Wyoming Low-Volume Roads Traffic Volume Estimation Phase II

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Attachment A
InterAgency Agreement between Wyoming Department of Transportation
And the University of Wyoming

December, 2015

Wyoming Low-Volume Roads Traffic Volume Estimation

This proposal is for Phase II of the Wyoming Low-Volume Traffic Volume Estimation study. Phase I included a review of the various models which have been implemented for estimating traffic volumes for low volume roads, the development and verification of two regression models for Wyoming, and the development, implementation, and verification of a travel demand model for four counties in south eastern Wyoming. This second phase will expand the use of the travel demand model to the rest of Wyoming as well as carrying out a verification of model's predictions for county roads.

Background

Historically, transportation planning has been led by urban and metropolitan planning. Much of this effort has been directed towards reducing traffic congestion and providing adequate capacity. More recently, there has been increased emphasis on estimating traffic on rural low-volume roads driven at least in part by safety and air quality concerns.

Recent advances in GIS software's analytical capabilities allow for more sophisticated analyses of transportation networks and the traffic they carry. Techniques that even a decade ago would not have been seriously considered may now be possible. Improved analytical capabilities may allow for more information to be extracted from the same data collections efforts. Additionally, with more sophisticated analytical methods, traffic counting and other data collections efforts can be focused more efficiently.

In an effort to enable estimation of traffic for low-volume roads in Wyoming, WYDOT funded a study to develop traffic estimation models. Phase I of the study was carried out from 2013 to 2015. The first stage involved the determination of models appropriate for cost-effective traffic volume estimation for low volume roads, implementation of the models, and recommendations for their implementation. Two model types – regression models and a travel demand model - were developed in phase I with the following recommendations for their implementation:

Regression models: Two regression models were developed and their utility for the entire state of Wyoming verified. The first regression model (the linear regression model) utilized road characteristics, socioeconomic, and demographic variables to estimate discrete traffic data for roads. A logistic model was the second regression model and it utilized the variables to predict the traffic levels of a road using five levels. Due to the ease and swiftness of model implementation for the regression models, they were recommended for applications where a quick estimate of traffic volume is desired.

Travel demand model: The four-step process was implemented for Converse, Platte, Laramie, and Goshen counties. Trip rates, diurnal factors, and vehicle occupancy factors were adopted from the NCHRP Report 365. The model was verified and calibrated after it was implemented for the four counties and compared to the linear regression model. The travel demand model had higher prediction accuracy with a Root Mean Square Error (RMSE) of 50.3% compared to 73.4% for the linear regression model. Fitting predicted volumes to actual volumes indicated an R^2 value of 0.74 for the travel demand model compared to 0.64 for the linear regression model.

The promising prediction accuracy of the travel demand model and its ability to predict adequately for higher road classes in addition to low volume roads resulted in a recommendation being made to WYDOT to implement this model statewide in the second phase. Beyond the model implementation, recommendations will be made for the frequency at which the model should be updated to ensure that traffic volume estimates available to WYDOT do not become obsolete.

Objectives

There are three basic goals of this project. First, the travel demand model developed in phase I will be enhanced by including oil and gas impacts in the model and improving the transportation analysis zone (TAZ) delineation of the study location. The second goal will be to implement the model for the remaining 19 counties in Wyoming. The model will apply travel behavior parameters to network, demographic, and economic data in the four-step modeling process to estimate traffic volumes. Finally, an analysis will be carried out to determine the length of time over which estimates can be considered valid and when to update the model to improve accuracy of results to account for traffic variations in the future.

By accomplishing these three goals, a more efficient means of providing low-volume roads traffic information will be developed for the entire state; this will support a wide variety of design, planning, and management functions on both the state and county road networks.

Using improved models will make better traffic volume estimates possible with the same data, thereby lowering costs and improving the quality of traffic information. By taking advantage of better software and better models, more and higher quality information may be provided, leading to improvements in safety and other planning efforts.

Benefits of Low-Volume Road Traffic Estimation

As part of the federally mandated Highway Performance Management System (HPMS), each state is required to provide summary data for their rural minor collector and local road networks. A primary element of this summary data is the total vehicle miles traveled on these roads.

Traffic flows and volumes are primary pieces of information when making transportation design, planning, safety, administration and management decisions *(Wang and Kockelman 2009, Sharma et al 2000, Seaver et al 2000)*. Unfortunately, resource constraints often restrict agencies from conducting counts at all areas of interest *(Pulugurtha and Kusam 2012)*. In Florida, improved estimates of travel on local roads are used to "apportion federal funds, estimate vehicle emissions, determine crash rates, and prepare bridge condition ratings" *(Blume et al 2005)*. In

Australia, better estimates of low-volume roads' traffic are used to more equitably assign the prices paid by heavy vehicles for using the low-volume roads network *(ARRB 2005)*. The utility of traffic flow information, combined with the prohibitive expense of counting traffic on a high percentage of the many low-volume roads, makes an easy, inexpensive method for estimating low-volume road traffic highly desirable.

AASHTO recognizes a number of benefits from traffic data; some of these are relevant to low-volume roads, while others are not. Those which may be relevant to low-volume roads include: project selection; pavement design; safety analysis; pavement and bridge management systems; traffic simulation; traffic forecasting; air quality; and implementation of access controls. In addition to these direct agency benefits, further benefits identified include those to: commerce and economic development; motel and service station chains; chambers of commerce; and litigation tort claims *(AASHTO 1992)*.

Two recent motivating factors for increased low-volume road traffic counting and estimating efforts relate to their roles in air quality and in safety mitigation. It is widely recognized that traffic fatality rates on rural roads are higher than on other roads. With better estimates of traffic on low-volume county and secondary state roads, better targeted and more effective safety improvement efforts can be made. In broader terms, better estimates of traffic volumes on low-volume roads will allow for more effective planning and more efficient operations.

Better traffic models on lower volume roads will allow more information to be obtained with minimal additional data, and perhaps more information may be provided with less data. This improvement would allow for more cost effective management of both county and secondary state roads. Traffic originating on county roads usually ends up on state highways. The ability to apply comprehensive traffic models to the state's lower volume roads will provide a better understanding of traffic on our state's low-volume, rural roads, thereby allowing for more effective planning. More effective planning will lead to a safer and more efficient statewide transportation network.

Highway Performance Monitoring System

> "A biennial Conditions & Performance estimate of the future highway investment needs of the nation is mandated by Congress (23 U.S.C. 502(h)) for the United States Department of Transportation (U.S. DOT) to prepare for its customers. Highway Performance Monitoring System (HPMS) data are used for assessing highway system performance under the U.S. DOT and FHWA's strategic planning and performance reporting process in accordance with requirements of the Government Performance and Results Act (GPRA, Sections 3 and 4) and for apportioning Federal-aid highway funds under the Transportation Equity Act for the 21st Century (TEA-21), (23 U.S.C. 104). To address these needs, the HPMS was first developed in 1978 as a national highway transportation system database." *(FHWA 2012)*

States are required to provide statewide summaries for non-federal aid rural minor collector and local roads. Statewide summary data includes:

- Information on travel
- System length
- Vehicle classification by:
    - Functional class
    - Area type
        - Rural
        - Small urban
        - Urbanized
- Land area
- Population by area type

The statewide summaries include four individual databases, which are:

1. Statewide
    - Population
    - Land area
    - Daily travel, VMT
    - Length
        - Rural *or* small urban
        - Paved *or* unpaved
2. Vehicle travel activity by:
    - Vehicle type
    - Functional system group
        - Rural *and* Urban
            - Interstate
            - Other Arterial
            - Other (Collectors and Locals)
3. Urban summaries for local classification
    - Travel data
    - Population
    - Land area
4. County summaries
    - Length, including NHS
        - Rural minor collector
        - Local
    - Ownership
        - Public

        - Private
    - Include park roads, military roads, toll roads, public roads at an airport, school or university, and roads under the jurisdiction of the Bureau of Indian Affairs *(FHWA 2012)*

Compliance with the federal data requirements, particularly the vehicle mile traveled estimates on the lower volume roads, should be carried out as efficiently as possible. Therefore, the best possible models should be used, both to improve information quality and to minimize data collection costs.

Literature Review

Traffic volume estimation began in earnest during the 1930's using manual counts. In the 1940's, mechanical counters became common *(Albright 1991a)*. Right after World War II, a national study examined the accuracy and precision of traffic counts using sample periods of 24, 48 and 72 hours. It was concluded that for low-volume roads with several hundred vehicles per day, a 48-hour count was adequate. It was also recognized at this time that seasonal, daily and hourly variation was also significant, and that these variations need to be accounted for when using sample counts *(Petroff 1947)*. During the 1950's, efforts were made to evaluate traffic specifically on low-volume roads. Early attempts at classifying and categorizing rural traffic took place in two rural districts in western Minnesota in the 1950's where local roads were classified as either 'resort' – roads serving lakes and fishermen – or 'farm' – roads serving farms and farmers. Considerable improvements in traffic estimates were achieved using this categorization approach *(Darrell et al 1958)*. Though earlier analytical approaches had assumed that counts in roads near each other would be similar, it was recognized during the 1950's that adjustment factors based on similar road use provided better results than simply adjusting traffic counts based on proximity *(Albright 1991a)*.

Over the next few decades, other elements of traffic data analysis became apparent. Primary among these is that traffic distribution is not normal. Therefore, simply examining the mean of traffic volumes does not completely describe traffic on a given road or road network. Also, it must be kept in mind when performing statistical analyses that many procedures assume data normality and homogeneity of variance, which may not be valid for traffic volume data *(Albright 1991b)*.

Over the years, the most common method for estimating traffic flows has used the 'four-step model.' This model uses trip generation, trip destination, mode choice, and route choice to predict traffic flows on roads and streets. In urban areas, this approach has worked quite well *(McNally 2007)*.

While traffic evaluation in urban areas became highly advanced and sophisticated, rural traffic assessments on low-volume roads did not see such advances *(Mohammad et al 1998)*. A study of local roads, both urban and rural, was conducted on traffic counts collected by the Georgia

Department of Transportation. Unfortunately, the models they generated did not perform particularly well on rural roads. However, by using some stratification – grouping roads by whether they were paved or unpaved and by whether they were within the metropolitan statistical area – and performing cluster regression analysis with data from the U.S. Census Bureau, reliable models were developed. It was also suggested that clusters might be based on counties rather than on demographic patterns to yield useful models *(Seaver et al 2000)*.

More recently, spatial effects are re-emerging as GIS technology improves. A technique known as 'Kriging' involves examining the spatial distribution of error terms *(Wang and Kockelman 2009)*. Other efforts to achieve the goal of applying spatial corrections involve the use of applying boundaries based on land use categories such as urban, small urban, and rural *(FHWA 1994)*.

Oil and Gas Trip Generation

ITE's *Trip Generation* is the standard publication for estimating trip generation. The closest appropriate category for oil and gas drilling activities listed in *Trip Generation* is 'Land Use: 120 General Heavy Industrial' which cites the average vehicle occupancy rate of 1.3 persons per automobile for all industrial uses. Sites in Delaware and Wisconsin were surveyed in the 1970's to generate this data. In summary, there is no relevant data for estimating oil and gas drilling traffic in the ITE *Trip Generation Informational Report (ITE 2008)*.

A report published in 1983 evaluated oil field impacts on low volume paved roads in Texas. This report estimated that drilling a single well takes about 60 days and that 1,365 trucks larger than a pickup are needed during preparation and drilling. Additionally they estimated that production typically lasts about three years and that 150 large trucks serve each well per month *(Mason and Scullion 1983)*.

More recently, a study conducted in 2010 in North Dakota estimated that an average of 2,024 rig-related truck trips were made per well. This information was classified by trip type. Using this information and sources of the various loads hauled to and from the wells allowed them to perform origin-destination estimates of traffic on the local roads. Further predictions of freight movement were made using ArcGIS® and Cube® software *(Tolliver and Dybing 2010)*.

Wyoming in the 1970's and 1990's

Two studies, one conducted about forty years ago and the other conducted about twenty years ago, evaluated traffic on Wyoming's highways.

The study conducted in the 1970's identified three travel types:

- Commercial travel
- Non-commercial travel by Wyoming residents

- Non-commercial travel by out-of-state residents

Additionally, four trip types were identified based on whether or not trips originated and ended within an individual county or within the state:

- Intracounty
  - Trips within a county
- Intercounty
  - Trips from one county to another
- Internal-External and External-Internal
  - Trips either to Wyoming from out-of-state or from Wyoming to out-of-state
- External-External
  - Trips through Wyoming

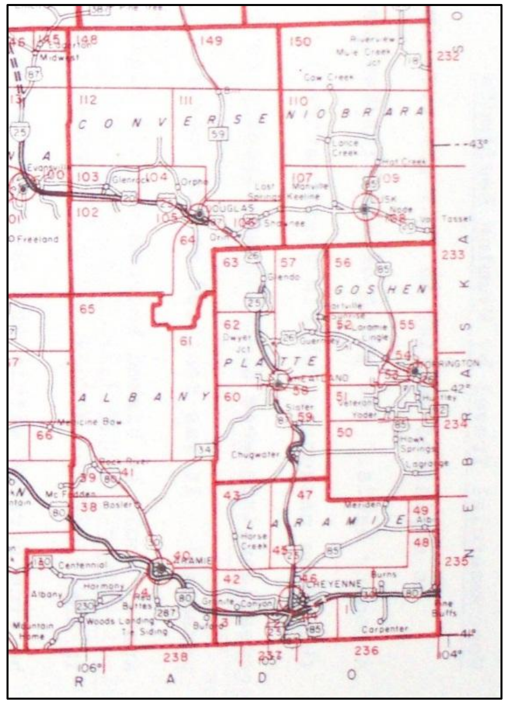

Figure 1. Travel analysis zones in southeastern Wyoming *(Babcock et al 1975)*.

The purpose of the study was to project future traffic based on assumptions about population growth. Trips within zones were not predicted in this study. Generally there are several zones per county as shown in Figure 1, with a total of 220 zones encompassing the Wyoming state highway system, and 32 external zones, 30 in adjacent states and 2 in Yellowstone National Park. This reflects the purpose of this study; it is a planning tool for the state highway system which connects cities with each other and the surrounding countryside. Therefore, traditional urban trip generation predictions are not particularly helpful since these traditional urban planning techniques mainly predict trips within urban areas, not between them.

Data for this study was collected in several ways. Heavy commercial travel was assessed using data from the Wyoming Department of Revenue. Light commerical traffic was surveyed by mail. Non-commercial traffic by Wyoming residents was assessed using mailed surveys and surveys distributed when drivers renewed their driver's licenses. Non-commerical, non-resident traffic was assessed by referring to a study from 1963 and 1964 and by examining traffic counts on roads entering and exiting the state.

An empirical trip distribution model was developed to predict trip production for the three travel types listed above. There were four principal inputs to this model:

1. Expanded trip productions for each zone;
2. Expanded trip attractions for each zone;
3. The trip length frequency distribution of the trips produced by each zone; and

4. A vehicle-mile control total.

The following equation was used to determine the trips from zone *i* to zone *j*:

$$T_{ij} = [P_i D_{ik}] A_{jk}$$

Where:
T_{ij} = trips produced in zone *i* and attracted to zone *j*
P_i = estimated trip productions in zone *i*
D_{ik} = the proportion of trips produced in zone *i* that are attracted to zones in distance band *k*
A_{jk} = (estimated number of attractions of trips of length *L* to zone *j*)/(total estimated number of attractions of trips of length *L* to all zones in distance band *k*)
L is the width of band *k*

County expansion factors for resident, non-commercial trips, the number by which standard traffic estimates should be multiplied to scale up or down for an individual county, were generated by multiplying the trips per person times the county population for two age groups, those over and under 30. County-wide expansion factors were established since the survey data were collected on a county-by-county basis, without regard for where in the county the respondents lived.

In addition to age, several other factors appeared to influence the expansion factors. Trip rates are inversely related to population, probably because those in larger counties don't need to leave the county as often to get things they need. Trip rates were lowest in Laramie, Natrona and Albany counties, the state's three most populous counties at the time. Distance between cities and towns also influences trip rates. Big Horn County has the highest trip rates, probably reflecting trips between the county's several smaller towns and to nearby larger cities such as Worland, Cody, and Sheridan. Similarly, Converse County and Platte County also have high trip rates, probably reflecting trips to Casper and Cheyenne, respectively *(Babcock et al 1975)*.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 initiated a boom in statewide transportation planning. The Act required states to develop and implement statewide transportation plans (STP) and to maintain them annually. Practices developed for urban environments were not particularly useful for statewide planning.

As a part of the Wyoming Multimodal Statewide Transportation Planning model, a method was developed that allowed for the generation of trip tables – those tables used to predict origin-destination values – using traffic counts and basic assumptions about traffic flows within the state. Once such assumption is that city-to-city work commutes are negligible since most Wyoming cities are so far apart *(Wilson and Wang 1995)*.

The model stratified total traffic volumes into several major groups by travel characteristics, such as the reason for the trip and trip end points based on the judgment of planners and on categorized traffic counts. Trips were assigned to one of three types: goods movement; work (commuter); and tourist (non-commuter). Work trips were defined as regularly scheduled trips, while tourist trips comprise irregular business trips, social and recreational trips, and shopping trips. These three categories were tailored to Wyoming's rural travel characteristics *(Wang and Wilson 1995)*. The overall modeling process is summarized in Figure 2. Links and nodes were established at intersections and points of trip generation. When developing the planning network, the state was viewed as a big city. However, travel and land use characteristics are very different.

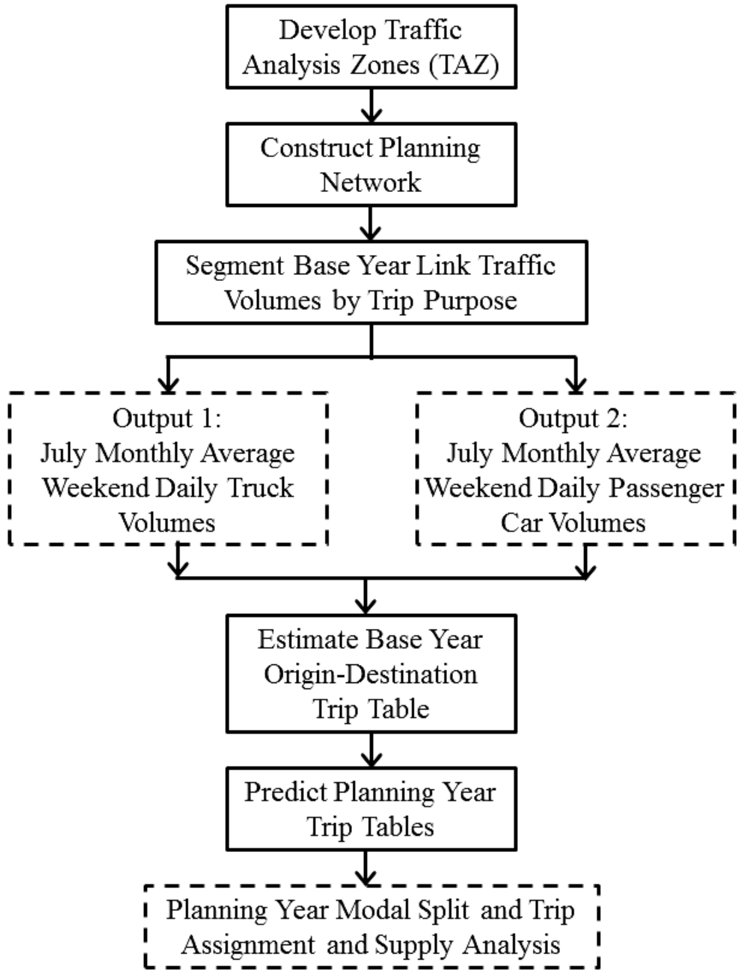

Figure 2. Wyoming statewide transportation modeling procedure *(Wilson and Wang 1995)*.

Traffic counts were obtained from a variety of sources, including 78 permanent count stations, 14 fixed automated vehicle classifiers and 4 or 5 weigh in motion sensors associated with permanent count stations, 16 Port of Entry counters, and 90 portable automatic vehicle classifiers. Then the traffic counts were assigned to individual links on the state highway system. The traffic counts were then input to the origin-destination model. The data was processing using Excel with Visual Basic. In addition to traffic counts, sales tax data was also examined.

Though data was fairly good for primary highways, relatively less data existed for the secondary highways which generally carried traffic volumes from 300 to 4000 vehicles per day *(Wilson and Wang 1995)*.

An analytical process was developed that incorporated inputs from planners. It allowed for the use of traffic data from several sources. Traffic was analyzed for five counties in southeastern Wyoming: Albany, Carbon, Goshen, Laramie and Platte Counties. It provided insights into the types of traffic traveling state highways, particularly in terms of whether their origins and destinations were within or outside the study area *(Wang and Wilson 1997)*.

A critical difference between this analysis and typical urban planning processes was that survey-based trip generation and trip distribution models were replaced with an origin-destination trip table using link traffic counts and an expert survey *(Wilson and Wang 1995)*.

The two Wyoming studies conducted roughly twenty and forty years ago both focused on the higher volume roads in the state system – arterials and interstates. Both studies primarily examined longer distance trips – travel from zone to zone, not within zones. Neither study addressed specific traffic sources, such as oil and gas development, nor did they focus on the lower classes of roads – collectors and local roads.

Summary

There are at least two basic gaps in earlier Wyoming transportation studies, and there is an opportunity to fill these gaps. One gap is in estimating and predicting traffic on collector and local roads; the other relates to sporadic, energy-related traffic. Both the studies by Babcock in the 1970's and by Wilson in the 1990's focused on overall, statewide traffic flows – mainly traffic on the state's interstate and primary arterial highways. This study will fill these gaps by addressing traffic on local and collector roads and by quantifying energy-related traffic on these lower volume roads.

Another element making this the time to develop traffic models is the availability of more sophisticated traffic analysis software. As GIS and related software development has progressed, more comprehensive traffic analyses have become possible.

A final element making this the time to address traffic estimates on lower volume roads is the large number of collector and local roads that are nearing the end of their service lives. Many roads and streets initially paved or treated with asphalt, particularly those built in the 1940's through the 1960's, are now experiencing deterioration related to both aging of the asphalt and in many cases to substantial increases in heavy truck traffic. Therefore, an inexpensive means of estimating traffic on the state's many miles of lower volume roads is highly desirable. It will allow for more effective planning and management of the state's rural collector and local road networks.

Findings of Phase I

Phase I of the study involved two tasks. The first task was to develop models for predicting traffic volumes on low-volume roads. This task was carried out to develop three traffic prediction models. The models were a linear regression model, a logistic regression model, and a travel demand model. The second task was to verify the utility of the models developed for the state of Wyoming. The two regression models were verified for the entire state of Wyoming. The travel demand model was verified for four counties in south eastern Wyoming – Laramie, Converse, Goshen, and Platte counties. Traffic count data were collected from across the entire state of Wyoming and used for developing and verifying the regression model. Count data from south eastern Wyoming were used for the verification of the travel demand model. A summary of the findings and recommendations of phase I are presented below.

Linear Regression Model

The linear regression model was developed to predict traffic volumes using socioeconomic and roadway characteristics from 13 randomly selected counties in Wyoming. A logarithmic transformation of traffic volume (dependent variable) was necessary to ensure a constant error variance and a linear scatter in the residual plots. The final model predictors were; land use (categorized into cropland, pastureland, industrial and subdivision), pavement type (categorized into pave and unpaved), access to highway, and population. The model analysis indicated an R square value of 0.64 for the final model. The application of the model in estimating traffic volumes in counties not included in the model development indicated consistencies in prediction accuracy. Pearson's correlation was used to confirm the linear association between predicted traffic volumes and actual traffic volumes. The Pearson's correlation value for the counties used in developing the model was 0.687 and that for counties not used in developing the model was 0.610. A Root Mean Square Error (RMSE) value of 73.4% was obtained for the model.

Logistic Regression Model

A second regression model was developed for estimating traffic volumes using logistic regression. Unlike the linear regression model that estimated discrete traffic volumes, the logistic regression model predicted the probability of a road's volume falling within a selected threshold. The data from the 13 randomly selected counties used in developing the linear regression model were also used in developing the logistic regression model. Data from nine of the remaining counties were used to verify the prediction accuracy of the model. Five logistic regression models were developed to determine the odds of a road's ADT falling below five thresholds. The thresholds used are as follows:

Threshold 1: ADT of 50 or less

Threshold 2: ADT of 100 or less

Threshold 3: ADT of 150 or less

Threshold 4: ADT of 175 or less

Threshold 5: ADT of 200 or less

A sixth equation converted the odds (obtained from one of the five model equations) into a probability of the road's ADT falling below the threshold of interest. A calculated probability of 0.5 or more meant a road's ADT is within the threshold of interest, whereas roads with probabilities less than 0.5 have ADTs outside the threshold. The model was also verified and found to have an acceptable prediction accuracy ranging from 78% to 89%.

Travel Demand Model

The travel demand model was developed for four counties in south eastern Wyoming using the four-step process. The steps were trip generation, trip distribution, mode choice, and highway assignment. Parameters and procedures from the NCHRP Report 365 and the ITE Trip Generation report were used in the model development. Transportation analysis zones were created by aggregating census blocks to ensure that none of the zones had a population of zero. Estimates from the travel demand model were calibrated and validated by comparing estimated traffic volumes to actual traffic volumes on 100 roads in the study area. A RMSE of 50.33% and an R square value of 0.74 were obtained from the verification process. These results were found to be consistent with traffic volume estimations for low-volume roads in other studies. The presence of special generators (oil and gas, mines, and plants) and the methodology used in delineating transportation analysis zone low population rural areas were pointed out as issues that could be addressed to improve the model's estimation accuracy in future studies.

Based on the results of the model verification processes, recommendations were made to utilize the regression models for quick estimates due to their swiftness and ease of implementation. Travel demand models were found to be relatively more accurate in predictions compared to the regression models and so were recommended for implementation by WYDOT. Further recommendations were made to improve the travel demand model by developing a TAZ delineation methodology for Wyoming low-volume roads. Recommendations were also made to include special generators such as oil and gas fields, mines, and plants in the models. The improved travel demand model was recommended for expansion to include the remaining 19 counties and its reliability and accuracy verified.

Phase II: Model Improvements, Statewide Model Implementation and Verification

The following tasks will be performed in Phase II.

Task 1: Develop Improved Travel Demand Model Based on Model from Phase I

Task 1.1: Review Model Development Process in Phase I

A thorough review of the travel demand model developed in Phase I for the four south eastern counties will be carried out. Additionally, the parameters used in the model development will be examined in detail.

Task 1.2: Develop a TAZ Delineation Methodology

While performing the TAZ delineation for phase I, recommendations from a document prepared by Cambridge Systems, Inc. and AECOM Consult for Florida DOT (Cambridge Systematics Inc., 2007) were reviewed and modified to suit the rural study area in south eastern Wyoming. However, the model was plagued with issues where some roads were wholly located in a zone or where TAZ areas were formed from aggregation of dissimilar land uses.

A review of TAZ delineation principles will be carried out to recommend procedures for creating TAZs that will be implemented for the entire state. Improper delineation of TAZs will have a negative impact on the trip generation, distribution and assignment steps of the model and may result in inaccurate traffic volume estimations.

Task 1.3: Undertake Surveys to Determine Trip Rates for Oil and Gas Wells

The trips generated by special generators such as oil and gas wells were not considered in the travel demand model developed in Phase I. A recommendation was therefore made to improve the model by including these special generators in future models. In a North Dakota study *(Tolliver and Dybing 2010)*, trips associated with oil and gas fields for the entire life-cycle of a well were used in freight models to determine transportation investment needs resulting from increased oil and gas drilling activity.

However, the current study requires daily trip rates for a typical well to estimate average daily trips generated by a zone in the four-step modeling process. A survey of oil and gas companies will therefore be carried out to determine the trip rates of regular oil and gas wells. The survey will enable an understanding of the trips generated at oil and gas wells as well as their origins or destinations.

Task 1.4: Undertake Traffic Counts for Oil and Gas Wells to Confirm Survey Results

Traffic count stations will be setup at entrances to oil and gas well sites to count the vehicles that are generated at the sites. These counts will be compared with the results from the surveys to confirm and calibrate trip rates per well for inclusion in the trip rate equations.

Task 1.5: Implement Improved Model for South East Wyoming

Using Citilabs Cube Software, an enhanced model that includes oil and gas special generators will be implemented for south east Wyoming. The model will utilize a more harmonious TAZ delineation method compared to the TAZ used in phase I.

Task 1.6: Verify the Utility of the Model for South East Wyoming

Road segments will be selected for verifying the prediction accuracy of the model. The prediction accuracy of the enhanced model will be compared to the previous model that excluded oil and gas activity in their development. Prediction verification will also be carried out for higher road classes such as arterials and highways.

Task 2: Implement Improved Model for the Remaining 19 Counties

Task 2.1: Develop TAZs for Each County

Using the TAZ development method that will be developed in Task 1.2, zones are developed for each county with their associated demographic and socioeconomic data. Data for oil and gas well counts will be included in the TAZ to enable trips generated by oil and gas wells to be estimated.

Task 2.2: Develop Road Networks for Each County

Road network data obtained from the Tiger/Lines webpage of the US Census will be developed to represent the transportation system in each county. The developed shapefiles will contain data on speed limits, number of lanes, direction of travel, and functional class of the road. These information will be used in distributing and assigning trips.

Task 2.3: Store Input Data

The TAZ and network datasets for each county will be assembled and stored in ArcGIS® with associated location information.

Task 2.4: Implement the Four-Step Modeling Process

The enhanced four-step model implemented in Task 1 for south eastern Wyoming will be implemented for each county in Wyoming.

Task 2.5: Generate Traffic Volume Estimates

The model will use the TAZ and network datasets of each county to generate traffic volumes for each road in the study area.

Task 2.6: Store Output Data

The estimated traffic volume data will be assembled and stored in ArcGIS® and Excel database files for each county.

Task 2.7: Verify the Utility of the Model for Each County

The utility of the model will be verified by comparing actual traffic volumes to predicted traffic volumes. This task will utilize traffic data collected in phase I of the project.

Task 3: Develop Recommendations for Model Applications

Based on the results of the model verification, suitable applications for the model predictions will be recommended.

Task 4: Recommend Shelf Life for Model Predictions

An analysis of the model will be carried out to determine the shelf life of the model predictions to recommend appropriate years beyond which the model will need to be reviewed and updated.

Task 5: Prepare Final Report. Present Findings and Recommendations

A final report will be prepared that documents the model generation and verification processes. Results from the model will be generated and assembled in a final report. The studies' findings and recommendations will be presented.

Timeline

The second phase will involve five tasks. Four of these tasks will involve data collection and analysis while the final task involves the preparation of a final report to present the findings and recommendations of the study.

The duration of Phase II is two years. Early results will be communicated with WYDOT and the WYDOT feedback will be used to enhance the accuracy of predictions.

Budget

As shown in Table 3, the total cost of the phase I of this project is $119,100. That cost will cover all data collection activities in two summers. In addition, it will cover 50% of the salary of a post doc for two years.

Table 3. Traffic Estimation on Low Volume Rural Roads (Phase II)

University of Wyoming

February 1, 2016 – February 1, 2018

CATEGORY	Budgeted Amount	Explanatory Notes
Faculty Salaries: Ksaibati & New Transportation Faculty Member	$ 9,500	
Administrative Staff Salaries	$	
Post Doc Salaries	$ 45,000	
Staff Benefits	$ 27,250	
Total Salaries and Benefits	$ 81,750	
Computer	$ 2,000	
Supplies	$ 3,000	Final report
Domestic Travel	$ 12,500	Data collection and presentations to insure proper technology transfer
Foreign Travel	$	
Other Direct Costs (specify)	$	
Total Other Direct Costs	$ 17,500	
F&A (Indirect) Costs	$ 19,850	
TOTAL COSTS	$ 119,100	

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