Water and Sewer Infrastructure Challenges as a Barrier to Housing Development in the Marcellus Shale Region

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Building on prior research on the housing effects brought on by the natural gas industry in Pennsylvania which found that a lack of water and sewer infrastructure served as a significant barrier to developing new housing needed to alleviate the shortage and resulting high rents in affected communities, this article focuses on the connections between natural gas development, housing need, and provision of water and sewer infrastructure. Through case studies of two water and sewer providers in Lycoming County, Pennsylvania, it was found that supplying infrastructure is complicated by the timing and the costs involved with the Chesapeake Bay cleanup, enforcement of the Clean Water Act, and other regulatory hurdles facing suppliers of water and sewer services. These added costs, and their resulting effects on needed housing development, serve as challenges both in areas served by older providers charged with maintaining aging facilities and newer providers who must balance capacity with cost. Both adequate and affordable housing and a healthy environment are vital needs, but at least in the short run, there is a tension between these two needs and their costs for to taxpayers, rate payers, service providers, and developers. Potential solutions for overcoming these challenges are discussed.

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The first slickwater hydraulically fractured gas well in Pennsylvania's share of the Marcellus Shale formation was drilled in 2004. In the intervening eight years, the Commonwealth has seen a boom in the natural gas industry, leading to a wide range of effects on local communities. The nature of these effects is subject to significant debate. Without engaging in the qualitative debate over the net effects of the development of Marcellus gas play, research is needed to better understand the impacts the Marcellus gas industry has on communities. This article discusses the connection between Marcellus natural gas development, the pressure it has placed on housing in affected communities, and the effects of environmental initiatives on the ability to provide water and infrastructure to meet increased housing demand in those communities.

Lycoming County, Pennsylvania, is used as a case study to present each of these interrelated effects. The cases studies presented here illustrate how supplying that infrastructure is complicated by the timing and the costs involved with the Chesapeake Bay cleanup, enforcement of the Clean Water Act, and other regulatory hurdles facing suppliers of water and sewer services. Adequate and affordable housing and a healthy environment are both vital needs, but at least in the short run, there is a tension between these two needs and the costs they bring to taxpayers, rate payers, service providers, and developers.

Infrastructure Challenges to Housing Development

The rapid growth of the development of natural gas from nonconventional drilling in the Marcellus Shale region in Pennsylvania brought with it a great deal of research on the scale and scope of its economic impact (Kelsey et al., 2011, 2012). While this research has not been without its critics who argue the economic benefits of the industry are much more limited (Christopherson, 2011; Herzenberg, 2011), it is clear from both academic sources as well as government data that natural gas development has created at least

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some level of job growth and increased economic activity in the region (Costanzo and Kelsey, 2012).

As the debate over the overall economic impact of Marcellus Shale has developed, a number of researchers have turned to study more specific community and economic impacts of the industry. Ranging from the effects on school districts (Schafft, 2012) to public health (Goldstein, Kriesky, and Pavliakova, 2012), this research, while still in its infancy and just beginning to be connected to similar research in other contexts (Weigle, 2011), has begun to outline the positive and negative outcomes that result from the emerging industry's activity and to develop solutions to maximize the benefits while mitigating negative consequences. State and local government-sponsored research has also just begun to capture the specific effects that industry is having on communities (Lycoming County, PA, 2012a,b).

Contributing to this research, Williamson and Kolb (2011) studied the housing effects brought on by the gas industry. Their study identified a complex, interconnected set of circumstances affecting market rate and subsidized housing in both the rental and the owner-occupied markets. In essence, depending on the nature and pace of the natural gas industry, a perfect storm of housing demand-and-supply issues can lead to a shortage of housing and dramatically increased prices in the rental market. Rising rents impact broad segments of housing consumers, including new residents working in the gas industry, but falls most heavily on low-income renters. New forms of homelessness can result, leading to other community problems. In general, the research suggests that the increased demand for housing brought about by increased economic activity linked to natural gas will need to be met by an increased supply of housing. Yet, for communities where little housing development at any scale has occurred in several decades, the research found limited developer capacity to provide immediate relief in terms of increasing the housing supply (Williamson and Kolb, 2011).

Even if developer capacity existed, from interviews of county planners, municipal officials, and developers, Williamson and Kolb's study identified the lack of water and sewer infrastructure as a significant barrier to developing new housing. In many of the rural and small-town communities where there is natural gas development, there is a significant lack of infrastructure, including water and sewer systems. In rural contexts, housing instead relies on wells and septic systems, which has limited scalability to meet demands for additional housing. Even in the region's communities served by sewer systems, the existing infrastructure has little capacity to absorb this new, unexpected growth.

Left unanswered by their research was the question of the specific issues beyond the costs involved that limited the expansion of water and sewer infrastructure, and how those limitations might be overcome. The analysis here explores those questions through a case study of communities in Lycoming County that are facing pressure on their housing stock with limited ability to meet the infrastructure needs to support that additional housing. More specifically, this article seeks to understand the connections between the barrier that the lack of water and sewer infrastructure presents to housing development and efforts to improve environmental conditions by increasing the quality standards being placed on water and sewer providers by federal and state regulators.

Methodology

In seeking to understand the ability of water and sewer providers to respond to the needs for housing development, this article uses the experiences of two water and sewer authorities in Lycoming County as case studies of the trade-offs faced. The authors interviewed public officials from the Williamsport Municipal Water Authority (WMWA) and the Williamsport Sanitary Authority (WSA), the Lycoming County Planning Department, Loyalsock Township, and the Lycoming County Water and Sewer Authority (LCWSA). The WMWA/WSA are authorities with shared leadership that are challenged by providing service while saddled with an aging infrastructure. The LCWSA is challenged by providing new infrastructure in a cost effective and timely manner. The semistructured interviews conducted for this study during the spring of 2012 were supplemented by information gathered from interviewing over 70 housing stakeholders from across Pennsylvania who were interviewed during the authors' 2011 study. In both cases, the authors and the interviewees agreed that comments would not be attributable.

Lycoming County was chosen for several related reasons. By nearly any measure (rig counts, drilling permits issues, wells drilled), Lycoming County is among the counties experiencing the most natural gas development activity [Baker Hughes, 2012; Pennsylvania Department of Environmental Protection (PA DEP), 2012]. These reports confirm that a significant labor force is working in the county to support the drilling and completion processes to support these rigs; in addition, the county has become a focal

point for the gas industry in the north-central part of the state (Thompson, 2012a). The presence of available office space, rail-served industrial sites, and government, legal, and financial services has attracted regional headquarters for larger oil and gas exploration and drilling companies. In turn, the presence of these regional headquarters has attracted the companies that service the gas industry. While other counties in Pennsylvania may have faced even greater housing pressure (Bradford and Greene Counties fall into this category) (Lowenstein, 2010) or larger job growth because of the establishment of regional headquarters (Washington County, for example) (Schwartzel, 2012), Lycoming County's unique combination of significant drilling activity and job creation through regional headquarters, along with its combination small-scale urban, suburban, and rural populations, make it suitable for the study of the housing and infrastructure effects discussed here.

Facing the Challenge of Supplying a Community's Water and Sewer Needs

An obvious link exists between supplying the needed sewer and water infrastructure and providing adequate housing to a community. Those interviewed were asked what limits the capability of water and sewer infrastructure to be developed to meet the needs for new housing. The short answer is cost. Even while labor and material costs have increased, those charged with maintaining, upgrading, and expanding these infrastructure systems report that developing new water systems and new sewage treatment systems, as well as expanding existing systems, is a costlier proposition than when many systems were originally built. Environmental concerns result in regulations that, although necessary to protect water as a resource, also add significantly to the costs of developing new capacity.

The challenges these costs represent today are more difficult to meet than those of past periods of economic expansion in this region's history. At the time water and sewer systems in the industrial Northeast were first established in the early to mid-20th century, the costs of providing the infrastructure were borne by a combination of local resources and federal and state programs, according to those interviewed. The costs themselves were lower because fewer regulations existed and material and labor costs were cheaper. An expanding local residential and industrial tax base justified the creation of the infrastructure in the first place and provided funding to support the costs. Interviewees reported that state and federal governments prioritized infrastructure investment through funding to a greater extent than today. At the same time, local governments and their tax base were not weighed down by costs of maintaining aging infrastructure and other legacy costs passed on to them by their predecessors. In other words, the period when water and sewer was first established in many of these communities was a different fiscal epoch than we see today.

In addition to the financial burden of maintaining the current infrastructure, which is aging and reaching capacity, water and sewer providers face higher material and labor costs, along with contemporary regulations requiring water and sewer facilities to meet higher standards. For example, on the sewage treatment side, primary treatment facilities in many communities were installed in the 1950s, with secondary treatment generally added in the 1970s following the passage of the Clean Water Act [United States Environmental Protection Agency (US EPA), 1972]. Sewer and water services were initially established as a way to protect the public's health (Knowlton, 2001).

Only later was the issue of environmental health considered when writing regulations. The latest tertiary treatment requirements require upgrades as part of Pennsylvania's Chesapeake Watershed Implementation Plan (WIP) (PA DEP, 2010). Pennsylvania's WIP was in response to the US Environmental Protection Agency's Chesapeake Bay Total Maximum Daily Load (TMDL) established in 2010. The TMDL mandates reductions in pollutants from sources of nitrogen, phosphorus, and sediment being discharged into the Chesapeake Bay watershed, which encompasses parts of six states and the District of Columbia (US EPA, 2010). In other words, as one person interviewed suggested, new facilities or expansion of existing facilities must meet the cumulative standards of decades of improved environmental regulation all at once, whereas existing facilities were funded by multiple generations of public officials, taxpayers and rate payers over time.

Funds to pay for these costs are also more difficult to come by, according to those interviewed. The bulk of the existing infrastructure in communities like those in Lycoming County was installed by using both private and public funds at times of national economic expansion and significant infrastructure investment at the local, state, and federal levels. The fiscal environment today faced by private investors and public entities at all levels makes infrastructure investment more difficult.

The next section explores in more detail several areas of increased costs and the difficulties faced in funding those

costs. Two brief case studies tell the story. The first discusses the challenges faced by the WMWA/WSA in meeting the nutrient reduction requirements of the Chesapeake Bay initiative while struggling to maintain and upgrade an existing sanitary system. At the same time, partner communities using the WMWA/WSA services, such as Loyalsock Township, have struggled to manage mandated efforts to reduce storm runoff into the sanitary system. The second explains LCWSA's efforts to expand new water infrastructure to meet residential and industrial needs within a costly regulatory environment.

The WMWA/WSA: The Story of the Chesapeake Bay and an Aging System

Many communities, including those served by the WMWA and the WSA, experiencing Marcellus-related growth are also facing the combined costs of maintaining aging water and sewer infrastructure while meeting relatively new regulatory requirements, according to those interviewed. On one hand, the WMWA's water supply is plentiful and of high quality; the authority is permitted for 12 million gallons a day but uses only 6 million gallons. This excess capacity is largely a result of population and industry decline over the last 50 years. Agency representatives report that their business model is unlike that of a typical private business. For a water supplier, fewer customers does not mean less cost but only less revenue. The cost of maintaining the system remains the same even when the population declines. Before Marcellus-related activity, the WMWA faced the potential of further declines in the customer base and, therefore, even less revenue. Even so, the WSA's Act 537 plan, a document that predates Marcellus gas development in the area, optimistically assumes a steady population and plans for modernization expenditures on that basis (Williamsport Sanitary Authority, 2008). The WSA is grateful for having done so. If it had not, it would be in an even more difficult position as it now tries to provide more service and meet regulations.

The largest challenge in the modernization process has been meeting the requirements imposed by the Chesapeake Bay initiative to reduce point-source nutrients, primarily phosphorous and nitrogen, discharged from treatment plants into the West Branch of the Susquehanna River. Based on plans outlined in their Act 537 plan, the WSA is currently undergoing $120 million in upgrades to its two treatment plants, with the costs split between reducing nutrients and generally upgrading aging equipment in plants dating from the 1950s (Maroney, 2011b).

The costs for these upgrades have been borne almost entirely by local customers, who have seen their sewer bills triple since the construction began (Johnson, 2012). Since many residents in the area are older and poorer than the state average (US Census Bureau, 2010), this additional cost has been a significant burden. State and federal funds have been scarce, both because of the tight fiscal circumstances each level of government has experienced in recent years and because local sewer rates generally fell below national norms as a share of local income levels (Maroney, 2011a).

Also, stretching budgets have been efforts to reduce storm-sewer infiltration into the sanitary systems mandated under the Clean Stream Act. During rain events, the volume of water traveling to the WSA's treatment plants from the municipal partners, such as Loyalsock Township who theoretically should have separated storm sewer and sanitary systems, increased dramatically, indicating that storm water is infiltrating the aging sanitary infrastructure. The township was required to reduce wet-weather water flows into the Williamsport sewage-system plant.

After careful testing to determine the most cost-effective means to reduce peak flows, according to township officials, Loyalsock Township, under the watchful eye (and restrictions preventing new tap-ons) of the US EPA, required its property owners to replace laterals connecting to the sanitary system. These lateral repairs cost the home owner an average of about $5,000; in addition, they simultaneously began to pay higher sanitary charges needed to fund the repair and lining of the sewer mains and manholes in the most deteriorated sections of the municipality (Walker, 2010). The replacement of the laterals along with the construction of a three-million-gallon holding tank have been effective in reducing the flow and getting closer to the number mandated by federal and state pollution control guidelines.

In the near term, given the restrictions faced by communities like Loyalsock Township, development of new housing can be directly blocked by US EPA restrictions in the municipalities' ability to add customers. In the medium term, Loyalsock and similar communities face the need of adding capacity or extending infrastructure to new areas to support growth. Loyalsock is a geographically large community with a rolling landscape. The beautiful hills and valleys are attractive to developers and newcomers to the area. Yet, according to those interviewed, the geography leads to expensive engineering and construction costs to get storm water to the river and sewage to the treatment facilities. While the engineering challenge can be solved,

the challenge of how the development costs are to be shared is much more difficult. It is simply too expensive for the township to run a main sewer line a mile or more to the edge of a newly proposed development, interviewees report. They argue they are fiscally tapped out by having just paid to maintain and upgrade their existing systems. Therefore, the demand for additional housing created by the growth of the natural gas industry remains unmet by increased supply.

Lycoming County Water and Sewer Authority and the Struggle to Provide Cost-Effective Service

Less common in the story of Marcellus communities is a tale of a new and growing provider of water and sewer services. In the case of the LCWSA, which was formed in 1989 as an independent authority, the primary goal dating to the pre-Marcellus period was to provide water and sewer availability in the Lycoming County's designated growth corridor (Thompson, 2012b). LCWSA's sewage facilities began operation in 1998 and, according to those interviewed, have adequate capacity to meet current and future plans. They report that LCWSA's challenge is supplying water. In 2005, prior to Marcellus natural gas development, the LCWSA completed a plan to develop the water capacity over a 20-year period. They estimate that, as of 2012, the demand for water, because of Marcellus-related developed, is five years ahead of their plans.

They have primarily three potential sources for water. The nearby presence of the West Branch of the Susquehanna River is the most obvious known quantity, but also the most expensive because of permitting requirements imposed by the Susquehanna River Basin Commission (SRBC) and because of treatment needs, according to their representative. Gaining the approval of the SRBC for water withdrawal has become more complicated by the high demand for water from the natural gas industry for use in hydrofracking. Municipal water suppliers report that they must compete directly with industrial users because municipal suppliers have no advantage in the first-come-first-served application process for withdrawal permits.

The next obvious source for water is via wells. While generally less costly than using river water, wells are more risky because drilling does not always find water. In addition, the permitting process requires much more scrutiny for higher-capacity wells, leading to trade-offs between the need for water volume and the need for speedy approvals. For example, LCWSA's current well could have been permitted to supply in excess of 100,000 gallons per day, but those interviewed indicated that the choice was made to permit it for 60,000 because of the considerably more streamlined permitting process at that level. The trade-off resulted in quicker development of the water source, but at the cost of reduced capacity to meet LCWSA's growing demand for water.

The final potential source of water for the LCWSA is to purchase it from surrounding municipal sources. The LCWSA currently meets some of its needs through water purchases of up to 20,000 gallons per day from Muncy Borough and the Muncy Borough Municipal Authority through the interconnection of their water systems (LCWSA, 2012). There are at least three other potential neighboring partners according to those interviewed, including Montoursville Borough Water Works, Williamsport Municipal Water Authority, and Hughesville Borough Water Authority, but there are several barriers to moving forward with expanding supply in this way according to officials interviewed. First, water coming from some distance requires the infrastructure to be laid to connect the source to the water supply. That cost must be borne by the LCWSA. Second, the water would need to be used immediately and regularly or new costs would be incurred to maintain water quality and prevent stagnation of unused water sitting in pipes from becoming an issue. Third, political issues involved make some communities reluctant to share, even at a profit, their valuable community asset. These issues appear to result either because they prefer to maintain control over the water or because of a competitive environment for economic development exists between municipalities. This problem is seemingly exacerbated by the fragmented municipal government structure that exists in Pennsylvania.

In the end, the LCWSA is faced with a chicken-and-egg scenario in which the LCWSA poised to expand but faces difficulty justifying to current customers the rate increases needed to fund the investment necessary to add capacity to their water-supply system. Customers (residential, industrial, and commercial), however, are reluctant to locate in the target area without existing water infrastructure.

The situation is made more complex by the incompatible time frames of the public and private sectors. LCWSA officials indicated that adding significant capacity to their water system generally requires 18 months, given the regulatory, bidding, and construction processes. Those officials report that developers, who when the project is ready to go must move quickly, are reluctant to share their plans until the last minute for fear that public knowledge of their development will increase costs or spur competition. As a

result, municipal water officials are unable to anticipate developments' water needs with enough lead time to meet private-sector time lines.

In sum, the development of infrastructure to support additional housing (and industry) is hampered by high costs. Although developers and customers may wish to build, they find that water authorities are unable to provide assistance. The development of the capacity to serve a hundred customers may cost in the millions. In the past, the cost of such development was lower and the financing of such development could rely on state or federal funding assistance. In today's fiscal environment, the cost must be borne by current residents who interviewees report are unhappy with the local water or sewer authority increasing their rates. Explanations that the regulations benefit the Chesapeake Bay leave authority customers unsatisfied; according to those interviewed, rate payers express their frustration to the authorities over bearing the costs for benefits that accrue hundreds of miles away.

Proposed Solutions

Discussions with water and sewer authorities resulted in three proposed solutions to the quandary of how to provide infrastructure in a cost-efficient manner while still meeting regulatory safeguards. What follows builds upon their ideas, with the authors' interpretations of their strengths and weaknesses, along with a brief discussion of the steps needed to overcome the barriers to adopting each solution. These proposed solutions include building where the infrastructure is already located, encouraging brownfield development by razing older, substandard housing for new development, and encouraging cooperation between developers and infrastructure providers across developments to encourage proximate development and maximize the customers served by new infrastructure.

Build Where the Pipes Are

Many of the rural Pennsylvania communities now in decline had been the home of industry. This industry was often located close to working-class housing built at a time when the family breadwinner would leave home with lunchbox in hand and walk to the local factory. Much of this industry has now left the country. In modern communities, the close proximity of housing and industry is not welcomed. Any new industry that is built will most likely be in industrial parks, not in areas near housing. However, under the streets of many of our older towns is a legacy of industry in the area; that is, a water and sewer system, designed to meet the needs of industry, that is often more than adequate for housing needs.

Razing abandoned buildings and cleaning up brownfield sites to make them suitable for infill residential development would help communities solve seemingly unrelated problems by using existing water and sewer capacity efficiently, adding needed housing stock, and revitalizing the targeted areas. Depending on local circumstances, some of this housing development could take the form of adaptive reuse of existing structures: those interested in preservation make the case for adaptive reuse to preserve historically significant structures while meeting modern needs (Brachman, 2012). For example, the current owner of a hundred-year-old former pajama factory in Williamsport who has found success attracting tenants by marketing the building as artist studio and gallery space has recently begun to pursue the development of the upper floors of the several-hundred-thousand-square-foot facility as loft apartments, again targeting artists as tenants (Maroney, 2012b).

Conversion of underutilized industrial sites to housing comes with significant challenges, however. At the most basic level, such sites would need to be rezoned for residential use. Whereas their disuse would normally imply that such rezoning would not normally be problematic, the same forces resulting from natural gas development driving the need for new housing are leading to increased demand for at least some industrial spaces. For example, in Lycoming County, rail-served industrial sites now bring a premium (Maroney, 2012a).

Beyond zoning, redevelopment of industrial sites, especially older ones, includes problems of environmental cleanup. Funds are needed to complete phase 1 and phase 2 brownfield assessments to determine what remediation steps are required. Then funds are needed to complete the remediation. Development costs for greenfield sites are generally seen as much lower and time frames are much shorter, according to developers.

To overcome these barriers, a concentrated focus on redevelopment of particular industrial facilities, including creative packaging of funding sources, is necessary. Because projects of this type can be more costly, public and private money must be leveraged to make these projects doable. Beyond having the right developer with the willingness and experience to take on such a challenge, such projects require public officials to see the interconnections between the diverse set of goals that the targeted project aims to

achieve and be willing to think outside the box to package funds from sources with as diverse goals as environmental cleanup, infrastructure investment, housing development, and historic preservation. The City of Williamsport, in cooperation with the County of Lycoming, an established community housing development organization (CHDO), a for-profit developer, and a tax-credit developer, is pursuing the redevelopment of a former silk mill by following this model (Maroney, 2011c).

Redevelopment of Old Neighborhoods

A related solution to redevelopment of underutilized industrial sites is the development of new housing on the site of current substandard housing. Two approaches can be taken to achieve this end. In some cases, the existing housing may be in poor condition, but with rehabilitation could be attractive housing for either market-rate or subsidized housing. In an older community, rehabilitation maintains the historic character of neighborhoods and can be done in such a way to minimize the disruption of the character of the existing community.

The challenges of rehabilitation focus primarily on economics and scale. Developers often shy away from rehabilitation because of the unknowable costs associated with such projects as compared to new construction (Williamson and Kolb, 2011). Financing is also more difficult for rehabilitation compared to new construction (Ware, 2007). In addition, while upgrading a substandard housing unit may have other community benefits, it does not add units to a community's housing stock. Furthermore, the slow pace of such projects can make them less attractive to community leaders and developers alike when compared to new construction. To overcome these challenges, public-private partnerships can come into play once again. To the degree that private investment is inhibited by unknown risks that could lead to high costs and to the degree that rehabilitation is in the community's interest, public funds can be used to encourage rehab projects.

An alternative approach to neighborhood revitalization is to add new housing stock to a community by replacing older homes. Many older communities have blocks of small homes on small lots that in the past were thought perfect for working-class families. Now, such houses are undesirable for residents if they have any other choice economically. Therefore, the homes often become rental units for low-income residents. Because the rents are low, landlords do not have the funds for the maintenance that older homes require. Such homes become more decrepit and less desirable over time until they finally sit vacant. While the homes are declining, the infrastructure for water and sewer exists right below street level. The advantage of such development, then, is that the existing infrastructure can be used to meet the housing needs of modern housing just as well as older, undesirable housing, without the cost of creating new infrastructure.

However, such an approach has numerous disadvantages. While such existing housing may not be well maintained, it may not support neighborhoods with a strong tax base, and its residents may be associated with other socially undesirable outcomes, such housing does provide homes to a share of a community's population that has few other options. Displacing a neighborhood of low-income residents to replace their homes with housing they cannot afford has led to a range of well-studied undesirable outcomes (Brueckner and Rosenthal, 2009; Essoka, 2010). In addition, replacing small housing units with modern housing usually results in reduced housing density. To the degree that natural gas development increases the need for additional housing units, this goal is not met.

Finally, there are political implications for advocating urban redevelopment or urban renewal, to use the terms that described such efforts dating from the 1960s and 1970s (Bailey and Robertson, 1997). Beyond being unpopular among those displaced, the failure of many such projects across the country to bring lasting community and economic growth can linger in the minds of citizens and leaders alike. When such an experience is part of a community's local collective memory, such an effort is less likely to be pursued. In the context of Williamsport, there are both a failed history of urban renewal in the community's past and a contemporary parallel in the purchase and demolition of over one hundred homes to support the expansion of a local hospital and the YMCA (Best, 1994; Hutchinson, 2012).

Cooperative Development Planning

A final solution is to work to develop cooperative public-private relationships, in particular between developers and infrastructure providers. The earlier and more freely a water and sewer provider can work with a developer during project planning, the more responsive each party can be to the others' needs, reducing costs to the developer and the public authority and enabling better-synced time frames.

Real estate development includes risk to the developer, requiring plans to be held close to the vest to hold down

land acquisition costs and to prevent competitors from preempting development plans. The developers, in competition with one another, want their development to be the only one built. They are uninterested in cooperating directly with a developer that would potentially steal customers and may fear that information shared with public officials will be shared, intentionally or otherwise, with their competition.

Such competitive behavior limits effective planning for public entities such as water and sewer authorities. If developers do not share their plans with infrastructure providers, then needed infrastructure could be delayed or stalled altogether, given the differing time frames between public and private development. Furthermore, provision of public infrastructure to isolated private development is made more difficult because, as one interviewee stated, "It is hard to justify spending millions to serve hundreds [in a single new development]."

While public authorities need to carefully protect the confidence of developers they work with, early cooperation would enable the authorities to coordinate infrastructure projects and suggest cost-saving changes to development plans across projects. If water and sewer providers can coordinate investments to support expansion needed for multiple developments simultaneously, they are more likely to be able to justify extending new infrastructure because they know there will be enough customers to justify the cost of the expansion.

Beyond building trust between public and private entities, these barriers can be overcome indirectly through careful zoning. Communities can designate specific growth corridors, as does Lycoming County (Lycoming County, PA, 2006), and preemptively signal to potential developers where they will find support for such projects through infrastructure improvements.

Conclusion

The need to improve environmental standards for water and sanitary systems and the need for housing exacerbated by Marcellus Shale natural gas development are priorities competing for limited resources. The costs involved in meeting newly implemented environmental standards, along with the costs of maintaining aging infrastructure, strain the resources of local water and sewer authorities, their rate payers, and taxpayers generally. In a perfect storm, the Marcellus-related housing needs hit many of the same communities already struggling with water and sewer maintenance and upgrade costs.

When development requires the extension of existing infrastructure beyond the current limits of an authority's service area, water and sewer providers enter into negotiations with developers as to who will pick up the costs of extending those services. Now that costs are higher because, in part, of increased regulation, these negotiations become more difficult. While developers are generally expected to assume the costs of infrastructure improvements within their land development plans, developers generally want the providers to assume extension costs. At the same time, because they must finance upgrades, water and sewer authorities are reluctant to take on additional costs for extension. Furthermore, any costs of infrastructure construction borne by the developer must be included in the total project costs. The problem for the developer is that infrastructure availability generally adds little to the marketable value of the property to potential buyers. Therefore, since such costs are likely to be passed onto development, new housing is less likely to be developed.

Similarly, the costs of extending infrastructure do not vary with the value of the housing being developed. If a mile of water or sewer piping is laid to support a new development, the costs are the same whether $80,000 or $300,000 homes are being built. Therefore, developers are going to be more reluctant to assume infrastructure costs for low-priced housing than for higher-priced housing. The fixed costs represent a larger share of the overall sale price for an affordable housing development and are therefore harder to recoup.

The end result of these two factors means that higher infrastructure development costs, partially from the need to meet environmental regulations, limit the capability of housing development to respond to the increasing housing need, especially for the creation of affordable housing available to those most affected by the current situation.

Short of extensive investment in extending water and sewer infrastructure to greenfield sites, solutions to provide housing relief need to maximize the use of existing infrastructure while helping to accomplish related community goals. Reclaiming underutilized industrial zones that already have adequate water and sewer infrastructure for housing use, revitalizing substandard housing, and concentrating infrastructure project investments are potential paths to increasing housing supply, given infrastructure constraints.

Overcoming barriers to each generally necessitates public and private partners working in cooperation.

Finally, the qualitative, semistructured interviews presented here that are focused on water and sewer issues in Lycoming County, Pennsylvania, help to develop an understanding of this specific context and to generate hypotheses for testing in other contexts. The dynamic, contemporaneous interaction involving gas development, housing pressure, and demands on infrastructure to meet environmental standards necessitates a qualitative approach until the adequate passage of time allows for the development of quantitative indicators of the topics discussed. Further research is required in order to understand the generalizability of these findings in other geographic contexts and to test interview subjects' perceptions quantitatively.

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