Appendix C

Demand Analysis for the Lockwood Multimodal Terminal Project

PARKING DEMAND ANALYSIS

BACKGROUND

Downtown Houston and Texas Medical Center (TMC) are two major employment centers along the Metropolitan Transit Authority of Harris County (METRO) Light Rail Transit (LRT) line in Houston. A September 2015 downtown parking inventory[1] indicates that the average parking rate in Downtown Houston is approximately $15/day. Additionally, the City of Houston Department of Parking Management indicates that approximately 30% of vehicles in downtown Houston are circulating in a search for parking[2]. The 2013 Texas Medical Center Mobility Study[3] also targeted remote parking facilities to reduce traffic congestion and parking deficiency as the priority for TMC's mobility plan. Additional activity centers along the LRT lines include the University of Houston (UH), Rice University (TSU), and the Museum District. Currently, there are significant parking deficiencies in and around all of these employment and activity centers.

A parking facility along METRO East End Line will help relieve parking deficiencies and associated traffic congestion at these major activity centers. The METRO East End Line is a 3.34 miles double track LRT line, with five stations (*Figure 1*). The stations along the East End LRT line are:

- Coffee Plant / Second Ward
- Lockwood / Eastwood
- Altic / Howard Hughes
- Cesar Chavez / 67th Street
- Magnolia Transit Center

The highest concentrations of population in the corridor are located around the Lockwood/Eastwood, Altic, and Magnolia Transit Center stations; and 32 percent of the total population within ½ mile of the East End line lives within ½ mile of the Lockwood station (2010 Census).

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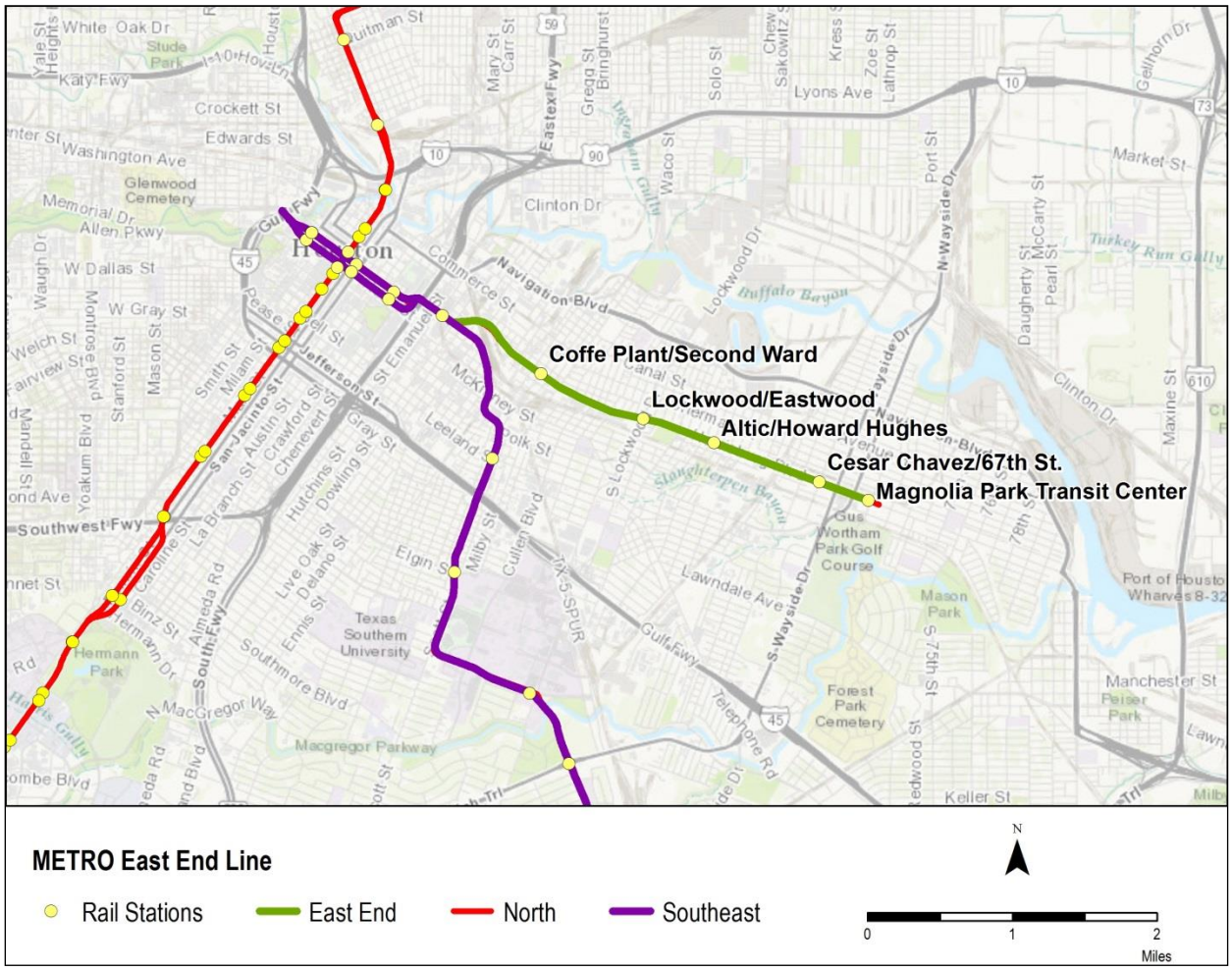
[1] https://www.downtownhouston.org/site_media/uploads/attachments/2014-09-29/140915_Downtown_Rates_and_Map.pdf

[2] https://www.houstonpublicmedia.org/articles/news/2016/07/18/160853/new-downtown-houston-parking-program-designed-to-keep-traffic-moving/

[3] https://edocs.publicworks.houstontx.gov/documents/divisions/traffic/final_tmc_cmp_process_report_july_2013.pdf

Public parking in the East End corridor is limited with only 56 spaces located at the Magnolia Transit Center, 32 spaces at Settegast Park, and 69 spaces at Eastwood Park (near the Lockwood/Eastwood stop). Furthermore, the public parking at Settegast Park and Eastwood Park is reserved for park users and cannot be used for the purposes of public transit. The lack of parking currently available supports the need for a parking facility along East End Corridor for commuters to park and use the LRT service to access major activity centers along the METRO rail lines.

FIGURE 1: METRO EAST END LINE



Eastwood Intermodal Terminal Parking Facility

Lovett Commercial (private developer) and the Greater East End Management District (GEEMD) are proposing to build the Eastwood Intermodal Terminal to include a structured parking facility at Lockwood/Eastwood rail station (*Figure 2*). The site address for the new terminal is 1516 Harrisburg Boulevard, Houston, Texas. It is a 9.25-acre property located in the East End of Houston at the intersection of Harrisburg Blvd. and Lockwood Drive along the METRO LRT.

Compared with other stations, the proposed facility at Lockwood Station would service the most population due to the highest residential population density near Lockwood Station. The proposed parking facility would allow the residents living outside the walkable distance of all East End light rail stations to park their vehicles at the proposed facility and use the LRT service to access all of the major activity centers along the METRO rail network. The proposed parking facility would also help with relieving parking deficiencies at these major activity centers and improve the traffic flow in Downtown Houston. Additionally, transit users can reduce out of pocket costs associated with parking downtown, at the TMC, and other activity centers along METRORail.

EASTWOOD INTERMODAL TERMINAL PARKING FACILITY

PARKING DEMAND ANALYSIS

TGC's Demand Analysis estimates the parking demand at the proposed intermodal terminal for transit use only. The parking demand was derived from the following:

- Employee Parking Demand
- Visitor Parking Demand

The following sections review the methodologies and tools used to calculate the projected demand for the parking facility. It is projected that the total parking demand at the proposed facility will be 460 in 2018 and 451 in 2025.

Methodology

The methodology used to determine parking demand derived from transit for spaces in the proposed terminal was developed by Texas A&M Transportation Institute (TTI) and is based on TTI's *Procedures for Estimating Park-and-Ride Demand in Large Texas Cities*. The report outlines six methodologies to estimate park & ride (P&R) demand. This report uses the Modal Split methodology.

The TTI Modal Split methodology has four steps:

The first step is to determine the destination area and determine the market area by overlaying the market area boundary (parabola) on traffic analysis zones (TAZs).

The second step is to aggregate all the home base work trips (HBW) trips and home based non-work (HBNW) trips from the market area(s) to destination area(s).

The third step is to calculate a transit modal split for the HBW and HBNW trips. The modal split can be obtained by the standard modal split used in the Houston-Galveston Area Council (H-GAC) Travel Demand Forecast (TDF) Model or observed modal splits in the region.

The fourth step is to determine the parking and ridership demand. Ridership can be divided by "patrons per parked vehicle" to derive the spaces needed (demand) for the new park and ride facility.

Define Catchment Areas and Destination Areas of Parking Facilities

The Modal Split methodology requires identifying the catchment and destination areas of the proposed parking facility. The Modal Split methodology also requires an analysis of the population and workers that will be served by the proposed facility, or the population "up-stream" of the facility given the ultimate "down-stream" destination. Following guidelines outlined by TTI, typical park and ride service area (up-stream) is parabolic in shape with a base of six to eight miles and length of five to seven miles. The distance between the park and ride facility and the tip of the parabola should be 0.5 to 1.5 miles (*Figure 3*). Additionally, the standard TTI service area can be adapted to the pattern of access provided by major arterial streets and freeways serving the proposed park and ride lot. The parabolic shape can be decreased in size due to the shorter distance of the market area to the destination area. The parabola should be faced pointing toward the destination of the park and ride bus service.

The intermodal terminal will be constructed adjacent to the METRO Lockwood Station and serve as a light rail station parking facility. Transit users can park at the facility and take the light rail to their destination of choice. Therefore, the candidate destination area of the facility would be TAZs proximity to half mile radius area of METRO Rail stations. However, considering land use type, parking spaces available, parking cost and short distance of parking facility to

candidate destination area, the destination areas of the proposed facility are only limited to TAZs of major activity centers along rail stations. These include downtown, TMC, Rice University, Museum District and UH. The destination areas were also divided into three categories based on spatial location:

- Downtown Destination Area – Downtown TAZs
- TMC, Rice University and Museum District Destination Area –TAZs of TMC, Rice University and Museum Districts
- University of Houston Destination – TAZs of UH

For each category of destination area, a parabola was drawn to represent the corresponding catchment area. The parabola was drawn in relation to the overall area of potential parking facility over TAZs obtained from H-GAC's TDF Model. The catchment areas were reduced and were adapted from a parabolic shape to the pattern of access provided by major arterial streets and freeways serving the proposed terminal. In addition, the catchment areas of the proposed facility were also trimmed to exclude the walkable area, which is defined as TAZs within half mile walkable distance of light rain stations. It is assumed that people living inside the walkable area can walk to a rail station without the need for a parking space at the proposed facility. *Figures 4 to 6* depicts destination areas and their corresponding catchment areas of the proposed parking facility.

FIGURE 3: TYPICAL PARK AND RIDE MARKET AREA

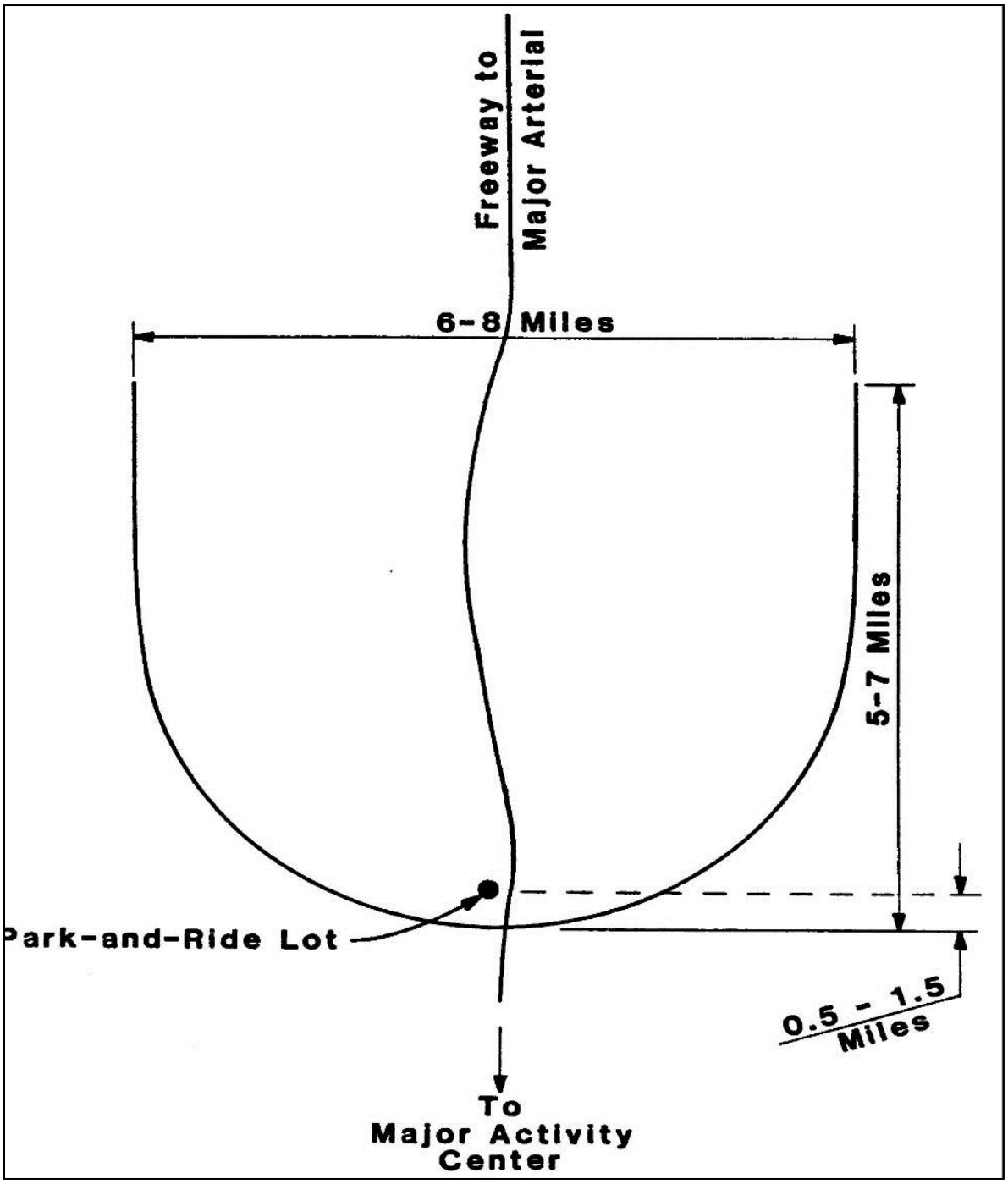
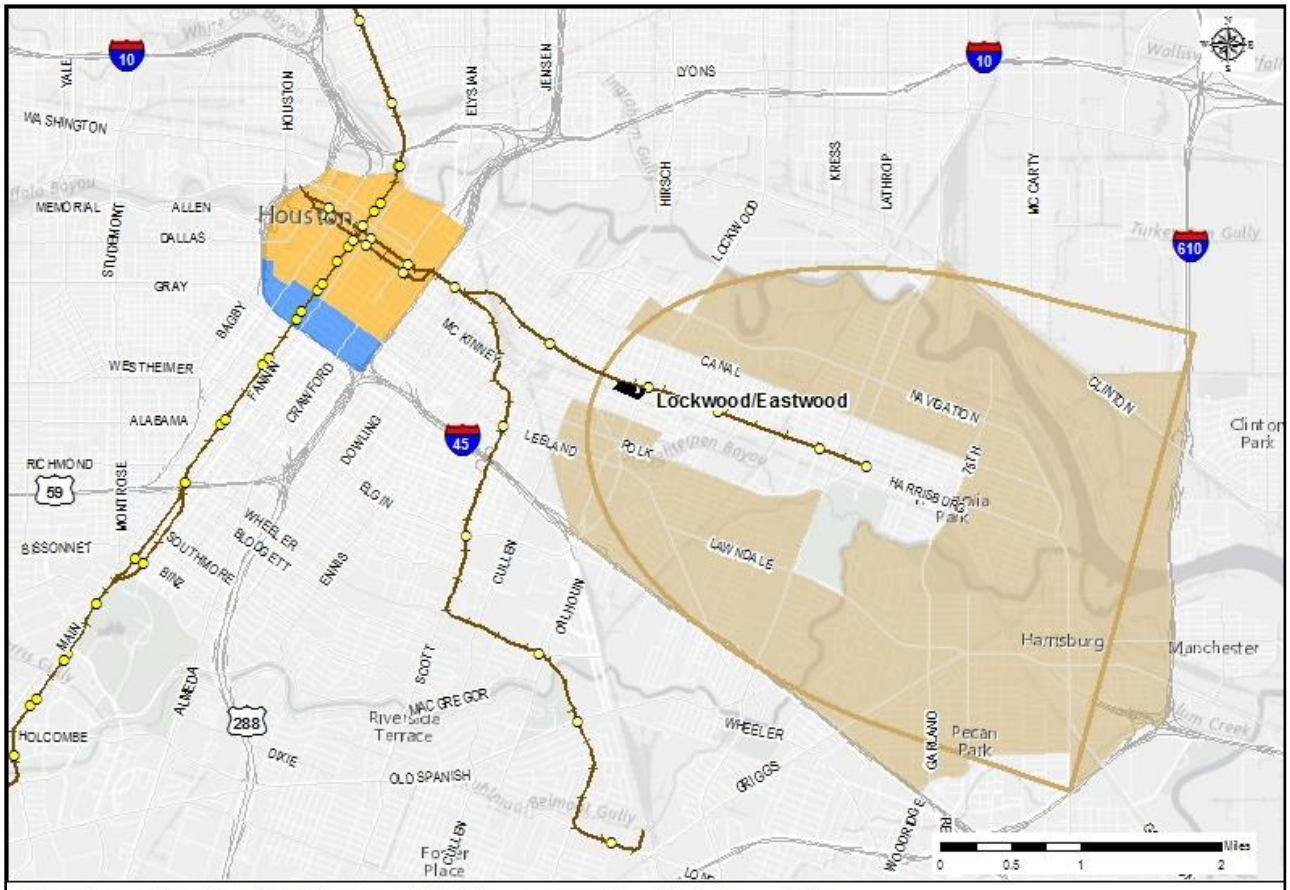


FIGURE 4: DOWNTOWN DESTINATION AREA AND ITS CORRESPONDING CATCHMENT AREA



Downtown Destination Area and Its Corresponding Catchment Area

- Rail Stations
- Metro Rail
- Proposed Parking Facility
- Parabola
- Downtown Destination Area (Transfer Needed)
- Downtown Destination Area (No Transfer Needed)
- Corresponding Catchment Area

FIGURE 5: TMC, RICE UNIVERSITY AND MUSEUM DISTRICT DESTINATION AREA AND CORRESPONDING CATCHMENT AREA

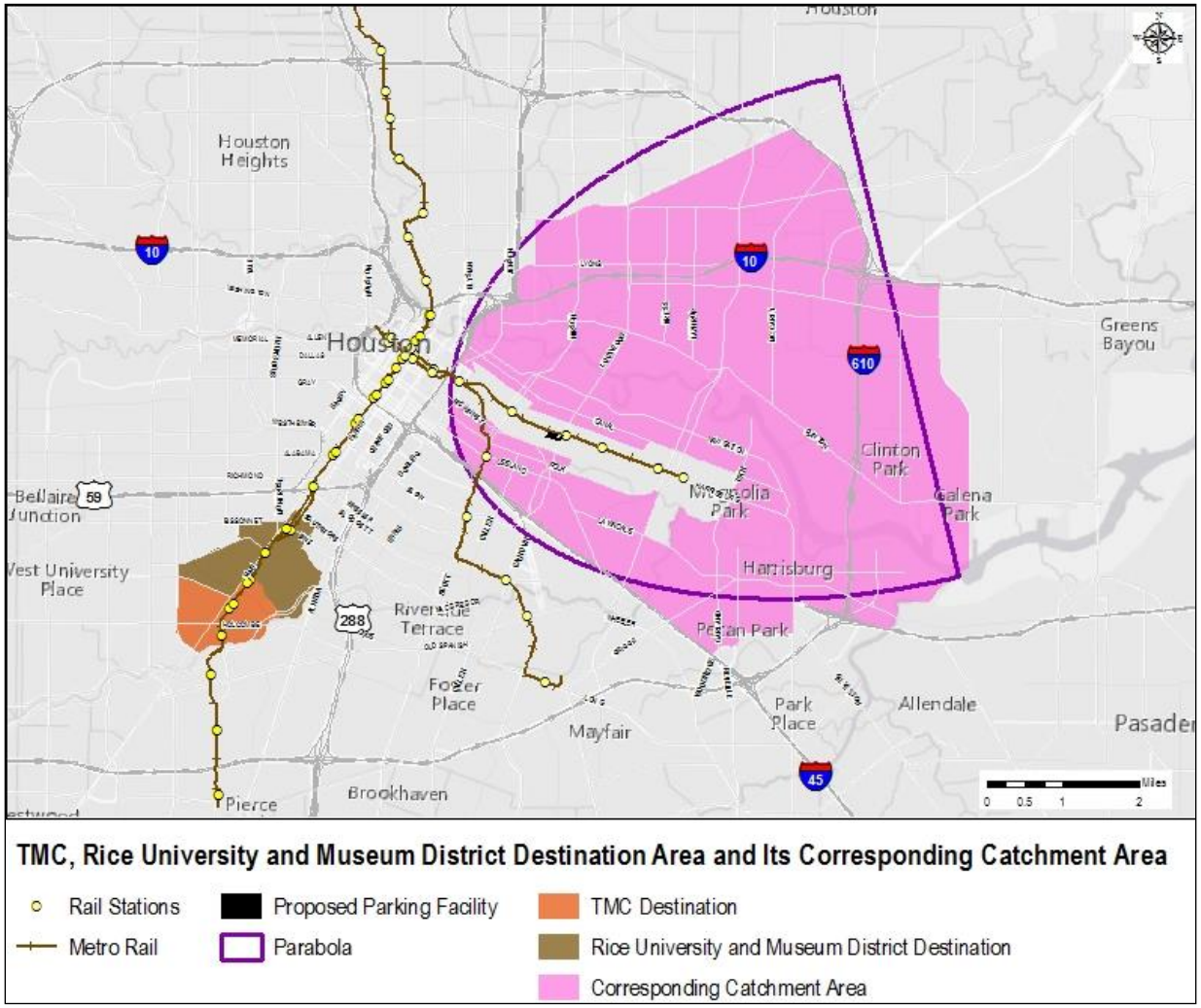
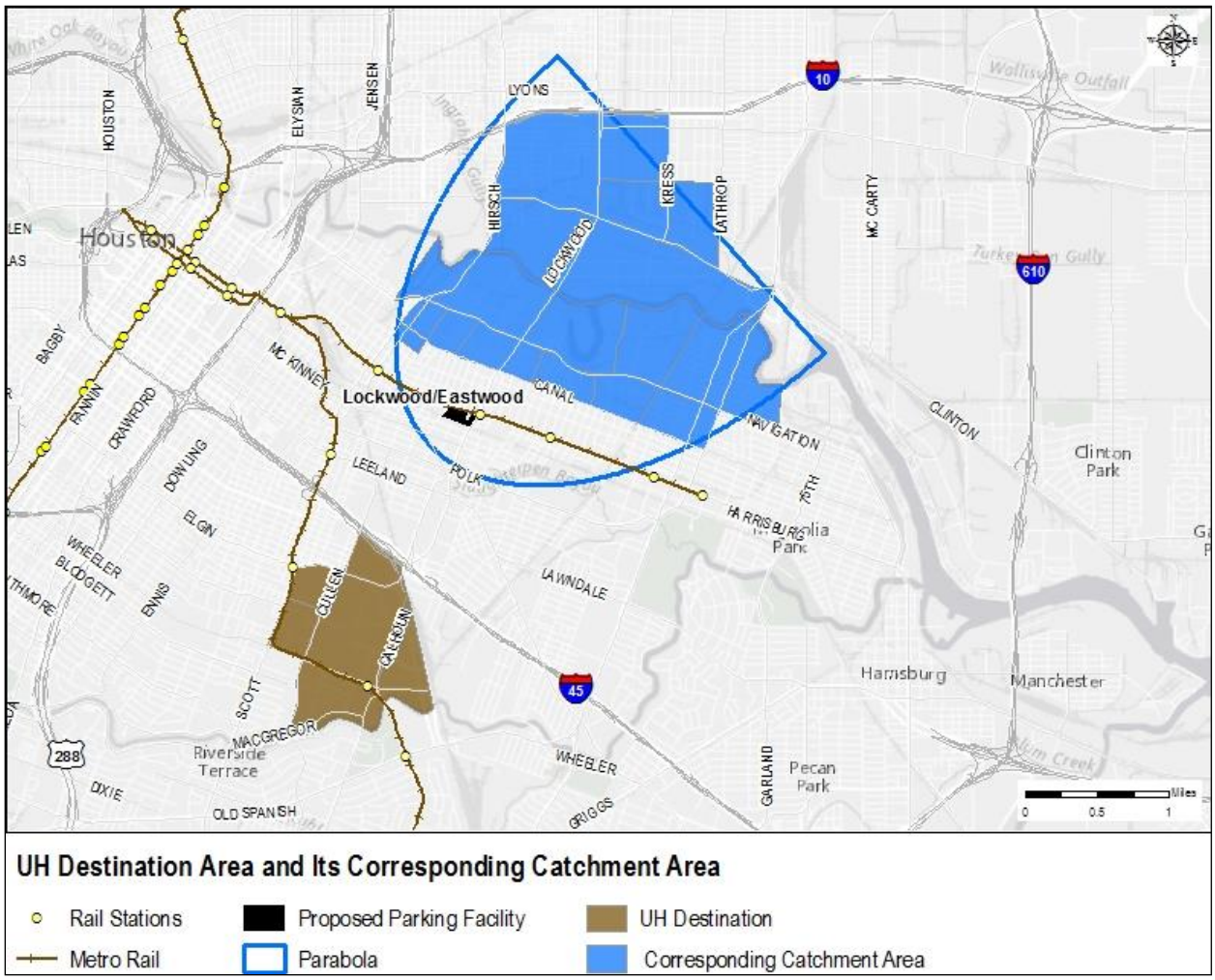


FIGURE 6: UH DESTINATION AREA AND ITS CORRESPONDING CATCHMENT AREA



HBW TRIPS AND HBNW TRIPS FROM MARKET AREAS TO DESTINATION AREAS

The proposed parking facility allows people living within the P&R catchment area to park their vehicle at the proposed facility and take the METRO LRT to destination locations.

Prior to examining the number of workers and visitors that originate from the proposed transit center market area and travel to destinations along all METRO light rail stations, a review of the trip generation and distribution steps of the H-GAC TDF Model[4] is needed to maintain a high confidence level in the projected parking demand.

Step 1 of a TDF Modal, Trip Generation, estimates the number of trips produced in and attracted to each TAZ. To accomplish this, the model uses estimates of projected population, employment, and other socioeconomic and household characteristics of each zone. Trips are divided into three major categories, HBW; HBNW;[5] and non-home based trips.[6]

Step 2 of a TDF Modal, *Trip Distribution,* links the trip ends[7] estimated from trip generation to form zonal trip interchanges.[8] The output of the second step is a trip table, a matrix containing the number of trips occurring between every origin-destination zone combination. Trip distribution is performed for each trip purpose.

Using the H-GAC TDF trip generation and distribution output, HBW and HBNW trips between parking facility catchment area TAZs to destination areas were presented in Tables 1 for model years 2018 and 2015.

As shown in *Table 1*, for both model years 2018 and 2025, there are approximately 2,500 workers living in all three parking facility catchment areas. Among the 2,500 workers, 1,200 are employed in Downtown Houston, and approximately 1,400 are employed in TMC, Rice University and Museum District. The remaining 40 were UH employees. *Table 1* also depicts approximately 13,000 daily visitors to Houston Downtown, TMC, Rice University, Museum District, and the University of Houston, and resides in the service area of the proposed parking facility. The 2,500 workers and 13,000 visitors are the target population group with the potential to use the proposed parking facility. The proposed parking facility would provide these 2,500 workers and 13,000 visitors with another mode to access destinations.

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[4] 2016 H-GAC TDF Model with 5,217 TAZs

[5] Trips to/from home to/from non-work destinations.
[6] Trips between non-home origins/destinations.
[7] Trip ends represent the point from which the trip is produced or to which it is attracted.
[8] Movements between two zones.

TABLE 1: DAILY HOME-BASE WORK TRIPS FROM PARKING FACILITY CATCHMENT AREAS TO DESTINATION AREAS

	2018 Home-Base Work Trips	2018 Home Base Non-Work Trips	2025 Home-Base Work Trips	2025 Home Base Non-Work Trips
from Downtown Market Area to Downtown Destination Area				
No Transfer Destination	1,122	7,334	1,069	7,387
Transfer Destination	104	884	110	953
Subtotal	1,226	8,218	1,179	8,340
from TMC Market Area to				
TMC Destination	1,207	3,511	1,176	4,406
Rice and Museum Destination	160	745	156	806
Subtotal	1,367	4,256	1,332	5,212
from UH Market Area to UH Destination				
UH Destination	39	481	34	486
Subtotal	39	481	34	486
Total	**2,632**	**12,955**	**2,545**	**14,038**

ESTIMATE TRANSIT SHARE AND PARKING DEMAND FOR HBW TRIPS FROM PARKING FACILITIES CATCHMENT

Areas to Destination Areas

Not all HBW trips generated from the P&R catchment areas to destinations areas would use public transportation. Modal splits for different areas of the region vary. Modal split is affected by factors including traffic conditions, toll way costs, gasoline prices, and parking costs.

Modal Split for HBW Trips to Downtown and TMC Destination. According to The H-GAC TDF, the modal split outputs for 2018, based on the current base transit network and no highway improvements, estimate that 37 percent would utilize transit to downtown and 36 percent would utilize transit to TMC. The modal split outputs for 2025, based on the current base transit network and the highway improvements in Regional Transportation Plan (RTP), estimate that 49 percent would utilize transit to downtown Houston and 38 percent would utilize transit to TMC (*Table 3*). The 2013 Downtown Houston Commute Survey indicates that 30 percent of downtown Houston workers utilize transit to work destinations. The 2016 modal split data from (METRO) indicates that 34 percent of downtown Houston workers would utilize transit to downtown and 36 percent would utilize transit to TMC (*Table 3*). The transit modal splits from H-GAC TDF model output, 2013 Downtown Commute Survey and METRO all indicate that transit modal splits for both downtown and TMC trips are at least 30 percent.

The proposed parking facility will need to provide a high level of service and a strong marketing plan to capture the maximum amount of riders. Therefore, in the planning for this facility it was decided that a more conservative model split should be used rather than the 30 percent indicated in previous studies. In order to meet this conservative threshold, a modal split of 20 percent for the downtown and TMC destination areas was used to estimate the parking demand in this report. Additionally, for downtown destination areas outside the half mile buffer of east end line and a transfer from east end line to red line needed to reach, a reduced mode split of 15% was used to reflect the transfer penalty.

Modal Split for HBW Trips to UH, Rice University and Museum District. According to American Community Survey 2015, the means of transportation to work using public transit is around 5%[9] for City of Houston. Although parking costs in UH, Rice and Museum District are lower than in downtown Houston and TMC, employee parking permit cost and peak hour traffic along Main Street have the potential to incentivize workers to take METRO rail to work rather than to drive and park. In this study, a conservative modal split of 5 percent was used for HBW trips to UH, Rice University, and the Museum District.

[9] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?fpt=table

TABLE 3: MODAL SPLITS FROM TDF MODEL OUTPUT, 2013 DOWNTOWN COMMUTE SURVEY AND METRO

Destination	Transit Modal Split for H-GAC HBW Trips (Source Metro - Base Transit Network, Phase 2 Rail Network, No Highway Improvements)	Transit Modal Split for H-GAC HBW Trips (Source Metro - Base Transit Network, Phase 2 Rail Network, Highway Improvements In RTP)	Transit Modal Split from 2013 Downtown Commute Survey	2016 Transit Modal Split from METRO
	2018	2025		
Downtown Houston	37%	49%	30%	32%
TMC	36%	38%	-	36%

Using transit modal split as discussed above, it is estimated that the transit parking demand for employees would be 447 in 2018 and 432 in 2025 (*Table 4 and 5*).

TABLE 4: 2018 TRANSIT PARKING DEMAND FOR EMPLOYEES

	2018 Home-Base Work Trips	Transit Modal Split	Total One-Way Transit Trips	PPV*	Parking Demand
from Downtown Market Area to Downtown Destination Area					
No Transfer Destination	1,122	20%	224	1.1	204
Transfer Destination	104	15%	16	1.1	14
Subtotal	1,226		240		218
from TMC Market Area to					
TMC Destination	1,207	20%	241	1.1	219

Rice and Museum Destination	160	5%	8	1.1	7
Subtotal	1,367		249		226
from UH Market Area to UH Destination					
UH Destination	39	5%	2	1.1	2
Subtotal	39		2		2
Total	**2,632**		**491**		**446**

* Auto Occupancy for the H-GAC region for HBW Trips is 1.1

TABLE 5: 2025 TRANSIT PARKING DEMAND FOR EMPLOYEES

	2025 Home-Base Work Trips	Transit Modal Split	Total One-Way Transit Trips	PPV*	Parking Demand
from Downtown Market Area to Downtown Destination Area					
No Transfer Destination	1,069	20%	214	1.1	194
Transfer Destination	110	15%	17	1.1	15
Subtotal	1,179		230		209
from TMC Market Area to					
TMC Destination	1,176	20%	235	1.1	214
Rice & Museum Dest.	156	5%	8	1.1	7
Subtotal	**1,332**		**243**		**221**
from UH Market Area to UH Destination					
UH Destination	34	5%	2	1.1	2
Subtotal	34		2		2
Total	**2,545**		**475**		**432**

* Auto Occupancy for the H-GAC region for HBW Trips is 1.1

ESTIMATE TRANSIT SHARE AND PARKING DEMAND FOR HBNW TRIPS FROM PARK AND RIDE CATCHMENT AREAS TO DESTINATION AREAS

According to H-GAC TDF, the future daily HBNW trips generated from the catchment area of the proposed facility to various destinations are around 13,000 (*Table 1*). The purpose of these trips includes medical trips to TMC, downtown visitors, visitors to Hermann Park, museums, and recreational trips to Rice University and UH. In this study, the transit modal split for home based non-work trips from the park and ride catchment area to destinations is assumed at a conservative 2 percent.

Parking duration is defined as the average time parked at a given parking space. It is the ratio of total vehicle hours to the number of vehicles parked. Parking turnover is defined as the average number of vehicles parked at one space per study period. It is ratio of number of vehicles parked in duration to the number of parking spaces[10].

Compared with employee parking, visitor parking is mostly short-term parking. Normally, Parking duration (a maximum of 4 hours) is limited and sufficient. Therefore, during the 12 hour study period (7 am to 7 pm), the parking turnover would be 3. One parking space can be repeated used 3 times within a 12 hour period. Additionally, the employee parking spaces can be used for visitor parking after 7 pm. Therefore, the visitor parking demand estimated in this section is mostly to accommodate the day time visitor parking for the period between 7 am to 7 pm, when the same parking spaces can be repeatedly used 3 times given a maximum of 4 hours parking limitation.

Using the 2% transit modal split and the maximum 4 hours parking limitation as discussed above, the visitor parking demand for the proposed transit center would be 69 in 2018 and 75 in 2025 (*Table 5*).

[10] http://www.engineeringcivil.com/parking-patterns-in-order-to-menace-traffic-chaos.html

TABLE 6: 2018 TRANSIT PARKING DEMAND FOR VISITORS

	2018 Home Base Non-Work Trips	Transit Modal Split	Total One-Way Transit Trips	PPV*	Total One-Way Auto Trips	Maximum Parking Durations (Hours)	Parking Space Turnover Rate	Visitor Parking Demand
from Downtown Market Area to Downtown Destination Area								
No Transfer Destination	7,334	2%	147	1.25	117	4	3	39
Transfer Destination	884	2%	18	1.25	14	4	3	5
Subtotal	**8,218**		**164**		**131**			**44**
from TMC Market Area to								
TMC Destination	3,511	2%	70	1.25	56	4	3	19
Rice & Museum Destination	745	2%	15	1.25	12	4	3	4
Subtotal	**4,256**		**85**		**68**			**23**
from UH Market Area to UH Destination								
UH Destination	481	2%	10	1.25	8	4	3	3
Subtotal	481		10		8			3
Total	**12,955**		**259**		**207**			**70**

* Auto Occupancy for H-GAC area for HBNW Trips is 1.25

TABLE 7: 2025 DAILY TRANSIT PARKING DEMAND FOR VISITORS

	2025 Home Base Non-Work Trips	Transit Modal Split	Total One-Way Transit Trips	PPV*	Total One-Way Auto Trips	Maximum Parking Durations (Hours)	Parking Space Turnover	Visitor Parking Demand
from Downtown Market Area to Downtown Destination Area								
No Transfer Destination	7,387	2%	148	1.25	118	4	3	39
Transfer Destination	953	2%	19	1.25	15	4	3	5
Subtotal	**8,340**		**167**		**133**			**44**
from TMC Market Area to								
TMC Destination	4,406	2%	88	1.25	70	4	3	23
Rice and Museum Destination	806	2%	16	1.25	13	4	3	4
Subtotal	**5,212**		**104**		**83**			**27**
from UH Market Area to UH Destination								
UH Destination	486	2%	10	1.25	8	4	3	3
Subtotal	486		10		8			3
Total	**14,038**		**281**		**224**			**74**

* Auto Occupancy for H-GAC area for HBNW Trips is 1.25

CONCLUSION

Providing parking spaces for transit users is the priority because of the facility's primary function as a light rail terminal. In this analysis, the parking demand for transit use was estimated and summarized in *Table 8.*

TABLE 8: PARKING DEMAND FOR TRANSIT USE

	2018 Employee Parking Demand	2025 Employee Parking Demand	2018 Visitor Parking Demand	2025 Visitor Parking Demand	2018 Total Parking Demand	2025 Total Parking Demand
from Downtown Market Area to Downtown Destination Area						
No Transfer Destination	204	194	39	39	243	234
Transfer Destination	14	15	5	5	19	20
Subtotal	**218**	**209**	**44**	**44**	**262**	**254**
from TMC Market Area to						
TMC Destination	219	214	19	23	238	237
Rice and Museum Destination	7	7	4	4	11	11
Subtotal	**226**	**221**	**23**	**27**	**249**	**248**
from UH Market Area to UH Destination						
UH Destination	2	2	3	3	4	5
Subtotal	2	2	3	3	4	5
Total	**446**	**432**	**s**	**74**	**515**	**507**

Combining the parking demand for both home based work trips and home based non-work trips, the transit parking demand of the proposed parking facility is estimated to be 515 in 2018 and 507 is 2025.

Currently, Magnolia Park Transit Center has 56 parking spaces available. Subtracting the existing parking supply, the demand of parking spaces would be 459 in 2018 and 451 in 2025.

Appendix D

Quantification of Benefits for Project Improvements

BENEFIT COST ANALYSIS

In this chapter, the benefit of the proposed project including the structured parking facility and pedestrian-transit improvements were evaluated. The benefit evaluation process is based on current criteria as established by the Federal Highway Administration (FHWA) through its Benefit Cost Analysis Guidance for Transportation Investment Generating Economic Recovery (TIGER) Grant Applicants, as well as guidance provided by the Houston-Galveston Area Council (H-GAC) through its 2015-2018 Transportation Improvement Program (TIP) Call for Projects. These criteria were followed to provide the most accurate, up to date, and generally accepted methodologies for benefit assessment. The intent of assessing benefits are to provide the information needed to fund the proposed project.

EVALUATION PERIOD OR PROJECT LIFECYCLE

Benefits and costs are typically evaluated for a period that includes the construction period and an operations period ranging from 20 to 50 years after the initial project is completed. When building roads and other highway investments, longer operating periods are assumed, due to the longevity of such projects. For the proposed terminal project, the evaluation period includes the relevant (post-design) construction period during which capital expenditures are undertaken, plus 40 years of operations beyond project completion within which to accrue benefits. For the purposes of this study it has been assumed that construction will begin in 2017 and be completed at the end of 2018. This analysis calculates all benefits and costs over a 40 years' evaluation period after the project built. As a simplifying assumption, all benefits and costs are assumed to occur at the end of each year.

CONSTANT DOLLARS AND DISCOUNT DOLLARS

A constant dollar is an adjusted value of currency used to compare dollar values from one period to another. Due to inflation, the purchasing power of the dollar changes over time, so in order to compare dollar values from one year to another, conversion from nominal (current) dollar values to constant dollar values would be conducted. Constant dollar value may also be referred to as real dollar value.

In this analysis, the monetized benefits and costs are estimated in constant dollars (2017 dollars), discounted to 2019 (when benefit starts), with future dollars discounted in compliance with TIGER requirements using a 7 percent real rate, and sensitivity testing at 3 percent. It is noted that the discount rate of 7% is preferred by U.S. Department of Transportation.

PROJECT COST

Total project costs, including construction and future maintenance cost, are $28,379,871 in constant dollars. Table 1 includes the breakdown of cost by project components.

TABLE 1: PROJECT COST

Over 40 Years Evaluation Period			
Project Components	**In Constant Dollars**	**Discount at 7 Percent**	**Discount at 3 Percent**
Sidewalks	$12,288,995	$10,733,684	$11,583,556
Parking Site and Facility	$11,660,055	$10,184,344	$10,990,720
Facility Maintenance	$4,430,821	$1,343,669	$2,472,084
Total Cost	**$28,379,871**	**$22,261,696**	**$25,046,360**

PROJECT BENEFIT ANALYSIS

Ridership and VMT Projections

Parking Facility

The proposed parking facilities would reduce auto trips, reduce vehicle miles traveled (VMT) and increase transit ridership. Annual ridership and VMT projections are based on the daily transit demand estimated in the previously completed demand analysis. Assuming an average of annual 234 days for home-based work (HBW) trips (excluding sick leave and vacation leave) and an average annual 312.5 day for home-based non-work (HBNW) trips, it is expected that the proposed parking facility would reduce 169,291 one way auto trips in 2018 with total reduction of VMT over 1.5 million. The projected increase of transit ridership is estimated to be 391,872 (Table 2).

TABLE 2: 2018 VMT REDUCED AND TRANSIT RIDERSHIP INCREASED FROM PROPOSED PARKING FACILITY

	2018 One Way Auto Trips Reduced	Average One Way Auto Trip Length* (mile)	2018 Vehicle Miles Travelled Reduced	2018 Increased Transit Ridership
from Downtown Market Area to Downtown Destination Area				
No Transfer Destination	84,406	2.9	489,559	196,658
Transfer Destination	7,739	3.1	47,987	18,354
from TMC Market Area to				
TMC Destination	68,907	7.0	964,802	156,878
Rice and Museum Destination	5,427	7.3	79,275	13,062
from UH Market Area to UH Destination				
UH Destination	2,820	2.3	12,959	6,919
Total	**169,291**		**1,594,482**	**391,872**

*Based on google map

Pedestrian-transit VMT Projections

The proposed pedestrian-transit improvement will accommodate a healthier lifestyle by promoting walking and walkable communities within the East End. Increased pedestrian activity would reduce the usage of auto vehicles and therefore reduce VMT. Following H-GAC guidance regarding quantifying VMT from sidewalk improvements, the proposed improvements are estimated to reduce 60,444 VMT in 2018 (See Appendix D for methodology of estimating VMT from sidewalks).

Ridership and VMT Projection Over Evaluation Period

Assuming no growth of VMT reduction (parking facility and pedestrian-transit improvements) and ridership increase over the project evaluation period, the accumulated VMT and ridership over the next 40 years would be 64,542,127 and 15,674,865, respectively (Table 3).

TABLE 3: TRANSIT RIDERSHIP AND VMT PROJECTION

Projections Over Evaluation Periods	
VMT Reduced	64,542,127
Ridership Increase	15,674,865
One Way Auto Trips Reduced	6,771,629

Benefit Criteria

Following the guidance established by FHWA and H-GAC, five benefits were considered for the proposed project. The five benefits include:

- Economic
- Safety
- Environmental
- Livability
- Existing Capital Productivity

Among the five criteria selected, economic, safety and environmental benefits are quantified.

ECONOMIC BENEFIT

Job Creation

The proposed project is expected to generate economic impacts and create jobs. In the short term, it is estimated that the project will create construction jobs monthly in the region over the entire construction period. This includes skilled positions such as project supervisors, machine operators, welders, carpenters, concrete workers, and general laborers. Personnel who are hired to fill vacant positions will receive on-track safety training, on-the-job rail worker training, and other training opportunities that will increase their skill set and may lead to further employment in the construction industry. In the long term, the project will preserve

jobs by providing annual maintenance of the proposed parking facility within the next 40 years. In addition, the project's procurement plan is likely to create follow-on jobs and near-term economic activity for manufacturers and suppliers. All materials and capital equipment used on the project will be purchased from U.S. manufacturers (to comply with Buy America standards), creating additional jobs within the U.S. The project's job creation impact from the construction expenditures on the economy of the United States was estimated, based on the employment impact multiplier recommended by the Council of Economic Advisors (CEA) as described in Appendix A.

Fare Box Revenue from Increased METRO Rail Riders

It is expected that the proposed parking facility would increase METRORail ridership by allowing residents within the market area of the proposed facility to park their vehicles at the proposed site and use METRO rail service to travel to destinations. Fare box revenue from increased ridership would increase the fare coverage ratio of METRO's rail operating expense.

Parking Revenue for GEEMD

The proposed parking facility is not designed for free parking. Parking revenue generated from the facility users can be used to cover the annual maintenance/operating costs of facility and excess funds can be reinvested into additional pedestrian-transit related infrastructure within GEEMD.

Transportation Out-of-Pocket Cost Saving

Savings in out-of-pocket costs apply are experienced for pedestrians or transit users who are diverted from autos. Out of pocket costs are composed of five vehicle operating costs: fuel, oil, tires, maintenance, and depreciation. The consumption rates for these costs are derived from average vehicle speeds and are combined with unit cost estimates to derive total out-of-pocket costs per mile and per trip. The out-of-pocket costs are combined with estimated parking costs to estimate the total out-of-pocket cost per trip for auto users. The decrease in out-of-pocket cost represents out-of-pocket cost savings for users. For travelers who divert from auto to public transit, the out-of-pocket savings are estimated by subtracting transit fare payments from out-of-pocket costs.

Safety Benefit

The proposed parking facility improves overall safety and security and reduces risk and/or severity of motor vehicle crashes by promoting public transit use. Reduced auto usage and VMT will lower the incidence of traffic accidents.

The proposed pedestrian-transit improvements will further meet the goals of the H-GAC Livable Centers program, which is designed, in part, to improve integration of transit facilities into their surrounding communities. Streetscape enhancements surrounding the facility will provide a safer pedestrian environment. In addition to a safer pedestrian, the reduction of VMT will lower the incidence of traffic accidents.

Environmental Benefit

The U.S. EPA has classified the Houston-Galveston-Brazoria area in a severe eight-hour ozone nonattainment standard and, therefore, the air quality does not meet federal air quality standards. This investment in transit infrastructure would produce environmental benefits and help create a cleaner, healthier environment that will be important to the region's future growth.

The proposed project will result in a reduction in harmful air pollutants and VMT resulting from decreased auto use and the addition of the solar panel system. H-GAC, the Houston-Galveston Metropolitan Planning Organization (MPO), models harmful air pollutants, such as Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC), and Carbon Monoxide (CO). In addition to a reduction in harmful air pollutants, the proposed project will result in a decrease in fuel and auto costs.

Existing Capital Productivity Benefit

The proposed parking facility will enhance use of METRORail service. Commuters traveling from the catchment areas of proposed parking facility will be able to board METRORail to destination areas. Currently, the headways for the existing METRO rail is 7 minutes. METRO operates 2 trains with capacity for more than 200 passengers including seating and standing room. The existing service can accommodate the projected transit demand induced from the proposed parking facility. The ability to utilize the excess load capacity will result in an increased utilization and performance for METRO rail service.

Livability Benefit

The U.S. DOT encourages major transit investment projects to focus development towards such strategies as transit oriented, mixed-use development, and land recycling – to increase community revitalization, improve the efficiency of public works investments, and safeguard rural landscapes. The proposed project will provide an opportunity to invest in a mixed-use TOD and land recycling to spur community revitalization. The study area is currently a target area for mixed-use development. H-GAC defines these areas as Livable Centers. Livable Centers are safe,

convenient, and attractive areas where people can live, work, and play with less reliance on their cars.

BENEFIT QUANTIFICATION

Economic Benefit

1) Job Creation

The total project cost would be $28,379,871 in constant dollars. Using the methodologies in Appendix A, it is estimated the proposed project would generate 225 jobs including 135 direct and indirect jobs, and 90 induced jobs within construction period. In this case, direct and indirect job are construction related and the induced jobs are retail related jobs supporting the construction activities. Additionally, the annual maintenance cost of the proposed parking facility is approximately $20,000, which would also create one permanent job within the next 40 years.

2) Fare Box Revenue from Increased METRO Rail Riders

Fare box revenue is estimated using $1.25 fare for METRO rail multiplied by the projected additional ridership in Table 3. The project is projected to generate around $6.1 million in additional fare box revenue for METRO over the next 40 years when discounted at 7% (Table 4).

TABLE 4: MONETIZED VALUE OF FARE BOX REVENUE

Over Benefit Evaluation Period			
	In Constant Dollars	Discount at 7 Percent	Discount at 3 Percent
Fare Box Revenue from Increased Ridership	**$19,593,582**	**$6,103,176**	**$10,992,747**

3) Parking Revenue for GEEMD

Parking revenue is estimated using average parking cost at the proposed facility multiple by the parked vehicles or one way auto trips reduced in Table 3. Assuming an average of $5 parking fee per vehicle per use at the proposed facility, GEEMD is expected to have an annual parking revenue of $846,454. The parking revenue within the project evaluation period would be $10,546,423 with a discount of 7% (Table 5).

TABLE 5: MONETIZED VALUE OF PARKING REVENUE

Over Benefit Evaluation Period			
	In Constant Dollars	Discount at 7 Percent	Discount at 3 Percent
Parking Revenue	$33,858,143	$10,546,423	$18,995,710

4) Transportation Out-of-Pocket Cost Savings

The vehicle operating costs are estimated using consumption rates for fuel, oil, tires, maintenance, and depreciation. Estimates of vehicle miles traveled and unit costs are applied to these consumption rates to calculate total vehicle operating costs. Appendix A provides the unit cost estimates used in the analysis, along with other out-of-pocket costs, such as parking fees and transit fares.

Table 6 below presents the out-of-pocket transportation cost saving over the project evaluation periods. The monetized value is over 50 million in constant dollars, which the saving from reduced VMT, as well as the cost savings from avoiding parking at downtown, TMC, Rice, UH and Museum District.

TABLE 6: MONETIZED VALUE OF TRANSPORTATION COST SAVING

Over Benefit Evaluation Period			
	In Constant Dollars	**Discount at 7 Percent**	**Discount at 3 Percent**
Operating Cost Saving	$35,746,409	$11,134,596	$20,055,099
Parking Cost Saving	$33,858,143	$10,546,423	$18,995,710
METRO Rail Fare Cost	$(19,593,582)	$(6,103,176)	$(10,992,747)
Transportation Cost Saving	**$50,010,970**	**$15,577,843**	**$28,058,062**

Safety Benefit

Reductions in VMT lower the incidence of traffic crashes. The preventable crashes due to reduced driving over the benefit evaluation periods are projected to 183. Around 1,376 injuries can be prevented (See Appendix B for the methodology used to assess safety benefits).

Accident cost saving from the proposed project would be $25,255,842 in constant dollars over the project's lifecycle (Table 7).

TABLE 7: MONETIZED VALUE OF ACCIDENT COST SAVING

Over Benefit Evaluation Period			
	In Constant Dollars	Discount at 7 Percent	Discount at 3 Percent
Accident Cost Saving	$25,255,842	$7,502,994	$13,922,399

Environmental Benefit

Three categories of environmental impacts from the proposed project are considered in this analysis:

- Reduction in greenhouse gas emissions, which are measured in carbon dioxide (CO2) equivalents;
- Reduction in gasoline consumption, which is measured in gallons of gasoline consumption reduced; and
- Reduction in air pollutant emissions which is measured in tons of volatile organic compounds (VOC), carbon monoxide (CO), Particulate Matters (PM 2.5 and PM 10).

1) Reduced Air Pollutant Emissions

A decrease of 64,542,127 VMT (Table 3) generates an estimated reduction of approximately 65 metric tons of harmful air pollutants over the project evaluation period. The total monetized value of the 65 metric tons of emissions is $196,456 in constant dollars. (See Appendix C for the methodology used to assess environmental benefits).

2) Reduced Greenhouse Gas Emissions

The reduction of greenhouse gas emission was estimated using the reduction in vehicle miles travelled over the project evaluation period in Table 3 multiplied by the unit value of greenhouse gas emission per mile driven as stated in Appendix C. The proposed project is estimated to reduce approximately 23,756 metric tons with the total economic value of $1,819,931 in constant dollars over the project evaluation period.

3) Reduced Gasoline Consumption

The reduction of gasoline consumption was estimated using the reduction in vehicle miles travelled over the project evaluation period in Table 3 multiplied by the unit value of gasoline consumption per mile driven as stated in Appendix C. The estimated total saving of gasoline consumption would be 2,677,853 gallons by 2058. The economic benefit would be $11,291,122 in constant dollars.

4) Summary of Environmental Benefit

Combining the economic benefit from air pollutants emission reduction, greenhouse gas emission reduction and gasoline consumption reduction, the accumulated environmental benefit of proposed project would be $13,307,508 in constant dollars (Table 8)

TABLE 8: MONETARY VALUE OF EMISSIONS REDUCTIONS AND GASOLINE CONSUMPTION SAVINGS

Type	Quantity	Unit	Monetary Value		
			In Constant Dollars	Discount at 7 Percent	Discount at 3 Percent
Air Pollutants Emission Reduction	65	Metric Tons	$196,456	$87,967	$127,778
CO2 Emission Saving	23,756	Metric Tons	$1,819,931	$504,108	$1,715,459
Gasoline Consumption Reduction	2,677,853	Gallons	$11,291,122	$2,740,430	$5,638,053
Total Savings			**$13,307,508**	**$3,332,505**	**$7,481,290**

BENEFIT EVALUATION

Key Benefit-Cost Evaluation Measures

There are three common benefit-cost evaluation measures, each tailored to compare benefits and costs from different perspectives. The benefit-cost analysis converts potential gains and losses from the proposed investment into monetary units and compares on the basis of economic efficiency, as in net present value (NPV). For example, NPV = PVB (present value of benefits) – PVC (present value of costs). In essence, NPV gives the magnitude of the project's economic feasibility in terms of net benefits discounted to present values using real discount rate assumptions. Under this criterion, a scenario with an NPV greater than zero may be considered "economically feasible." The NPV provides some perspective on the overall dollar magnitude of benefits not reflected by the other two measures.

Economic Rate of Return

The Economic Rate of Return (ERR) is the discount rate that makes the present value of all benefits just equal to the present value of all costs. The ERR measures the social or economic return on investment. As an evaluation measure, it allows comparison of the proposed investment package with other similar packages and/or alternative uses of investment funds that may have different costs, different benefit flows, and/or different timing. The ERR is interpreted as a real rate of return, since the assumption is that benefits and costs are expressed in constant dollars. As such, it should not be directly compared with investment returns calculated from inflated or nominal future year dollars. In some cases, a threshold value for the ERR may be established where exceeding that threshold results in the determination of an economically justified project.

Benefit/Cost Ratio

The evaluation also estimates the benefit-cost ratio, where the present value of incremental benefits divided by the present value of incremental costs yields the benefit-cost ration (B/C ratio = PVB/PVC). In essence, the B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent by which a project's benefits either exceed or fall short of their associated costs. The B/C ratio can be useful when the objective is to prioritize or rank projects or portfolios of projects with the intent to decide how to best allocate an established capital budget, assuming equivalent classification of benefits and costs.

Monetizing Benefit

Table 9 summarizes the benefit cost analysis findings. Assuming a seven percent (7%) discount rate, $22,261,696 in discounted project construction and life cycle costs generates $42,979,541 in net benefits, or a benefit-to-cost ratio of 1.93 to 1. Given these assumptions, the projects net present value is around $20.7 million and the internal rate of return is 8.72%.

With a 3 percent real discount rate, the net present value of the project would increase to $54 million, for a benefit-to-cost ratio of 3.16.

TABLE 9: BENEFIT SUMMARY

Benefit(s)	In Constant Dollars	Discounted Values (7% Real Discount Rate)	Discounted Values (3% Real Discount Rate)
Economic			
Transportation Cost Savings	$50,010,970	$15,577,843	$28,058,062
Fare Box Recovery	$52,115,431	$16,566,199	$29,590,739
Environmental			
CO2 Emission Saving	$1,819,931	$504,108	$1,715,459
Gasoline Consumption Reduction	$11,291,122	$2,740,430	$5,638,053
Air Pollutants Emission Reduction	$196,456	$87,967	$127,778
Safety			
Accident Reduction	$25,255,842	$7,502,994	$13,922,399
Total Benefits ($)	**$140,689,751**	**$42,979,541**	**$79,052,490**
Cost of Facility and Sidewalks	**$28,379,871**	**$22,261,696**	**$25,046,360**
Total Costs ($)	**$28,379,871**	**$22,261,696**	**$25,046,360**
B/C Ratio	**4.96**	**1.93**	**3.16**
NPV	**$112,309,880**	**$20,717,844**	**$54,006,130**
Economic Rate of Return (Internal Return Rate)	**16.33%**	**8.72%**	**12.99%**

Sensitivity Analysis

In order to test the robustness of the estimated NPV, ERR and B/C ratio, the economic analysis also conducts several sensitivity tests, where the estimated measures are recalculated under varying scenarios. The scenarios include:

- Scenario A1: 7% discount rate; 15% increase in all calculated benefits
- Scenario A2: 7% discount rate; 15% decrease in all calculated benefits
- Scenario A3: 7% discount rate; 15% increase in initial capital costs
- Scenario A4: 7% discount rate; 15% decrease in initial capital costs
- Scenario B1: 3% discount rate; 15% increase in all calculated benefits
- Scenario B2: 3% discount rate; 15% decrease in all calculated benefits
- Scenario B3: 3% discount rate; 15% increase in initial capital costs
- Scenario B4: 3% discount rate; 15% decrease in initial capital costs

Table 10 presents the evaluation results for eight sensitivity tests. All benefits and costs were estimated in constant 2017 dollars, over an evaluation period extending 40 years beyond project completion.

TABLE 10: BENEFIT SENSITIVITY TEST

Benefit(s)	Net Present Value (NPV)	Economic Rate of Return (ERR)	Benefit-Cost Ratio (B/C)
7% discount rate	$20,717,844	8.72%	1.93
Sensitivity Tests			
A1: 15% increase in benefits	$27,164,775	11.57%	2.24
A2: 15% decrease in benefits	$14,270,913	5.99%	1.66
A3: 15% increase in cost	$17,378,590	6.34%	1.70
A4: 15% decrease in cost	$24,057,099	11.43%	2.57
3% discount rate	$54,006,130	12.99%	3.16
Sensitivity Tests			
A1: 15% increase in benefits	$65,864,004	15.95%	3.62
A2: 15% decrease in benefits	$42,148,257	10.15%	2.68
A3: 15% increase in cost	$50,249,176	10.52%	2.74
A4: 15% decrease in cost	$57,763,085	15.80%	4.46