Montana Department of Transportation

Working Paper #4: Model Results

Final

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1 INTRODUCTION

This Working Paper is part of the US 2/MT 16 Theodore Roosevelt Expressway Development Study. The purpose of the study is to identify the economic, regulatory, or operational changes that would result in traffic and safety conditions justifying the expansion of the Theodore Roosevelt Expressway section in Montana to a four-lane facility.

This Working Paper provides a detailed presentation and analysis of the traffic forecasting model's results. The paper is a continuation of the TRED Working Paper series and, specifically, is a direct extension of Working Paper #3, Methodological Framework. Within this paper the reader will find forecasts of overall average annual daily traffic (AADT) and the percentage of this overall AADT that can be attributed to large truck traffic along the Theodore Roosevelt Expressway's sections of MT 16 and US 2 that lie within the State of Montana. These forecasts will be presented first as mean expected outcomes and then within a risk analysis framework.

The results presented in this Working Paper utilize input assumptions designed to forecast long-term average traffic volumes along the study area corridor. By focusing on long-term averages, any short-term fluctuations due to such events as economic booms, recessions, or droughts are evened out over time. Therefore, the research team believes the forecasting results generated by this modeling process are neither overly optimistic nor pessimistic in nature.

After this introductory chapter, Chapter 2 provides mean expected outcomes of the model results. Chapter 3 then presents the risk analysis results and Chapter 4 provides a summary of the findings and conclusions that the results support. Analysis of safety performance along the corridor, taking into account the model's forecasts, will be detailed in a forthcoming document.

The traffic forecasting results presented in this paper were developed specifically for the study area corridor and, therefore, should not be considered applicable to other corridors in Montana.

2 MEAN EXPECTED OUTCOMES

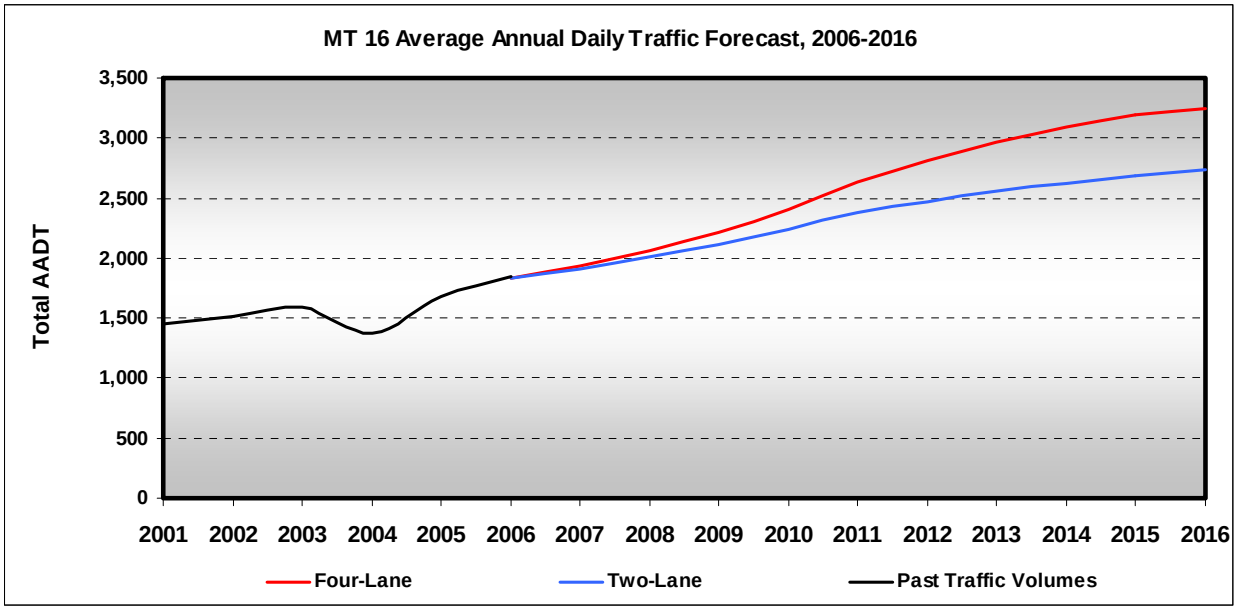
This section presents the mean expected outcomes of the model's forecasts for overall traffic volumes and the percentage of traffic attributable to trucks over the next 30 years.

2.1 Near-Term Forecasts

The following forecasts represent the expected levels of AADT and percentage of overall traffic attributable to large trucks from 2006 to 2016, a 10 year[1] forecast horizon.

Figure 1 below presents the expected AADT (number of vehicles) for MT 16 for both the base case of a two-lane corridor and for the alternative four-lane highway expansion. Both forecasts include the mean expected outcomes calculated with the itemized traffic opportunities and indirect employment effects, while the four-lane forecast further includes the induced traffic due to a four-lane expansion.

Figure 1

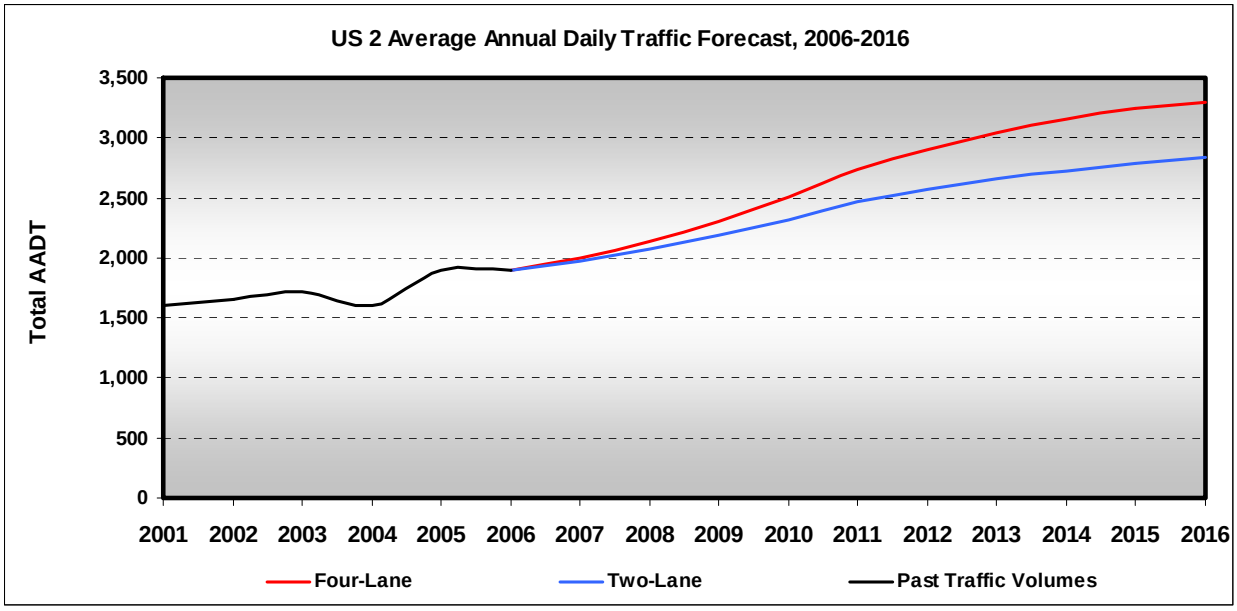


MT 16 10-Year AADT Forecast, Mean Expected Outcomes

[1] Although there are 11 years within the period 2006-2016, there are only 10 forecast years; since 2006 values are assumed known and therefore do not represent a forecast.

Similarly, Figure 2 includes the expected AADT (number of vehicles) forecast for US 2 under both the current two-lane configuration and with a four-lane corridor expansion.

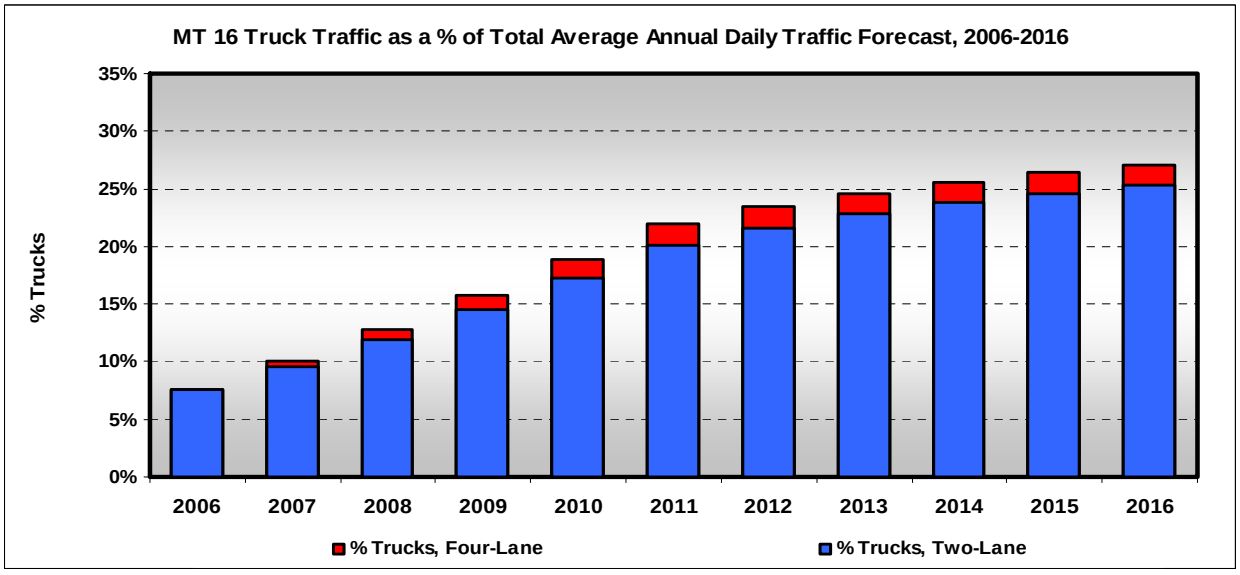
Figure 2



US 2 10-Year AADT Forecast, Mean Expected Outcomes

The expected ratio of truck traffic to overall traffic is presented in Figure 3. Because of high expected growth in the volume of truck traffic as compared to personal vehicle traffic, the percentage of total AADT that is attributed to trucks grows quite vigorously over time. As can be seen the four-lane expansion would be expected to have a slightly higher percentage of trucks than the current two-lane corridor.

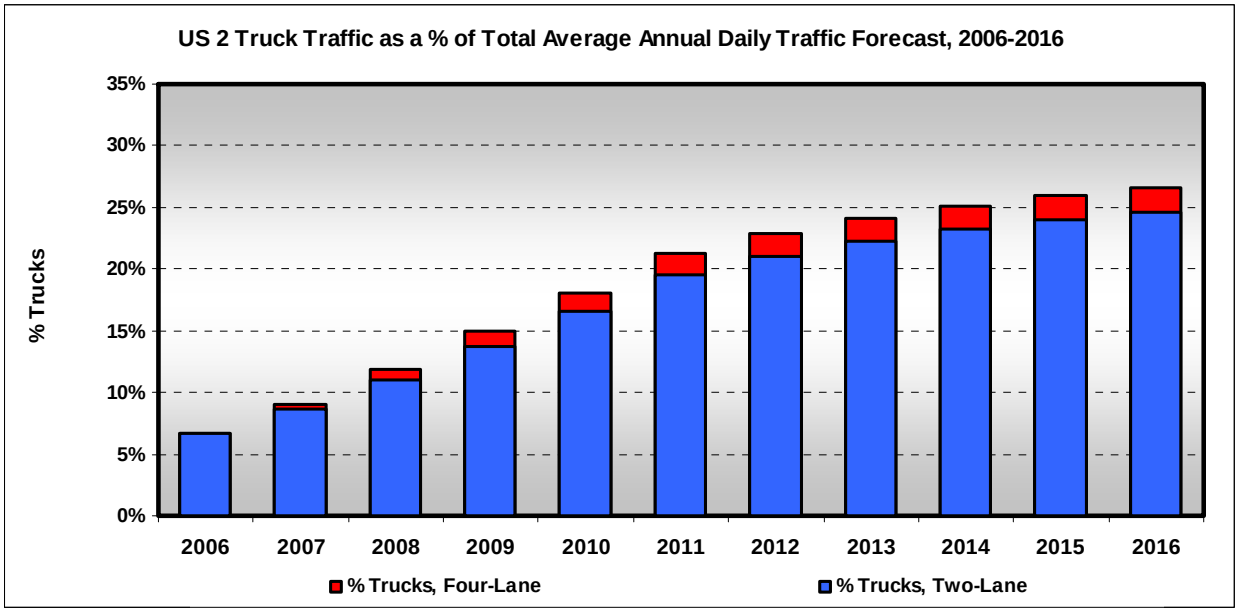
Figure 3



MT 16 10-Year Percentage of AADT, Trucks; Mean Expected Outcome

As illustrated in Figure 4 below, the expected growth in the ratio of truck traffic to overall traffic is also very large along the US 2 corridor.

Figure 4



US 2 10-Year Percentage of AADT, Trucks; Mean Expected Outcomes

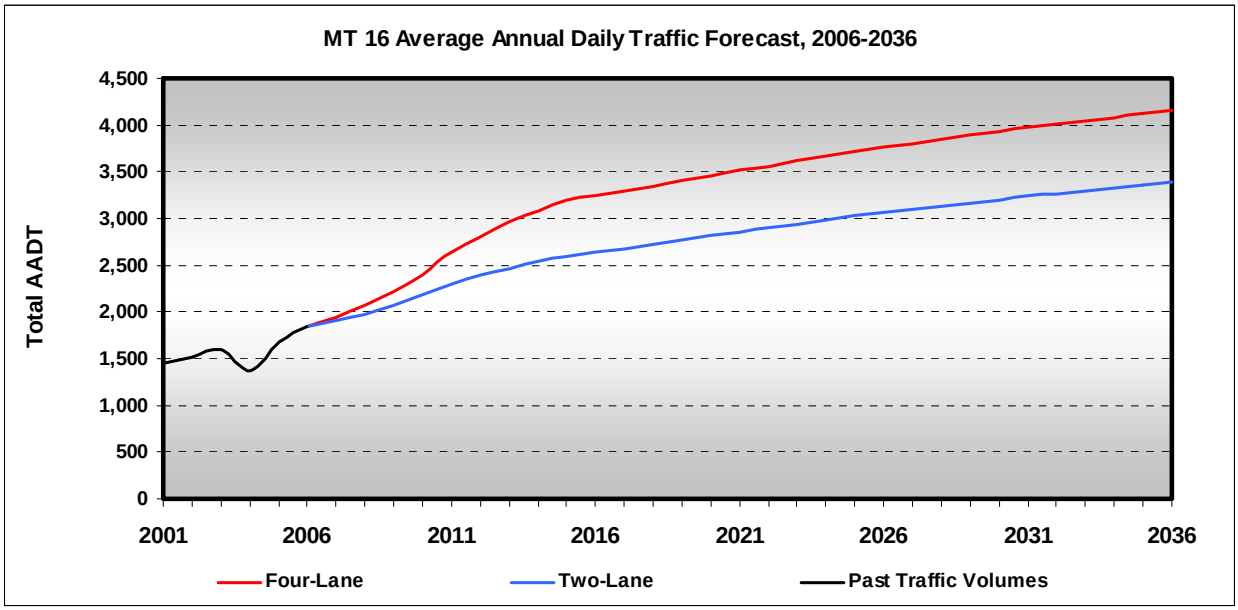
2.2 Long-Term Forecasts

The following forecasts now assume a 30 year time horizon and represent the mean expected outcomes for both AADT and the percentage of total AADT attributable to truck traffic in each year for both MT 16 and US 2[2] under the two-lane base case and under a four-lane corridor expansion scenario.

[2] Mean expected traffic volume forecasts for MT 16 and US 2 illustrating ADT due to historical growth rates and additional growth due to opportunities, separately, are shown in Appendix A

Figure 5 illustrates the mean expected growth of traffic for MT 16 over the next 30 years for both the two-lane and four-lane scenarios. As can be seen, AADT is expected to double under the two-lane corridor scenario and more than double over 30 years if the corridor were expanded to four-lanes.

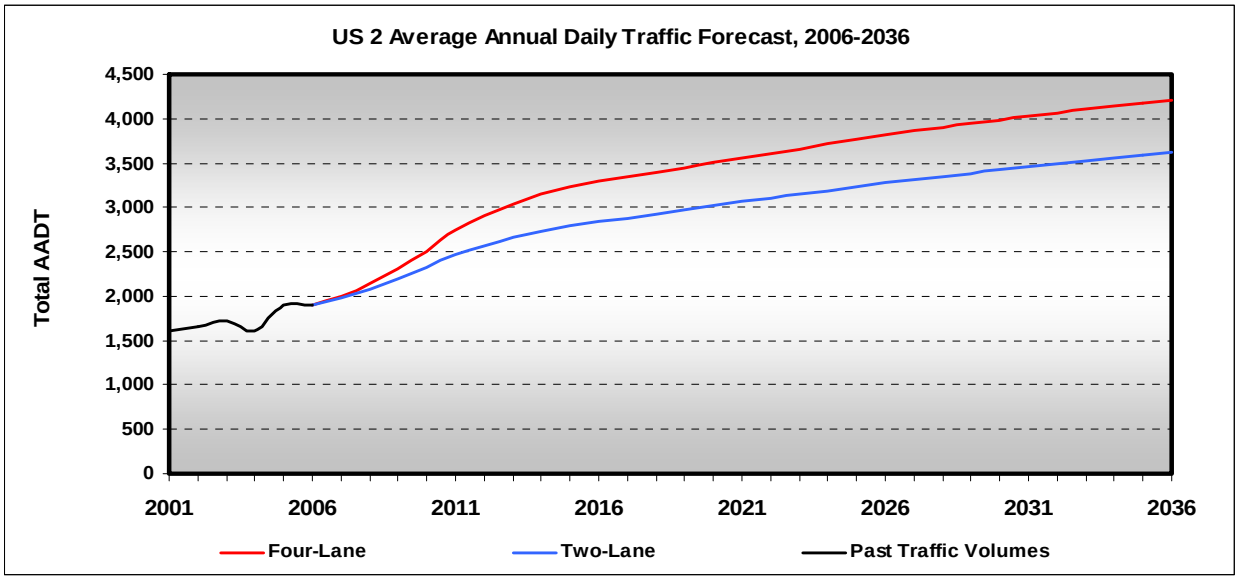
Figure 5



MT 16 30-Year AADT Forecast, Mean Expected Outcomes

Figure 6 shows the mean expected results for US 2 over the next 30 years. Growth is very similar to that expected for MT 16 with US 2 AADT being only slightly higher than that expected for MT 16, for both the two-lane and four-lane scenarios.

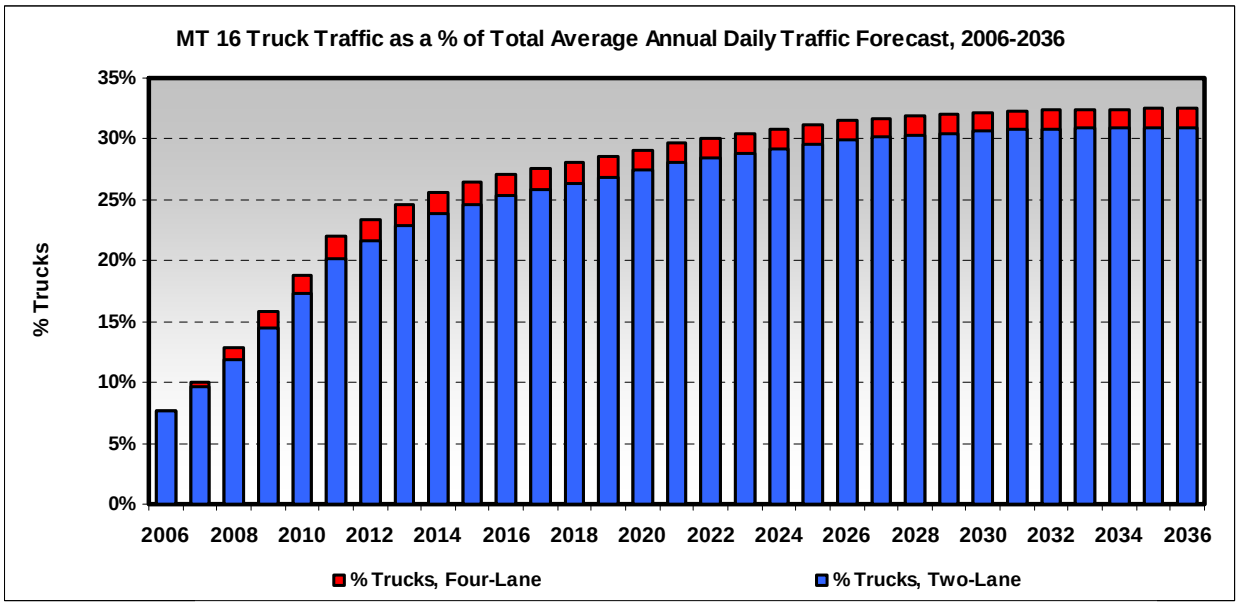
Figure 6



US 2 30-Year AADT Forecast, Mean Expected Outcomes

Figure 7 presents the mean expected percentage of overall traffic that can be attributed to trucks for MT 16 over the next 30 years. As can be seen the growth in truck traffic is expected to lead to over 30% trucks in the overall traffic stream in both the two-lane and four-lane scenarios.

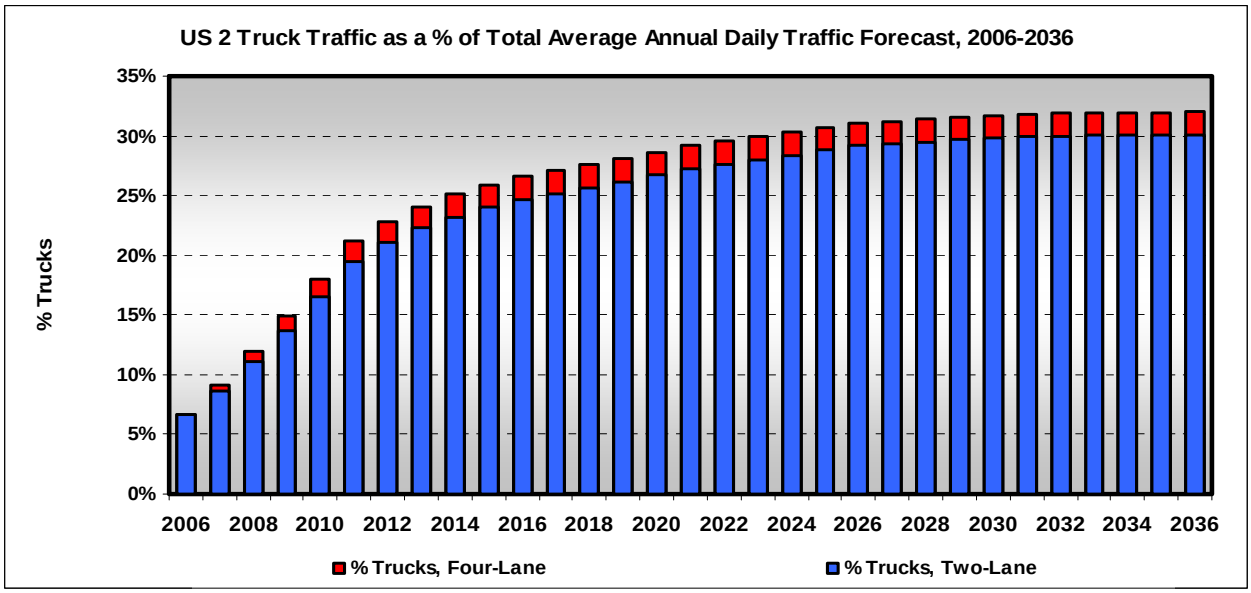
Figure 7



MT 16 30-Year Percentage of AADT, Trucks; Mean Expected Outcomes

Figure 8 illustrates the expected percentage of truck traffic along US 2 over the next 30 years. The results are very similar to those for MT 16, though the overall percentage of trucks in the traffic stream along US 2 is expected to be slightly lower than that for MT 16 over the forecast horizon.

Figure 8



US 2 30-Year Percentage of AADT, Trucks; Mean Expected Outcomes

To summarize, both the MT 16 and US 2 sections of the TRE corridor are expected to experience similar growth in both overall AADT and in the percentage of trucks along the corridors over the next 30 years in both the two-lane and four-lane scenarios. However, MT 16 is expected to have a slightly higher percentage of truck traffic than the US 2 section of the corridor for both the two-lane and four-lane scenarios. The US 2 section is expected to have slightly higher overall AADT than the MT 16 corridor in both the two-lane and four-lane scenarios.

3 RISK ANALYSIS RESULTS

This section presents the results of the forecasting model within a risk analysis framework. Specifically, 80% confidence intervals were calculated and the results are presented for each forecast.

3.1 Risk Analysis of AADT Growth

In this report, confidence intervals take the form of a central estimate that represents the median[3] level bounded above and below by an upper and a lower bound. Within an 80% confidence interval the upper bound represents values where any values higher than those that lie along that upper bound have only a 10% chance of occurring. Similarly, the lower bound represents values where any values lower than those that lie along the lower bound have only a 10% chance of occurring. This means that the probability that a value lies below the upper bound and above the lower bound is 80%.

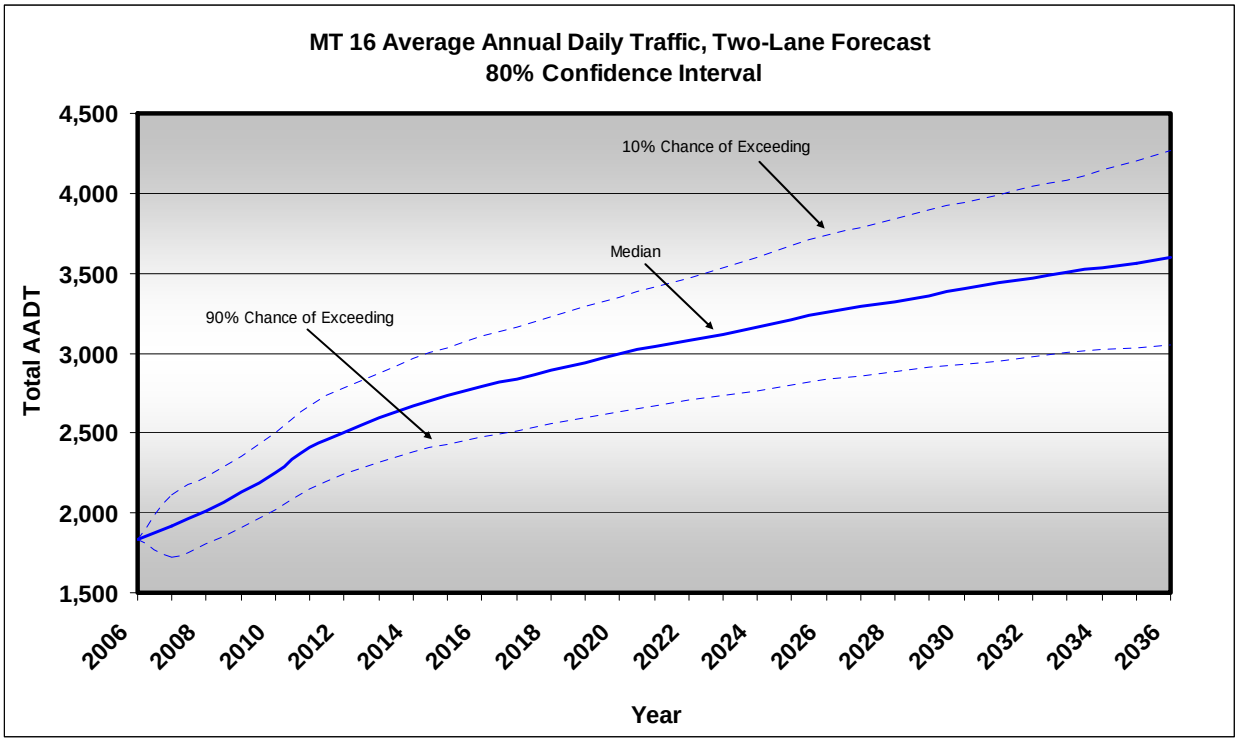
3.1.1 Two-Lane Forecasts

This section presents forecasts within a risk analysis framework for overall AADT for both the MT 16 and US 2 sections of the TRE corridor, assuming these sections remain two-lanes over the next 30 years.

[3] A median value represents a true central value that is defined in such a way that any value above the median has a 50% chance of occurrence; likewise any value below the median value also has a 50% chance of occurrence.

Figure 9 represents an 80% confidence interval forecast for the overall AADT along the MT 16 section of the study area corridor over the next 30 years. As can be seen in the chart, there is a 50% (median) chance that AADT will reach approximately 3,600 vehicles in 2036, and a 10% chance that overall AADT will grow to about 4,300 vehicles by the same year. Similarly, there is a 10% chance that the number of vehicles will only reach approximately 3,100 in 30 years.

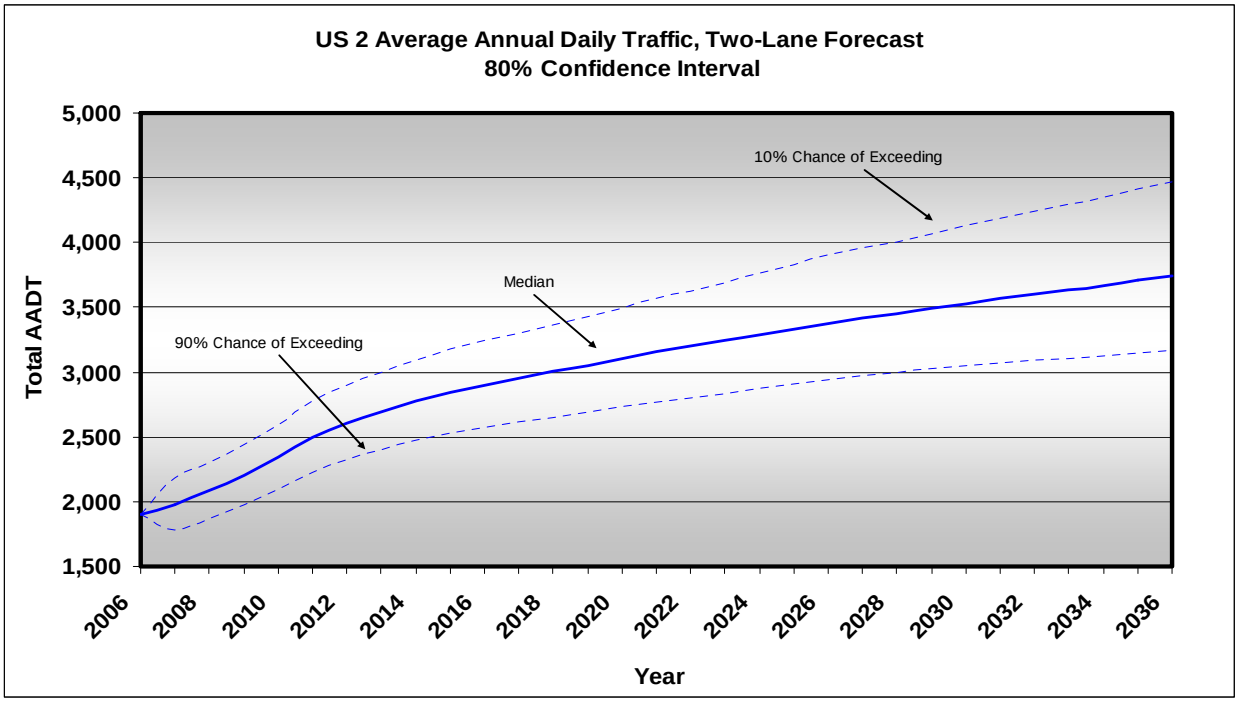
Figure 9



MT 16 30-Year AADT Forecasts, 80% Confidence Interval Two-Lane Outcomes

Figure 10 illustrates the risk analysis AADT forecast results for the US 2 section of the study area corridor for the next 30 years assuming it remains at two-lane capacity. The results are very similar to those presented above for the MT 16 section. Overall AADT has a 50% chance of reaching about 3,700 vehicles in 2036, while there is a 10% chance the AADT will be approximately 4,500. There is also a 10% chance that AADT will only grow to about 3,200 vehicles in the next 30 years.

Figure 10



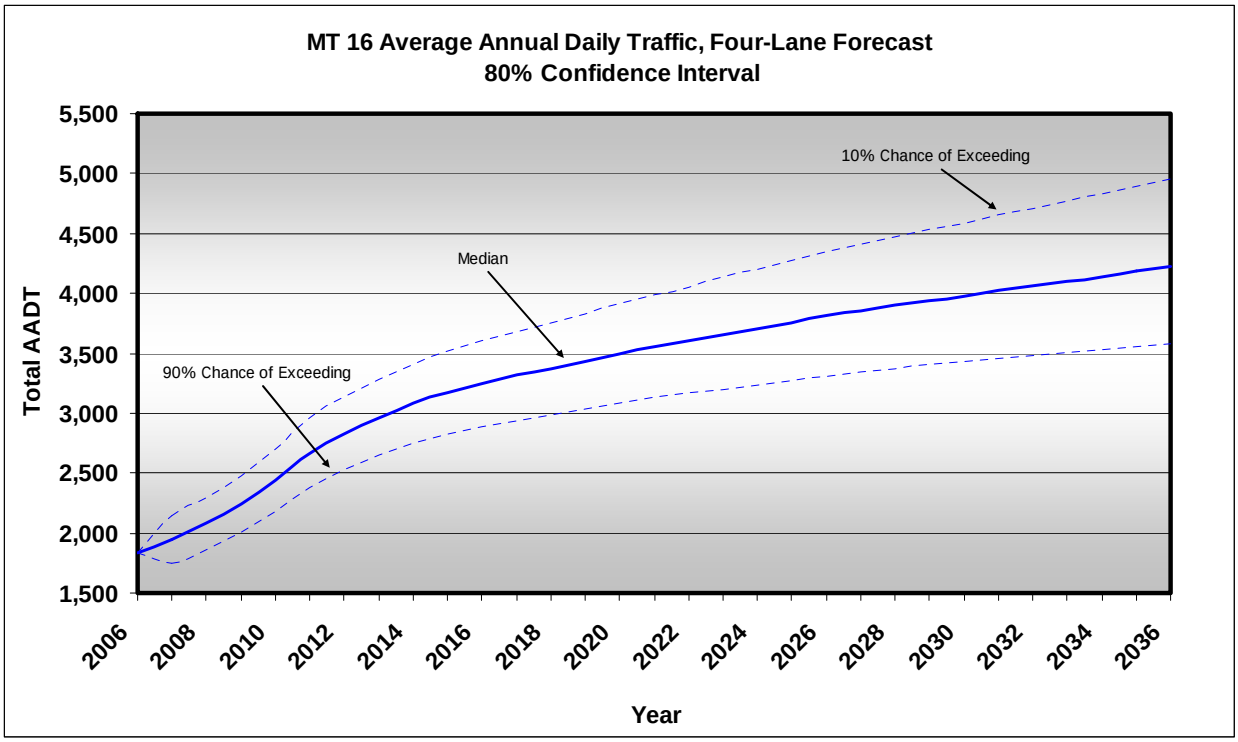
US 2 30-Year AADT Forecasts, 80% Confidence Interval Two-Lane Outcomes

3.1.2 Four-Lane Forecasts

In this section, risk analysis forecasts for overall AADT on the MT 16 and US 2 sections of the study area corridor are presented under the assumption that these sections have been expanded to four-lane capacity.

Figure 11 illustrates the AADT risk analysis results for the MT 16 section of the study area corridor for the next 30 years, assuming the roadway was expanded to a four-lane capacity. As can be seen, there is a 50% (median) chance that AADT will reach about 4,250 in 2036, while there is a 10% chance that AADT will grow to approximately 5,000 in 30 years. There is also a 10% chance that AADT will only grow to about 3,600 within the next 30 years.

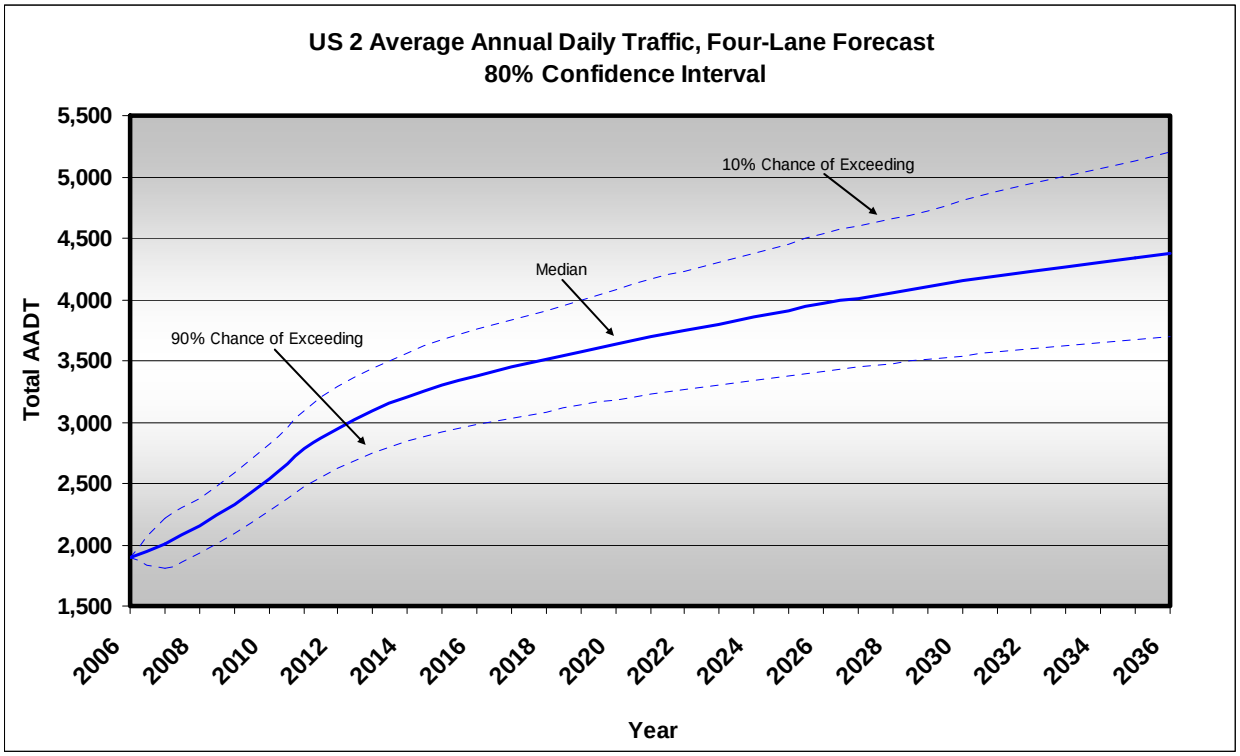
Figure 11



MT 16 30-Year AADT Forecasts, 80% Confidence Interval Four-Lane Outcomes

Figure 12 shows the risk analysis forecast for AADT along the US 2 section of the TRE corridor for the next 30 years. The results are very similar to those already presented for the MT 16 section, though AADT is projected to be slightly higher on the US 2 section. There is a 50% (median) chance AADT will grow to about 4,400 vehicles by 2036, while there is a 10% chance that AADT will be approximately 5,200 by that year. On the lower end, there is a 10% chance that AADT will only reach about 3,700 within 30 years.

Figure 12



US 2 30-Year AADT Forecasts, 80% Confidence Interval Four-Lane Outcomes

3.1.3 Peak Season Forecasts

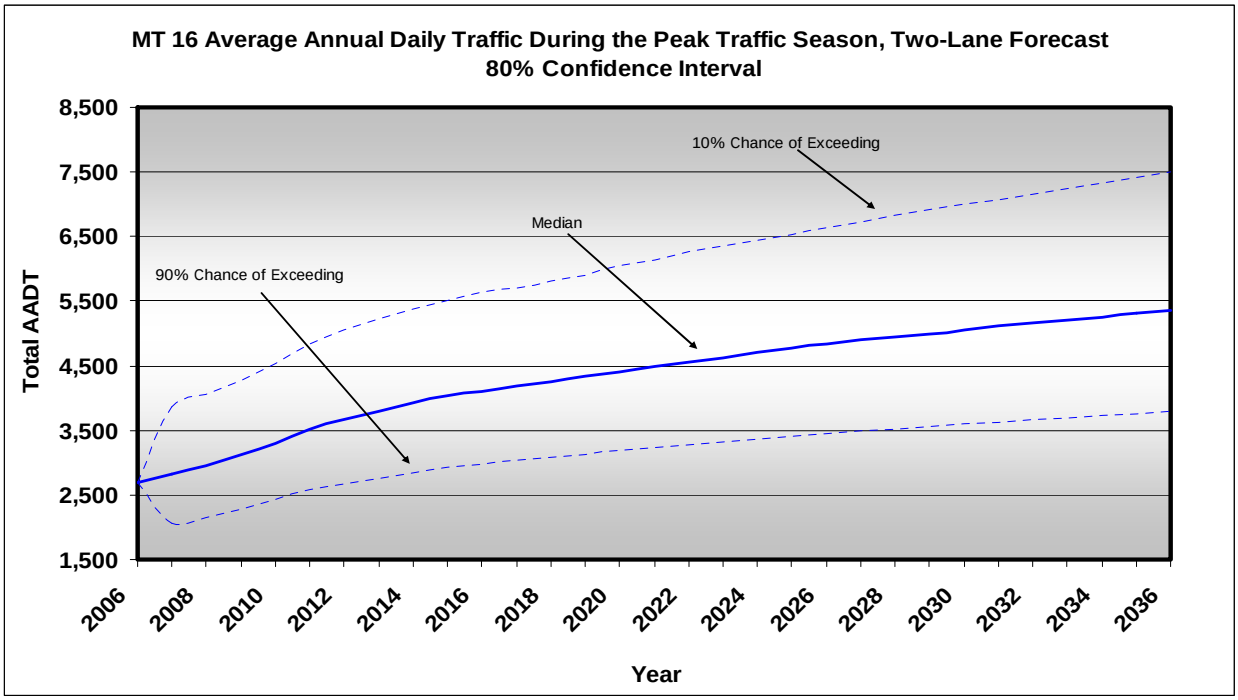
There are times of the year when traffic volumes are inordinately high compared to the average annual daily rate. These times are referred to as the peak season for traffic and can be the result of many factors, such as, transport seasonality of agricultural crops to market or an increase in tourism trips due to prime vacation season. For the purposes of this analysis the peak season can be defined generally as the months of June through October of each year. This section presents the risk analysis AADT forecast results for both the MT 16 and US 2 sections of the study area corridor for the next 30 years during the peak traffic season.

3.1.3.1 Two-Lane Forecasts

Peak season forecasts for both MT 16 and US 2 assuming that the roadway corridors remain at two-lane capacities over the next 30 years are illustrated in the next two figures.

Figure 13 represents an 80% confidence interval for MT 16 projected peak season AADT, assuming a two-lane corridor. According to the chart, there is a 50% chance of traffic reaching about 5,400 vehicles per day in 2036, and a 10% chance of the AADT growing to approximately 7,500 by that same year. There is also a 10% chance that peak season AADT will only be about 3,800 within 30 years.

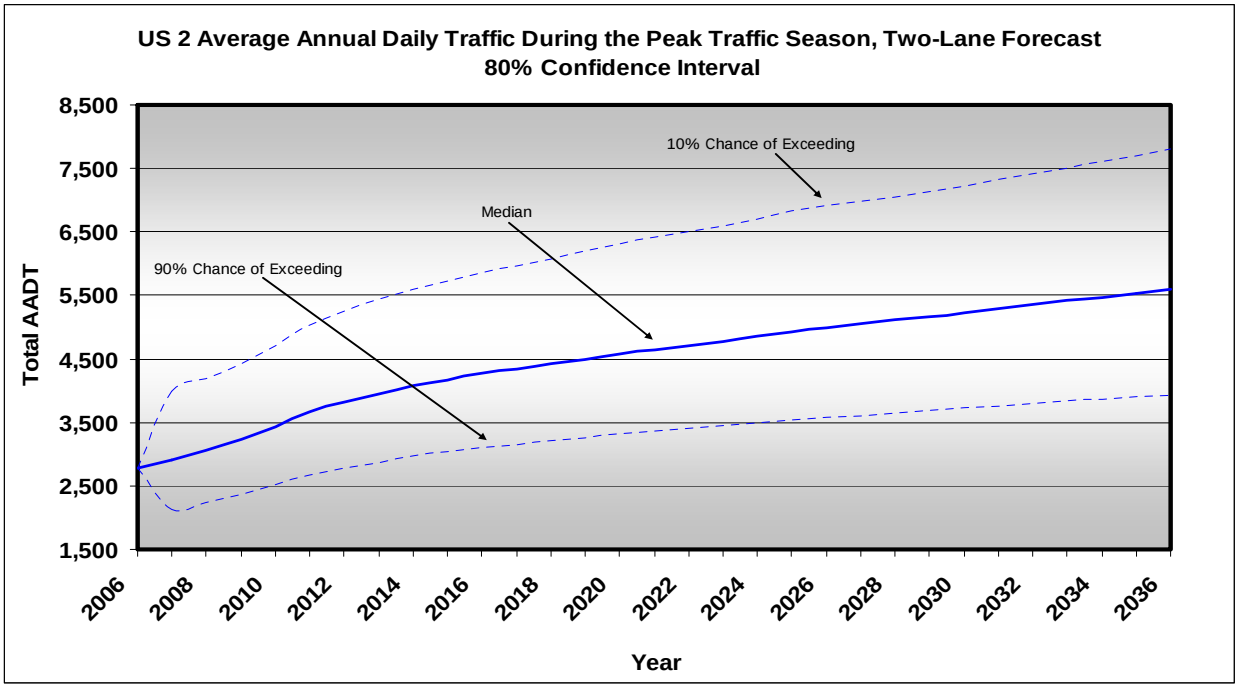
Figure 13



MT 16 30-Year Peak Season AADT Forecasts, 80% Confidence Interval Two-Lane Outcomes

According to Figure 14, median AADT along the US 2 section of the study area corridor during the peak season is projected to surpass 5,600 by 2036. There is also a 10% chance that peak season AADT would reach 7,700 in 2036. However, there is also a 10% chance that the peak season AADT would only grow to 4,000 vehicles within the next 30 years.

Figure 14



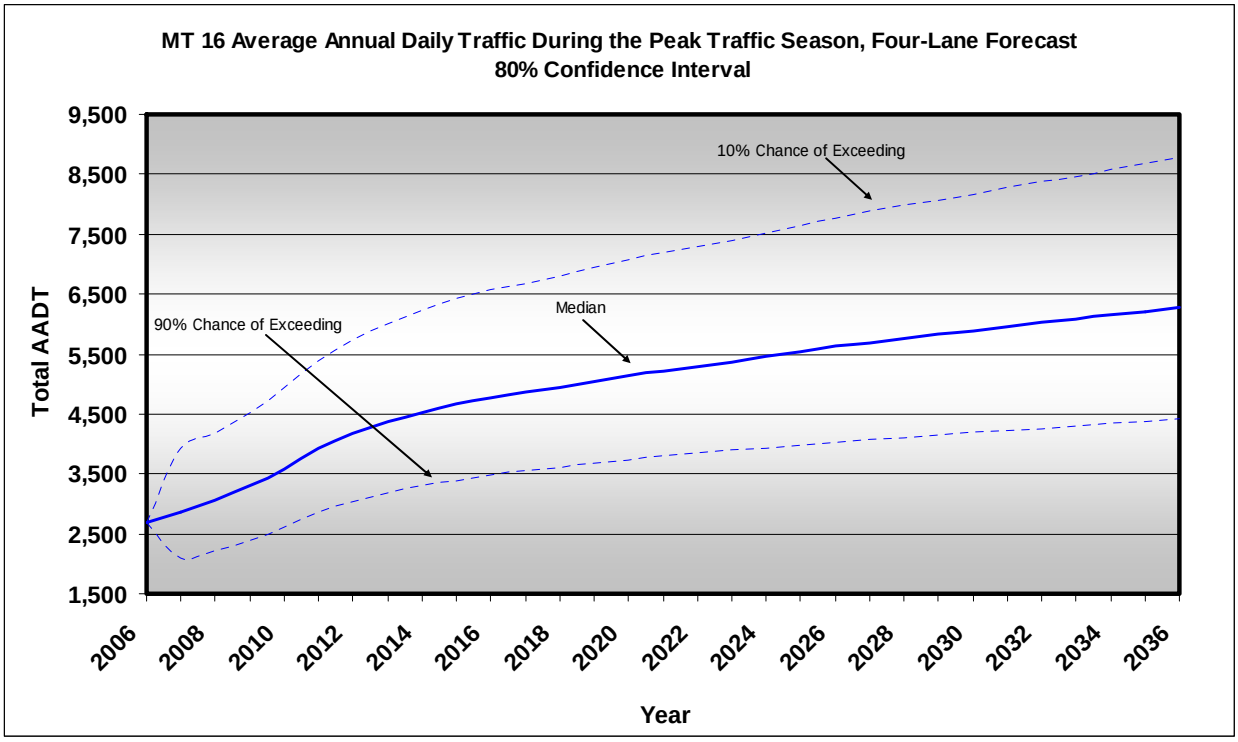
US 2 30-Year Peak Season AADT Forecasts, 80% Confidence Interval Two-Lane Outcomes

3.1.3.2 Four-Lane Forecasts

This section presents 30 year risk analysis forecasts of peak season AADT along the MT 16 and US 2 sections of the study area corridor assuming that the sections are expanded to four-lane capacities.

Figure 15 below depicts the peak season AADT forecasts for the MT 16 section of the study area corridor assuming a four-lane capacity. As can be seen, there is a 50% chance that AADT will reach about 5,800 vehicles in the next 30 years, while there is a 10% chance that the AADT could be as high as 8,700 within the same time frame. A 10% chance also exists for peak season AADT to only grow to about 4,500 vehicles by 2036.

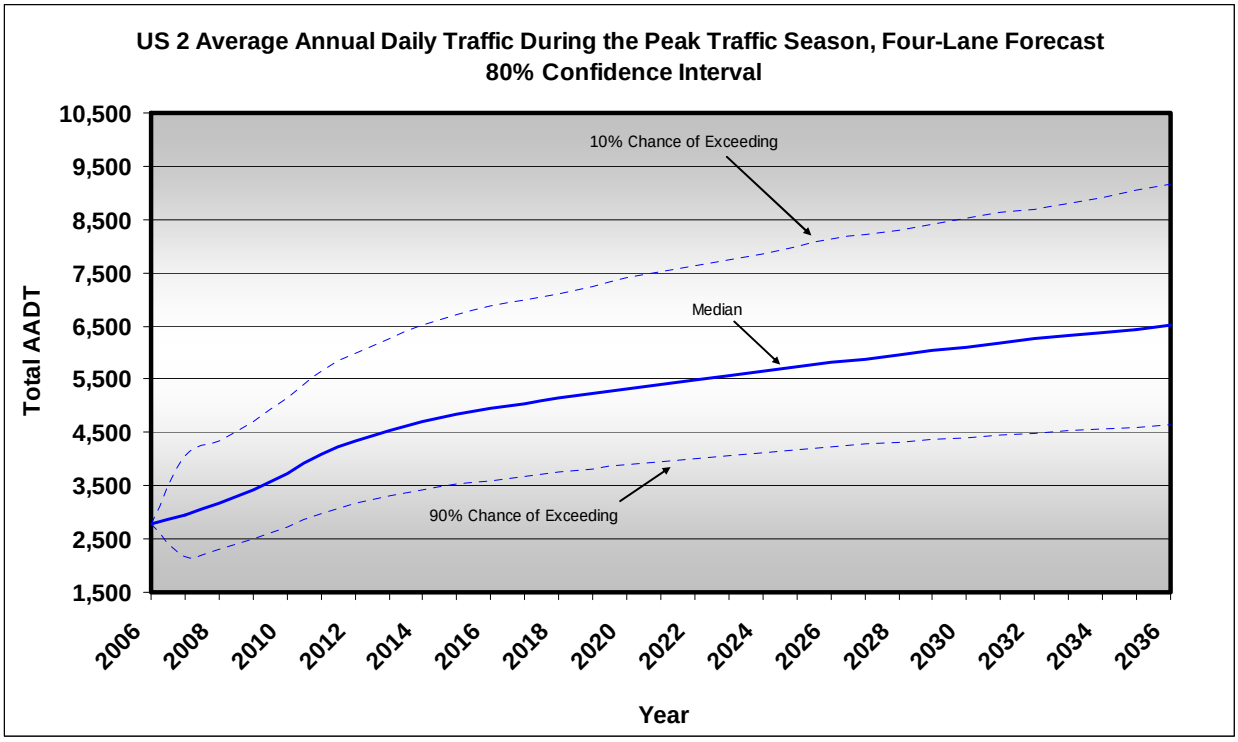
Figure 15



MT 16 30-Year Peak Season AADT Forecasts, 80% Confidence Interval Four-Lane Outcomes

In Figure 16 the peak season AADT forecasts for the US 2 section of the study area corridor are pictured. The median level of AADT during the peak season is expected to be about 6,500 by 2036. Meanwhile, there is a 10% chance that the AADT could be as high as 9,000 in the same year; but, there is also a 10% chance that the AADT might only grow to approximately 4,600 within the next 30 years.

Figure 16



US 230-Year Peak Season AADT Forecasts, 80% Confidence Interval Four-Lane Outcomes

3.2 Risk Analysis of Vehicle Distribution

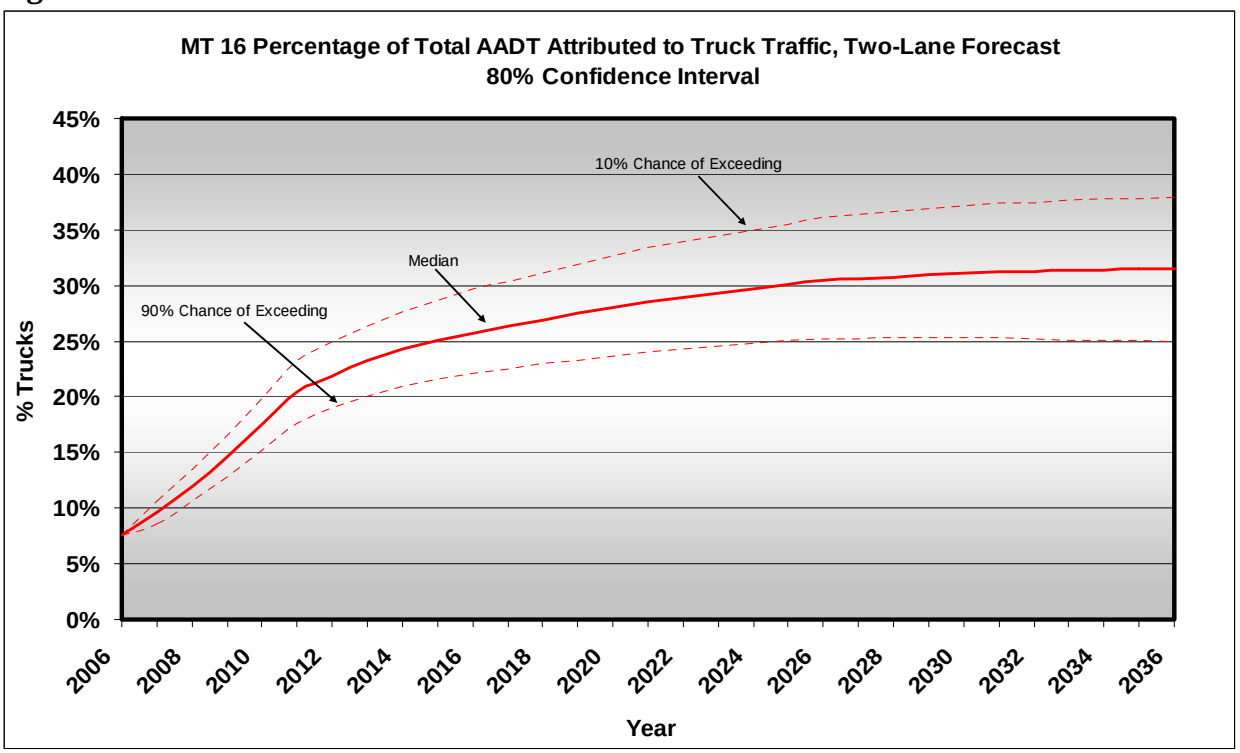
In this section risk analysis results for the forecasts of the percentage of overall AADT that is attributable to truck traffic are presented. These forecasts are for both the MT 16 and US 2 study area corridor sections under both two-lane and four-lane scenarios over the next 30 years. These forecasts, like the previous section's risk analysis forecasts, are presented in the form of 80% confidence intervals.

3.2.1 Two-Lane Forecasts

Figures 17 and 18 that follow represent 80% confidence interval forecasts under the two-lane corridor scenario for the MT 16 and US 2 sections of the study area corridor.

In Figure 17 it can be seen that the median percent trucks level for the MT 16 section of the corridor is projected to be about 32% in 2036, while there is a 10% chance this level could reach about 38% by the same year. There is also a 10% chance that the percent of trucks in the traffic stream only reaches 25% within the next 30 years.

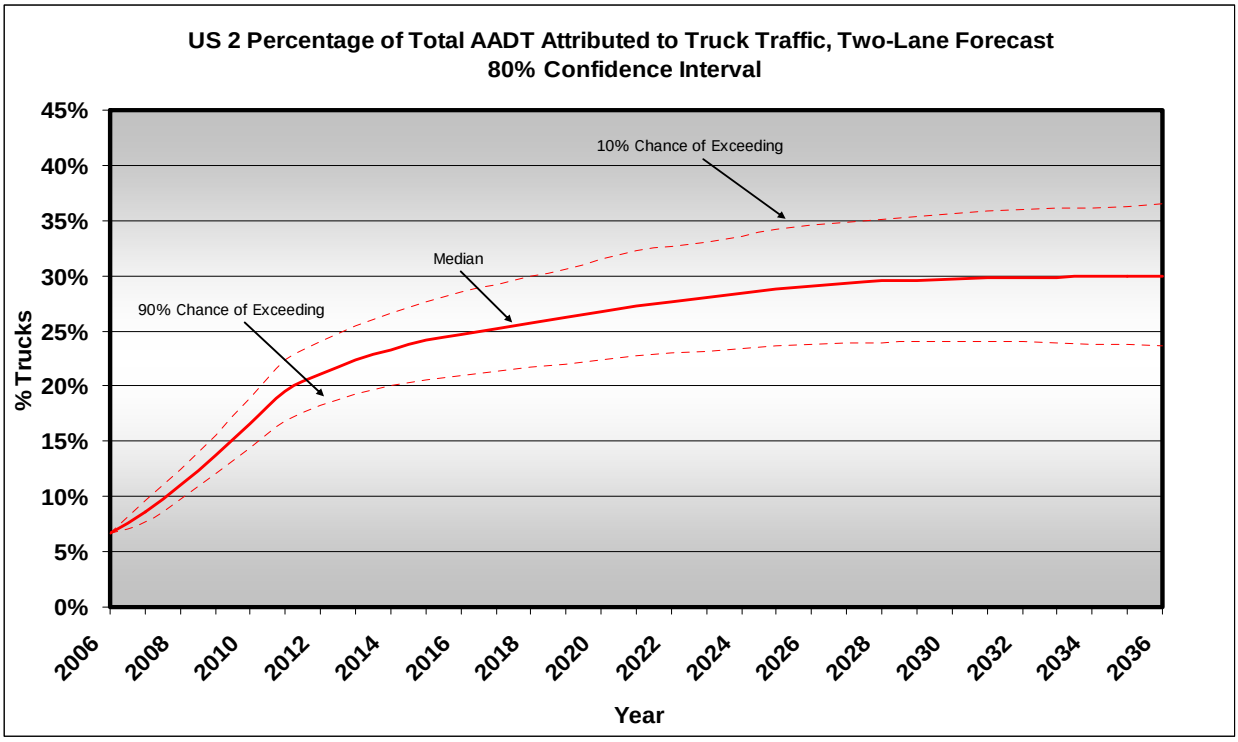
Figure 17



MT 16 30-Year Forecasts, Percentage of AADT, Truck; 80% Confidence Interval Two-Lane Outcomes

Figure 18 shows the risk analysis forecast for the percent trucks along the US 2 section of the study area corridor. In 2036 it is projected that the median level of truck traffic share will be 30%, while there is a 10% chance this share could be 37% by the same year. A 10% chance also exists that the share of truck traffic will only reach 24% within the next 30 years.

Figure 18



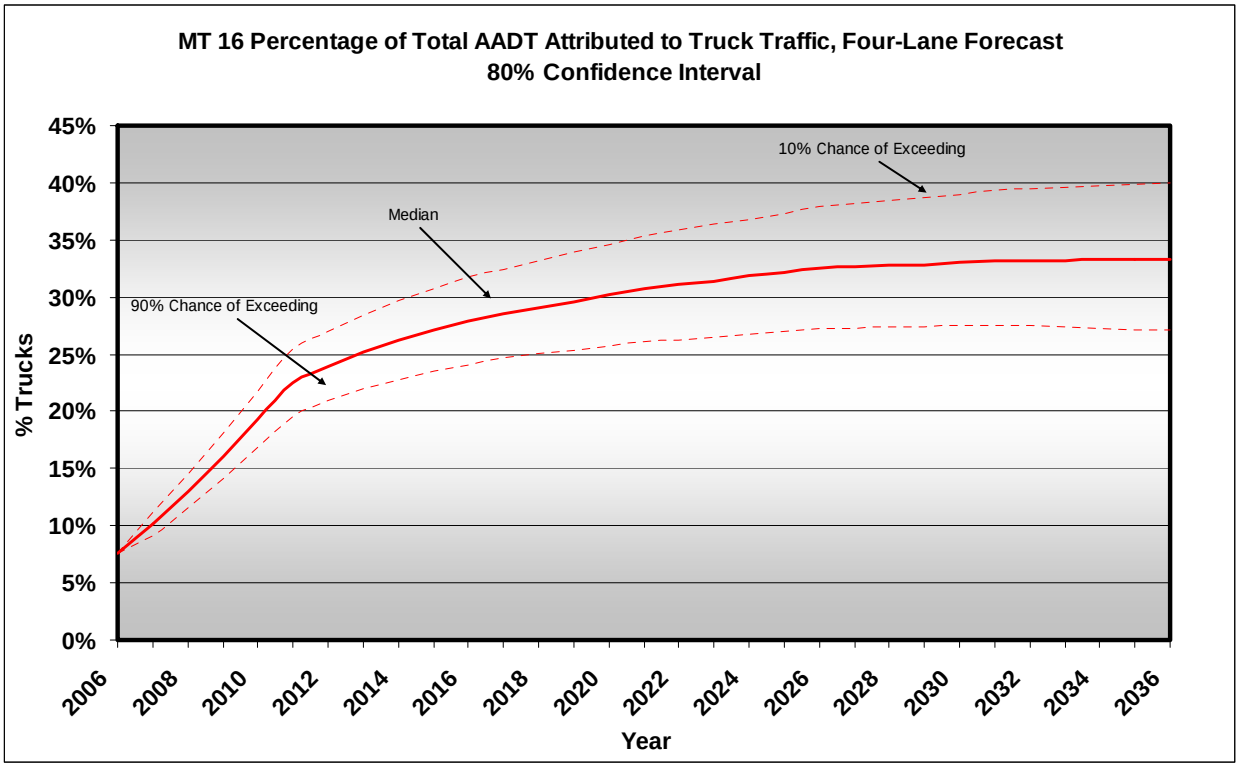
US 2 30-Year Forecasts, Percentage of AADT, Truck; 80% Confidence Interval Two-Lane Outcomes

3.2.2 Four-Lane Forecasts

The risk analysis forecasts of the percent trucks in the traffic stream for the study area corridor sections, assuming that they are expanded to four-lane capacities, are presented in the following figures.

Figure 19 illustrates the four-lane forecasts for the MT 16 section of the study area corridor with regards to the percentage of overall traffic attributable to truck traffic. By 2036, it is projected that the median level of trucks in the overall traffic volume will be about 33%, while by the same year there is a 10% chance that the share of trucks amongst overall traffic could be as high as 40%. There is also a 10% chance that truck traffic would only be as high as about 27% of the overall traffic.

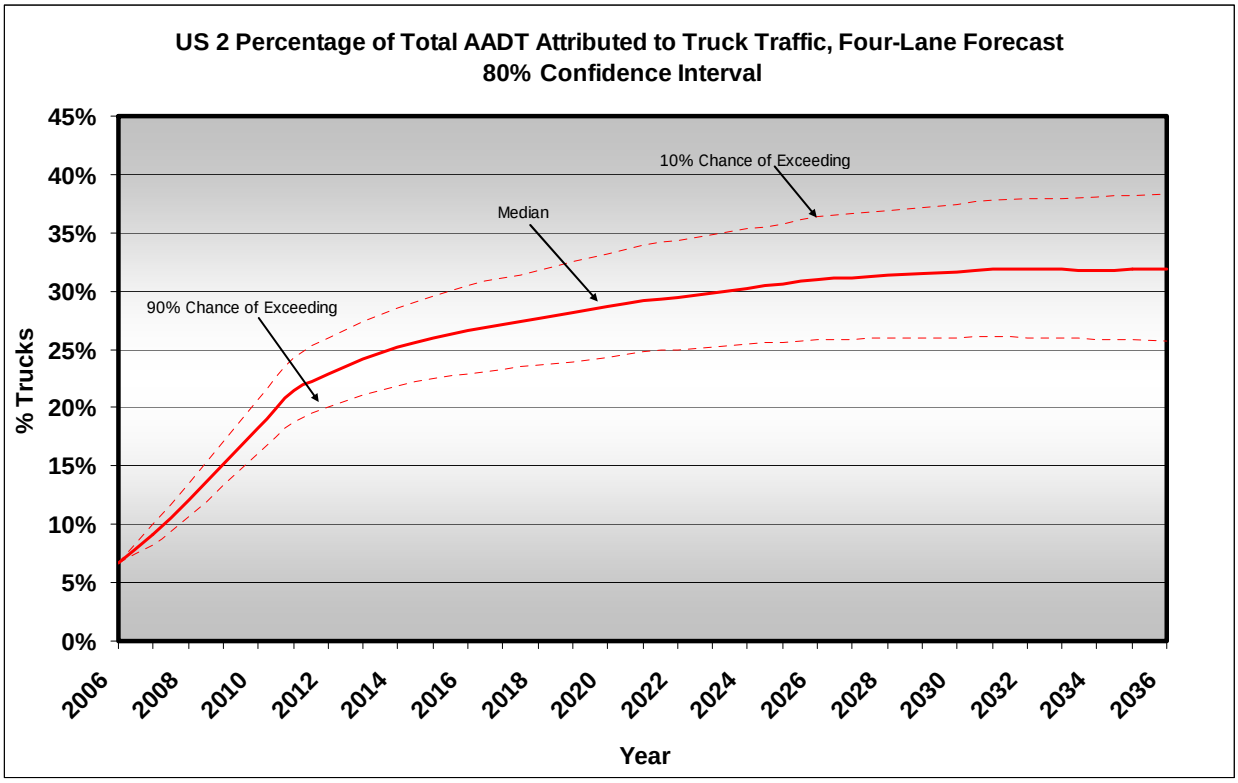
Figure 19



MT 16 30-Year Forecasts, Percentage of AADT, Truck; 80% Confidence Interval Four-Lane Outcomes

Figure 20 shows the truck traffic percentage forecasts for the US 2 section of the study area corridor. Within the next 30 years, the median level of truck traffic is projected to be about 32% of the overall traffic stream. There is also a 10% chance that the truck distribution could be about 38% and also a 10% chance that this distribution might only be about 26% within the next 30 years.

Figure 20



US 2 30-Year Forecasts, Percentage of AADT, Truck; 80% Confidence Interval Four-Lane Outcomes

3.2.3 Peak Season Forecasts

To account for the peak season increases in traffic volumes a general factor was used to increase overall traffic to peak season levels. Because this factor affects all traffic, both auto and truck, there is no change in the relative distribution of truck traffic to the overall traffic volume. Thus the peak season forecasts for the percentage of overall traffic attributable to truck traffic remain at the same levels as those presented in the previous section.

3.3 Tabular Results

Numerical risk analysis results in tabular format for the MT 16 and US 2 sections of the study area corridor is presented within this section. Results are presented for overall AADT and the percentage of traffic attributable to truck traffic by selected years and also for both the two-lane and four-lane scenarios.

3.3.1 Two-Lane Forecasts

Table 1, which follows, summarizes the risk analysis forecasts of AADT and percentage of traffic attributable to trucks for both the MT 16 and US 2 corridor sections for the two-lane scenario.

Table 1

Two-Lane Corridor, Forecasts

Year	Highway Segment	Median	90% Chance of Exceeding	10% Chance of Exceeding
2006	**MT 16, AADT**	1,838	-	-
	MT 16, % Trucks	7.6%	-	-
	US 2, AADT	1,897	-	-
	US 2, % Trucks	6.7%	-	-
2011	**MT 16, AADT**	2,407	2,148	2,670
	MT 16, % Trucks	20.4%	17.6%	23.3%
	US 2, AADT	2,501	2,231	2,779
	US 2, % Trucks	19.6%	16.9%	22.3%
2016	**MT 16, AADT**	2,795	2,478	3,108
	MT 16, % Trucks	25.7%	22.1%	29.7%
	US 2, AADT	2,902	2,577	3,244
	US 2, % Trucks	24.7%	21.0%	28.6%
2026	**MT 16, AADT**	3,255	2,833	3,739
	MT 16, % Trucks	30.4%	25.2%	36.1%
	US 2, AADT	3,378	2,943	3,903
	US 2, % Trucks	29.1%	23.8%	34.6%
2036	**MT 16, AADT**	3,597	3,047	4,266
	MT 16, % Trucks	31.4%	24.9%	37.9%
	US 2, AADT	3,739	3,169	4,472
	US 2, % Trucks	29.9%	23.6%	36.5%

3.3.2 Four-Lane Forecasts

In Table 2, the risk analysis forecasts are presented for the study area corridor, assuming that the corridor sections were expanded to four-lane capacity.

Table 2

Four-Lane Corridor, Forecasts

Year	Highway Segment	Median	90% Chance of Exceeding	10% Chance of Exceeding
2006	MT 16, AADT	1,838	-	-
	MT 16, % Trucks	7.6%	-	-
	US 2, AADT	1,897	-	-
	US 2, % Trucks	6.6%	-	-
2011	MT 16, AADT	2,668	2,381	2,966
	MT 16, % Trucks	22.4%	19.5%	25.4%
	US 2, AADT	2,784	2,476	3,098
	US 2, % Trucks	21.4%	18.7%	24.3%
2016	MT 16, AADT	3,246	2,885	3,603
	MT 16, % Trucks	27.9%	24.1%	31.7%
	US 2, AADT	3,381	2,978	3,759
	US 2, % Trucks	26.6%	22.9%	30.5%
2026	MT 16, AADT	3,813	3,312	4,354
	MT 16, % Trucks	32.5%	27.2%	37.9%
	US 2, AADT	3,967	3,418	4,539
	US 2, % Trucks	31.0%	25.8%	36.3%
2036	MT 16, AADT	4,226	3,582	4,957
	MT 16, % Trucks	33.3%	27.0%	39.9%
	US 2, AADT	4,380	3,699	5,203
	US 2, % Trucks	31.8%	25.7%	38.3%

3.3.3 Peak Season Tabular Forecasts

Tables 3 and 4 present numerical tabular results for peak season AADT and traffic distribution for selected years for the MT 16 and US 2 study area corridor sections under both the two-lane and four-lane scenarios.

Table 3

Two-Lane Corridor, Peak Season Forecasts

Year	Highway Segment	Median	90% Chance of Exceeding	10% Chance of Exceeding
2006	**MT 16, AADT**	2,697	-	-
	MT 16, % Trucks	7.6%	-	-
	US 2, AADT	2,784	-	-
	US 2, % Trucks	6.7%	-	-
2011	**MT 16, AADT**	3,524	2,580	4,833
	MT 16, % Trucks	20.4%	17.6%	23.3%
	US 2, AADT	3,660	2,676	5,040
	US 2, % Trucks	19.6%	16.9%	22.3%
2016	**MT 16, AADT**	4,106	2,973	5,642
	MT 16, % Trucks	25.7%	22.1%	29.7%
	US 2, AADT	4,267	3,103	5,865
	US 2, % Trucks	24.7%	21.0%	28.6%
2026	**MT 16, AADT**	4,828	3,445	6,630
	MT 16, % Trucks	30.4%	25.2%	36.1%
	US 2, AADT	4,999	3,578	6,919
	US 2, % Trucks	29.1%	23.8%	34.6%
2036	**MT 16, AADT**	5,362	3,790	7,510
	MT 16, % Trucks	31.5%	25.0%	38.0%
	US 2, AADT	5,590	3,931	7,800
	US 2, % Trucks	30.0%	23.6%	36.5%

Table 4

Four-Lane Corridor, Peak Season Forecasts

Year	Highway Segment	Median	90% Chance of Exceeding	10% Chance of Exceeding
2006	**MT 16, AADT**	2,697	-	-
	MT 16, % Trucks	7.6%	-	-
	US 2, AADT	2,784	-	-
	US 2, % Trucks	6.7%	-	-
2011	**MT 16, AADT**	3,928	2,863	5,393
	MT 16, % Trucks	22.4%	19.6%	25.5%
	US 2, AADT	4,092	2,984	5,649
	US 2, % Trucks	21.4%	18.7%	24.3%
2016	**MT 16, AADT**	4,768	3,472	6,577
	MT 16, % Trucks	27.9%	24.1%	31.8%
	US 2, AADT	4,946	3,603	6,866
	US 2, % Trucks	26.6%	22.9%	30.5%
2026	**MT 16, AADT**	5,630	4,032	7,770
	MT 16, % Trucks	32.5%	27.2%	37.9%
	US 2, AADT	5,819	4,241	8,123
	US 2, % Trucks	31.0%	25.8%	36.4%
2036	**MT 16, AADT**	6,272	4,424	8,785
	MT 16, % Trucks	33.4%	27.1%	40.0%
	US 2, AADT	6,507	4,643	9,155
	US 2, % Trucks	31.9%	25.7%	38.3%

4 SUMMARY OF FINDINGS AND CONCLUSIONS

4.1 Summary of Findings

Overall median daily traffic on the MT 16 and US 2 sections of the TRE are projected to double over the next 30 years.

Table 5 illustrates two-lane and four-lane forecasts for the median levels of overall traffic and the percent of that traffic attributable to trucks that is projected to occur over the next 30 years along each highway segment.

Table 5
Growth in Vehicle Traffic and Percent Trucks, Two-Lane and Four-Lane Forecasts

		Two-Lane	Four-Lane
Year	Highway Segment	Median	Median
2006	MT 16, AADT	1,838	1,838
	MT 16, % Trucks	7.6%	7.6%
	US 2, AADT	1,897	1,897
	US 2, % Trucks	6.7%	6.7%
2036	MT 16, AADT	3,597	4,226
	MT 16, % Trucks	31.5%	33.4%
	US 2, AADT	3,739	4,380
	US 2, % Trucks	30.0%	31.9%

The percentage of trucks in overall traffic within the study area corridor is expected to increase from under 10 percent today to over a median level of 30 percent after 2036.

4.2 Conclusions

The MT 16 and US 2 sections of the TRE corridor within Montana are projected to gradually transform into a freight corridor over the next 30 years creating significant vehicular traffic growth, especially in large trucks. The growth in freight volumes traversing the corridor is forecasted to increase steadily over the next 30 years to a point where 30% of the overall vehicle daily traffic is expected to be comprised of large trucks.

Since trucks consume more of a highway's capacity than do passenger vehicles, and various qualities of a roadway affect its potential capacity, detailed analysis is required to determine a roadway's level of service rating, beyond just utilizing traffic counts. Furthermore, the safety

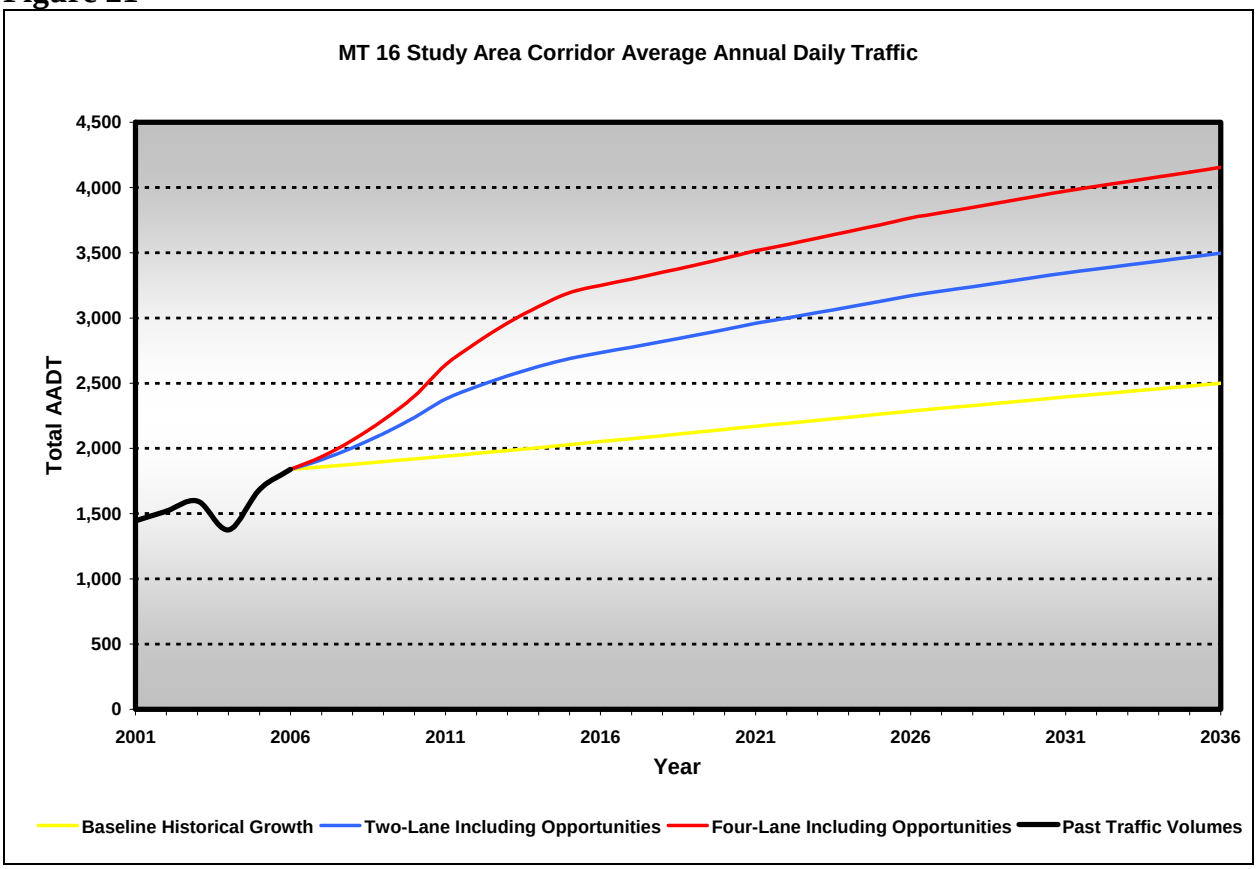
performance of rural two-lane roadways as compared to four-lane rural highways needs to be analyzed to be able to calculate the safety benefits, if any, that would arise from expansion of the study area corridor to four lane capacity.

With these concerns in mind, level of service calculations and an analysis of the safety ramifications of the study area corridor's vehicle growth will be presented, in detail, within a separate document, Working Paper #5.

5 APPENDIX A: TRAFFIC VOLUME FORECAST DECOMPOSITIONS

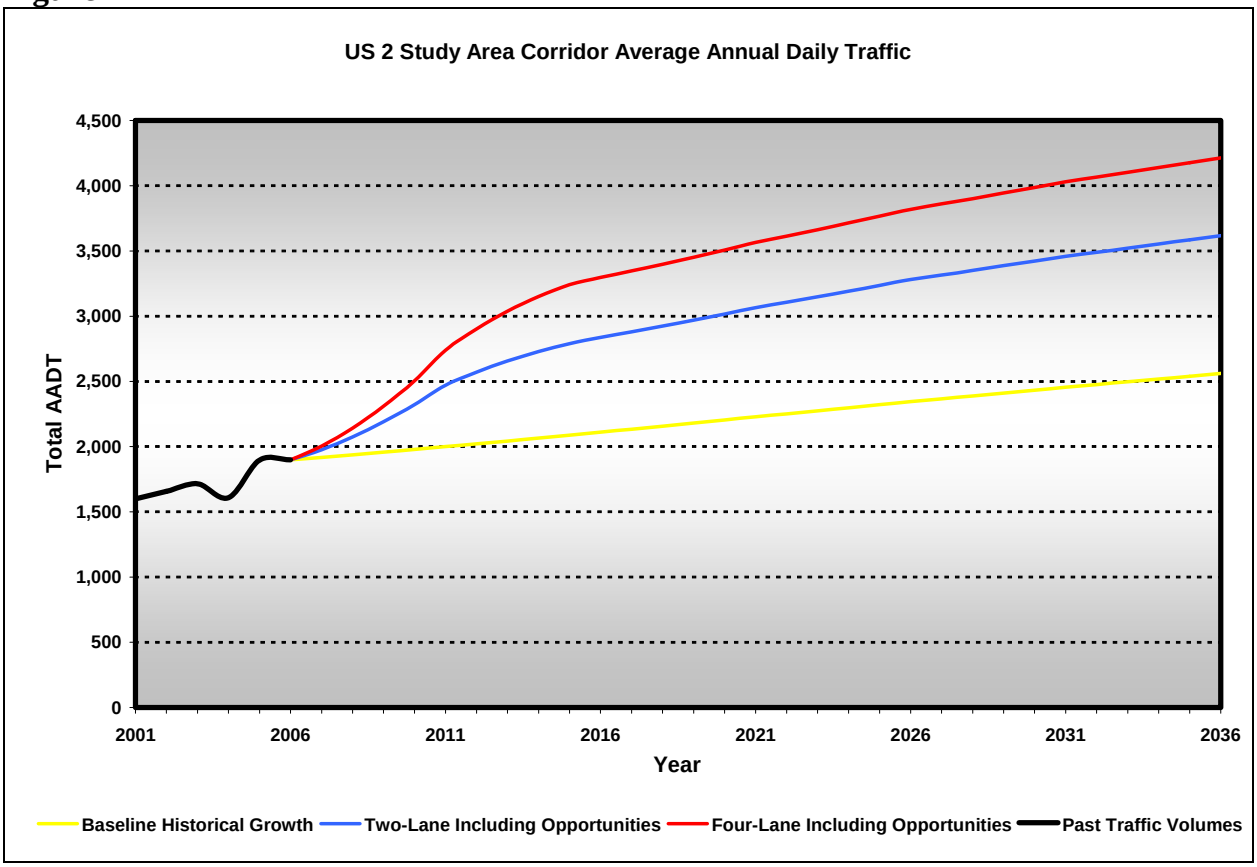
Figures 21 and 22 illustrate the baseline historical growth in traffic volume and forecasts of traffic volumes for both a two-lane and a four-lane corridor. Forecasts shown for the two-lane and four-lane corridor include the baseline historical growth plus traffic growth due to itemized opportunities and additional ADT growth due to opportunities beyond those listed in the opportunity register.

Figure 21



MT 16 AADT Forecasts, Mean Expected Outcomes

Figure 22



US 2 AADT Forecasts, Mean Expected Outcomes

6 REFERENCES

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