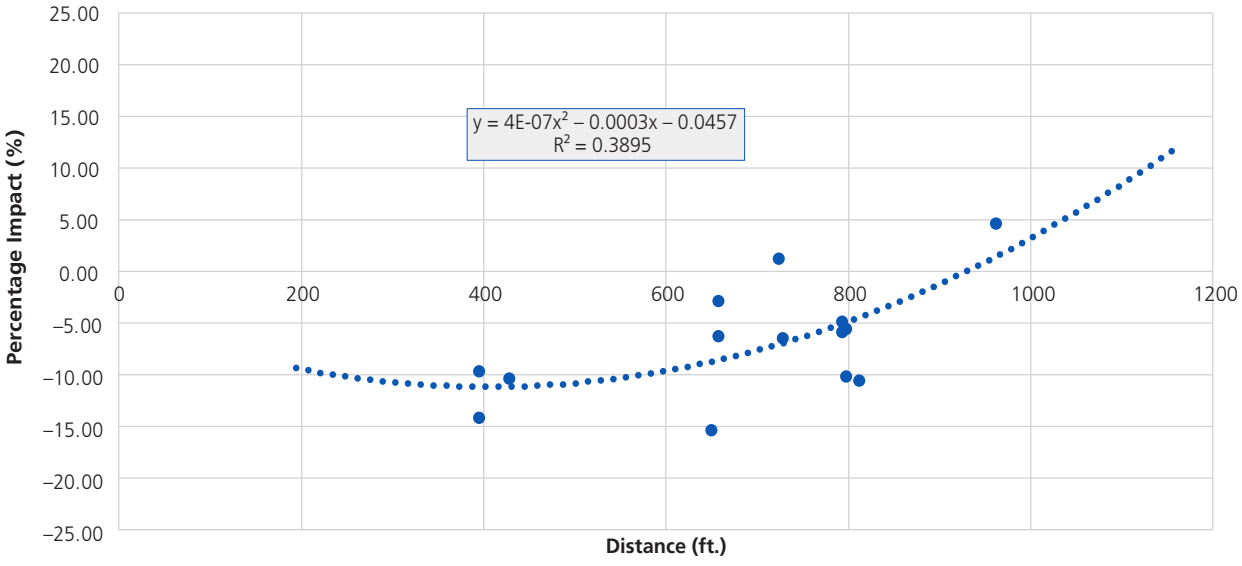


Exhibit 24 Downingtown Polynomial Linear Regression: Distance vs. Percentage Impact, Outliers Removed



also a function of the limited number of data points in the regression.

Nonetheless, the trend line describes a negative impact on property values within approximately 800 feet of the compressor station and no impact at a distance in excess of 800 feet. There is one data point indicating a potential adverse impact of about −15% at a distance under 400 feet. When the cluster of data points between 600 feet and 800 feet is considered, the average impact at that distance is about −6.75%.

The trend line indicates the predicted value impacts from the compressor station beginning 200 feet from the station as shown in Exhibit 25. It indicates no statistically measurable negative impacts on value for average distances of 950± feet from the Downingtown Compressor Station.

The marketing times (days on market) for homes within 1,000 feet were compared to the marketing times for homes located at a distance greater than 1,000 feet. If proximity to the Downingtown Compressor Station was adversely impacting the marketplace, it would be expected that homes in closer proximity to the compressor station take longer to sell. However, as indicated in Exhibit 26, homes located within 1,000 feet of the compressor station typically took less time to sell than those located farther away, an indication that proximity to the compressor station did not increase marketing time. Note that in some years there is no data or the data set is limited, so the significance of the marketing time comparison in Exhibit 26 is limited. Despite this, there is a general pattern to the comparison indicating that marketing times for homes within 1,000 feet are typically less than for homes farther away.

Exhibit 25 Trend Line Predicted Value Impacts by Distance from Downingtown

Distance (Feet)	Approximate Value Impact (%)
200	–10.0
400	–11.0
600	–10.0
800	–5.0
950	No Impact
1,000+ Feet	No Impact

Conclusion for West Bradford Township, Pennsylvania TransCanada/Columbia Midstream Pipeline Case Study

Comparisons of the average sale price per square foot indicate a price differential of between −6.0% and −6.5% for homes located within

Exhibit 26 Marketing Time (Days on Market)

	Proximate (<1,000 ft.)	Control (>1,000 ft.)
1992	14	78
1993	9	63
1994	18	23
1995	50	54
1996	36	—
1997	125	175
1998	—	126
1999	9	20
2000	—	10
2001	—	25
2002	10	44
2003	—	26
2004	7	—
2005	—	0
2006	—	35
2007	51	17
2008	—	—
2009	30	—
2010	11	—
2011	—	—
2012	—	91
2013	—	—
2014	53	—
2015	—	41
2016	—	9
2017	—	—
Average	32.5 Days	49.2 Days

1,000 feet of the compressor station on the pipeline. The trend line analysis indicates a differential in property values of between −5.0% and −10.0% within approximately 800 feet of the compressor station and no impact at a distance in excess of 800 feet. When the cluster of data points between 600 feet and 800 feet is considered, the average impact at that distance is about −6.75%. While that differential in prices could be due to proximity to the compressor station, it could also be due in whole or in part to the presence of the power line that runs through the neighborhood. Even though sales directly abutting the power line were excluded from the analysis, it is necessary to drive under the power lines to access the properties in closest proximity to the compressor station, which could be a factor affecting prices that buyers are willing to pay.

Case Study 4: Marietta Compressor Station 24A, Lancaster County, Pennsylvania, Incident (2012)

The Pipeline, the Compressor Location, and the Incident

Marietta Compressor Station 24A is located on the 9,096-mile Texas Eastern Transmission pipeline (Exhibit 27), connecting Texas and the Gulf Coast with electric generation facilities in the northeast.

Compressor Station 24A is located in southeastern Pennsylvania close to the Susquehanna River in western Lancaster County. The station is on 29.2± acres on the north side of River Road (PA 441), west of Maytown Roads (S. River Street) in East Donegal Township, Lancaster County, Pennsylvania, as shown on the map in Exhibit 28.

A 33-mile finger of pipeline extending south from Marietta to Transco Compressor Station 195 near Delta, Pennsylvania, began construction in

Exhibit 27 Texas Eastern Transmission Pipeline

Source: LinkSystem Informational Postings, https://infopost.enbridge.com/infopost/TEHome.asp?Pipe=TE

Exhibit 28 Location Marietta Compressor Station 24A

2010. As part of that project, the company also intended to replace existing compressors with more efficient units at its compressor stations. Ultimately, a 39-mile pipeline was constructed and in conjunction with the compression expansion began service on August 26, 2011.[33]

On April 13, 2012, there was a gas leak and explosion incident event at the Marietta Compressor Station.

Media Coverage of the Incident

That incident was reported in the local press, and the Pipeline and Hazardous Materials Safety Administration (PHMSA) followed up with an incident investigation and report. The incident was reported in "Lancaster Online" as involving no injuries and "the situation was declared under control within an hour."[34]

The PHMSA reported that "the station operator suffered injuries during the explosion and was taken to a local hospital for treatment...Damage to the station was confined to the air piping within the main compressor building. There was no release of gas and no fire resulting from this incident."[35]

Case Study Home Sale Price Data Research

To understand the effect of the compressor station and the incident on home prices, sale prices between 2000 and 2017 for homes located at various distances within one mile of the Texas Eastern Compressor Station in Marietta were collected and analyzed.[36] Exhibit 29 shows the locations of the sales.

The areas delineated in Exhibit 29 are respectively 500 feet, 1,000 feet, and 1,500 feet from the perimeter of the compressor facility site, and represent roughly one-tenth of a mile, two-tenths of a mile, and one-third of a mile distances.

All the residential units in this analysis were part of a single subdivision and were built in a similar time frame with units of similar design and construction. The single-family homes in the area located outside of the 1,500-foot perimeter were significantly different in character from the homes in the selected data set and therefore were excluded from the analysis.

A scatter plot trend line analysis of townhome prices paid per square foot at various distances from the compressor station was prepared. The scatter plot trend line analysis indicated that four outliers needed to be removed. Exhibits 30 and 31 show the corrected scatter plot and polynomial trend lines for the distance comparisons. Note that the average price per square foot for townhome sales within 500 feet of the compressor station is higher than for townhomes located at greater distances.

The R^2 (or *R*-squared) value for the polynomial trend lines for 500 feet, 1,000 feet, and greater than 1,000 feet are 0.7761, 0.6901, and 0.7587, respectively. All three of those *R*-squared values are higher than in the straight-line scatter plot, indicating that a polynomial model better reflects the changes in the marketplace over time.

The polynomial trend line model appears to show a potential temporary impact on prices about the same time as the April 2012 incident. Before 2010, the polynomial trend line for town-

33. "New Northeast Natural Gas Pipeline Capacity Comes Online," US Energy Information Administration, January 27, 2012, https://bit.ly/3WfVEXs.

34. David O'Connor, "Emergency Crews Respond to Gas Leak Near Marietta at the Texas Eastern Junction Building," Lancaster Online, April 13, 2012, updated September 12, 2013, https://bit.ly/3B7rrA0.

35. US DOT, "Failure Investigation Report—Texas Eastern Transmission (SPECTRA), Marietta Station Incident, Date of Failure April 13, 2012," report date October 29, 2012, https://bit.ly/3pjGAvm.

36. There were only home sales north of the compressor station. The area is otherwise developed with industrial properties.

Exhibit 29 Home Sales Proximate to Marietta Compressor Station 24A

Exhibit 30 Scatter Plot Trend Line, Townhouse Sale Price per Square Foot, Outliers Removed

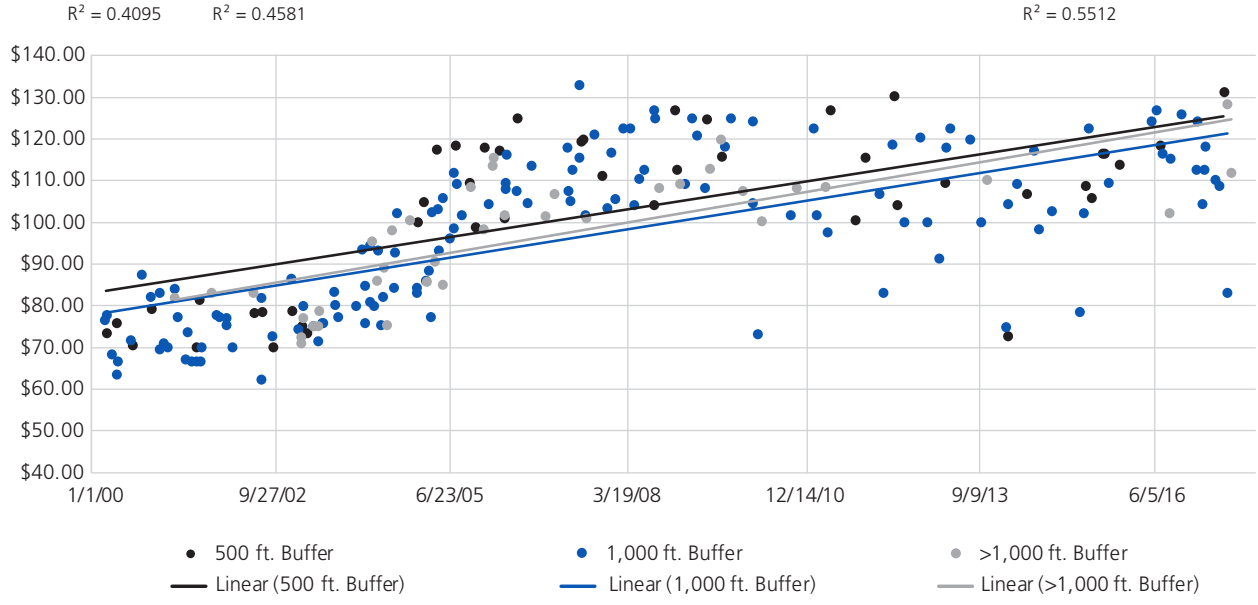
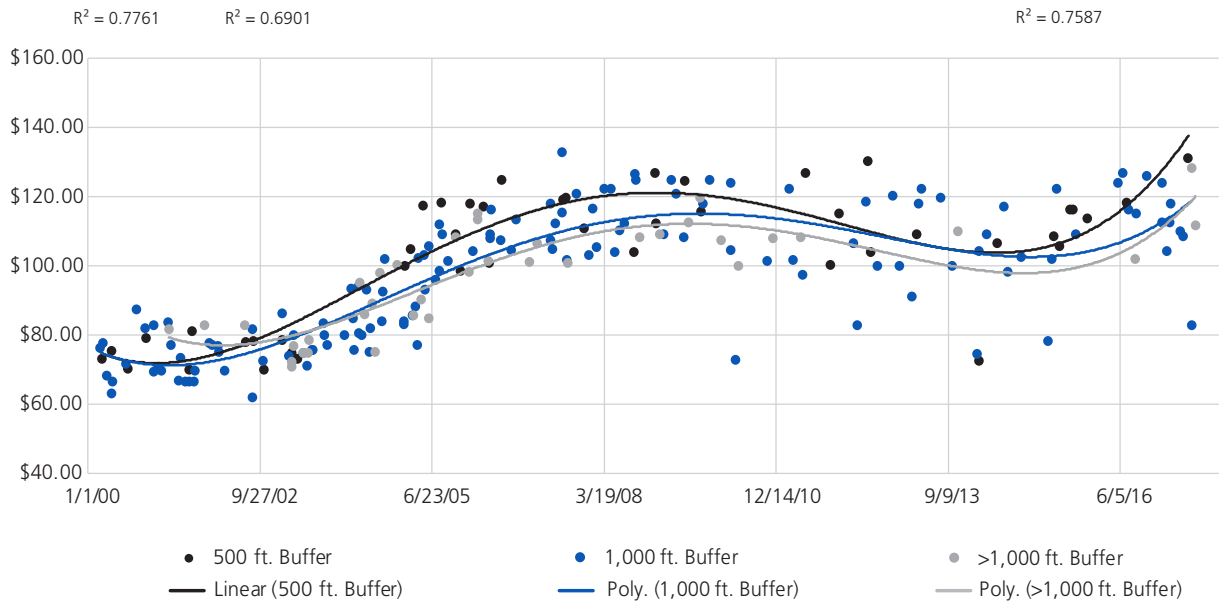


Exhibit 31 Polynomial Trend Lines, Townhouse Sale Price per Square Foot, Outliers Removed



home prices within 500 feet was significantly higher than for townhomes 500–1,000 feet, or those greater than 1,000 feet. In 2011 through 2013, however, the polynomial trend line for 500 feet dips to be essentially equal to the trend line for home prices between 500 and 1,000 feet from the compressor facility. After 2013, however, the relationship between the trend lines for 500 feet and for 500–1,000 feet return to the same essential relationship they had prior to 2011. Therefore, if there was an impact from the April 2012 incident on townhome prices, it was only temporary and ended by some point in 2014. If there was an impact between 2012 and 2014, it only affected prices paid for townhomes within 500 feet of the compressor station. The relationship between the trend line for 500 to 1,000 feet and the trend line for greater than 1,000 feet was essentially the same both before and after the April 2012 event.

The single-family detached home sales were also analyzed. The linear regression trend line and polynomial regression trend line after removing the two outliers are indicated in Exhibit 32 and Exhibit 33.

The R^2 (or *R*-squared) values for the polynomial trend lines for 500 feet, 1,000 feet, and greater than 1,000 feet are 0.7755, 0.6999, and 0.581, respectively. All three *R*-squared values are higher than in the straight-line scatter plot, indicating that a polynomial model better reflects the changes in the marketplace over time.

The polynomial trend line comparisons for single-family homes show that prior to late 2004 or early 2005, there was little variation in sale prices for single-family homes based on distance from the compressor station. If there was a premium for single-family homes located farther from the compressor station, it was quite small. By mid-2005, however, that relationship began to change. Between 2005 and the end of 2013, sale prices for single-family homes located within 500 feet were significantly lower than sale prices for homes located farther from the compressor station. Toward the end of 2013, however, that relationship began to change again, and by 2016, sale prices for single-family detached homes located within 500 feet were trending higher than the trend line for homes located farther away.

That data indicates that if there was an impact on single-family detached home prices due to proximity to the compressor station, it was temporary and began in 2005 and ended in 2013. Since the compressor station incident occurred in

Exhibit 32 Single-Family Sale Price per Square Foot, Outliers Removed, Linear Regression

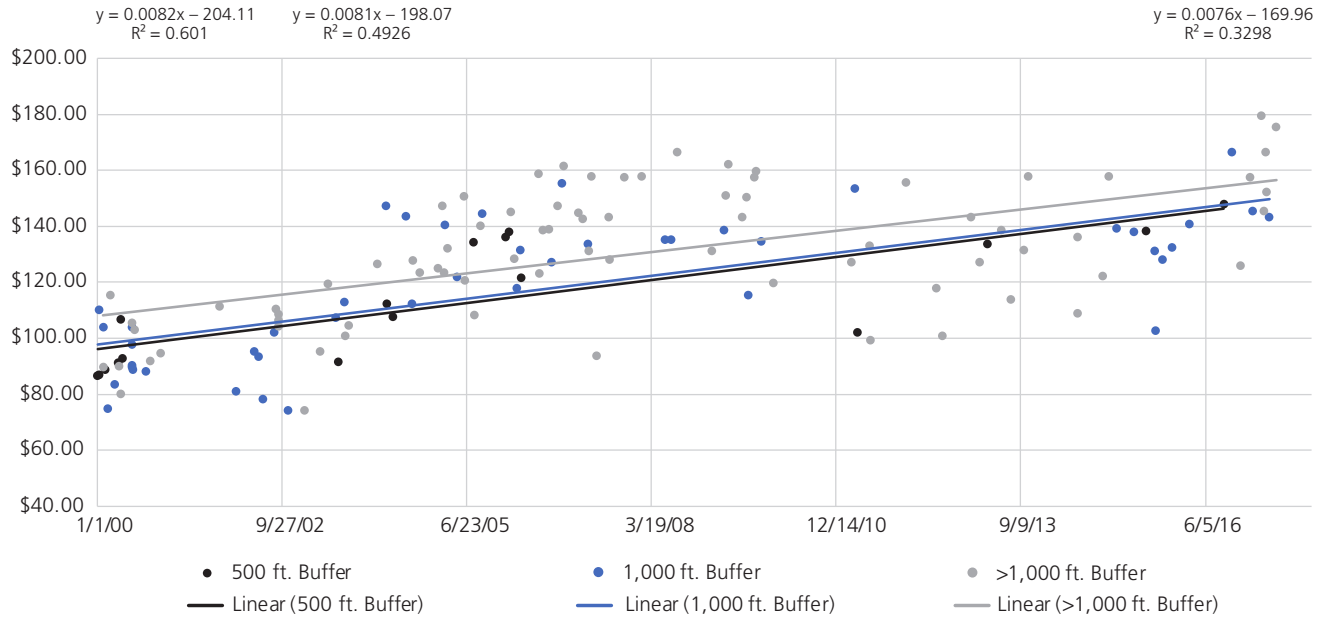
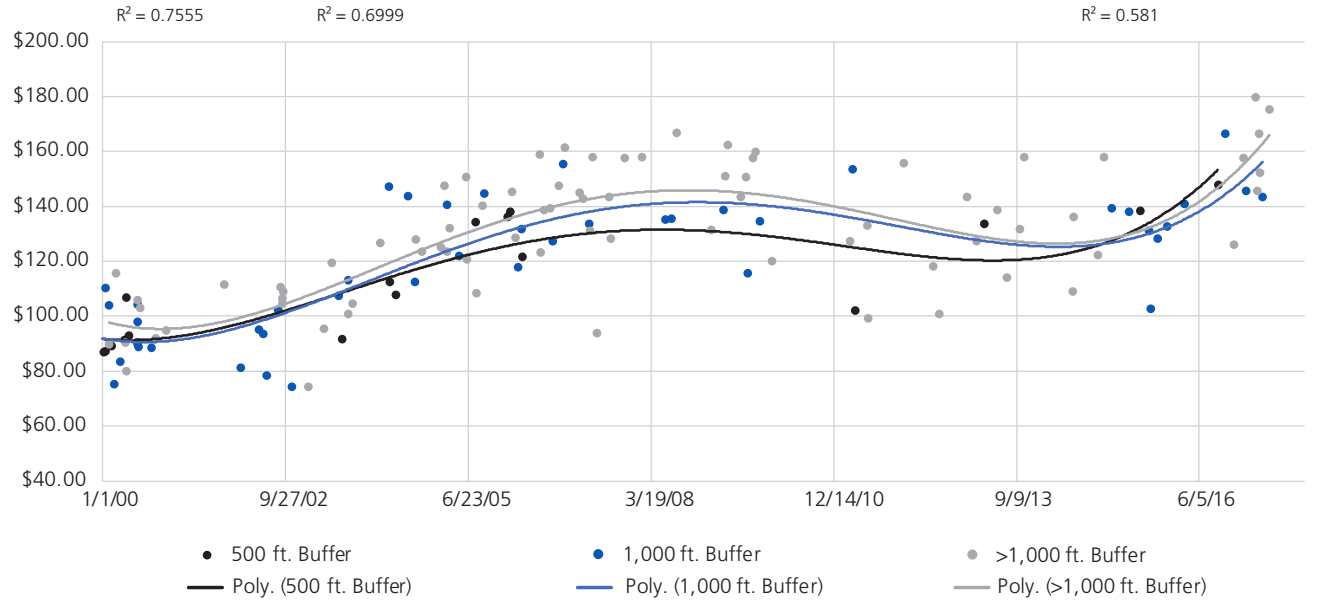


Exhibit 33 Single-Family Sale Price per Square Foot, Outliers Removed, Polynomial Regression



April 2012, it could not have been the reason for the diverging trend lines that began in 2005.

Additional analysis of the single-family detached home price data is necessary, however. Unlike the townhouse units, whose average size variation is nominal and has no impact on variations on sale price per square foot, single-family detached homes can vary in size to the extent that it has a measurable effect on the sale price per square foot. Exhibits 34 and 35 show average annual sale prices per square foot (as opposed to individual unit prices). Exhibit 34 shows average unadjusted prices and Exhibit 35 shows average annual sale prices per square foot adjusted for variations in unit size.

Exhibit 34 indicates that the average sale price per square foot for units at a distance greater than 1,000 feet were higher until 2009. After that date, the sale prices per square foot were higher for units in closer proximity to the compressor station. After adjusting for variations in unit size as shown in Exhibit 35, the relationship between the average annual price trend lines changes significantly and the divergence between prices begins as early as 2006.

After adjusting for unit size variations, the average annual sale price per square foot within 1,000 feet of the compressor station is typically higher than the average annual price per square foot for single-family detached homes located at a distance greater than 1,000 feet from the compressor station. And the premium paid per square foot has been increasing.

The average annual townhome price trend is similar to the trend in single-family detached home prices. Exhibit 36 shows that between 2001 and 2005 the relationship between townhouse unit prices was relatively consistent between the three trend lines based on distance from the compressor station. Beginning in 2005, the average annual price per square foot trend line for townhome units closest to the compressor station began to increase at a rate that exceeded the rate of increase in the slope of the trend lines for 1,000 feet and 1,500 feet.

Average annual townhome prices immediately before and after the April 12, 2012, event were also compared. As the data points in Exhibit 36 indicate, the average annual price for townhomes within 500 feet of the compressor station

Exhibit 34 Single-Family Sales Annual Average Sale Price per Square Foot

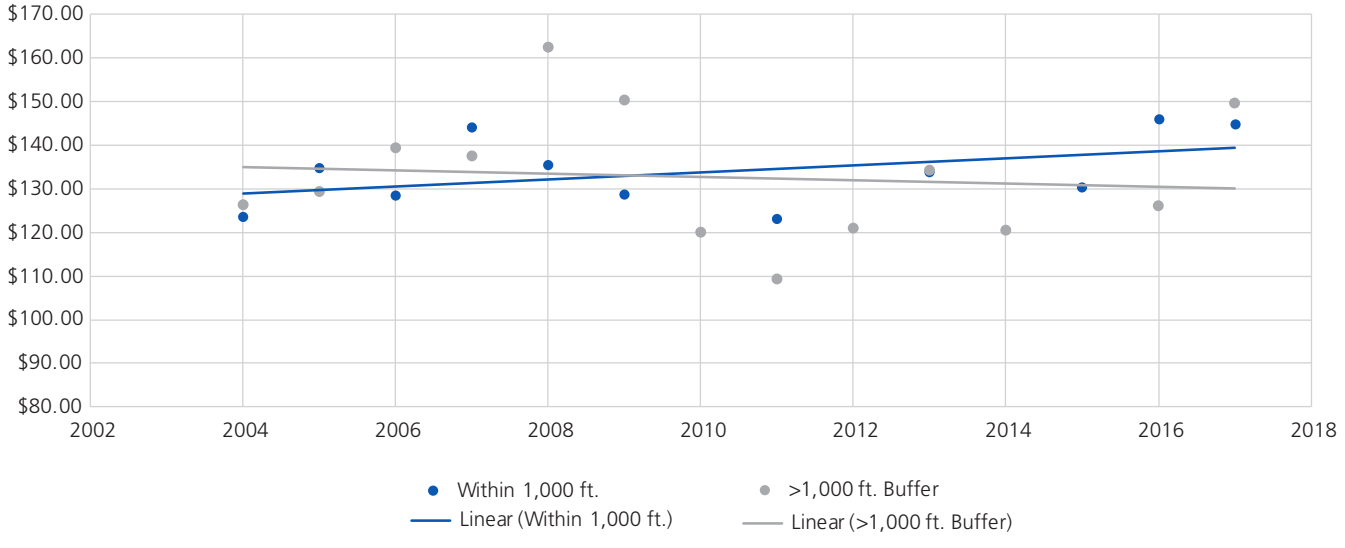


Exhibit 35 Single-Family Sales Annual Average Size-Adjusted Sale Price per Square Foot

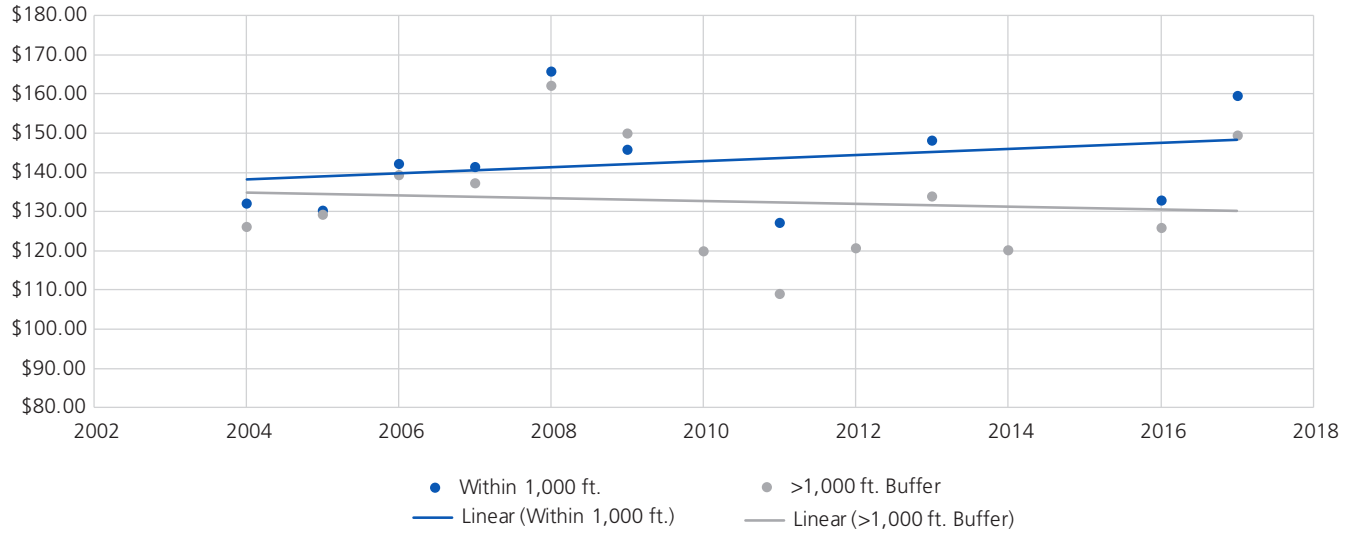
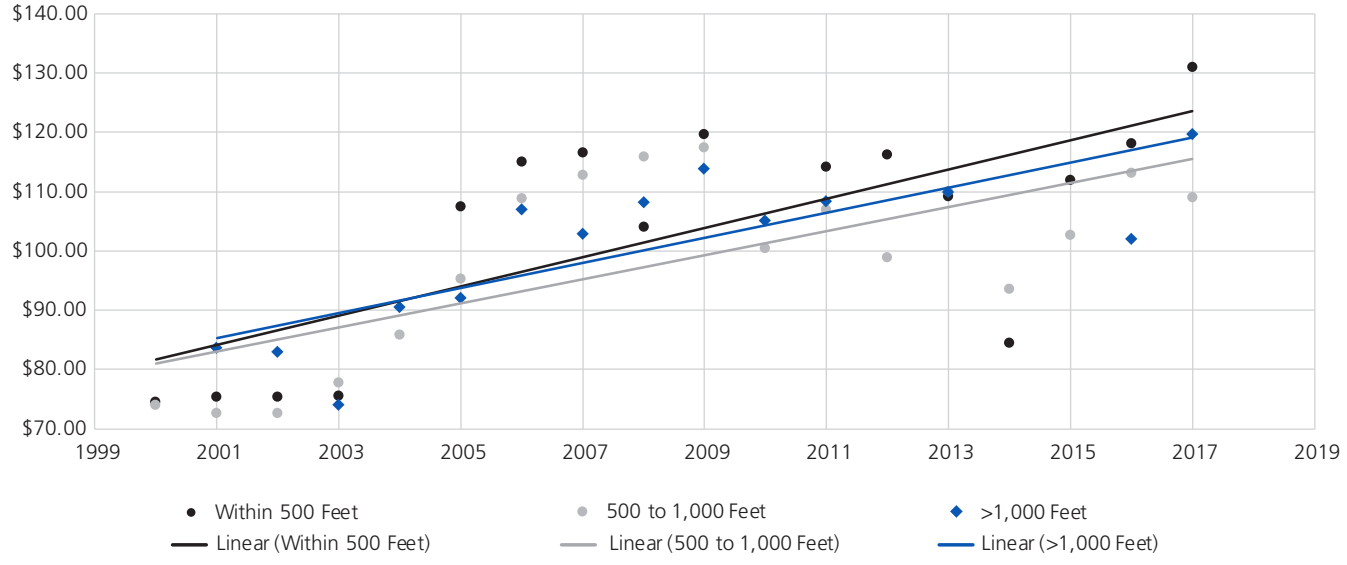


Exhibit 36 Townhouse Sales Annual Average Sale Price per Square Foot



increased in 2012, but then dropped below 2010 and 2011 levels in 2013 and dropped again in 2013 before recovering in 2014 through 2017. The average annual price paid for townhouses located between 500 and 1,000 feet from the compressor stations dropped in price in both 2012 and 2013 before recovering. Those annual price comparisons seem to confirm evidence from the townhome polynomial regression model trend line comparison—townhome prices were affected by the incident, but the impact was temporary (ending by 2015 or 2016), and did not affect homes located at a distance greater than 1,000 feet from the compressor station.

Conclusion from the Marietta, Pennsylvania Texas Eastern Transmission Pipeline Case Study

The case study analysis gives mixed signals concerning whether proximity to the pipeline adversely affected prices.

The single-family detached polynomial regression model data indicates that if there was an impact on home prices due to proximity to the compressor station, it was temporary and began in late 2004 or early 2005 and ended by 2013. Since the compressor station incident occurred in April 2012, it could not have been the reason for the diverging trend lines that began in 2004 or 2005. The impact on single-family detached home prices from proximity to the compressor station shown in the trend line comparisons over the seventeen years in the study was not more than approximately −10.0% for homes within 1,000 feet of the compressor station.

However, when single-family detached home prices are adjusted for differences in size and when average prices paid on an annual basis are considered, there is no impact from proximity to the compressor station on either townhome or single-family detached home prices.

Both the polynomial trend line model for townhome prices and the annual sale price comparison indicated a possible temporary impact on prices about the same time as the April 2012 incident. If there was an impact from the April 2012 incident on townhome prices, it was only temporary, ended by some point in 2015 or 2016, and only affected prices paid for townhomes within 500 feet or 1,000 feet of the compressor station.

Conclusions from Case Study Research and Limitations of Analysis Related to Impact of Fracking Transmission Line Facilities on Nearby Home Prices

Among the conclusions and implications that can be drawn from the compressor station and dehydration facility case study impact research are the following:

- Like the published research into the generalized effect of pipeline proximity on nearby home prices, the data analyzed in the four compressor station case studies researched indicate no generalized adverse impact on nearby home prices from proximity in location to compressor stations. The prices paid per square foot for the homes located closest to the pipelines in the case studies were typically, but not always, as high or higher than the prices paid for homes located at greater distances from the pipeline. So like the previous articles, some of the case study data indicates such impacts generally while other data indicate no such impact. That variability makes location and market-specific analysis necessary.

- Similarly, like the published research on possible price impacts of pipeline spills and leaks, the compressor case study data does not indicate that reported incidents involving fires or emissions at compressor stations automatically adversely affected nearby home prices. One case study found reliable evidence of such an impact while the other two case studies in which prices before and after an event date were analyzed were inconclusive—some of the data indicated impacts but other data did not.

- The case studies, again similar to the published pipeline spill research, indicate that when there are impacts on home prices from compressor station incidents, such impacts are temporary, lasting from a few months to a few years before prices return to the pattern they followed pre-incident.

- It is important to consider the effect of outliers in linear or polynomial regression trend line analysis. The relationships between trend

lines prices at various distances from a pipeline or compressor station can be influenced by the inclusion or exclusion of outliers.

- There can be compounding additional environmental influences affecting home prices that must be accounted for in the analysis. For example, in Case Study 3 involving the West Bradford Township compressor station, a high-voltage transmission line ran through the study neighborhood. Prices paid for homes closest to the high-voltage transmission line were eliminated from the data to minimize any effect of that potential disamenity on prices. However, it is necessary to drive under the power lines to access the properties in closest proximity to the compressor station, which could be a factor that also affected prices that buyers were willing to pay.

- Although trend line regression models based on only two variables (price per square foot and date) may have low *R*-squared values,[37] a comparison of the changing relationship between the trend lines over time can be helpful when an appraiser is attempting to understand the effects of proximity to fracking transmission line facilities and to the effect of specific incidents on prices.

- The number of data points can affect the slope and direction of a polynomial regression model trend line analysis. For example, in Case Study 1 involving Transco Compressor Station 505 the change in the relationship between the distance variable trend lines in late 2015 and early 2016 is likely due to the limited number of sales within one of the distance zones after February of 2016.

- Simple linear trend line analysis showing prices at various distances from a fracking transmission line facility can also be helpful in understanding the effect of a compressor station on prices.

- Finally, the case study research indicates the importance of accounting for differences between homes, first, by using price per square foot to eliminate some of the effect of home size differences, and second by accounting, if possible, for other differences such as lot size, model type, dates of construction, views, and topography. Analysis of townhome prices rather than single-family detached home prices may provide more supportable comparisons and analytical results because townhome prices typically require fewer such adjustments for variables than single-family detached home prices.

There are limitations to this study. First, it is intended to describe and apply only case study analysis and paired-data analysis, two of the five generally accepted methods that can be used by an appraiser when confronted with an assignment involving properties in proximity to a potential environmental disamenity such as a pipeline compressor station. Multiple regression analysis, another recognized method, can also be used in situations where the number of sales is sufficient to allow differentiation of the contribution to value of omitted variables that may be affecting home prices and were not separately analyzed in the paired data analyses used in the case studies analyzed here. In some situations such a more robust statistical analysis may provide a more precise measurement of the correlation between distance from a disamenity and home prices.[38] Second, as in most case study research, data lim-

37. *R*-squared values would be expected to be higher in a predictive value or price analysis using multivariate hedonic regression modeling, which is not the type of modeling done in this article. In multivariate hedonic regression modeling, omitted variables can be responsible for low *R*-squared values, and testing of such models is necessary to understand the effect of the omitted variables on the outcome of the model. Low *R*-squared values are not necessarily indicative of a problem in a trend line analysis. Instead, review of the residuals in the trend line analysis can be undertaken to determine if there is some other variable that is consistently accounting for over- or underestimates of the relationship between the trend lines. There is a low correlation between the residual errors in the trend lines involved in the models in the case studies.

38. Other generally recognized methods include "use of market interviews to collect data and information used in other approaches or to support or supplement the results of other analyses" and "adjustment of income and yield capitalization rates to reflect environmental risk premiums in an income capitalization analysis." Thomas O. Jackson, "Methods and Techniques for Contaminated Property Valuation," *The Appraisal Journal* (October 2003): 311–320.

itations affect the generalized applicability of the results to other appraisal situations. In some of the years in the case studies analyzed, there were very few sales and in some years no sales. The sales data analyzed did not include information about any seller disclosures to prospective buyers about proximity to a pipeline or a compressor station.[39] It was not possible to determine how specific disclosure of proximity to a compressor station or to a specific environmental event may have affected some prices but not others. However, in the Pennsylvania case studies, there was no state-imposed requirement for a specific disclosure of any off-site environmental conditions.[40]

About the Authors

Richard J. Roddewig, MAI, is a managing director with JLL Valuation and Advisory Services LLC. Roddewig works nationally on appraisal and consulting assignments and has more than forty years of appraisal experience. He has authored, coauthored, or contributed to nineteen books including the fourteenth and fifteenth editions of *The Appraisal of Real Estate* and the sixth and seventh editions of *The Dictionary of Real Estate Appraisal*. He has authored or coauthored nineteen prior articles in *The Appraisal Journal*. **Contact: Richard.Roddewig@jll.com**

Michael J. Samuels, MAI, is a principal in the Philadelphia office of Clarion/Samuels Associates. Samuels has more than forty years of appraisal and real estate development experience and specializes in complex real estate appraisal assignments, many of which involve expert testimony. He has a bachelor of science degree in finance from the University of Illinois and a master of science in real estate appraisal and investment analysis from the University of Wisconsin. **Contact: mikes@clarionsamuels.com**

Anne S. Baxendale is a senior vice president on the complex real estate analysis and litigation support team at JLL Valuation Advisory. Baxendale specializes in modeling and analysis of large-scale market and transactional data using custom-built databases and geographic information system (GIS) spatial analysis technology. She is a past contributor to *The Appraisal Journal* and *Real Estate Issues*. She holds a bachelor of science degree in political science from the University of Dayton and master of urban planning and policy degree from the University of Illinois Chicago. **Contact: Annie.Baxendale@jll.com**

Joseph R. De Marinis, MAI, is a senior associate with Clarion/Samuels Associates in Philadelphia. He is a certified general real estate appraiser in Pennsylvania. Much of his appraisal work involves feasibility studies for land development projects, including residential, commercial, industrial, and mixed-use development. De Marinis has a bachelor of science degree in mechanical engineering from Widener University. **Contact: joed@clarionsamuels.com**

SEE NEXT PAGE FOR ADDITIONAL RESOURCES >

39. Those disclosure statements were not available as part of the data set analyzed in the case studies in this article. In addition, seller disclosure requirements vary from state to state, and sometimes from one multiple listing service or residential brokerage company to another.

40. The state-imposed disclosure requirement in Pennsylvania only requires disclosure of environmental concerns on the property itself. As a result, a home seller in Pennsylvania would not necessarily be legally required to disclose proximity to a nearby pipeline or compressor station. In other states, the standard disclosure statement requires reporting of some types of off-site environmental conditions that may affect the property. For example, the New Jersey standard disclosure statement asks if the seller is "aware of any condition that exists on any property in the vicinity which adversely affects, or has been identified as possibly adversely affecting, the quality or safety of the air, soil, water, and/or physical structures present on this property." How a seller in New Jersey would interpret that requirement in relation to a nearby pipeline or compressor station could vary significantly. The New Jersey disclosure statement also warns prospective buyers that it is the buyer's obligation "to carefully inspect the surrounding area for any off-site conditions that may adversely affect the property." New Jersey Association of Realtors Standard Form of Seller's Property Condition Disclosure Statement, NJAR Form 140-5/04, https://www.realmart.com/pdf/SellerDisclosure.pdf.

Additional Resources

Suggested by the Y. T. and Louise Lee Lum Library

American Gas Association—Research & Policy
https://www.aga.org/research-policy/

American Petroleum Institute—Natural Gas & Oil
https://www.api.org/news-policy-and-issues

Appraisal Institute

- **Guide Note 6, "Consideration of Hazardous Substances in the Appraisal Process,"** ***Guide Notes to the Standards of Professional Appraisal Practice***
  http://www.appraisalinstitute.org/assets/1/7/guide-note-6.pdf
- **Lum Library holdings**
  - *Beyond the Fracking Wars: A Guide for Lawyers, Public Officials, Planners, and Citizens* (Chicago: American Bar Association, 2013)
  - Lum Library External Resources [Login required]
    Information Files—Real estate damages, impact of fracking
- **Publications**
  - *Real Estate Damages*, third edition (Chicago: Appraisal Institute, 2016)
  - *Valuing Contaminated Properties: An Appraisal Institute Anthology*, vol. 2 (Chicago: Appraisal Institute, 2014)

Federal Energy Regulatory Commission—Natural Gas
https://www.ferc.gov/natural-gas

International Association of Drilling Contractors—*Drilling Contractor* magazine
http://www.drillingcontractor.org

MineralWise—Oil and Gas Terminology
http://www.mineralweb.com/library/oil-and-gas-terms

NaturalGas.org—Shale
http://naturalgas.org/shale/

US Energy Information Administration—Natural Gas
http://www.eia.gov/naturalgas/

US Environmental Protection Agency (EPA)—Unconventional Oil and Natural Gas Development
https://www.epa.gov/uog