GIS-Based Methodology for Quantifying Impact of Shale Energy Traffic Loads on Pavement Structures

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ABSTRACT

The use of horizontal drilling and hydraulic fracturing techniques to extract oil and gas resources has increased dramatically in the United States. This paper describes a GIS-based methodology to estimate truck volumes and equivalent single axle loads (ESALs) at the individual roadway segment level. Anticipated applications of the methodology include, but are not limited to, estimation of truck volumes and ESALs at the roadway segment and corridor levels, determination of roadway and roadside maintenance needs, prioritization of pavement maintenance and rehabilitation projects, evaluation of truck route plans, analysis of traffic operations and safety impacts, and analysis of congestion and access management requirements.

Key Words: Shale Energy Development, GIS-Based, Truck Traffic, ESALs

INTRODUCTION

The use of horizontal drilling and hydraulic fracturing techniques to extract oil and gas resources has increased dramatically in the United States (*1, 2*). One of the impacts has been significant increases in truck traffic, especially on secondary roads where most activities are carried out. However, the impact is widespread and includes major interstate highways, state highways, county roads, and local roads. The correlation between energy development activities and pavement deterioration is well known, but the extent of the impact is not well documented. Some references in the literature are beginning to look at the spatial relationship between energy developments and the transportation network.

This paper describes a GIS-based methodology to estimate truck volumes and ESALs at the individual roadway segment level for any number of oil or gas wells that are developed and operated in a geographic area. Anticipated applications of the methodology include, but are not limited to, estimation of truck volumes and ESALs at the roadway segment and corridor levels, determination of roadway and roadside maintenance needs, prioritization of pavement maintenance and rehabilitation projects, evaluation of truck route plans, analysis of traffic operations and safety impacts, and analysis of congestion and access management requirements.

The analysis presented in this paper adopted the four-step travel demand modeling process to determine truck volumes and ESALs for pavement maintenance and design purposes. However, the modeling approach was specifically adapted to take into account unique trip generation, trip distribution, and route assignment characteristics of typical unconventional energy developments.

CASE STUDY IN KARNES COUNTY

The researchers conducted a case study using wells completed in Karnes County in 2013 to evaluate the feasibility of the modeling approach. The researchers conducted the analysis using TransCAD 7.0. The researchers obtain input data from various sources, including TxDOT officials, Railroad Commission of Texas databases, and online search. Although all the wells used for modeling were located in Karnes County, the researchers included a large number of surrounding counties to account for a wide range of material or service supplier locations.

The researchers prepared a trip generation table showing the number of trips generated by trip productions and attractions. In the absence of any additional information about factors that contribute to the selection of material or service suppliers, trip distribution was only based on travel time considerations, assuming that the impedance between a well and a supplier location was only a function of the shortest travel time between them. Using the trip generation table and impedance between trip productions and attractions, the researchers used an all-or-nothing assignment method to complete the route assignment step. In essence, this method assigned all the trips between each origin-destination pair to the shortest path between that pair, regardless of roadway capacity or congestion. The output was segment-based truck flow for each direction of travel.

For the conversion of truck volumes to ESALs, the researchers used the results of an analysis that estimated ESALs for each truck type based on axle weight distributions from WIM station readings (*3*). The researchers then calculated the total number of ESALs for each segment (in each direction) by multiplying the number of assigned trucks for each activity by the corresponding number of ESALs per truck, adding the number of ESALs for each phase, and aggregating the three phases of development, operation, and re-fracking.

The modeling results were developed using all 493 wells that were completed in 2013. Figure 1 shows the spatial distribution of higher directional ESALs.

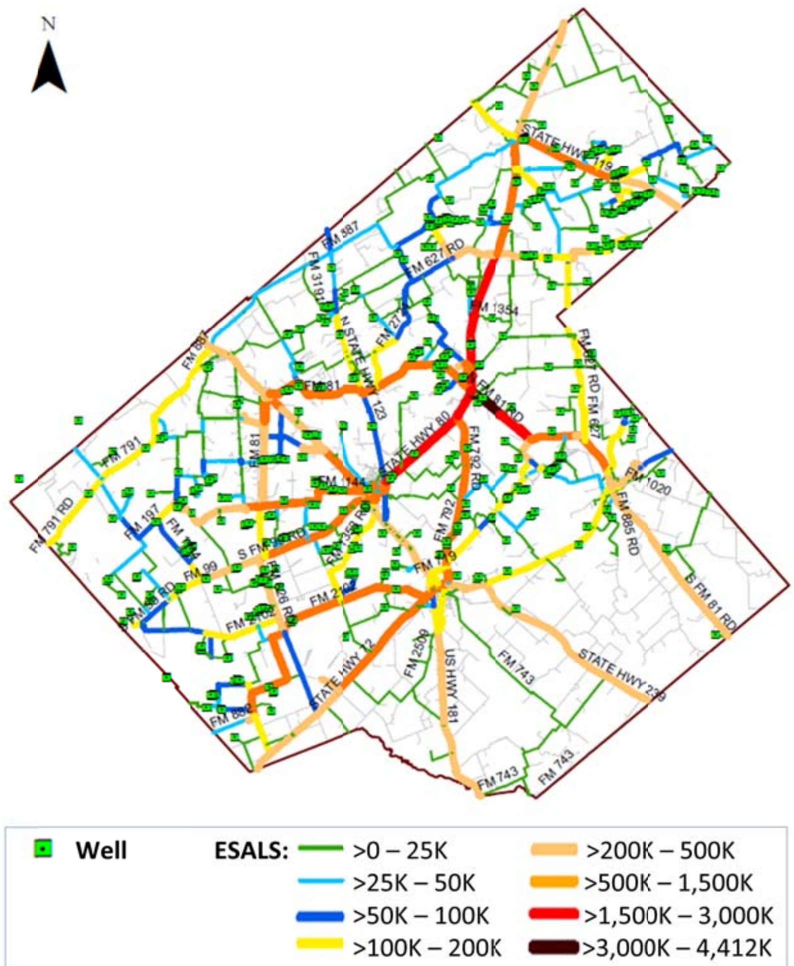

Figure 1. Total Number of ESALs (Higher Directional ESALs)

CONCLUSIONS

This paper describes a methodology that enables users to map truck traffic in connection with energy developments to the surface transportation network. A case study was conducted to evaluate the feasibility of the methodology using data for well development and operation in

Karnes County located in the Eagle Ford Shale area in South Texas. Potential applications of the methodology include, but are not limited to, the following:

- Forecast the spatial distribution of ESALs due to the development and operation of any number of wells over a specified analysis period.
- Forecast the spatial-temporal distribution of ESALs due to the development and operation of any number of wells.
- Evaluate alternative scenarios.
- Forecast the spatial distribution of ESALs in urbanized areas due to well developments that take place in rural areas.

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