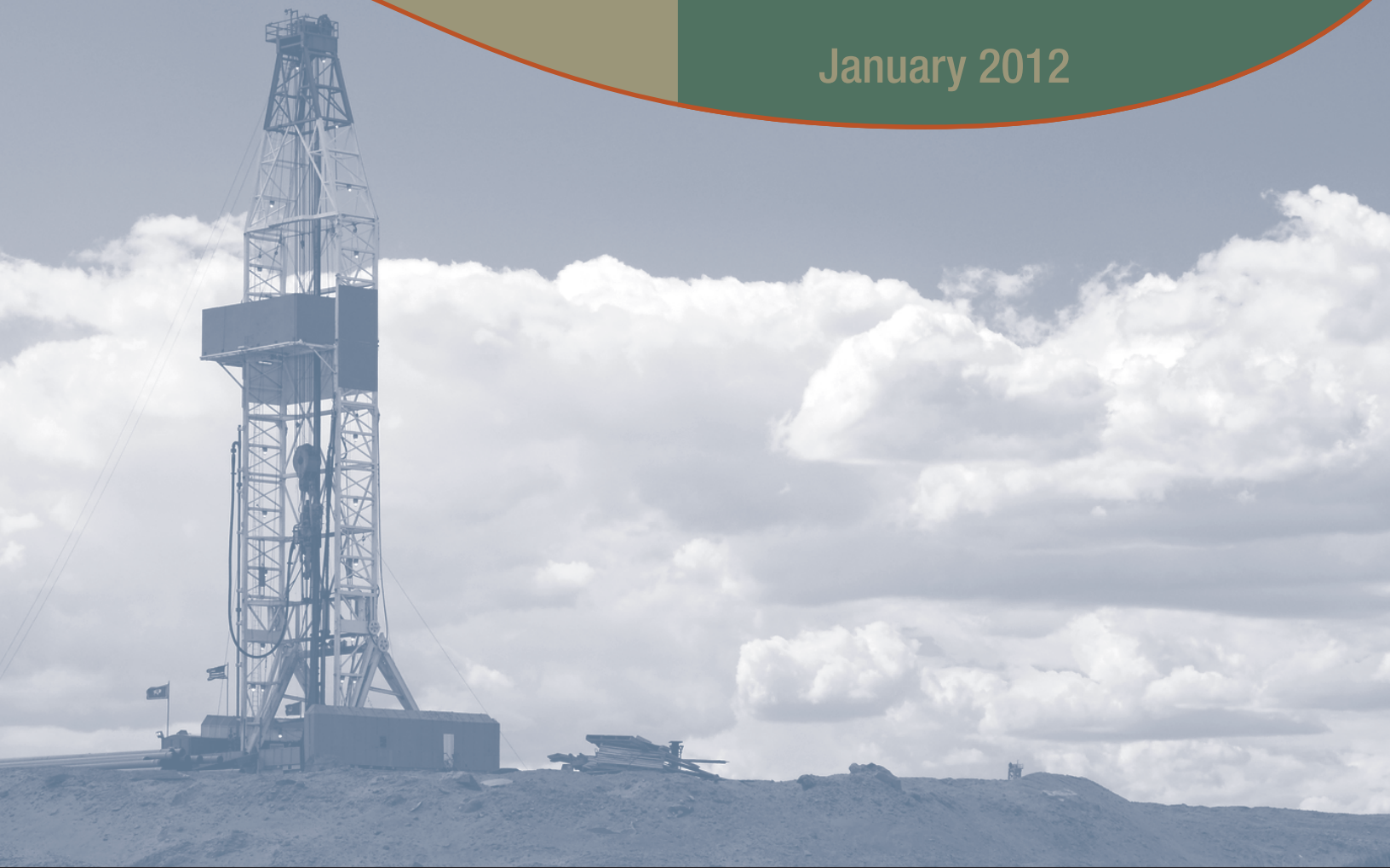


Douglas County
Oil & Gas Production
Transportation Impact Study



January 2012



Douglas County Oil & Gas Production Transportation Impact Study



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FHU Reference No. 11-091-01



ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

With a recent surge in oil and gas leases in Douglas County, the County has commissioned this study to understand the potential impacts to their roadway system that could result from oil and gas development and production. One of Colorado's largest oil and gas producing shale formations is the Niobrara, which covers over half of Douglas County. The Niobrara basin has been a highly productive source of oil and gas in Colorado's northern front range, most notably in Weld County. To date, there has been no oil and gas drilling activity in Douglas County; however, 2011 has shown a marked increase in the number of oil and gas leases obtained by oil and gas companies in Douglas County. As shown on **Figure ES-1**, a high volume of the current oil and gas leases are located near the eastern border of Douglas County with clusters in the northeast corner and the southeast region. There are a scattered number of leases in the central and east-central regions of the County.

Because of uncertainties associated with oil and gas development in Douglas County, this study looks at three potential development scenarios (high, medium, and low) in order to provide a range of potential impacts and revenues associated with resource development in the County. This study is not intended to predict oil and gas development, rather it is intended to provide County officials with information about the potential impacts to the transportation system and associated investment needs using an informed set of development scenarios based on the best available data.

Resource Development

There are five stages in the development and operation of an oil and gas well.

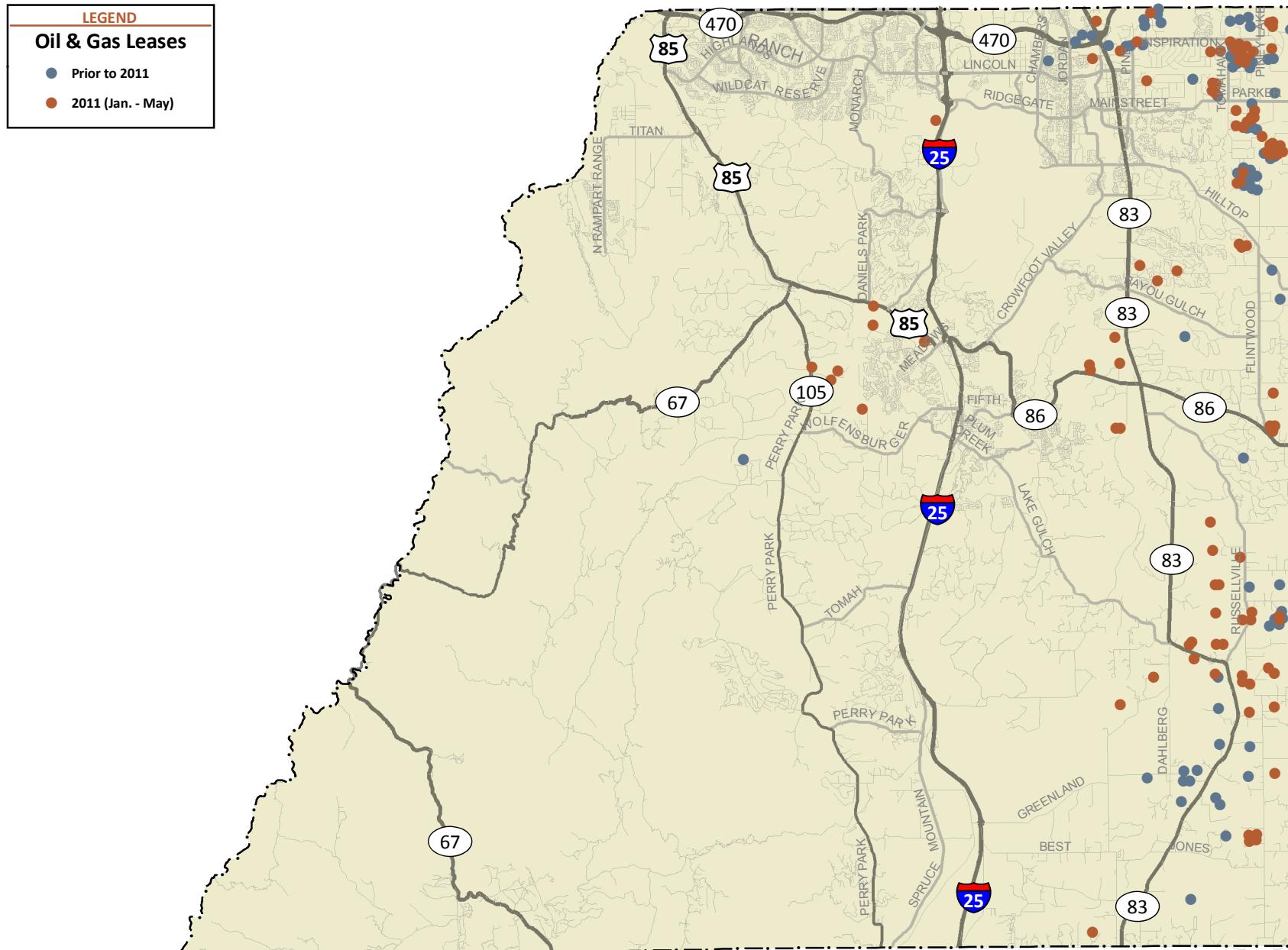
Leasing and Exploration –Energy companies that have an interest in exploring an area for energy prospects must first buy or lease the appropriate subsurface ownership rights which are often, but not exclusively, owned apart from a property's surface rights. After securing the mineral rights and confirming a drilling and spacing plan with the Colorado Oil and Gas Conservation Commission (COGCC), exploratory wells are placed in order to obtain core samples to determine the likely productivity of the target shale.

Pad Construction – After the team of geologists and geophysicists identify the best site for drilling, a team of about 10 workers begin developing the well pad. Typically a well pad is a leveled one to five acres of land This stage includes construction of a gravel access road for supply transport.

Drilling – When the pad is fully constructed, a drilling rig can be moved onto the pad to begin drilling the well. The drilling rig requires two, six-person crews, typically working 12 hour shifts to operate the rig 24 hours a day. Once the well bore is drilled, finalizing a well requires the installation of thousands of feet of pipe and casing material to secure the well. In the Niobrara basin, once a well is drilled to the desired depth, it is typical to commence horizontal drilling in preparation for fracturing the shale deposit.

Figure ES-1

Oil & Gas Leases in Douglas County





Completion – The completion stage takes a drilled well and makes it suitable for energy extraction. In the Niobrara, the most likely well completion method is fracking, which involves the use of a highly pressurized water mixture to fracture the shale formation in order to release trapped oil or gas. The completion stage results in the most intense transportation demands; primarily for transporting fresh water to and removed produced water from the pad site.

Production – A well’s production stage involves pumping the oil, gas, and produced water from the well for storage, disposal or distribution.

For a single well, the pad construction, drilling and completion stages typically occur over a 45 to 60 day time frame. The production stage lasts for the remaining life of the well, possibly 15-20 years.

Oil and Gas Development Scenarios

Based on producing wells in neighboring counties, energy development in Douglas County will likely be seeking oil rather than natural gas, and well depths will likely be between 5,000 and 9,000 feet. In order to increase production and extraction efficiency, pad sites in Douglas County will likely accommodate multiple-wells and horizontal drilling, a process that allows access to more of the formation without having to build an entirely new well pad for each well. This process lessens the surface impact, reduces drilling and completion times, and improves development efficiency in comparison with multiple single-well pad sites. Operating multiple wells on a single well pad is an increasingly common practice in the Niobrara basin and will likely be the dominant practice in Douglas County.

Energy companies are in the beginning stages of exploration in Douglas County. Many national and international factors will shape future levels of drilling activity, including oil and gas prices, national economic growth prospects, and the merit of the Niobrara Shale relative to other production areas. Locally, a host of additional factors will influence how quickly efforts are made to determine a new field’s prospects. Douglas County is one of several counties that lie above the Niobrara Shale. Depending on the geology of the shale, drilling could occur in any of the counties.

The study team developed a set of three future development scenarios based on actual well development activity data obtained from the COGCC. This exercise is not an attempt to predict the future, but rather an effort to develop an informed set of development scenarios based on the best available data. By looking at the number of active wells in top five oil and gas producing counties in the state (Garfield, Weld, Yuma, Las Animas, and La Plata), the study team was able to estimate the number of annual wells developed in each county over a six year period. The average annual increase in active wells in these top five producing counties is just under 510 wells per year. This figure is used in establishing an upper limit for the well development scenarios in Douglas County.

The study team developed three scenarios to input into the transportation impact model—high, medium and low development pace scenarios.

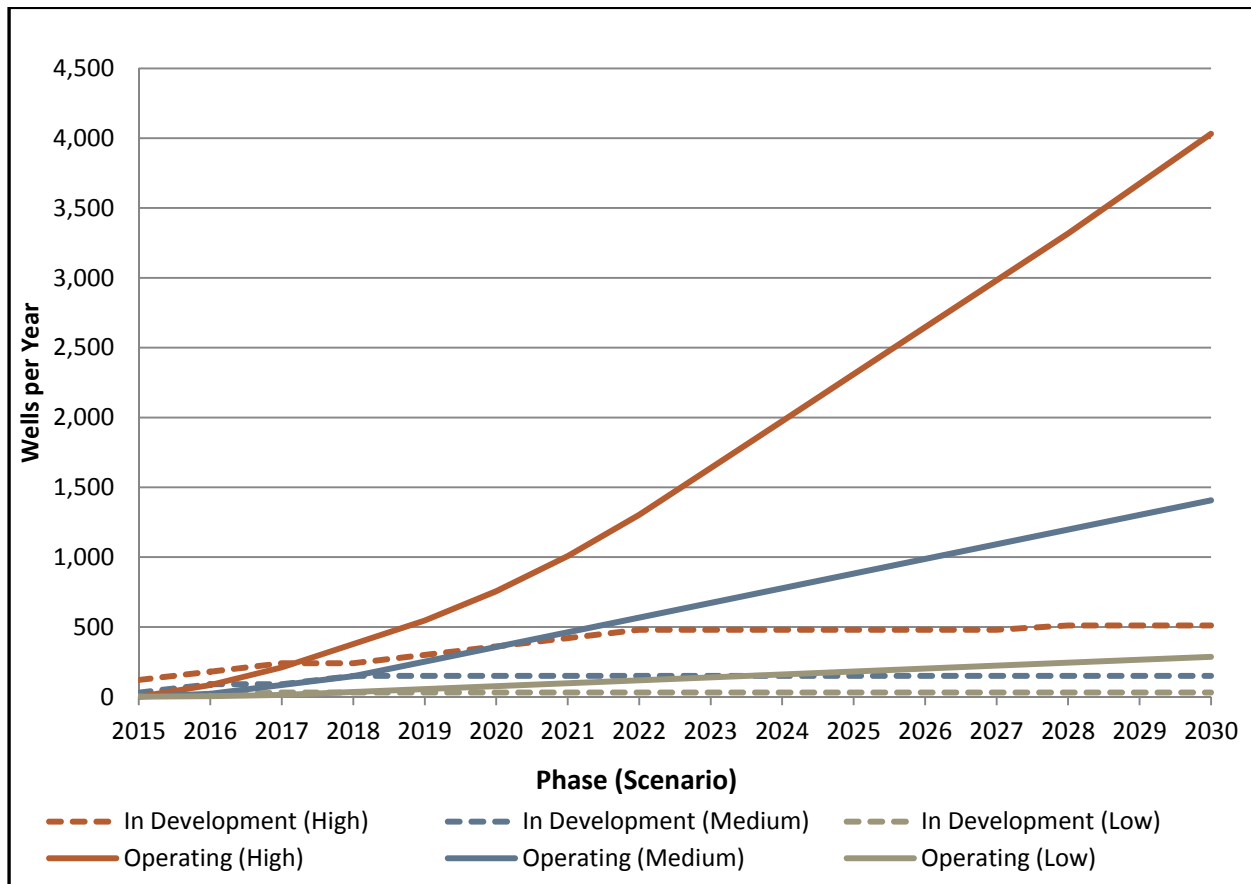
- ▶ The high development scenario was selected as the annual average increase in active wells in the top five oil and gas producing Colorado Counties—about 510 wells developed per year.
- ▶ For the medium scenario, the study team selected 150 wells developed per year, which is approximately the development pace in La Plata County over the last six years.



- ▶ The low scenario resembles the development pace observed in Boulder, Adams and Moffat Counties—about 30 wells per year. All well development scenarios are assumed to involve clustered development and horizontal drilling techniques.

The year-by-year profile of each of the development scenarios is shown on **Figure ES-2**. Each scenario assumes that oil and gas development would begin in earnest in 2015 (with leasing and exploration occurring in the years leading up to 2015). The addition of new wells each year begins at a slow rate and ramps up to the annual development figures described above. After the development phase, the production phase includes a 70 percent success rate for new wells drilled to effectively enter the operating stage.

Figure ES-2. Douglas County Development Scenario Profiles



Note: Douglas County development scenarios assume six wells per pad
Source: BBC Research and Consulting

As a check to the methodology described above, the study team contacted COGCC staff to discuss the scenarios developed above. COGCC staff described an alternate methodology, where drilling rigs and the well drilling period are used to calculate the total amount of annual wells drilled per year. According to the most current estimate, there are about 80 drilling rigs currently operating in Colorado. Based on typical drilling durations, the high scenario described above would require 43 drill rigs per year; over half of the state's current operating rigs. Based on this information, the study team believes the high scenario to be a plausible upper limit. It is important to note that this exercise is not intended to assign a probability to any of the scenarios occurring, but to appropriately define potential maximum and minimum levels of well development activity.



Travel Model

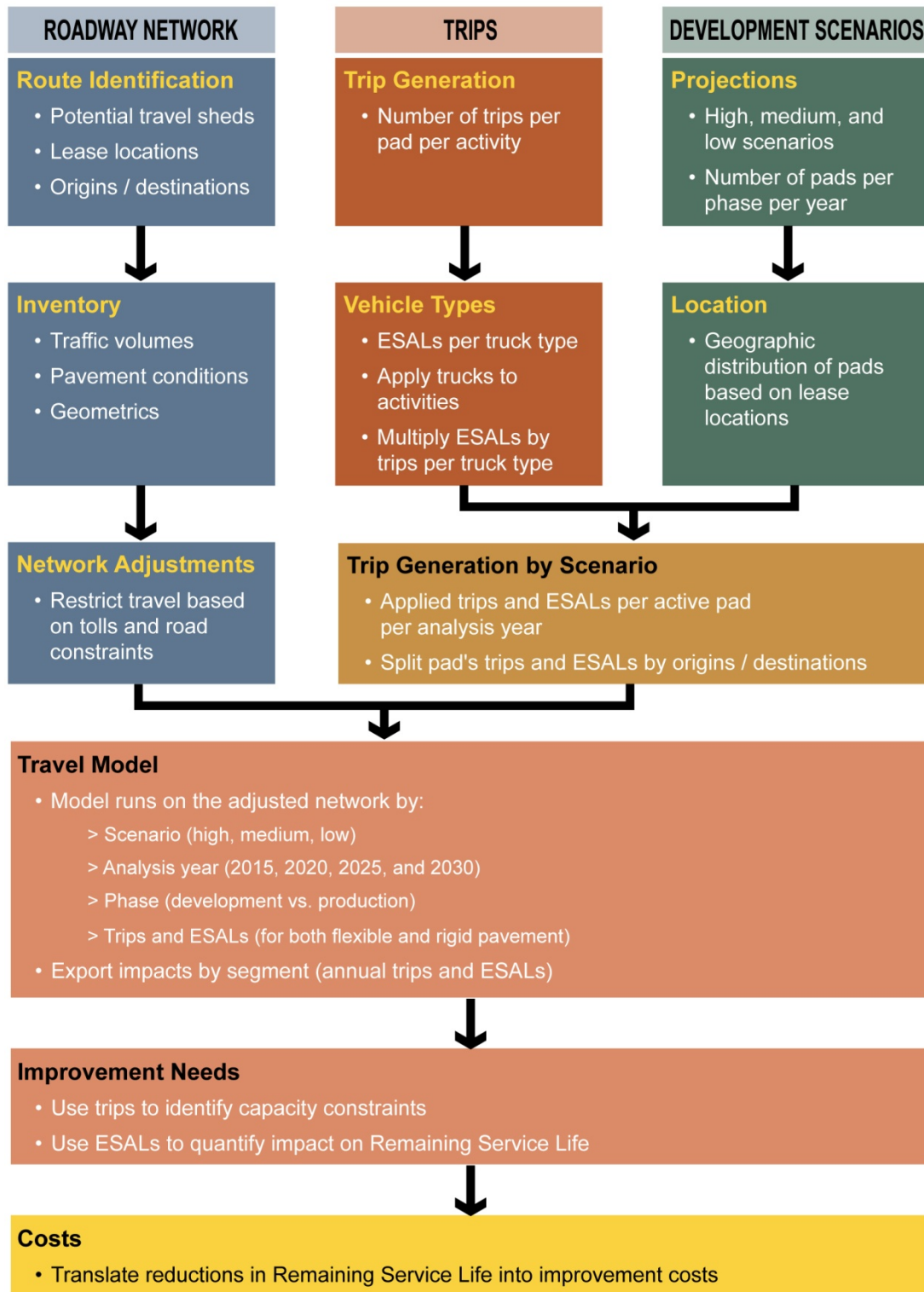
A travel model has been developed using TRAFFIX software to assign the trips and vehicle-loads associated with the high, medium, and low development scenarios to the Douglas County roadway system. Oil and gas development will result in increased traffic on the roadway network, as well as increased loads on the County's roads from the many heavy vehicle trips associated with the industry. For this reason, the travel model has been used to estimate not only vehicle trips, but also loads (as measured in equivalent single-axle loads [ESALs]). The travel model looks at potential industry impacts in five year increments from 2015 through 2030.

The process for estimating transportation impact costs is shown in **Figure ES-3**. This methodology required first identifying the likely travel routes for oil and gas vehicles. The oil and gas lease locations represent the best information available to date about likely geographic distribution of oil and gas development in the County. Given the uncertainty of where oil and gas pads may be developed, the lease locations were used to represent general areas where potential development might occur. The likely travel routes to access these locations are shown on **Figure ES-4**.

In anticipation of horizontal drilling and multiple wells per pad site in Douglas County, the study team has estimated trip generation rates primarily relying on the MIT/NTC analysis for the Marcellus formation, which is a reasonable comparison with the Niobrara formation. **Table ES-1** shows the development phase trip generation rates that have been used in the travel model. As shown, truck traffic is expected to average 11,040 vehicle trips per pad site with each pad accommodating six wells. Once the oil or gas well is fully operational, trip generation will be substantially reduced to approximately 730 vehicle-trips per year (two trips per day), as shown in **Table ES-2**. The typical truck configurations, ESAL factors and likely origins and destinations for each activity are also shown in these tables.

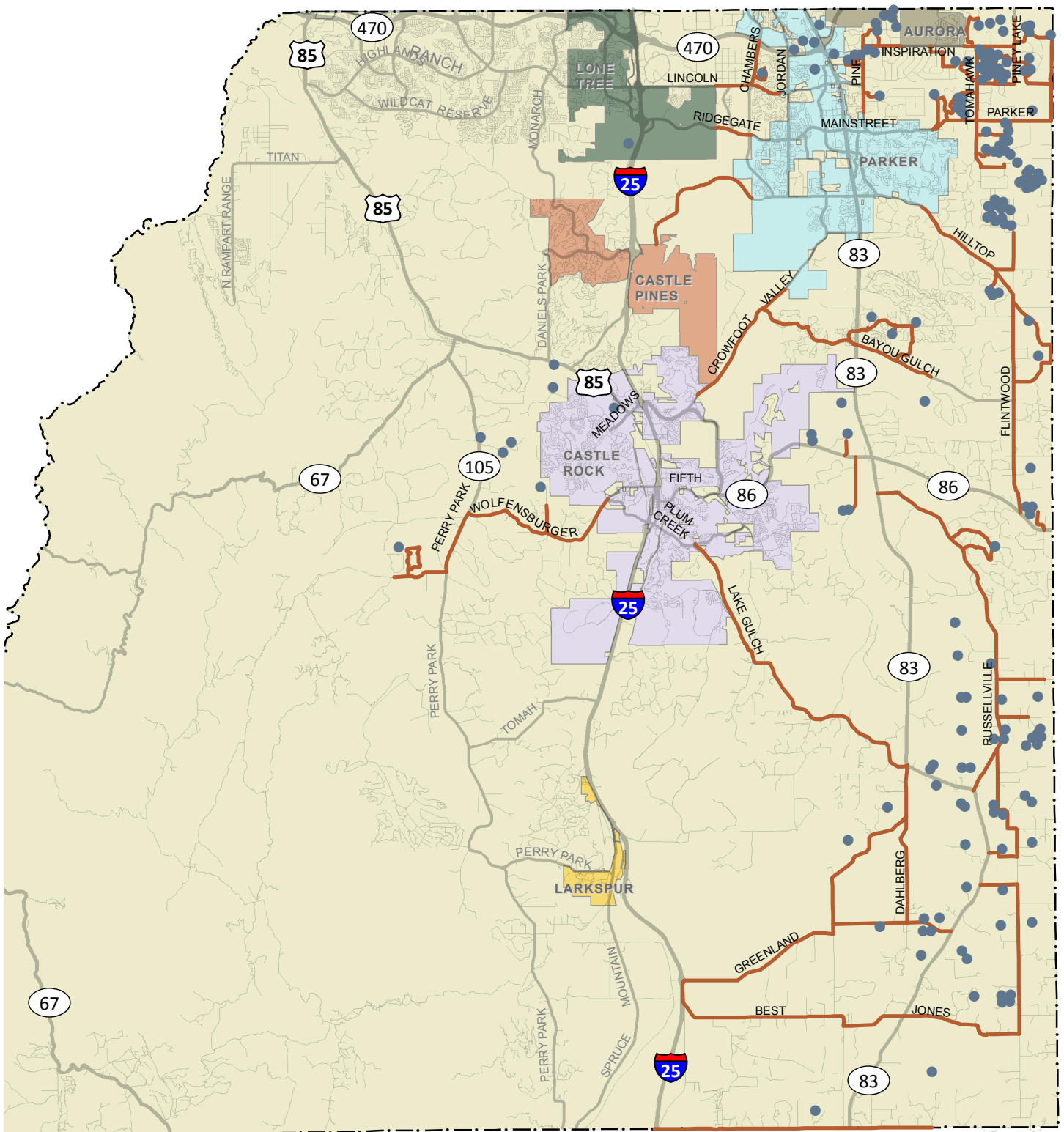


Figure ES-3. Process for Estimating Transportation Impact Costs



ESAL = Equivalent Single Axle Load

Oil & Gas Lease Locations and Travel Paths



LEGEND

- Lease Location
- Roads Analyzed
- Roads Not Analyzed





Table ES-1. Development Phase Trip Summary

Stage	Activity	1-Way Truck Trips (1 Pad, 6 Wells)	Duration (Days)	Average Truck Trips per Day (by Stage)	Average Truck Trips per Day (by Activity)	Typical Truck Types	ESAL Factors (Average for 1- Way Trip)	Origin (or Destination) of Trucks
Construction	Pad and Road Construction	60	10	6.0	6.0	3-axle & 5-axle haulers	Flex: 1.009 Rigid: 1.537	I-25 N/S
Drilling	Drilling Rig	60	153	6.3	0.4	Heavy 5-axle, other 3-axle	Flex: 1.043 Rigid: 1.300	I-25 N/S
	Drilling Fluid and Materials	450			2.9	3-axle & 5-axle tankers	Flex: 1.362 Rigid: 1.988	I-25 N, E-470
	Drilling Equipment (casing, drill pipe, etc)	450			2.9	5-axle haulers	Flex: 0.405 Rigid: 0.621	I-25 N/S, E-470
Completion	Completion Rig	30	102	98.2	0.3	Heavy 5-axle, other 3-axle	Flex: 0.925 Rigid: 1.083	I-25 N/S
	Completion Fluid and Materials	180			1.8	3-axle & 5-axle tankers	Flex: 1.362 Rigid: 1.988	I-25 N, E-470
	Completion Equipment (pipe, wellhead, etc)	20			0.2	5-axle haulers	Flex: 0.405 Rigid: 0.621	I-25 N/S
	Fracturing Equipment (pump trucks, tanks, etc)	520			5.1	Specialty, 3-5 axles	Flex: 0.724 Rigid: 0.782	I-25 N/S, E-470
	Fracture Water	6,000			58.8	5-axle tankers	Flex: 1.363 Rigid: 2.260	Castle Rock, Littleton
	Fracture Sand	270			2.6	5-axle haulers	Flex: 1.363 Rigid: 2.260	I-25 N, E-470
	Flowback Water Disposal	3,000			29.4	5-axle tankers	Flex: 1.363 Rigid: 2.260	I-25 N, E-470
Total		11,040	265	41.7	41.7			



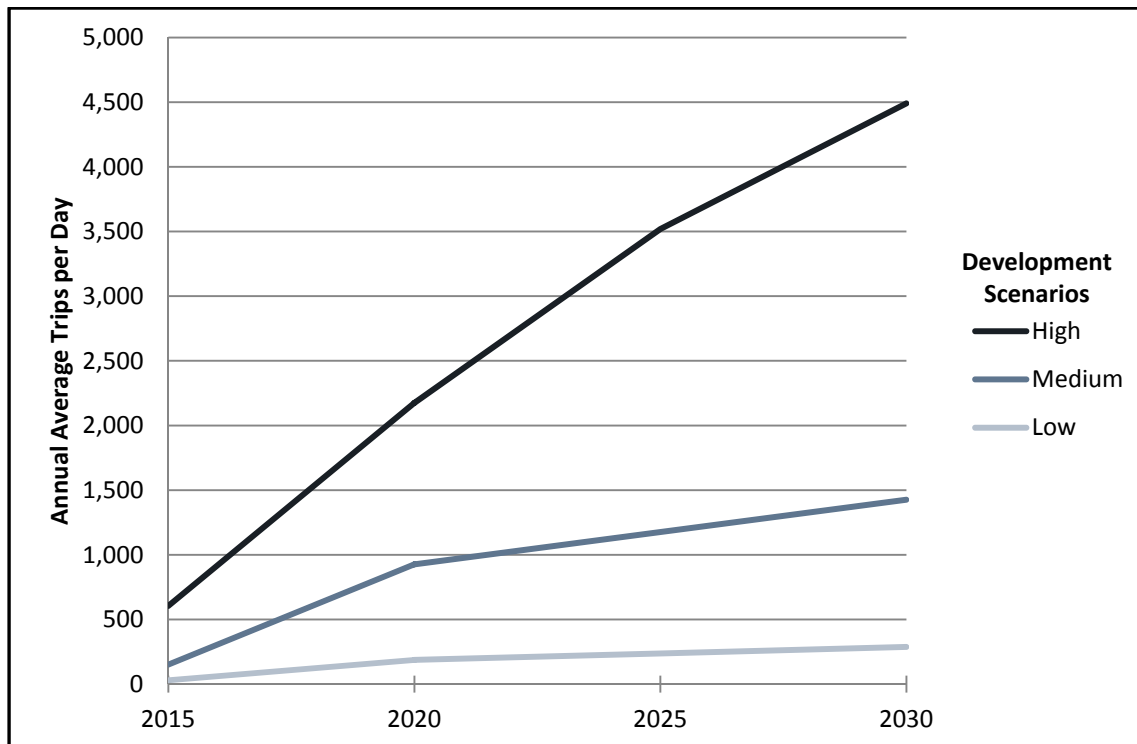
Table ES-2. Production Phase Trip Summary

Stage	Activity	1-Way Truck Trips (1 Pad, 6 Wells)	Duration (Days)	Average Truck Trips per Day (by Stage)	Average Truck Trips per Day (by Activity)	Typical Truck Types	ESAL Factors (Average for 1- Way Trip)	Origin (or Destination) of Trucks
Production	Oil & Water Removal	580	Daily	2.0	1.6	3-axle & 5-axle tankers	Flex: 1.362 Rigid: 2.146	I-25 N, E-470
	Operations & Maintenance	150	Daily		0.4	Work Trucks	Flex: 0.150 Rigid: 0.165	I-25 N, E-470
Total		730	365	2.0	2.0			



The oil and gas trips have been modeled on an annual basis; in order to present the results in a more manageable fashion, trips from both phases (development and production) were aggregated and converted to average annual daily trips by simply dividing the annual trips by 365. **Figure ES-5** illustrates the average number of oil and gas trips per day for each scenario of the four analysis years. This figure depicts the cumulative trips of all pad being developed and producing wells.

Figure ES-5. Estimated Oil & Gas Annual Average Trips per Day

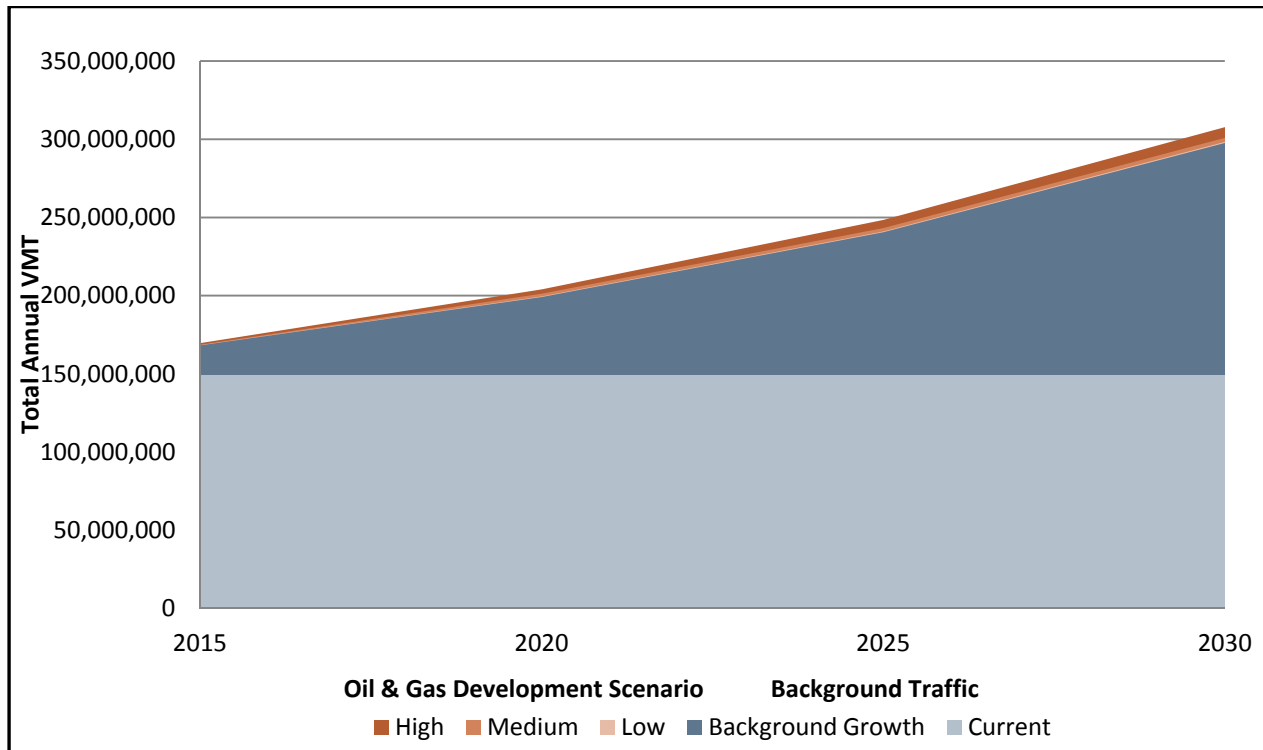


Based on the travel model results, these trips are expected to occur over a large portion of the identified potential travel shed roadways. Some corridors handle a large portion of these trips, while others handle only one pad's worth or less. For Douglas County's roads, Lincoln Avenue and Lake Gulch Road show the highest number of both development and production trips. The highest number of predicted oil and gas trips for one County-maintained road segment is roughly 1,800 trips per day in 2030 for Lincoln Avenue east of Chambers Road, which is forecast to have 54,000 vehicles per day in total traffic in 2030. No road is expected to exceed the existing capacity threshold due to added oil and gas trips associated with the three development scenarios tested in this study.

The trips assigned by TRAFFIX were also converted into vehicle miles traveled (VMT) to compare the increase in VMT caused by oil and gas operations with existing VMT on the travel shed roads and predicted VMT growth based on the *Douglas County 2030 Transportation Plan*. **Figure ES-6** compares current VMT on County roads to predicted background growth and the three scenarios of oil and gas operations. At its highest point within this study's analysis horizon (2030) oil and gas operations would increase VMT by about 3.4% over the estimated background VMT.



Figure ES-6. Estimated Oil & Gas Vehicle Miles of Travel (VMT) Compared to Existing and Background Growth VMT



Although the number of the trips generated by the oil and gas industry in the three scenarios is relatively small in comparison to the existing traffic and the anticipated background growth, the much greater transportation impact associated with industry is due to the weight of the vehicles. The load impact of oil and gas trucks can be in the range of 5,000 – 30,000 times greater than that of a passenger car. Due to the high impact of heavy vehicles on the roads, Equivalent Single Axle Loads (ESALs) are essential in calculating potential improvements needed and the costs associated with those improvements, as described in the following section.

Improvement Needs and Costs

The improvements and associated costs represent the additional costs or funding needs attributable to growth in oil and gas traffic. They do not include baseline maintenance and/or improvement costs incurred by the County prior to substantial growth of oil and gas traffic.

Oil and gas traffic was distributed to the County's network of roads, and an ESAL was applied to the associated traffic. The ESALs were determined at 5-year increments starting at 2015 and extending to 2030. Road improvements and costs were then defined for the paved and unpaved roads impacted by oil and gas traffic based on the high, medium, and low development scenarios. The study team worked closely with Douglas County staff to establish a methodology for estimating improvements (and the associated costs) that is consistent with the County's current maintenance and reconstruction procedures.



- ▶ For unpaved roads, the improvements needed to offset the impacts of oil and gas trucks include more frequent dust suppressant application, grading, graveling, and paving where the truck volume is expected to exceed 100 vehicles per day.
- ▶ For asphalt roads, increased truck traffic from the oil and gas industry will primarily result in the need for more frequent, and thicker, overlays.
- ▶ On concrete roadway segments, oil and gas traffic will decrease the overall pavement service life, resulting in the need for reconstruction sooner than would be expected under current uses. The improvement costs for concrete roadway are based on the incremental reconstruction costs that result from decreased service life.

The estimated annual improvement costs by development scenario are presented in **Table ES-3**. The design year values represent the incremental improvement costs required to offset the impacts specifically associated with oil and gas vehicles in each of the high, medium, and low scenarios. The total incremental improvement costs for the time period 2015 through 2030 have been calculated by interpolating the improvement costs for the interim years (e.g., 2016, 2017, 2018, 2019, etc.).

Table ES-3. Estimated Annual Improvement Costs by Development Scenario

Design Year	Low	Medium	High
2015	\$170,100	\$861,800	\$2,921,900
2020	\$926,000	\$4,682,500	\$9,507,600
2025	\$950,900	\$6,670,500	\$9,808,600
2030	\$1,314,300	\$5,508,400	\$10,184,300
Total (2015-2030)	\$13,837,700	\$75,875,600	\$135,899,600

On average, the County currently has about \$40 million in revenue available for transportation capital projects, operations and maintenance each year.¹ Assuming a continuation of average funding, this equates to an estimated \$640 million over the 16 year time period from 2015 through 2030. The estimated incremental improvement costs associated with the oil and gas industry over the same time period in the low, medium, and high scenarios represent a 2%, 12%, and 21% increase, respectively, over current Road and Bridge funding levels.

County Oil and Gas Revenue Projections

Property tax and severance tax are the major revenue sources that will increase as oil and gas wells are drilled and begin to produce. These tax revenues are designed to offset the additional county expense incurred to provide infrastructure and services to the industry. The following provides a general discussion of the factors that influence resource-based property and severance tax followed by a detailed description of each revenue source.

Perhaps the greatest factor that influences the amount of property and severance tax collected each year is the market value of oil and gas. Property is assessed and severance tax is imposed on the value of resource produced at each well. There are many factors that influence the value of oil and gas, including international

¹ The \$40 million figure represents an annual average that is net of transportation funds transferred annually to municipalities. The figure was obtained through discussions with Douglas County finance staff.



supply, world demand, geo-political issues and natural disasters. The amount of resource related revenue Douglas County receives will ultimately be dependent on the value of resource recovered.

The study team conducted a fiscal analysis to estimate potential revenues associated with the high, medium and low development scenarios. **Table ES-4** combines projected property tax and severance tax revenue to calculate total revenue. It shows annual severance tax and property tax revenue collected by Douglas County.

Under the low scenario, oil and gas development will produce an additional \$4.8 million in property and severance tax revenue over 15 years. Douglas County will collect about \$22.4 million in the medium scenario over 15 years in the medium scenario. Under the high scenario, Douglas County will collect about \$57.5 million in property tax and severance revenue over 15 years.

Table ES-4. Douglas County Well Scenarios and Projected Total Tax Revenue (2015-2030)

	Low	Medium	High
Severance Tax Revenue	\$890,000	\$3,325,000	\$8,214,000
Road & Bridge Property Tax	\$891,000	\$4,330,000	\$11,228,000
Other Property Tax	<u>\$3,028,000</u>	<u>\$14,711,000</u>	<u>\$38,070,000</u>
Total Revenue	\$4,809,000	\$22,366,000	\$57,510,000

Source: BBC Research & Consulting.

Capital Needs and Revenue

There are three important factors that should be considered in determining the likelihood that the Douglas County oil and gas industry will generate sufficient new tax revenue to cover industry associated road improvement expenses. These factors are; revenue time lags; compounding revenue growth; and field productivity, which are discussed below.

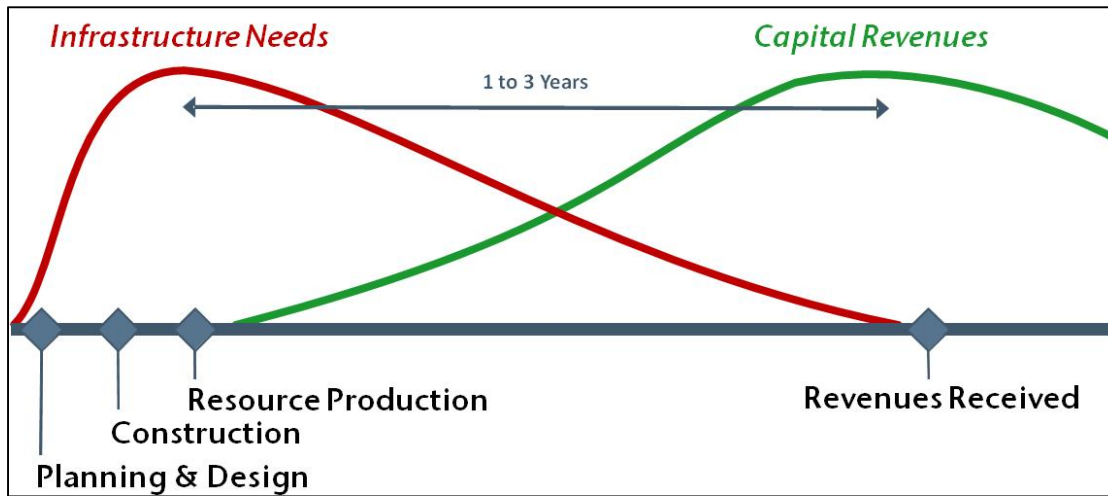
Revenue Time Lag

The development of oil and gas has the potential to require substantial front-end, capital investment in order to maintain, expand and improve affected road infrastructure. Generally, road systems need to be improved or expanded in advance of, or at least concurrent with, drilling activity. Road costs associated with oil and gas drilling occur largely in the early well development period. The tax revenues stemming from oil and gas associated property and severance tax will lag initial drilling by 1-3 years.

Simply stated, the energy industry and the residents of Douglas County need functioning and accommodating road infrastructure in order to drill and complete wells and support baseline traffic requirements, but revenue sources (property taxes and severance taxes) occur only after drilling and production is complete. **Figure ES-7** below shows a graphical depiction of the revenue lag issue.



Figure ES-7. Revenue Lag Issue



Compounding Revenue Growth

It should be noted that in a successful field, over time, the number of ongoing productive wells will outstrip the number of annual new wells and thus the problems of revenue time lag will diminish and, assuming prices and production remain high, annual energy related revenues will grow far faster than new road improvement costs. The critical factor here is simply the ratio of productive wells to new annual drilling. Although the pace of drilling is unknown, most counties have found that oil and gas tax revenues catch up and exceed associated costs.

Well Success and Productivity

A third factor to consider in determining appropriate tax policy is the impact of well success rates and well productivity on local tax revenue. The modeling presented here assumes a 70 percent well success rate. Non-productive wells produce road costs associated with drilling, but very little of the property and severance tax revenue. Similarly highly productive wells are also highly productive for tax revenue, while road costs will remain fairly stable on per well basis, regardless of well productivity.

In essence, the county is sharing the risk and reward of well success with the field developers.

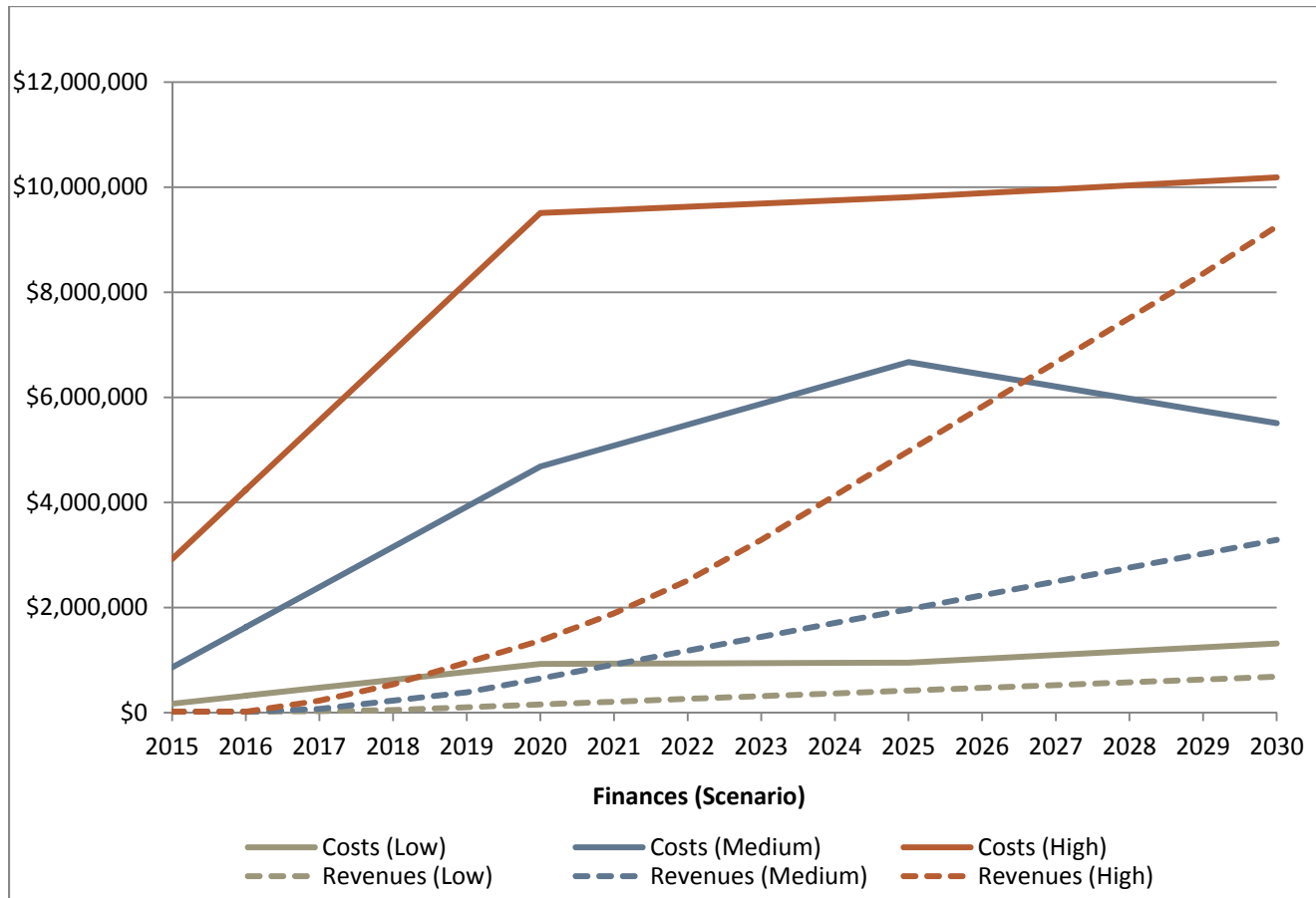
Other Potential Revenue Sources

The heavy truck traffic associated with oil and gas development will place new demands for road infrastructure investment in Douglas County. Truck traffic could potentially increase on many county roads that are not presently designed to accommodate the weight and volume of traffic if substantial resource deposits are discovered in Douglas County. Oil and gas activity also may generate substantial revenue for Douglas County through property and severance tax.

Given present local property tax rates and state severance tax redistribution practices, the study team projects a transportation funding gap over the 15 year study timeframe, as depicted on **Figure ES-8**.



Figure ES-8. Estimated Transportation Infrastructure Funding Gap, Douglas County, 2015 - 2030²



The estimated funding gap for each of the three development scenarios can be summarized as follows:

- ▶ **Low Scenario:** Funding gap ranges from \$150,000 to \$770,000 per year, with an average funding gap of \$560,000 per year
- ▶ **Medium Scenario:** Funding gap ranges from \$850,000 to \$4.7 million per year, with an average funding gap of \$3.3 million per year.
- ▶ **High Scenario:** Funding gap ranges from \$930,000 to \$8.1 million per year, with an average funding gap of \$4.9 million per year.

The funding gap shown in **Figure ES-8** is largely the product of the revenue lag issue shown on **Figure ES-7**. Annual oil and gas net revenues are dependent on the ratio of producing wells to new wells drilled each year. Annual revenues will likely eventually exceed annual transportation costs, particularly if the number of new wells being drilled tapers.

² The revenue figures in Figure ES-8 include all severance tax revenue and property tax revenue. In practice about three-quarters of property tax revenue is allocated to the general fund, social services fund and developmental disabilities fund. The property tax funds currently allocated toward the road and bridge fund account for about one-quarter of the property tax funds shown in Figure ES-8. There may be other funding priorities in the County aside from transportation needs.



Options for Douglas County officials to consider offsetting the projected transportation funding shortfall include:

- ▶ Public improvement district(s);
- ▶ Impact fees;
- ▶ Direct contributions; and
- ▶ Property tax reallocation.

Each option has its advantages and disadvantages (as described in Chapter VII), and the County should potentially consider using several of the above options together.

Over the course of this project, the study team had many conversations with industry and local government officials regarding industry transportation impacts in active resource development areas. Both industry and local government officials indicated that establishing a regular forum or working group for industry and local government officials to discuss community concerns has proven beneficial to both parties. There are regular working group meetings between industry and county officials in many active oil and gas areas, including Garfield, Weld and Rio Blanco Counties. Douglas County officials should engage the industry before widespread development occurs to develop an ongoing dialogue regarding industry road impacts and potential mitigation strategies. These working groups are crucial to the success of securing funding through any of the above recommended funding strategies. Interviews with county officials also indicated that ongoing monitoring of county roads has helped in assessing the impact of oil and gas development on the transportation system. A regular road condition monitoring system will allow the County to assess and appropriately address road degradation related to potential heavy oil and gas traffic.



I. INTRODUCTION

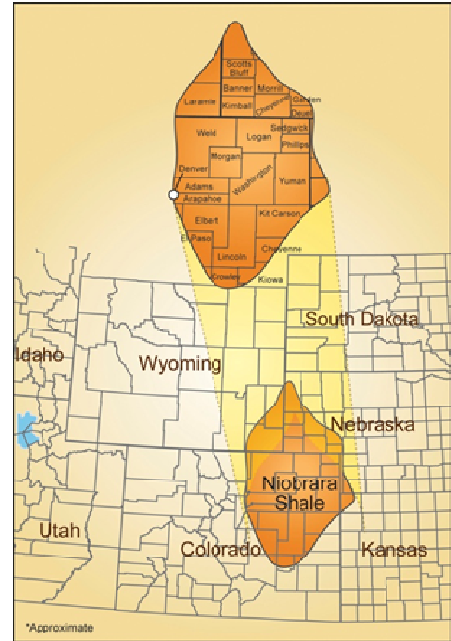
Colorado has substantial energy resources; in 2009, Colorado produced 2,483 trillion British thermal units (Btu) of energy, making it the ninth highest energy producing state, accounting for approximately 3.4 percent of the nation's total energy production. The potential for further energy development in Colorado is considerable; ten of the nation's 100 largest natural gas fields and three of its 100 largest oil fields are found in Colorado (source: U.S. Energy Information Administration). One of the state's largest oil and gas producing shale formations is the Niobrara, which covers over half of Douglas County.

To date, there has been no oil and gas drilling activity in Douglas County. However, 2011 has shown a marked increase in the number of Douglas County oil and gas leases. Oil and gas drilling and production can impact local road systems, as well as other public infrastructure and services. Douglas County has commissioned this study to understand the potential impacts of oil and gas development and production on the County's road system.

Background

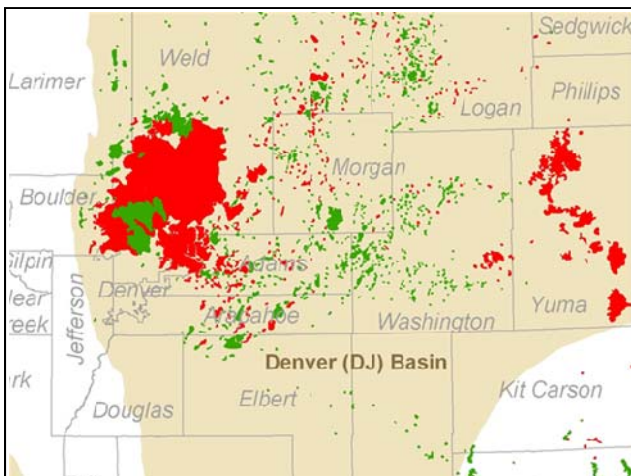
The Niobrara Shale

The Niobrara shale formation is a large geologic zone located in the central plains of North America. The shale formation is comprised of the remnants of ancient microorganisms that lived in this inland sea about 85 million years ago. The geological zone spans portions of four states, including eastern Colorado, southeast Wyoming, western Nebraska and a small portion of northwest Kansas. The Niobrara is also referred to as the Denver-Julesburg Basin.



The Niobrara Shale Region covers parts of Colorado, Wyoming, Nebraska and a small portion of Kansas.

Source: Oil & Gas Financial Journal



Oil and gas well locations in the Niobrara Shale in Colorado. Red indicates gas wells and green indicates petroleum wells. Source: Buffalo Royalties, an energy management and investment company, 2011.

Mining of coal and gold in the Niobrara began in the 1850's and continued until the 1970's. In 1901, the discovery of petroleum in Boulder County introduced energy production to the Niobrara. Because of advancements in technology and growing demand, oil and natural gas extraction began to dominate resource extraction activity in the basin. As shown to the left, the production of natural gas occurs predominately in the Colorado counties of Weld, Yuma and Washington and in southwestern Nebraska. Oil production is scattered throughout the region with higher concentrations in the north central and southwest part of the shale formation. As of July 2011, there were 95,674 producing oil or gas wells in Colorado, 22,620 (approximately one-quarter) of which were in the Niobrara formation. A majority (about 17,000) of these wells are located in Weld County. Colorado Front Range resource development over the



past decade has been concentrated in Weld County. In 2010, over 700 drilling permits were issued in Weld County while only a total of 11 drilling permits were issued in Adams, Arapahoe, Morgan and Washington counties. No new drilling permits were issued in Elbert County. Issuance of drilling permits in this area has declined significantly since a 2008 peak when natural gas prices were at historic highs.

Douglas County Energy Development

Within Douglas County, energy companies are just beginning the exploration stage of resource development. Oil and gas interests are actively leasing mineral rights from land owners but there is no current drilling and no active wells in the County. Energy companies are effectively “positioning” for future well locations but there is no assurance that leasing will result in extensive drilling. The companies may begin to operate on their leases once they have completed sufficient field study through seismic and geological research. According to a senior employee of one energy company leasing in Douglas County, their group is still very early in the process and does not expect active development operations for another two years.

As of June 2011, there were 78 oil and gas leases in Douglas County which were obtained prior to 2011 and 104 leases which were obtained in 2011 (January through June).

As shown in **Figure 1** on the following page, a high volume of the current oil and gas leases are located near the eastern border of Douglas County with clusters in the northeast corner and the southeast region. There are a scattered number of leases in the central and east-central region of the County. Based on producing wells in neighboring counties, energy development will likely be seeking oil rather than natural gas, and well depths will likely be between 5,000 and 9,000 feet.

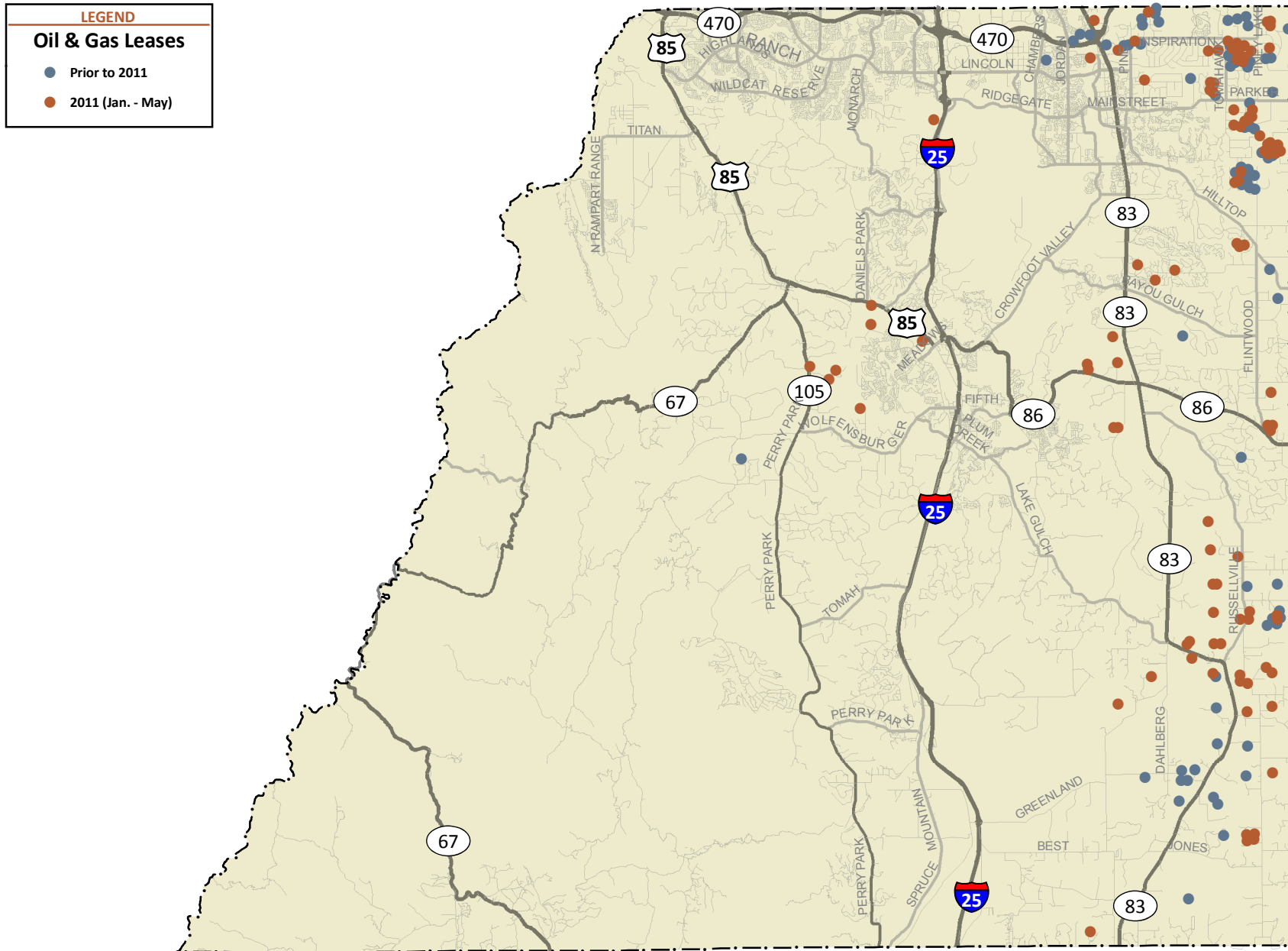
Study Purpose

With the recent surge in oil and gas leases in Douglas County, the County has commissioned this study to understand the potential impacts to the County roadway system that could result from oil and gas development and production. Douglas County’s situation presents an analytical challenge because the field’s productivity is uncertain and much will depend on whether the initial exploratory wells reveal a promising field or not. Resource production can be very lucrative for county governments; under state law, a share of certain severance taxes is rebated to local governments to help cover the impact of resource development, and property taxes on the oil and gas activity can be substantial. Just as oil and gas production levels in the County are uncertain, tax revenues are also uncertain as both property taxes and severance taxes are tied to the value of the resource, which historically has varied widely from year to year.

Because of the uncertainties associated with oil and gas development in Douglas County, this study looks at three potential development scenarios (high, medium, and low) in order to provide a range of potential impacts and revenues associated with resource development in the County. This study is not intended to predict oil and gas development location or intensity, rather it is intended to provide County officials with information about the potential impacts to the transportation system and associated public investment needs using an informed set of development scenarios based on the best available data. While property and severance taxes from oil and gas development would be a substantial revenue source for the County, this study also provides a discussion of other mechanisms by which the County could offset the transportation-related impacts of oil and gas development.

Figure 1

Oil & Gas Leases in Douglas County



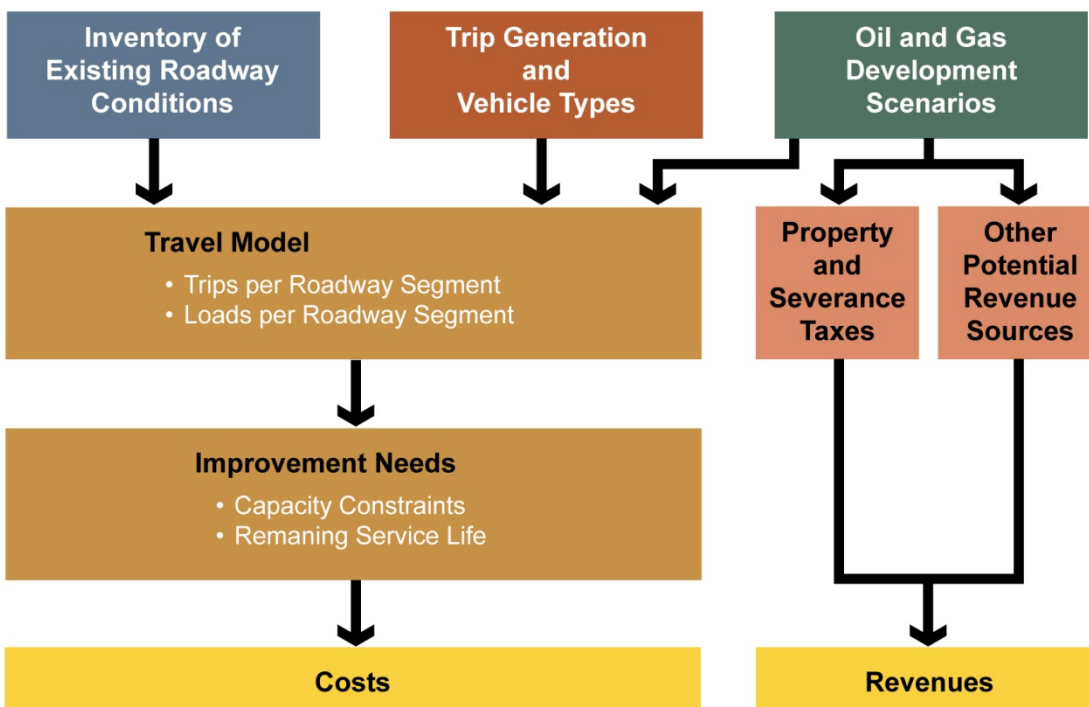


Process

To achieve the study purpose of assessing the potential impacts to the transportation system and associated investment needs, a series of analytical techniques have been used. The three primary inputs to the study process are shown on the top row of **Figure 2**. The inventory of current roadway conditions provides a baseline for identifying investment needs that might result from oil and gas truck impacts. The trip generation and vehicle types provide the foundation for assigning trips and vehicle loads to the County's roadway network. Finally, the oil and gas development scenarios serve to bracket the potential levels of impact.

All three primary inputs have been used in the development of a travel model, which assigns both oil and gas trips and loads to individual County road segments. Based on the results of the travel model, improvement needs can be identified based on roadway capacity constraints (widening needs) and remaining service life (maintenance and reconstruction needs), resulting in roadway improvements costs associated with each development scenario. Revenues related to the oil and gas industry are directly tied to the development scenarios, as well as other variables including the value of the resource.

Figure 2. Study Process Diagram



Each box in **Figure 2** represents a complex set of calculations, many of which require assumptions because of the uncertainties of oil and gas development in general (e.g., the value of the resource), as well as the unproven development potential of the field in Douglas County. The study team has relied heavily on input from previous studies pertaining to the impacts of oil and gas development including Environmental Impact Statements (EISs) from the Rocky Mountain region and nationwide. Likewise, the study team conducted a series of interviews with key industry representatives for insight in establishing the development scenarios and understanding how and where oil and gas trucks could potentially impact the County's roads. A list of references and a summary of the interviews are provided in Appendix A and Appendix B, respectively.



II. RESOURCE DEVELOPMENT

Well Development Overview

There are five stages in the development and operation of an oil or gas well:

- ▶ **Leasing and exploration** – Obtaining mineral rights and developing a well drilling program.
- ▶ **Pad construction** – Preparing the site, including building the access road and the well pad.
- ▶ **Drilling** – The process of drilling the vertical well to the desired depth and completing the requisite number of horizontal bores.
- ▶ **Completion** – Converting the well system to a producing well, typically by fracturing the shale and completing the production well requirements.
- ▶ **Production** – Extracting, storing and distributing the resource.

This process, as it is likely to occur within Douglas County, is described in greater detail in the following sections.

Leasing and Exploration

Drilling requires acquisition of subsurface mineral rights, which are often, but not exclusively, owned apart from a property's surface rights. Energy companies that have an interest in exploring an area for energy prospects, or extracting resources from a known reserve, must first buy or lease the appropriate subsurface ownership rights. Companies often negotiate mineral right acquisition on speculation, before the presence of productive resource is certain. In many instances, there can be aggressive leasing activity, which is followed by very little immediate development activity, or an area can be determined to be an unproductive source after a few test wells. Active mineral leasing efforts do not ensure future energy extraction.

Geologists and petroleum engineers will target an area for exploration, typically based on nearby well development patterns, and then company representatives will seek out property owners to acquire leases. Companies often try to maintain secrecy in this process in order to reduce speculation and keep lease costs down. Most companies will try to control a large area so that multiple wells can be drilled and the economic benefits of expensive exploration, leasing and well field development can be efficiently recovered. Often multiple companies will share in an individual well's, or a field's, financial returns. As of November 2011, energy companies are still in the leasing and exploration phase in Douglas County. It is important to note that there are no completed wells in Douglas County, although there are many active wells in adjacent counties.

With mineral rights secured, energy companies will approach the Colorado Oil and Gas Conservation Commission (COGCC) for confirmation of a drilling and spacing plan, which suggests the area in which initial drilling will occur. Companies may approach drilling operations slowly, spending time researching and surveying to determine the best locations for individual well development. If mineral rights are secure, companies sometimes allow other operators to proceed, modifying their own plans based on their competitors' success or failures. Many factors can influence how quickly efforts are made to determine a new field's prospects. Geological surveys, seismic exploration, core sampling and exploratory wells are common tools used to gauge the potential productivity of a region.

Exploratory wells are placed in order to obtain core samples and determine the likely productivity of the target shale. Results from the exploratory wells and the geography of an individual company's mineral rights holdings will dictate the larger field development strategy.



Pad Construction

With core sampling and exploration completed, a company will typically develop a drilling plan, attempting to define a plan for efficient recovery of reserves while continuing to confirm the location, depth and nature of the target resource. After the team of geologists and geophysicists identify the best site for drilling, a team of about 10 workers begin developing the well pad. Typically a well pad is a leveled one to five acres of land. The construction team connects the well pad to the nearest road with a gravel access road for supply transport. The length of this road depends on the remoteness of the well location from the existing road network.



A natural gas well pad under construction in Springfield Township, PA
Source: Democrat and Chronicle Newspaper, Rochester, NY, June 2011

In addition to the drilling rig, well pads often accommodate water tanks, equipment, spoilage ponds and some form of an administrative and operations trailer.

Drilling

After the well pad and access road are constructed, a drilling rig is moved onto the pad to begin drilling the well. The drilling rig requires two six-person crews, typically working 12 hour shifts to operate the rig 24 hours a day.



Nabors 818 drilling rig and pad site
Source: Harris Drillina, LLC, oil & gas development consultants

Once the well bore is completed, finalizing a well requires the installation of thousands of feet of pipe and casing materials to secure the well. Typically, in Niobrara wells, once the well is completed to the desired depth, the workers will commence horizontal drilling in preparation for fracturing the shale deposit.

Horizontal drilling is a technological advance that has expanded the types of rock formations that offer viable energy extraction. Instead of simply drilling vertical wells straight down into the rock formation, vertical wells are drilled into the depth of the formation and then turn to proceed horizontally and deeper into the layer of shale.

This method, though more time consuming and

expensive, allows a single well to access a much greater portion of the gas or oil trapped in the formation. Where once dozens of individual vertical wells were needed to harvest oil or gas deposits, one single well can now access large areas of the same shale layer. This method minimizes the surface disturbance and maximizes the operator's ability to extract the resource.



In most cases, multiple horizontal wells are drilled on a single pad, allowing access to more oil or gas reserve from one pad site. A typical well requires about 15-25 days to be drilled to the desired depth and fully extended by horizontal lines. If the site is a multi-well pad, then the drilling stage is extended. Once completed, the well is ready to be “stimulated” for production. At this point, the drilling rig and associated workers leave the pad and the completion rig and a new set of workers begin the completion phase.

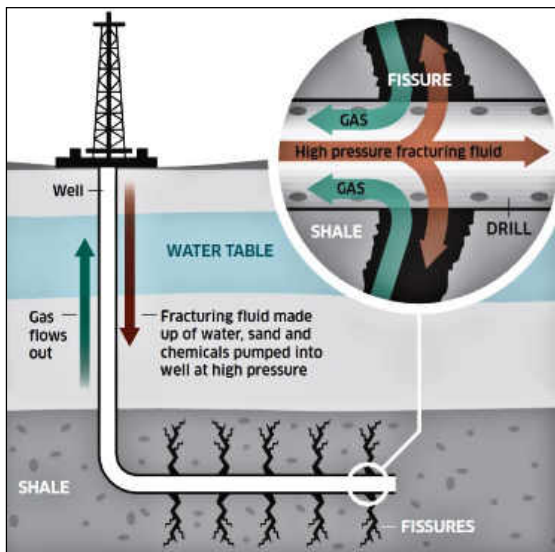
Completion

The completion stage takes a drilled well and makes it suitable for energy extraction. Within the Niobrara, the most likely well completion method is fracking, which involves the use of highly pressurized water mixture to fracture the shale formation in order to release trapped oil or gas. The completion rig involves a network of trucks, tanks, hoses, blenders and pipes that push fracking material deep into the well to release trapped energy deposits.



Completion rig and trucks on a well pad.
Source: Chesapeake Energy, March 2011

The workers first use a fracking gun to penetrate through the well casing and fracture the shale at the furthest depths of the well. Once each extension of the drilled well has been penetrated by the fracking gun, a highly pressurized mixture of water is pumped into the fractures starting with the segment at the deepest end of the well. The fracking fluid flows through the fractures and begins to crack the shale along natural weaknesses in the rock. Proppant, usually a sand mixture, is introduced into the fractures to keep the cracks open and help oil and gas escape into the well. The workers use a series of plugs to maintain the pressure of a fracked segment and continue to frack the shale along the horizontal well. During this stage, between three and five million gallons of water are pumped at high pressures into the shale and then subsequently retrieved during the production stage. Under the state’s Oil and Gas Commission guidelines, all water used in this process is either recycled or properly disposed of under Commission regulations. The importation of water to the well and the subsequent removal to an approved disposal site is the most truck intensive element of a well’s development.



Drilling and completion stage technology: hydraulic fracturing and horizontal drilling.

Source: Sustainable Online Magazine, 2010

Once each of the arms of a well is sufficiently fractured, the plugs are removed and the well is ready for production, or the extraction of oil and gas. The completion stage takes between 15-20 days, depending on the depth and horizontal extension of the well.



Transportation Demands of Oil and Gas Development

Oil and gas development requires the transport of heavy equipment to the well site to build access roads, construct a well pad and transport a drilling rig. Heavy trucks are also required to bring fresh water to the well site and often to transport produced water and extracted resources off site. In order to estimate the transportation impacts of prospective oil and gas well development in Douglas County, the study team reviewed earlier traffic modeling efforts completed for the Colorado Department of Transportation (CDOT), Garfield County and the Associated Governments of Northwest Colorado. The study team also conducted a literature review to determine if new research has been published related to energy development and transportation effects (a list of references is included in Appendix A). The team interviewed knowledgeable persons that are connected to oil and gas development in the Niobrara Basin, as well as planning officials in Garfield, Gunnison, and Weld Counties (a summary of the interviews is included in Appendix B).

Trip Generation

Each stage of well development varies in the intensity, character and duration of the associated traffic generation. The leasing and exploration phase produces very little new traffic until a decision is made to drill exploratory wells. Well specific traffic generation estimates were developed using national data on drilling and well service traffic generation ratios and adjusting for the drilling characteristics likely to prevail in the Douglas County/Niobrara Basin. The transition from single well pad sites to multi-well developments alters the traffic patterns associated with gas development.

National Data Sources on Single Well Trip Generation

Table 1 shows data extracted from multiple national and regional studies examining vehicle trip production by well development phase. There is considerable variation in these estimates; as a result, the outlier data point for each phase of well development has been excluded to produce an average value from the remaining three studies.

Table 1. National Data on Trip Generation per Well

Phase	Source				Average Trips per Well ¹
	NDDOT	UDOT	MIT Marcellus	BLM Wyoming	
Well Development					
Construction	160	20	20	854	67
Drilling	572	508	160	600	560
Completion	892	1,072	1,600	488	1,055
Development Total	1,624	1,600	1,780	1,942	1,682
Well Production (annual)	400	-	400	730	510

¹ Due to data sources' high variability, the average trip generation omits outlying data points that do not apply to the Niobrara shale formation.

Sources: North Dakota DOT, Oil & Gas Division of the North Dakota Industrial Council and Missouri Basic Well Service, 2010.

Uinta Basin Highway Freight Traffic. Daniel B. Kuhn, UDOT Freight Planner, 2006.

NTC Consultants. Impacts on Community Character of Horizontal Drilling and High Volume Hydraulic Fracturing in the Marcellus Shale and Other Low-Permeability Gas Reservoirs, September 2009.

Pinedale, WY SEIS. Ultra Resources, Inc., Shell Exploration & Production Company, Questar Market Resources, 2008.



All trip estimates in **Table 1** include both inbound and outbound trips (Example: NDDOT identified 160 construction trips or 80 inbound and 80 outbound trips). The average trips per well data are for a specified development period of roughly 1.5-2 month, while the production related trips are expressed as annual trips and will continue for the duration of the well's production.

These data suggest that a typical well will generate about 1,682 trips during its two month development period or an average of 28 trips per day, largely related to water delivery and removal.

Multi-Well Pad Site Trip Generation

The above unadjusted trip generation rates represent the direct trips associated with well services, resource development and final production, and assume a high percentage of single well pads. Recent Colorado Niobrara drilling experience suggests that virtually all wells in Douglas County, if developed, will use horizontal drilling and fracturing techniques that will allow for multiple wells on a single pad and, therefore, will change the duration of steady traffic generation and the traffic profile associated with drilling activity.

In order to increase production and extraction efficiency, pad sites in Douglas County will likely accommodate multiple-wells and horizontal drilling, a process that allows access to more of the formation without having to build an entirely new well pad site for each well. This process lessens the surface impact, reduces drilling and completion times, and improves development efficiency in comparison with multiple, single-well pad sites. In addition, environmental review and compliance costs associated with other Colorado COGCC regulations are reduced. Operating multiple wells on a single well pad is an increasingly common practice in the Niobrara Basin and will likely be the dominant practice in Douglas County.

Multiple-well pads offer vehicle-trip savings on a per well basis by avoiding duplicate pad development costs and realizing some operating efficiencies during the well development process, although this process means that activity at any single drilling site will continue for a longer period of time than had a single well been drilled.

The effect of multiple wells on trip generation, in comparison with single well development, is reflected in **Table 2**, which is drawn from a recent MIT study of the United States shale gas industry. These data appear to be the most authoritative source for multi-well drilling practices.

According to the MIT/NTC analysis, which is based on drilling in the Marcellus formation—a reasonable comparison with the Niobrara formation—using a single pad to complete eight wells, instead of one pad per one well, can decrease the number of truck trips per well by nearly 18 percent.



Table 2. Trip Generation Comparison for Single- and Multi-Well Pads

Activity	1 Rig, 1 Well	2 Rigs, 8 Wells
Construction Stage		
Pad and Road Construction	20-90	20-90
Drilling Stage		
Drilling Rig	60	120
Drilling Fluid and Materials	50-100	400-800
Drilling Equipment (casing, drill pipe, etc.)	50-100	400-800
Completion Stage		
Completion Rig	30	60
Completion Fluid and Materials	20-40	160-320
Completion Equipment (pipe, wellhead, etc.)	10	20
Fracturing Equipment (pump trucks, tanks, etc.)	300-400	600-800
Fracture Water	800-1,200	6,400-9,600
Fracture Sand	40-50	320-400
Flowback Water Disposal	<u>400-600</u>	<u>3,200-4,800</u>
Total	1,780-2,680	11,700-17,810

Source: MIT/NTC Consulting



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III. OIL AND GAS DEVELOPMENT SCENARIOS

This section provides potential future oil and gas development scenarios in Douglas County based on historic well development in active counties in Colorado. The study team employed a second estimation methodology using drilling rig utilization to provide a check on the development scenario estimates.

Energy companies are in the beginning stages of exploration in Douglas County. Many national and international factors will shape future levels of drilling activity, including oil and gas prices, national economic growth prospects, and the merit of the Niobrara Shale relative to other production areas. Locally, a host of additional factors will influence how quickly efforts are made to determine a new field's prospects. Douglas County is one of several counties that lie above the Niobrara Shale. Depending on the geology of the shale, drilling could occur in any of the counties.

The study team developed a set of three future development scenarios based on actual well development activity data obtained from the COGCC. The following exercise is not an attempt to predict the future, but rather an effort to develop an informed set of development scenarios based on the best available data.

Recent Oil and Gas Development in Colorado

The following provides a discussion of recent oil and gas development in active counties in the Niobrara Shale area and elsewhere across the state.

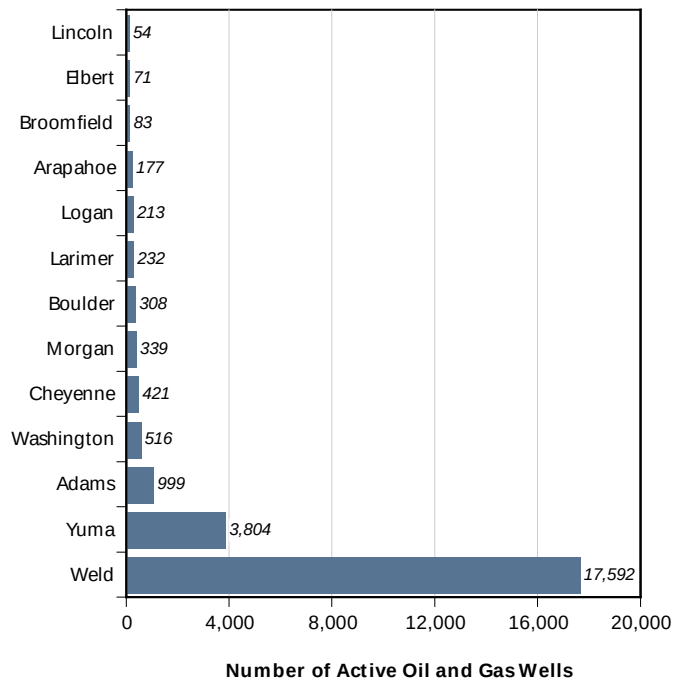
Existing Colorado Oil and Gas Wells

As of November 2011, Colorado has about 46,000 active wells, Douglas County has no active wells and neighboring Elbert County has only 71 active wells. Most of Elbert County's wells were drilled in the 1990s and do not employ horizontal drilling or multi-well pads. Over the past five years, only four wells have been drilled in Elbert County. The majority of Colorado's Front Range oil and gas wells are located in Weld County, which currently has over 17,500 active wells or nearly 40 percent of all active wells within the state. **Figure 4** shows COGCC data on active oil and gas wells in Weld County and other producing Front Range Counties.

The chart shows most production occurring in Weld County, Yuma County and Adams County. Most other counties that lie above the Niobrara Shale currently have about 500 active oil and gas wells or fewer. Historically, most drilling and production activity has occurred in the northern Front Range and in counties in the northeastern portion of the state.



Figure 4. Active Oil and Gas Wells in Colorado's Front Range (2011)

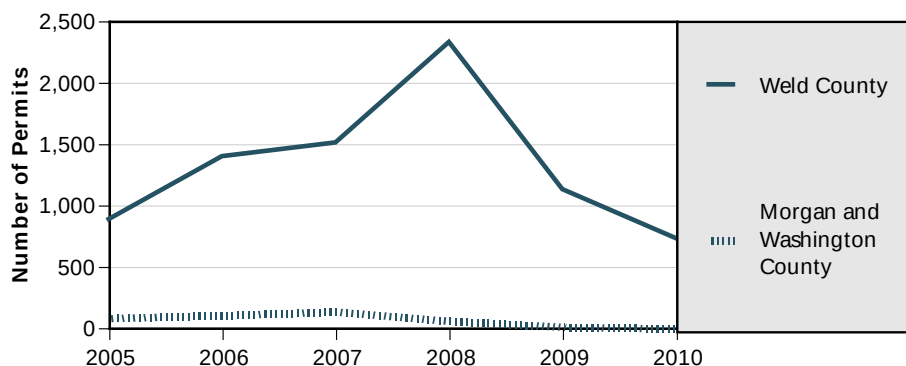


Source: COGCC, November 2011

Permitting Activity

Figure 5 shows COGCC data on drilling permits issued in Weld County and the most drilling-active counties near Douglas County. As noted previously, neighboring Elbert County has witnessed only four well permits in five years. Similarly, the combined number of well permits pulled in Arapahoe, Elbert, Morgan, Washington and Adams counties has declined from 147 in 2008 to 11 in 2010. Although there is a great deal of Douglas County leasing activity, there has not been a great deal of nearby drilling activity and just one permit has been pulled in the County. Regardless, new technology has changed the profile of candidate fields, and activity could easily spike with one or two productive exploratory wells.

Figure 5. Drilling Permits by Year in Surrounding Counties



Note: Approximately 50% of drilling permits result in a drilling operation within the term of the permit.

Source: COGCC, 2005 – 2010.



Well Development

The study team obtained data on active wells by county for the five most active producing counties from the COGCC for each of the last six years and calculated the year-over-year change in active wells to examine well development activity in Colorado. **Table 3** shows the annual change in active wells for the five most active resource producing counties.

Table 3. Change in Active Wells per Year Colorado's Top 5 Producing Counties (2006-2011)

	2006	2007	2008	2009	2010	2011	Average
Garfield	575	641	845	1,042	1,272	1,236	935
Weld	566	546	548	1,286	1,262	1,313	920
Yuma	245	468	580	331	186	175	331
Las Animas	272	274	412	324	113	38	239
La Plata	143	37	132	147	100	111	<u>112</u>
Annual Average per County							507

Source: COGCC; BBC Research & Consulting.

Between 2005 and 2010, active wells have increased by over 15,000 in the five most active counties in the state. Garfield County had the largest increase in active wells—an annual average increase of over 930. Weld County had an annual average increase of over 920 wells over the same period. Active wells in Yuma County and Las Animas County increased by between 200 and 350 wells per year in the last six years. Active wells in La Plata County increased by about 100 per year over the same period. The average annual increase in active wells in the top five producing counties in the last six years is just under 510 wells per year. This figure is used in establishing an upper limit in the well development scenarios used in transportation impact modeling.

Douglas County Development Scenarios

The study team developed three scenarios to input into the transportation impact model—high, medium and low development pace scenarios. Again, this is not an attempt to predict the future and the study team does not assign any measure of the likelihood of one scenario to occur over another. The geology of the field, relative productivity compared to other resource plays and global commodity markets all affect the pace at which the Niobrara Shale is developed.

The high development scenario was selected as the annual average increase in active wells in the top five oil and gas producing Colorado Counties—about 510 wells developed per year. For the medium scenario, the study team selected 150 wells developed per year, which is approximately the development pace in La Plata County over the last six years. The low scenario resembles the development pace observed in Boulder, Adams and Moffat Counties—about 30 wells per year. All well development scenarios are assumed to involve clustered development and horizontal drilling techniques described in Section II of this report. The corresponding number of well pads developed per year is also shown in **Table 4**.



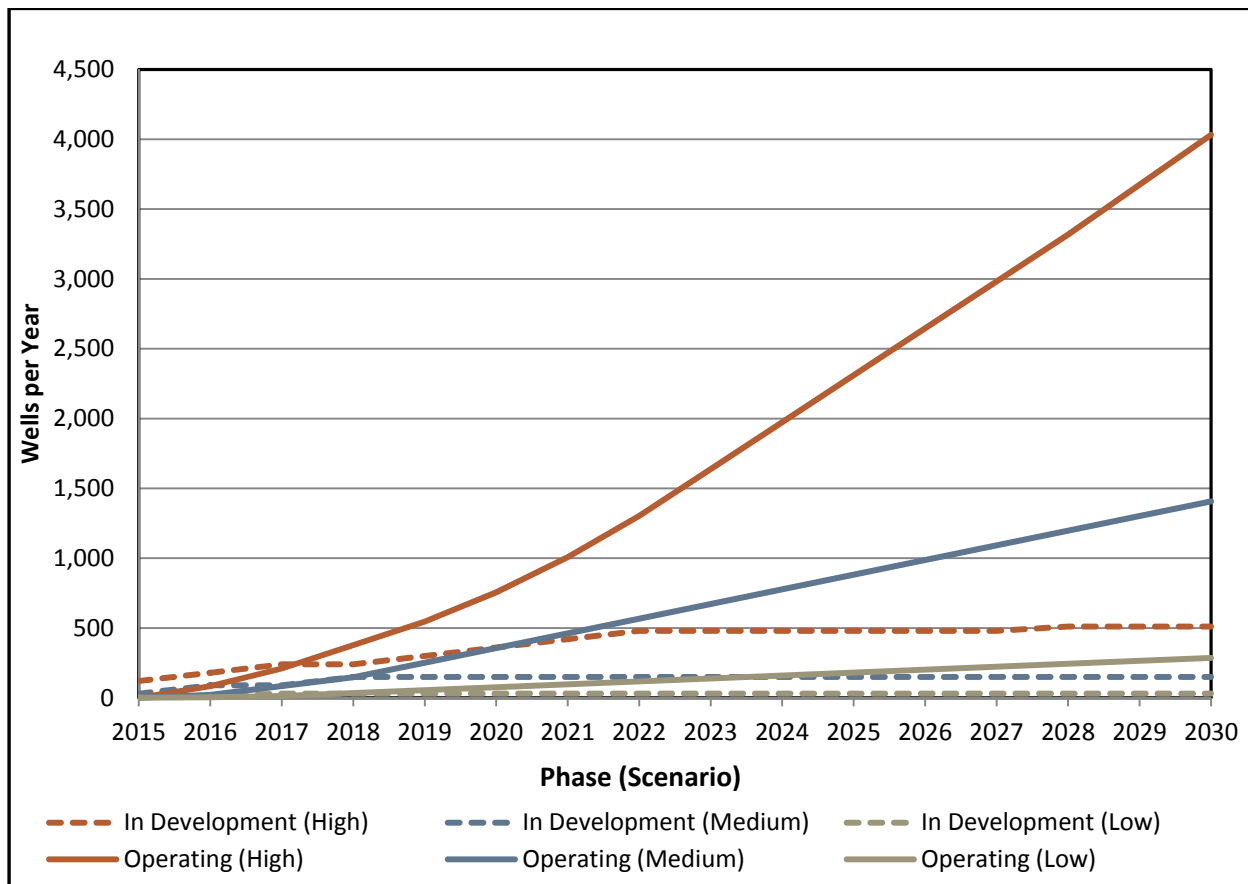
Table 4. Douglas County Development Scenarios

	High	Medium	Low
Wells per year	510	150	30
Pads per year	85	25	5

Source: BBC Research and Consulting

The year-by-year profile of each of the development scenarios is shown on **Figure 6**. Each scenario assumes that oil and gas development would begin in earnest in 2015 (with leasing and exploration occurring in the years leading up to 2015). The addition of new wells each year begins at a slow rate and ramps up to the annual development figures shown in **Table 4**. For the purpose of this study, any single well's development is assigned to a single calendar year, and that well would be in production in all subsequent years (through 2030). After the development phase, the production phase includes a 70 percent success rate for new wells drilled to effectively enter the operating stage.

Figure 6. Douglas County Development Scenario Profiles



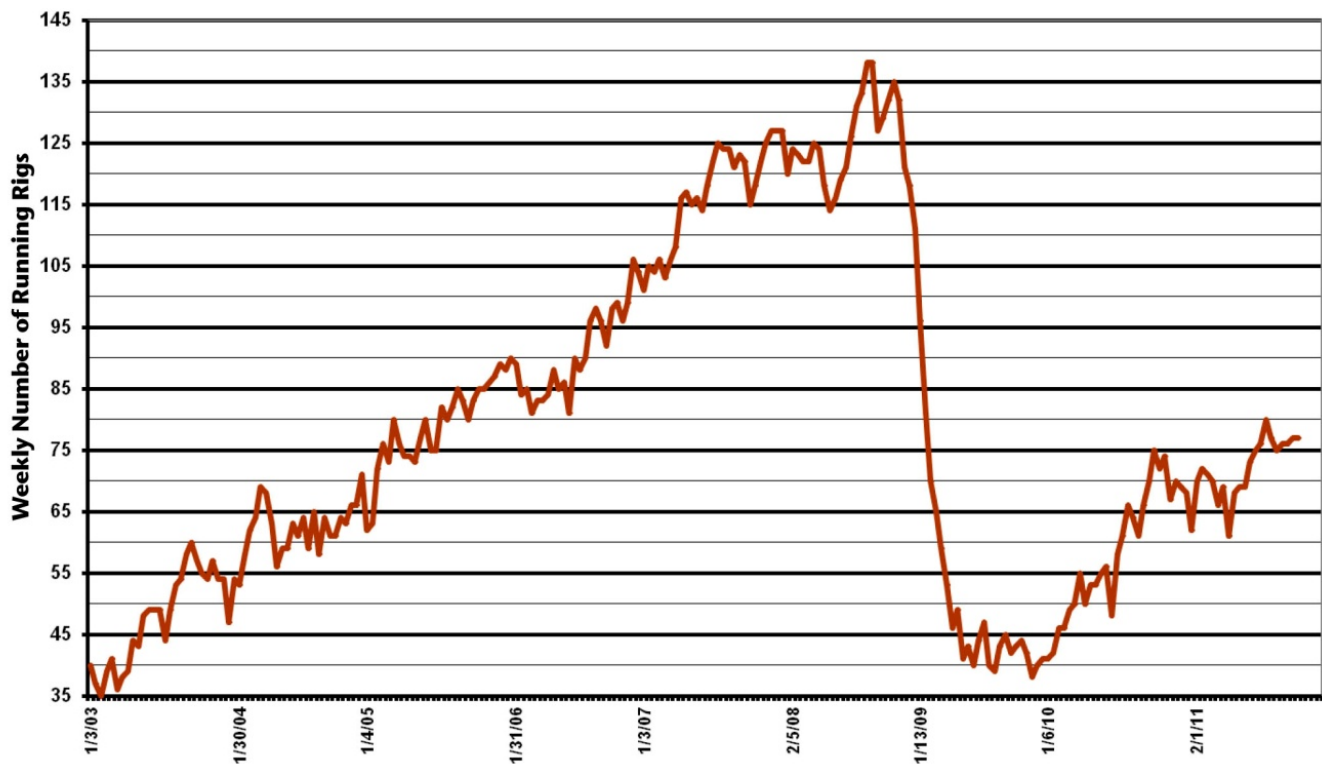
Source: BBC Research and Consulting



Rig Utilization

As a check to the methodology described above, the study team contacted COGCC staff to discuss the scenarios developed above. COGCC staff described an alternate methodology, where drilling rigs and the well drilling period are used to calculate the total amount of annual wells drilled per year. **Figure 7** shows the number of drilling rigs in operation in Colorado by week from 2003 to the present.

Figure 7. Total Drilling Rigs Running in Colorado (2003-2011)



Source: Conservation Commission Colorado Weekly & Monthly Oil & Gas Statistics, 11-07-11.

The graph above shows operating drilling rigs peaked in fall 2008, before dropping precipitously. In fall 2008, there were nearly 140 drilling rigs in operation in Colorado. According to the most current estimate, there are about 80 drilling rigs currently operating in Colorado.

The information presented in Chapter II indicates that, in general, a typical well would take approximately 30 days to drill. Therefore, one drilling rig can drill about 12 wells per year. Oil and gas companies have a finite amount of capital resources and operating a drilling rig is expensive and requires a significant capital commitment. The Douglas County portion of the Niobrara Shale is a relatively small portion of the Front Range shale play. Oil and gas operators will allocate drilling rigs to areas that show the most promise in developing a productive well. Depending on their land holdings, oil and gas companies will consider other counties along the Front Range, Western Slope and across the nation, when deciding where to drill.

Table 5 shows the three well development scenarios, the number of drilling rigs required for each scenario and the percentage of historic peak and current statewide drilling rigs allocated to Douglas County in each scenario.



Table 5. Rig Utilization by Scenario

Scenario	Wells Drilled per Year	Required Drill Rigs	Percent of Historical Peak Rig Count	Percent of Current Rig Count
High	510	43	31%	56%
Medium	150	13	9%	17%
Low	30	3	2%	4%

Source: COGCC, BBC Research and Consulting

The table shows the substantial amount of drilling rigs necessary to drill the amount of wells in the high scenario. The high scenario would also require a significant allocation of statewide drilling rigs to Douglas County by any historical or current measure of rig allocation. Based on this information, the study team believes the high scenario to be a plausible upper limit. Again, it is important to note that this exercise is not intended to assign a probability to any of the scenarios occurring, but to appropriately define potential maximum and minimum levels of well development activity.



IV. TRAVEL MODEL

Methodology

A travel model has been developed using TRAFFIX software to assign the trips and vehicle-loads associated with the high, medium and low development scenarios to the Douglas County roadway system. TRAFFIX is a GIS-based interactive computer program that assigns traffic to a network based on trip generation, trip distribution, and roadway network characteristics. Although the travel model includes roadways outside the jurisdiction of Douglas County (Interstate and State Highways, and municipal roads), for the purpose of this study, the transportation impacts (and associated improvement needs and costs) have been assessed only on roads under the jurisdiction of Douglas County.

As described in Chapter II, the most intense transportation impacts of oil and gas development occur during the well pad construction, drilling, and completion activities. For a single pad site, these three activities are estimated to occur over a nearly nine month period. Because oil and gas development occurs year-round, it has been assumed that the cumulative impacts of well pad development will be evenly distributed over the course of a calendar year. Therefore, all outputs from the travel model are on an annual basis. To assess the potential transportation impacts over time, the study team has evaluated four time periods: 2015, 2020, 2025, and 2035.

Oil and gas development will result in increased traffic on the roadway network (vehicle-trips), as well as increased loads on the County's roads from the many heavy vehicle trips associated with the industry. For this reason, the TRAFFIX model has been used to estimate not only vehicle trips, but also loads as measured in equivalent single-axle loads (ESALs). The impact of heavy vehicles is dependent on a roadway's surface type (flexible pavement [gravel or asphalt] versus rigid pavement [concrete]). To properly calculate the ESAL impacts on Douglas County's roads, two ESAL model iterations are required; one for flexible pavement and one for rigid pavement.

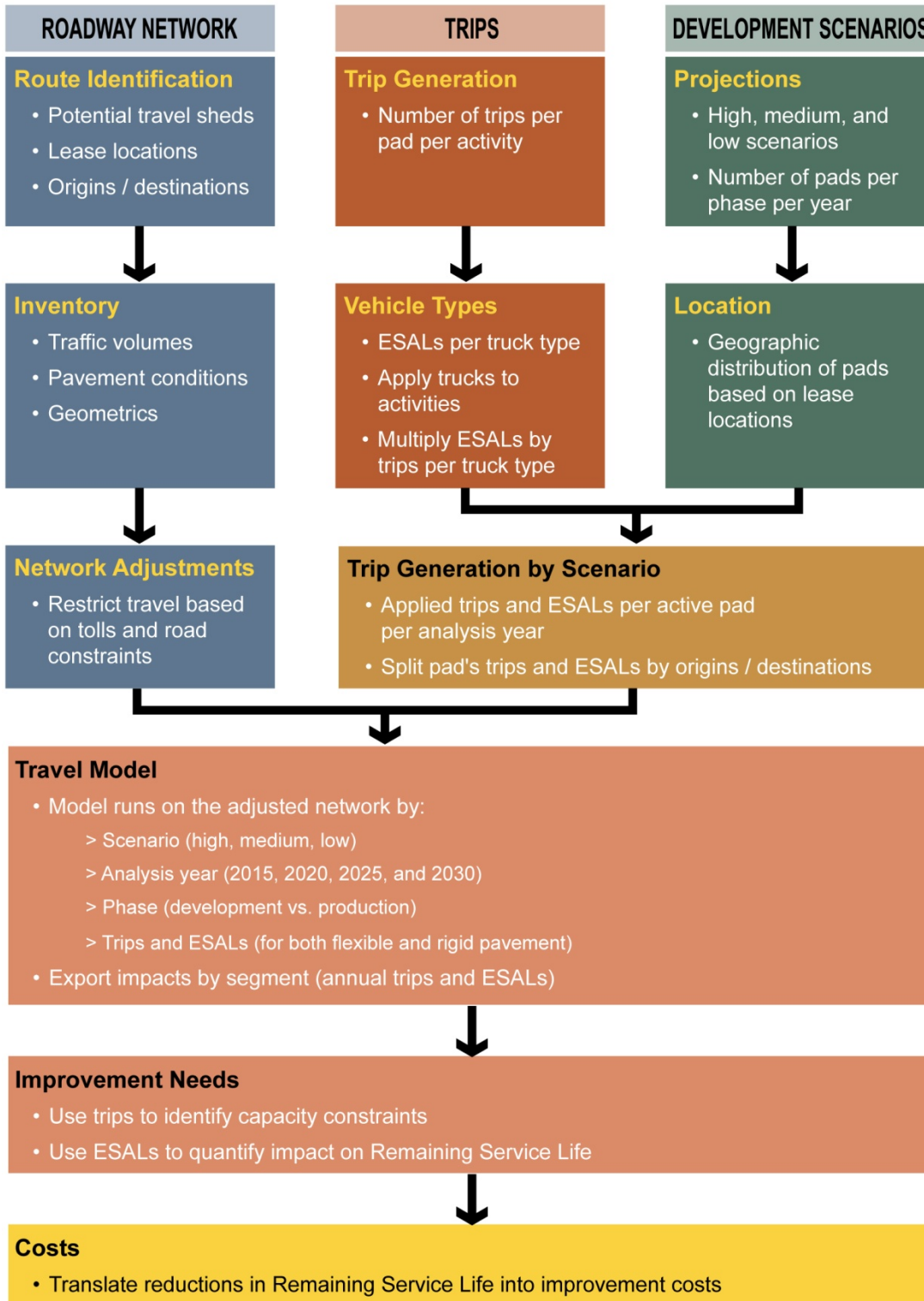
The trip generation characteristics for oil and gas development phase are substantially different from the trip generation characteristics during the on-going well production phase. Therefore, for each evaluation year, the travel model has been run separately.

The assignment process was conducted for a combination of each development scenario (low, medium, and high), each analysis year (2015, 2020, 2025, and 2030), for trips by phase (development and production), and for ESALs by surface type (flexible and rigid), resulting in a total of 63 iterations of the travel model.

Figure 8 provides an overview of the process used for estimating the transportation improvement needs and associated costs. Each element of the process is described in detail in the subsequent sections.



Figure 8. Process for Estimating Transportation Impact Costs



ESAL = Equivalent Single Axle Load



Trip Origins/Destinations

Trip origins and destinations were identified by determining where oil and gas development trips will likely be traveling to and from. For all trips, the pad site serves as either the point of origin or the destination. Trips will either involve a loaded truck delivering items to the site, removing elements to an off-site location, or transporting workers and machinery to and from the pad. At the onset of this study (June 2011), 182 oil and gas leases had been obtained and were active in Douglas County, as shown on **Figure 1**. These locations identify plots of land leased by an oil and gas company for potential exploration. Given the uncertainty of where oil and gas pads may be developed, the lease locations were used to represent general areas where potential development might occur.

Locations of the other end of oil and gas trips were estimated by categorizing and researching the reasons for travel (trip purposes). There are four primary trip purposes associated with oil and gas development, each of which uniquely impact where oil and gas trucks will travel:

- ▶ Bringing fresh water to the site
- ▶ Removing produced water from the site
- ▶ Transporting equipment
- ▶ Transporting other materials

Fresh Water

Water is a key resource in the well drilling process as well as during the high pressure fracturing stage, where water is mixed with sand and chemicals. For oil and gas development in Douglas County, fresh water would likely be purchased from local water providers. Due to the vast amounts of water required for well development, only water providers with bulk water services are likely candidates for fresh water. Based on conversations with water providers in Douglas County (see Appendix B for interview summaries), Castle Rock and Littleton were identified as the two providers in the area with bulk water supply capabilities. Castle Rock Water's bulk water access point is located south of the City of Castle Rock's Justice Center, southwest of I-25 and Meadows Parkway. The precise location of Littleton's bulk water access point was not identified, as it is outside of Douglas County. Trips to and from the Littleton water district are assumed to enter the County's road system from either C-470 or US 85. Depending on pricing and transport costs, it is conceivable that fresh water could be purchased from further outside of Douglas County. However, given the uncertainty of these factors, it was assumed that oil and gas developers would acquire water from the nearest resources (either Castle Rock or Littleton water districts).

Produced Water

Water is also a major byproduct of both the development and production phases. Produced water from the fracturing process and from the extraction of oil and/or gas is generated and must be appropriately treated. Based on an interview with the head of COGCC's Underground Injection Well Unit (refer to Appendix B for an interview summary), for most fields in Colorado's Front Range, roughly 20 percent of the produced water is put into onsite evaporation ponds, another 20 percent is typically either discharged to local water bodies (if it meets quality standards) or used as dust abatement on dirt roads. The remaining 60 percent is usually injected into underground injection control (UIC) wells. No Class II UIC wells (which are associated with oil and gas production) currently exist in Douglas County and they would not likely be drilled until the field is proven with numerous producing oil or gas wells. Colorado has roughly 800 UIC wells, with the nearest UIC wells located in



Weld County. Thus it was assumed that produced water that needs to be removed from the site would be trucked to Weld County by way of I-25 or E-470 (to a lesser extent because of the tolls).

Equipment

The equipment required for oil and gas development, including the drilling rig, the well structure, pumps, and well casings, could come from any location where oil and gas companies have operations, or where contractors providing such services are located. This equipment is ever moving from site to site or between storage locations and new sites. With this in mind, two sources were identified as likely suppliers of oil and gas equipment. The first is other oil and gas producing counties in Colorado that likely have equipment in use or in storage. Most of the relevant equipment within Colorado was identified to exist primarily in the Weld County-Denver area or in western Colorado. I-25 at the northern boundary of Douglas County has been treated as an origin for



An oil derrick being hauled.

Source: Colorado Motor Carriers Association

equipment transport. E-470 may also be used to transport equipment to Douglas County; however, because of the tolls on E-470, I-25 has been used as the primary route.



Transport of well equipment.

Source: Colorado Motor Carriers Association

Equipment could also come from the Gulf of Mexico region. Some specialty equipment is scarce in Colorado and may be brought in from other regions with a greater supply. Places such as Louisiana and Texas have previously been identified as possible source locations for such equipment for oil and gas operations in Utah, so such travel patterns could exist for operations in Colorado as well (Kuhn, 2006). Therefore, I-25 at the southern boundary of Douglas County has also been treated as an origin for equipment transport, but the northern access point remains the dominant location for equipment trips.

Materials

Oil and gas development requires a variety of other materials in addition to water. Gravel, sand, piping, cement, chemicals, and other construction materials must be trucked to the site at different stages of the development phase. These resources would likely come from where supply is the greatest, trucking distance is shortest, and prices are the cheapest. Because these factors create a great deal of uncertainty as to where a resource may arrive from, it has been assumed that materials would arrive via I-25 from the north and south, with a greater likelihood of trips to the north given the greater Denver area's capacity to provide a wide array of materials or to receive materials via rail from locations outside of Colorado.



Inventory of Travel Shed Roadways

Once origins and destinations of the oil and gas trips were established, potential paths between them were identified. ArcGIS was used to determine the nearest minor and major roadways in proximity to each lease site. This inventory of roads was then linked to roadways that could allow trips to travel to/from the origins and destinations described in the previous section. Where no clear path was evident to provide a link between origins and destinations, all reasonable nearby routes were included. With the potential travel sheds identified, all selected roadways were transferred from ArcGIS to TRAFFIX in order to model travel patterns and volumes and loadings. **Figure 9** shows the potential travel sheds used in the TRAFFIX model.

Once aggregated, the potential travel sheds formed the backbone for estimating where trips would occur and the degree to which they would be impacted. In order to evaluate the level of impact that oil and gas trips would have on the selected routes, the current status of each roadway was obtained. The following data were collected for travel shed roadways under the jurisdiction of Douglas County.

Traffic Counts

One of the primary goals of the modeling process is to estimate traffic volumes on the travel sheds as a result of oil and gas activity. It is useful to compare these estimates to existing and future background traffic to provide perspective and determine if the travel demand on any roadway segments might exceed the existing capacity. Daily traffic counts, including classification of vehicles, were recorded at 38 locations on the identified travel sheds. **Figure 10** illustrates current traffic volumes for a typical weekday, while **Figure 11** shows the percent truck traffic.

Geometrics

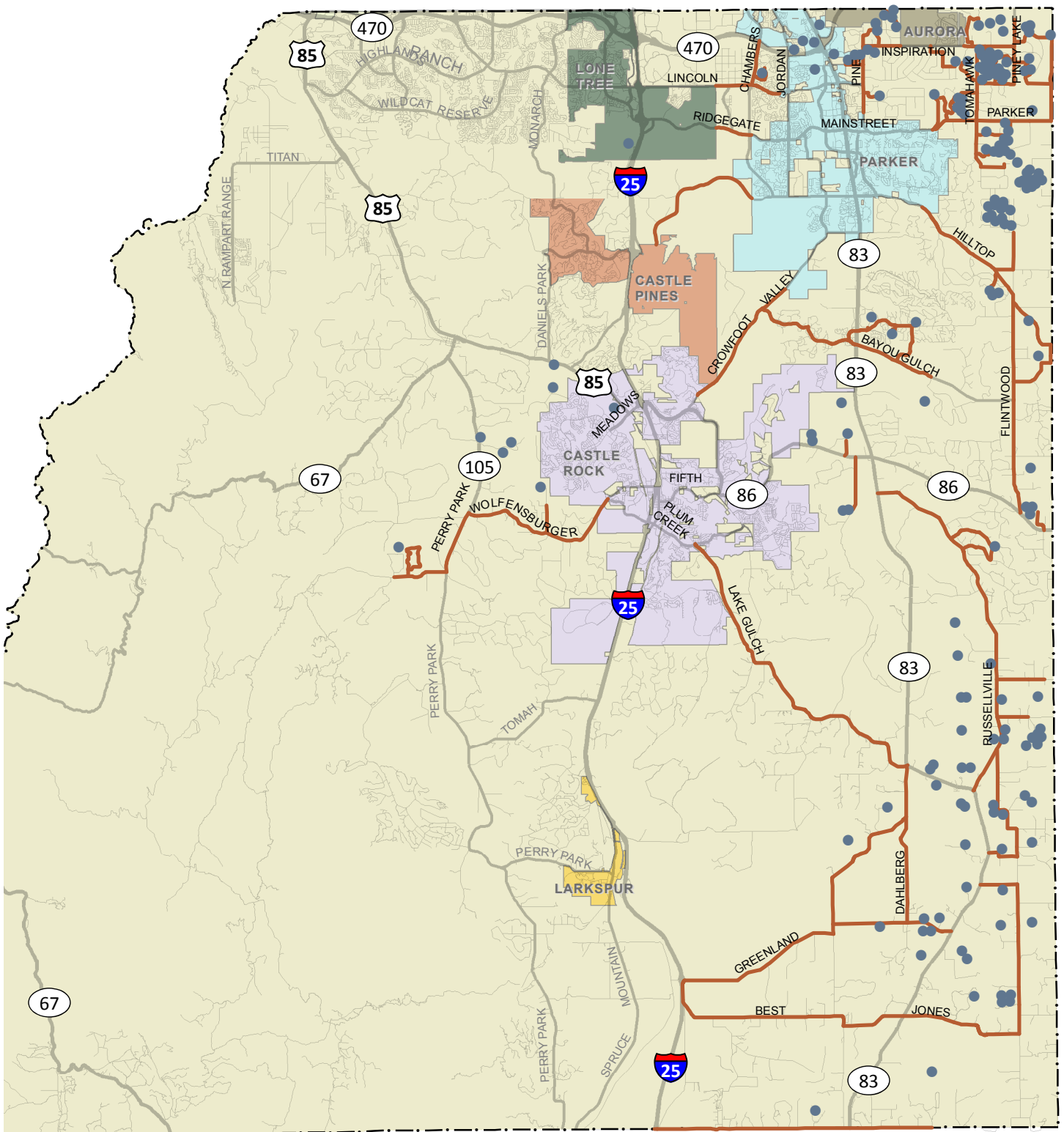
Varying geometric configurations affect how well a roadway could accommodate the heavy truck traffic associated with the oil and gas industry. In order to best estimate the need for and costs of future improvements for the roads used by oil and gas trucks, the following geometric data were collected by Douglas County on travel shed roadways:

- ▶ Number of travel lanes
- ▶ Travel lane widths
- ▶ Shoulder widths

Data from the 2008 Federal Highway Administration's (FHWA) National Bridge Inventory (NBI) for bridges on the potential travel shed was also obtained in order to determine if there would be any weight or height restrictions that would limit use by oil and gas trucks. Only one bridge was identified to potentially have a weight concern (less than 5 out of 5 posting rating), located over West Plum Creek on Jackson Creek Road just west of its intersection with Perry Park Road. The NBI bridge posting rating for this bridge was 4 out of 5, with an operating rating of 14.8 metric tons. There were a handful of bridges that were noted to have height limits, but none appear to be a concern for oil and gas trucks and all are on the highway system including I-25 and E-470 (Federal Highway Administration, 2008).

Figure 9

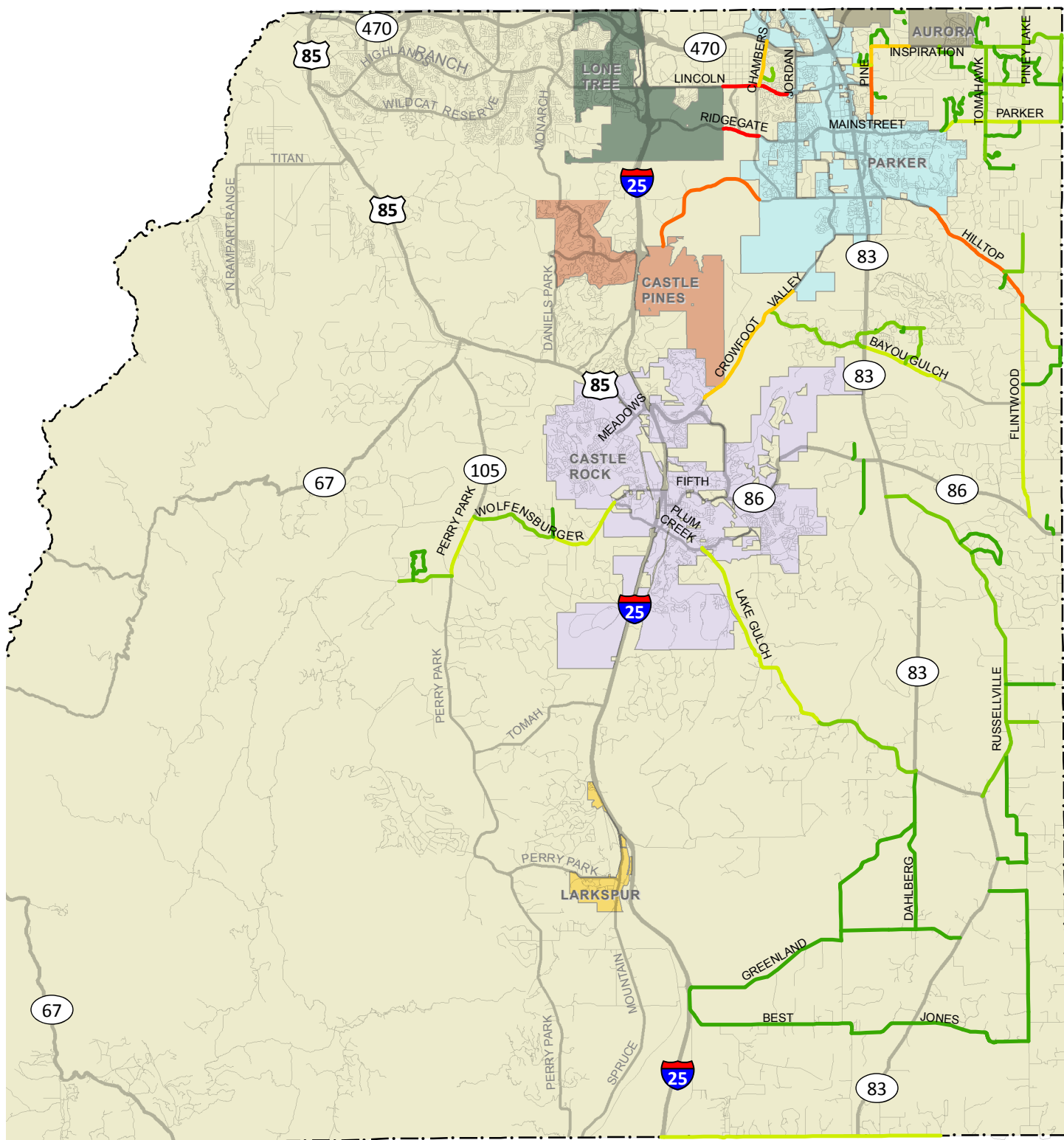
Oil & Gas Lease Locations and Travel Paths



LEGEND

- Lease Location
- Roads Analyzed
- Roads Not Analyzed

2011 Daily Traffic Volumes



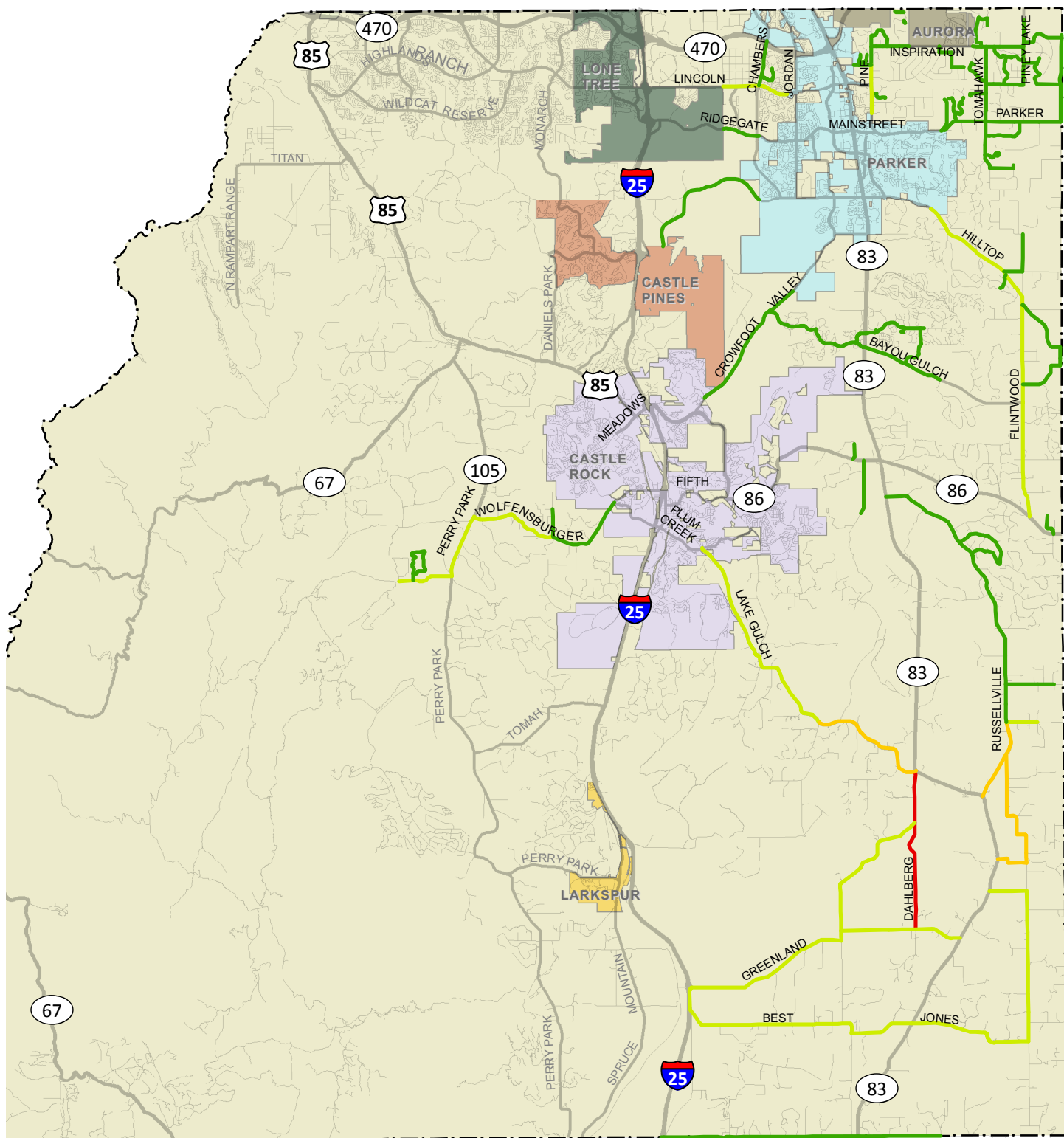
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2011 Daily Traffic Volumes



Figure 11

2011 Truck Volume Percentages



LEGEND

2011 Truck Volume Percentages

- 0% - 2%
- 2% - 5%
- 5% - 10%
- > 10%

— Roads Not Analyzed



Surface Conditions

Of the identified Douglas County travel shed roadways, approximately 34 percent (by centerline mileage) are gravel, 58 percent are asphalt, and eight percent are concrete. **Figure 12** shows the surface type for each of the travel shed roadways. The surface condition, including the surface type, and the remaining service life, significantly affect how well a particular roadway segment can accommodate heavy truck traffic. The addition of numerous heavy trucks will over time cause a roadway to age at a greater rate than may have been originally anticipated. In order to estimate the degree to which the schedule for improvements on these roads would be accelerated, and to provide time-based costs of these improvements, the remaining service life (RSL) of each road segment was calculated. Douglas County provided RSLs for gravel roads on the travel shed roadways and pavement condition index (PCI) ratings for paved roads, which were converted into an estimated RSL. **Figure 13** displays the RSL (in years) for each roadway segment on the travel sheds maintained by Douglas County.

Trip Generation and Vehicle Classification

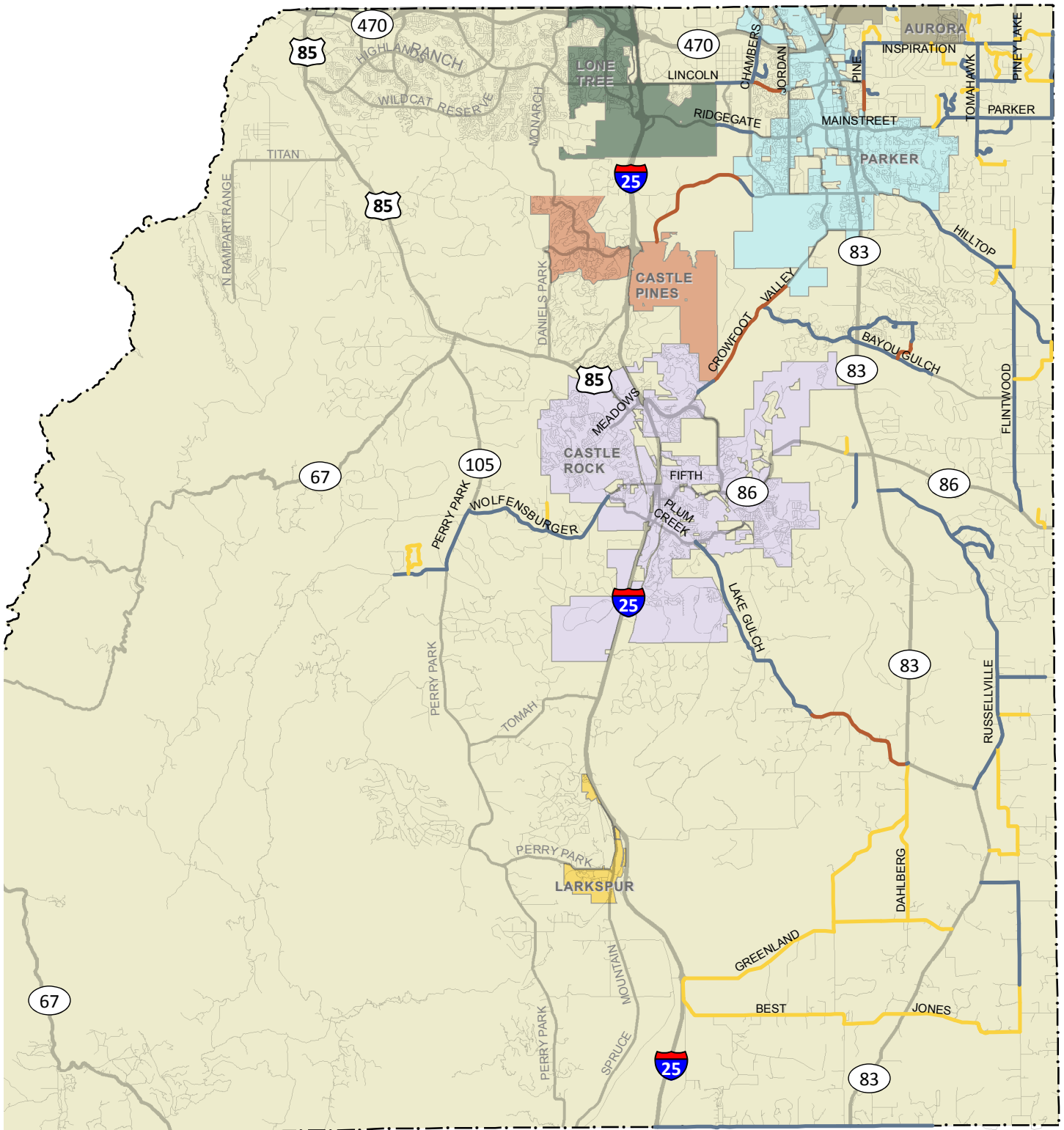
Both the development and production phases have different stages and activities that use a variety of truck types to complete each activity. Each activity also generates a unique number of trips and may have varying origins/destinations for those trips. To best estimate where oil and gas traffic would travel and the impacts those trips would have, the trips and typical truck configurations for each activity have been estimated. Appendix C provides greater detail into truck types, configurations, and impacts.

Trip Generation by Activity

In anticipation of horizontal drilling and multiple wells per pad site in Douglas County, the trip generation rates used for this study rely heavily on the MIT/NTC analysis for the Marcellus formation (as described in the Chapter II), which is a reasonable comparison with the Niobrara formation. The multi-well pad trip generation shown in **Table 2** has been adjusted to account for six (as opposed to eight) wells per pad and one (as opposed to two) drilling rigs per pad. The mid-point of trip generation ranges for each activity have been used, resulting in the trip generation estimates shown below in **Table 6**. This calculation suggests that truck traffic will average 11,040 vehicle trips per pad site during the development phase with each pad accommodating six wells. Once the oil or gas well is fully operational, trip generation will be substantially reduced to approximately 730 vehicle-trips per year (two trips per day). The trip generation rates shown in **Table 6** have been used in the travel model.

Figure 12

Roadway Surface Types



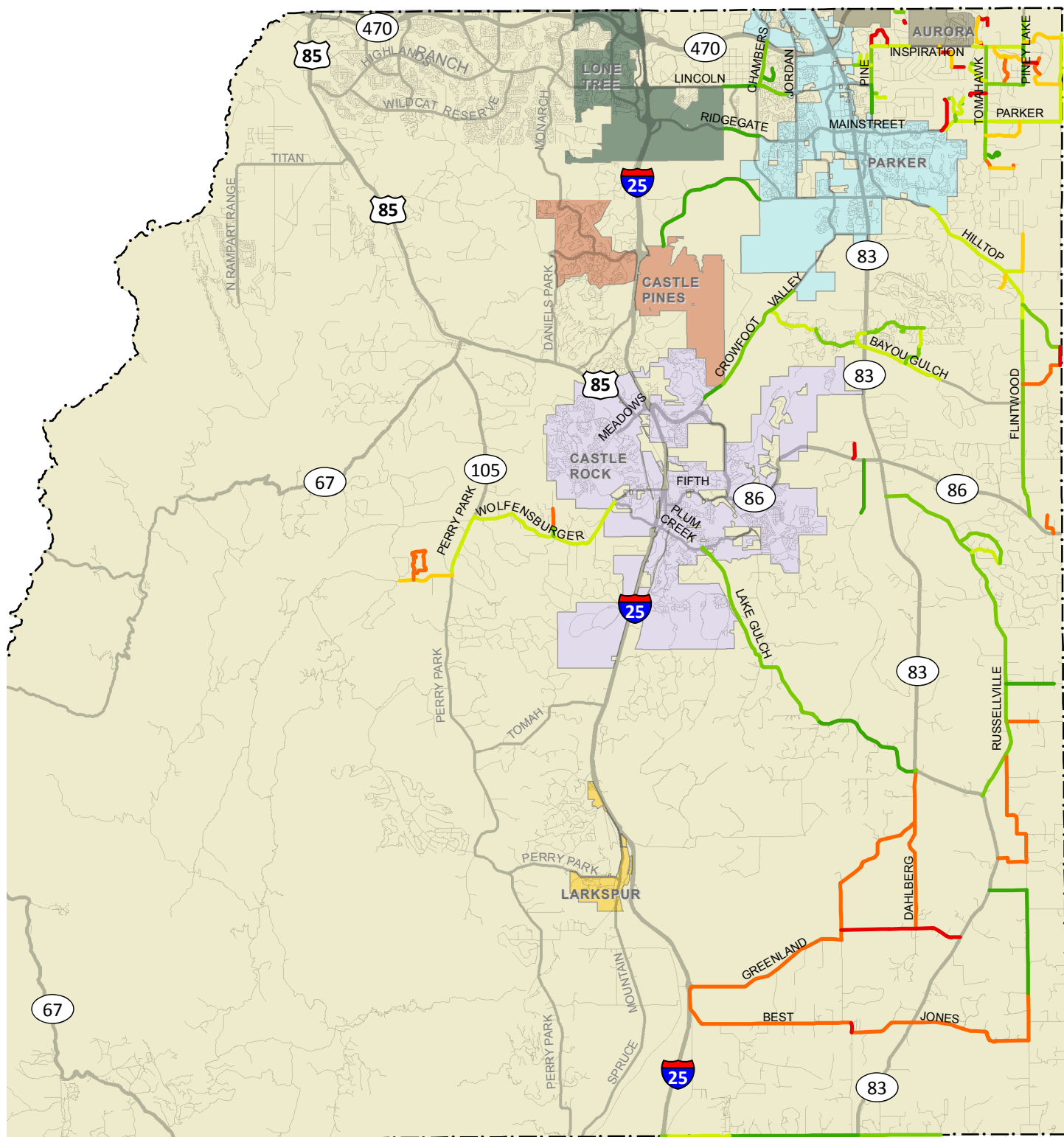
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Surface Types

- Asphalt
- Concrete
- Gravel
- Roads Not Analyzed

Figure 13

Remaining Service Life



LEGEND

Remaining Service Life (Years)





Table 6. Trip Generation by Activity

Activity	1 Rigs, 6 Wells
DEVELOPMENT PHASE	
Construction Stage	
Pad and Road Construction	60
Drilling Stage	
Drilling Rig	60
Drilling Fluid and Materials	450
Drilling Equipment (casing, drill pipe, etc.)	450
Completion Stage	
Completion Rig	30
Completion Fluid and Materials	180
Completion Equipment (pipe, wellhead, etc.)	20
Fracturing Equipment (pump trucks, tanks, etc.)	520
Fracture Water	6,000
Fracture Sand	270
Flowback Water Disposal	<u>3,000</u>
DEVELOPMENT PHASE TOTAL (ONE-TIME)	11,040
PRODUCTION PHASE (ANNUAL)	730

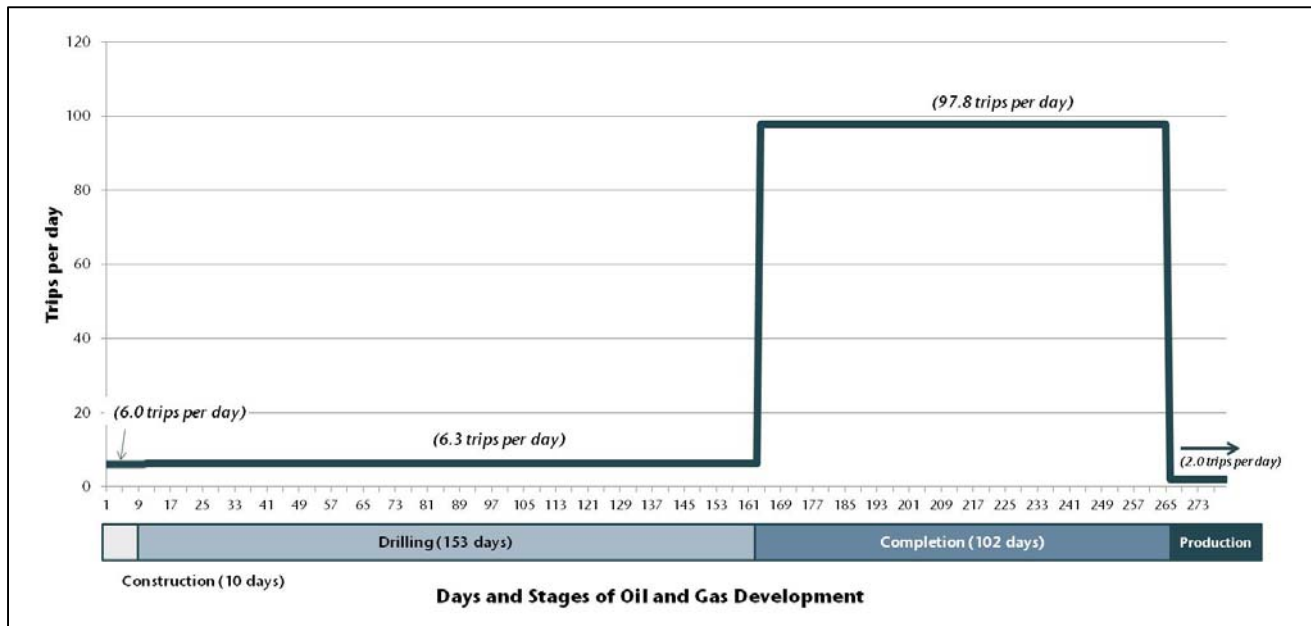
Source: MIT/NTC Study data adjusted by BBC to reflect likely drilling practices in Douglas County.

Vehicle trip generation varies significantly depending on the phase of well development. Truck trip generation increases between each stage of well development, reaching the highest levels during the completion stage. After the completion stage, trip generation is minimal, typically averaging two trips per day depending on the well's productivity.

The efficiencies of drilling on one site are assumed to produce a 15 percent reduction in average well development time in comparison with six individual pads with single wells. This suggests an average pad (six wells) development period of 8.8 months. Average daily trip generation for each stage of development is shown in **Figure 14**. In total this represents an average of about 44 trips per day for nearly nine months. Well completion activities, which last about 102 days, or a little more than one third of the well development period, will generate peak period traffic of about 98 trips per day.



Figure 14. Average Daily Trip Generation (per Pad) by Stage



It should be noted that the trip generation figures are for truck trips and there may be modest levels of incidental automobile trips involving owners, investors, and periodic additional workers or other well monitoring staff.

In the early months of well production, oil transportation may require 2-3 truck trips per day and occasional maintenance activity. Over time, production trips will be reduced in line with diminished well production. It is possible that a highly productive area would eventually be served more efficiently by piping and collective regional storage.³

Oil and gas industry representatives have indicated that there can be significant variation in the drilling time period on any given well and that further time savings can be achieved with multiple wells on one pad. Multiple wells will extend the drilling period although not in direct proportion to the number of wells.

Well Development and Trip Generation Modeling

The study team created the trip generation model to estimate the trips generated by the three development scenarios (as described in Chapter III) over a 15-year period. The model projects well development, production and trip generation with gradual escalation of development activity in each scenario. The level of well development activity is translated into trips using the trip generation data presented in **Table 6**. After the development phase, the production phase includes a 70 percent success rate for new wells drilled to effectively enter the operating stage. Detailed breakdowns of the annual trip generation and general well pad locations for each scenario are provided in Appendix D. The distribution of active wells around the County is based on a number of factors related to current mineral lease locations and geographic characteristics. For the purpose of

³ It is possible that Niobrara wells may require occasional restimulation (re-fracking) to maintain steady resource production. The study team could not obtain credible data on likely frequency and transportation impact of potential restimulation activities. These potential impacts are not included in the transportation model. In practice, every well is different and may or may not require restimulation.



this study, the County has been divided into three areas: West (west of I-25), Northeast (north of SH 86 and east of I-25) and Southeast (south of SH 86 and east of I-25). The following is a description of each scenario.

Low Development Scenario

Assuming the start of well development in 2015 and a gradual increase to 30 new wells developed per year, about 76 wells will be operational in Douglas County by the fifth year of operations. Given this level of activity, about 68,000 additional annual trips or 190 average daily trips related to oil and gas activity are expected. In 2030, the fifteenth year of operation, the model projects 286 operating wells producing 105,000 annual trips or 290 average daily trips related to oil and gas activity.

Medium Development Scenario

In the medium scenario, about 150 wells are projected to be developed per year once operations mature. In the fifth year of operations, about 360 wells will be operational producing about 338,000 annual trips or 930 average daily trips related to resource development and production. In 2030, the fifteenth year of operation, about 1,400 wells will be operating, producing 521,000 annual trips or 1,400 average daily trips related to oil and gas drilling and extraction.

High Development Scenario

In the high scenario, about 510 wells are projected to be drilled per year once development activity matures. In the fifth year of operations, about 760 wells will be operational producing about 794,000 annual trips or about 2,200 average daily trips related to oil and gas drilling and production. In 2030, the fifteenth year of operation, about 4,000 wells will be in operation, generating 1.6 million annual trips or 4,500 average daily trips associated with oil and gas activity.

Vehicle Classification

There are a variety of vehicle types used in oil and gas development and operations, with varying levels of impact. Some truck types are used in multiple stages and activities, while others are used only once. And for those trucks operating within more than one activity, their number of trips varies by activity. This variation requires each activity to have a vehicle classification profile where truck types, trip shares, and impacts are identified for input into the travel model.

The most heavy truck activity during the development of a well comes from the transportation of water to and from the well during the drilling and hydraulic fracturing process (completion stage). According to Chesapeake Energy, between three and five million gallons of water are used during the drilling and completion stages of developing a well. This water is used to assist with cutting through rock and cooling the drill. Generally, one water truck will transport 15,000 gallons of water in a single trip. Given that there is a need for up to five million gallons of water per well, about 666 trips are generated to bring water to the site (333 inbound and 333 outbound trips). Workers transport produced water and flowback water, extracted during the production phase, to a separate wastewater site, resulting in about 200 trips.

A variety of resources including environmental impact studies of oil and gas development within the Rocky Mountain and Great Plains regions were used to identify truck types and their configurations. An initial list of specific trucks used was compiled by stages/activities of development and production. Where available, the percentage makeup of different truck types by activity was noted. Likewise a list of typical truck configurations for oil and gas operations was compiled, which documented the following characteristics:



- ▶ Axle configurations
- ▶ Weight configurations (total empty and full, and per axle)
- ▶ Level of impact expressed in equivalent single-axle load (ESAL) factors

Some of the resources consulted provided all three of these characteristics, but most provided only one or a combination of two. In order to best estimate the impact on roads, any configuration that could have a unique ESAL value was recorded. Once all unique configurations were identified, any holes in information for configuration were estimated based on other similar configurations. For configurations without a documented ESAL factor, the factor has been estimated based on the Pavement Tools Consortium's ESAL equations for flexible and rigid surfaces, which produce ESAL factors consistent with the American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures* that defines ESALs for different truck configurations. Because these equations take roadway characteristics into account that were not obtained during this study (such as the serviceability index and structural number), values were generalized.

The specific truck types and their respective characteristics were assigned to the truck configurations identified based on the truck's purpose and observed descriptions within the various reports and studies consulted. This simplified the impact estimation process by grouping similar truck types and their uses into one configuration, thus assigning an ESAL value to a truck type. Appendix C documents the simplified truck configurations and their estimated ESALs.

Merging Trip Generation and Vehicle Classifications

The truck configuration profiles were linked with their respective activity within each stage of the development and production phases. Because descriptions were not available as to exactly which trucks are used for each activity, the reports and studies consulted were used to produce a best estimate as to how trucks are used. These resources were also referenced to estimate the average share of an activity's trips that each truck configuration would account for, and if the truck is loaded for inbound, outbound, or both trip directions. With trips and loads estimated for each truck per activity, their ESAL factors were calculated for a round-trip to be run through the travel model in order to estimate the trucks' impacts on the travel shed roadways.

Table 7 documents the stages and activities for the development phase, along with each activity's number of generated one-way trips, most common truck types, estimated average ESAL factors for flexible and rigid surfaces, and origins/destinations. **Table 8** documents the same information for the production phase.



Table 7. Development Phase Trip Summary

Stage	Activity	1-Way Truck Trips (1 Pad, 6 Wells)	Duration (Days)	Average Truck Trips per Day (by Stage)	Average Truck Trips per Day (by Activity)	Typical Truck Types	ESAL Factors (Average for 1- Way Trip)	Origin (or Destination) of Trucks
Construction	Pad and Road Construction	60	10	6.0	6.0	3-axle & 5-axle haulers	Flex: 1.009 Rigid: 1.537	I-25 N/S
Drilling	Drilling Rig	60	153	6.3	0.4	Heavy 5-axle, other 3-axle	Flex: 1.043 Rigid: 1.300	I-25 N/S
	Drilling Fluid and Materials	450			2.9	3-axle & 5-axle tankers	Flex: 1.362 Rigid: 1.988	I-25 N, E-470
	Drilling Equipment (casing, drill pipe, etc)	450			2.9	5-axle haulers	Flex: 0.405 Rigid: 0.621	I-25 N/S, E-470
Completion	Completion Rig	30	102	98.2	0.3	Heavy 5-axle, other 3-axle	Flex: 0.925 Rigid: 1.083	I-25 N/S
	Completion Fluid and Materials	180			1.8	3-axle & 5-axle tankers	Flex: 1.362 Rigid: 1.988	I-25 N, E-470
	Completion Equipment (pipe, wellhead, etc)	20			0.2	5-axle haulers	Flex: 0.405 Rigid: 0.621	I-25 N/S
	Fracturing Equipment (pump trucks, tanks, etc)	520			5.1	Specialty, 3-5 axles	Flex: 0.724 Rigid: 0.782	I-25 N/S, E-470
	Fracture Water	6,000			58.8	5-axle tankers	Flex: 1.363 Rigid: 2.260	Castle Rock, Littleton
	Fracture Sand	270			2.6	5-axle haulers	Flex: 1.363 Rigid: 2.260	I-25 N, E-470
	Flowback Water Disposal	3,000			29.4	5-axle tankers	Flex: 1.363 Rigid: 2.260	I-25 N, E-470
Total		11,040	265	41.7	41.7			



Table 8. Production Phase Trip Summary

Stage	Activity	1-Way Truck Trips (1 Pad, 6 Wells)	Duration (Days)	Average Truck Trips per Day (by Stage)	Average Truck Trips per Day (by Activity)	Typical Truck Types	ESAL Factors (Average for 1- Way Trip)	Origin (or Destination) of Trucks
Production	Oil & Water Removal	580	Daily	2.0	1.6	3-axle & 5-axle tankers	Flex: 1.362 Rigid: 2.146	I-25 N, E-470
	Operations & Maintenance	150	Daily		0.4	Work Trucks	Flex: 0.150 Rigid: 0.165	I-25 N, E-470
Total		730	365	2.0	2.0			



Trip Distribution and Assignment

With trips per pad site and their vehicular makeup established, the high, medium, and low development and production scenarios could be modeled. To model where trips would go and the impacts they would generate, trips and ESALs were loaded (separately) in the TRAFFIX model. This process consists of two primary steps: distributing the trips and ESALs, and assigning them to the network.

Trip Distribution

In order to model where trucks would likely travel, pad sites had to be selected for each analysis year of each scenario. This selection allows the trips to be distributed across the county at locations where oil and gas could occur (generally based on currently oil and gas lease locations); at the high, medium, and low development scenarios; and at a frequency depending on the year of observation. Because there is no certainty as to when – if at all – pad sites would be developed and where, pad locations were randomly selected from the current lease locations. This selection was based on how many sites were estimated to be developed within the specific analysis year of each development scenario. The selection also ensured that each higher development scenario retained the same pads being developed as the previous scenario, and within the same year. Within each scenario, pads developed in one year were carried forward as producing pads from that point forward in order to maintain the reality of the oil and gas development and production process.

With active pads for the development and production phases identified for each analysis year of each scenario, the trips and ESALs for those pads could be applied and totaled. This step was necessary due to some scenario years needing more pads in development and/or production than lease sites identified, requiring more than one pad being developed and/or in production at a given lease location in a given year. Again, lease locations do not represent an exact location of a pad, but a plot of land leased for oil and gas exploration. Therefore, lease points represent a general area where pads could exist, which could include multiple pads within a location. Once the trips and ESALs per pad were calculated, they were entered into the TRAFFIX travel model at each pad, distributing trips and ESALs to origins and destinations based on activities as described previously. **Table 9** outlines how trips were allocated to/from each pad site.

Table 9. Trip Distribution Assumptions

Trip Profile	Trip Origin or Destination				
	I-25 to the North	E-470	I-25 to the South	Castle Rock (Water District)	Littleton (Water District)
North Access	90%	10%	--	--	--
North or South Access	45%	5%	50%	--	--
Fresh Water Access	--	--	--	All pads south of Hess Road alignment	All pads north of Hess Road alignment

Trip Assignment

With trips and ESALs distributed and linked, the TRAFFIX travel model was used to assign the trips and ESALs to the network based on which path would provide the shortest travel time. Because oil and gas trips take place at all hours of the day and every day of the week, background traffic and congestion were not factored into the modeling process to impact assignment. The assumptions made that impact how TRAFFIX assigned trips and



ESALs to the network are documented in Appendix E. These assumptions were made in order to address constraints that the network has but are not adequately captured in the travel model.

The assignment process was conducted for a combination of each scenario level (low, medium, and high), each analysis year (2015, 2020, 2025, and 2030), for trips by phase (development and production), and for ESALs by surface type (flexible and rigid), resulting in a total of 63 iterations of the travel model.

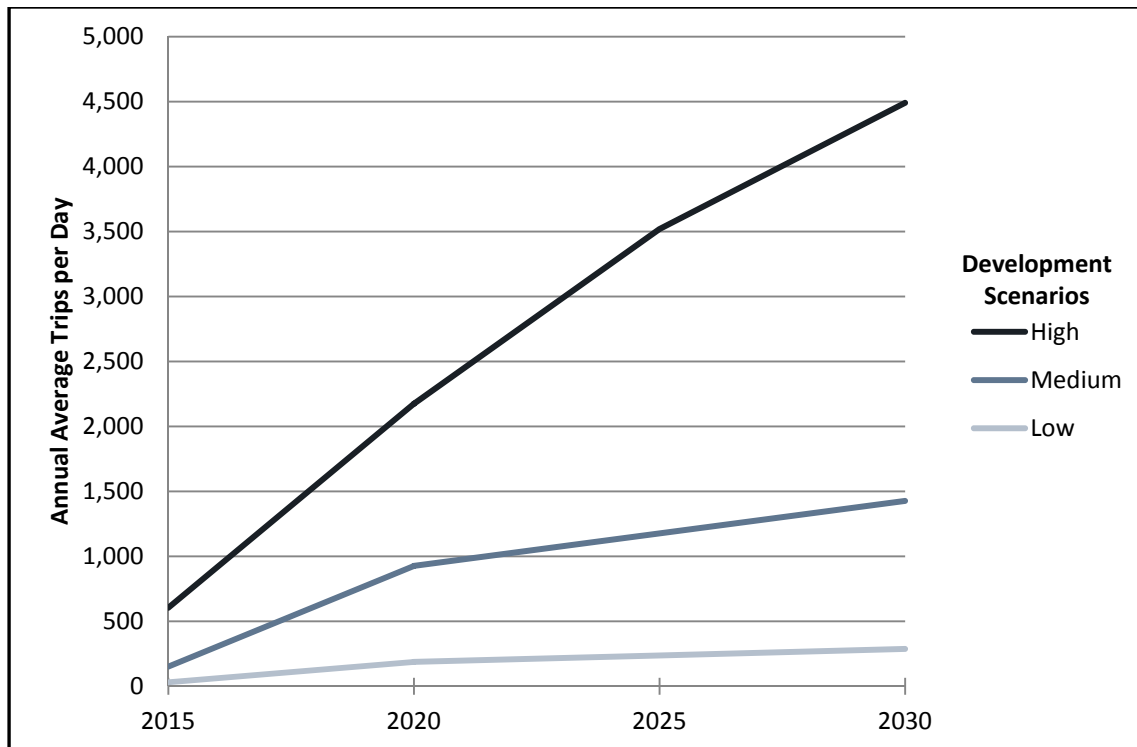
Model Results

As described previously, the TRAFFIX travel model output the number of trips and ESALs on each road segment. Based on these model runs and exported data, the following sections summarize the results.

Trips

The trips were modeled on an annual basis; in order to present trips in more manageable fashion, trips from both phases (development and production) were aggregated and converted to average annual daily trips by simply dividing the annual trips by 365. **Figure 15** illustrates the average number of oil and gas trips per day for each scenario over the four analysis years. This figure depicts the cumulative trips of all pads being development and producing wells. By dividing the annual trips evenly over the year, it is assumed that well development will be distributed over time resulting in a relatively even distribution of trips in total. It is important to note that trip generation will peak during the development phase at a particular pad site, resulting in a more profound local impact.

Figure 15. Estimated Oil & Gas Annual Average Trips per Day





Based on the travel model results, these trips are expected to occur over a large portion of the identified potential travel shed roadways. Some corridors handle a large portion of these trips, while others handle only one pad's worth or less. For Douglas County's roads, Lincoln Avenue and Lake Gulch Road show the highest number of both development and production trips. The highest number of predicted trips for one County-maintained road segment was roughly 1,800 trips per day in 2030 for the high scenario for Lincoln Avenue east of Chambers Road. This same stretch of roadway currently sees nearly 40,000 vehicles per day and almost 54,000 vehicles per day are forecast in 2030 based on growth rates obtained from the *Douglas County 2030 Transportation Plan*. No road is expected to exceed the existing capacity threshold due to added oil and gas trips associated with the three development scenarios tested in this study.

Figure 16 illustrates the magnitude of development trips on the travel shed roadways for the High scenario in 2030, while **Figure 17** illustrates the same information for production trips. These maps illustrate how many oil and gas trips each road segment is expected to carry relative to the other oil and gas travel sheds. Appendix F provides the same illustrations for the remaining of the scenarios and their analysis years. Note that earlier analysis years and other scenarios (Low and Medium) have fewer pads in operation, meaning not all lease sites may have an active pad. Given the random selection of active pads, paths could change if active pads were rearranged. However, the arrangement tested with the TRAFFIX travel model is as likely as any other potential arrangement of active pads given the information obtained for this study. Furthermore, routes with high volumes in these scenarios and years are major routes regardless of how pad sites are arranged, as they provide essential links that eventually must be used.

Vehicle Miles Traveled

The trips assigned by TRAFFIX were also converted into vehicle miles traveled (VMT) to compare the increase in VMT caused by oil and gas operations with existing VMT on the travel shed roads and predicted VMT growth based on the *Douglas County 2030 Transportation Plan*. All VMT values were calculated for roads maintained only by Douglas County and were shown to be used by in the travel model for oil and gas trips. **Figure 18** compares current VMT to predicted background growth and the three scenarios of oil and gas operations. At its highest point within this study's analysis horizon (2030) oil and gas operations would increase VMT by about 3.4% over the estimated background VMT.

Although the number of the trips generated by the oil and gas industry in the three scenarios is relatively small in comparison to the existing traffic and the anticipated background growth, the much greater transportation impact associated with industry is due to the weight of the vehicles. As described in the following section, the load impact of oil and gas trucks can be several magnitudes greater than that of a passenger car.

Figure 16

**Estimated 2030 Annual Directional Oil & Gas Related Volumes -
High Scenario Development Phase**

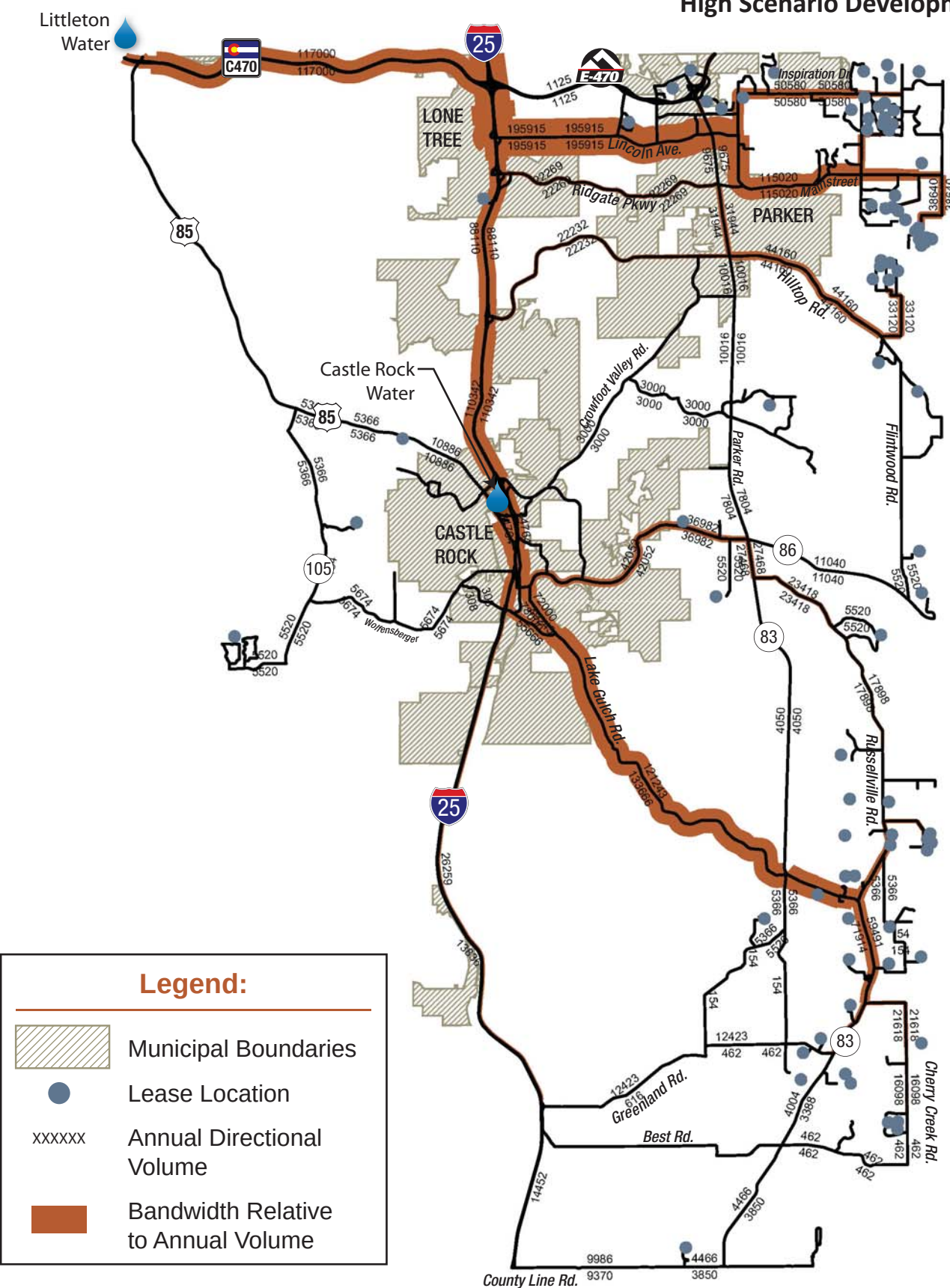


Figure 17

Estimated 2030 Annual Directional Oil & Gas Related Volumes - High Scenario Production Phase

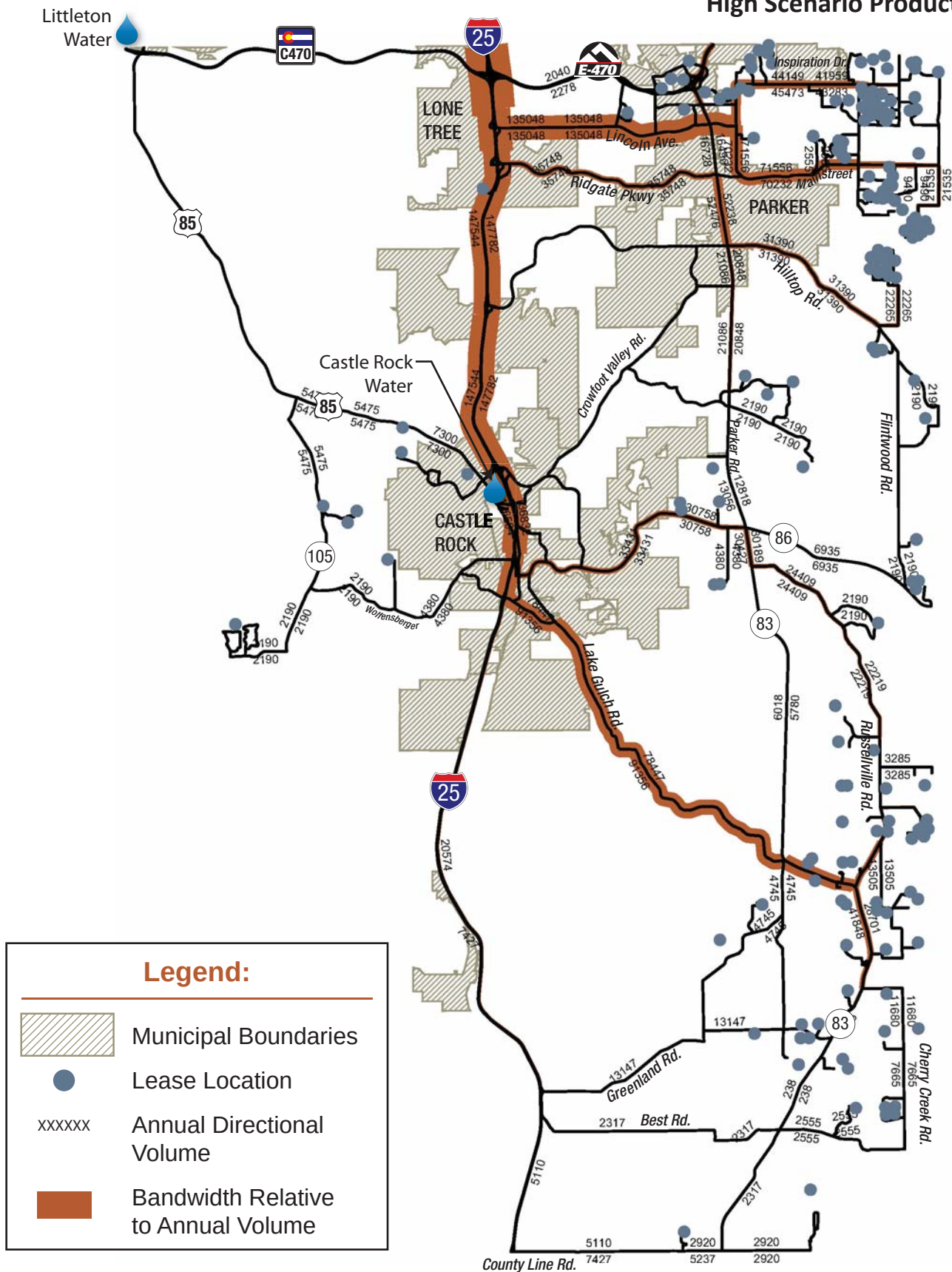
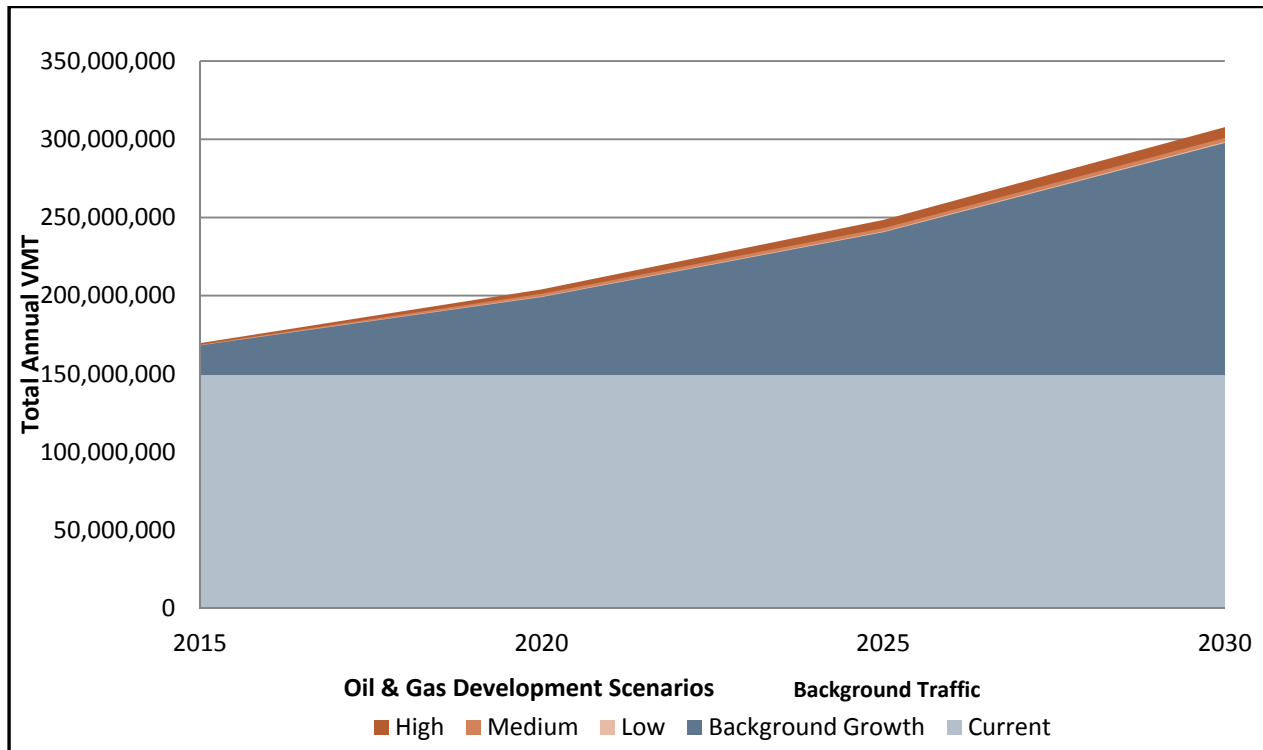




Figure 18. Estimated Oil & Gas Vehicle Miles of Travel (VMT) Compared to Existing and Background Growth VMT



Equivalent Single-Axle Loads

Due to the high impact of heavy vehicles on roads, ESALs are essential in calculating potential improvements needed and the costs associated with those improvements.

To translate ESALs into a useable format from TRAFFIX, ESALs from the flexible ESAL model runs were used for gravel and asphalt roads, while ESALs from the rigid ESAL model runs were used for concrete roads. ESALs from each phase were aggregated for each road segment. These final ESAL aggregations were then used in calculating reductions in the remaining service life of each analyzed road segment, forming the basis for estimating needed improvements and costs, as described in more detail in the next chapter.

To put ESAL factors for oil and gas vehicles into perspective, an average 4,000 pound passenger vehicle (2,000 pounds per axle) has an estimated ESAL factor of 0.0004 when using the Pavement Tools Consortium's equations for both flexible and rigid pavements. In comparison, the largest and heaviest oil and gas truck used in this study has an estimated full-load ESAL factor of 7.7 on flexible pavement and 12.6 on rigid pavement (Source: Upper Great Plains Transportation Institute, 2010). That is, the load impact to a road is 20,000 – 30,000 times that of a passenger car. A loaded water truck (the vehicle with the highest frequency of trips to and from an oil and gas well) has an estimated ESAL factor of 2.6 on flexible pavement and 4.4 on rigid pavement, 6,500 – 11,000 times the load impact of a passenger car.



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V. IMPROVEMENT NEEDS

The improvements and associated costs presented in this chapter represent the additional costs or funding needs attributable to growth in oil and gas traffic compared with baseline maintenance and/or improvement costs without substantial growth of oil and gas traffic.

As described previously, oil and gas traffic was distributed to the County's network of roads, and an Equivalent Single Axle Load (ESAL) was applied to the associated traffic. The ESALs were determined at 5-year increments starting at 2015 and extending to 2030. Road improvements and costs were then defined for the paved and unpaved roads impacted by oil and gas traffic based on the high, medium, and low development scenarios.

Unpaved Road Analysis

The unpaved roads analyzed in this study were classified by the estimated additional truck traffic due to increased oil and gas development. The categories include: Low (0-25 average daily traffic [ADT]), Elevated (25-50 ADT), Moderate (50-100 ADT), and High (100+ ADT). The following methodology describes how costs were attributed to each category.

Methodology

The improvement costs of an unpaved road include the initial improvement cost if existing deficiencies were noted by the County. In addition, the increase in maintenance costs is a key element in determining the improvement cost for unpaved roads. On gravel surfaces, as the ADT increases, the frequency of blading and gravel application must increase to preserve the surface quality. The anticipated increased frequency of blading and gravel application as a result of the oil and gas industry was estimated based on discussions with Douglas County maintenance staff. It is important to note that the frequency of blading treatments, in particular, can be greatly affected by weather. Some counties in Colorado and other states have implemented trucking restrictions on certain gravel roads during the freezing and thawing seasons because of the associated increases in maintenance requirements. All increases in blading are expressed as an annual average monthly increase.

Maintenance Costs

If oil and gas traffic utilizes an unpaved road as a transportation route, the road will have to be treated with a dust suppressant material to satisfy the State's Regulation 1 requirements. For this study, the impacted unpaved roads will have to be treated once each year. The County's average cost utilized for applying a dust suppressant material to a non-impacted gravel road is \$9,000 per mile.

The County's average cost of a grading operation is approximately \$350 per mile each time the road is graded. The blading cycle within the County is dependent on the traffic volume of the road as well as if a dust suppressant can be applied. Some low volume, non-impacted gravel roads need to be graded only once every two months. However, if the road cannot be treated with a dust suppressant material (e.g., because of vertical grade, sensitive vegetation, etc.), the non-impacted, unpaved road may be graded up to two to three times per month.

The County's average cost per mile for graveling is \$45,000 per mile. This cost includes material, labor and equipment. Similar to the blading cycle, the graveling cycle within the County is dependent on the traffic volume of the road. For this study, the graveling cycle time is six years for non-impacted unpaved roads. For purposes of this analysis, all graveling intervals were converted to a base yearly interval. That is, since the County provided a six-year cycle, the costs were converted to a yearly graveling cost that corresponds to the traffic projections.



Low Category

For the low-impact category, it is assumed that little additional work will be done to the road surface. Therefore, initial improvement costs were not calculated for correcting existing deficiencies on unpaved roads classified with low impacts. The only improvement costs attributed to low impact roads are an increased maintenance cost that consists of additional application of dust suppressant and blading. For this study, the blading cycle would be increased to once per month instead of once every two months (annual average). The graveling cycle would still occur every six years as described above.

Elevated and Moderate Categories

In addition to the increases in routine maintenance on the elevated and moderate impact gravel road sections, road reconstruction improvements have been identified to address existing deficiencies. The estimates for the elevated and moderate impact categories also reflect reconstruction during the first period to repair road deficiencies. These deficiencies include inadequate roadway width, sub-standard horizontal curves, steep vertical grades and minimal sight distances. In the analysis, an improvement cost of \$100,000 per mile is utilized for reconstruction.

For the elevated impact category, the maintenance improvement is to shorten the gravel application cycle by half, or to occur every three years to maintain the surface condition. The application of a dust suppressant would occur an additional two times per year. The blading cycle would be increased to twice per month (annual average).

For the moderate category, the maintenance improvement is to shorten the gravel application cycle by two-thirds, or to occur every two years to maintain the surface condition. The application of a dust suppressant would occur an additional three times per year. The blading cycle would be increased to three times per month (annual average).

High Category

For high impact gravel road sections, when oil and gas traffic exceeds 100 ADT which primarily consist of truck traffic, paving the gravel road becomes a lower cost option when life-cycle cost is considered. Using this rationale, the high impact category utilizes an improvement cost of \$700,000 per mile to convert the road surface to an asphalt pavement.

Paved Road Analysis

Two factors are critical in analyzing the capabilities of paved roads to accommodate additional truck traffic: the current condition of the pavement and the structural rating, which is measured through the pavement structural number (SN). The SN is a function of the thickness of the surface and base layers and the materials of these layers.

The paved roads analyzed in this study were separated by the pavement type which consists of hot mix asphalt or concrete. The County provided a weighted average for the Pavement Condition Rating (PCI) for all of the paved roads within this study. Surface treatments for either pavement type were not included in the improvement cost because these treatments do not have an impact on the structural ability of the pavement. However, it is noted that surface treatments aid in the prevention of oxidation of the pavement, which in turn,



prolongs the life of the pavement. The following sections describe the methodology that was utilized for each pavement type.

Hot Mix Asphalt Pavement Methodology

The approach to determine the associative impacts of oil and gas traffic on hot mix asphalt pavement roads requires the determination of the SN for existing traffic as well as existing traffic plus oil and gas traffic.

In order to determine the existing SN, the existing serviceability, initial serviceability, terminal serviceability, background ESAL, reliability level and standard deviation have to be defined. The existing serviceability is based on the weighted average PCI, as provided by the County, for each travel shed roadway. The existing serviceability is interpolated based on the PCI and values shown in **Figure 19**. The values shown in **Table 10** are based on industry standards for the different roadway classifications. These values are then utilized to solve for SN within the following 1993 AASHTO Guide equation for flexible pavement:

$$\log W_{18} = Z_R \times S_0 + 9.36 \log(SN + 1) - 0.20 + \frac{\log\left(\frac{\Delta PSI}{4.2 - 1.5}\right)}{0.40 + \frac{1094}{(SN + 1)^{5.19}}} + 2.32 \log(M_R) - 8.07$$

W_{18} = predicted number of 18,000 lbs. (ESALs)

Z_R = Standard Normal Deviate

S_0 = Standard Deviation

SN = Structural Number

ΔPSI = Existing Serviceability – Terminal Serviceability

M_R = Subgrade Resilient Modulus (in psi)

After the SN is calculated for the existing conditions, the SN is calculated for the existing traffic plus the oil and gas traffic. The SN Deficiency is then calculated ($SN_{COMBINED} - SN_{EXISTING}$). The required pavement overlay for the oil and gas traffic is then calculated by dividing the SN Deficiency by the Standard Deviation. A cost for the required overlay was then calculated for each respective section of hot mix asphalt road. An example of this process follows.



Figure 19. Pavement Condition Rating

Pavement Condition	PCI	Existing Serviceability		Existing Asphalt Structural Coefficient
Excellent	100	all roads 4.5		0.44
Very Good	85	arterials, major collectors 4.0	minor collectors, locals 4.0	0.37
Good	70	3.5	3.3	0.30
Fair	55	3.0	2.6	0.22
Poor	40	2.5 Terminal Serviceability		0.15

Table 10. Assumptions for Existing Pavement Sections

Roadway Classification	Design EDLA	Design ESAL	Reliability (%)	Standard Normal Deviate (Z_R)	Initial Serviceability	Terminal Serviceability	Standard Deviation	Structural Number ¹ (SN) (New)
Major Arterial	250	1,825,000	95	-1.645	4.5	2.5	0.44	5.06
Minor Arterial	200	1,460,000	95	-1.645	4.5	2.5	0.44	4.84
Major Collector	100	730,000	90	-1.282	4.5	2.5	0.44	4.18
Minor Collector	50	365,000	85	-1.037	4.5	2.0	0.44	3.52
Local	10	73,000	80	-0.841	4.5	2.0	0.44	2.86

¹ A subgrade resilient modulus (M_R) of 3,500 psi was used for all roadway classifications.



Hot Mix Asphalt Pavement Example

Bayou Gulch Road (State Highway 83 to Fox Sparrow Road)

Roadway Classification – Major Collector

Weight of Average PCI = 72.3

Pavement Condition = Very Good

Design ESAL = 730,000 (from Table 10)

2015 Design ESAL = EDLA x Design Period = 100 x 365 = 36,500

Existing Serviceability = 3.58 (Interpolate from Figure 18)

Terminal Serviceability = 2.5 (from Table 10)

Reliability Level = 90% (from Table 10)

Standard Normal Deviate (Z_R) = -1.282 (from Table 10)

Existing SN = Solving AASHTO Equation = 2.82

2015 Oil & Gas ESAL = 14,207

Combined ESAL = 36,500 + 11,040 = 50,707

Combined SN = Solving AASHTO Equation = 3.01

SN Deficiency = $SN_{COMBINED} - SN_{EXISTING} = 3.01 - 2.82 = 0.19$

Required Overlay to achieve the Same Remaining Life = $SN \text{ Deficiency} / \text{Standard Deviation} = 0.19 / 0.44 = 0.43''$

Utilizing a ratio of 110 lbs./Square Yard/Inch of Asphalt as well as a Unit Price of \$50/Ton, the impact cost can be calculated as shown below.

Associated Costs = Required Overlay x Length of Road x Roadway Width (including Shoulders) x Asphalt Unit Price = \$32,500

Concrete Pavement Methodology

The approach to determine the associative impacts of oil and gas traffic on concrete pavement roads requires the determination of the pavement service life. Standard design for pavement service life is a span of 20 years. The associated ESAL for the 20 year pavement service life are shown in **Table 11**.

Table 11. Standard Design ESALS for Concrete

Roadway Classification	Design ESAL
Major Arterial	1,825,000
Minor Arterial	1,460,000
Major Collector	730,000
Minor Collector	365,000
Local	73,000



Oil and gas traffic will decrease the overall pavement service life for concrete roads. The amount of this decrease is calculated as a percentage and based on the calculated ESAL amount for oil and gas traffic divided by the overall Design ESAL. This percentage is then multiplied by the improvement costs per mile to reconstruct a concrete pavement road in its entirety. In the analysis, a reconstruction cost of \$572,725 per lane per mile is utilized for reconstruction. This cost was derived from the Colorado Department of Transportation (CDOT) Transportation Facts for 2011 publication.

Concrete Pavement Example

Crowfoot Valley Road (Scott Road to Pradera Parkway)

Roadway Classification – Major Collector

Weight of Average PCI = 86.1

Pavement Condition = Excellent

Design ESAL = 730,000

2015 Oil & Gas ESAL = 40,554

Pavement Service Life Impact = 2015 Oil & Gas ESAL/Design ESAL = 40,554/730,000 = 0.056 or 5.6%

Associated Costs = Impact x Length of Road x Lanes x Reconstruction Cost = \$155,780

Estimated Improvement Costs

The overall road improvement costs for the different levels of oil and gas traffic growth are shown in **Table 12**. The design year values represent the incremental improvement costs required to offset the impacts specifically associated with oil and gas vehicles in each of the high, medium, and low scenarios. The total incremental improvement costs for the time period 2015 through 2030 have been calculated by interpolating the improvement costs for the interim years (e.g., 2016, 2017, 2018, 2019, etc.). The road improvements and costs by roadway segment for the three development scenarios are included in Appendix G.

Table 12. Estimated Annual Improvement Costs by Development Scenario

Design Year	Low	Medium	High
2015	\$170,100	\$861,800	\$2,921,900
2020	\$926,000	\$4,682,500	\$9,507,600
2025	\$950,900	\$6,670,500	\$9,808,600
2030	\$1,314,300	\$5,508,400	\$10,184,300
Total (2015-2030)	\$13,837,700	\$75,875,600	\$135,899,600



On average, the County currently has about \$40 million in revenue available for transportation capital projects, operations and maintenance each year.⁴ Assuming a continuation of average funding, this equates to an estimated \$640 million over the 16 year time period from 2015 through 2030. The estimated incremental improvement costs associated with the oil and gas industry over the same time period in the low, medium, and high scenarios represent a 2%, 12%, and 21% increase, respectively, over current Road and Bridge funding levels.

⁴ The \$40 million figure represents an annual average that is net of transportation funds transferred annually to municipalities. The figure was obtained through discussions with Douglas County finance staff.



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VI. COUNTY OIL AND GAS REVENUE PROJECTIONS

The previous chapter provided estimates of road improvement costs associated with potential energy development in Douglas County. This chapter describes direct energy related county revenue sources and provides a range of estimates of county revenue for the energy development scenarios presented in Chapter III. The revenue model projects natural resource driven revenues that will be available to Douglas County through increases in property tax and severance tax.

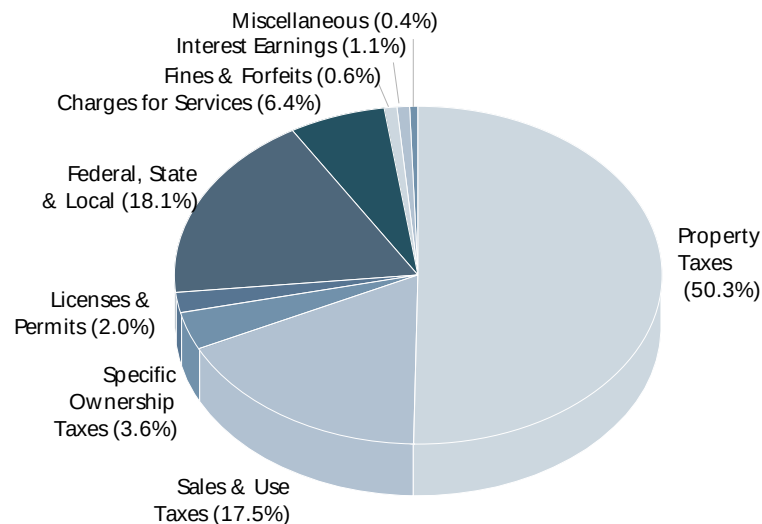
Oil and gas development has the potential to generate substantial revenue for local governments through property and severance tax. Producing wells are subject to property tax that has generally shown to produce significant revenue in other Colorado counties with an active energy industry. State redistributed severance tax revenue is another source of revenue that will potentially increase as energy development occurs in Douglas County.

Current Douglas County Revenues and Expenditures

Douglas County, like all Colorado counties, is heavily dependent on property taxes to help fund county operations. About half of all county revenues come from property taxes. About 70 percent of Douglas County's property tax is allocated to the general fund. The road and bridge fund is allocated about 23 percent of property tax. The remaining 7 percent of county property tax is allocated to the social services and developmental disabilities funds. **Figure 20** illustrates the revenues in Douglas County's 2011 budget **Table 13** provides a breakdown of property tax allocation between major county funds.

The county's reliance on property tax revenues is generally beneficial because of high assessed valuation associated with oil and gas activity. Douglas County is "de-Bruced" and is not limited by the TABOR amendment and related restrictions.

Figure 20. Douglas County Revenues (2011)



Source: Douglas County.



Table 13. Douglas County Property Tax Allocation by Fund (2011)

Fund	Mill Levy	Percent of Total
General	13.965	70.6%
Road & Bridge	4.493	22.7%
Social Services	0.316	1.6%
Developmental Disabilities	1.000	5.1%
Total	19.774	100.0%

Source: Douglas County Assessor

Revenue Sources

Property tax and severance tax are the major revenue sources that will increase as oil and gas wells are drilled and begin to produce. The following provides detailed description of each revenue source followed by a general discussion of the factors that influence resource-based property and severance tax.

Resource Based Property Taxes

The following describes the valuation, assessment and ad valorem taxation process for oil and gas producing lands.

Natural resource related property tax receipts, which generally accrue to counties and certain schools and special districts, will be a significant factor in determining Douglas County's ability to provide continued transportation system maintenance and infrastructure investment if there is significant energy development. Many factors influence property tax revenues on oil and gas resources—chief among these are: oil and gas field formations and resultant well production levels; resource market value, access to national markets; assessment formulae and mill levies.

In practice, the assessment procedures for developing “actual value” for property assessment purposes on resource extraction operations is complex. There is considerable fluctuation in resource value (sales price of oil or gas at the wellhead) and considerable time lags between project construction, resource development, property assessment and tax receipts. In most instances, property tax payments are deducted from mineral severance taxes further clouding projections of total revenues. Oil and gas real property is assessed at 87.5 percent of actual value, which is significantly higher than commercial real property (29 percent) and residential real property (7.96 percent). Each dollar of oil and gas real property value is worth roughly 3 times the amount of commercial real property and about 11 times the amount of residential real property for county property tax purposes.

In order to make a reasonable projection of revenues given the high variability of the property assessment of oil and gas, the project team analyzed the total assessed value of all oil and gas real and personal property for oil and gas producing counties along the Colorado Front Range. The total assessed value of oil and gas real and personal property in each county is divided by the number of producing wells to estimate assessed value per well.

The study team adjusted the data by excluding the year 2009 from the sample due to a spike in the market value of oil and gas in 2008 (refer to **Figures 23 and 24** in a subsequent section of this report). There is considerable variation in assessed value per well. Figures range from about \$20,000 in Arapahoe County to over \$130,000 in Weld County. Weld County is the only county in the sample that has seen substantial recent horizontal drilling,



which will most likely be the preferred method for resource recovery in Douglas County. Most wells in the other Front Range counties were drilled prior to the widespread use of horizontal drilling techniques.

Nevertheless, the potential productivity of Douglas County wells is unknown. In consideration of this uncertainty, the study team employed a weighted average method to estimate potential assessed value per well in Douglas County. The assessed value per well figures are shown in **Table 14**.

Table 14. Price of Resource, Resource Property Assess Value and Severance Tax Direct Distribution

County	Total Assessed Value			Active Wells			Assessed Value per Well			Weighted Average
	2007	2008	2010	2007	2008	2010	2007	2008	2010	
Adams	\$57,195,001	\$49,502,971	\$31,570,701	955	948	969	\$59,890	\$52,218	\$32,581	\$48,144
Arapahoe	\$3,723,700	\$3,801,870	\$3,592,770	177	175	178	\$21,038	\$21,725	\$20,184	\$20,978
Elbert	\$2,248,660	\$2,805,940	\$2,332,460	75	75	72	\$29,982	\$37,413	\$32,395	\$33,275
Larimer	\$5,231,424	\$4,888,065	\$5,164,060	206	205	207	\$25,395	\$23,844	\$24,947	\$24,731
Logan	\$9,882,860	\$9,994,260	\$10,249,030	204	210	212	\$48,445	\$47,592	\$48,344	\$48,125
Washington	\$42,648,026	\$40,036,227	\$27,697,491	548	561	534	\$77,825	\$71,366	\$51,868	\$67,183
Weld	\$1,681,199,878	\$1,634,046,148	\$1,555,893,403	11,330	11,876	13,710	\$148,385	\$137,592	\$113,486	\$131,952
Yuma	\$157,400,080	\$165,318,150	\$89,606,870	1,952	2,420	3,331	\$80,635	\$68,313	\$26,901	\$53,528
Total										\$109,447

Source: State of Colorado, Department of Local Affairs, Division of Property Taxation.

The weighted average assessed value per well is about \$109,000. **Table 15** shows that Douglas County could generate about \$2,000 in annual property tax revenue per producing well at current mill levies if well productivity is similar to that recently reported in other Front Range counties. About \$500 of property tax revenue per well would accrue to the county road and bridge fund. Under current Colorado assessment procedures, an average well has roughly the same assessed value as a \$1.4 million dollar house.



Table 15. Douglas County Mill Levy and Projected Property Tax per Well

	Total
Average Assessed Value Per Well	\$109,447
County Total Mill Levy	19.774
General	13.965
Road & Bridge	4.493
Social Services	0.316
Dev Disabilities	1.000
Road & Bridge Property Tax Per Well	\$492
Other Categories Property Tax per Well	\$1,672
Total Average Tax per Well	\$2,164

Source: Douglas County Assessor; BBC Research & Consulting.

Annual Property Tax Revenue Projection

The property tax per well figure is applied to the well development scenarios presented in Section III to calculate potential annual Douglas County property tax revenue. **Table 16** below shows projected annual property tax revenue for the low, medium and high oil and gas development scenarios.

The low scenario generates about \$573,000 in annual property tax revenue in the 15th year of production (2030). The medium scenario generates about \$2.8 million annually in the 15th year while the highest development scenario generates about \$7.95 million annually in the 15th year. The county road and bridge fund receives about one-quarter of property tax revenue.

The revenue figures in **Table 16** are based on recently reported assessed value and production figures from comparable counties. Actual Douglas County property tax revenue may vary substantially from the figures presented if future tax rates, resource prices or production characteristics differ from historical data.



Table 16. Douglas County Well Development Scenarios and Projected Property Tax Revenue

Scenario	2015	2016	2017	2018	2019	2020	2021	2022
Low Scenario								
Producing Wells	—	4	13	34	55	76	97	118
Road & Bridge Property Tax Revenue	—	—	\$1,968	\$6,396	\$16,728	\$27,060	\$37,392	\$47,724
Other Property Tax Revenue	—	—	\$6,688	\$21,736	\$56,848	\$91,960	\$127,072	\$162,184
Total Property Tax Revenue	—	—	\$8,656	\$28,132	\$73,576	\$119,020	\$164,464	\$209,908
Medium Scenario								
Producing Wells	—	21	84	147	252	357	462	567
Road & Bridge Property Tax Revenue	—	—	\$10,332	\$41,328	\$72,324	\$123,984	\$175,644	\$227,304
Other Property Tax Revenue	—	—	\$35,112	\$140,448	\$245,784	\$421,344	\$596,904	\$772,464
Total Property Tax Revenue	—	—	\$45,444	\$181,776	\$318,108	\$545,328	\$772,548	\$999,768
High Scenario								
Producing Wells	—	84	210	378	546	756	1,008	1,302
Road & Bridge Property Tax Revenue	—	—	\$41,328	\$103,110	\$185,598	\$268,086	\$371,196	\$494,928
Other Property Tax Revenue	—	—	\$140,448	\$343,980	\$619,164	\$894,348	\$1,238,328	\$1,651,104
Total Property Tax Revenue	—	—	\$181,776	\$447,090	\$804,762	\$1,162,434	\$1,609,524	\$2,146,032
<i>continued</i>	2023	2024	2025	2026	2027	2028	2029	2030
Low Scenario								
Producing Wells	139	160	181	202	223	244	265	286
Road & Bridge Property Tax Revenue	\$58,056	\$68,388	\$78,720	\$89,052	\$99,384	\$109,716	\$120,048	\$130,380
Other Property Tax Revenue	\$197,296	\$232,408	\$267,520	\$302,632	\$337,744	\$372,856	\$407,968	\$443,080
Total Property Tax Revenue	\$255,352	\$300,796	\$346,240	\$391,684	\$437,128	\$482,572	\$528,016	\$573,460
Medium Scenario								
Producing Wells	672	777	882	987	1,092	1,197	1,302	1,407
Road & Bridge Property Tax Revenue	\$278,964	\$330,624	\$382,284	\$433,944	\$485,604	\$537,264	\$588,924	\$640,584
Other Property Tax Revenue	\$948,024	\$1,123,584	\$1,299,144	\$1,474,704	\$1,650,264	\$1,825,824	\$2,001,384	\$2,176,944
Total Property Tax Revenue	\$1,226,988	\$1,454,208	\$1,681,428	\$1,908,648	\$2,135,868	\$2,363,088	\$2,590,308	\$2,817,528
High Scenario								
Producing Wells	1,638	1,974	2,310	2,646	2,982	3,318	3,675	4,032
Road & Bridge Property Tax Revenue	\$640,584	\$805,896	\$971,208	\$1,136,520	\$1,301,832	\$1,467,144	\$1,632,456	\$1,808,100
Other Property Tax Revenue	\$2,176,944	\$2,738,736	\$3,300,528	\$3,862,320	\$4,424,112	\$4,985,904	\$5,547,696	\$6,144,600
Total Property Tax Revenue	\$2,817,528	\$3,544,632	\$4,271,736	\$4,998,840	\$5,725,944	\$6,453,048	\$7,180,152	\$7,952,700

Notes: Assuming \$2,164 annual property tax per well; See Chapter III for well development scenario description.

Source: BBC Research & Consulting.

Severance Tax

State redistributed severance tax is another county revenue source that will likely grow as oil and gas development occurs in Douglas County. Severance tax is imposed on the sale of natural resources (oil, gas, coal and metal) and is collected by the state. A portion of state severance tax revenue is allocated for distribution to local government. Numerous factors affect the amount of revenue collected by the state and the distribution to the counties. The following is a discussion of the severance tax collection and distribution process.

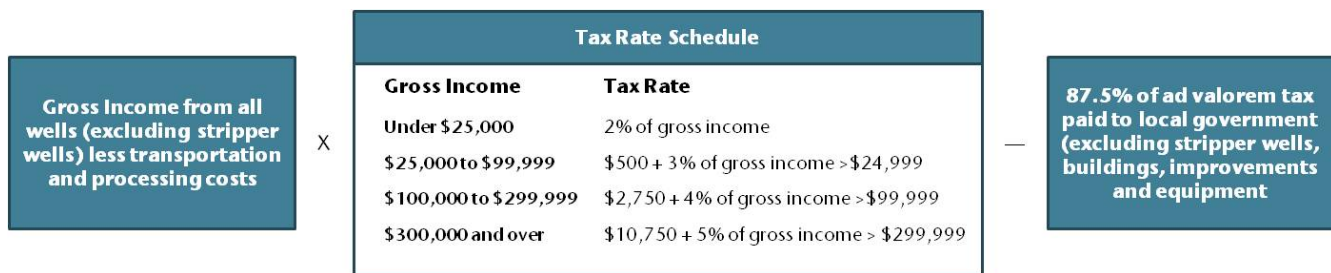


Tax Rates

Colorado severance tax applies to the extraction of nonrenewable natural resources; revenues are collected by the State of Colorado. For oil and natural gas, annual taxes are based on gross income produced by all wells except “stripper wells” (those producing less than 15 barrels of crude oil or 90,000 cubic feet of gas per year on average). Certain production costs, which include transportation, processing and manufacturing costs are deducted to account for the costs to move the gas from the point of severance (the wellhead; where valuation is supposed to occur) to the point of valuation (usually a regional gathering location).

As shown in **Figure 21** the resultant value is and multiplied by a variable tax rate to determine gross severance tax due. Taxpayers may credit 87.5 percent of ad valorem taxes paid to local governments on oil and gas production (not including taxes related to stripper wells or taxes on buildings, improvements and equipment) to determine the net severance tax due.⁵

Figure 21. Calculation of Severance Taxes



Source: Colorado Department of Revenue.

State severance tax receipts and subsequent local government distributions have varied widely over the years as a result of resource price volatility, uneven annual deductions for property tax and allowed production costs, and the lag between production and receipt of revenues.

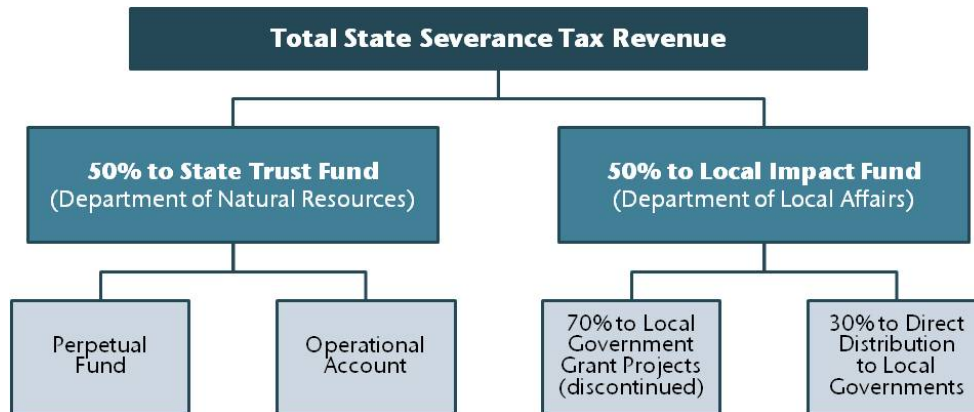
Tax Distribution

Once collected, severance taxes are distributed through a complex state process, as depicted on **Figure 22**. Colorado’s severance tax revenues are first split 50-50 between State Trust Fund and the Local Impact Fund. The State Trust Fund provides funding for Water Conservation and Department of Natural Resources operations. Before 2009, the Local Impact Fund allocated 70 percent of its collections to a local government grant program that awards funding through a competitive process. The grant program has been suspended beginning in 2009 and the funds were reallocated to the state general fund to mitigate a statewide budget deficit. The remaining 30 percent of Local Impact Fund revenue is directly distributed to local governments.

⁵ This credit is designed to eliminate the disincentive to invest in counties/jurisdictions with high property taxes.



Figure 22. Severance Tax Distribution (2011)



Source: Colorado Department of Local Affairs.

The direct distribution to local governments has two steps. The first step is a county allocation, where monies are allocated among Colorado counties based on local resource production, energy employee residence and drilling/mining permits. Each county's proportion of the state total for each of these factors is weighed to determine payout of severance tax direct distribution receipts. The current allocation for each factor is 40 percent to energy employee residence, 30 percent to mining and well permits and 30 percent to mineral production. If 10 percent of the state's energy workers reside in a county, then that county is entitled to 10 percent of the 40 percent of severance tax revenue allocated for energy employee residence. If that same county produces 5 percent of the state's energy resources, then that county is entitled to five percent of the 30 percent of severance tax revenue allocated for energy production.

The second step is a sub-county allocation, where the severance tax funds allocated to each county is divided among the county and its municipalities based on road mileage, population and energy worker residence. Each factor is weighed roughly evenly in the sub-county allocation process. Douglas County will accrue severance tax funds based on the proportion of road mileage, population and energy worker population residing in the unincorporated county. Severance tax funds will be allocated to municipalities in Douglas County based on the proportion of each allocation factor occurring in each municipality. Variables that affect the amount of severance tax distributed to local governments include:

- ▶ County Allocation
 - Property tax collected on oil and gas
 - Oil and gas commodity prices
 - Statewide and Douglas County oil and gas workers
 - Statewide and Douglas County drilling permits
 - Statewide and Douglas County oil and gas production
- ▶ Sub-County Allocation
 - Oil and gas workers living in unincorporated Douglas County vs. Douglas County municipalities
 - Population in unincorporated Douglas County vs. Douglas County municipalities
 - Road miles in unincorporated Douglas County vs. Douglas County municipalities



Forecasting severance tax collections for future energy development in Douglas County is a challenging process. In addition to projecting the number, location, timing and production of oil and gas and other resource extraction activity, tax projections require forecasts of resource prices, resource production, number and productivity of small wells and fluctuations in workers per well. Adjustments for production by exempted groups, estimation of applicable mill levies, deductions for property tax payments, transportation, processing and manufacturing costs, and adjustment for timing lags between severance tax and associated property tax payments are also required.

Current Severance Tax Revenue Distribution

Table 17 provides a sample of Colorado counties, their share of wells, oil and gas employees, population, and each county's severance tax direct distribution. The sample includes top producing counties and several Front Range Counties.

Table 17. Severance Tax Direct Distribution by County (2011)

County	2011 Severance Tax Distribution	Number of Oil and Gas Employees	Number of Wells	Population
Garfield County	\$2,079,304	350	7,973	22,653
Weld County	\$1,727,872	401	17,177	42,473
Mesa County	\$1,673,125	1,043	1,067	71,607
La Plata County	\$1,066,623	147	3,265	31,427
Las Animas County	\$431,019	127	3,039	5,537
Yuma County	\$255,577	69	3,692	3,920
Adams County	\$142,899	36	1,002	88,292
Larimer County	\$103,763	7	231	65,860
Douglas County	\$16,182	13	0	171,031

Source: Colorado Department of Local Affairs, 2011.

As shown in **Table 17**, the severance tax payout is highly variable and specific to each particular county. Mesa County and Adams County have almost the same number of wells but Mesa County collected almost 12 times the amount of severance tax—primarily because unincorporated Mesa County is home to a large portion of the state's energy workers. Mesa County and Weld County received similar severance tax distributions even though Weld County has far fewer energy workers than Mesa County. Weld County has most of the state's wells and produces a substantial amount of oil and gas, which drives its severance tax distribution. Douglas County received about \$16,000 in severance tax revenue in 2011.

Severance tax revenue projection

Although revenue projections are a consideration for state planning, the issue for local government is how much severance tax revenue might come back to the area to offset costs. As presented previously, the amount of severance tax revenue Douglas County will ultimately receive is based on 14 different variables. **Table 17** shows the significant variation in severance tax revenue across major resource producing counties. Douglas County must become home to a significant amount of energy workers and produce a significant amount of oil and gas relative to other Colorado counties in order to receive significant amounts of annual severance tax revenue.

In 2011, the oil and gas direct distribution of severance tax for the State of Colorado was about \$20.6 million. Severance tax was assessed on resource production in 2010. At the end of 2010, the total number of active oil



and gas wells in the state was about 42,000 according to the COGCC. Given the statewide active well count and the total amount of oil and gas severance tax, the average amount of severance tax per well is \$491, as shown in **Table 18** below.

After the initial county allocation of severance tax, there is a sub-county allocation to each county's municipalities and the county government. The factors discussed on pages 52-53 determine each jurisdiction's allocation of the county pool. In 2011, Douglas County was allocated \$22,821 in the initial county pool. Of this total, the county government's take was \$16,182 in the sub-county pool or about 71 percent of the initial pool. The remaining revenue was allocated to municipalities within Douglas County. Projected Douglas County severance tax per well in the sub-county pool (\$348) is calculated by applying this proportion (71 percent) to the severance tax per well figure in the county pool (\$491).

Table 18. Potential Douglas County Severance Tax Revenue (2030)

Category	Value
Colorado Oil & Gas Severance Tax Direct Distribution	\$20,638,220
Colorado Active Wells, January 2011	41,993
Severance Tax Per Well (County Pool)	\$491.47
Proportion of Severance Tax Retained by Douglas County	70.9%
Douglas County Severance Tax Revenue per Well (Sub-county Pool)	\$348.49

Source: Colorado Department of Local Affairs; BBC Research & Consulting

The project team developed severance tax revenue projections associated with each well development scenario. The severance tax per well figure is applied to the well development scenarios presented in Section III to calculate potential annual Douglas County property tax revenue. **Table 19** on the following page shows projected annual severance tax revenue for the low, medium and high oil and gas development scenarios.

The low scenario generates about \$108,500 in annual severance tax revenue in the 15th year of production. The medium scenario generates about \$470,000 annually in the 15th year while the highest development scenario generates about \$1.3 million annually in the 15th year.



Table 19. Douglas County Well Scenarios and Projected Severance Tax Revenues

Scenario	2015	2016	2017	2018	2019	2020	2021	2022
Low Scenario								
Producing Wells		4	13	34	55	76	97	118
County Severance Tax Revenue	\$16,182	\$16,182	\$17,576	\$20,713	\$28,031	\$35,350	\$42,668	\$49,987
Medium Scenario								
Producing Wells	—	21	84	147	252	357	462	567
County Severance Tax Revenue	\$16,182	\$16,182	\$23,501	\$45,456	\$67,412	\$104,004	\$140,596	\$177,189
High Scenario								
Producing Wells	—	84	210	378	546	756	1,008	1,302
County Severance Tax Revenue	\$16,182	\$16,182	\$45,456	\$89,367	\$147,915	\$206,463	\$279,648	\$367,470
<i>continued</i>	2023	2024	2025	2026	2027	2028	2029	2030
Low Scenario								
Producing Wells	139	160	181	202	223	244	265	286
County Severance Tax Revenue	\$57,305	\$64,624	\$71,942	\$79,261	\$86,579	\$93,897	\$101,216	\$108,534
Medium Scenario								
Producing Wells	672	777	882	987	1,092	1,197	1,302	1,407
County Severance Tax Revenue	\$213,781	\$250,374	\$286,966	\$323,559	\$360,151	\$396,744	\$433,336	\$469,929
High Scenario								
Producing Wells	1,638	1,974	2,310	2,646	2,982	3,318	3,675	4,032
County Severance Tax Revenue	\$469,929	\$587,025	\$704,121	\$821,216	\$938,312	\$1,055,408	\$1,172,504	\$1,296,919

Source: BBC Research & Consulting.



Total Oil and Gas Related Revenue

Table 20 combines projected property tax and severance tax revenue to calculate total revenue. It shows annual severance tax and property tax revenue collected by Douglas County.

Under the low scenario, oil and gas development will produce an additional \$4.8 million in property and severance tax revenue over 15 years. Douglas County will collect about \$22.4 million in the medium scenario over 15 years in the medium scenario. Under the high scenario, Douglas County will collect about \$57.5 million in property tax and severance tax revenue over 15 years.

Table 20. Douglas County Well Scenarios and Projected Total Tax Revenue

Scenario	2015	2016	2017	2018	2019	2020	2021	2022	2023
Low Scenario									
Producing Wells	—	4	13	34	55	76	97	118	139
Severance Tax Revenue	\$16,182	\$16,182	\$17,576	\$20,713	\$28,031	\$35,350	\$42,668	\$49,987	\$57,305
Road & Bridge Property Tax	—	—	\$1,968	\$6,396	\$16,728	\$27,060	\$37,392	\$47,724	\$58,056
Other Property Tax	—	—	\$6,688	\$21,736	\$56,848	\$91,960	\$127,072	\$162,184	\$197,296
Total Property Tax Revenue	—	—	\$8,656	\$28,132	\$73,576	\$119,020	\$164,464	\$209,908	\$255,352
Total Revenue	\$16,182	\$16,182	\$26,232	\$48,845	\$101,607	\$154,370	\$207,132	\$259,895	\$312,657
Medium Scenario									
Producing Wells	—	21	84	147	252	357	462	567	672
Severance Tax Revenue	\$16,182	\$16,182	\$23,501	\$45,456	\$67,412	\$104,004	\$140,596	\$177,189	\$213,781
Road & Bridge Property Tax	—	—	\$10,332	\$41,328	\$72,324	\$123,984	\$175,644	\$227,304	\$278,964
Other Property Tax	—	—	\$35,112	\$140,448	\$245,784	\$421,344	\$596,904	\$772,464	\$948,024
Total Property Tax Revenue	—	—	\$45,444	\$181,776	\$318,108	\$545,328	\$772,548	\$999,768	\$1,226,988
Total Revenue	\$16,182	\$16,182	\$68,945	\$227,232	\$385,520	\$649,332	\$913,144	\$1,176,957	\$1,440,769
High Scenario									
Producing Wells	—	84	210	378	546	756	1,008	1,302	1,638
Severance Tax Revenue	\$16,182	\$16,182	\$45,456	\$89,367	\$147,915	\$206,463	\$279,648	\$367,470	\$469,929
Road & Bridge Property Tax	—	—	\$41,328	\$103,110	\$185,598	\$268,086	\$371,196	\$494,928	\$640,584
Other Property Tax	—	—	\$140,448	\$343,980	\$619,164	\$894,348	\$1,238,328	\$1,651,104	\$2,176,944
Total Property Tax Revenue	—	—	\$181,776	\$447,090	\$804,762	\$1,162,434	\$1,609,524	\$2,146,032	\$2,817,528
Total Revenue	\$16,182	\$16,182	\$227,232	\$536,457	\$952,677	\$1,368,897	\$1,889,172	\$2,513,502	\$3,287,457
<i>continued</i>	2024	2025	2026	2027	2028	2029	2030	Total	
Low Scenario									
Producing Wells	160	181	202	223	244	265	286	286	
Severance Tax Revenue	\$64,624	\$71,942	\$79,261	\$86,579	\$93,897	\$101,216	\$108,534	\$890,046	
Road & Bridge Property Tax	\$68,388	\$78,720	\$89,052	\$99,384	\$109,716	\$120,048	\$130,380	\$891,012	
Other Property Tax	\$232,408	\$267,520	\$302,632	\$337,744	\$372,856	\$407,968	\$443,080	\$3,027,992	
Total Property Tax Revenue	\$300,796	\$346,240	\$391,684	\$437,128	\$482,572	\$528,016	\$573,460	\$3,919,004	
Total Revenue	\$365,420	\$418,182	\$470,945	\$523,707	\$576,469	\$629,232	\$681,994	\$4,809,050	
Medium Scenario									
Producing Wells	777	882	987	1,092	1,197	1,302	1,407	1,407	
Severance Tax Revenue	\$250,374	\$286,966	\$323,559	\$360,151	\$396,744	\$433,336	\$469,929	\$3,325,362	
Road & Bridge Property Tax	\$330,624	\$382,284	\$433,944	\$485,604	\$537,264	\$588,924	\$640,584	\$4,329,108	
Other Property Tax	\$1,123,584	\$1,299,144	\$1,474,704	\$1,650,264	\$1,825,824	\$2,001,384	\$2,176,944	\$14,711,928	
Total Property Tax Revenue	\$1,454,208	\$1,681,428	\$1,908,648	\$2,135,868	\$2,363,088	\$2,590,308	\$2,817,528	\$19,041,036	
Total Revenue	\$1,704,582	\$1,968,394	\$2,232,207	\$2,496,019	\$2,759,832	\$3,023,644	\$3,287,457	\$22,366,398	
High Scenario									
Producing Wells	1,974	2,310	2,646	2,982	3,318	3,675	4,032	4,032	
Severance Tax Revenue	\$587,025	\$704,121	\$821,216	\$938,312	\$1,055,408	\$1,172,504	\$1,296,919	\$8,214,116	
Road & Bridge Property Tax	\$805,896	\$971,208	\$1,136,520	\$1,301,832	\$1,467,144	\$1,632,456	\$1,808,100	\$11,227,986	
Other Property Tax	\$2,738,736	\$3,300,528	\$3,862,320	\$4,424,112	\$4,985,904	\$5,547,696	\$6,144,600	\$38,068,212	
Total Property Tax Revenue	\$3,544,632	\$4,271,736	\$4,998,840	\$5,725,944	\$6,453,048	\$7,180,152	\$7,952,700	\$49,296,198	
Total Revenue	\$4,131,657	\$4,975,857	\$5,820,056	\$6,664,256	\$7,508,456	\$8,352,656	\$9,249,619	\$57,510,314	

Source: BBC Research & Consulting.

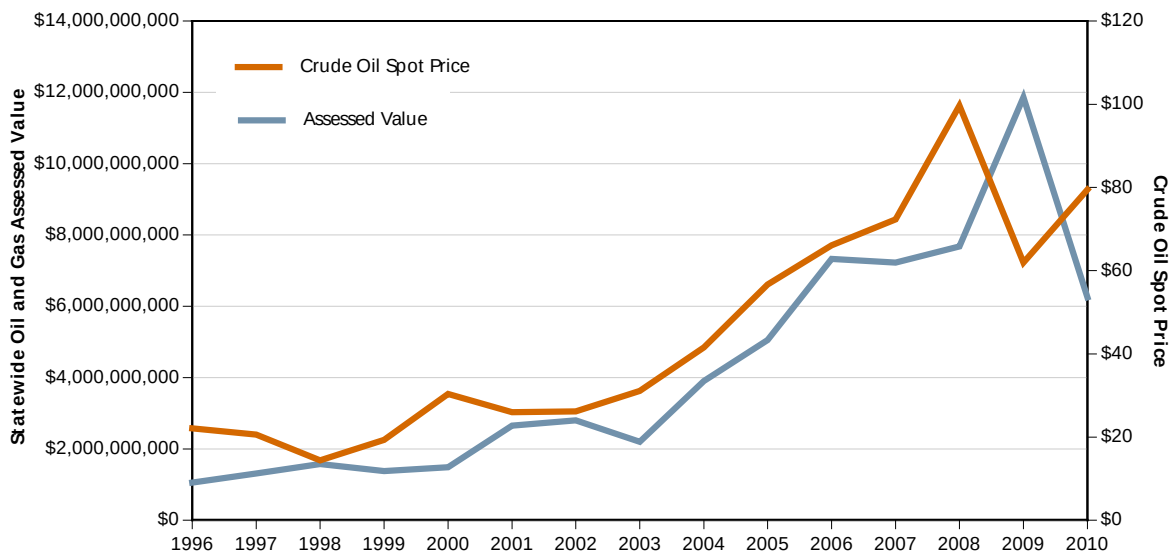


Revenue Variability

The greatest factor that influences the amount of property and severance tax collected each year is the market value of oil and gas. Property is assessed and severance tax is imposed on the value of resource produced at each well. There are many factors that influence the value of oil and gas, including international supply, world demand, geo-political issues and natural disasters. The amount of resource related revenue Douglas County receives will ultimately be dependent on the value of resource recovered.

Volatility in oil and gas markets has significantly influenced the statewide assessed value of oil and gas property and severance tax available for local distribution. **Figures 23 and 24** show the relationship between world crude oil prices, statewide oil and gas assessed value and statewide severance tax revenue allocated for local distribution. Severance tax revenue and the assessed value of resource property is based on the previous year's production figures, which results in a one year lag in production levels, property assessment and distribution of funds. The amount of revenue the County receives will be dependent on local well productivity and world resource prices. Crude oil prices peaked in 2008, which caused a substantial increase in 2009 assessed value and severance tax revenue. As the price of crude oil fell in 2009, severance tax revenue and assessed value decreased in 2010.

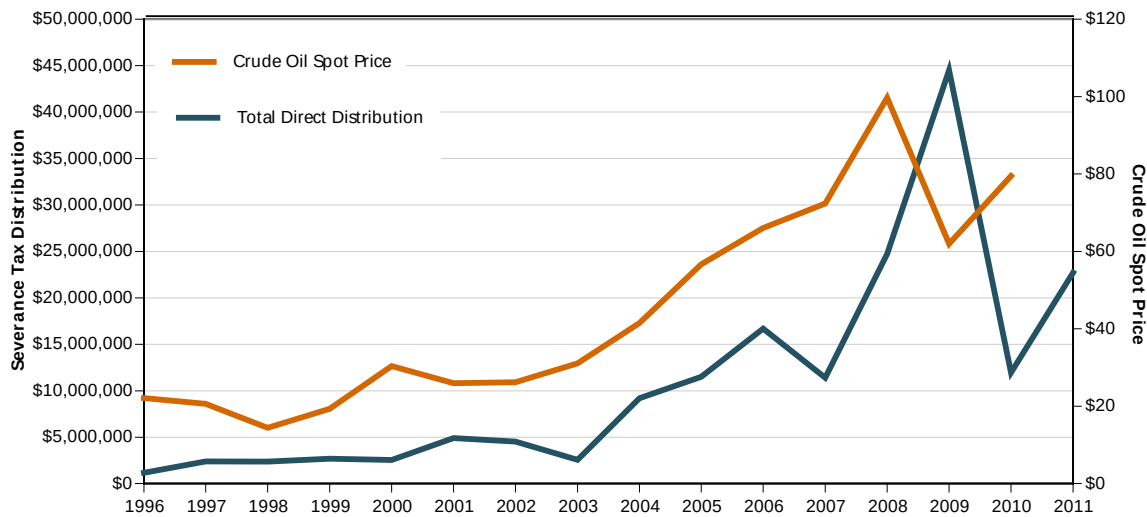
Figure 23. Price of Resource and Resource Property Assessed Value



Source: State of Colorado, Division of Property Taxation; State of Colorado Department of Revenue; U.S. Energy Information Administration.



Figure 24. Price of Resource and Severance Tax Direct Distribution



Source: State of Colorado, Division of Property Taxation; State of Colorado Department of Revenue; U.S. Energy Information Administration.

Property tax payments are based on the property assessments of the prior year, which is based on the value of oil and gas in the year before assessment. This creates essentially a two year lag between property tax payment and the valuation year of resource property.

Well owners are entitled to a property tax credit that allows the taxpayers to deduct the amount paid in property tax from the amount owed in severance tax. This can reduce the severance tax liability of an energy producer to zero. Therefore, the effective tax base for severance tax is the difference between the gross value of resource production and the aforementioned property tax credit.



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VII. POTENTIAL ADDITIONAL REVENUE SOURCES

This section provides a discussion of the transportation funding challenge facing Douglas County and presents several options for generating additional revenues for road improvement cost recovery needs.

Capital Needs and Revenue

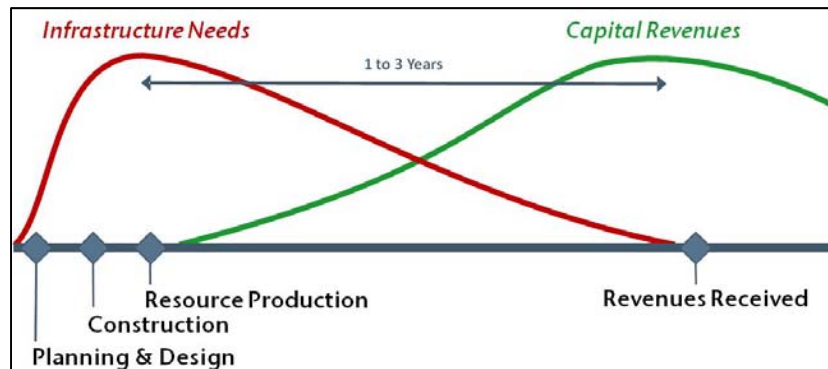
There are three important factors that should be considered in determining the likelihood that the Douglas County oil and gas industry will generate sufficient new tax revenue to cover industry associated road improvement expenses. These factors are; revenue time lags; compounding revenue growth; and field productivity, which are discussed below.

Revenue Time Lag

As demonstrated in Chapter VI, the development of oil and gas has the potential to require substantial front-end, capital investment in order to maintain, expand and improved affected road infrastructure. Generally, road systems need to be improved or expanded in advance of, or at least concurrent with, drilling activity. Road costs associated with oil and gas drilling occur largely in the early well development period. The tax revenues stemming from oil and gas associated property and severance tax will lag initial drilling by 1-3 years.

Simply stated, the energy industry and the residents of Douglas County need functioning and accommodating road infrastructure in order to drill and complete wells and support baseline traffic requirements, but revenue sources (property taxes and severance taxes) occur only after drilling and production is complete. **Figure 25** below shows a graphical depiction of the revenue lag issue.

Figure 25. Revenue Lag Issue



Source: BBC Research and Consulting

Compounding Revenue Growth

It should be noted that in a successful field, over time, the number of ongoing productive wells will outstrip the number of annual new wells and thus the problems of revenue time lag will diminishes and, assuming prices and production remain high, annual energy related revenues will grow far faster than new road improvement costs. The critical factor here is simply the ratio of productive wells to new annual drilling. Although the pace of drilling is unknown, most counties have found that in a relatively short period, gas and oil taxes revenues catch up and exceed associated costs.



Well Success and Productivity

A third factor to consider in determining appropriate tax policy is the impact of well success rates and well productivity on local tax revenue. The modeling presented here assumes a 70 percent well success rate. Non-productive wells produce road costs associated with drilling, but very little of the property and severance tax revenue. Similarly highly productive wells are also highly productive for tax revenue, while road costs will remain fairly stable on per well basis, regardless of well productivity.

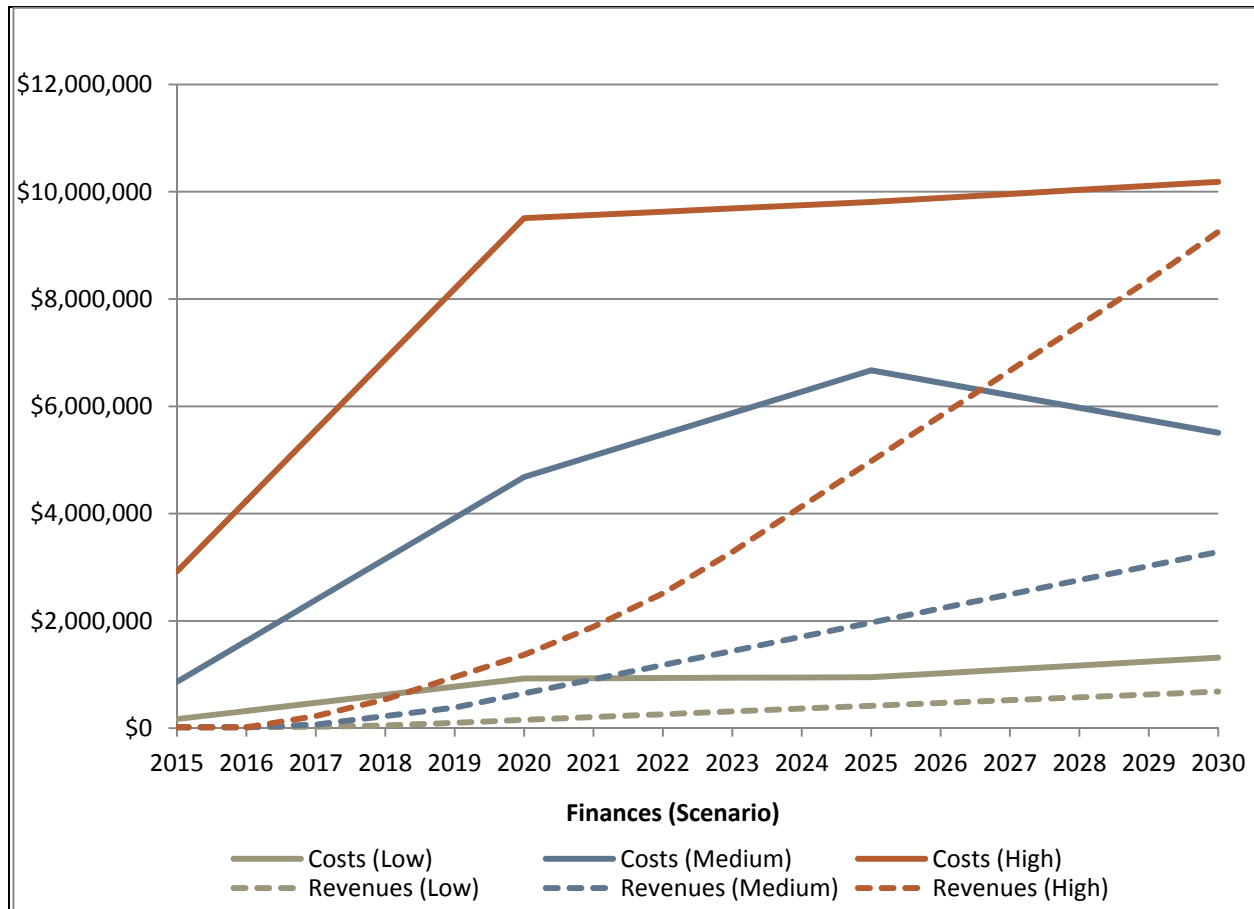
In essence, the County is sharing the risk and reward of well success with the field developers.

Estimated Road Costs in Comparison with Available Funds

The timing of road infrastructure expenditure in the early years of activity will likely be the County's primary fiscal challenge in managing oil and gas development impacts. Under the high development scenario, the study team estimates \$135.9 million in necessary road infrastructure investments over the 15 years time frame. Projected energy related road and bridge property and severance tax funding is expected to exceed \$57.5 million, resulting in a funding gap of an estimated \$78.4 million.

The following **Figure 26** shows the projected road infrastructure funding gap under current county revenue allocation practices for each scenario.

Figure 26. Estimated Transportation Infrastructure Funding Gap, Douglas County, 2015 - 2030





Under the medium and low development scenarios, the funding gap is estimated to be \$53.5 million and \$9.0 million, respectively. The calculations in the table above include all severance tax revenue and all county property tax revenue. In practice, about 23 percent of total annual property tax revenue is allocated to the road and bridge fund. The remaining 77 percent of property tax revenue is allocated to the general fund, social services fund and developmental disabilities fund. Severance tax revenue currently accrues to the County's general fund.

The funding gap shown in **Figure 26** is largely the product of the revenue lag issue shown on **Figure 25**. Annual oil and gas net revenues are dependent on the ratio of producing wells to new wells drilled each year. Annual revenues will likely eventually exceed annual transportation costs, particularly if the number of new wells being drilled tapers.

The following is a discussion of several additional revenue raising methods Douglas County might employ to offset the funding gap presented in **Figure 26**.

Potential Additional Revenue Sources

There are several options available to Douglas County to raise additional revenue from oil and gas development and production, including:

- ▶ Public improvement district(s);
- ▶ Impact fees;
- ▶ Direct contributions; and
- ▶ Property tax reallocation.

The following presents a description of each option and highlights the benefits and drawbacks to Douglas County if adopted.

Public Improvement District (PID)

A PID is defined as a sub-county political division of the state having the authority to impose property taxes. A PID is governed by a board that is typically comprised of county commissioners or their designees. PIDs are created to construct, install, acquire, operate and maintain public infrastructure, including roads and bridges. If oil and gas development occurs in a concentrated region or regions, Douglas County could overlay the regions with a PID and impose an additional property tax to improve and maintain the roads within the PID area. A PID must be formed by petition of landowners within the district and must have approval by the county commissioners. A PID could potentially be a useful tool to fund road infrastructure in specific regions of the county without diverting countywide road and bridge funds. If there are regions of the county where a small group of interests will benefit from road improvements, a PID assigns the funding burden to the parties that benefit.

A property tax is the primary revenue raising authority of a PID, which means PID revenue may lag behind infrastructure needs. PIDs, however, are authorized to issue general obligation and revenue bonds to obtain funds for specific improvements in advance of need. Property tax is imposed on all property within a PID, so PID boundaries must be designed with consideration to include only properties that will be benefitted from road improvements. Although, due to the difference in assessment rates between oil and gas property (87.5 percent), residential property (7.96 percent) and commercial/agricultural property (29 percent), oil and gas properties will



provide the vast majority of district revenue per dollar of assessed valuation. In sum, a PID may prove to be a useful revenue raising tool for Douglas County, especially if oil and gas development occurs in concentrated regions of the county. Oil and gas companies deduct property tax from their state severance tax payments and would generally support paying a property tax that would directly benefit their operations while reducing their total tax liability.

Impact Fees

Transportation impact fees are generally defined as one-time charges used to recover the transportation capital costs occurring as a result of the system demands associated with new growth. Impact Fee design is governed by principles established in both state and federal law, most recently Colorado's Senate Bill 15, which was passed in 2001 and specifically gives cities, towns and counties the authority to levy impact fees. Impact fees are one time charge, defined as "any fee charge, or assessment relating to a capital expenditure which is imposed on land development as a condition of approval..."⁶ There are specific requirements associated with the design and implementation of impact fees. An impact fee can only be used to fund capital improvements and cannot be used to fund transportation operations or maintenance. By law, impact fees must be imposed on all forms of new growth that contribute to the need to expand infrastructure systems—not just a single industry or land use. Most importantly, impact fees must be fair and proportional to the magnitude of the associated impacts, which means that fees cannot be arbitrarily set and fees must ensure that each form of land use is the appropriate and proportional share of future capital expansion requirements.

If Douglas County were to enact impact fees, the fees must be imposed on all future residential and commercial development as well as oil and gas development. Impact fees would help mitigate the revenue lag issue described above because they are typically collected during the development permitting process before development occurs.

In this instance, impact fees could also provide benefits to the oil and gas industry and land developers. Well designed impact fees can : 1) standardize infrastructure costs for all future transportation system users; 2) clarify the kinds of facilities and improvements for which industry/developers are responsible; 3) ensure that the county spends funds collected through impact fees on capital improvements that directly benefit fee payers; and 4) ensure that capital improvements are completed within a reasonable time after fees are paid. Although impact fees are currently used by many counties and municipalities to offset the capital expenditure necessary to accommodate residential, commercial and industrial growth, only Rio Blanco County imposes impact fees on oil and gas development. Designing impact fees that capture the impact of oil and gas development and meet the state proportionality requirements will be challenging. The baseline circumstances in Douglas County are very different than in Rio Blanco County and the process applied in Rio Blanco County may not be suitable for Douglas County. In Rio Blanco County, oil and gas transportation impacts occur in a relatively localized area along Piceance Creek Road. The impact fees mostly fund road improvements in this area and the oil and gas operators likely perceive that paying the fees provide a direct benefit. This may not be the case in Douglas County. County officials should be aware that impact fees on oil and gas development are a new form of revenue recovery in Colorado that has not received a high level of judicial scrutiny. Weld County imposes transportation impact fees on residential, commercial and industrial development but does not impose fees on oil and gas wells.

⁶ Colorado Municipal League, *Paying for Growth, Impact Fees under Senate Bill 15*, April 2002, p. 3.



Direct Contributions

Douglas County could approach the oil and gas industry and negotiate direct monetary contributions for road projects that specifically benefit industry interests. This informal method of raising funds has proved beneficial in Garfield County.

In Garfield County, oil and gas companies sometimes provide additional funds to the county for road projects that are directly affected by nearby gas development. These projects, often road system improvements or expansions in gas development areas, are generally accounted for in the road and bridge fund. Garfield County has an informal process for collecting direct contributions from natural gas operators for special road improvement projects. In general, the industry is asked to directly support projects for rural road improvements that clearly benefit gas development projects. As a general practice, Garfield County resists funding capital projects outside those identified and prioritized in the capital improvement plan. Direct industry contributions generally fund non-priority rural road improvement projects.

Direct contributions could be useful in providing one-time funds for specific road capital projects, but would not contribute to ongoing operations and maintenance needs. In practice, funds obtained through direct contributions would vary widely year to year and would not provide a regular revenue source. In order for this strategy to be successful, Douglas County must begin meeting with industry representatives before widespread resource development occurs to establish appropriate relations. This strategy for cost recovery will only be successful if the industry is willing to discuss transportation impacts and voluntarily negotiate a funding arrangement with Douglas County.

Property Tax Reallocation

Under current practices, about a quarter of all property tax collected by Douglas County is dedicated to the road and bridge fund and about 70 percent is allocated to the general fund. The remaining 5 percent accrues to the social services and developmental disabilities funds. This allocation of property taxes has evolved through voter approved measures and reflects an accepted tax revenue allocation to serve the current mix of residential, commercial and industrial land uses. Oil and gas development places heavier demand on road infrastructure and maintenance than other types of development, while potentially placing lighter demand on other county services.

Each oil or gas well is projected to produce over \$2,000 in total county property tax revenue—the equivalent of a \$1.4 million home. Under current property tax allocation practices, only about 25 percent of that amount is allocated towards roads. Douglas County may consider reallocating how its oil and gas related property tax is spent, either through annual general fund transfers to road projects or a rebalancing of county mil levies to dedicate more revenue to transportation operations, maintenance and infrastructure. If desired, county finance staff could work with the assessor to calculate the amount of property tax received from oil and gas activity and reallocate those funds to better reflect the service demands of the industry. A reallocation of property tax revenue could help mitigate the transportation funding gap without raising property taxes for current property owners in Douglas County.

Summary

The heavy truck traffic associated with oil and gas development will place new demands for road infrastructure investment in Douglas County. Truck traffic could potentially increase on many county roads that are not presently designed to accommodate the weight and volume of traffic if substantial resource deposits are



discovered in Douglas County. Oil and gas activity also may generate substantial revenue for Douglas County through property and severance tax.

Given present local property tax rates and state severance tax redistribution practices, the study team projects a transportation funding gap over the 15 years timeframe. This section presents four options for Douglas County officials to consider to mitigate the projected transportation funding shortfall. Each option has its advantages and disadvantages, and the county should potentially consider using several of the above options together.

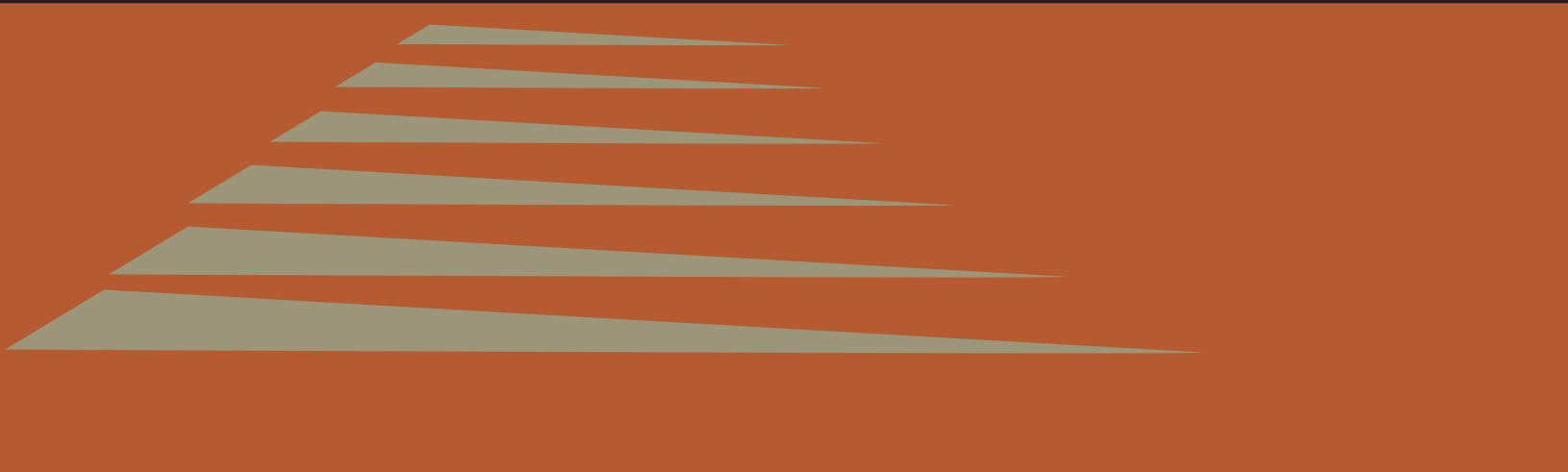
Over the course of this project, the study team had many conversations with industry and local government officials regarding industry transportation impacts in active resource development areas. Both industry and local government officials indicated that establishing a regular forum or working group for industry and local government officials to discuss community concerns has proven beneficial to both parties. There are regular working group meetings between industry and county officials in many active oil and gas areas, including Garfield, Weld and Rio Blanco Counties. Douglas County officials should engage the industry before widespread development occurs to develop an ongoing dialogue regarding industry road impacts and potential mitigation strategies. These working groups are crucial to the success of securing funding through any of the above recommended funding strategies. Interview with county officials also indicated that ongoing monitoring of county roads has helped in assessing the impact of oil and gas development on the transportation system. A regular road condition monitoring system will allow the County to assess and appropriately address road degradation related to potential heavy oil and gas traffic.

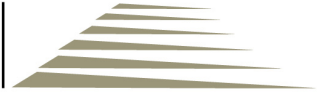


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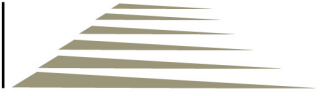
engineering paths to transportation solutions

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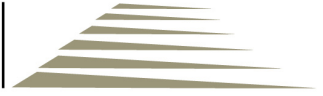




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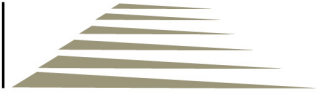
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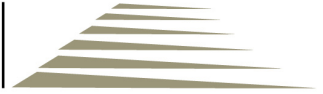
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APPENDIX B INTERVIEW SUMMARIES



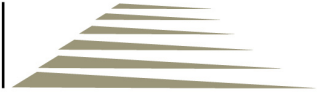
A. Colorado Oil and Gas Conservation Commission

Interviewee: Denise Onyskiw
Email: Denise.Onyskiw@state.co.us

- ▶ Denise Onyskiw (Denise.Onyskiw@state.co.us), head of the COGCC's Underground Injection Well Unit at the Colorado Oil & Gas Conservation Commission, stated that there are currently no Class II Underground Injection Control (UIC) wells in Douglas County.
- ▶ Denise confirmed that for most fields in the Front Range, roughly 20% of produced water is put into onsite evaporation ponds while another 20% is typically either discharged to local water bodies (if it meets quality standards) or used as dust abatement on dirt roads. The remaining 60% is usually injected into UIC wells.
- ▶ Denise indicated that locations of UIC wells could be viewed online on COGCC's web map viewer.
- ▶ Denise provided a 2nd contact at COGCC, Debbie Baldwin (Debbie.baldwin@state.co.us – 303-894-2100 x5111), head of the COGCC's Waste Disposal Unit.

Interviewee: Debbie Baldwin
Phone Number: (303) 894-2100 x5111
Email: Debbie.Baldwin@state.co.us

- ▶ Debbie stated that no underground injection wells currently exist in Douglas County, and would not likely be drilled until the field is "proven" with numerous producing oil/gas wells.
- ▶ She stated that Colorado has roughly 800 UIC wells throughout the state.
- ▶ Debbie indicated that producers do not typically drill a UIC on site due to the cost of drilling a UIC well.
- ▶ She stated that producers typically truck the produced water for injection to UIC wells, though in more developed basins, water may be put into a pipeline to a UIC.
- ▶ Debbie stated that there is no "typical amount" of water produced at a well and that the volume of water produced is highly variable.
- ▶ She stated that the amount of produced water at existing wells can be viewed on COGCC's map viewer and that we could compare levels from other nearby wells in the Niobrara Basin to determine a typical value.
- ▶ She explained that NE Colorado has good underground formations for UIC wells and that not every basin is suitable for UIC wells.
- ▶ She explained that the San Juan Basin in Southern Colorado has perfect formations for UIC wells and that 95% of produced water in the basin is disposed of in UIC wells.
- ▶ Debbie indicated that evaporation pond waste left over after the water has evaporated is commonly reclaimed and the solid waste is not removed.
- ▶ Debbie stated that landfills used to typically accept solid waste from oil & gas production and that the material used to be desirable to the landfill operators (they would layer it with municipal trash).



- ▶ Debbie suggested that we contact Weld County for more information on waste disposal and typical thresholds for injection well creation/use.

Interviewee: Thom Kerr

Thom Kerr is Permitting Manager for the Colorado Oil and Gas Conservation Commission (COGCC). The COGCC provides information about the Colorado permitting process and historical data of county oil and gas operations. Data pertaining to permit count, well count and drilling success rate were also provided by the COGCC. Thom assisted in guiding researchers to find accurate data through search queries and online databases. He also provided insight in regards to COGCC's methods of maintaining an accurate and reliable record of oil and gas activity in Colorado. Thom provided input for the rig utilization section in Chapter III and commented on the development scenarios.

Specific information provided:

- ▶ Counts of drilling permits for each Colorado county between the years 1996 and 2011;
- ▶ The factors and variability of converting drilling activity data into producing well figures;
- ▶ Well completion data per county for 2010.

B. Water Providers

Parker

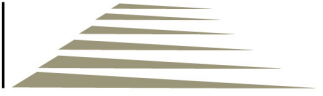
Date: 8/19/2011
Phone Number: (303) 841-4627
Interviewee: Pat / Jim

Talked to Pat, who forwarded questions to an engineer named Jim. He stated that Parker does not have the water capacity for large water use.

Aurora

Date: 8/16/2011
Phone Number: (303) 739-7370
Interviewee: Nicole

Talked to Nicole, who stated that Aurora's only water access in Douglas County is a small residential location that is not a bulk water access point. She also stated that no alternate access point could provide bulk water in the southern portion of the Aurora district, and if there was a location that could, it would be in the northern portion.



Note: No further discussion took place about any possible northern bulk water access in Aurora, as travel would likely require travel on E-470 or great distance on busy state highways and/or local arterials. Therefore, it was determined that oil and gas operations would prefer Castle Rock and Littleton as water providers.

Castle Rock

Date: 8/19/2011
Phone Number: (720) 733-1600
Interviewee: Shauna

Talked to Shauna who stated that Castle Rock is the only local bulk water supplier in the area. The bulk water access location is at I-25 and Meadows Pkwy (behind the justice center). She also stated that Littleton was likely the only other nearby water provider with bulk water access.

Note: No further discussion took place about where Littleton's bulk water access is located, as it lies outside of the travel shed. Traffic would use C-470 or US 85 within Douglas County, which are state-maintained facilities.

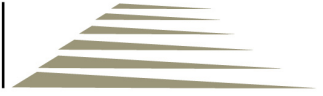
C. Gunnison County Public Works

Interviewee: Allen Moores

Alan is a Director of Public Works for Gunnison County. Information provided was based around the county's means of paying for road improvements and maintenance due to heavy traffic by the energy industry. Alan also discussed how their county regulates truck traffic through county legislation. He explained how Gunnison County is able to finance bridge repair. The county official also provided truck traffic count figures to provide insight into trip modeling. Gunnison County also collaborated with private industry to encourage road and bridge improvements.

Specific information provided:

- ▶ Gunnison County regulates truck traffic with of oversize/overweight permits;
- ▶ The county finances road a bridge repair thorough DOLA severance tax grants, which have since been discontinued;
- ▶ Confidential trip data on County Road 265 provided speed, length and volume of trucks using the route to and from production sites;
- ▶ The county worked closely with energy companies to encourage communication and encouraged company sponsored road and bridge improvements of \$500,000.



D. Chesapeake Energy

Interviewee: John Dill – Director, Corporate Development and Government Relations, Rockies Region,
Date: July 13, 2011

BBC staff met with John Dill, Director Corporate Development and Government Relations of the Rockies Region of Chesapeake Energy. The purpose of the meeting was to talk with an industry official about the potential energy development in Douglas County in order to characterize the potential impacts of development. John expressed that his company was pursuing leases in the area as a method of positioning for future activity in the county. He was uncertain of any specifics in regards to the expected level of drilling or any particulars of the development process as no test wells or real exploration had occurred within the county.

The company staff provided a very thorough and comprehensive explanation of the development process and stages that would take place in Douglas County. Specific information about potential truck trip activity was unknown at the time of the meeting. The company shared videos of the many stages and processes of constructing, drilling, completing and producing a well and answered question in regards to timing and worker needs per stage of development. Information about horizontal drilling techniques and the environmental impact was discussed as well.

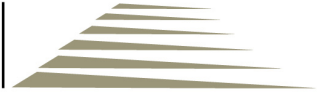
Specific information provided:

- ▶ The construction stage involves considerable attention to the protection against seepage into the ground beneath the well pad;
- ▶ The drilling and completion phases involve the heaviest truck traffic because of the heavy requirement for water and wastewater;
- ▶ The equipment used during each stage of development and the approximate period of time for each step;
- ▶ The mechanics of drilling horizontally, hydraulic-fracturing and the precautions taken to prevent any contamination of groundwater;
- ▶ All wells drilled in the Douglas County region of the Niobrara will be horizontal wells and use the latest hydraulic-fracking technology;
- ▶ Industry perspective into the current energy market and regulatory environment and how this contributes to the uncertainty of energy activity in Douglas County.

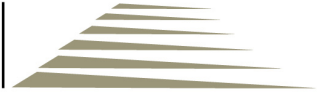
E. Rio Blanco County

Interviewee: Ken Parsons, County Commissioner

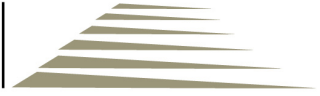
Rio Blanco County is the only jurisdiction in Colorado that imposes impact fees on oil and gas development. Ken Parsons was interviewed via phone to understand the events leading to fee adoption and the interaction between industry and local government. The following are highlights from the interview:



- ▶ Ken began the conversation by saying that Rio Blanco County and industry representatives meet monthly to share information and discuss issues. Ken believes that this working group is instrumental to fostering good industry/government relations.
- ▶ Ken's original thought as to the best way to access the industry to secure funds for specific road improvement projects was to establish a public improvement district in the Piceance Basin. To his surprise, it had no traction with the industry.
- ▶ Some companies were very opposed to the fees when they were introduced, but every operator in Rio Blanco pays the fees now.
- ▶ Rio Blanco county's road impact fee have little opposition from the industry mainly because most of the improvements financed by the fees is in the Piceance Creek Rd. area which is heavily used by the industry.
- ▶ Ken pointed out that the fees are a very small percentage of the cost of drilling and completing a well.
- ▶ The impact fee is tiered based on the depth of the well. It is collected when the drilling commences. (Spud time)



APPENDIX C OIL AND GAS TRUCKS



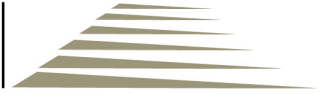
A. Truck Types, Configurations, and Impacts Development

Type	Configuration	Weight (pounds)		ESALs**				Loaded Trip
		Empty*	Loaded	Empty*		Loaded		
				Flexible	Rigid	Flexible	Rigid	
Pickup	S-1	--	8,000	--	--	0.004	0.004	In/Out
Rig Truck	S-1-3	--	106,000	--	--	7.740	12.617	In/Out
Construction Equipment Semi	S-2-2	30,500	80,000	0.091	0.117	2.634	4.402	In or Out
Gravel Hauler	S-2	22,600	54,000	0.344	0.268	2.380	3.707	In
Drilling Support Trucks	S-3	--	56,000	--	--	1.110	1.780	In/Out
Rig Equipment	S-2-2	30,500	60,000	0.091	0.117	0.719	1.125	In
Chemical Tanker	S-2	22,600	54,000	0.344	0.268	2.380	3.707	In
Cement Truck	S-2	22,600	54,000	0.344	0.268	2.380	3.707	In
Fuel Truck	S-2	22,600	54,000	0.344	0.268	2.380	3.707	In
Water Truck – Fresh	S-2-2	30,500	80,000	0.091	0.117	2.634	4.402	In
Water Truck – Produced	S-2-2	30,500	80,000	0.091	0.117	2.634	4.402	Out
Sand Trucks	S-2-2	30,500	80,000	0.091	0.117	2.634	4.402	In
Work Trucks	S-1	--	20,000	--	--	0.175	0.161	In/Out
Service Trucks	S-1	--	30,500	--	--	1.744	1.410	In/Out

* "--" indicates the vehicle was analyzed as always full

** If the ESAL was calculated with the Pavement Tools Consortium equation, it assumed a SI of 2.5 and SN of 5 for flexible pavements, and SI of 2.5 and Slab Depth of 10 in. For ESALs obtained from studies and reports, assumed values for these variables are unknown.

Note: Configurations read as S-x-y where S represents a steering axle (only the front axle in this study), x = the number of grouped axles for the second axle location, and y = the number of grouped axles for the third axle location (if present).



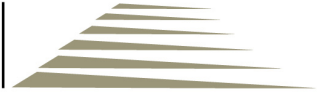
Production

Type	Configuration	Weight (pounds)		ESALs**				Loaded Trip
		Empty*	Loaded	Empty*		Loaded		
				Flexible	Rigid	Flexible	Rigid	
Pickup	S-1	--	8,000	--	--	0.004	0.004	In/Out
Rig Truck	S-1-3	--	106,000	--	--	7.740	12.617	In/Out
Water Truck	S-2	22,600	54,000	0.344	0.268	2.380	3.707	Out
Oil Tanker	S-2-2	30,500	80,000	0.091	0.117	2.634	4.402	Out
Work Trucks	S-1	--	20,000	--	--	0.175	0.161	In/Out
Service Trucks	S-1	--	30,500	--	--	1.744	1.410	In/Out

* "--" indicates the vehicle was analyzed as always full

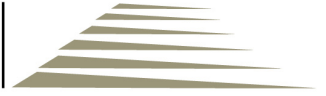
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Note: Configurations read as S-x-y where S represents a steering axle (only the front axle in this study), x = the number of grouped axles for the second axle location, and y = the number of grouped axles for the third axle location (if present).



B. Pairing Truck Types, Activities, and One-Way Annual Trips *Development*

Activity	Total Trips	Truck	%	Trips
Pad and Road Construction	60	Pickups	26%	16
		Construction Equipment Semis	24%	14
		Gravel	50%	30
Drilling Rig	60	Pickups	25%	15
		Drilling Support Trucks	15%	9
		Work Trucks	30%	18
		Service Trucks	25%	15
		Rig Truck	5%	3
Drilling Fluid and Materials	450	Chemicals	40%	180
		Cement	30%	135
		Fuel Trucks	30%	135
Drilling Equipment	450	Rig Equipment	100%	450
Completion Rig	30	Pickups	27%	8
		Drilling Support Trucks	13%	4
		Work Trucks	30%	9
		Service Trucks	27%	8
		Rig Truck	3%	1
Completion Fluid and Materials	180	Chemicals	40%	72
		Cement	30%	54
		Fuel Trucks	30%	54
Completion Equipment	20	Rig Equipment	100%	20
Fracturing Equipment	520	Pickups	25%	130
		Drilling Support Trucks	15%	78
		Work Trucks	30%	156
		Service Trucks	25%	130
		Sand Trucks	5%	26
Fracture Water	6,000	Water Trucks	100%	6,000
Fracture Sand	270	Sand Trucks	100%	270
Flowback Water Disposal	3,000	Water Trucks	100%	3,000
TOTAL	11,040			11,040



Production

Activity	Total Trips	Truck	%	Trips
Production	730	Pickups	18%	131
		Work Trucks	2%	15
		Service Trucks	1%	7
		Rig Truck	> 0%	1
		Oil Tanker	46%	336
		Water Trucks	33%	240
TOTAL	730			730

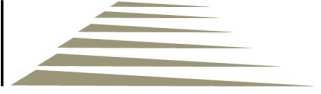
C. Resources Consulted

Impact Reports

- ▶ Chapita Wells / Stagecoach Area Final EIS – Utah (Bureau of Land Management, 2007)
- ▶ Silt EA – Colorado (Bureau of Land Management, 2011)
- ▶ Rio Blanco County Road & Bridge Department Impact Fee Support Study – Colorado (RPI Consulting, LLC; 2008)
- ▶ Jonah Infill Drilling Project Development Procedures Technical Support Document – Wyoming (TRC Mariah Associates & SWCA Environmental Consultants, 2006)
- ▶ La Plata County Impact Report – Colorado (La Plata County, 2002)

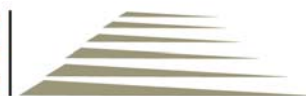
Studies

- ▶ Truck Weight Limits: Issues and Options (Transportation Research Board, 1990)
- ▶ Additional Road Investments Needed to Support Oil and Gas Production and Distribution in North Dakota (Upper Great Plains Transportation Institute, 2010)
- ▶ Impact of Oil Development on State Highways (North Dakota Department of Transportation, 2006)
- ▶ The Future of Natural Gas (Massachusetts Institute of Technology, 2011)
- ▶ Highway Freight Traffic Associated with the Development of Oil and Gas Wells (Kuhn, 2006)
- ▶ Comprehensive Truck Size and Weight Study Vol. 3 – Scenario Analysis (Federal Highway Administration, 2000)



APPENDIX D

OIL AND GAS DEVELOPMENT SCENARIOS



Well Development and Trip Generation – Low Scenario

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New Pads (Annual)	1	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5
NE	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SE	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating Pads (Cumulative)	-	1	3	8	13	18	23	28	33	38	43	48	53	58	63	68
Operating Wells (Cumulative)	-	4	13	34	55	76	97	118	139	160	181	202	223	244	265	286
Annual Development Trips	11,040	22,080	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200	55,200
Annual Production Trips	-	730	2,190	5,840	9,490	13,140	16,790	20,440	24,090	27,740	31,390	35,040	38,690	42,340	45,990	49,640
Total Annual Trips	11,040	22,810	57,390	61,040	64,690	68,340	71,990	75,640	79,290	82,940	86,590	90,240	93,890	97,540	101,190	104,840
Trips Per Day - Development	30	60	151	151	151	151	151	151	151	151	151	151	151	151	151	151
Trips per Day - Production	0	2	6	16	26	36	46	56	66	76	86	96	106	116	126	136
Trips Per Day - Total	30	62	157	167	177	187	197	207	217	227	237	247	257	267	277	287
By Geographic Area																
NE	18	37	94	100	106	112	118	124	130	136	142	148	154	160	166	172
SE	12	25	63	67	71	75	79	83	87	91	95	99	103	107	111	115
W	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

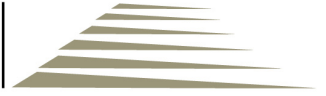
Well Development and Trip Generation – Medium Scenario

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New Pads (Annual)	5	15	15	25	25	25	25	25	25	25	25	25	25	25	25	25
NE	3	8	9	14	14	14	14	14	14	14	14	14	14	14	14	14
SE	2	6	6	10	10	10	10	10	10	10	10	10	10	10	10	10
W	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Operating Pads (Cumulative)	-	5	20	35	60	85	110	135	160	185	210	235	260	285	310	335
Operating Wells (Cumulative)	-	21	84	147	252	357	462	567	672	777	882	987	1,092	1,197	1,302	1,407
Annual Development Trips	55,200	165,600	165,600	276,000	276,000	276,000	276,000	276,000	276,000	276,000	276,000	276,000	276,000	276,000	276,000	276,000
Annual Production Trips	-	3,650	14,600	25,550	43,800	62,050	80,300	98,550	116,800	135,050	153,300	171,550	189,800	208,050	226,300	244,550
Total Annual Trips	55,200	169,250	180,200	301,550	319,800	338,050	356,300	374,550	392,800	411,050	429,300	447,550	465,800	484,050	502,300	520,550
Trips Per Day - Development	151	454	454	756	756	756	756	756	756	756	756	756	756	756	756	756
Trips per Day - Production	0	10	40	70	120	170	220	270	320	370	420	470	520	570	620	670
Trips Per Day - Total	151	464	494	826	876	926	976	1,026	1,076	1,126	1,176	1,226	1,276	1,326	1,376	1,426
By Geographic Area																
NE	91	260	295	476	505	534	563	592	620	649	678	707	736	764	793	822
SE	60	173	197	318	337	356	375	394	414	433	452	471	490	510	529	548
W	0	30	2	32	34	36	38	40	42	44	46	48	50	52	54	56



Well Development and Trip Generation – High Scenario

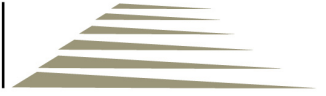
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New Pads (Annual)	20	30	40	40	50	60	70	80	80	80	80	80	80	85	85	85
NE	11	17	23	23	29	34	40	46	46	46	46	46	46	49	49	49
SE	8	12	15	15	19	23	27	30	30	30	30	30	30	32	32	32
W	1	1	2	2	2	3	3	4	4	4	4	4	4	4	4	4
Operating Pads (Cumulative)	-	20	50	90	130	180	240	310	390	470	550	630	710	790	875	960
Operating Wells (Cumulative)	-	84	210	378	546	756	1,008	1,302	1,638	1,974	2,310	2,646	2,982	3,318	3,675	4,032
Annual Development Trips	220,800	331,200	441,600	441,600	552,000	662,400	772,800	883,200	883,200	883,200	883,200	883,200	883,200	938,400	938,400	938,400
Annual Production Trips	-	14,600	36,500	65,700	94,900	131,400	175,200	226,300	284,700	343,100	401,500	459,900	518,300	576,700	638,750	700,800
Total Annual Trips	220,800	345,800	478,100	507,300	646,900	793,800	948,000	1,109,500	1,167,900	1,226,300	1,284,700	1,343,100	1,401,500	1,515,100	1,577,150	1,639,200
Trips Per Day - Development	605	907	1,210	1,210	1,512	1,815	2,117	2,420	2,420	2,420	2,420	2,420	2,420	2,571	2,571	2,571
Trips per Day - Production	0	40	100	180	260	360	480	620	780	940	1,100	1,260	1,420	1,580	1,750	1,920
Trips Per Day - Total	605	947	1,310	1,390	1,772	2,175	2,597	3,040	3,200	3,360	3,520	3,680	3,840	4,151	4,321	4,491
By Geographic Area																
NE	345	549	747	793	1,020	1,241	1,491	1,734	1,826	1,917	2,008	2,099	2,190	2,372	2,470	2,567
SE	230	366	498	529	680	827	994	1,156	1,217	1,278	1,339	1,399	1,460	1,582	1,646	1,711
W	30	32	64	68	72	107	113	149	157	165	173	181	189	197	205	213



APPENDIX E TRAVEL MODE ASSUMPTIONS



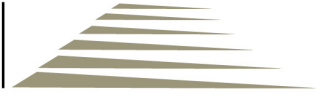
Assumption	Reasoning
Standardized speed limits based on functional classifications	▶ Speed limits within GIS files were found to be inconsistent with posted speed limits observed using Google StreetView ▶ Acquiring accurate speed limits for every segment of roadway analyzed would have been too time consuming with little benefit ▶ Helped simplify complex situations where one direction of a road was a posted speed, while the opposite direction was a different speed, which posed issues with the setup of the TRAFFIX model
All highway ramps entered into the model as a one-lane roadway	▶ Congestion was not factored within the model, and all ramps in the travel shed are the responsibility of CDOT
Intersection controls were not defined	▶ To have intersection controls accurately handled within the model, signal timing would have been a necessary input, which would have been too time consuming with little benefit ▶ The delay caused by intersection controls would be minimal in comparison to the total trip time, thus likely not impacting route selection to a point worth modeling
Turn lanes were not included within the network	▶ The delay reduction provided by turn lanes would be minimal in comparison to the total trip time, thus likely not impacting route selection to a point worth modeling ▶ Programming turn lanes into the model would be too time consuming with little benefit
No pad-to-pad travel	▶ Data on pad-to-pad travel patterns and volumes were unavailable ▶ Such travel patterns are complex to predict and involve a large amount of uncertainty and chance
Paths connecting pad sites to the network avoided water crossings and ravines	▶ Connections would likely take the path of least resistance ▶ No pad site was forced to take an overly exhausted route to navigate around a water or ravine crossing ▶ Construction of a bridge to perform such a crossing would be costly ▶ Change in potential roads being impacted and to what extent was minimal or often non-existent
Trucks using E-470 would enter via a toll-free access point	▶ Using free access points saves on toll costs ▶ Detours to free access points from the shortest travel time path were minimal in length ▶ Transport industries are typically toll-averse
No trucks would use E-470 to access Interstate 25 or to travel to Littleton for water	▶ Transport industries are typically toll-averse ▶ Advantage in time savings is minimal



APPENDIX F

OIL AND GAS DEVELOPMENT SCENARIO

ANNUAL TRIPS

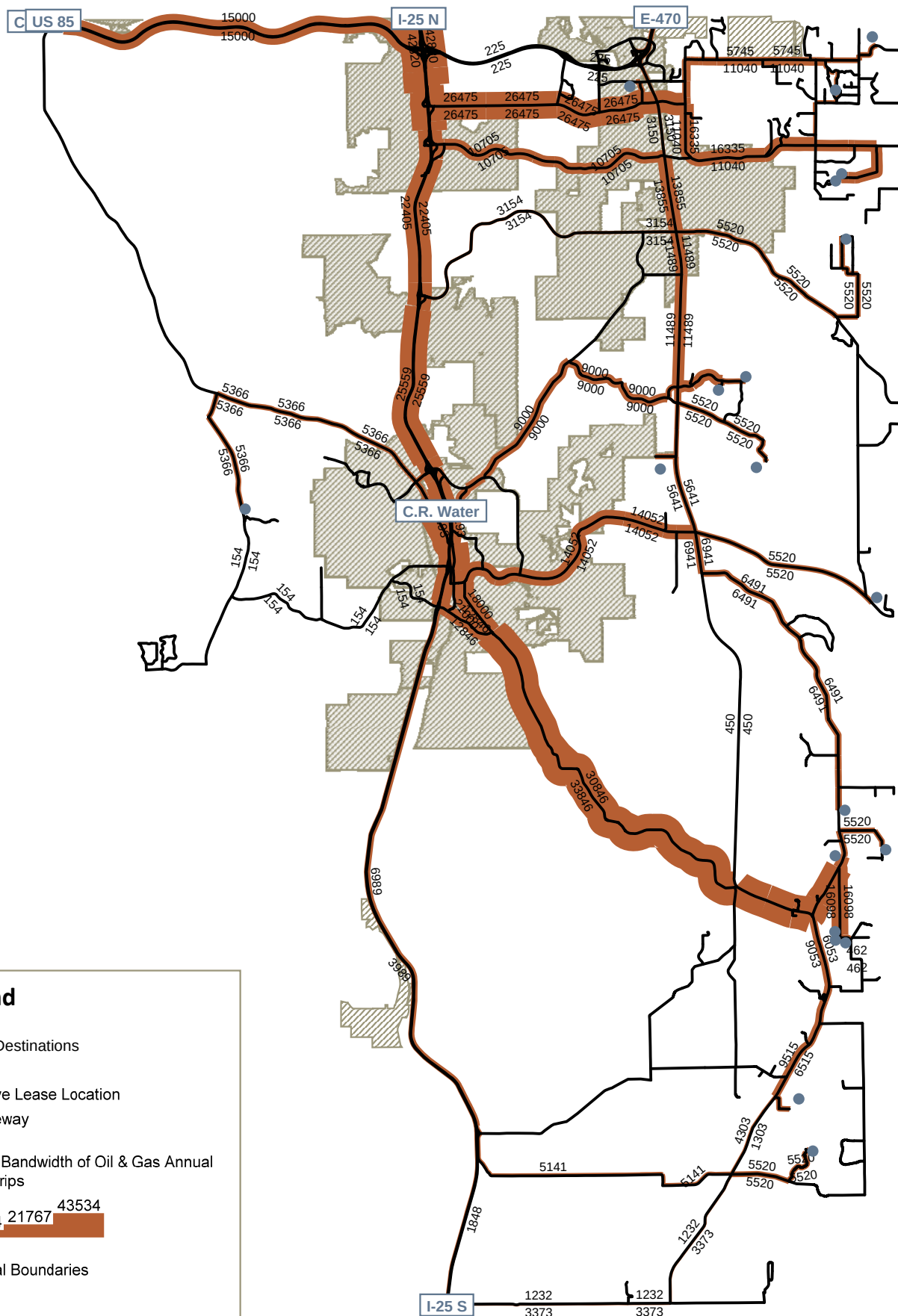


Model Runs

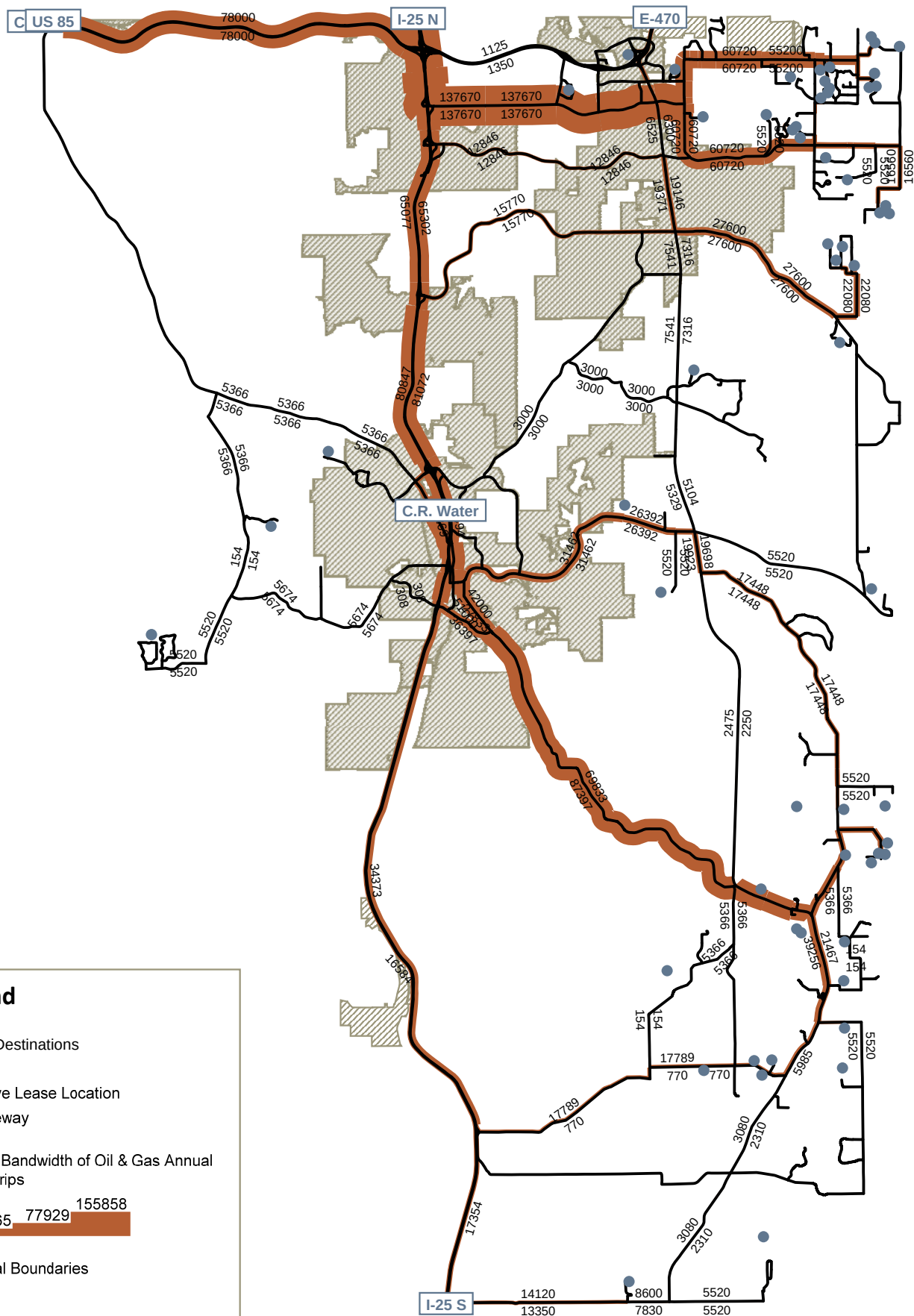
Scenario	Analysis Year	Phase
High	2015	Development
		Production
	2020	Development
		Production
	2025	Development
		Production
Medium	2030	Development
		Production
	2015	Development
		Production
	2020	Development
		Production
Low	2025	Development
		Production
	2030	Development
		Production
	2015	Development
		Production

Model Run Volume Results

Estimated 2015 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Development Phase



Estimated 2020 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Development Phase



Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

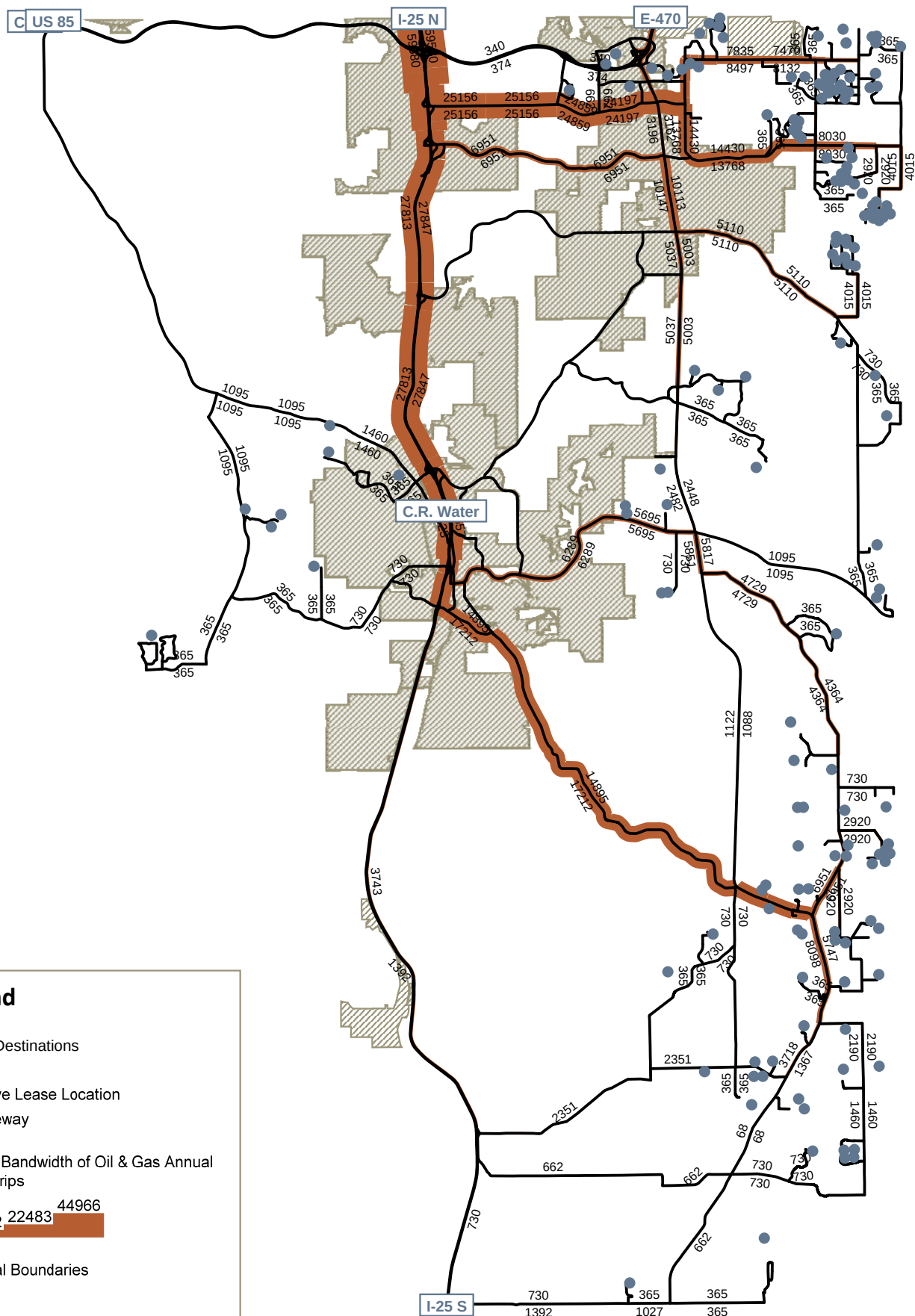
Relative Bandwidth of Oil & Gas Annual Added Trips



Municipal Boundaries



Estimated 2020 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Production Phase

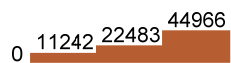


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

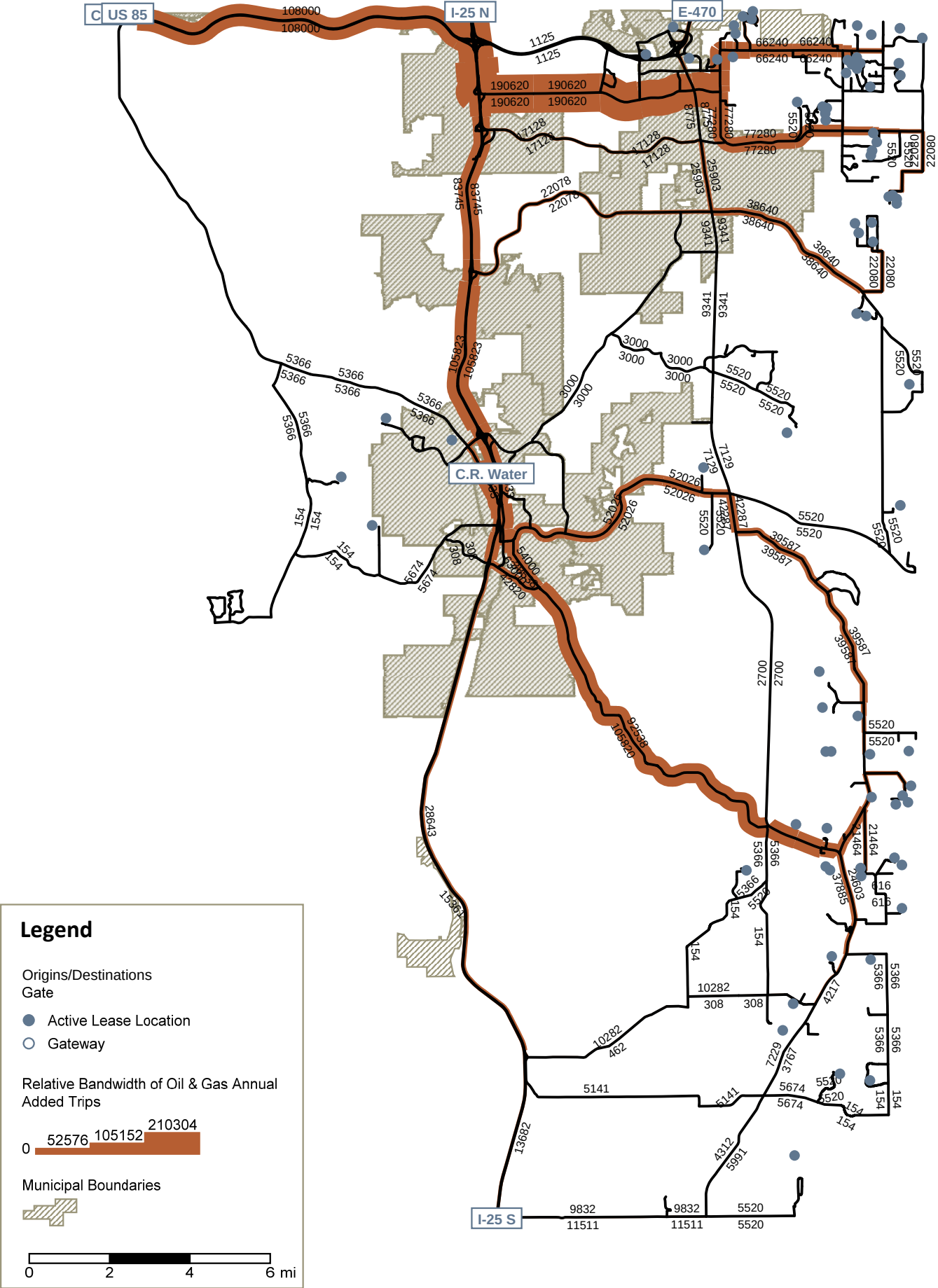
Relative Bandwidth of Oil & Gas Annual
Added Trips



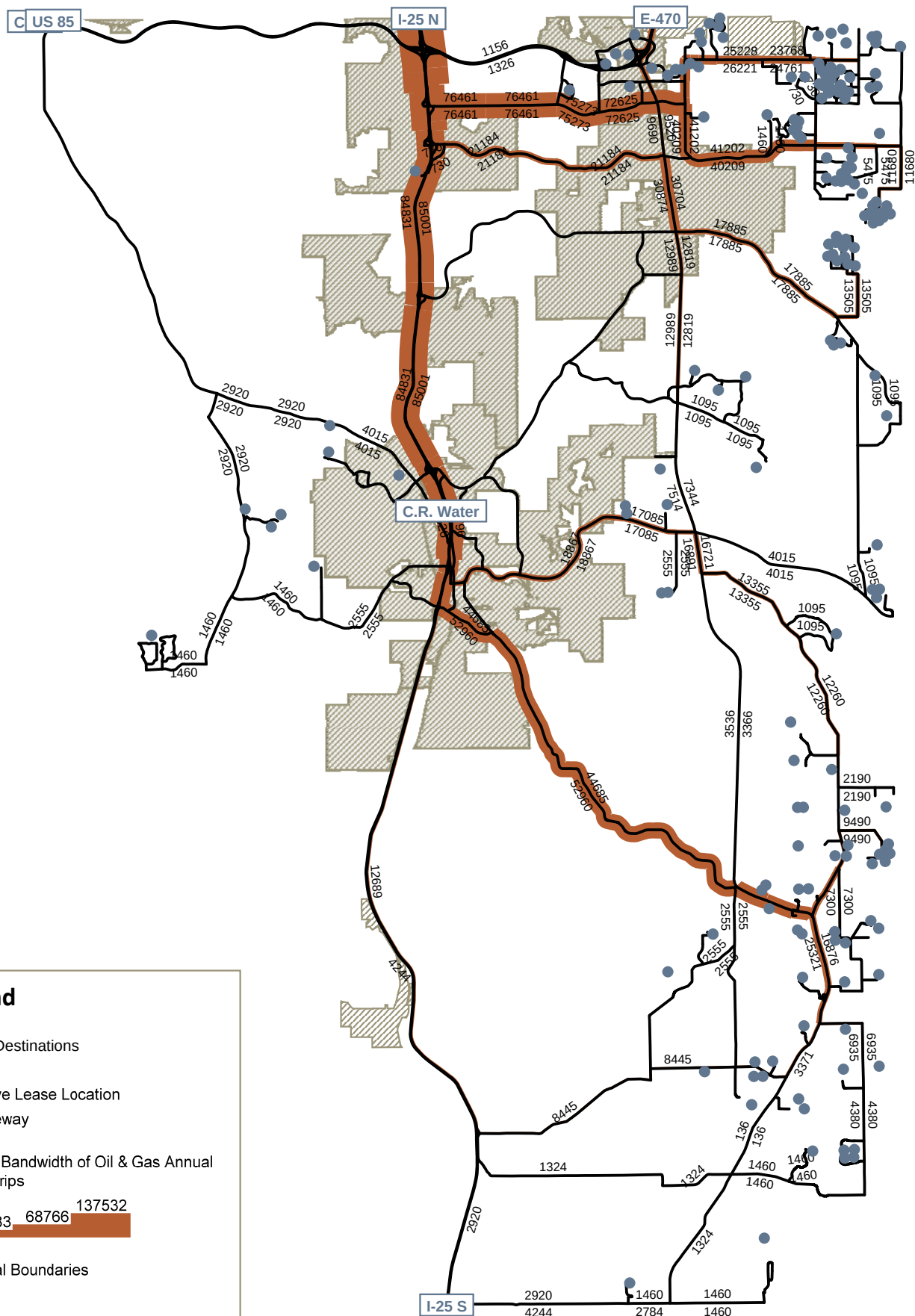
Municipal Boundaries



Estimated 2025 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Development Phase



Estimated 2025 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Production Phase

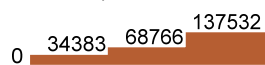


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

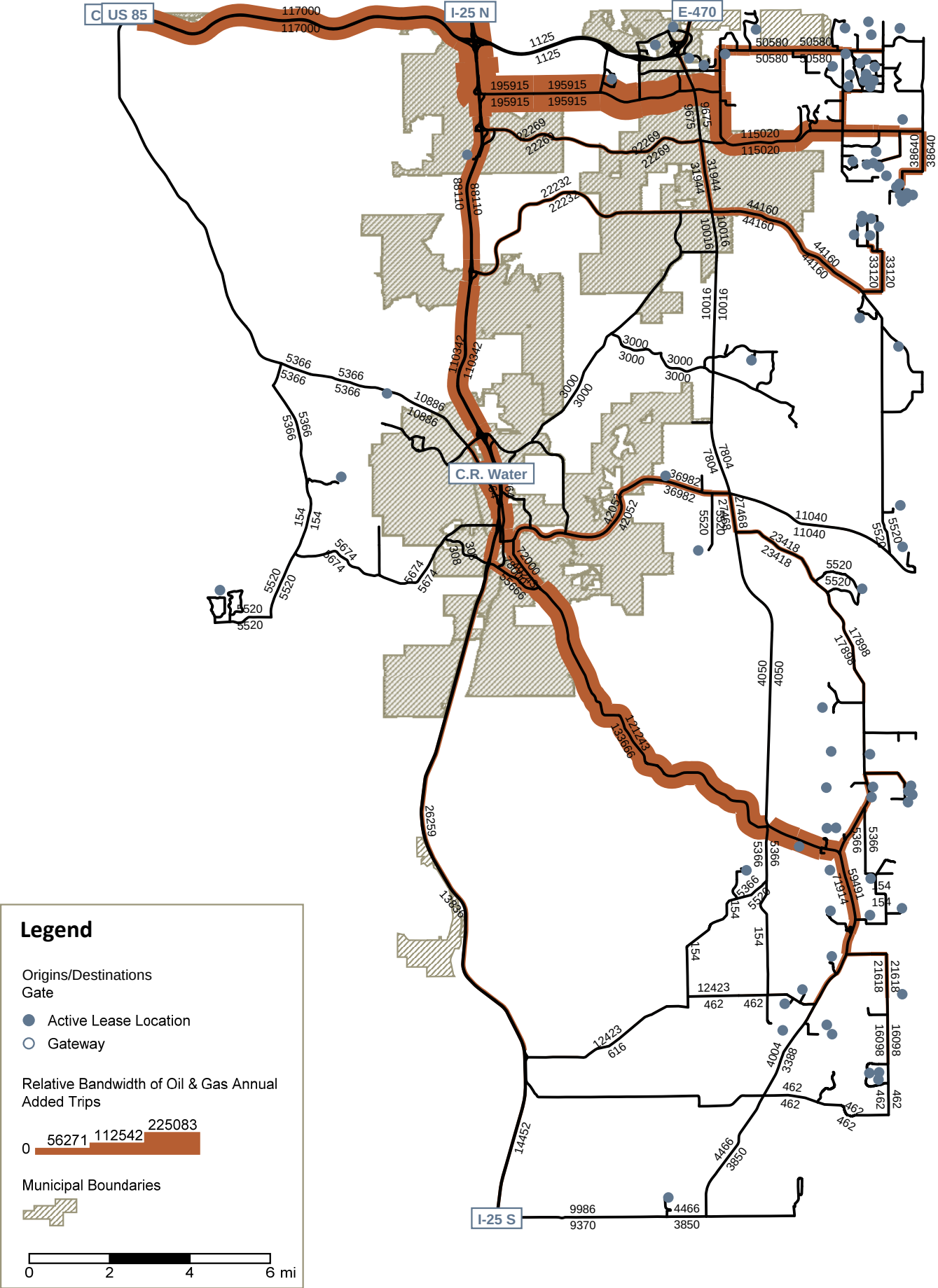
Relative Bandwidth of Oil & Gas Annual
Added Trips



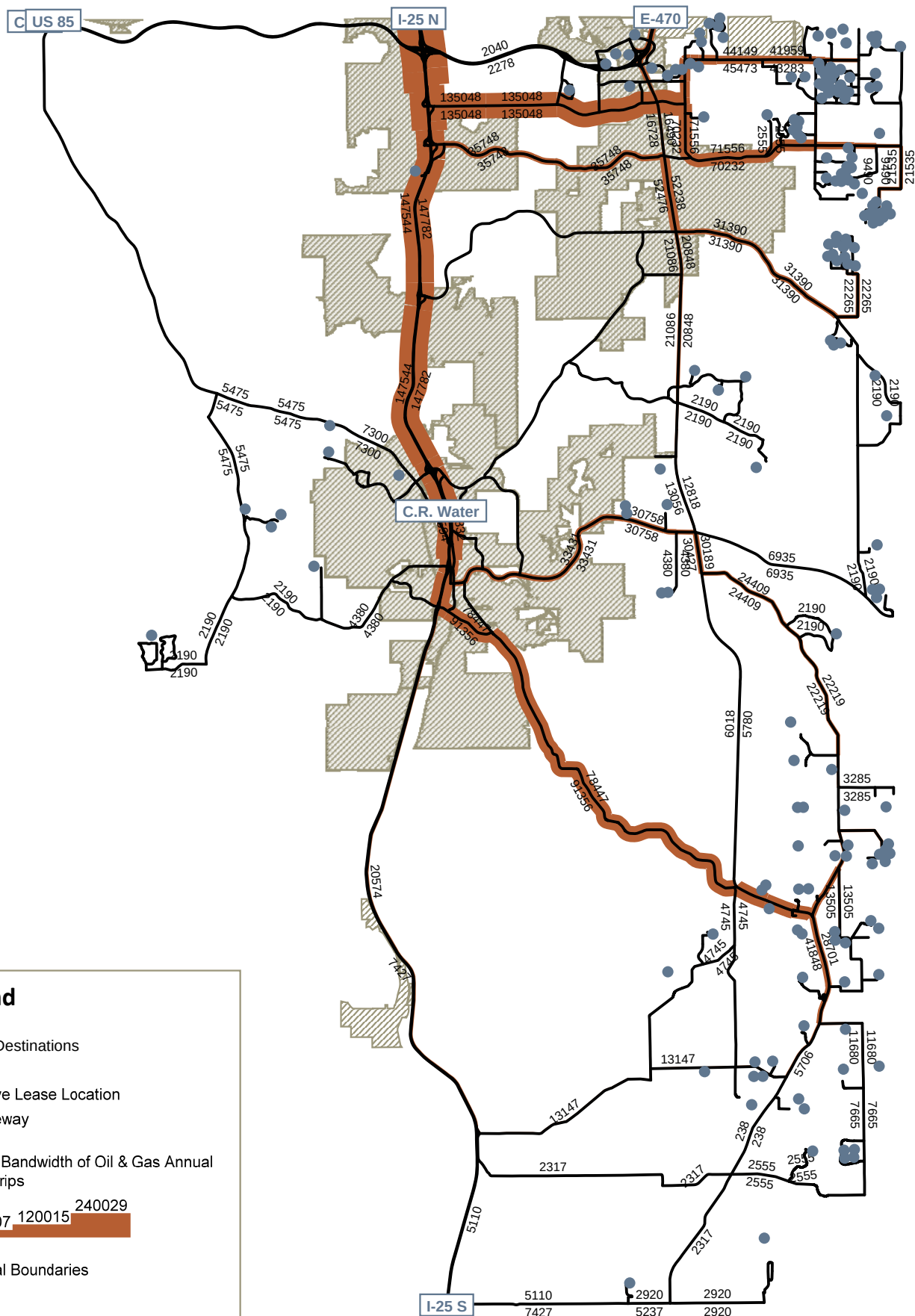
Municipal Boundaries



Estimated 2030 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Development Phase



Estimated 2030 Annual Directional Oil & Gas Related Volumes - HIGH Scenario Production Phase



Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

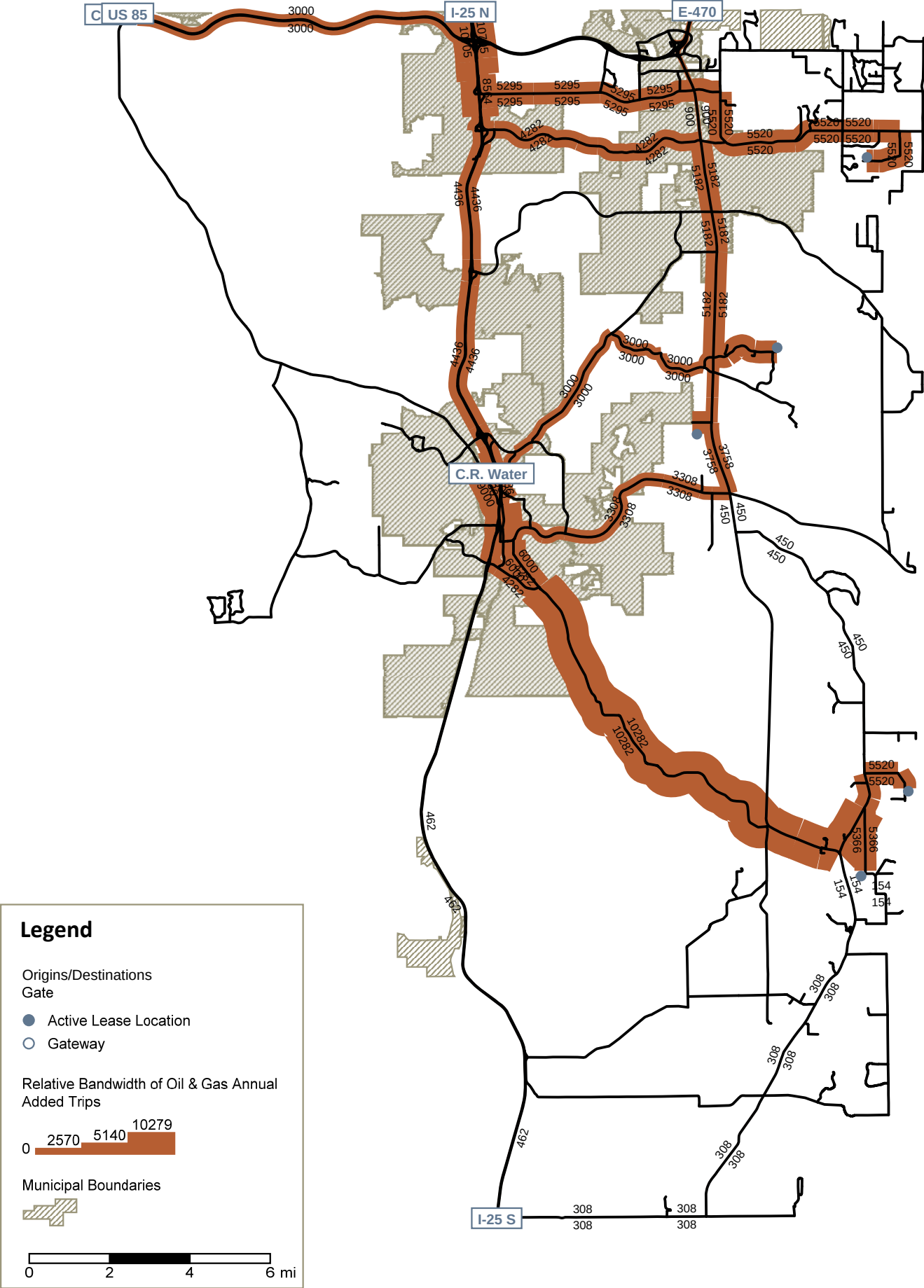
Relative Bandwidth of Oil & Gas Annual
Added Trips



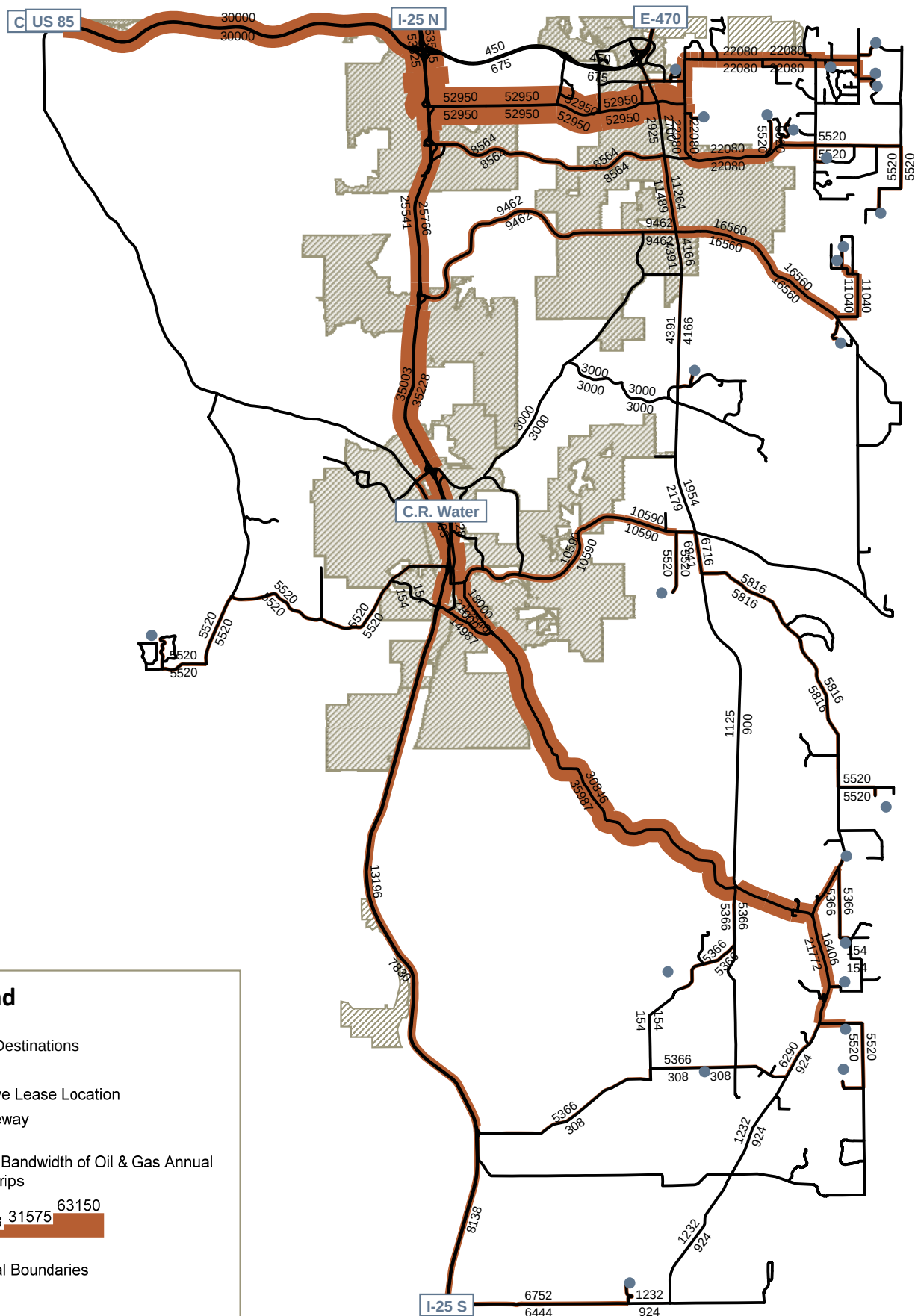
Municipal Boundaries



Estimated 2015 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Development Phase



Estimated 2020 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Development Phase

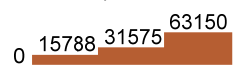


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

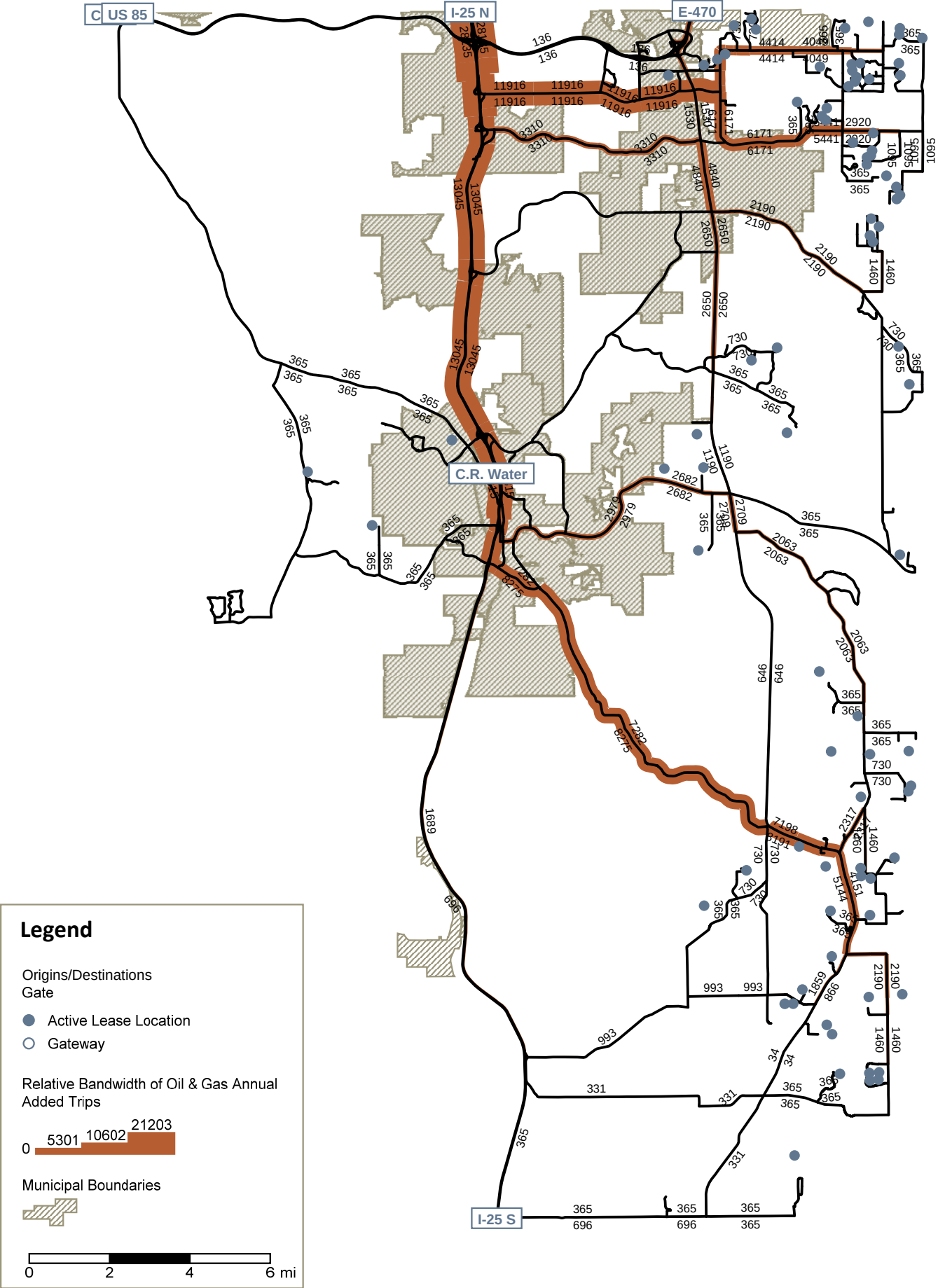
Relative Bandwidth of Oil & Gas Annual
Added Trips



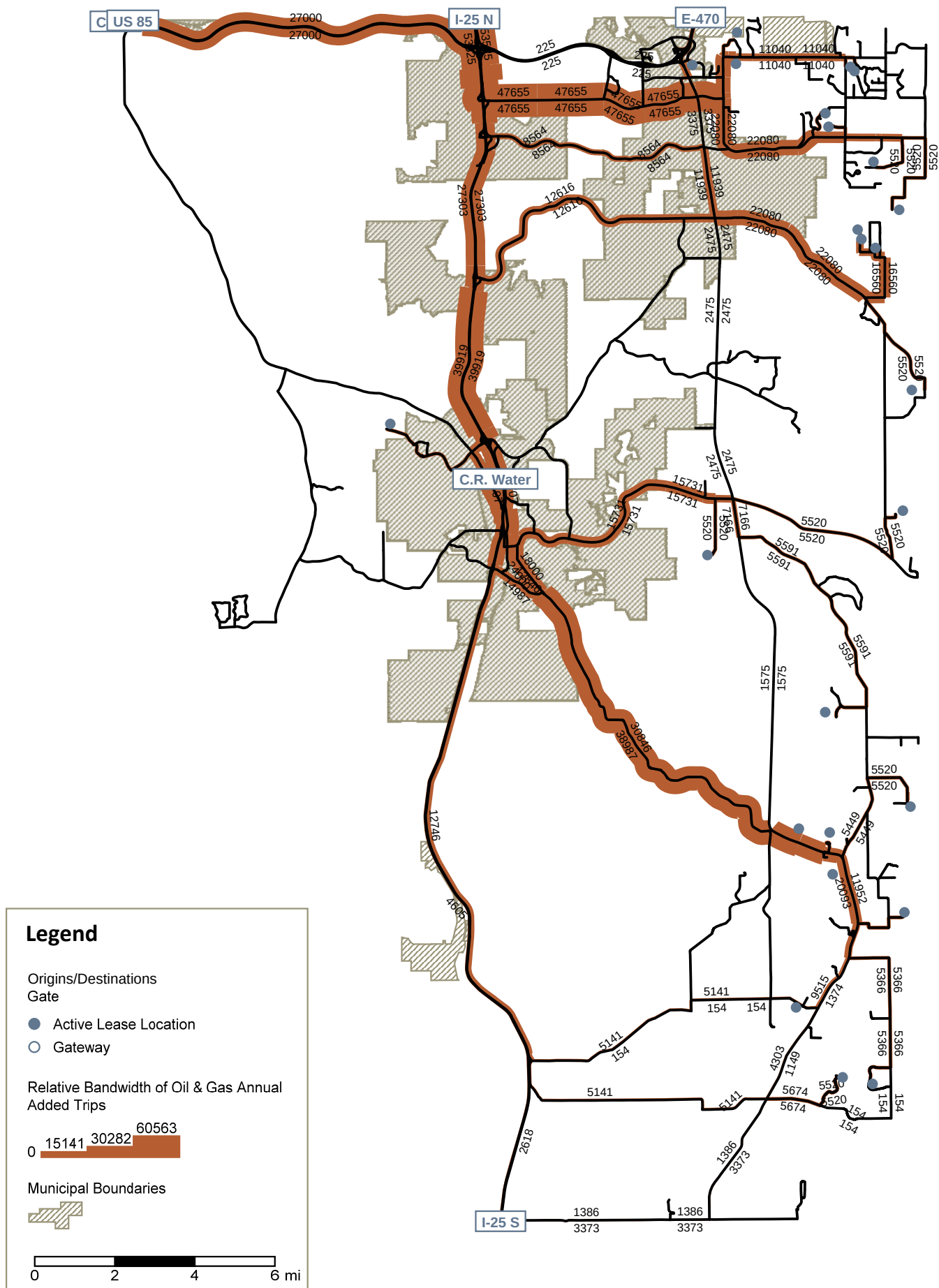
Municipal Boundaries



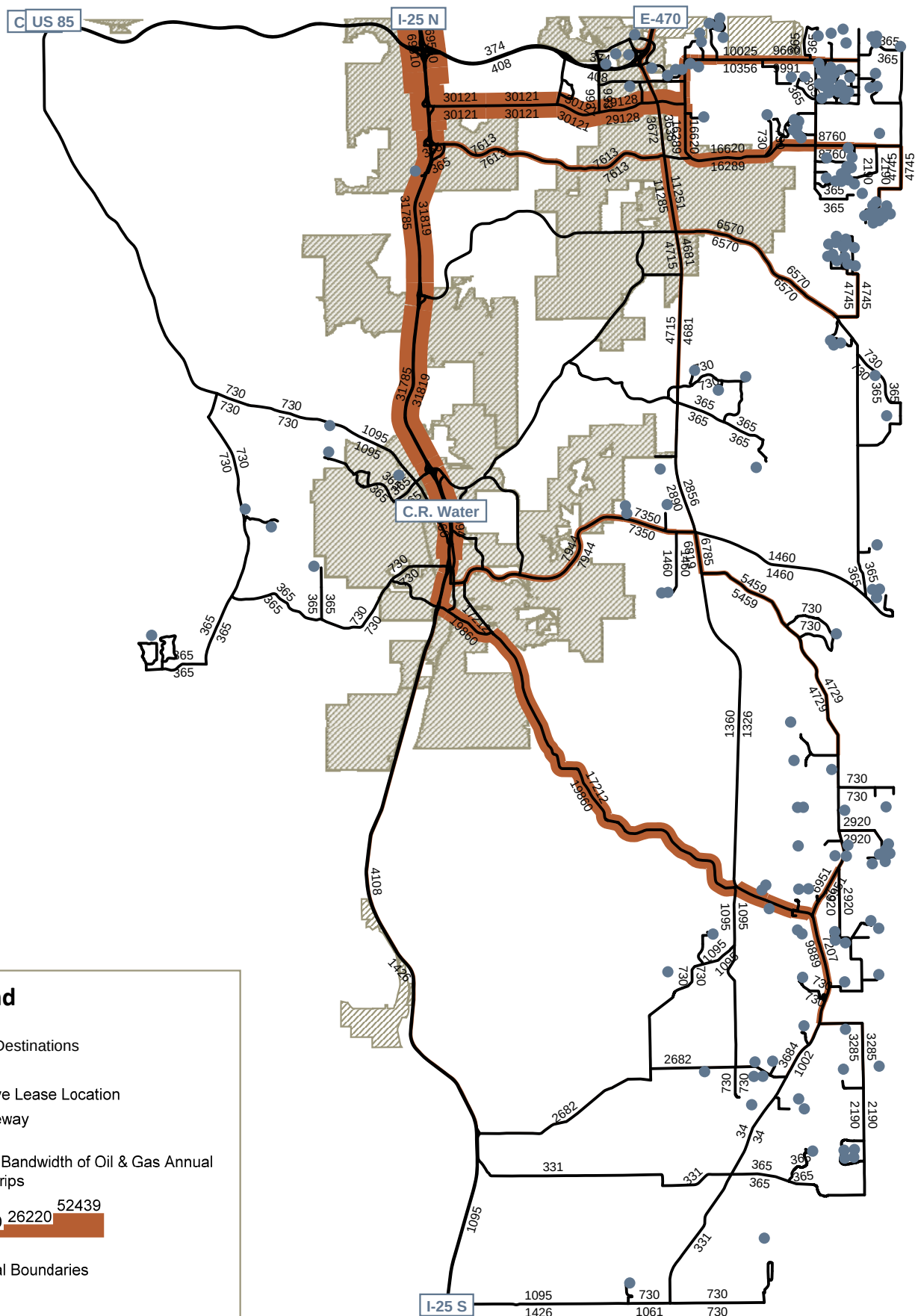
Estimated 2020 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Production Phase



Estimated 2025 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Development Phase



Estimated 2025 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Production Phase



Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

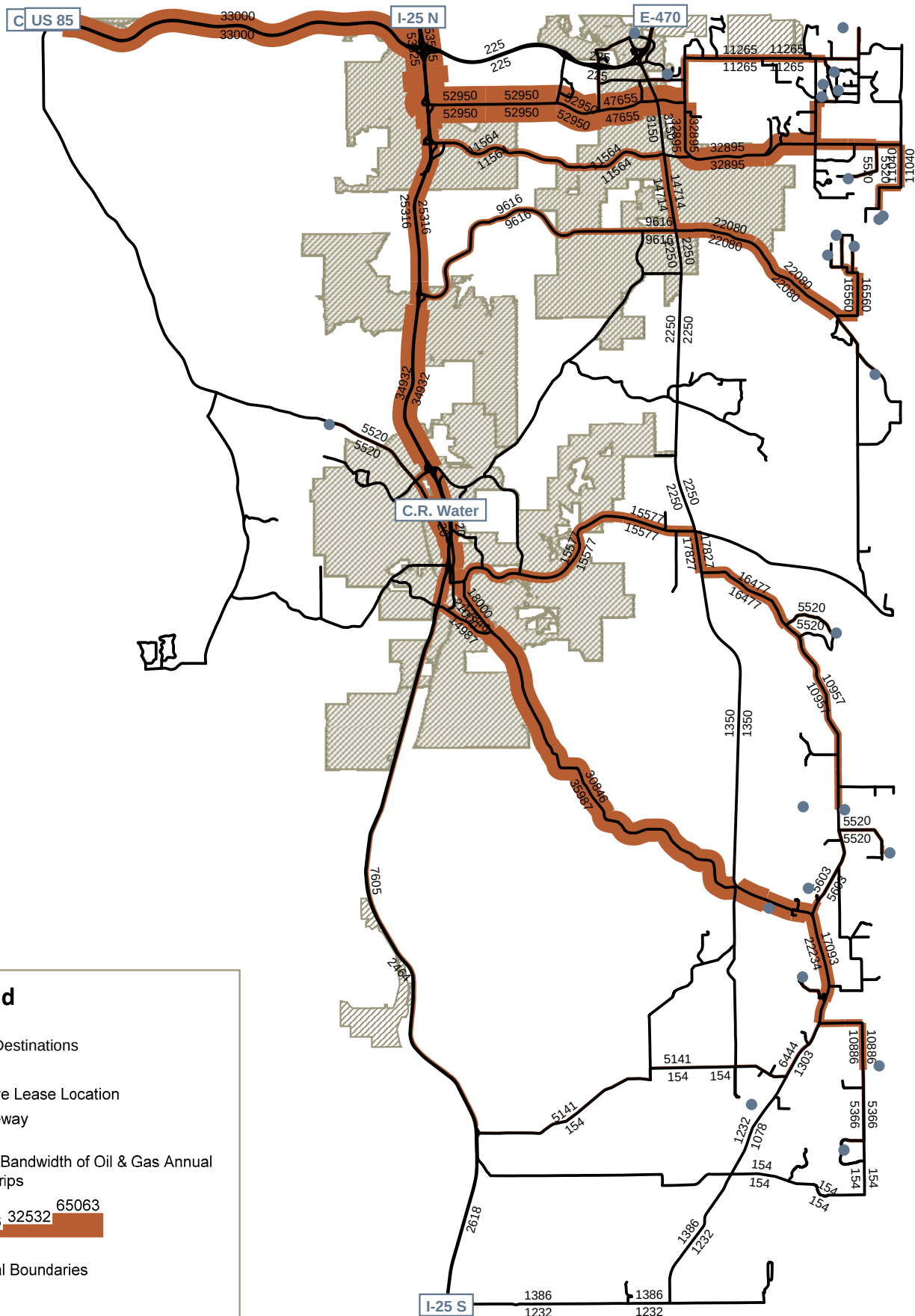
Relative Bandwidth of Oil & Gas Annual Added Trips



Municipal Boundaries



Estimated 2030 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Development Phase



Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

Relative Bandwidth of Oil & Gas Annual
Added Trips

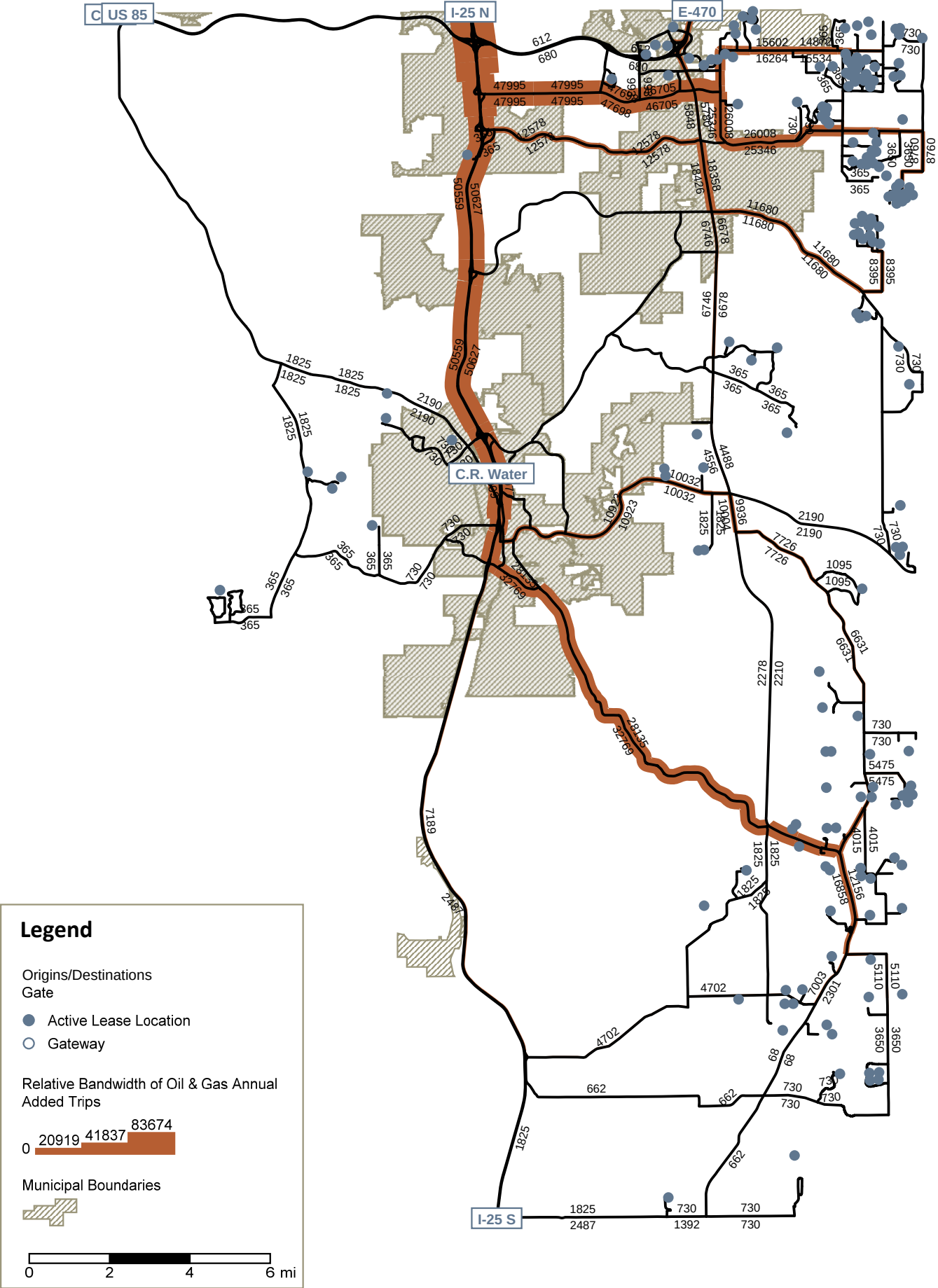
0 16266 32532 65063

Municipal Boundaries

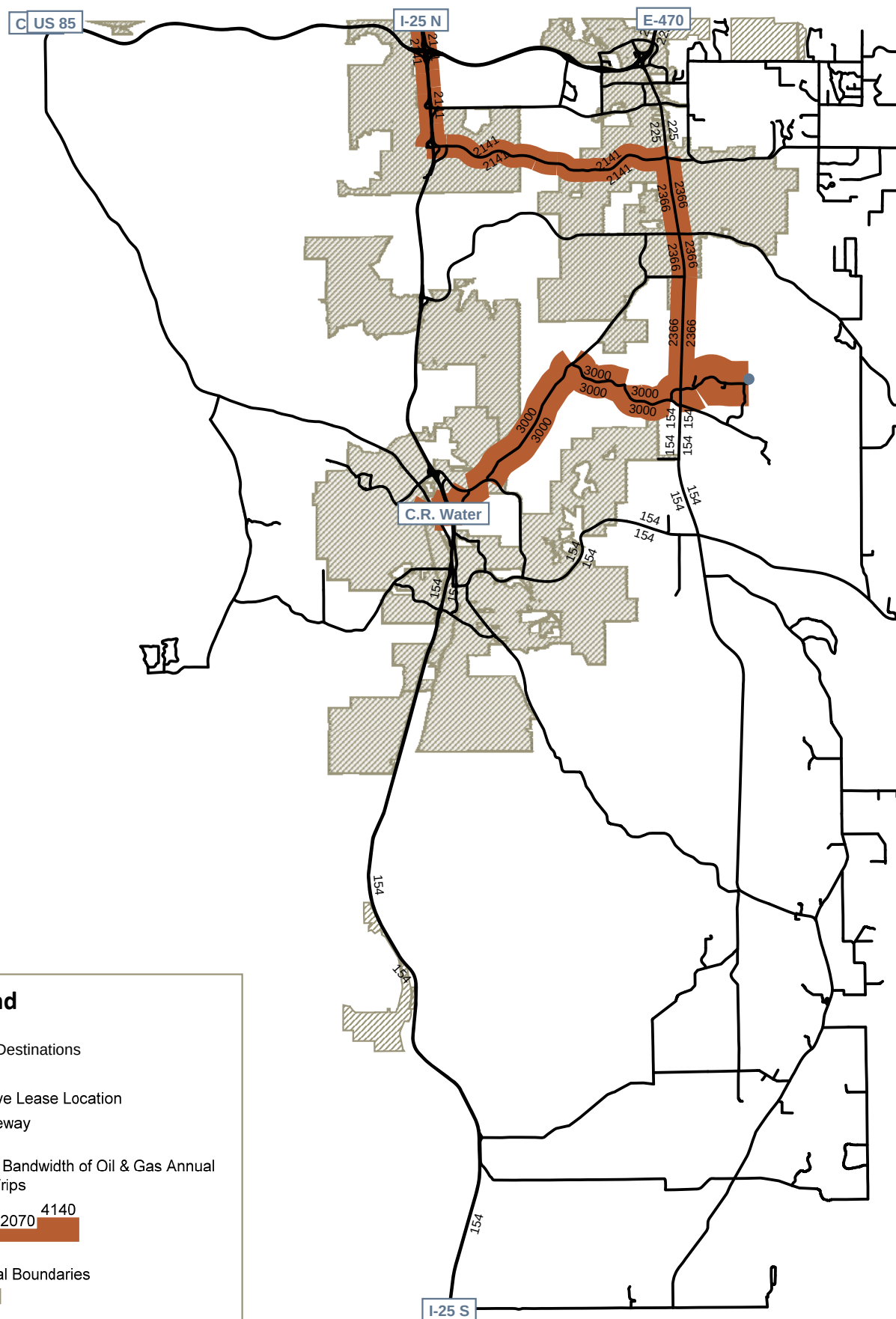


0 2 4 6 mi

Estimated 2030 Annual Directional Oil & Gas Related Volumes - MEDIUM Scenario Production Phase



Estimated 2015 Annual Directional Oil & Gas Related Volumes - LOW Scenario Development Phase

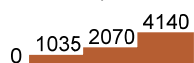


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

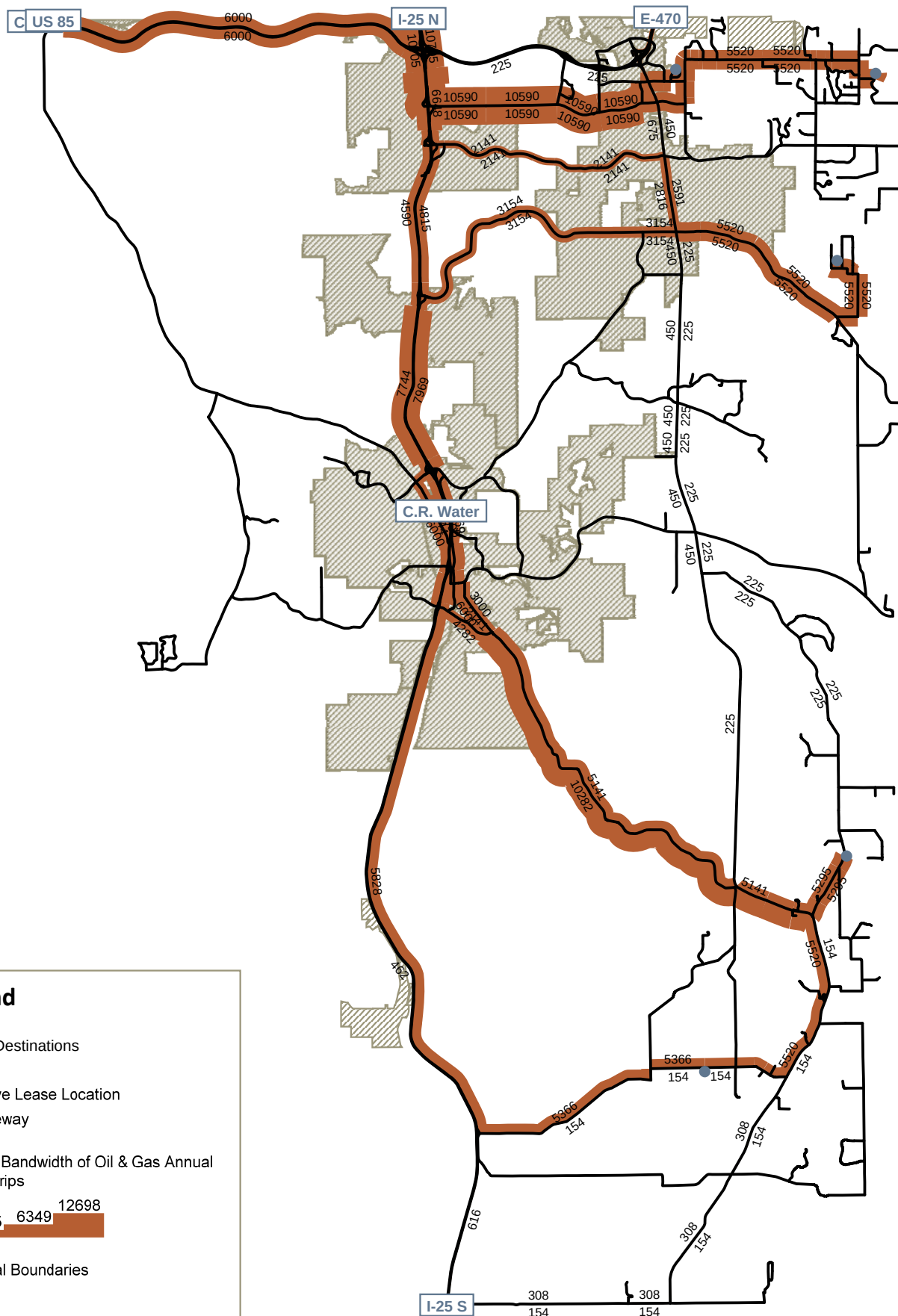
Relative Bandwidth of Oil & Gas Annual Added Trips



Municipal Boundaries



Estimated 2020 Annual Directional Oil & Gas Related Volumes - LOW Scenario Development Phase

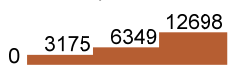


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

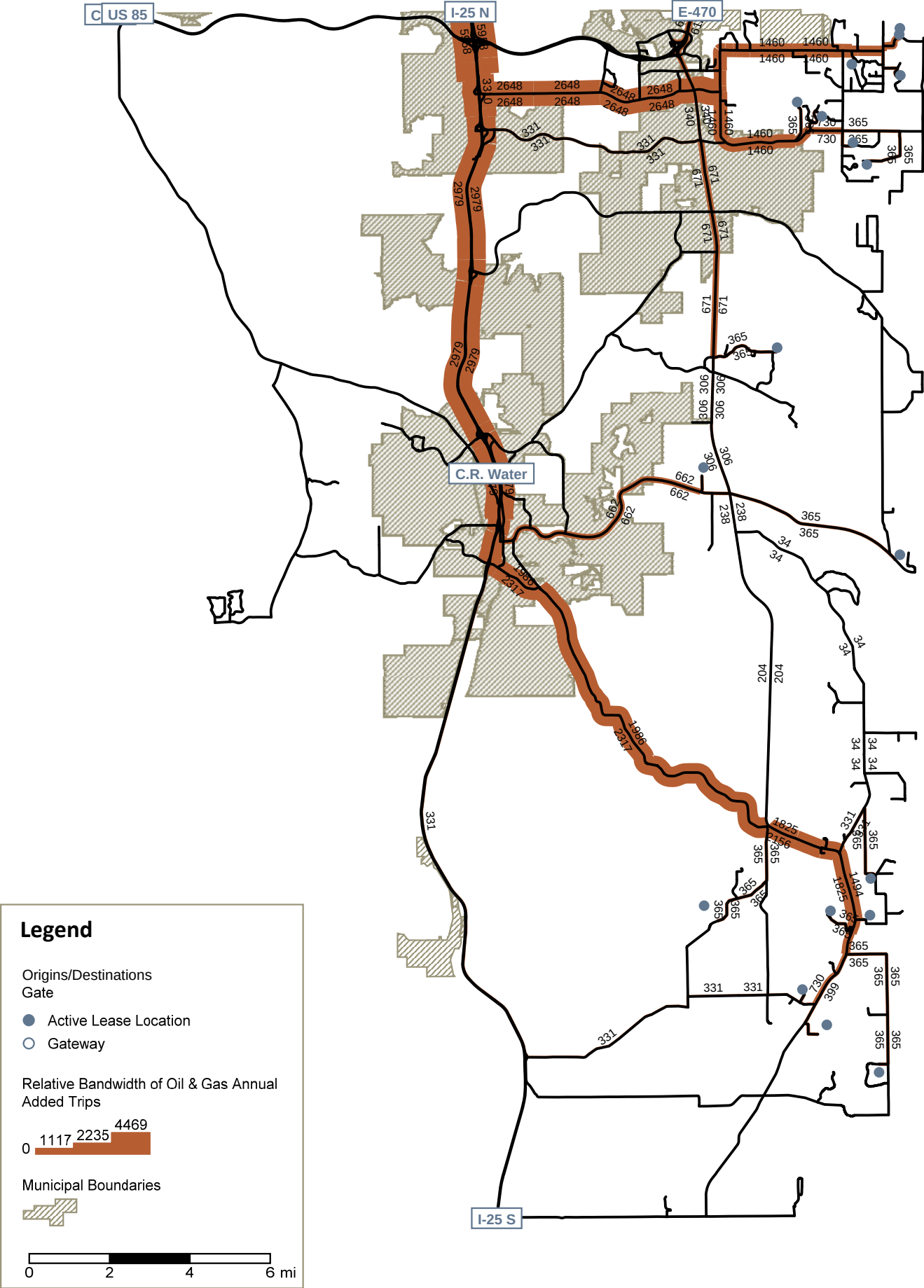
Relative Bandwidth of Oil & Gas Annual
Added Trips



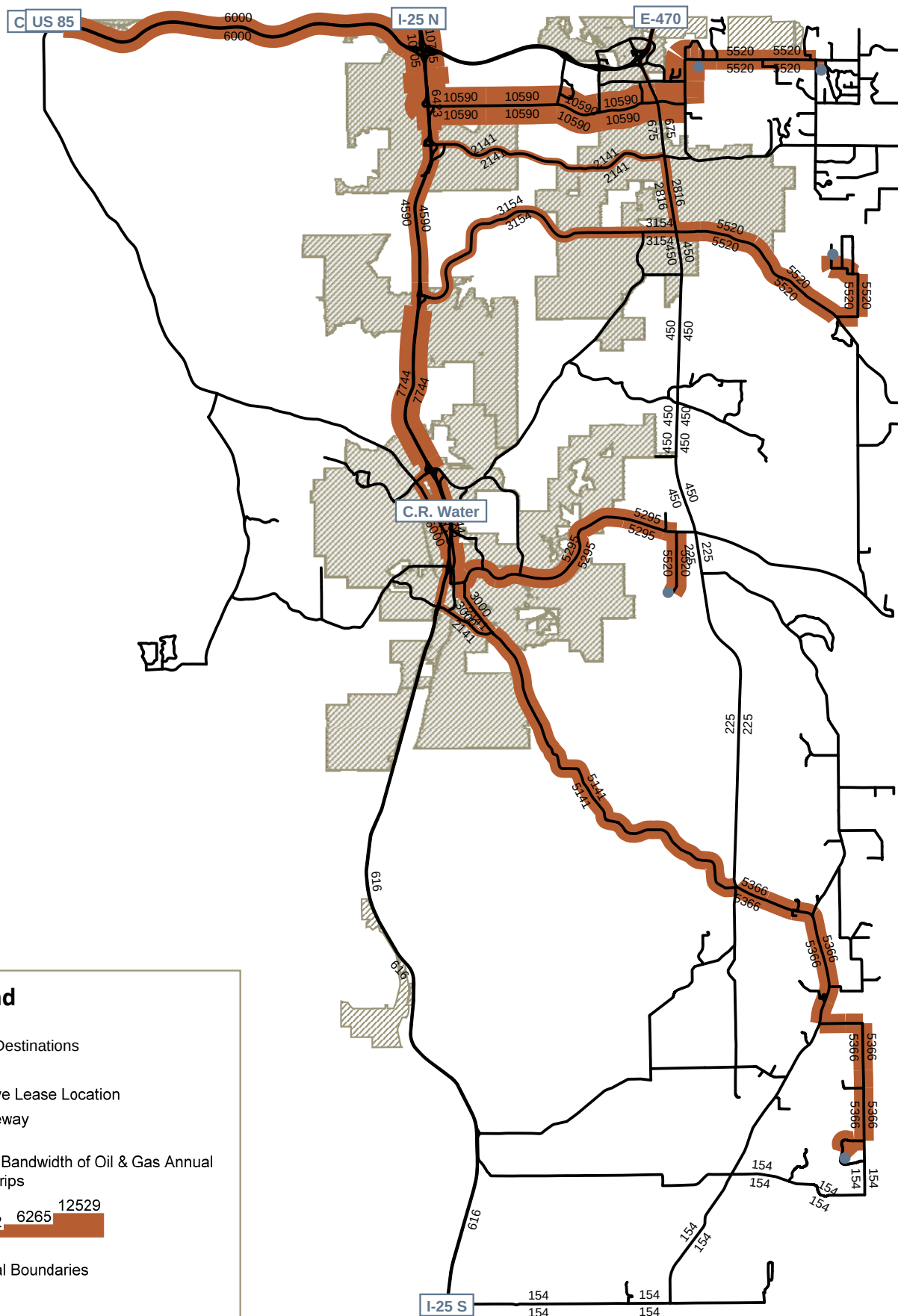
Municipal Boundaries



Estimated 2020 Annual Directional Oil & Gas Related Volumes - LOW Scenario Production Phase



Estimated 2025 Annual Directional Oil & Gas Related Volumes - LOW Scenario Development Phase

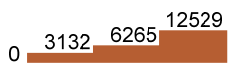


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

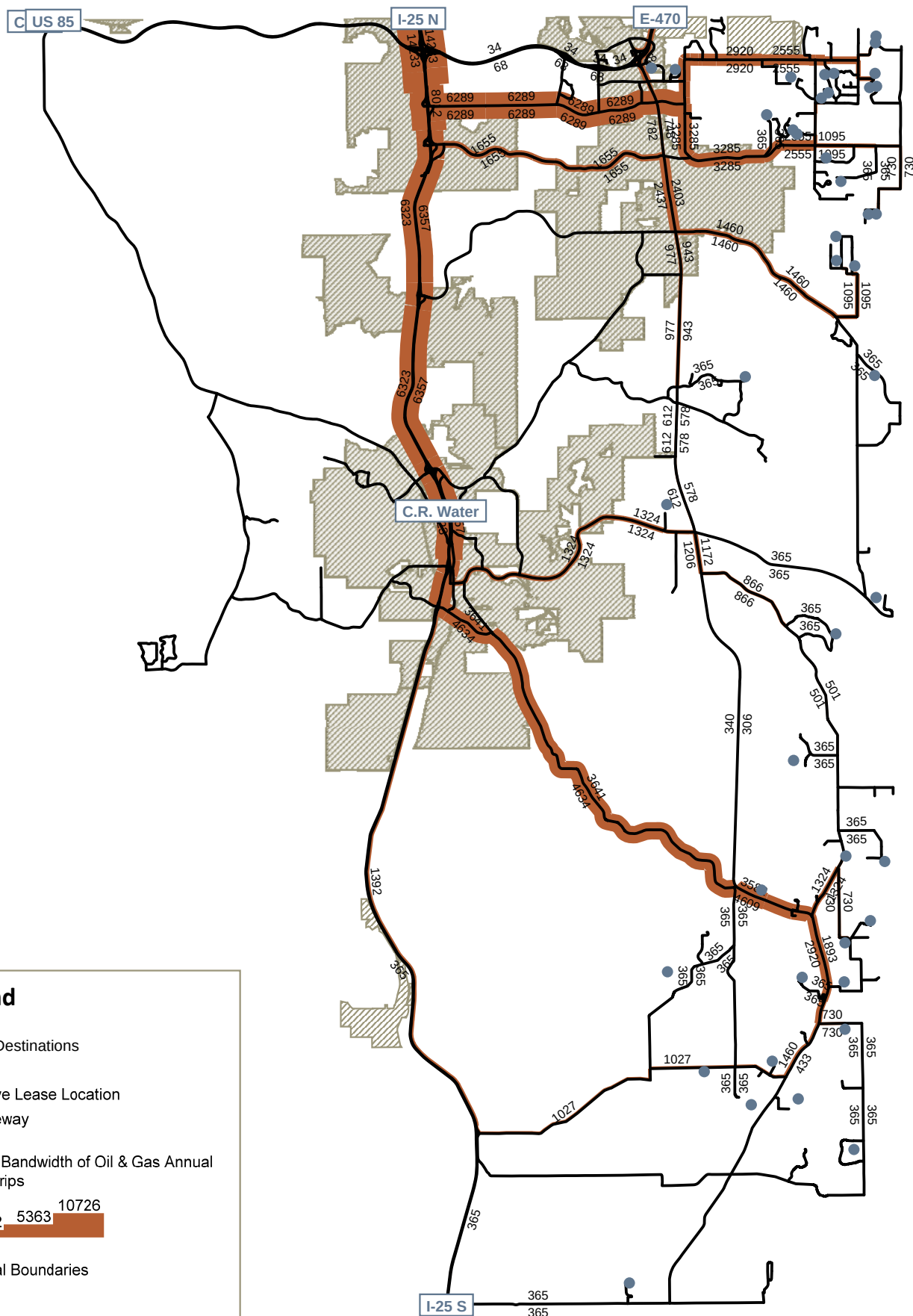
Relative Bandwidth of Oil & Gas Annual
Added Trips



Municipal Boundaries



Estimated 2025 Annual Directional Oil & Gas Related Volumes - LOW Scenario Production Phase

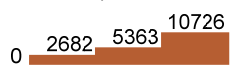


Legend

Origins/Destinations
Gate

- Active Lease Location
- Gateway

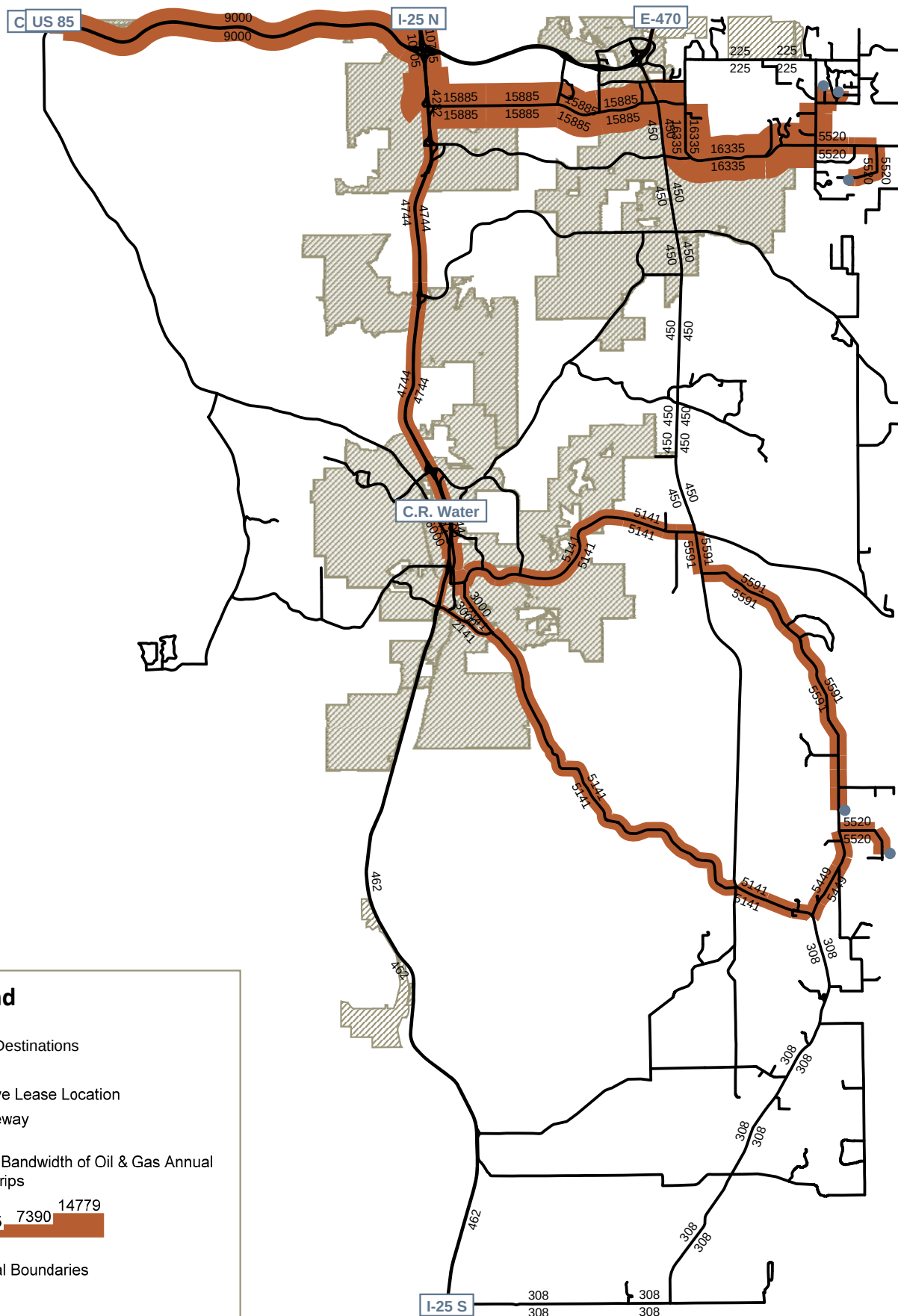
Relative Bandwidth of Oil & Gas Annual Added Trips



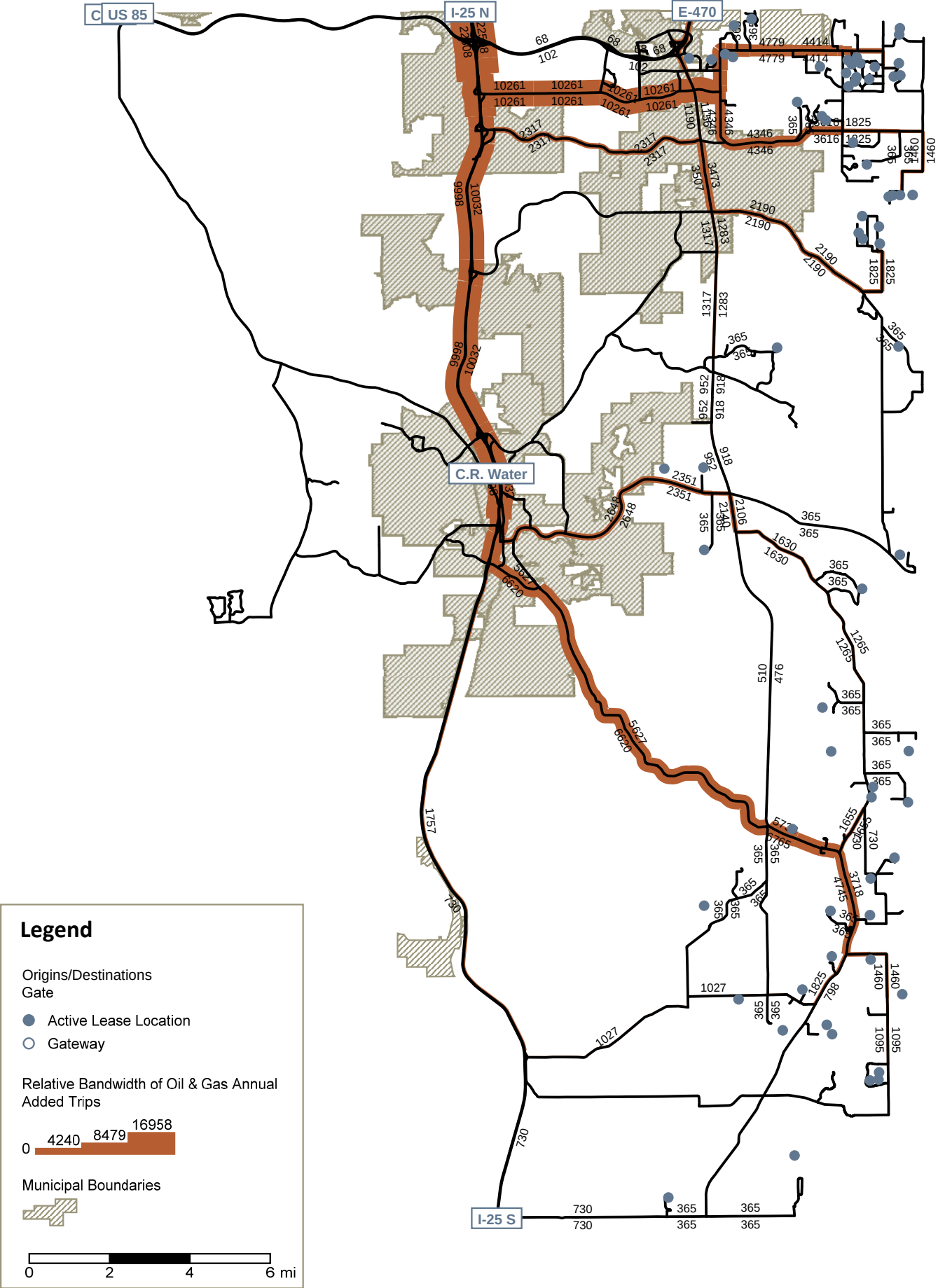
Municipal Boundaries

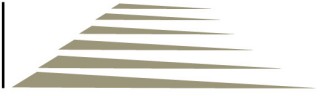


Estimated 2030 Annual Directional Oil & Gas Related Volumes - LOW Scenario Development Phase



Estimated 2030 Annual Directional Oil & Gas Related Volumes - LOW Scenario Production Phase





APPENDIX G

ROAD IMPROVEMENTS AND COSTS

Potential Travel Sheds (High Scenario)

END

TRAFFIC #		Co. #	Name	From	To	Classification	Lanes	Major/Minor	Surface (concrete/asphalt/gravel)	Road Width	Shoulder Width	Pavement/Gravel Condition	Remaining Service Life	Weighted Average PCI	Sections Classification	Section Classification	ESALs	Overlay (Inches)	Costs (\$2011)	Sections Classification	Section Classification	2020 ESALs	Overlay (Inches)	Costs (\$2011)	Sections Classification	Section Classification	2025 ESALs	Overlay (Inches)	Costs (\$2011)	Sections Classification	Section Classification	2030 ESALs	Overlay (Inches)	Costs (\$2011)
116	694	11715	SUMMIT RIDGE RD	Summit Ridge Ct	Tomahawk Rd	Local	2	Minor	Asphalt	24	4		14	70.9			0	0.00	\$0			808	0.14	\$5,300			1,615	0.26	\$9,800			17,437	1.39	\$52,000
119	286	12405	& TOMAHAWK RD	Spring Creek Rd	Beechwood Dr	Collector	2	Minor	Asphalt	24	3		16	80.0			4,127	0.18	\$2,200			35,174	1.01	\$12,200			33,286	0.97	\$11,700			129,218	2.13	\$25,600
119	288	12410	& TOMAHAWK RD	BEECHWOOD DR	TOM TOM DR	Collector	2	Minor	Asphalt	24	3		16	80.0			4,127	0.18	\$4,400			35,982	1.02	\$24,700			49,107	1.25	\$30,100			132,448	2.15	\$52,000
119	292	12405	& TOMAHAWK RD	Tom Tom Dr	E Parker Rd	Collector	2	Minor	Asphalt	24	3		16	80.0			4,127	0.18	\$2,200			51,804	1.29	\$15,600			67,352	1.51	\$18,200			139,715	2.21	\$26,700
119	296	12410	& TOMAHAWK RD	Summit Ridge Rd	Spring Creek Rd	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			730	0.03	\$200			1,460	0.07	\$300			16,557	0.58	\$2,700
119	598	12400	TOMAHAWK RD	GRAVEL CHANGE (Buffaloberry Dr.)	Arrowhead Ln	Local	2	Minor	Class 5 Gravel	24	--	Good	5		0	-	0		\$0	2	LOW	808		\$600	6	LOW	2,423		\$600	40	ELEVATED	18,245		\$37,100
119	602	12400	TOMAHAWK RD	Pinewood Dr	3300 ft	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			808	0.04	\$600			3,230	0.14	\$2,300			34,066	0.97	\$15,300
119	624	12400	TOMAHAWK RD	Rancho Montecito Dr	Buffaloberry Dr	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			808	0.04	\$300			2,423	0.11	\$800			18,245	0.62	\$4,500
119	626	12400	TOMAHAWK RD	E Parker Rd	Pinewood Dr	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			15,822	0.56	\$12,700			6,460	0.26	\$6,100			38,103	1.05	\$23,800
119	634	12405	TOMAHAWK RD	3300 ft	Rancho Montecito Dr	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			808	0.04	\$700			2,423	0.11	\$1,800			18,245	0.62	\$10,200
119	1016	12410	& TOMAHAWK RD	Inspiration Dr	460 ft	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			15,092	0.54	\$2,200			32,606	0.96	\$3,900			23,161	0.75	\$3,100
119	1021	12405	& TOMAHAWK RD	460 ft	1250 ft	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			15,092	0.54	\$4,000			31,798	0.94	\$6,900			7,340	0.30	\$2,200
119	1023	12410	& TOMAHAWK RD	1250 ft	3000 ft	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			885	0.04	\$700			15,977	0.57	\$8,900			4,110	0.18	\$2,800
119	1024	12410	& TOMAHAWK RD	3000 ft	Summit Ridge Rd	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			78	0.00	\$100			155	0.01	\$200			880	0.04	\$700
120	564	12460	TOWHEE RD	S Pinery Pkwy	Running Fox Way	Local	2	Minor	Asphalt	32	0		17	83.7			14,207	1.17	\$7,000			1,615	0.25	\$1,500			2,423	0.35	\$2,100			17,437	1.31	\$7,800
124	232	13755	W WOLFENSBERGER RD	Perry Park Rd	Faver Dr	Minor Arterial	2	Major	Asphalt	24	4		13	66.7			199	0.00	\$700			15,213	0.35	\$43,500			3,429	0.08	\$10,400			19,250	0.44	\$53,900
125	1149	12960	WALKER RD	END	SH 86	Local	2	Minor	Sandy Gravel	24	--	Fair	2		0	-	0		\$0	2	LOW	808		\$900	34	ELEVATED	15,822		\$55,000	8	LOW	3,230		\$900
129	758	29440	WINCHESTER WAY	Rose Ridge Rd	Ranger Rd	Local	2	Minor	Class 5 Gravel	26	--	Good	8		0	-	0		\$0	2	LOW	808		\$1,700	6	LOW	2,423		\$1,700	38	ELEVATED	17,437		\$103,200
124	234	13755	WOLFENSBERGER RD	Faver Dr	CASTLE ROCK LINE	Minor Arterial	2	Major	Asphalt	24	4		13				199	0.00	\$600			16,020	0.37	\$43,400			20,058	0.45	\$53,200			24,095	0.53	\$62,600
130	360	13795	WOODLAND TRL	S AURORA LINE	Summit Rd	Local	2	Minor	Class 5 Gravel	26	--	Good	8		0	-	0		\$0	32	ELEVATED	15,015		\$21,600	8	LOW	3,230		\$400	12	LOW	4,845		\$400
															\$2,921,900								\$9,507,600				\$9,808,600				\$10,184,300			

Potential Travel Sheds (Medium Scenario)

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														2015					2020					2025					2030						
TRAFFIC	Co. #	Name	From	To	Classification	Lanes	Major/Minor	Surface (concrete/asphalt/gravel)	Road Width	Shoulder Width	Pavement/Gravel Condition	Remaining Service Life	Weighted Average PC	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2015 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2020 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2025 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2030 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)		
#	#																																		
68	1020	N DELBERT RD	NORTHERN COUNTY LINE	Stagecoach Dr	Minor Arterial	2	Minor	Asphalt	24	4		14	70.0			0	0.00	\$0			808	0.02	\$100			808	0.02	\$100			1,615	0.03	\$200		
69	1144	3830 N DELBERT RD	Hilltop Rd	1600 ft	Local	2	Minor	Sandy Gravel	24	--		2		0	-	0		\$0			2	LOW	\$2,600			15,015		\$46,700	64	MODERATE	1,615		\$700		
70	684	3945 N DIXON DR	SIERRA CIR	Pine Ln	Local	2	Minor	Asphalt	24	4		13	63.7			0	0.00	\$0			15,822	1.39	\$6,700			2,423	0.38	\$1,900			19,052	1.55	\$7,400		
70	990	3945 N DIXON DR	SIERRA CIR	Lookout Dr	Local	2	Minor	Asphalt	24	4		13	63.7			0	0.00	\$0			14,207	1.31	\$13,300			808	0.14	\$1,500			1,615	0.27	\$2,800		
72	570	10225 N ROCKY CLIFF TRL	END	SH 86	Local	2	Minor	Sandy Gravel	24	--		16		0	-	0		\$0			0	-	\$0			808		\$1,300	4	LOW	808		\$1,300		
73	244	10040 N RUSSELLVILLE RD	SH 83	Red Deer Rd	Collector	2	Major	Asphalt	24	5		4	81.9			1,139	0.03	\$4,700			19,727	0.49	\$68,400			26,703	0.64	\$88,000			59,962	1.17	\$162,300		
74	586	29400 N TRAILWAY	S Trailway	Inspiration Rd	Local	2	Minor	Class 5 Gravel	24	--		8		0	-	0		\$0			14,207		\$55,500			2,423		\$900	20	LOW	4,038		\$900		
135	1270	29750 OLD SCHOOLHOUSE RD	Bayou Gulch Rd	SH 83	Collector	2	Minor	Asphalt	32	0		14	68.6			8,214	0.37	\$8,000			8,214	0.37	\$8,000			0	0.00	\$0			0	0.00	\$0		
97	230	23030 PERRY PARK RD (CH 105)	SH 105	Jackson Creek Rd	Minor Arterial	2	Major	Asphalt	24	4		13	65.3			0	0.00	\$0			14,207	0.34	\$30,600			808	0.02	\$1,900			808	0.02	\$1,900		
77	312	9050 PINE DR	Inspiration Dr	Pine Ln	Collector	2	Major	Asphalt	22	5		15	75.5			0	0.00	\$0			69,824	1.61	\$41,200			85,536	1.81	\$46,200			74,942	1.68	\$42,900		
77	314	9050 PINE DR	Pine Ln	LANE SPLIT	Collector	2	Minor	Asphalt	22	5		15	75.5			0	0.00	\$0			66,228	1.56	\$31,000			80,158	1.74	\$34,600			68,273	1.59	\$31,600		
77	878	9050 PINE DR	LANE SPLIT	E LINCOLN AVE	Collector	2	Minor	Asphalt	22	5		15	75.5			0	0.00	\$0			66,228	1.56	\$12,000			80,158	1.74	\$13,400			68,273	1.59	\$12,200		
77	880	9050 PINE DR	CENTENNIAL DR	E LINCOLN AVE	Major Arterial	4	Minor	Concrete	80	0		19	96.1			23,099		\$6,400			136,827		\$37,900			151,042		\$41,800			229,976		\$63,700		
77	882	9050 PINE DR	E Mainstreet	E Mainstreet	Major Arterial	4	Minor	Concrete	80	0		19	96.1			23,099		\$15,400			113,728		\$95,500			149,780		\$99,400			227,452		\$150,900		
78	872	24610 PINE LN	E PARKER LINE	Dixon Dr	Collector	2	Minor	Asphalt	48	0		15	75.0			0	0.00	\$0			3,596	0.16	\$1,700			5,378	0.24	\$2,400			6,669	0.29	\$2,900		
78	890	24610 PINE LN	Dixon Dr	Pine Dr	Collector	2	Minor	Asphalt	24	0		11	55.4			0	0.00	\$0			19,418	1.06	\$13,500			7,801	0.47	\$6,100			25,720	1.33	\$16,900		
80	310	9190 PINNEY LAKE RD	Inspiration Dr	Stagecoach Dr	Collector	2	Minor	Asphalt	24	4		15	74.3			0	0.00	\$0			17,437	0.64	\$4,200			5,653	0.25	\$1,700			21,475	0.75	\$4,900		
81	670	9190 PINNEY LAKE RD	Inspiration Dr	Black Forest Dr	Local	2	Minor	Asphalt	24	3		18	90.9			0	0.00	\$0			30,028	1.68	\$27,800			5,653	0.65	\$10,800			8,075	0.82	\$13,700		
81	678	9190 PINNEY LAKE RD	Bronco Dr	Homestake Ln	Local	2	Minor	Asphalt	24	3		18	90.9			0	0.00	\$0			0	0.00	\$0			1,615	0.25	\$2,400			3,230	0.43	\$4,200		
81	696	9190 PINNEY LAKE RD	Black Forest Dr	Bronco Dr	Local	2	Minor	Asphalt	24	3		18	90.9			0	0.00	\$0			30,028	1.68	\$7,200			5,653	0.65	\$2,800			8,075	0.82	\$3,600		
80	1014	9190 PINNEY LAKE RD	N COUNTY LINE	1500 ft	Collector	2	Minor	Asphalt	24	4		15	74.3			0	0.00	\$0			808	0.04	\$700			808	0.04	\$700			15,015	0.57	\$9,600		
80	1015	9190 PINNEY LAKE RD	1500 ft	Stagecoach Dr	Collector	2	Minor	Asphalt	24	4		15	74.3			0	0.00	\$0			808	0.04	\$600			1,615	0.08	\$1,100			16,630	0.62	\$8,900		
83	728	24630 PONDEROSA CIR	Pine Dr	Ponderosa Cir (Mid)	Local	3	Minor	Gravel	24	--		3		0	-	0		\$0			2	LOW	\$1,400			68	MODERATE	15,822		\$97,300	12	LOW	2,423		\$1,400
83	1002	24630 PONDEROSA CIR	Ponderosa Cir (W)	PONDEROSA CIR (E)	Local	2	Minor	Gravel	24	--		3		0	-	0		\$0			0	-	\$0			4	LOW	808		\$200	4	LOW	808		\$200
84	362	? POPE RD	END	E Parker Rd	Local	2	Minor	Sandy Gravel	24	--		2		0	-	0		\$0			32	ELEVATED	\$120,900			8	LOW	1,615		\$2,000	8	LOW	1,615		\$2,000
132	1228	30610 PRADERA PKWY	Crowfoot Valley Rd	Bayou Gulch Rd	Collector	2	Major	Asphalt	36	0		13	63.0			8,214	0.33	\$27,900			8,214	0.33	\$27,900			0	0.00	\$0			0	0.00	\$0		
86	478	9795 RANGER RD	Winchester Way	Inspiration Dr	Local	2	Minor	Gravel	24	--		2		0	-	0		\$0			808		\$300			4	LOW	808		\$300	4	LOW	808		\$300
87	1154	9935 RED DEER RD	S Russellville Rd	WELL	Local	2	Minor	Asphalt	24	5		15	76.7			0	0.00	\$0			0	0.00	\$0			1,615	0.25	\$18,800			16,630	1.32	\$96,700		
88	328	RIDGEGATE PKWY	E LONE TREE LINE	Meridian Village Pkwy	Major Arterial	2	Major	Asphalt	24	6		20	100.0			10,449	0.12	\$3,100			0	0.00	\$0			37,688	0.40	\$10,000			56,852	0.57	\$14,100		
89	692	29310 ROSE RIDGE RD	Winchester Way	END	Local	2	Minor	Gravel	24	--		3		0	-	0		\$0			2	LOW	\$1,000			4	LOW	808		\$1,000	4	LOW	808		\$1,000
90	1100	10320 ROUNDUP RD	WELL	Bronco Dr	Local	2	Minor	Class 5 Sandy Gravel	24	--		6		0	-	0		\$0			32	ELEVATED	\$18,900			8	LOW	1,615		\$400	8	LOW	1,615		\$400
90	1101	10320 ROUNDUP RD	WELL	Bronco Dr	Local	2	Minor	Class 5 Sandy Gravel	24	--		6		0	-	0		\$0			32	ELEVATED	\$30,100			12	LOW	2,423		\$500	16	LOW	3,230		\$500
91	740	31670 ROY CLARKE BLVD	Bell Cross Cir	E Parker Rd	Local	2	Minor	Asphalt	24	0		16	78.6			0	0.00	\$0			15,015	1.23	\$12,500			17,437	1.34	\$13,600			4,845	0.60	\$6,200		
93	572	10395 RUNNING FOX WAY	END	Towhee Rd	Local	2	Minor	Asphalt	32	0		17	84.0			0	0.00	\$0			808	0.13	\$500			808	0.13	\$500			808	0.13	\$500		
94	844	2455 S CHAMBERS RD	BROOKSTONE DR	E LINCOLN AVE	Minor Arterial	4	Major	Asphalt	72	0		17	83.3			0	0.00	\$0			0	0.00	\$0			0	0.00	\$0			808	0.01	\$500		
95	408	32120 S EAST CHERRY CREEK RD	Big Sky Trl	Big Sky Trl	Collector	2	Minor	Gravel	24	--		6		0	-	0		\$0			2	LOW	\$1,100			8	LOW	1,615		\$1,100	8	LOW	1,615		\$1,100
96	434	32120 S EAST CHERRY CREEK RD	16400 ft	Lucas Ave	Local	2	Minor	Gravel	24	--		6		1	LOW	199		\$600			1	LOW	\$600			64	MODERATE	15,015		\$39,000	8	LOW	1,615		\$600
95	444	32120 S EAST CHERRY CREEK RD	Big Sky Trl	Jones Rd	Collector	2	Minor	Gravel	24	--		6		0	-	0		\$0			0	-	\$0			2	MODERATE LOW	199		\$1,700	2	LOW	199		\$1,700
95	446	32120 S EAST CHERRY CREEK RD	8000 ft	Big Sky Trl	Collector	2	Minor	Asphalt	32	4		18	91.7			0	0.00	\$0			3,230	0.13	\$10,700			18,853	0.61	\$48,400			22,083	0.68	\$54,300		
96	458	32120 S EAST CHERRY CREEK RD	10100 ft	16400 ft	Local	2	Minor	Gravel	24	--		6		1	LOW	199		\$2,500			1	LOW	\$2,500			0	-	0		\$0	0	-	0		\$0
95	464	32120 S EAST CHERRY CREEK RD	Gillian Ave	5800 ft	Collector	2	Minor	Asphalt	32	4		18	91.7			0	0.00	\$0			19,052	0.61	\$43,400			21,276	0.66	\$47,100			39,520	1.01	\$72,000		
95	472	32120 S EAST CHERRY CREEK RD	5800 ft	8000 ft	Collector	2	Minor	Asphalt	32	4		18	91.7			0	0.00	\$0			18,245	0.59	\$16,000			20,468	0.64	\$17,400			23,698	0.72	\$19,400		
96	1167	32120 S EAST CHERRY CREEK RD	S Russellville Rd	8200 ft	Local	2	Minor	Gravel	24	--		6		29		14,008		\$110,400			37	ELEVATED	\$49,900			32	ELEVATED	6,460		\$49,900	44	ELEVATED	8,883		\$49,900
96	1168	32120 S EAST CHERRY CREEK RD	8200 ft	10100 ft	Local	2	Minor	Gravel	24	--		6		1	ELEVATED LOW	1,009		\$700			33	ELEVATED	\$42,400			4,038	LOW	\$700		\$700	28	ELEVATED	5,653		\$10,300
98	544	33780 S PINERY PKWY	SINGLE TREE LN	Towhee Rd	Collector	2	Minor	Asphalt	42	0		16	80.5			14,207	0.52	\$29,300			1,615	0.07	\$4,200			1,615	0.07	\$4,200			2,423	0.11	\$6,100		
98	548	33780 S PINERY PKWY	FOX SPARROW RD	Towhee Rd	Collector	2	Minor	Asphalt	42	0		16	80.5			14,207	0.52	\$15,900			808	0.04	\$1,200			808	0.04	\$1,200			1,615	0.07	\$2,300		
98	554	33780 S PINERY PKWY	FOX SPARROW RD	WELL	Collector	2	Minor	Asphalt	42	0		16	80.5			14,207	0.52	\$3,600			808	0.04	\$300			808	0.04	\$300			1,615	0.07	\$600		
98	906	33780 S PINERY PKWY	SINGLE TREE LN	State Highway 83	Collector	2	Minor	Asphalt	42	0		16	80.5			14,207	0.52	\$12,100			15,822	0.56													

Potential Travel Sheds (Medium Scenario)

END

															2015					2020					2025					2030				
#	TRAFFIC #	Co. #	Name	From	To	Classification	Lanes	Major/Minor	Surface (concrete/asphalt/gravel)	Road Width	Shoulder Width	Pavement/Gravel Condition	Remaining Service Life	Weighted Average PCI	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2015 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2020 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2025 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2030 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)
119	286	12405 & 12410	TOMAHAWK RD	Spring Creek Rd	Beechwood Dr	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			2,345	0.10	\$1,300			6,821	0.28	\$3,400			53,424	1.31	\$15,800
119	288	12405 & 12410	TOMAHAWK RD	BEECHWOOD DR	TOM TOM DR	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			3,153	0.14	\$3,400			7,628	0.31	\$7,500			54,231	1.33	\$32,000
119	292	12405 & 12410	TOMAHAWK RD	Tom Tom Dr	E Parker Rd	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			3,960	0.17	\$2,100			23,450	0.76	\$9,200			56,654	1.36	\$16,500
119	296	12410 & 12405	TOMAHAWK RD	Summit Ridge Rd	Spring Creek Rd	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			0	0.00	\$0			730	0.03	\$200			730	0.03	\$200
119	598	12400	TOMAHAWK RD	GRAVEL CHANGE (Buffaloberry Dr.)	Arrowhead Ln	Local	2	Minor	Class 5 Gravel	24	--	Good	5		0	-	0		\$0	2	LOW	808		\$600	4	LOW	808		\$600	4	LOW	808		\$600
119	602	12400	TOMAHAWK RD	Pinewood Dr	3300 ft	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			808	0.04	\$600			1,615	0.07	\$1,200			1,615	0.07	\$1,200
119	624	12400	TOMAHAWK RD	Rancho Montecito Dr	Buffaloberry Dr	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			808	0.04	\$300			808	0.04	\$300			808	0.04	\$300
119	626	12400	TOMAHAWK RD	E Parker Rd	Pinewood Dr	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			15,822	0.56	\$12,700			3,230	0.14	\$3,200			3,230	0.14	\$3,200
119	634	12400	TOMAHAWK RD	3300 ft	Rancho Montecito Dr	Collector	2	Minor	Asphalt	30	4		16	81.7			0	0.00	\$0			808	0.04	\$700			808	0.04	\$700			808	0.04	\$700
119	1016	12405 & 12410	TOMAHAWK RD	Inspiration Dr	460 ft	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			0	0.00	\$0			16,707	0.59	\$2,400			4,923	0.21	\$900
119	1021	12410 & 12405	TOMAHAWK RD	460 ft	1250 ft	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			0	0.00	\$0			15,900	0.57	\$4,200			3,308	0.14	\$1,100
119	1023	12410 & 12405	TOMAHAWK RD	1250 ft	3000 ft	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			0	0.00	\$0			885	0.04	\$700			1,693	0.08	\$1,300
119	1024	12410 & 12405	TOMAHAWK RD	3000 ft	Summit Ridge Rd	Collector	2	Minor	Asphalt	24	3		16	80.0			0	0.00	\$0			0	0.00	\$0			78	0.00	\$100			78	0.00	\$100
120	564	12460	TOWHEE RD	S Pinery Pkwy	Running Fox Way	Local	2	Minor	Asphalt	32	0		17	83.7			0	0.00	\$0			808	0.13	\$800			808	0.13	\$800			808	0.13	\$800
124	232	13755	W WOLFENSBERGER RD	Perry Park Rd	Faver Dr	Minor Arterial	2	Major	Asphalt	24	4		13	66.7			0	0.00	\$0			14,207	0.41	\$50,100			808	0.02	\$2,900			808	0.02	\$2,900
125	1149	12960	WALKER RD	END	SH 86	Local	2	Minor	Sandy Gravel	24	--	Fair	2		0	-	0		\$0	2	LOW	808		\$900	4	LOW	808		\$900	4	LOW	808		\$900
129	758	29440	WINCHESTER WAY	Rose Ridge Rd	Ranger Rd	Local	2	Minor	Class 5 Gravel	26	--	Good	8		0	-	0		\$0	2	LOW	808		\$1,700	4	LOW	808		\$1,700	4	LOW	808		\$1,700
124	234	13755	WOLFENSBERGER RD	Faver Dr	CASTLE ROCK LINE	Minor Arterial	2	Major	Asphalt	24	4		13	66.7			0	0.00	\$0			15,015	0.43	\$50,100			1,615	0.05	\$5,700			1,615	0.05	\$5,700
130	360	13795	WOODLAND TRL	S AURORA LINE	Summit Rd	Local	2	Minor	Class 5 Gravel	26	--	Good	8		0	-	0		\$0	2	LOW	808		\$400	4	LOW	808		\$400	8	LOW	1,615		\$400
															\$861,800										\$4,682,500					\$6,670,500				

Potential Travel Sheds (Low Scenario)

END

#	TRAFFIC #	Co. #	Name	From	To	Classification	Lanes	Major/Minor	Surface (concrete/asphalt/gravel)	Road Width	Shoulder Width	Pavement/Gravel Condition	Remaining Service Life	Weighted Average PCI
95	464	32120	S EAST CHERRY CREEK RD	Gillian Ave	5800 ft	Collector	2	Minor	Asphalt	32	4		18	91.7
95	472	32120	S EAST CHERRY CREEK RD	5800 ft	8000 ft	Collector	2	Minor	Asphalt	32	4		18	91.7
96	1167	32120	S EAST CHERRY CREEK RD	S Russellville Rd	8200 ft	Local	2	Minor	Gravel	24	--	Good	6	
96	1168	32120	S EAST CHERRY CREEK RD	8200 ft	10100 ft	Local	2	Minor	Gravel	24	--	Good	6	
98	544	33780	S PINERY PKWY	SINGLE TREE LN	Towhee Rd	Collector	2	Minor	Asphalt	42	0		16	80.5
98	548	33780	S PINERY PKWY	Towhee Rd	FOX SPARROW RD	Collector	2	Minor	Asphalt	42	0		16	80.5
98	554	33780	S PINERY PKWY	FOX SPARROW RD	WELL	Collector	2	Minor	Asphalt	42	0		16	80.5
98	906	33780	S PINERY PKWY	State Highway 83	SINGLE TREE LN	Collector	2	Minor	Asphalt	42	0		16	80.5
99	242	31690	S RUSSELLVILLE RD	1900 ft	State Highway 83	Collector	2	Major	Asphalt	30	3		17	84.6
99	250	10410, & 10420	S RUSSELLVILLE RD	Pinevalley Dr	Running Buffalo Rd	Collector	2	Major	Asphalt	24	4		16	78.2
99	254	31690	S RUSSELLVILLE RD	HEIDEMANN AVE	1300 ft	Collector	2	Major	Asphalt	30	3		17	84.6
99	260	10410, & 10420	S RUSSELLVILLE RD	Red Deer Rd	Pinevalley Dr	Collector	2	Major	Asphalt	24	4		16	78.2
99	264	31690	S RUSSELLVILLE RD	S East Cherry Creek Rd	1900 ft	Collector	2	Major	Asphalt	30	3		17	84.6
99	270	10410, & 10420	S RUSSELLVILLE RD	ANDERSON AVE	3100 ft	Collector	2	Major	Asphalt	24	4		16	78.2
99	1157	10410, & 10400,	S RUSSELLVILLE RD	Running Buffalo Rd	2200 ft	Collector	2	Major	Asphalt	24	4		16	78.2
99	1158	10410, & 10420	S RUSSELLVILLE RD	2200 ft	Anderson Ave	Collector	2	Major	Asphalt	24	4		16	78.2
99	1160	10410, & 10420	S RUSSELLVILLE RD	3100 ft	HEIDEMANN AVE	Collector	2	Major	Asphalt	24	4		16	78.2
99	1161	31690	S RUSSELLVILLE RD	1300 ft	3300 ft	Collector	2	Major	Asphalt	30	3		17	84.6
99	1162	31690	S RUSSELLVILLE RD	3300 ft	S East Cherry Creek Rd	Collector	2	Major	Asphalt	30	3		17	84.6
103	356	10560	SAND CREEK RD	Forest Canyon Dr	Pine Vista Trl	Local	2	Minor	Sandy Gravel	24	--	Fair	2	
107	600	10985	SINGING HILLS RD	Hilltop Rd	Flintwood Dr	Minor Arterial	2	Minor	Asphalt	24	4		13	63.4
109	676	11206	SPRING CREEK RD	TOMAHAWK RD	CASEY LN	Local	2	Minor	Asphalt	30	0		16	80.3
109	770	11206	SPRING CREEK RD	Casey Ln	Bonanza Rd	Local	2	Minor	Asphalt	30	0		16	80.3
110	484	& 11295	SPRING VALLEY RD	Dahlberg Rd	Kramer Ranch Rd	Collector	2	Minor	Gravel	20	--	Good	5	
110	780	32720 & 11295	SPRING VALLEY RD	E Greeland Rd	E Greeland Rd	Collector	2	Minor	Gravel	20	--	Good	5	
110	1171	32720 & 11295	SPRING VALLEY RD	Kramer Ranch Rd	4600 ft	Collector	2	Minor	Gravel	20	--	Good	5	
112	1019	24750, 24760,	STAGECOACH DR	Piney Lake Rd	2800 ft	Local	2	Minor	Class 5 Gravel	24	--	Good	8	
114	358	24780 & 11695	SUMMIT RD	Woodland Trl	Forest Canyon Dr	Local	2	Minor	Sandy Gravel	26	--	Fair	2	
119	286	12405 & 12410	TOMAHAWK RD	Spring Creek Rd	Beechwood Dr	Collector	2	Minor	Asphalt	24	3		16	80.0
119	288	12405 & 12410	TOMAHAWK RD	BEECHWOOD DR	TOM TOM DR	Collector	2	Minor	Asphalt	24	3		16	80.0
119	292	12405 & 12410	TOMAHAWK RD	Tom Tom Dr	E Parker Rd	Collector	2	Minor	Asphalt	24	3		16	80.0
119	626	12405 & 12410	TOMAHAWK RD	E Parker Rd	Pinewood Dr	Collector	2	Minor	Asphalt	30	4		16	81.7
119	1016	12405 & 12410	TOMAHAWK RD	Inspiration Dr	460 ft	Collector	2	Minor	Asphalt	24	3		16	80.0
119	1021	12405 & 12410	TOMAHAWK RD	460 ft	1250 ft	Collector	2	Minor	Asphalt	24	3		16	80.0
119	1023	12405 & 12410	TOMAHAWK RD	1250 ft	3000 ft	Collector	2	Minor	Asphalt	24	3		16	80.0
125	1149	12960	WALKER RD	END	SH 86	Local	2	Minor	Sandy Gravel	24	--	Fair	2	
130	360	13795	WOODLAND TRL	S AURORA LINE	Summit Rd	Local	2	Minor	Class 5 Gravel	26	--	Good	8	

2015					2020					2025					2030				
ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2015 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2020 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2025 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)	ADT (Used for Unpaved Sections Classification)	Unpaved Section Classification	2030 Oil & Gas ESALs	Required Overlay (Inches)	Improvement Costs (\$2011)
		0	0.00	\$0			808	0.04	\$2,600			14,816	0.50	\$35,800			3,230	0.13	\$9,600
		0	0.00	\$0			808	0.04	\$1,000			14,816	0.50	\$13,600			2,423	0.10	\$2,800
0	-	0		\$0	2	LOW	808		\$3,300	4	LOW	1,615		\$3,300	4	LOW	1,615		\$3,300
0	-	0		\$0	2	LOW	808		\$700	4	LOW	1,615		\$700	4	LOW	1,615		\$700
		14,207	0.52	\$29,300			808	0.04	\$2,200			808	0.04	\$2,200			808	0.04	\$2,200
		14,207	0.52	\$15,900			808	0.04	\$1,200			808	0.04	\$1,200			808	0.04	\$1,200
		14,207	0.52	\$3,600			808	0.04	\$300			808	0.04	\$300			808	0.04	\$300
		14,207	0.52	\$12,100			808	0.04	\$900			808	0.04	\$900			808	0.04	\$900
		0	0.00	\$0			14,367	0.36	\$7,700			2,920	0.08	\$1,800			17,486	0.43	\$9,100
		0	0.00	\$0			648	0.02	\$3,200			1,118	0.03	\$5,400			17,388	0.46	\$71,800
		0	0.00	\$0			648	0.02	\$300			963	0.03	\$500			14,876	0.38	\$5,500
		0	0.00	\$0			648	0.02	\$500			1,118	0.03	\$800			17,388	0.46	\$9,800
		0	0.00	\$0			14,367	0.36	\$19,600			2,920	0.08	\$4,500			17,486	0.43	\$23,200
		0	0.00	\$0			648	0.02	\$600			310	0.01	\$300			15,773	0.43	\$11,900
		0	0.00	\$0			648	0.02	\$400			310	0.01	\$200			16,581	0.45	\$7,700
		0	0.00	\$0			648	0.02	\$500			310	0.01	\$300			16,581	0.45	\$9,600
		0	0.00	\$0			648	0.02	\$500			310	0.01	\$300			1,156	0.04	\$900
		0	0.00	\$0			648	0.02	\$500			963	0.03	\$600			15,529	0.39	\$8,400
0	-	0	0.00	\$0	0	-	13,715	0.35	\$6,100	2	LOW	1,615	0.05	\$900	2	LOW	16,181	0.40	\$7,100
0	-	0	0.00	\$0	0	-	14,207	0.36	\$9,500	2	LOW	808	0.42	\$700	2	LOW	808	0.11	\$700
		0	0.00	\$0			0	0.00	\$0			16,630	0.25	\$11,000			4,038	1.74	\$2,900
		0	0.00	\$0			0	0.00	\$0			1,615	0.00	\$2,600			30,189	1.19	\$17,600
0	-	0		\$0	2	LOW	808		\$1,900	2	LOW	808		\$1,900	2	LOW	808		\$1,900
0	-	0		\$0	16	LOW	5,326		\$600	3	LOW	2,084		\$600	3	LOW	2,084		\$600
0	-	0		\$0	2	LOW	808		\$4,800	2	LOW	808		\$4,800	2	LOW	808		\$4,800
0	-	0		\$0	4	LOW	1,615		\$1,200	4	LOW	1,615		\$1,200	4	LOW	1,615		\$1,200
0	-	0		\$0	0	-	0		\$0	2	LOW	808		\$700	2	LOW	808		\$700
		0	0.00	\$0			0	0.00	\$0			1,615	0.07	\$900			30,189	0.91	\$11,000
		0	0.00	\$0			0	0.00	\$0			1,615	0.07	\$1,800			30,189	0.91	\$22,000
		0	0.00	\$0			0	0.00	\$0			2,423	0.11	\$1,400			30,997	0.92	\$11,200
		0	0.00	\$0			808	0.04	\$900			808	0.04	\$900			808	0.04	\$900
		0	0.00	\$0			0	0.00	\$0			14,207	0.52	\$2,100			1,615	0.07	\$300
		0	0.00	\$0			0	0.00	\$0			14,207	0.52	\$3,800			1,615	0.07	\$600
		0	0.00	\$0			0	0.00	\$0			0	0.00	\$0			808	0.04	\$600
0	-	0		\$0	2	LOW	808		\$900	2	LOW	808		\$900	2	LOW	808		\$900
0	-	0		\$0	0	-	0		\$0	2	LOW	808		\$400	2	LOW	808		\$400
				\$170,100					\$926,000					\$950,900					\$1,314,300