Traffic Loads for Developing and Operating Individual Wells

Implementation Report IR-16-03

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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. Secondary roads, in particular, were never designed to carry such high truck traffic volumes and heavy loads. The result has been accelerated degradation of pavements and roadside infrastructure, as well as increases in congestion and crash and fatality rates.

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. This report describes a methodology to determine truckloads (more specifically ESALs) in connection with the development and operation of a typical horizontal, hydraulically-fracked oil or gas well in the Eagle Ford Shale, Permian Basin, and Barnett Shale regions. Along with the results of an analysis of the anticipated number of wells that will use specific corridors in each of these regions, maintenance engineers and supervisors can use the ESAL estimates to design flexible pavements along those corridors.

PROCESS TO DETERMINE TRUCKLOADS

The general process to determine truckloads (more specifically ESALs) in connection with the development and operation of typical horizontal, hydraulically-fracked oil and gas wells in the Eagle Ford Shale, Permian Basin, and Barnett Shale regions of the state involved the following sets of activities:

- Determine well development and operation phases and activities. Well development involves pad preparation, drilling, and hydraulic fracturing. Well operation involves the continuous extraction of hydrocarbon products (oil, condensate, and/or gas) and water. Well operation also includes various maintenance activities. One such activity is re-fracking, which, if it happens, might conceivably occur at various times during the lifetime of a well. For the analysis, the researchers assumed that all oil and condensate production is moved by truck from a well to a designated truck off-load facility and all gas production is transported by pipeline.

- Determine the number of trucks per well phase activity, from pad construction to drilling, fracking, and operation of a typical well over a 20-year period. The industry did not provide meaningful information. As a result, it became necessary to estimate truck volumes by relying on a literature review from around the country as well as information gathered by TxDOT officials, well counts and other statistics from the Texas Railroad Commission, and data available from the FracFocus database (for the amount of water, sand, and additives used for fracking operations). Specific analyses and assumptions included the following:

  - Eagle Ford Shale region. The analysis included a review of the ten counties with the highest production of oil and condensate in the region since the energy boom started in 2009 and the corresponding number of regular producing wells. The number of trucks needed to haul the oil and condensate production involved specific assumptions about the proportion of trucks that use a steel tank versus an aluminum tank (see next section). The number of trucks needed to transport produced water involved an analysis of the ratio of injected water to oil and condensate production.

  - Permian Basin area. The analysis included a review of two specific counties (Reeves and Loving) where production from wells developed using unconventional techniques has been particularly high, according to monthly oil production levels per well. This methodology filtered out counties that had higher total production levels, but relied primarily on a myriad of vertical wells that have been developed and operated using traditional techniques.
  - Barnett Shale region. The analysis included a review of the top five gas producing counties in the region and the corresponding volumes of produced water that is injected into the ground (under the assumption that all produced water from a well is transported by truck to a disposal facility within the same county.
  - For all three regions, the number of trucks needed to re-frack a well is the same as the number of wells needed for the initial fracking operation.

- Estimate the axle weight distribution for the truck types used for each phase of well development. Deploying portable weigh-in-motion (WIM) systems in the immediate vicinity of a well under development was not technically or financially feasible. For this reason, an indirect approach was implemented, which relied on WIM readings from the network of permanent WIM stations along major TxDOT corridors and concurrent video data collection at the WIM station locations. The researchers used more than 50,000 sample trucks that were captured via video screenshots and their corresponding WIM readings to develop aggregated axle weight distributions at 1,000-lb intervals. For additional information, refer to Implementation Report IR-16-02 and Energy Sector Brief ESB-16-08.

- Determine a "typical" truck type and truck axle configuration for each well development, production, and re-fracking activity. The video screenshots from the WIM stations enabled the identification of multiple truck types. A frequently analysis was then used to select a prevalent or typical truck axle configuration for each well phase activity. For example, out of 19 different axle configurations for rig trucks in the WIM station video screenshot sample, the most prevalent truck axle configuration was single-single-tridem (with 28 percent of all rig trucks).

- Calculate load equivalency factors (LEFs) for loaded and unloaded axles using industry-standard AASHTO road test equations. For *unloaded* axles, the researchers assumed 5,000 lb for single axles, 14,000 for tandem axles, and 21,000 lb for tridem axles. For *loaded* axle weights of a particular axle type and truck type, the researchers calculated LEFs in 1,000-pound intervals by multiplying the LEF for each weight group with the relative frequency of that weight group and then added all interval LEFs to arrive at an axle type LEF. This calculation only included counts of axle weights larger than the unloaded axle weights given above.

- Select trip load condition (loaded or empty) for each well activity in each well development phase. For example, during well development, the assumption was that drilling rig trucks would arrive loaded and leave loaded, while fracking water trucks would arrive loaded and leave empty.

- Estimate the number of ESALs for each phase. This process involved calculating loaded truck ESALs and empty truck ESALs and adding the ESALS for each well activity to arrive at a total number of ESALs for trips to the well and a total number of ESALs for trips leaving the well.

ASSUMPTIONS

Assumptions behind the calculations to estimate the number of ESALs after the completion of a well included the following:

- All fluids extracted from an oil or gas well are transported by truck from the well to a designated terminal facility. Oil and condensate are transported to a truck off-load terminal facility for transportation via pipeline to a midstream or downstream facility. Overtime, it is reasonable to assume that the industry might build a pipeline network to connect each well directly to the existing pipeline infrastructure, therefore bypassing the roadway infrastructure. However, it is not clear whether this would ever happen and over how many years. For the analysis, the researchers assumed that all oil and condensate are transported by truck to a designated truck off-load terminal facility over the 20-year period of analysis. For gas extraction, the assumption is that all gas is transported by pipeline from the well location.

- All water extracted from a well is transported by truck to a disposal facility where the water is injected into the ground. It is not clear whether the industry would ever build a pipeline network to connect each well to a disposal facility and, if so, at what point. The assumption is that the pipeline network is not built, forcing all the produced water to be transported by truck from the well location. Because of the cost to transport the water, the assumption is that water extracted from a well is hauled a relatively short distance, typically within the same county.

- As wells age, hydrocarbon production decreases. At the same time, the proportion of produced water increases. At this point, it is not clear how the total volume of fluids extracted from the ground (including oil, condensate, and water) would evolve over time. For simplicity, the researchers assumed the total volume to remain approximately constant over time. To develop an estimate, the researchers queried the total oil and condensate production per county from the Railroad Commission database, queried the total amount of water injected into non-productive wells (i.e., disposal wells) from the Railroad Commission database, and then divided the total volume by the number of horizontal wells in the county.

Input variables assumed in the calculations included the following:

- Pavement Structural Number (SN) = 3.0
- Pavement Terminal Serviceability Index (P_t) = 2.5
- Analysis period = 20 years
- Number of re-fracking events per analysis period = 4
- Disposal liquid ratio (or ratio of the volume of disposed water to the volume of oil and condensate):
  - Eagle Ford Shale: 0.26
  - Barnett Shale: Not applicable (most of the hydrocarbon production is gas)
  - Permian Basin: 2.29
- Ratio of steel to aluminum tank trucks = 7:3 (or 2.33)
- Flowback water volume during fracking = 25% of the water used for fracking

RESULTS

Table 1 summarizes the number of trucks needed to develop, operate, and re-frack a well in the Eagle Ford Shale, Barnett Shale, and Permian Basin regions. Table 2 through Table 4 summarize the results of the ESAL calculation analysis for each region.

Table 1. Number of Trucks Needed to Develop, Operate, and Re-Frack a Well.

Well Development	**Number of Trucks**		
	Barnett Shale	**Eagle Ford Shale**	**Permian Basin**
Drilling pad and construction equipment	70	70	70
Drilling rig	4	4	4
Drilling fluid and materials	59	59	59
Drilling equipment: casing, drilling pipe	54	54	54
Fracking equipment: pump trucks, tanks	74	74	74
Fracking water:	533	1,021	527
Fracking water (steel tank)	373	715	369
Fracking water (aluminum tank)	160	306	158
Fracking sand:	57	147	66
Fracking sand (steel tank)	40	103	46
Fracking sand (aluminum tank)	17	44	20
Other additives/fluids etc.	4	24	11
Flowback water removal	133	255	132
Total	**988**	**1,708**	**997**

Well Production Activity	**Number of Trucks per Year**		
	Barnett Shale	**Eagle Ford Shale**	**Permian Basin**
Produced water (steel tank)	41	65	181
Produced water (aluminum tank)	14	22	62
Oil production (steel tank)	8	249	79
Oil production (aluminum tank)	3	83	27
Total	**66**	**418**	**349**

Well Re-Fracking Activity	**Number of Trucks per Event**		
	Barnett Shale	**Eagle Ford Shale**	**Permian Basin**
Fracking equipment: pump trucks, tanks	74	74	74
Fracking water (steel tank)	373	715	369
Fracking water (aluminum tank)	160	306	158
Fracking sand (steel tank)	40	103	46
Fracking sand (aluminum tank)	17	44	20
Other additives and fluids	4	24	11
Flowback water removal	133	255	132
Total	**801**	**1,515**	**810**

Table 2. Number of Trucks and ESALs per Well (Barnett Shale Region).

Item	Development	Production		Re-Fracking		Total
		Per Year	Total	Per Event	Total	
Number of trucks	988	66	1,320	801	3,205	5,513
ESALs (trip to well)	1,363	5	98	1,070	4,281	5,742
ESALs (trip from well)	474	93	1,864	423	1,694	4,031

Table 3. Number of Trucks and ESALs per Well (Eagle Ford Shale Region).

Item	Development	Production		Re-Fracking		Total
		Per Year	Total	Per Event	Total	
Number of trucks	1,708	418	8,366	1,521	6,085	16,160
ESALs (trip to well)	2,261	31	625	1,968	7,871	10,757
ESALs (trip from well)	689	591	11,815	639	2,555	15,059

Table 4. Number of Trucks and ESALs per Well (Permian Basin Region).

Item	Development	Production		Re-Fracking		Total
		Per Year	Total	Per Event	Total	
Number of trucks	997	349	6,975	810	3,239	11,211
ESALs (trip to well)	1,381	26	519	1,089	4,354	6,254
ESALs (trip from well)	472	492	9,850	422	1,689	12,011

Overall, the results indicate the following:

- The total number of trucks per well over a 20-year period in the Eagle Ford Shale region is almost three times as high as in the Barnett Shale region and almost 50% higher than in the Permian Basin region. One of the reasons is that wells in the Eagle Ford Shale region are using considerably more water and sand than in the other two regions. In addition, hydrocarbon production in the Eagle Ford Shale region is primarily oil and condensate (requiring truck transportation to an off-loading facility), whereas in the Barnett Shale, hydrocarbon production is mainly dry gas (and the assumption is that all this gas is transported by pipeline). With respect to the Permian Basin region, wells

- Although the number of re-fracking events over 20 years is unknown, the anticipated impact is that, all other things being equal, the number of trucks needed to re-frack a well in the Eagle Ford Shale region would be higher than in the Barnett Shale or Permian Basin regions. The reason, as mentioned above, is that the amount of water and sand needed to frack a well in the Eagle Ford Shale region is higher than in the other two regions.

- For both the Eagle Ford Shale and Permian Basin regions, the number of ESALs for trips leaving the well over 20 years is considerable higher than the corresponding number of ESALs for trips going to the well. The reason is the cumulative effect of operating the well over 20 years (more specifically by transportation oil and condensate by truck). By comparison, in the Barnett Shale region, the cumulative effect of operating the well is relatively minor, by re-fracking would have the highest impact on the number of ESALs.

HOW TO USE THE EXCEL TEMPLATE TO CALCULATE TRUCKLOADS

An Excel spreadsheet template enables users to calculate the following for each well:

- Total number of trucks needed by phase activity and analysis period.
- Total amount of ESALs for trips to the well by phase activity and analysis period.
- Total amount of ESALs for trips leaving the well by phase activity and analysis period.

The spreadsheet calculates these values based on inputs the user provides in various places of the spreadsheet, as shown in the red cells in Table 5 and Table 6. Once all the cells shaded in red are populated, the spreadsheet calculates the number of trucks and ESALs per well for the selected analysis period, both for trips to the well and trips leaving the well, as show in Table 7. If needed for further analysis, the Excel file also includes all the data and details used for the calculations.

Table 5. Input Parameters to Determine Number of Trucks and ESALs.

Input	
Pavement Structural Number (**SN**) =	3.0
Pavement Terminal Serviceability Index (**P_t**) =	2.5
Analysis Period (Years) =	20
Number of Re-Fracking Events per Analysis Period =	4
Disposal Liquid Ratio =	0.26
Ratio of Steel to Aluminum Tank Trucks =	2.33
Flowback water ratio =	0.25
Truck Volume per Well Assumption	TxDOT 2014, Eagle Ford Shale, and FracFocus

The pavement structural number and terminal serviceability index are flexible pavement design parameters that affect the calculation of load equivalency factors.

The analysis period covers the development, operation, and maintenance phases of an oil or gas well for pavement design purposes. A well could operate past the analysis period.

The number of re-fracking events per analysis period represents the number of times a well is re-fracked during the analysis period.

The disposal liquid ratio represents the ratio of produced water to oil and condensate (by volume), which must be transported by truck to a disposal facility.

The ratio of steel to aluminum tank trucks is the ratio of the number of steel tank trucks to the number of aluminum tank trucks.

The flowback water ratio is the ratio of the volume of water recovered to the volume of water injected during fracking.

Table 6. Trucks Needed to Develop, Operate, and Maintain a Well (Note: Users populate cells in red; other cells are calculated automatically).

Trucks Needed to Develop and Complete a Well	
Well Development Activity	**Truck Volume (per Well)**
Drilling pad and construction equipment	70
Drilling rig	4
Drilling fluid and materials	59
Drilling equipment: casing, drilling pipe	54
Fracking equipment: pump trucks, tanks	74
Fracking water	1,021
Fracking water (steel tank)	715
Fracking water (aluminum tank)	306
Fracking sand	147
Fracking sand (steel tank)	103
Fracking sand (aluminum tank)	44
Other additives and fluids	24
Flowback water removal	255
Total	**1,708**

Trucks Needed for Oil Production	
Well Production Activity	**Truck Volume (per Well and Year)**
Produced water (steel tank)	65
Produced water (aluminum tank)	22
Oil production (steel tank)	249
Oil production (aluminum tank)	83
Total	**418**

Trucks Needed for Re-Fracking	
Well Production Activity	**Truck Volume (per Well)**
Produced water (steel tank)	41
Produced water (aluminum tank)	14
Oil production (steel tank)	8
Oil production (aluminum tank)	3
Total	**66**

Table 7. Volume of Trucks and Number of ESALs per Well.

Output						
	Development	Production		Re-Fracking		Total
	Per Analysis Period	Per Year	Per Analysis Period	Per Event	Per Analysis Period	Per Analysis Period
Total volume of trucks per well	997	349	6,975	810	3,239	**11,211**
Total ESALs per well, trip *to* well	1,381	26	519	1,089	4,354	**6,254**
Total ESALs per well, trip *from* well	472	492	9,850	422	1,688.63	**12,011**