Appendix H
Economic Impact Analysis

1. Introduction

Situated northeast of the City of Houston, Texas, the proposed Grand Parkway Segments H and I-1 will result in economic implications for the counties in proximity to the highway[1]. Economic impacts to those counties stem from changes in travel patterns and costs, and from expenditure-related activities on the facility. Such implications are quantifiably estimated (where possible) through an application of various modeling processes, including a travel demand model and an applied economic impact model.

Three economic components of the Grand Parkway Segments H and I-1 facility are assessed, and the region-specific and statewide results are presented, by component and in aggregate, for:

1. Construction expenditures;
2. Operations and Maintenance and Lifecycle expenditures; and,
3. Changes in travel demand characteristics (i.e., travel efficiencies), and toll charges accruing to area businesses and households.

Modeling results indicate that the proposed Grand Parkway Segments H and I-1 is anticipated to yield net positive aggregate economic impacts to the analyzed Houston Region and the State of Texas over the cumulative analysis horizon spanning 2016 through 2039, as measured in terms of economic activity (or, value added) and employment (in job-years).

Presented herein is a description of the methodology applied and the estimated economic impacts derived from the process.

2. Economic Impact Analysis Methodology

Generally accepted methods for estimating the expenditures- and travel efficiency-based economic impacts of highway investments are the basis for this analysis. Economic impacts resulting from changes to transportation infrastructure or transportation policy are quantifiable with the assistance of various software tools, which widely range in complexity and capabilities, from simplistic (e.g., static multiplier spreadsheets) to complex (e.g., dynamic econometric general-equilibrium models). In this economic impact analysis of the Grand Parkway Segments H and I-1, the REMI®[2] model is employed, with certain input variables calculated from travel demand modeling, engineering estimates, etc.

---

[1] Analyzed study area pertains to a four-county Houston Region that includes: Chamber, Harris, Liberty, and Montgomery Counties. A study area map is included in **Appendix A**.

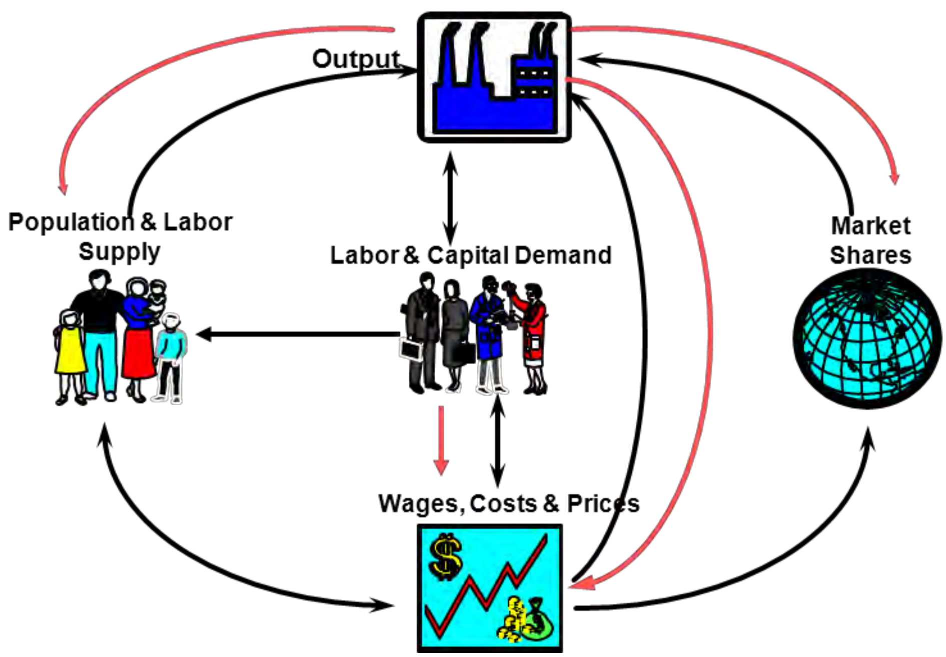
[2] REMI® Policy Insight + v.1.3 was used as the modeling tool in this evaluation.

2.1. REMI® Model Overview

Developed by Regional Economic Models, Inc., REMI® is a generalized, dynamic economic impact model that can simulate myriad policy changes to a defined economic geography, including transportation projects. It produces standardized impact metrics as annualized results over a forecast analysis horizon. REMI® and the standardized economic impact metrics are further described below, followed by an outline of the impact analysis inputs and general modeling process.

REMI® is a dynamic forecasting tool that combines input-output econometric modeling with economic geography. It is designed for modeling economic impacts of infrastructure and/or policy changes by identifying the interrelationships and ensuing impacts within five major block sectors[3] of the economy, through simultaneous equations reflecting the dynamic feedback effects of each sector on the others. The five-sector inter-linkages of the REMI® model are shown graphically below in **Exhibit 1**. Of these, output and population/labor supply are the primary drivers for this analysis, with the other three sectors reflecting resultant changes.

Exhibit 1: Economic Sectors in the REMI® Model*



Source: REMI, Inc.

REMI® is especially well-equipped to model the economic impacts of transportation investments, since it is both integrated and dynamic in nature. It is dynamic in that it

[3] Specifically: 1) output; 2) population and labor supply; 3) labor and capital demand; 4) wages, costs, and prices; and, 5) market shares.

simulates the interactions among the five block sectors by estimating substitution among production factors and uses built-in iterative feedback mechanisms to model sector linkages. REMI® is appropriate for analyzing the statewide and regional economic impacts of the proposed improvements because the model accounts for how relationships between prices, costs of doing business, and demographic variables interact with other economic variables such as employment, gross regional product, and others to influence economic performance.

All three of the analyzed Grand Parkway Segments H and I-1 components run through the REMI® modules, with the respective processes outlined in the following subsections. All three components are applied to the same modules simultaneously (though through different policy variables within the model) to determine the interactive dynamic cumulative effect; however, the results are then subdivided per component input to indicate a relative compositional breakdown.

2.2. Economic Impact Metrics

Economic impacts are calculated and presented in terms of standardized metrics: economic value-added (or, gross regional product), and annual employment.

Economic value-added is the monetary measure of the net additional economic activity (i.e., total output less gross intermediate inputs) in a defined economic region, synonymous with GRP (gross regional product) or GSP (Gross State Product). It includes employee and proprietor income, other income types, taxes, etc., required in the production of final goods and services.

Employment measures the human labor expended in the production of final goods and services within the regional economy. Employment impacts are presented in job-year terms[4] and, consequently, cumulative employment impacts over an analysis period (i.e., multiple years) do not necessarily reflect the total number of individually-employed persons. A job-year metric is a measure for standardizing human labor requirements for economic production while dismissing the difficulties of discerning the exact individual person-employment impacts.

All economic value-added impacts are presented in constant 2012 dollars, rounded to the nearest ten thousand; while employment impacts are rounded to the nearest ten job-years.

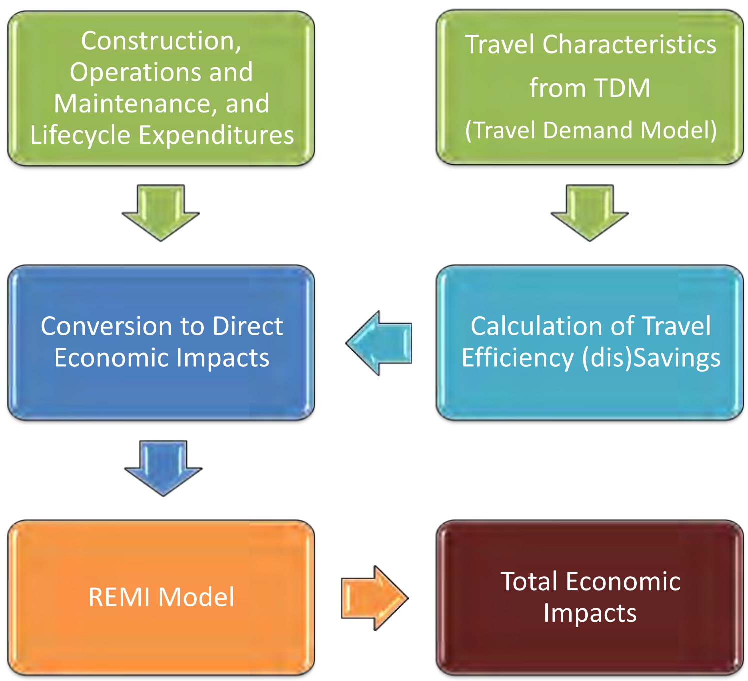
2.3. General Modeling Process

In a transportation-related economic impact analysis, the intention is to isolate the economic consequences of only one transportation change (infrastructure or policy), all else equal, which is conducted via a comparison of a *build* scenario relative to a *baseline/no-build* scenario. Comparing the scenarios identifies the incremental difference,

[4] A full-time equivalent (FTE) employment position over a one-year duration, or 2,080 labor-hours.

and provides a mechanism for determining the incremental impact stemming from the changed factor. In this analysis, the *build* scenario pertains to the Grand Parkway Segments H and I-1 facility commencing operations in 2019, following the construction phase (2016 through 2018), and with the lifecycle-, operations- and maintenance-related activities, as wells as tolling and travel efficiency changes occurring and analyzed through 2039. As a comparison, the *no-build* scenario is in reference to the absence of Grand Parkway Segments H and I-1/tolling, with roadway conditions remaining maintained to current standards, dismissive of the actual funding source acquired to maintain that standard (i.e., status quo). As such, the modeling inputs applied herein pertain to the characteristic differences between these two scenarios, and are translated into direct economic impacts, which with the aid of REMI®, are expanded into total economic impacts (see **Exhibit 2** for a visual representation of the process).

Exhibit 2: General Modeling Process Flow Summary



2.4. Expenditure-Based Modeling Component

Provided with incremental expenditure inputs (relative to the *baseline* scenario) and an assumed expenditure schedule and categorization, total regional impacts are derived by applying those respective direct expenditures, in the appropriate years, to the corresponding industry sectors within the model's economic structure. All input expenditure data are run through the internal social account matrix (that is, accounting for regional economic interdependencies) to determine how those initial direct expenditures flow through the regional economy and are translated into total impacts.

Industry-specific expenditures (i.e., roadway construction, operations and maintenance, and lifecycle) are initially spent within the defined region, and those direct expenditures then circulate throughout the region causing an economic ripple effect. Spending and the circulation of industry-specific expenditures result in direct, indirect, and induced economic impacts.

Direct impacts affect only the specific industry in which expenditures are spent, i.e., the direct impacts from highway construction expenditures occur only within the highway construction industry.

Indirect and induced impacts, commonly referred to as multiplier impacts, occur in all other applicable industries within the defined region. Purchases of intermediate production inputs (goods and services) by the construction industry from suppliers, and the intermediate production purchases by those suppliers, in turn, of goods and services from other industries create the indirect impacts. Induced impacts are the result of purchases by employees and proprietors with earned labor income received from the directly and indirectly impacted industries.

Total economic impacts are the cumulative direct, indirect, and induced impacts. REMI® only presents total impacts.

Incremental expenditures and spending schedule assumptions, serving as economic modeling inputs for the expenditure-based component of this analysis, were internally derived by the Consultant team and are presented below in **Exhibit 3**.

Exhibit 3: Expenditures Schedule (increments by category), in 2012$

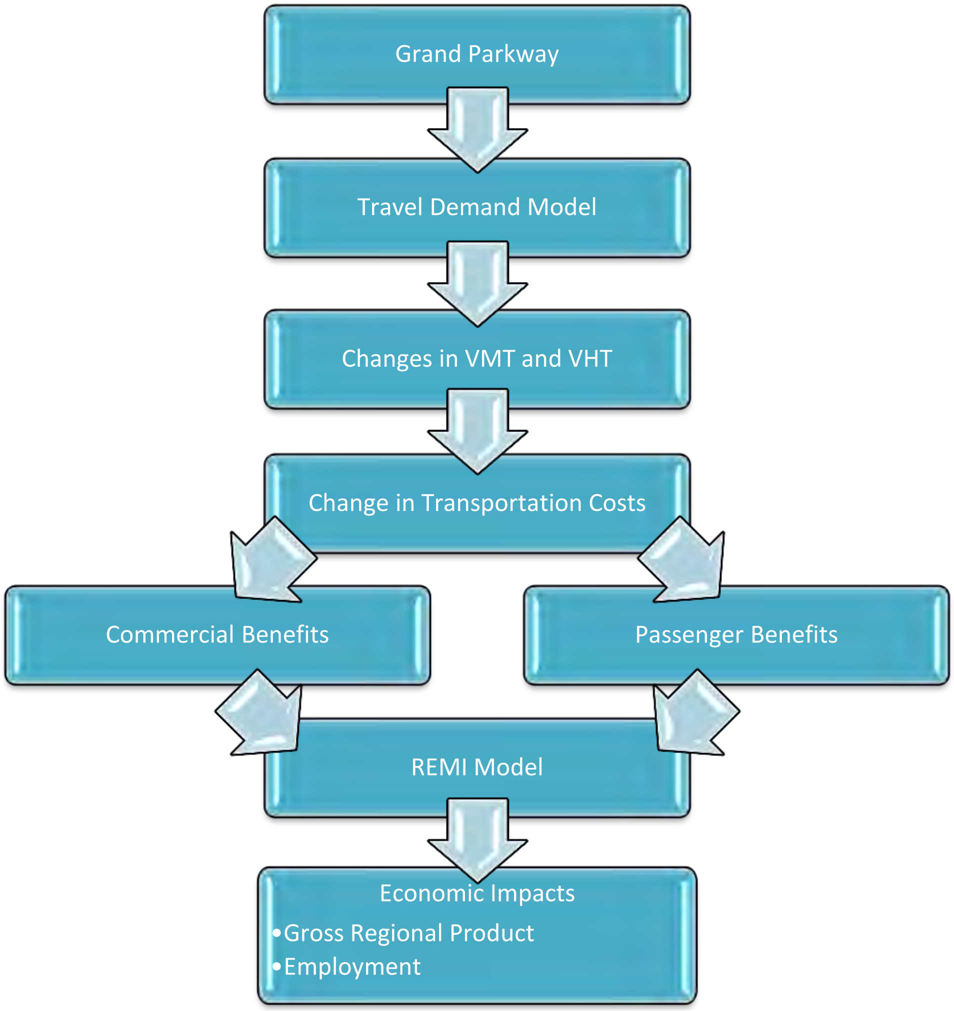
Year	Construction	O&M	Life Cycle	Total
2016	$ 267,180,000	$ -	$ -	$ 267,180,000
2017	$ 267,180,000	$ -	$ -	$ 267,180,000
2018	$ 267,180,000	$ -	$ -	$ 267,180,000
2019	$ -	$ 6,600,000	$ 1,550,000	$ 8,140,000
2020	$ -	$ 7,430,000	$ 1,760,000	$ 9,190,000
2021	$ -	$ 7,950,000	$ 2,750,000	$ 10,710,000
2022	$ -	$ 9,110,000	$ 2,050,000	$ 11,160,000
2023	$ -	$ 8,210,000	$ 2,000,000	$ 10,210,000
2024	$ -	$ 9,280,000	$ 3,000,000	$ 12,280,000
2025	$ -	$ 9,570,000	$ 2,050,000	$ 11,620,000
2026	$ -	$ 9,760,000	$ 2,080,000	$ 11,840,000
2027	$ -	$ 9,950,000	$ 2,770,000	$ 12,720,000
2028	$ -	$ 10,230,000	$ 9,080,000	$ 19,300,000
2029	$ -	$ 9,820,000	$ 3,970,000	$ 13,790,000
2030	$ -	$ 10,010,000	$ 4,460,000	$ 14,470,000
2031	$ -	$ 10,210,000	$ 3,490,000	$ 13,700,000
2032	$ -	$ 10,430,000	$ 3,540,000	$ 13,970,000
2033	$ -	$ 10,660,000	$ 7,180,000	$ 17,840,000
2034	$ -	$ 12,390,000	$ 5,800,000	$ 18,190,000
2035	$ -	$ 11,900,000	$ 5,310,000	$ 17,210,000
2036	$ -	$ 12,030,000	$ 6,280,000	$ 18,310,000
2037	$ -	$ 12,160,000	$ 5,360,000	$ 17,520,000
2038	$ -	$ 12,300,000	$ 16,340,000	$ 28,650,000
2039	$ -	$ 12,440,000	$ 6,850,000	$ 19,300,000
Total	$801,540,000	$212,450,000	$97,660,000	$1,111,650,000

Source: Summary of Atkins' Data
*note: rounded to the nearest ten thousand -- totals may not sum due to the rounding

2.5. Travel Efficiencies Modeling Component

Efficiencies (or inefficiencies) in travel accrue as a result of changes in travel demand characteristics following a transportation infrastructure or policy change. Differences in such demand characteristics are measured by metrics such as vehicle-miles travelled (VMT), vehicle-hours travelled (VHT), the number of trips made, congestion factors, vehicle-occupancy rates, average travel speeds, etc. Any such characteristic changes are identified via regional travel demand modeling (TDM). Such changes potentially result in various types of travel efficiency benefits (or dis-benefits), which include: travel-time, vehicle-operating, and safety/accident cost (dis)savings, etc. A generalized depiction of such process is provided below in **Exhibit 4**.

Exhibit 4: Travel Efficiencies Modeling Process Flow Summary



Direct travel efficiencies are modeled for each vehicle category/trip purpose separately because of the distinct demand characteristics of each and underlying assumptions. Two vehicle categories are analyzed herein: passenger vehicles and commercial vehicles. Passenger-vehicle transportation is further subcategorized into three separate trip purposes: business trips, commuting trips to/from places of employment, and personal or recreational trips (inclusive of other, undefined trip purposes). Again, this categorization and separate modeling is conducted because of the different parameters of each purpose.

Business trips refer to on-the-clock conference/meeting travel or any other business purposes, excluding commuting. *Commuting trips* refer to traveling between residences and employment locations. *Personal/recreational trips* refer to shopping, vacations, visiting friends and family, rest and relaxation, outdoor recreation, and other discretionary trip purposes unrelated to business or economically-productive activities.

2.5.1 Travel-Time Cost Savings

Travel-time cost (dis)savings accrue to drivers, passengers, crew, and cargo when transportation developments result in a reduction (or increase) in total vehicle-hours travelled. Changes in VHT are monetized by applying the respective values of time for the drivers, passengers, crew, and cargo, per trip purpose, resulting in direct travel-time cost savings. Vehicle-occupancy rates are also a factor, as the metric converts VHT changes into changes in person-hours travelled, such that the respective values of time per person can be applied. Prevailing wage rates serve as a proxy for the value of time for the different trip purposes. Drivers and crew for commercial vehicles are applied a value of time based on the prevailing wage rate for the truck transportation industry.

Regarding commercial vehicles, travel-time cost savings accrue not only to the drivers and crew, but to the freight itself, measured as the relative cost of a late delivery or the incremental cost required to stock additional inventory per hour. In accounting for freight savings, the average tonnage per commercial vehicle and the average freight value of time[5] serve as additional inputs for that specific vehicle category.

Allocating the direct travel-time cost savings to economic entities (industries, households, etc.) and applying such data through the regionally-specific multipliers in the model, the total economic impacts are thus calculated.

2.5.2 Vehicle-Operating Cost Savings

Vehicle-operating costs are vehicle expenditures, comprised of a fuel component and a non-fuel component (e.g., routine maintenance, vehicle depreciation, etc.). Vehicle-operating cost (dis)savings are primarily a function of changes in vehicle-miles travelled, obtained from travel demand modeling.

Changes in VMT, multiplied by the respective vehicle-operating costs per mile, per each trip purpose, lead to derivations of the direct vehicle-operating cost savings. As with travel-time cost savings, the direct vehicle-operating cost savings are applied to the appropriate economic entities in the model and run through the impact multipliers to ascertain the total economic impact stemming from this savings category.

2.5.3 Accident Cost Savings

Safety (accident) cost (dis)savings are primarily a function of changes in vehicle-miles travelled as well. However, the savings are also a function of changing accidents rates.

Safety/accident costs savings are comprised of accident subcategories, categorically adhering to the KABCO scale (as designated within police incidence reports on observed severity of accidents): killed/fatalities, incapacitating injuries, non-incapacitating injuries,

[5] Based on HERS methodology and average freight values (2002 CFS), inflation-adjusted.

possible injuries, and no injuries/property damage accidents. In accounting for these subcategories, respective costs assumptions are incorporated, per each accident type, within the impact calculation and applied to assumptions pertaining to the accident rates per VMT[6]. Changes in VMT and/or accident rates following the Grand Parkway Segments H and I-1 implementation result in total accident changes, per accident category. Costs per accident are applied to the accident changes resultant of VMT and accident rate changes, to calculate the direct accident cost savings. Allocated to the appropriate economic entities in the model, the direct accident costs savings are then translated into total economic impacts from this savings category.

2.5.4 Travel Efficiencies – Modeling Inputs and Phase-In

Various travel demand characteristics necessary for deriving travel efficiencies are obtained from the other tasks in the study (travel demand modeling). Differentials in the three major travel demand characteristic variables: vehicle-hours travelled, vehicle-miles travelled, and trips, between the *build* and the *baseline/no-build* scenarios and converted into monetary terms via application of the modeling assumptions, serve as the primary inputs into the REMI® model. Key relevant inputs obtained from the regional travel demand model output are shown in **Exhibit 5**.

[6] Source: H-GAC's processing of TXDOT CRIS accident database.

Exhibit 5: Travel Demand Model Output Summary (average daily terms)

	2019	2039
Vehicle Miles Travelled (VMT) - Four-County Network		
No Build (E+C) Scenario		
Passenger Occupied Vehicles (POV)	123,936,665	185,960,851
Commercial Vehicles (CV)	15,004,923	21,989,898
Total	*138,941,588*	*207,950,748*
Build Scenario		
Passenger Occupied Vehicles (POV)	124,101,420	186,047,239
Commercial Vehicles (CV)	15,036,983	22,073,992
Total	*139,138,403*	*208,121,231*
Differential (Build less No Build)		
Passenger Occupied Vehicles (POV)	164,755	86,389
Commercial Vehicles (CV)	32,060	84,094
Total	*196,814*	*170,483*
Vehicle Miles Travelled (VMT) - Grand Parkway Segments H and I-1		
Build Scenario		
Passenger Occupied Vehicles (POV)	263,172	658,960
Commercial Vehicles (CV)	160,895	422,009
Total	*424,067*	*1,080,968*
Vehicle Hours Travelled (VHT) - Four-County Network		
No Build (E+C) Scenario		
Passenger Occupied Vehicles (POV)	3,176,878	7,678,337
Commercial Vehicles (CV)	342,078	754,572
Total	*3,518,956*	*8,432,909*
Build Scenario		
Passenger Occupied Vehicles (POV)	3,176,958	7,557,360
Commercial Vehicles (CV)	341,474	737,149
Total	*3,518,432*	*8,294,509*
Differential (Build less No Build)		
Passenger Occupied Vehicles (POV)	80	-120,977
Commercial Vehicles (CV)	-604	-17,422
Total	*-524*	*-138,400*
Vehicle Trips (Total) - Four-County Network		
No Build (E+C) and Build Scenario		
Passenger Occupied Vehicles (POV)	16,090,252	22,461,090
Commercial Vehicles (CV)	1,169,678	1,608,449
Total	*17,259,930*	*24,069,539*

Base and horizon years are evaluated in calculating the monetized equivalent of the difference in the travel demand characteristics between the *build* and the *baseline/no-build* scenarios. Such analysis years correspond to the years available from the travel demand modeling, i.e., 2019 and 2039. Monetized direct travel efficiency (dis)benefits are, in turn, estimated for those respective years, with all other years interpolated, or scaled, for the analyzed subcomponent. With an annualized series of monetized direct (dis)benefits stemming from the travel efficiency-related components, those annualized data are input into the REMI® model for the appropriate constituent modeling policy variables.

2.6. Tolling Imposition Modeling Component

Tolling charges are out-of-pocket expenses for regional entities that increase the total cost of travel, resulting in negative economic implications. REMI® derives the economic impacts of tolling within the same policy variable cost module as travel efficiencies, as both components are recognized and quantified in terms of travel cost (dis)savings.

Economic impacts relating to tolling accrue to geographies based on the origination of the tolled trip; therefore, only the tolled trips with an origin in the modeled region were applied to derive the economic implications on the region. All tolled trips with origins located beyond the region result in out-of-pocket costs for users based outside the region; as such, the impacts ensuing from those costs would correspondingly occur outside the region. As tolls are imposed on the Grand Parkway Segments H and I-1, a portion of the total toll costs are thus exported in proportion to the percentage of trips originating beyond the regional boundaries (and thus, not calculated here, as the economic and travel demand modeling are only regional in focus). Inputs for tolling are based on travel demand modeling (applicable Grand Parkway Segments H and I-1 VMTs, and origin-destination percentages) and tolling charges per mile traveled.

2.7. Assumptions

Inputs related to transportation improvements resulting in travel efficiencies and other pertinent changes modeled within the REMI® model required a number of assumptions. For instance, unit time values, vehicle operating costs, accident rates, vehicle occupancy rates, etc., by vehicle type (auto vs. truck) and trip purpose (work versus personal) were compiled from numerous sources and consultant experiences. These various other input assumptions are summarized in **Exhibit 6**.

Exhibit 6: Key Input Assumptions for Impacts Calculations

Assumption/Parameter	Terms	Applied Value	Sources
General Travel Characteristics			
Vehicle Occupancy Rates			
Passenger Occupied Vehicles (POV)			
Recreation/Other (Personal)	persons/vehicle	2.20	USDOT FHWA, Work Zone Road User Costs - Concepts and Applications
Commuting	persons/vehicle	1.13	USDOT FHWA, Work Zone Road User Costs - Concepts and Applications
Business/Work	persons/vehicle	1.24	USDOT FHWA, Work Zone Road User Costs - Concepts and Applications
Commercial Vehicles (CV)			
Operating Crew	persons/vehicle	1.12	USDOT FHWA, Work Zone Road User Costs - Concepts and Applications
Logistics/Freight	tons/vehicle	8.6	2009 Pocket Guide to Transportation, BTS; Tables 4-1 and 4-4
Trip Purpose Allocation			
Passenger Occupied Vehicles (POV)			
Recreation/Other (Personal)	percent	73.8%	2009 National Household Travel Survey
Commuting	percent	20.3%	2010 National Household Travel Survey
Business/Work	percent	5.9%	2011 National Household Travel Survey
Annualization Factors			
Passenger Occupied Vehicles (POV)			
Recreation/Other (Personal)	days/year	365	CDM Smith
Commuting	days/year	260	CDM Smith
Business/Work	days/year	300	CDM Smith
Commercial Vehicles (CV)	days/year	300	CDM Smith
Workday to Weekday	percent	95.1%	TxDOT, Average Daily Traffic Volumes by day of week and month for 2009, Houston Report
Travel Time Component			
Values of Travel Time			
Passenger Occupied Vehicles (POV)			
Recreation/Other (Personal)	*2009$/person-hour*	$12.00	Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2011
Commuting	*2009$/person-hour*	$22.90	Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2011
Business/Work	*2009$/person-hour*	$12.50	Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2011
Commercial Vehicles (CV)			
Operating Crew	*2009$/person-hour*	$24.70	Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2011
Logistics/Freight	*2011$/ton-hour*	$2.00	CDM Smith
Vehicle Operating Cost Component			
Vehicle Operating Costs			
Passenger Occupied Vehicles (POV)	2012$/mi.	$0.60	AAA Your Driving Costs 2012
Commercial Vehicles (CV)	2011$/mi.	$0.95	ATRI: An Analysis of the Operational Costs of Trucking: A 2011 Update
Accident Component			
Accident Rates - Interstates			
Crashes	accidents/100M VMT	60.32	HGAC's extraction of TxDOT CRIS data
K (Killed/Fatalities)	accidents/100M VMT	0.34	HGAC's extraction of TxDOT CRIS data
A (Incapacitating Injuries)	accidents/100M VMT	1.71	HGAC's extraction of TxDOT CRIS data
B (Non-Incapacitating Injuries)	accidents/100M VMT	8.23	HGAC's extraction of TxDOT CRIS data
C (Possible Injuries)	accidents/100M VMT	25.69	HGAC's extraction of TxDOT CRIS data
O (No Injuries/Property Damage Only)	accidents/100M VMT	37.64	HGAC's extraction of TxDOT CRIS data
Accident Rates - Network			
Crashes	accidents/100M VMT	164.20	HGAC's extraction of TxDOT CRIS data
K (Killed/Fatalities)	accidents/100M VMT	0.95	HGAC's extraction of TxDOT CRIS data
A (Incapacitating Injuries)	accidents/100M VMT	5.04	HGAC's extraction of TxDOT CRIS data
B (Non-Incapacitating Injuries)	accidents/100M VMT	22.01	HGAC's extraction of TxDOT CRIS data
C (Possible Injuries)	accidents/100M VMT	64.14	HGAC's extraction of TxDOT CRIS data
O (No Injuries/Property Damage Only)	accidents/100M VMT	105.06	HGAC's extraction of TxDOT CRIS data
Costs			
K (Killed/Fatalities)	2012$/accident	$6,291,448	TIGER Benefit-Cost Analysis (BCA) Resource Guide
A (Incapacitating Injuries)	2012$/accident	$300,889	TIGER Benefit-Cost Analysis (BCA) Resource Guide
B (Non-Incapacitating Injuries)	2012$/accident	$81,953	TIGER Benefit-Cost Analysis (BCA) Resource Guide
C (Possible Injuries)	2012$/accident	$41,848	TIGER Benefit-Cost Analysis (BCA) Resource Guide
O (No Injuries/Property Damage Only)	2012$/accident	$3,405	TIGER Benefit-Cost Analysis (BCA) Resource Guide
Accident Applicability for Production Costs			
Proportional Percent	percent	20.0%	CDM Smith
Tolling Component			
Tolling Rates			
Passenger Occupied Vehicles (POV)	2012$/mile	$0.15	Traffic and Revenue Study: Grand Parkway 2011
Commercial Vehicles (CV)	2012$/mile	$0.47	Traffic and Revenue Study: Grand Parkway 2011

3. Economic Impact Results

Economic impacts from the proposed Grand Parkway Segments H and I-1 construction and implementation are presented at the regional and statewide levels, in annual impacts from year 2016 through 2039. Impacts presented pertain to total economic impacts[7].

3.1. Grand Parkway Segments H and I-1 Aggregate Total Economic Impacts

Economic impact components are presented separately and in aggregate below, in **Exhibit 7** through **Exhibit 9**, spanning the 2016 through 2039 horizon.

As shown, the net economic impact from implementing the proposed tolled Grand Parkway Segments H and I-1 facility is generally positive across the cumulative horizon years. However, some years immediately following the construction timeframe exhibit negative impacts across the aggregation of the impact components. A generally positive trend occurs because the initial Grand Parkway Segments H and I-1 facility construction produces relatively large-scale impacts (compared to the other evaluated economic impact components).

Constructing and implementing the Grand Parkway Segments H and I-1 facility is estimated to result in cumulative total employment impacts measuring almost 21,100 job-years over the future horizon spanning 2016 through 2039 for the regional area, and 24,500 job-years within the entire State of Texas (see **Exhibit 7**). In addition to the numerical tables, the impact results are presented graphically in **Exhibit** 8 for employment in the regional study area to depict the temporal allocation of the impacts. The pattern of total impacts is that of a large positive shock, due to the initial construction expenditures, between 2016 and 2019, then a sharp decline through about 2025, followed by a steady increase, thanks to the strong and positive travel efficiency-related impacts for the rest of the future time horizon. Value-added impacts adhere to a similar trend, as do the impact to the State of Texas at large.

Corresponding to the employment impacts are value-added impacts amounting to $2.11 billion (in 2012 dollars) for the regional area, and $2.44 billion for Texas, over the 2016 through 2039 analysis horizon (see **Exhibit 9**).

---

[7] Direct, indirect, and induced economic impacts, in aggregate.

Exhibit 7: Employment Impacts (by year and impact geography)

Year	Regional Study Area				Texas			
	Construction	O&M and Lifecycle	Travel Efficiencies & Tolling	Total	Construction	O&M and Lifecycle	Travel Efficiencies & Tolling	Total
2016	3,010	0	0	3,010	3,410	0	0	3,410
2017	3,030	0	0	3,030	3,470	0	0	3,470
2018	2,990	0	0	2,990	3,440	0	0	3,440
2019	-70	110	-150	-110	0	130	-200	-70
2020	-180	120	-180	-230	-140	140	-210	-210
2021	-220	140	-180	-260	-200	160	-200	-240
2022	-220	140	-150	-240	-210	160	-160	-220
2023	-200	120	-120	-190	-200	140	-120	-170
2024	-170	140	-60	-90	-180	180	-60	-50
2025	-120	120	0	0	-100	130	20	40
2026	-100	130	70	100	-80	140	100	160
2027	-70	130	150	220	-40	150	190	290
2028	-40	200	240	400	-20	220	290	500
2029	-10	140	340	460	10	160	390	560
2030	10	140	440	590	30	160	510	700
2031	20	130	550	700	50	150	620	820
2032	30	130	670	830	60	150	740	950
2033	30	160	790	990	60	190	870	1,130
2034	40	170	910	1,120	70	200	1,010	1,280
2035	40	160	1,050	1,240	70	190	1,150	1,400
2036	40	160	1,190	1,390	60	200	1,300	1,560
2037	30	160	1,330	1,520	60	190	1,460	1,700
2038	30	250	1,490	1,770	50	300	1,630	1,970
2039	30	170	1,650	1,850	50	210	1,800	2,060
Total	7,920	3,120	10,030	21,070	9,730	3,650	11,120	24,500

Source: CDM Smith's application of the REMI® model

*note: Employment expressed in job-years rounded to the nearest ten -- totals may not sum due to rounding

Exhibit 8: Employment Impacts for the Regional Study Area

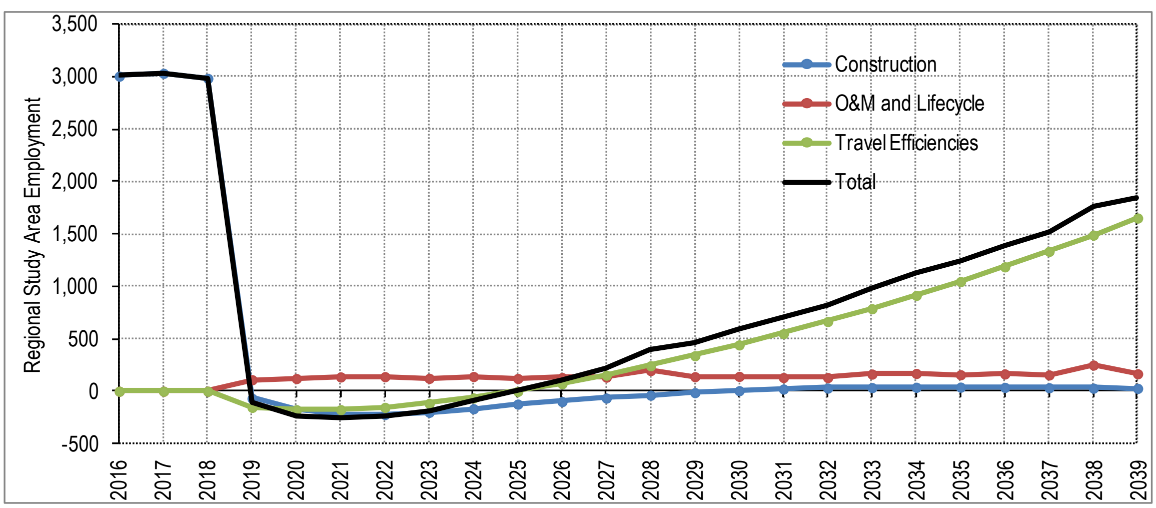


Exhibit 9: Value-Added Impacts (by year and impact geography)

Year	Regional Study Area				Texas			
	Construction	O&M and Lifecycle	Travel Efficiencies & Tolling	Total	Construction	O&M and Lifecycle	Travel Efficiencies & Tolling	Total
2016	$220,600	$0	$0	$220,600	$250,200	$0	$0	$250,200
2017	$221,700	$0	$0	$221,700	$255,700	$0	$0	$255,700
2018	$217,700	$0	$0	$217,700	$255,200	$0	$0	$255,200
2019	-$15,300	$7,500	-$15,200	-$23,000	-$5,700	$8,400	-$17,500	-$14,800
2020	-$25,600	$8,400	-$18,800	-$36,000	-$17,800	$9,600	-$20,600	-$28,800
2021	-$29,900	$9,600	-$19,500	-$39,800	-$23,900	$11,200	-$20,500	-$33,200
2022	-$29,800	$9,700	-$17,600	-$37,700	-$24,700	$11,100	-$17,900	-$31,500
2023	-$27,300	$8,400	-$13,600	-$32,500	-$23,100	$9,900	-$13,400	-$26,500
2024	-$23,600	$9,800	-$7,800	-$21,700	-$19,900	$11,700	-$6,800	-$15,000
2025	-$19,600	$8,800	-$300	-$11,100	-$18,100	$12,100	$1,700	-$4,300
2026	-$14,400	$8,000	$8,000	$1,600	-$11,200	$10,000	$10,200	$9,000
2027	-$11,600	$8,900	$18,800	$16,100	-$8,500	$10,900	$21,500	$23,900
2028	-$8,400	$14,200	$30,500	$36,300	-$4,900	$17,200	$33,600	$45,900
2029	-$5,400	$9,200	$43,200	$47,000	-$2,000	$11,800	$47,000	$56,800
2030	-$3,100	$9,400	$57,400	$63,800	$100	$12,200	$61,900	$74,200
2031	-$1,300	$8,500	$72,700	$79,900	$1,900	$11,000	$77,700	$90,700
2032	$100	$8,400	$89,400	$97,900	$3,200	$11,400	$94,900	$109,500
2033	$1,000	$11,600	$107,300	$119,900	$4,200	$15,200	$113,500	$132,900
2034	$1,500	$12,000	$126,700	$140,100	$4,500	$15,600	$133,700	$153,800
2035	$1,900	$11,000	$147,200	$160,000	$4,900	$14,700	$154,600	$174,200
2036	$1,800	$11,700	$169,600	$183,100	$4,600	$15,600	$178,300	$198,500
2037	$1,700	$10,900	$193,500	$206,100	$4,300	$15,000	$202,900	$222,200
2038	$1,300	$20,300	$219,300	$240,900	$3,400	$25,600	$230,100	$259,200
2039	$1,300	$12,200	$246,800	$260,300	$3,700	$16,800	$258,800	$279,300
Total	$455,300	$218,500	$1,437,400	$2,111,200	$636,200	$277,300	$1,523,700	$2,437,300

Source: CDM Smith's application of the REMI® model

*note: Value Added results are expressed in thousands of dollars (2012) and rounded to the nearest ten thousand -- totals may not sum due to the rounding

3.2. Expenditure-Based Component Impacts

According to the assumed expenditure schedule, as per **Exhibit 3**, the incremental spending between the *build* and the *no-build* scenario (status quo) for the Grand Parkway Segments H and I-1 facility amounts to about $1.11 billion for the years 2012 through 2039, exclusive of the right of way costs[8].

The construction expenditure schedule is strongly "front-loaded" over the analysis period, with a vast majority of the total spending differential necessarily occurring in the first few years for the construction of the Grand Parkway Segments H and I-1; that is,

[8] Right of way (ROW) purchases are considered asset transfers and are not translatable into economic output or employment impact metrics. As such, the ROW costs are of no relevance and dismissed herein.

$802 million from 2016 through 2018. Once the Grand Parkway Segments H and I-1 facility is constructed and use commences in 2019, operations/maintenance and lifecycle infrastructure costs arise. Operations and maintenance, and lifecycle expenditures amount to $310 million over the 2019 through 2039 analysis horizon. Data presented includes a construction cost contingency percentage assumption of 18%.

In the results, construction-related impacts are separated from the operating, maintenance, and lifecycle-related impacts, although the input estimated expenditures are applied to similar industry sectors within the economic model and exhibit proportional order-of-magnitude results.

Because the expenditure schedule and amounts are heavily "front-loaded", the pattern of economic impacts is consequently similar, with the largest and most pronounced impacts occurring during the first years of Grand Parkway Segments H and I-1 construction. According to the preceding impact tables, spending on construction activities for the Grand Parkway Segments H and I-1 facility translates into 7,920 job-years and $455 million in economic value-added for the regional study area across the analysis horizon; in Texas, the impacts are 9,730 job-years and $636 million, respectively.

However, as indicated in the impact tables, the economic impacts from construction expenditures are projected to be positive and relatively large in the years of construction (i.e., 2016 through 2018), but reverse sign and are negative in the years immediately following. This reversal reflects the relative economic shock, following the pronounced spending that is suddenly curtailed at the completion of the project construction. In the absence of similar construction spending patterns, the labor and capital dedicated for the construction activities leave the area for opportunities elsewhere.

Operations, maintenance, and lifecycle expenditures, which begin immediately following the construction activity timeframe (i.e., in 2019, with the opening of the facility) create positive economic impacts in each analysis year, varying in relative proportion to the expenditure amounts. In aggregate across the analysis horizon, the operations, maintenance, and lifecycle expenditure-related impacts are expected to yield employment impacts totaling 3,120 job-years for the regional study area, and 3,650 job-years for Texas. Associated value added impacts total $219 million for the regional study area and $277 million for Texas overall.

3.3. Travel Efficiencies and Tolling Component Impacts

Changes in travel demand characteristics stemming from Grand Parkway Segments H and I-1 result in travel-time, vehicle-operating, and safety cost changes accruing to households and business within the defined study area, and thus results in economic impacts.

Grand Parkway Segments H and I-1 is expected to increase vehicle-miles travelled in the regional study area. This will increase vehicle-operating costs and thus negative economic impacts, as those direct costs are attributed to the sectors in the economic model (as appropriate, depending on the trip purpose) and run through the economic multipliers. Although network vehicle-miles travelled are expected to increase with the implementation of the Grand Parkway Segments H and I-1, resulting in vehicle operation cost increases, the vehicle-hours travelled are expected to decline, leading to travel-time savings. Accidents, as a function of vehicle-miles travelled and the accident rates per mile, are also expected to decline in aggregate across the analysis horizon, as traffic shifts from the overall network to the Grand Parkway Segments H and I-1 highway (with the highway configuration having notably reduced accident rates than the overall network). Consequently, the accident reduction leads to societal accident costs savings, which are translated into positive economic impacts. Imposition of tolling on the local population is an out-of-pocket cost to household and businesses and generally by itself results in negative economic impacts.

Combining the results of the various travel demand characteristic-related economic impacts yields net positive results across the entire analysis horizon, although the impacts are negative in a few years following the opening of the Grand Parkway Segments H and I-1 facility, but within a few years revert to net positive impacts that escalate rather quickly thereafter. Reasoning for the pattern of impacts, beginning in the negative, and then crossing into the positive and escalating thereafter is driven by the negative impacts attributable to the vehicle operating cost increases and tolling impositions that are not sufficiently offset initially by accident and travel time savings. Furthermore, because the travel time savings escalate at a higher rate than the annual changes in the other travel demand characteristic-related components, the aggregate savings turn positive, together with the resulting total economic impacts around 2025.

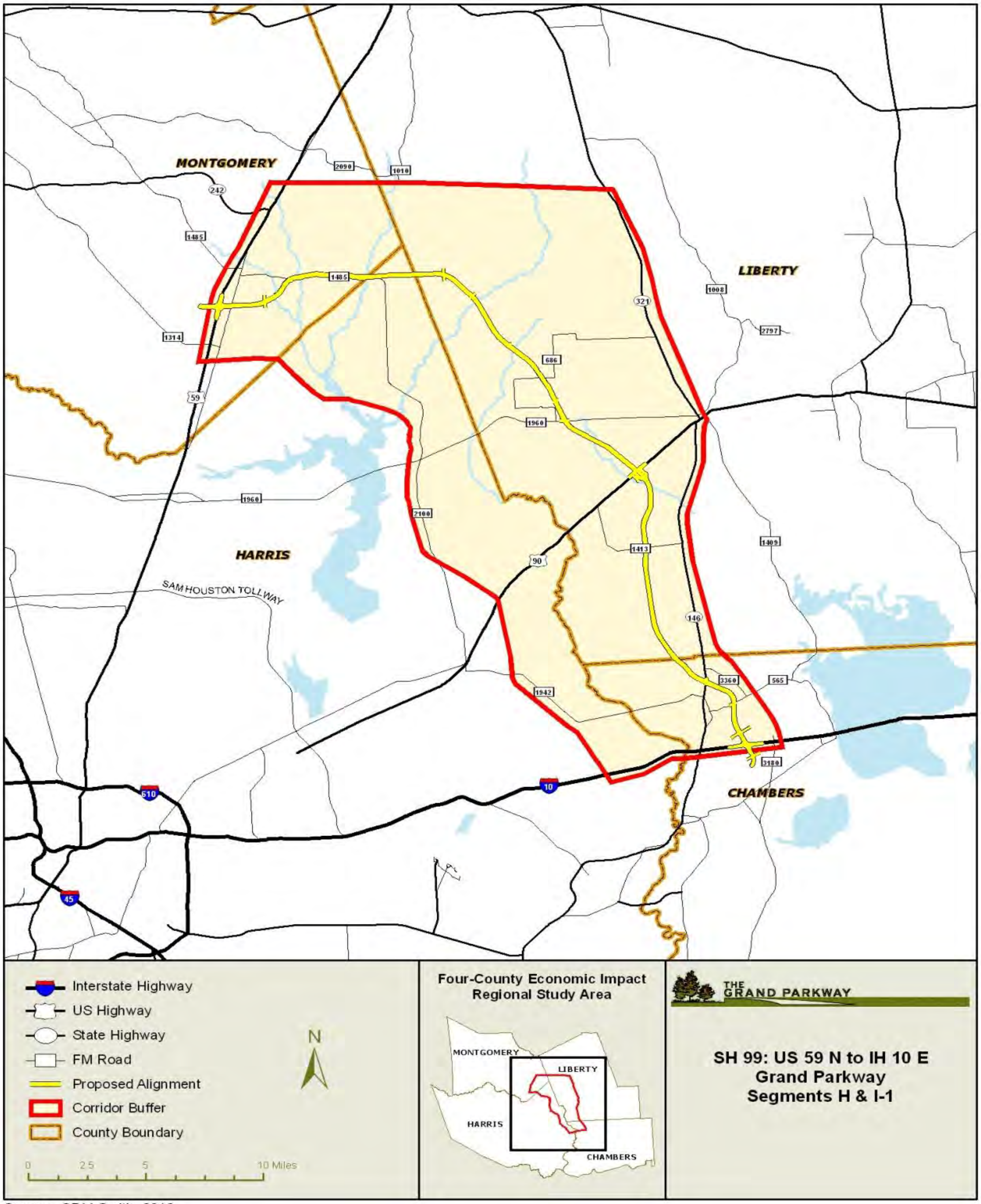
Combining all the components, the economic impacts resulting from travel efficiencies and tolling implementation on the Grand Parkway Segments H and I-1 is estimated to amount to $1.44 billion in economic value-added and 10,030 job-years over the analysis horizon spanning 2019 through 2039 for the regional study area and $1.52 billion and 11,120, respectively for the entire State of Texas.

4. Conclusion

This analysis examined two main sources of potential economic impacts arising from the Grand Parkway Segments H and I-1 investment: expenditures- and travel efficiencies-based. The travel efficiency benefits arise as a result of (dis)savings accruing to users of the facility such as travel time savings, vehicle operating costs savings and accident savings, while the expenditures-based impacts are a function of the magnitude of the outlays on the facility and the input-output structure of the regional economy.

In summary, the proposed Grand Parkway Segments H and I-1 corridor is expected to bring employment and economic activity to the Houston regional and statewide economies. The combined (of the different impact categories), cumulative (over the entire 2016-2039 analysis horizon) total employment impact is projected to amount to almost 21,100 job-years in the Houston Region and 24,500 Statewide. Corresponding economic activity (Gross Regional Product) impacts are projected to measure $2.1 billion and $2.4 billion in increased value added for the Houston Region, and Statewide, respectively.

Appendix A: Corridor Region Map



Source: CDM Smith, 2012