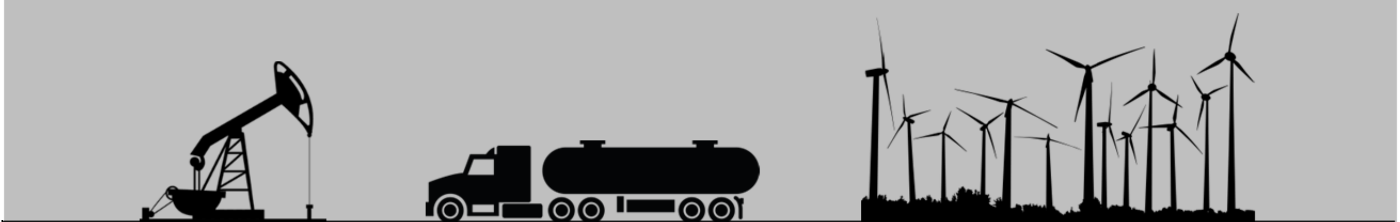
Descriptive Statistics and Well County Maps

Implementation Report IR-16-01



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INTRODUCTION

Energy developments that rely on horizontal drilling and hydraulic fracturing (also called fracking) technologies generate enormous amounts of truck traffic on state, county, and local roads. Quantifying the number of truck trips and resulting 18-kip equivalent single axle loads (ESALs) associated with the development and operation of oil and gas wells is a critical requirement for designing and maintaining pavement structures on energy sector roads. However, this is not enough. In order to implement roadway design, construction, and maintenance plans in energy sector areas, it is also necessary to document the location, number, and characteristics of existing and planned well developments.

This report includes relevant descriptive statistics that document locations and trends of oil and gas energy developments in the state. It also describes a methodology to prepare maps showing existing and permitted oil and gas wells at the county level, and provides a link to 120 county maps documenting these developments in the Barnett Shale, Eagle Ford Shale, and Permian Basin regions. These maps can be used for a variety of applications, including, but not limited to, documenting historical well development locations and trends as well as preparing short-term and mid-term energy development predictions.

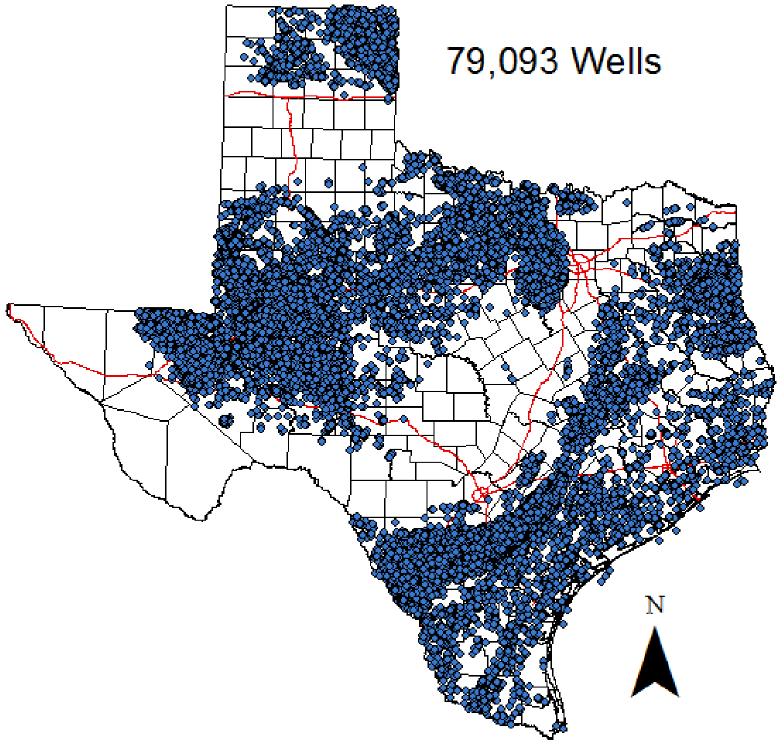
DESCRIPTIVE STATISTICS

Texas A&M Transportation Institute (TTI) researchers gathered and processed data from the Railroad Commission of Texas (RRC) to document locations and trends of oil and gas energy developments in the state. The outcome of this task was a geodatabase of oil and gas developments, which included geographic information system (GIS) files of oil and gas permit locations as well as drilling permit attribute data. This database enabled the production of tables, figures, and maps to document locations and trends of oil and gas energy developments in the state. A complete description of these products is available in Research Reports RR-15-01 and RR-16-01. As an illustration, this report includes the following maps:

- Figure 1 shows the location of 79,093 completed oil and gas wells from 2010-2015. The figure also shows the location of 21,420 uncompleted oil and gas wells with active drilling permits as of December 31, 2015, which provide an indication of the locations where drilling is highly likely to occur in the near future provided oil and gas prices are favorable.

- Figure 2 shows the cumulative number of horizontal oil and gas wells by county from 2010-2015.

Completed Wells from 2010-2015



Active Permits as of December 2015

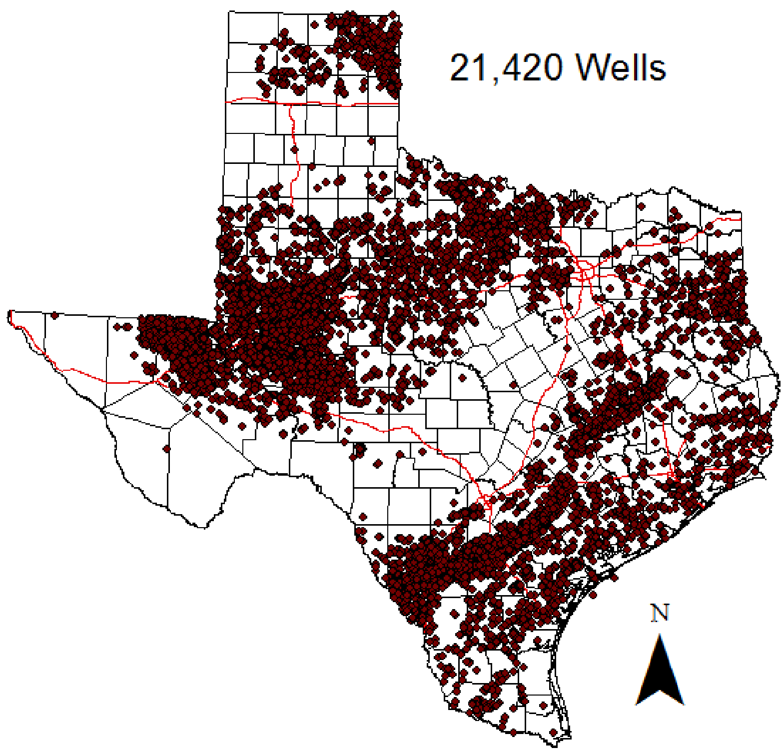
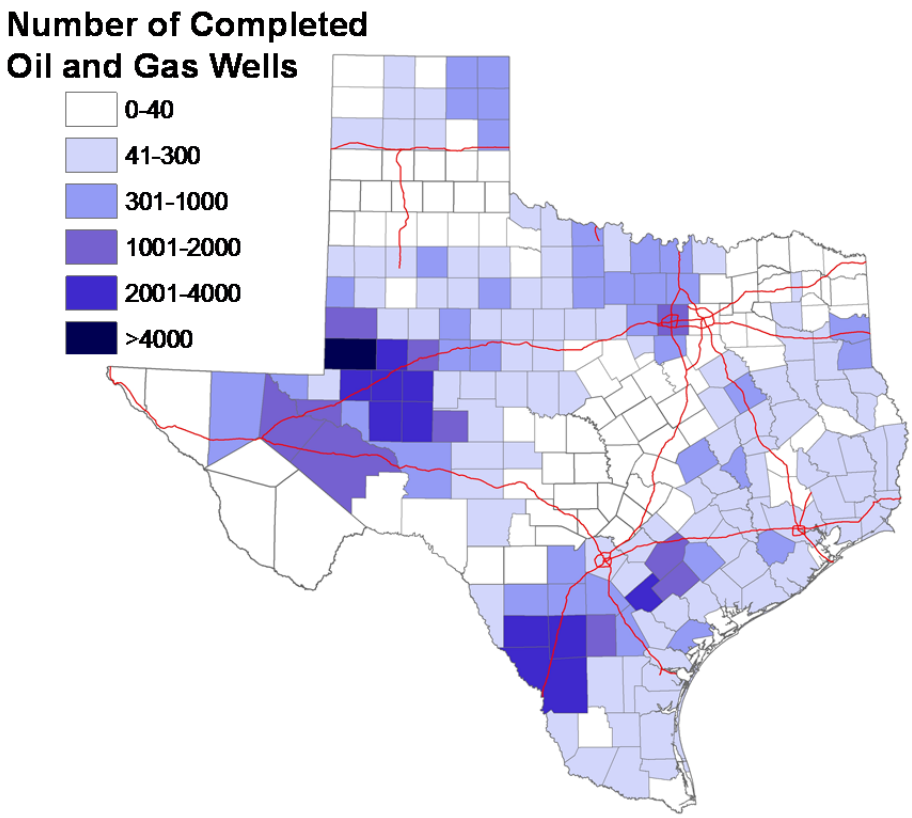


Figure 1. Oil and Gas Wells in Texas (2010–2015).

All Wells



Horizontal Wells

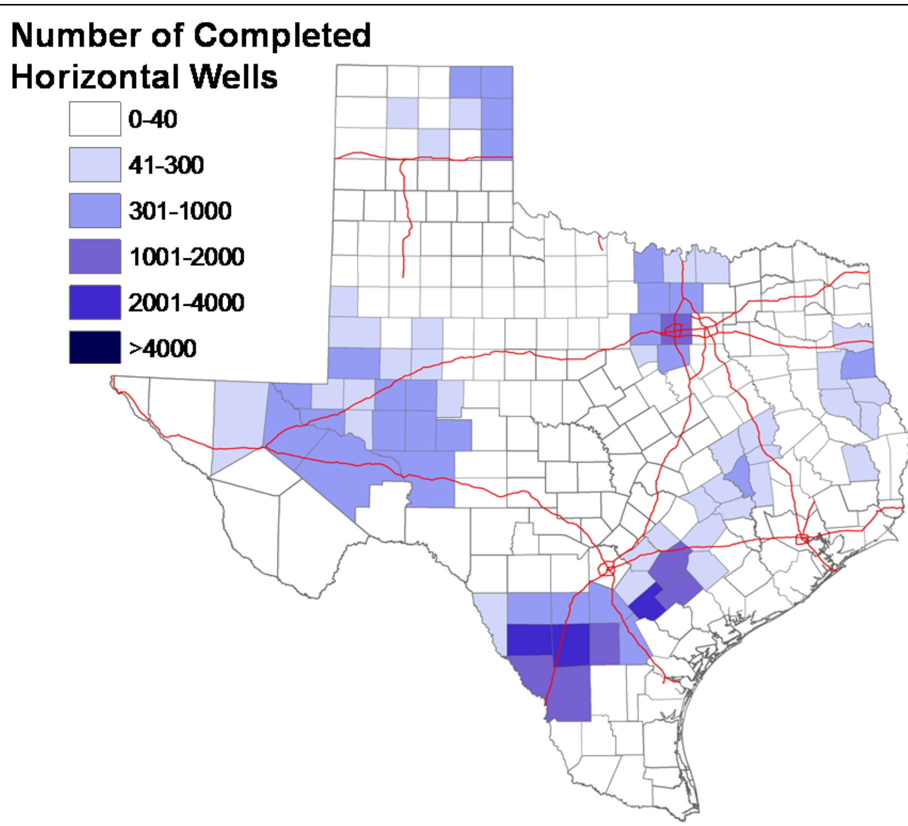


Figure 2. Cumulative Number of Oil and Gas Wells (2010-2015).

Figure 3 shows the number of permitted oil and gas wells from 1977-2015. Figure 4 shows the number of oil and gas wells completed during the same period. Both figures account for "surface" and "bottom" wells, according to the nomenclature that the Railroad Commission uses. Generally speaking, a "surface" well corresponds to the location of a wellhead (in the case of vertical wells) or a placeholder for all the wellheads that are connected to horizontal wells at the same pad location, all of which share the same American Petroleum Institute (API) number. For vertical wells, the relationship between "surface" well and "bottom" well locations is one-to-one. For horizontal wells, the relationship can be one-to-one (if there is only one lateral) or, increasingly, one-to-many. In 2015, for the first time, the number of new horizontal wells was higher than the number of new vertical wells. Industry insiders anticipate the number of new horizontal wells to continue to grow at a higher rate than the number of new vertical wells.

Some of the reported RRC data from 2015 may be incomplete and therefore are not as reliable as data from previous years. The reason is the lag between when certain events occur and when RRC updates the corresponding database records. For example, there is lag between the date that an operator completes a well, the date the operator submits the completion report to the Railroad Commission, and the date the RRC database officially registers a well as completed and ready for production. Although the Railroad Commission has allowed operators to submit completion reports online since February 2011, the completion date lag causes the inventory of completed wells to lag behind the actual number of completed wells in the field.

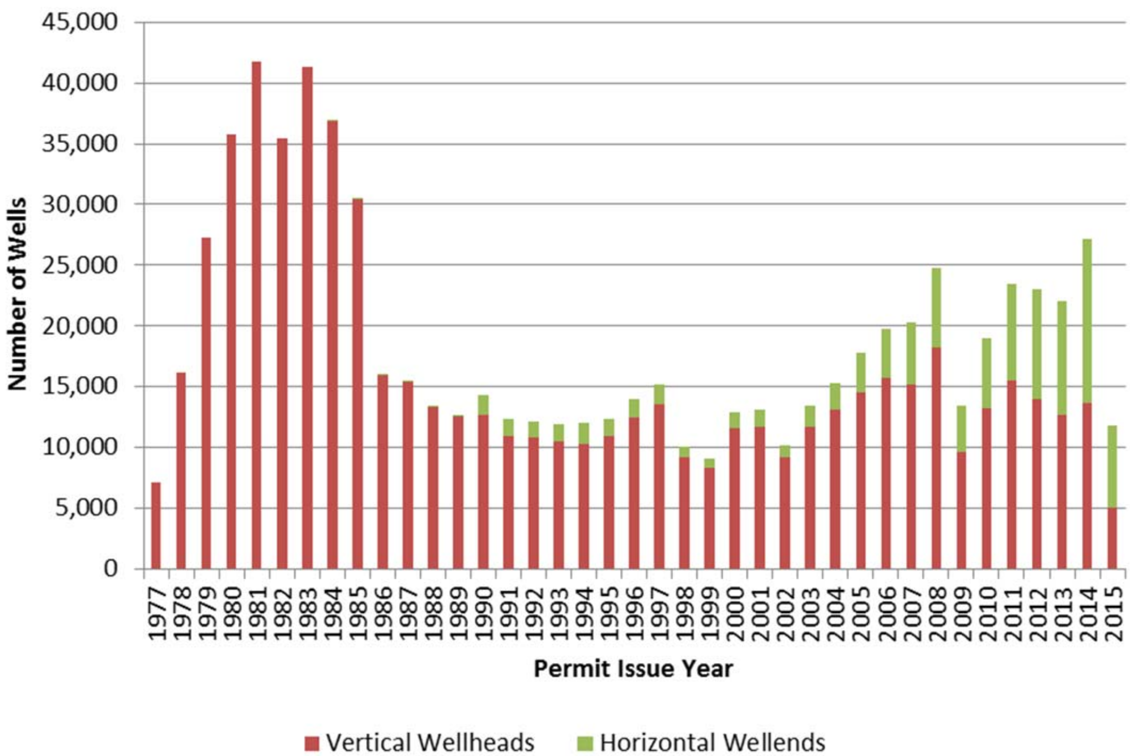


Figure 3. Oil and Gas Wells Permitted in Texas.

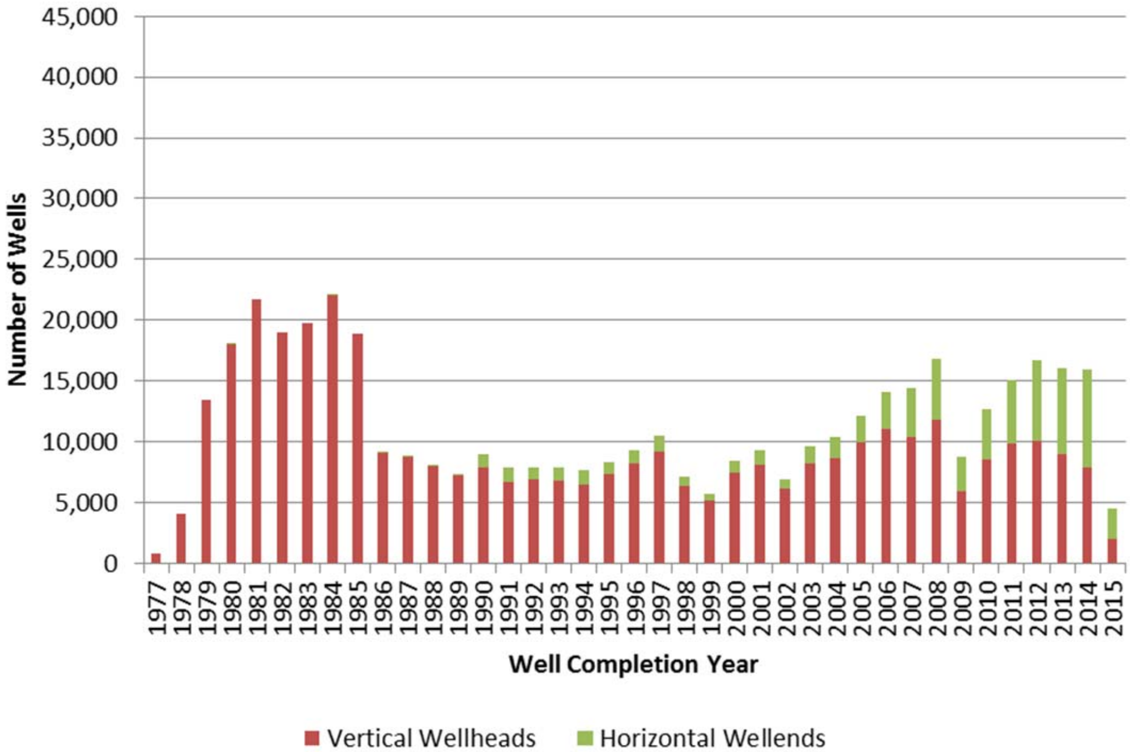


Figure 4. Oil and Gas Wells Completed in Texas.

The number of permitted or completed wells per year was very high in the late 1980s and early 1980s, consistent with a period of time when oil prices were also high. An oversupply of oil that followed caused a significant reduction in oil prices in the mid-1980s, which caused a corresponding reduction in the number of wells drilled. The number of wells began to increase substantially again in the early to mid-2000s, thanks to increases in the price of oil and gas, as well as advancements in drilling technology, mainly in connection with the combined use of horizontal drilling and 'slickwater' hydraulic fracturing. Oil production increased as a result. However, in 2015, oversupply of oil in the world market caused a collapse in oil prices, which, in turn, triggered a substantial decrease in the number of permitted wells. The U.S. Energy Information Administration (EIA) anticipates the price of crude oil to remain roughly unchanged between \$40-\$50/barrel through the end of 2017.

The amount of time needed to develop wells is increasing. As Figure 5 shows, the median duration between permit approval and well completion increased from about one month in 1977 to almost three months in 2014. The mean duration increased from a month and a half in 1977 to more than four months in 2014. There was also a significant increase in the median and mean durations from 2014 to 2015, which is consistent with a recent trend reported in the mass media about energy developers drilling wells but not immediately fracking those wells until oil prices become more favorable. Figure 5 also shows the 10^{th} and 90^{th} percentile durations. In particular, the 90^{th} percentile duration increased from approximately three months in 1977 to more than ten months in 2015. The volatility of this duration is probably associated with uncertainties that some individual operators experience, e.g., delays in drilling equipment deliveries or truck shortages.

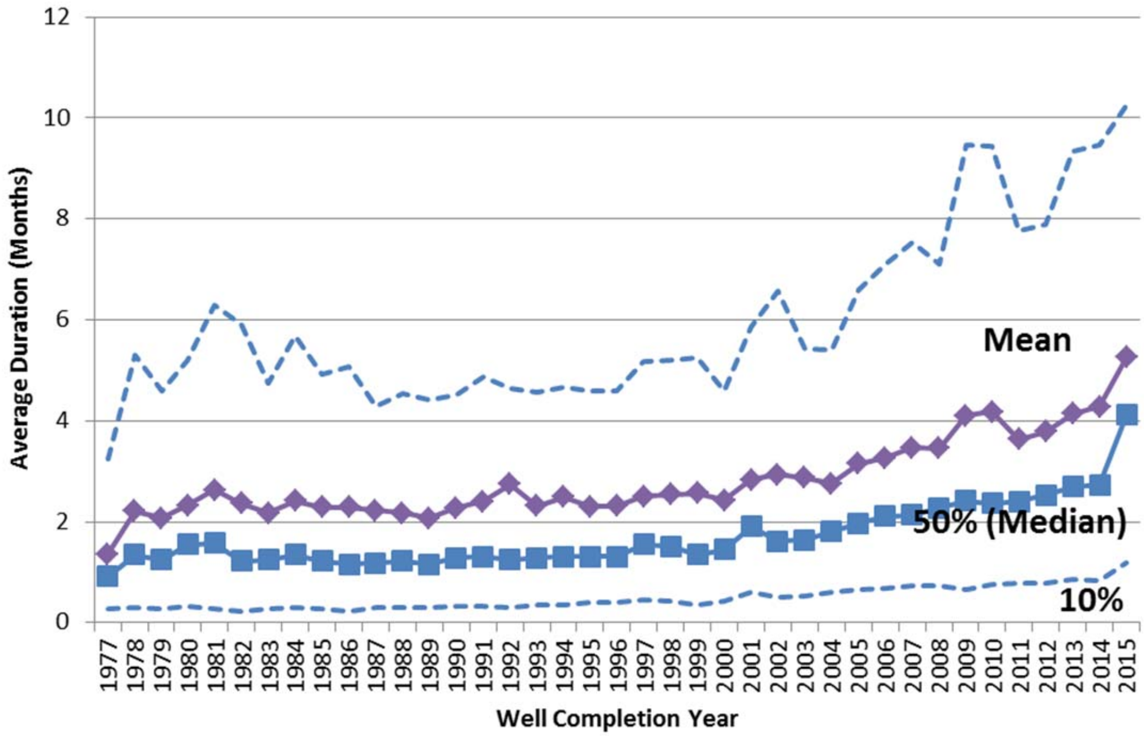
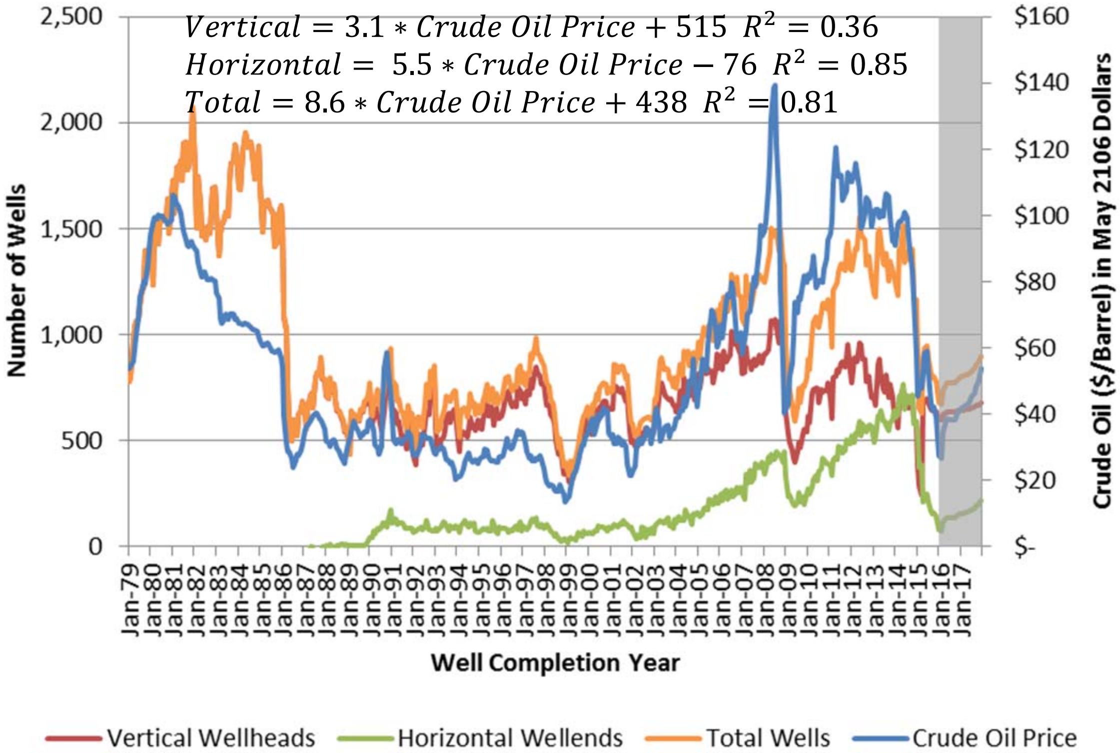


Figure 5. Duration between Permit Approval and Well Completion.

By combining EIA monthly crude oil price data with RRC well completion data, it is possible to estimate drilling activity as a function of crude oil price. Figure 6 shows the number of completed vertical wellheads, horizontal wellends, and total wells per month compared to the average monthly price of crude oil (adjusted to May 2016 dollars).

There is a strong correlation between the price of crude oil and the number of completed wells. The correlation is stronger for horizontal wellends than for vertical wellheads, and it is the highest after introducing a "lag" effect of three months (to account for the time it might take for energy developers to react to changes in oil prices). All correlations are positive, meaning that if the price of crude oil increases the number of wells completed increases and vice versa. Based on this information, TTI used a statewide linear regression model to estimate the number of completed wells as a function of the price of crude oil. Figure 6 shows the corresponding linear regression equations. Additional linear regression models can be prepared for individual regions (e.g., Eagle Ford Shale and Permian Basin) or for individual counties. The strength of the correlation varies depending on the geographic level considered. Research Report RR-16-01 provides additional information on this topic.



Note: The regression analysis period covered years 1990 through 2014.

Figure 6. Number of Completed Wells as a Function of Crude Oil Prices.

COUNTY MAPS

The geodatabase of oil and gas developments, which included GIS files of oil and gas permit locations as well as drilling permit attribute data, enabled the production of a wide range of maps to document locations and trends of oil and gas energy developments in the state. With the exception of the GIS files, processing the data involved activities, such as, but not limited to, processing the oil/gas production oracle data dump file, processing oil and gas master files, processing drilling permit master files, and processing the underground injection control file. As an illustration of the types of maps that are possible with the geodatabase, Figure 7 shows a map of completed wells in the Eagle Ford Shale region. Figure 8 shows a map of completed wells in Karnes County, with color codes representing the top oil well operators in the county. The figure shows both wellhead and horizontal drilling locations. Other types of maps, e.g., the county shaded maps shown in Figure 2, are also possible using the geodatabase.

TTI also prepared maps for each county located in the Barnett Shale region, Eagle Ford Shale region, and Permian Basin region. In total, 120 county maps in portable document format (PDF) were prepared. As an illustration, Figure 9 depicts the locations of the wellheads, wellends, and directional wells in Karnes County. The maps include completed wells, expired wells, and wells that are not expired and not completed as of December 31, 2015. The maps are accessible online at https://txdot.sharepoint.com/sites/division-MNT/SitePages/Home.aspx.

To facilitate user understanding of the data, each PDF file contains layers that can be turned on or off, each layer representing a specific type of information, as shown in Figure 10. The layers panel is visible on the left side of the document. By clicking the eye next to each layer, the layers may be turned off or on. Completed wells are grouped by completion year as classified by the Railroad Commission. Not completed and not expired wells are shown individually. Several background layers are included in the maps, such as the roadways, railroads, pipelines, county lines, city limits, and geological formations. The labels for county, city, and major roadway names may be turned off and on from the layer panel. Energy Sector Brief ESB-16-16 provides additional instructions and information on how to use the maps.

The maps could be used for a variety of applications. For example, a comparison between completed wells in 2014 and 2015, and permitted (non-completed) wells (see Figure 11), along with a regression prediction model, could be used to develop estimates of the approximate location (at the county level) where a certain number of wells are likely to be developed in the short-term, say, within a year.

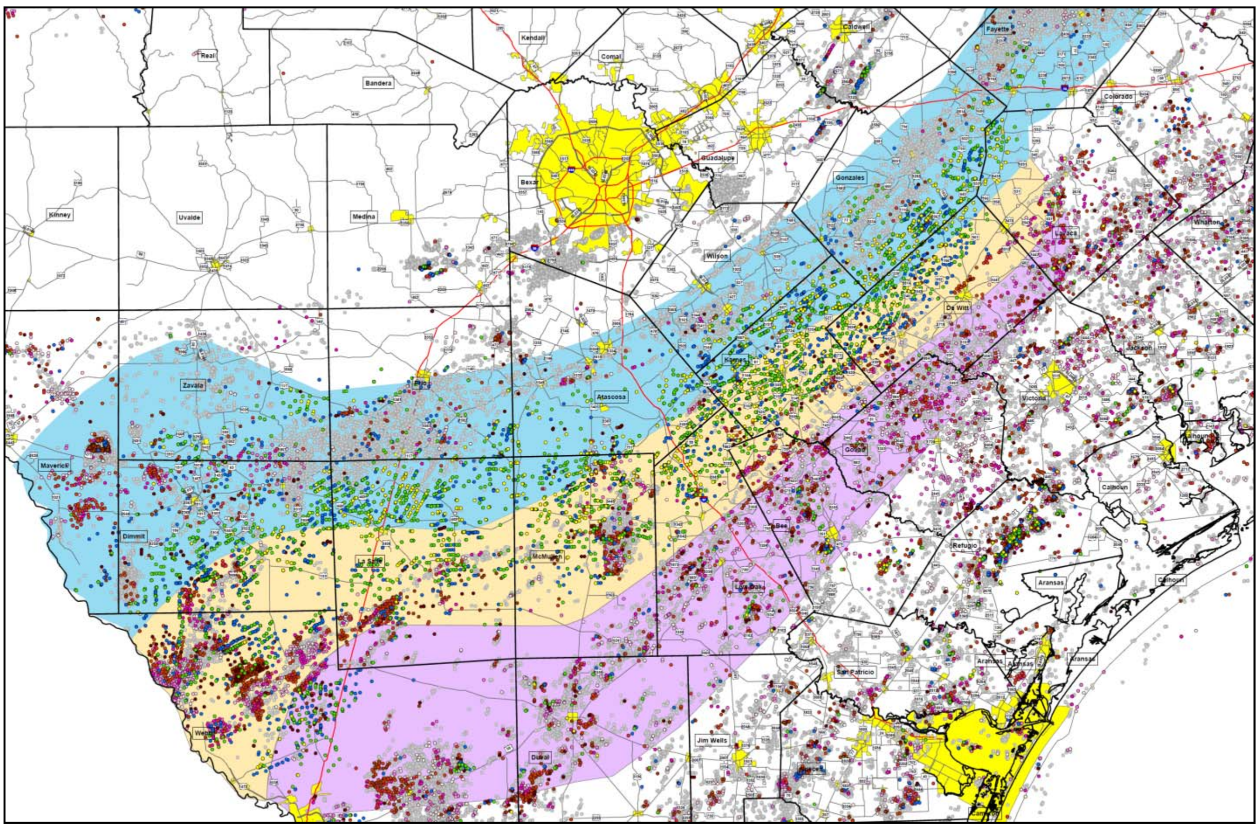


Figure 7. Map of Completed Wells in the Eagle Ford Shale Region.

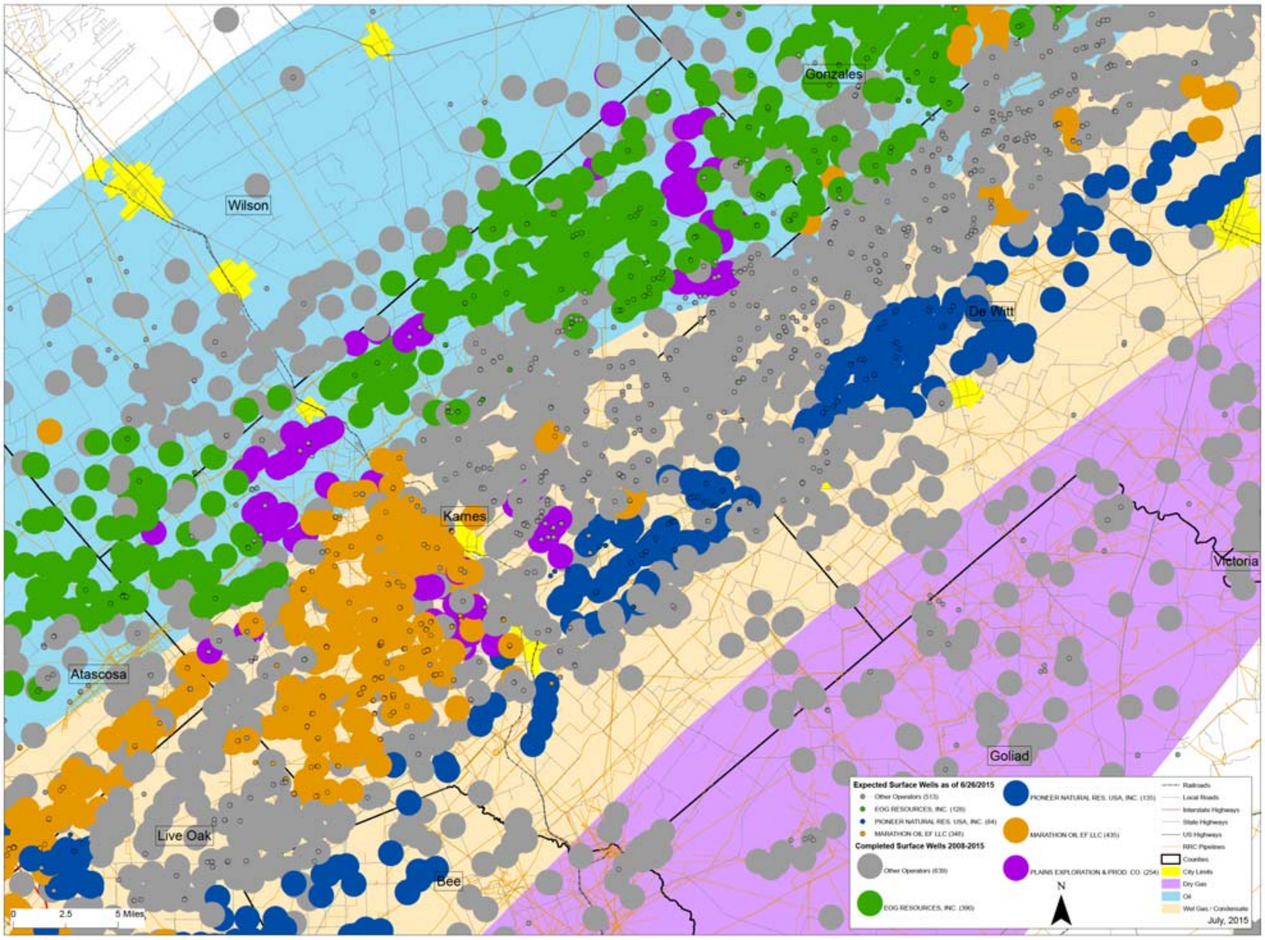


Figure 8. Wells Completed in Karnes County – Color Coded by Top Producers.

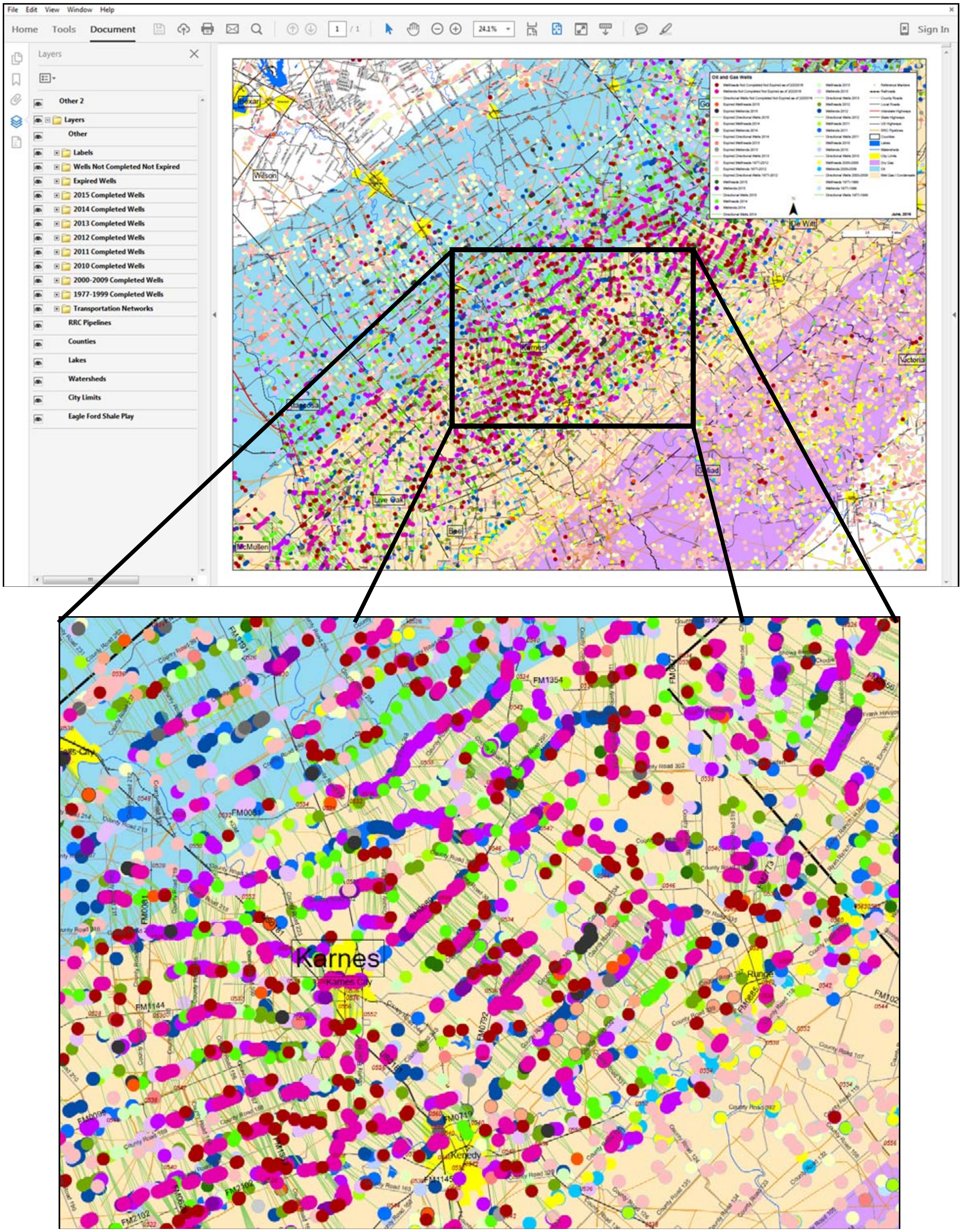


Figure 9. PDF Map Document for Karnes County with Layers.

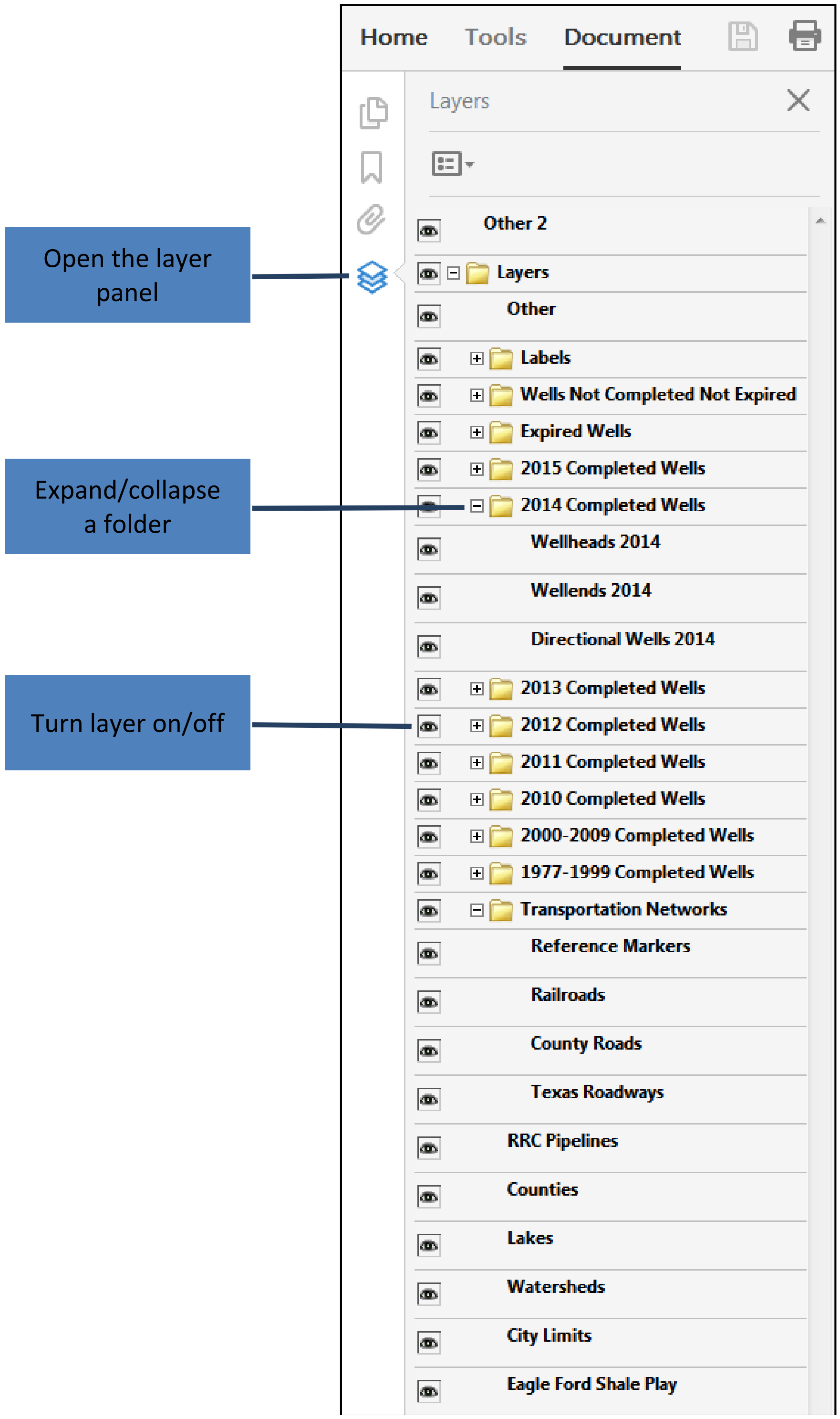
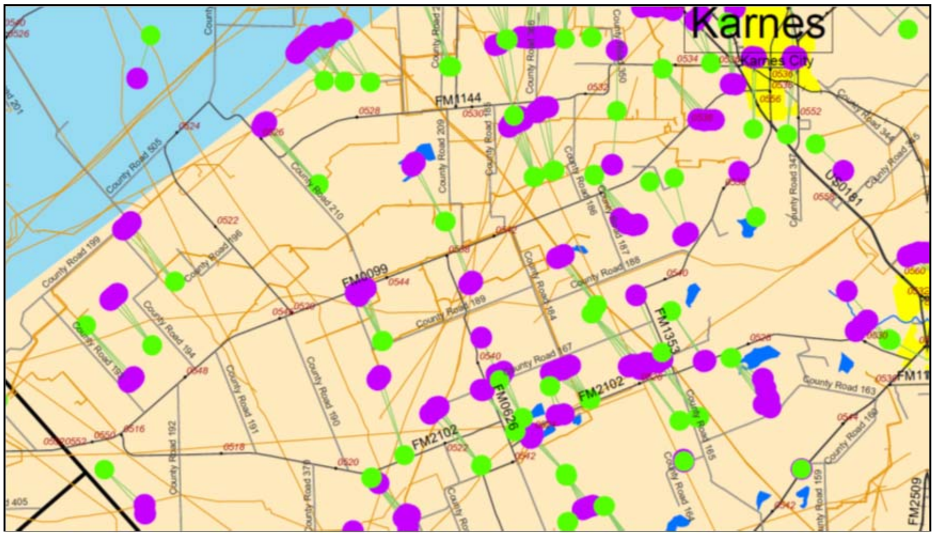
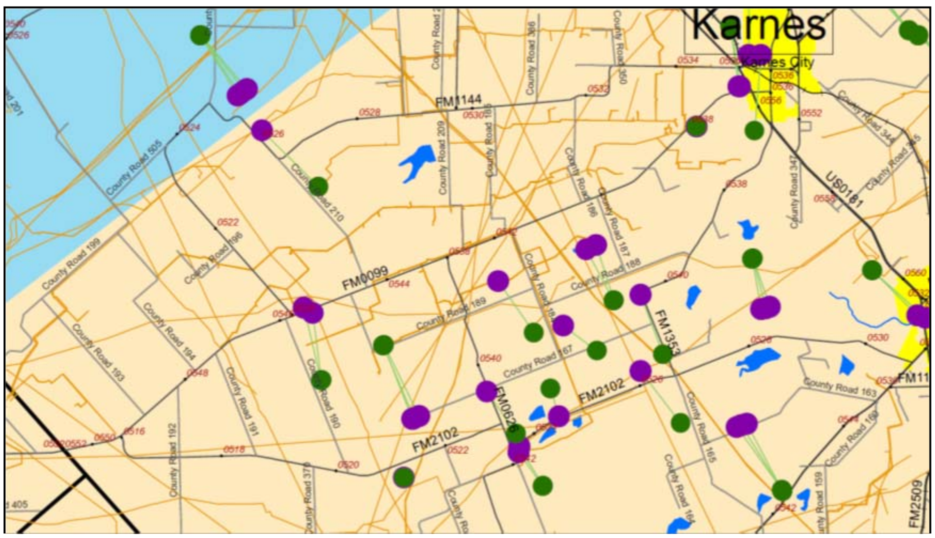


Figure 10. PDF Map Layer Menu.

Completed Wells in 2014



Completed wells in 2015



Permitted (non-completed) wells as of December 2015

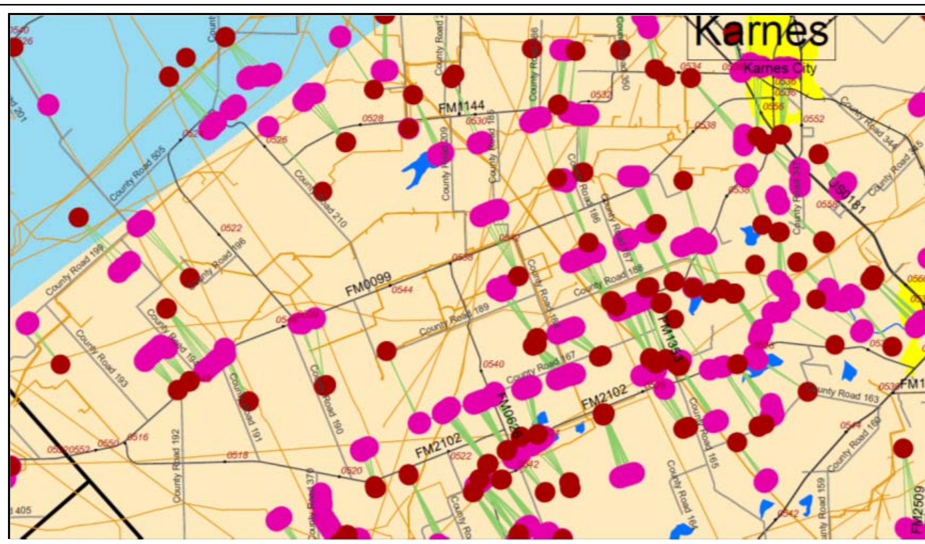


Figure 11. Comparison between Completed Wells in 2014, Completed Wells in 2015, and Permitted (non-Completed) Wells.