Energy Discipline Report

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SR 502 CORRIDOR WIDENING

IMPROVING SAFETY • INCREASING CAPACITY • REDUCING CONGESTION

I-5 TO BATTLE GROUND

FINAL
Energy Discipline Report

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September 2008

Revised February 2009

This project is also referred to as "SR 502/I-5 to Battle Ground – Add Lanes".

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Executive Summary

The purpose of this Executive Summary is to summarize the findings of the Energy Discipline Report for the SR 502 Corridor Widening Project.

What studies, methods and coordination were used to identify existing energy consumption in the study area?

Existing energy consumption was calculated by combining traffic data generated for the project, with vehicular fuel consumption data provided by the Department of Energy, and the Oak Ridge National Laboratory. This produces an estimate of fuel and energy consumption within the project corridor. As energy consumption is closely related to greenhouse gas emissions (GHG), the project's impact on GHG emissions burdens such as CO_2 is also be presented based on the project's effect on fuel consumption.

The Oak Ridge National Laboratory conducts research in energy production and consumption, and its effects.

How were effects to energy consumption determined?

Effects on energy consumption were calculated the same way existing consumption was calculated, but with traffic data modeled for the Build and No Build Alternatives. Energy consumed during construction of the project was calculated by a common method that relates cost of construction to energy expenditure. Overall CO_2 emission burden levels for each alternative were calculated by multiplying a CO_2 emission factor in terms of lbs. of CO_2 emitted per gallon of fuel consumed with the estimated amount of fuel consumed.

What is the existing energy consumption in the study area?

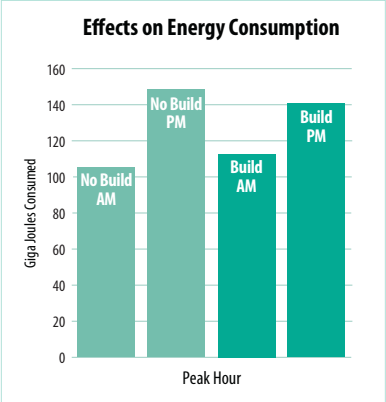
In the morning peak traffic conditions, gasoline consumption is about 389 gallons, equivalent to about 50.6 MBTU or 53.1 giga joules. In the afternoon peak, gasoline consumption is about 538 gallons, equivalent to about 69.9 MBTU or 73.4 giga joules.

What temporary effects to energy consumption would occur?

The consumption of energy during construction can be considered a temporary effect. Construction would consume between 581 and 743 MBTUs, or 610 and 780 giga joules. This represents a negligible portion of the state's overall energy consumption in 2005.

What long-term effects to energy consumption would occur?

Under the Build Alternative, morning peak traffic would consume about 825 gallons of gasoline, equivalent to about 107 MBTU, or 112.5 giga joules. In the PM peak, cars would consume about 1027 gallons, equivalent to about 134 MBTU or 140.7 giga joules. An estimated 16,005 pounds of CO_2 would be generated in the AM Peak. An estimated 19,924 pounds of CO_2 would be generated in the PM Peak.



What would be the effects to energy consumption if the project is not built?

Under the No Build Alternative, morning peak traffic would consume about 770 gallons of fuel, equal to about 100.1 MBTU, or 105.1 giga joules. In the PM Peak, cars would consume approximately 1087 gallons, equivalent to 141.3 MBTU or 148.4 giga joules. An estimated 14,938 lbs of CO_2 would be generated in the AM Peak. An estimated 21,087 lbs of CO_2 would be generated in the PM Peak. This means energy consumption and CO_2 emissions will be about the same whether the project is built or not.

What measures are proposed to minimize or avoid negative effects to energy consumption?

During construction, SR 502 widening would result in the consumption of energy. The total energy that would be consumed is estimated to be between 581 and 743 million BTU. This equates to such a small percentage of the state's overall energy consumption (605 trillion BTU in 2005) that it would not place substantial additional demand on energy sources or fuel availability in the state during the construction period.

The following measure could be taken to avoid and minimize temporary effects to energy:

- Implement traffic management plans that minimize delay and vehicle idling.

Since the project will have no effect on long-term energy consumption, there will be no adverse effects, and no mitigation is necessary.

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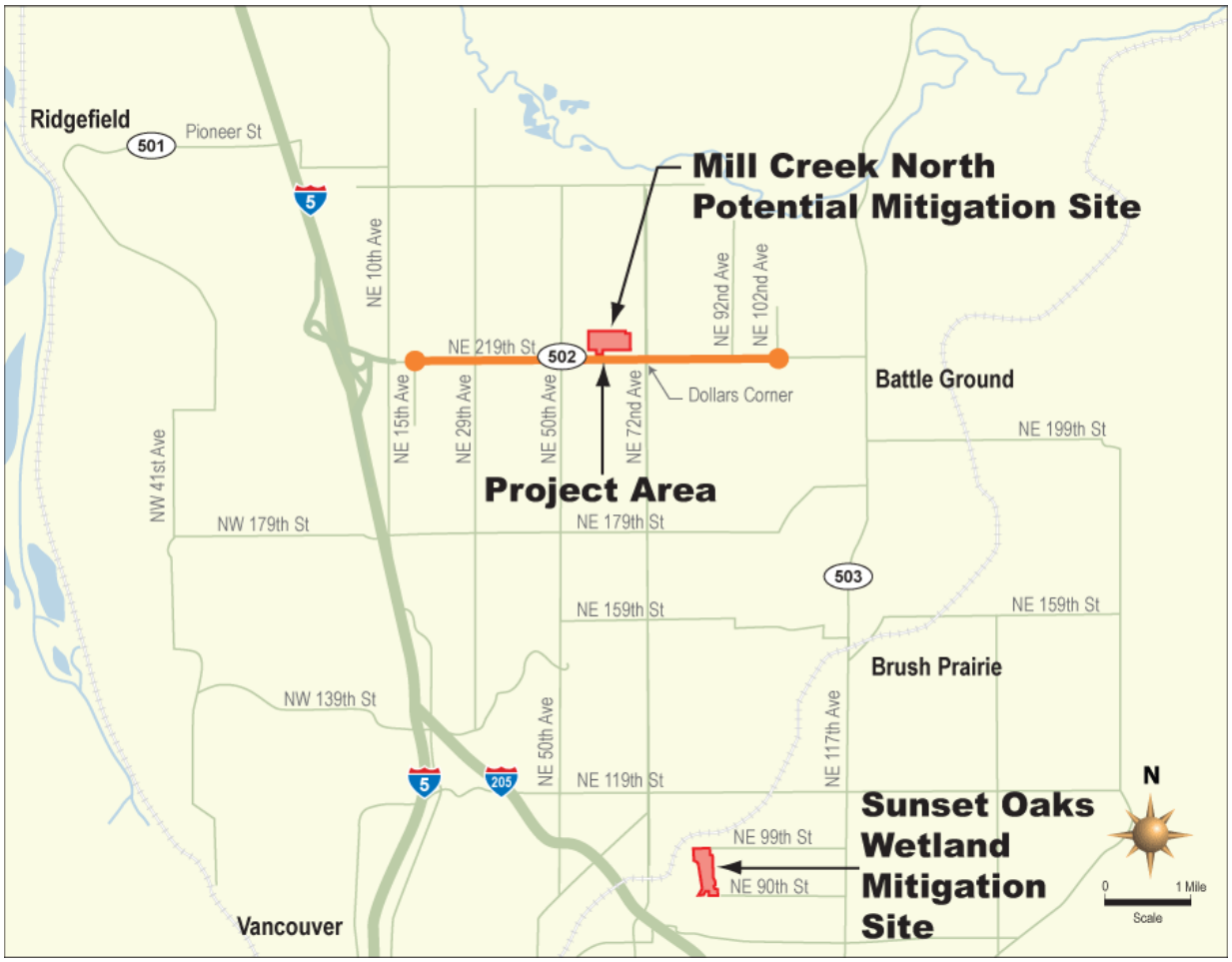
1.0 Introduction

The SR 502 Corridor Widening Project is located in north Clark County, Washington along SR 502 (NE 219th Street) between NE 15th Avenue and NE 102nd Avenue (Exhibit 1). The western terminus of the project area is approximately one mile east of Interstate 5 (I-5) and the eastern terminus is NE 102nd Avenue. The project would widen an approximate five mile segment of SR 502 from two travel lanes to four travel lanes and upgrade several intersections to improve mobility and safety. Currently, SR 502 is a rural, two-lane highway. There is one signalized intersection at SR 502 and NE 72nd Avenue. For a more detailed description of the project, see the separate *Revised Description of Alternatives* document (Parsons Brinckerhoff, 2008b).

Exhibit 1. Vicinity Map



The purpose of this document is to describe the existing energy consumption conditions, discuss effects and benefits the project would have on energy consumption, and identify mitigation measures to address adverse effects as needed. As energy consumption is closely related to greenhouse gas (GHG) emissions, the project's impact on GHG emission burdens will also be presented based on the project's effect on fuel consumption. The information contained in this discipline report will be used to support the project's Environmental Impact Statement (EIS).

Towards that end, the analysis considers operational energy consumption for the existing condition, and the design year (2033). The future-year analyses present Build and No Build calculations. Construction-related energy consumption is not presented for multiple years.

2.0 Background and Methods

2.1 Background

Energy is consumed during the construction and operation of transportation projects. It is used during construction to manufacture materials, transport materials, and operate construction machinery. Energy used during operation includes fuel consumed by vehicles using the roadway, and a negligible amount of energy for signals, lighting, and maintenance. Fuel consumption depends on the vehicle miles traveled (VMT) and travel conditions, such as vehicle type, speed of travel, roadway geometry, and pavement type. Of these variables, studies have shown that speed accounts for most of the variation in energy consumption (Davis and Diegel, 2007).

Common units of energy measurement are joules and British Thermal Units (BTUs). These are relatively small units, so energy is often reported in giga joules (billion joules) and million BTUs (MBTUs). One giga joule is the equivalent of 0.95 MBTUs. Even larger amounts of energy are reported in million MBTUs (Tera BTUs). One gallon of gasoline contains approximately 0.13 MBTUs.

Most energy consumption in the transportation sector is through petroleum. In 2005, transportation within the United States consumed approximately 28,000 Tera BTUs of petroleum and that amount is expected to increase to 39,000 Tera BTUs by 2030 (USDOE, 2006). Gasoline consumption in the United States is projected to increase an average of 1.2 percent annually through 2030.

In addition to the energy directly consumed by vehicles and used for facility operation and maintenance, transportation systems indirectly consume energy. For example, the manufacturing and routine maintenance of vehicles requires energy. Indirect energy consumption would vary little between the alternatives because construction of one alternative rather than another is not expected to affect people’s decisions to purchase new vehicles or have maintenance completed on their current vehicles. Indirect energy consumption includes all forms of energy, as it accounts for manufacturing and maintenance of all resources associated with, but not part of, the facility, such as the tires of cars that drive on SR 502.

Energy is also consumed during project construction. Direct energy consumption includes the energy used to operate construction machinery, provide construction lighting, and produce and transport materials such as asphalt. Indirect energy consumption includes activities such as manufacturing and maintaining construction equipment and the energy consumed by workers commuting to the project site. Because direct one-time energy consumption for roadway projects is much greater than indirect energy consumption and indirect energy consumption is difficult to define, only direct energy consumption is considered in this evaluation (Caltrans, 1983). More of the construction energy consumption is in the form of petroleum than electricity.

2.2 Greenhouse Gases

Gases that trap heat in the atmosphere are often referred to as greenhouse gases (GHG). GHG are necessary to life as we know it because they keep the planet's surface warmer than it otherwise would be. This is referred to as the Greenhouse Effect. As concentrations of greenhouse gases are increasing, however, the Earth's temperature is increasing.

Some GHG, such as carbon dioxide, occur naturally and are emitted to the atmosphere through natural processes and human activities. Other GHG, such as fluorinated gases, are created and emitted solely through human activities.

The principal GHG that enter the atmosphere because of human activities are described below.

2.2.1 Carbon Dioxide (CO2)

Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacturing of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

2.2.2 Methane (CH4)

Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

2.2.3 Nitrous Oxide (N2O)

Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

2.2.4 Fluorinated Gases

Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. These gases are typically emitted in small quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases.

National estimates show that the transportation sector (including on-road, construction, airplanes, and boats) accounts for almost 30 percent of total domestic CO2 emissions.[1] However, in Washington State, transportation accounts for nearly half of greenhouse gas emissions because the state relies heavily on hydropower for electricity generation, unlike other states that rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity. The next largest contributors to total gross GHG emissions in Washington are fossil fuel combustion in the

[1] This percentage is based on 2004 data from the International Energy Administration and is consistent with 1996 guidelines on greenhouse gas emissions calculations issued by the Intergovernmental Panel on Climate Change (IPCC).

residential, commercial, and industrial (RCI) sectors at 20 percent and in electricity generation facilities, also at 20 percent.

GHG differ in their ability to trap heat. For example, one ton of CO_2 emissions have a different effect than one ton of emissions of CH4. To compare emissions of different GHG, inventory compilers use a weighting factor called a "Global Warming Potential" or "GWP." To use a GWP, the heat-trapping ability of one metric ton (1,000 kilograms) of CO_2 is taken as the standard, and emissions are expressed in terms of CO_2 equivalent (CO_2e), but can also be expressed in terms of carbon equivalent. For mobile source analyses based on fossil fuel consumption, CO2 is the predominant greenhouse gas emitted; therefore, this analysis will focus on CO2 emission burdens generated by the project's energy consumption.

2.3 Methods

The analysis of operational energy within the study area is based on the transportation analyses prepared for this project. Net changes in overall energy consumption caused by operation of the alternatives were assessed by using peak hour vehicle miles traveled (VMT) and speed values.

Operational energy consumption is calculated by using average network speed to arrive at a fuel consumption rate (Davis and Diegel, 2007), and multiplying that rate by VMT. The fuel consumption rate is the inverse of fuel economy (i.e. 20 miles per gallon = 0.05 gallons per mile). The data used in this analysis is based on 1997 light duty vehicles (Davis and Diegel, 2003: Table 4-24). Note that the average network speed in the AM or PM Peak is the average of speed in each direction. Thus, the value reflects congested, slow-moving traffic in the corridor. This means that estimated energy consumption is over-stated, but because the same method is used throughout the analysis, the comparisons of any relative increase or decrease is valid. For this study, the network is defined as the portion of SR 502 between NE 15th Avenue and NE 102nd Avenue. It does not include any adjacent streets.

VMT multiplied by the fuel consumption rate produces a value in gallons of fuel consumed. That value is then converted into giga joules and MBTUs to create the data presented here. Because traffic data are presented by AM and PM peak hours, the energy consumption described in the results below is presented as energy consumption for each peak hour only. These values are only approximate for each alternative, and do not include the minimal energy used for facility maintenance and signal operation. However, this method provides a good basis for comparing the alternatives. Overall CO_2 emission burden levels for each alternative were calculated by multiplying a CO_2 emission factor in terms of pounds of CO_2 emitted per gallon of fuel consumed with the estimated amount of fuel consumed.

The construction-related energy consumption required to complete a project is proportional to the project size and the nature of the work involved. For projects of a specific type, the energy required for construction is proportional to the project cost, as the project cost is directly related to the project size. As a result, energy consumption for a specific project can be expressed as a function of cost and type. Caltrans has developed construction energy factors that were related to 1977 construction dollars (Caltrans, 1983). The U. S. Department of Labor (USDOL) tracks a price index for highway and street construction (USDOL, 2002). Using the highway and street construction price index, the energy factors can be referenced to year 2002 dollars (Exhibit 2).

Exhibit 2. Construction Energy Consumption Factors (2002 Dollars)

Facility Type	Factor (MBTU / thousand dollars)
Rural Freeway	26.5
Rural Conventional Highway	25.2
Rural Freeway Widen	16.5
Rural Conventional Highway Widen	17.8
Urban Freeway	10.5
Urban Conventional Highway	9.6
Urban Freeway Widen	9.4
Urban Conventional Highway Widen	8.9
Interchange	26.8

These construction energy consumption factors represent a simplified relationship between project size and energy consumption. The results obtained from their use are not exact, but provide a basis of comparison between alternatives. The Build Alternatives fall into the Rural Freeway Widen category and the approximate construction energy consumption factor for this category (adjusted to year 2002 construction cost dollars) is 16.5 MBTUs per thousand 2002 dollars of construction cost. Thus, the product of construction cost and 16.5 represents an estimate of energy consumption during construction (Exhibit 2).

3.0 Affected Environment

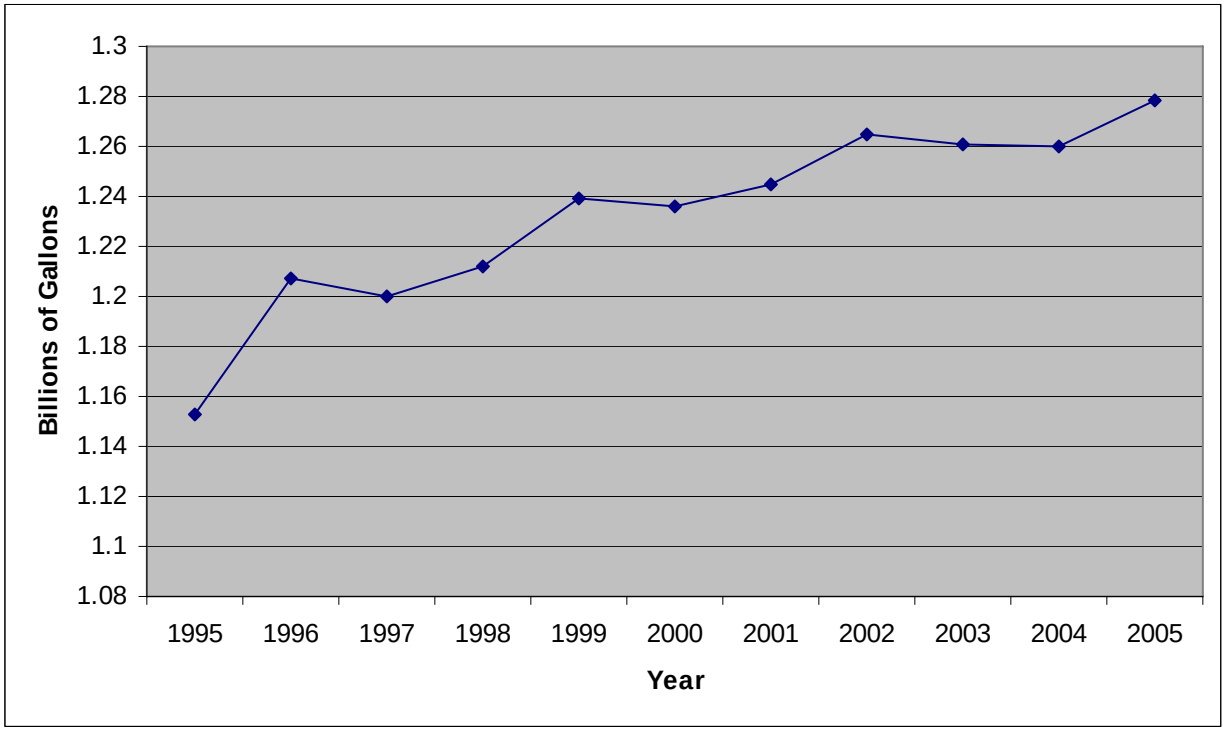
This section describes the affected environment, or existing conditions, within the study area.

3.1 Existing Energy Consumption

In 2005, petroleum use in Washington State accounted for approximately 41 percent of all energy consumption (USDOE, 2005). Approximately 40 percent of petroleum use is for motor vehicle fuel. Also in 2005, approximately 1.28 billion gallons of fuel were consumed by motor vehicles in Washington State. Total statewide annual energy consumption was 605 trillion BTUs in 2005 (USDOE, 2005).

Exhibit 3 illustrates gasoline consumption in Washington State between 1995 and 2005. It shows a trend of increasing consumption, beginning to flatten out approximately in 2002.

Exhibit 3. Gasoline Consumption in Washington - 1995 to 2005.



Existing operational energy consumption in the corridor is analyzed by the method described above, with existing VMT (existing year) and average network speed. These data are summarized in Exhibit 4.

Exhibit 4. Existing Traffic Conditions in the Project Corridor.

Measures of Effectiveness			Existing
Average Speed (mph)	Eastbound	AM Peak	42
		PM Peak	26
	Westbound	AM Peak	37
		PM Peak	31
Travel Distance (VMT)		AM Peak	12,040.4
		PM Peak	17,082.4

With an average speed of 39.5 mph (and a fuel consumption rate (FCR) of 0.0323), gasoline consumption at the AM peak is 389 gallons, equivalent to about 50.6 MBTU or 53.1 giga joules. In the PM peak the average speed is 28.5 mph (FCR = 0.0315). This means gasoline consumption in the PM peak is 538 gallons, equivalent to about 69.9 MBTU or 73.4 giga joules.

4.0 Effects and Benefits

This section identifies potential effects and benefits to energy associated with the No Build Alternative and the Build Alternative. Effects and benefits are discussed in terms of temporary

effects associated with construction activities, and long-term effects associated with the operation and maintenance of the facility or permanent changes resulting from the project. Indirect and cumulative effects of the project are documented in a separate report, *Final Indirect Effects and Cumulative Effects Discipline Report* (Parsons Brinckerhoff, 2008a).

4.1 Temporary Effects and Benefits

4.1.1 No Build Alternative

Under the No Build, the project would not be built, and there would be no temporary energy consumption as a result of the project.

4.1.2 Build Alternative

The consumption of energy during construction can be considered a temporary effect. As described in Section 2.3 above, construction–related energy consumption is correlated with the cost of the project. The appropriate category in Exhibit 2 for this project is "Rural Highway Widen." Therefore, energy consumption is estimated at 16.5 MBTU per thousand dollars spent. The project is estimated to cost between $45.6 and $58.3 million in 2012 dollars. This equals between approximately $35.2 and $45.0 million in 2002 dollars (Sahr, 2008). Following the method described in Section 2.2, this results in 581 MBTU, or 610 giga joules on the low end, and 743 MBTU or 780 giga joules on the high end.

4.2 Long Term Effects and Benefits

4.2.1 No Build Alternative

Under the No Build Alternative, SR 502 would not be widened, but all other improvements would be made as identified in various planning documents. Nonetheless, VMT would increase 56 percent from the existing AM Peak of 12,040 to 18,760 VMT. With an average speed of 14.5 mph (FCR = 0.0410), about 770 gallons of fuel would be consumed, equal to about 100.1 MBTU, or 105.1 giga joules. An estimated 14,938 pounds of CO_2 would be generated in the AM Peak. In the PM Peak, VMT would increase 18 percent, from 17,082 to 20,205 VMT. With an average speed of 9.5 mph (FCR = 0.0538) under the 2033 No Build Alternative, cars would consume approximately 1087 gallons, or 141.3 MBTU (148.4 giga joules), during the PM peak. An estimated 21,087 pounds of CO_2 would be generated in the PM Peak. Exhibit 5 lists these traffic data. These increases in fuel consumption represent about a 100 percent increase over existing energy consumption in both the AM and PM peak .

Exhibit 5. Traffic Data Under the 2033 No Build Alternative.

Measures of Effectiveness			2033 No Build
Average Speed (mph)	Eastbound	AM Peak	15
		PM Peak	9
	Westbound	AM Peak	14
		PM Peak	10
Travel Distance (VMT)		AM Peak	18,760.2
		PM Peak	20,205.2

4.2.2 Build Alternative

Under the Build Alternative, SR 502 would be widened to five lanes to relieve congestion. Traffic modeling (Exhibit 6) indicates that there would an increase in VMT from 18,760 under the No Build Alternative to 25,166 under the Build Alternative in the AM Peak, and an increase from 20,205 to 31,316 VMT in the PM Peak. Although VMT would be higher, so would the average speed on the facility. For the AM Peak, average speed would be 26 mph (FCR = 0.0328). This would consume about 825 gallons, equivalent to about 107 MBTU, or 112.5 giga joules. An estimated 16,005 pounds of CO2 would be generated in the AM Peak. For the PM peak, average speed would be 27.5 mph (FCR = 0.0328). This would consume about 1027 gallons, equivalent to about 134 MBTU, or 140.7 giga joules. An estimated 19,924 pounds of CO2 would be generated in the PM Peak.

Exhibit 6. Traffic Data Under the 2033 Build Alternative

Measures of Effectiveness			2033 Build
Average Speed (mph)	Eastbound	AM Peak	27
		PM Peak	24
	Westbound	AM Peak	25
		PM Peak	31
Travel Distance (VMT)		AM Peak	25,165.6
		PM Peak	31,315.5

This analysis shows no change in energy consumption between the Build Alternative and the No Build Alternative (Exhibit 7). During the AM Peak, there would be a slight increase (770 gallons to 825) and during the PM peak there would be a slight decrease (1087 gallons to 1027).. Owing to the increase in average speed under the 2033 Build Alternative, GHG emission burdens would reflect similar changes.

Exhibit 7. Summary Data for SR 502 Energy Consumption

Measures of Effectiveness			Existing	2033 No Build	2033 Build
Average Speed (mph)	Eastbound	AM Peak	42	15	27
		PM Peak	26	9	24
	Westbound	AM Peak	37	14	25
		PM Peak	31	10	31
Travel Distance (VMT)		AM Peak	12,040.4	18,760.2	25,165.6
		PM Peak	17,082.4	20,205.2	31,315.5
Fuel Consumption (gallons)		AM Peak	389	770	825
		PM Peak	538	1087	1027

5.0 Mitigation

This section discusses potential mitigation measures that could be used to avoid or minimize energy effects. Potential mitigation measures are discussed for the temporary effects and the long-term effects of the Build Alternative only.

5.1 Mitigation for Temporary Effects

During construction, SR 502 widening would result in the consumption of energy to manufacture and transport materials, as well as operate construction equipment. The total energy that would be consumed is estimated between 581 and 743 Million BTU. This equates to such a small percentage of the State's overall energy consumption (605 trillion BTU in 2005) that it would not place substantial additional demand on energy sources or fuel availability in the state during the construction period.

The following measure could be taken to avoid and minimize temporary effects to energy:

- Implement traffic management plans that minimize delay and vehicle idling.

5.2 Mitigation for Long-Term Effects

Since the project will have no effect on long-term energy consumption, there will be no adverse effects, and therefore, no mitigation is necessary.

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