

Section 3: Rates and Densities of Natural Gas Well Development

The Marcellus formation is an extensive resource that occurs beneath much of the State and will require tens of thousands of wells to fully exploit. The risks and impacts from any given individual well may be negligible and acceptable, but when evaluated in the context of hundreds or thousands of other wells, the risks and impacts may be significant and unacceptable. As such, cumulative impacts from many wells constructed throughout the watershed must be evaluated in order to fully characterize the potential risk from concurrent activities at multiple locations. Consistent with this understanding, the dSGEIS establishes the *aggregate* and not the *individual* as the appropriate basis for analysis of regional impacts: “*The level of impact on a regional basis will be determined by the amount of development and the rate at which it occurs.*”¹⁵

This section provides estimates for the annual rate and ultimate density of natural gas wells that could be developed in the NYC watershed under proposed regulations. These rates and densities are then combined with quantity estimates for various activities associated with one individual well to develop cumulative values (Section 4).

Sufficient data is available from shale gas plays that have been under development in other areas over the last two to ten years to develop reasonable ranges of annual rates of well construction (Appendix B). Since these other plays are still under development, the data from these plays underestimates the expected full build-out density. Therefore, estimates for the total number of wells to be constructed in the watershed are derived from estimates of developable area within the NYC West-of-Hudson watershed combined with average expected well densities per square mile.

3.1 Rates and Densities of Well Development in other Formations

Four major shale gas plays were identified for comparison purposes: Barnett (Texas), Fayetteville (Arkansas), Haynesville (Louisiana), and Marcellus (Pennsylvania) (Figure 1-1). These formations are all gas-bearing shales that require hydraulic fracturing for economic production and have been developed using a combination of horizontal and vertical wells.

Data on New York’s Marcellus formation depth, thickness, organic content, thermal maturity, and other factors that have been analyzed by the New York State Museum’s Reservoir Characterization Group indicate that the NYC watershed is underlain by portions of the Marcellus with high gas production potential. As such this assessment focuses on counties in other formations that have similarly high potential for gas production. Salient features of these formations and the counties selected for comparison are summarized in Table 3-1.

Well development rates and density for the four shale gas formations and their selected counties are summarized in Figure 3-1, Figure 3-2, and Figure 3-3. Figure 3-1 shows the annual rate of development in the other shale gas plays. Figure 3-2 depicts the density trends noted in the four comparable shale gas plays over the past decade, and Figure 3-3 presents current densities (2009).

¹⁵ dSGEIS Chapter 6.13.2.

Table 3-1: Areas of Major Shale Gas Plays Comparable to Marcellus formation in NYS

Formation (State)	Approximate # Years under Development	Total Formation Area (mi ²)	Selected Counties	Area (mi ²)	% of Formation Area in Selected Counties
Barnett (TX) (Newark East field)	13	5,000	Denton, Johnson, Tarrant, Wise	3,512	70%
Fayetteville (AR) (B-43 field)	6	9,000	Cleburne, Conway, Faulkner, Van Buren, White	3,589	40%
Haynesville (LA)	3	9,000	Bossier, Caddo, De Soto, Red River	3,100	34%
Marcellus (PA)	2	95,000	Bradford, Lycoming, Susquehanna, Tioga	4,374	5%

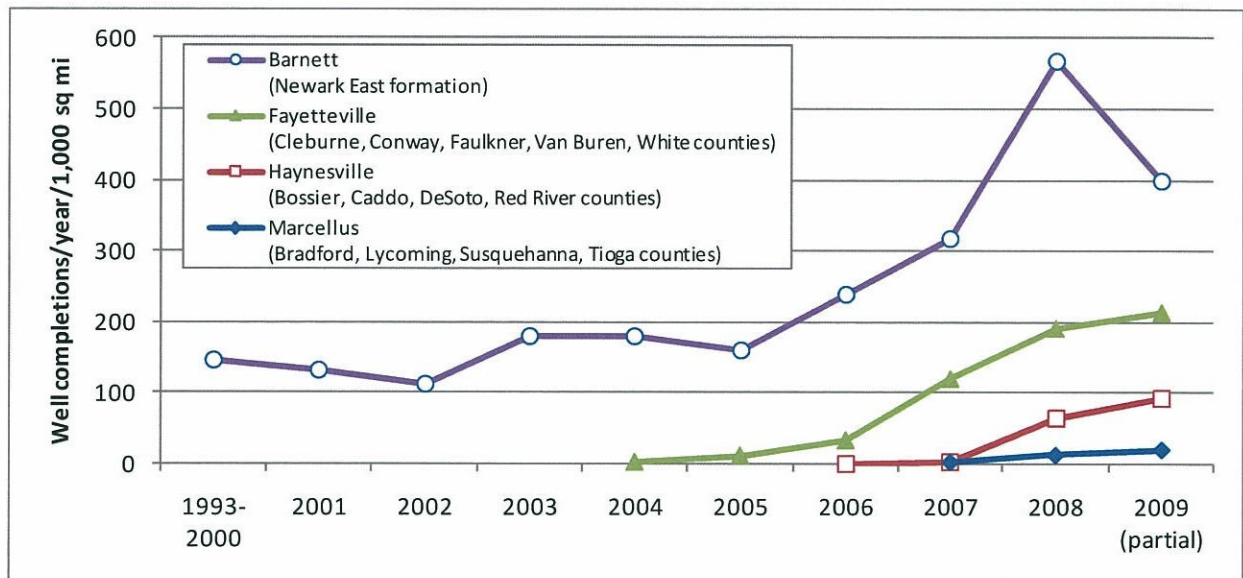


Figure 3-1: Annual Well Completion Rates in Core Counties of Comparable Shale Gas Plays (2001-2009)

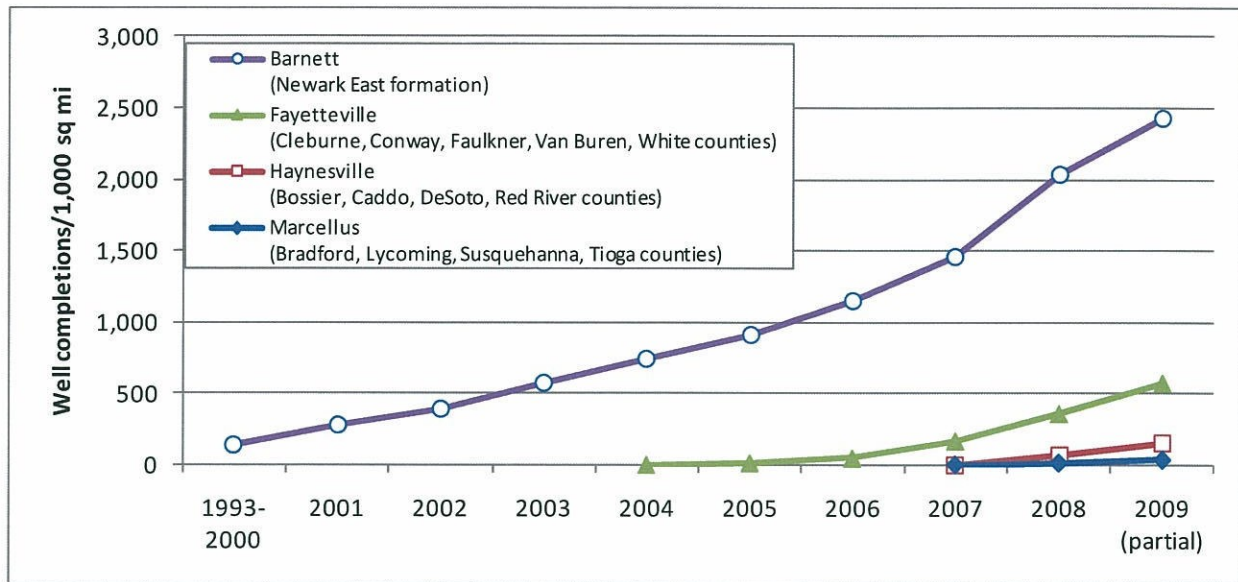


Figure 3-2: Well Density in Comparable Shale Gas Plays (2001-2009)

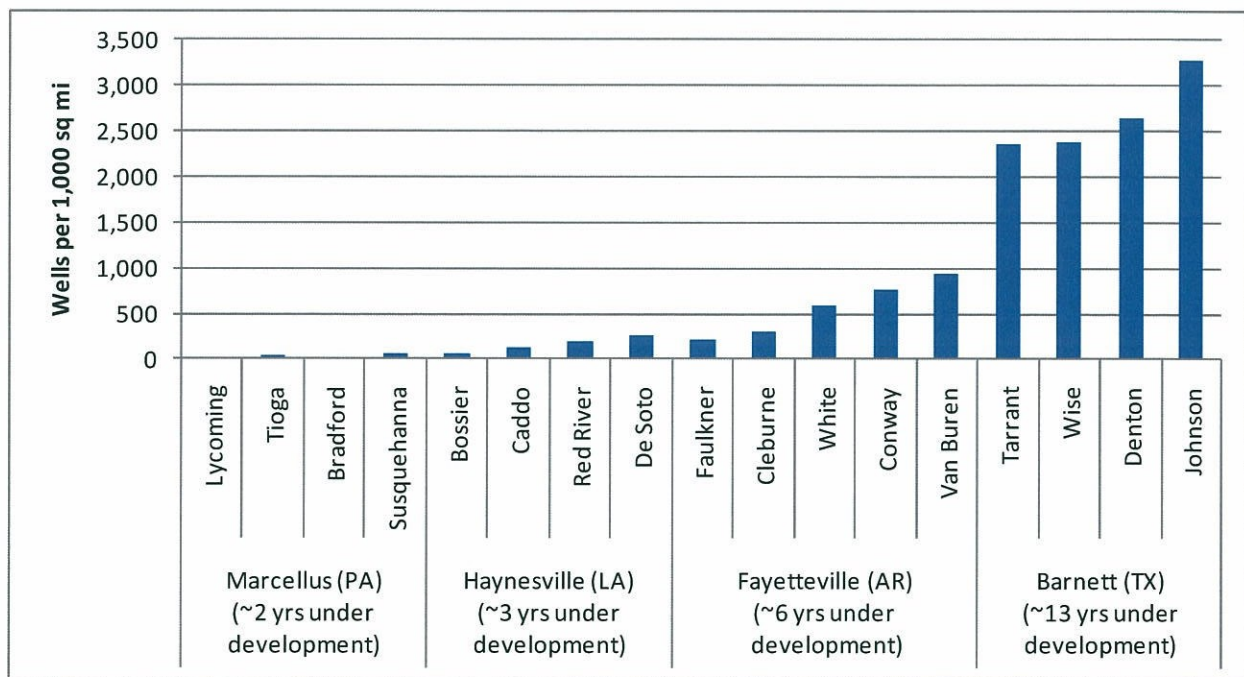


Figure 3-3: Current Well Density in Core Counties of Comparable Shale Gas Plays (2009)

Mapping of natural gas exploration activities in the Marcellus formation in eastern Pennsylvania reveal an accelerating rate of well construction over the two-year period from 2007 to 2009, as shown in Figure 3-4. NYSDEC Notices of Intent to issue well permits in neighboring portions of New York State are also shown. It is reasonable to expect that the pattern and pace of development that could occur in New York State would be similar to that experienced in eastern Pennsylvania. It is important to note that the level of well development shown in the bottom

figure reflects the very early stages of development of the formation, and that a roughly one order of magnitude increase in well density should be anticipated.

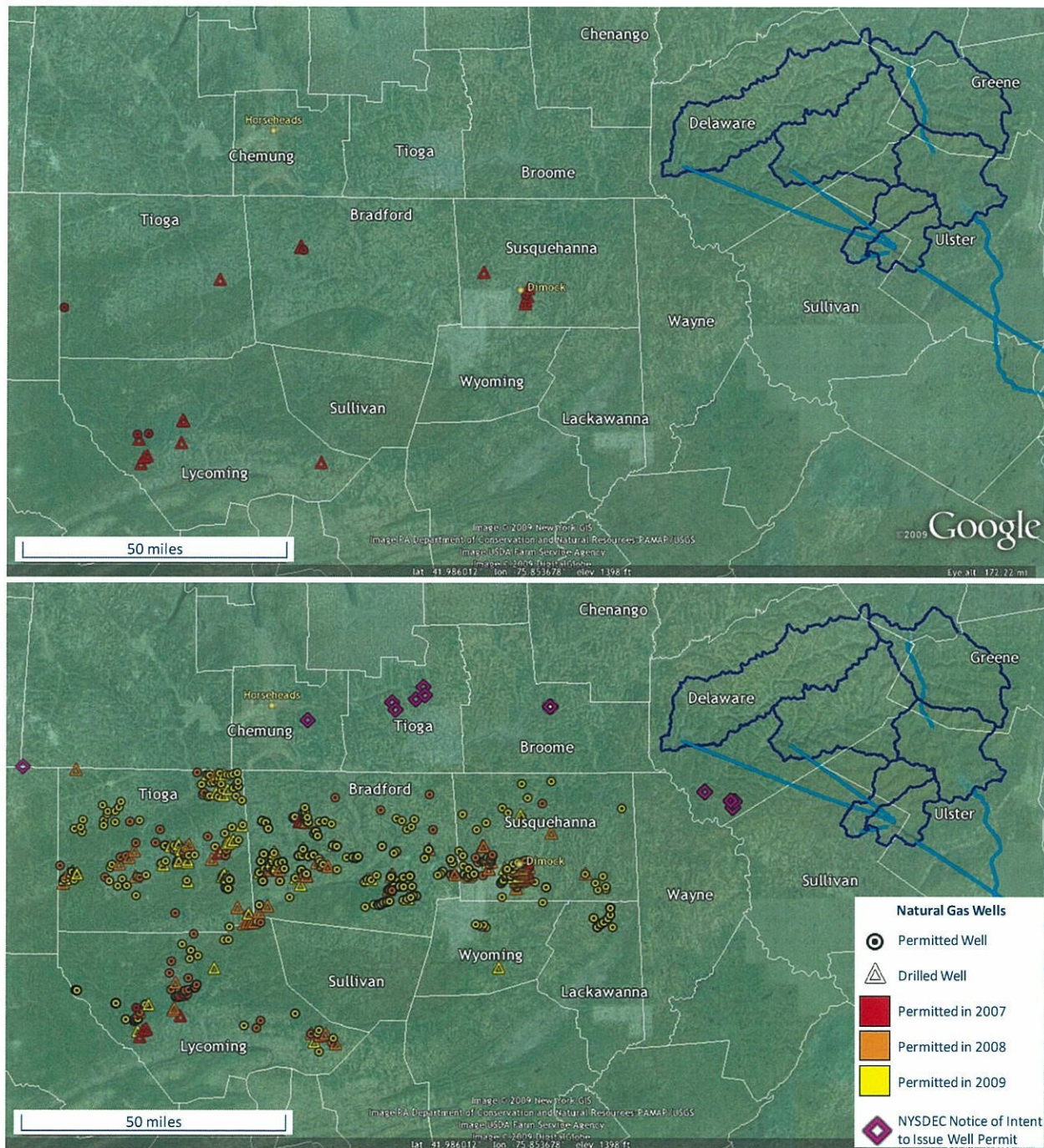


Figure 3-4: Marcellus Formation Gas Well Permitting and Completion in New York and Pennsylvania Core Counties in 2007 (Top) and 2009 (Bottom)¹⁶

¹⁶ Pennsylvania Department of Environmental Protection Well Data as of 9/30/09 (<http://www.dep.state.pa.us/dep/deputate/minres/oilgas/RIG09.htm>, accessed 10/21/09). NYSDEC data on Notices

Rates of natural gas well development in the comparable major shale gas formations provides the basis for the scenarios presented in Table 3-2 and are consistent with well development patterns observed to date. Therefore, the scenarios provided are reasonable for estimating potential impacts within the NYC watershed even though the actual rate of development is uncertain due to numerous factors, including natural gas prices, regional economic conditions, State regulations, and formation productivity.

Table 3-2: Annual Natural Gas Development Scenarios

Rate Scenario	Average Annual Well Completions per 1,000 Square Miles	Description
Low	5 to 20	Drilling rate during the early years of the play as operators refine their understanding of the resource and continue to lease land and apply for permits.
Moderate	100 to 300	Rate of well completion that has been sustained for a number of years in other shale gas plays
High	500, based on well completions (potentially as high as 800, based on permit applications)	Rate of development that could potentially occur in the most profitable areas under favorable conditions (e.g., gas prices are very high).

3.2 Rate and Density of Well Development in the NYC Watershed

To calculate the total number of wells that could be developed in the NYC watershed, an average well density was estimated and then applied across the total developable area within the watershed.

In estimating the developable area within the watershed, state forest preserve area¹⁷ and lands controlled by NYC through ownership and conservation easements (shown in Figure 3-5 and Figure 3-6) were excluded.¹⁸ The remaining “uncontrolled” area (1,076 square miles, or 68 percent of the watershed) was then assumed to be between 50 and 100 percent developable. This range of development is consistent with other nearby areas of the Marcellus formation region, such as Bradford County, which has experienced mineral leasing of nearly 85 percent of the total county land area. The resulting estimate of the land area in the NYC watershed available for natural gas development is thus on the order of 500 to 1,000 square miles.

Although New York regulations allow up to 16 wells per square mile, the dSGEIS indicates a lower density, approximately six to nine wells per square mile, is more likely. This estimate is corroborated by recent permit applications in Sullivan County, which are based on five to six wells per square mile.¹⁹ Well densities to date in excess of three wells per square mile over areas comparable in size to the NYC watershed have been documented in other shale gas plays with significantly higher localized densities (e.g., Denton County, TX has a well density of 5.5 wells

of Intent to Issue Well Permits in Spacing Units Which Conform to Statewide Spacing in New York State as of 10/26/2009 (http://www.dec.ny.gov/dmndata/Well_Reports/Unit_Spacing_SW_Rpt.html, accessed 10/27/2009)

¹⁷ The estimates of State forest preserve land in Figure 3-6 only include land in the Catskill State Forest Preserve, which cannot be leased or sold without a constitutional amendment. The estimates do not include other state land in the NYC watershed which is not afforded a similar level of protection.

¹⁸ Compulsory integration may bring peripheral areas of NYC-controlled or state lands under development.

¹⁹ NYSDEC. 2009. *Notices of intent to issue well permits in spacing units which conform to statewide spacing in New York state.* (http://www.dec.ny.gov/dmndata/Well_Reports/Unit_Spacing_SW_Rpt.html, accessed 9/2/09).

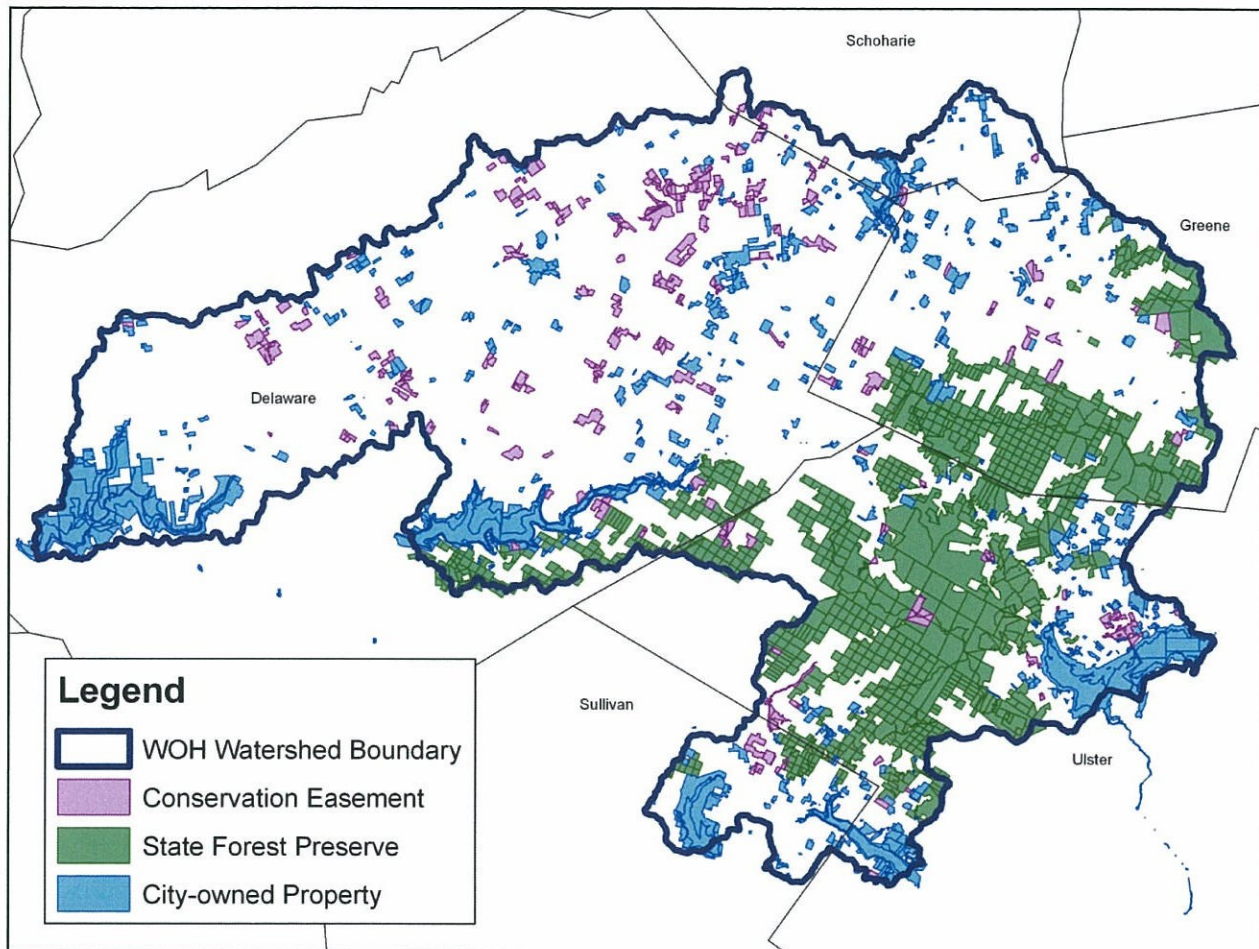


Figure 3-5: NYC West-of-Hudson Watershed Land Ownership (April 2009)

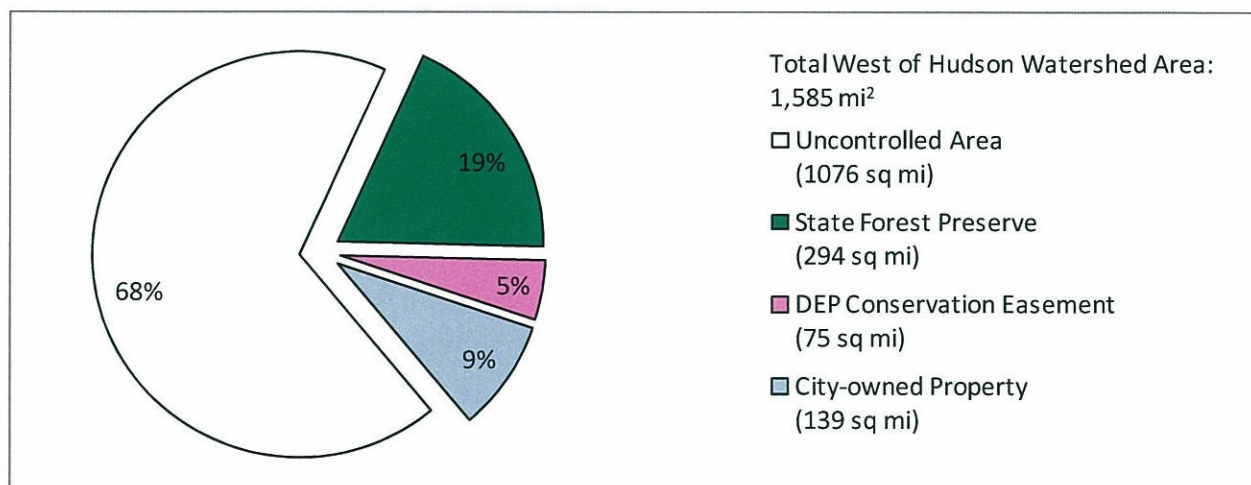


Figure 3-6: Ownership Status of West-of-Hudson Watershed Land (April 2009)

per square mile over approximately 400 square miles [40 percent] of the county area). It has not been established that these areas have been completely developed so still higher densities are possible. Similarly, annual well completion rates in excess of five wells per square mile have been documented, and permit applications suggest that these rates could be higher also. Given the available data, a working estimate of six wells per square mile over the developable area within the watershed is reasonable.

At six wells per square mile, and assuming that 50 to 100 percent of the currently uncontrolled land is ultimately developed, it is estimated that on the order of 3,000 to 6,000 wells could potentially be drilled in the watershed. This estimate is based on the best available data on industry intent for developing the resource in conformance with New York state regulations at this time, and presents a range of development within the watershed that is consistent with that observed in comparable plays.

3.3 Summary

Reasonably foreseeable natural gas well development scenarios for the NYC watershed can be calculated based on experience in comparable formations. Annual well completion rates would likely be 5 to 20 wells per year initially, but could accelerate rapidly under favorable economic and regulatory conditions, averaging 100 to 300 wells per year, and potentially peaking at 500 wells per year. Consistent with NYSDEC spacing unit requirements and development in other formations, it is estimated that between 3,000 and 6,000 wells could ultimately be drilled and fractured in the NYC watershed. This does not include re-fracturing of the same wells, nor does it include drilling and fracturing of wells to tap natural gas in the Utica, Oriskany, or Trenton/Black River formations underlying the NYC watershed.

