Texas Medical Center Mobility Study

FANNIN STREET CORRIDOR ANALYSIS
TECHNICAL MEMO

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1.0 INTRODUCTION

1.1 Purpose of Report

This report summarizes the analysis of potential transit, roadway and pedestrian improvements in the Fannin Street corridor through the Texas Medical Center to relieve traffic congestion and reduce conflicts among the various modes. The analysis was conducted as part of the TMC Mobility Study. The report first reviews existing traffic operations and safety issues along the Fannin Street corridor. Then both higher cost light rail transit (LRT) realignment options are presented and evaluated, followed by an assessment of lower cost roadway and signal modifications to improve conditions.

1.2 Study Area

The study area encompasses The TMC Central Campus area, and focuses on the Fannin Street corridor from Hermann Park north of Cambridge Street on the north to south of Braeswood Blvd. on the south, and between Main Street on the west and Cambridge, McGregor Way and Braeswood on the east (see Figure 2.1).

2.0 EXISTING CONDITIONS

2.1 LRT Operations along Fannin

The existing LRT operation on Fannin Street is part of the broader Red Line operating from downtown Houston to Reliant Stadium southwest of the TMC (see Figure 2.1). Service through most of the days on weekdays is every 6 minutes, and every 12 minutes on weekends. Early morning and late night service ranges from 12 minutes on weekdays to 18 minutes on weekends. There are three stations serving the TMC area along Fannin Street:

- Memorial Hermann Hospital/Houston Zoo
- Dryden TMC
- TMC Transit Center

The existing LRT line operates in the median of Fannin Street (see Figure 2.2). Between signalized intersections, the LRT line operates in a separate right-of-way, separated from adjacent general traffic lanes through bollards, curbing, and raised pavement makers. At four signalized intersections (Ross Sterling Street, John Freeman Street, University Blvd., Dryden Road), the trackway is shared with left turning vehicles The LRT is also grade separated under Holcombe Street.

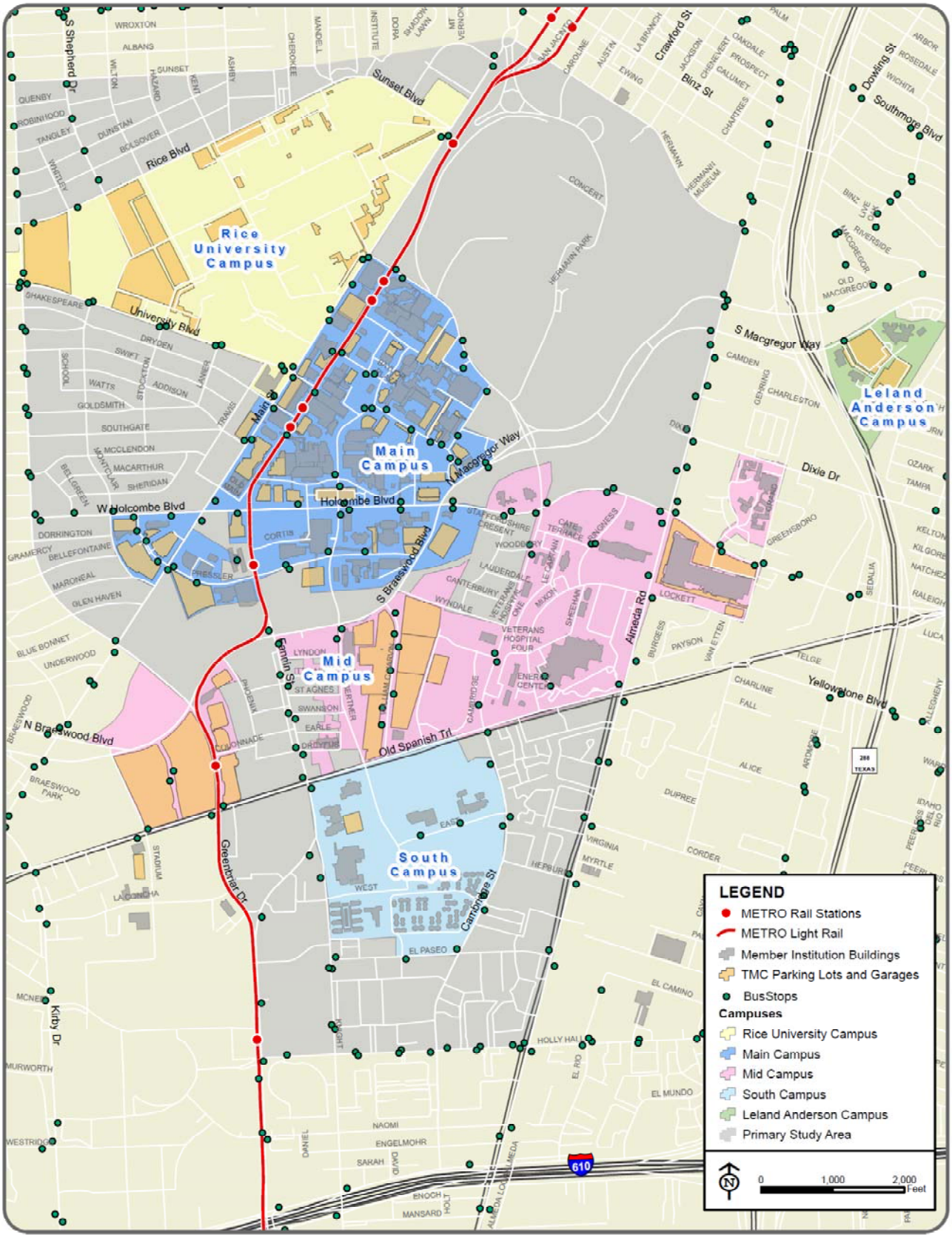

FIGURE 2.1
EXISTING LRT RED LINE CORRIDOR THROUGH TMC

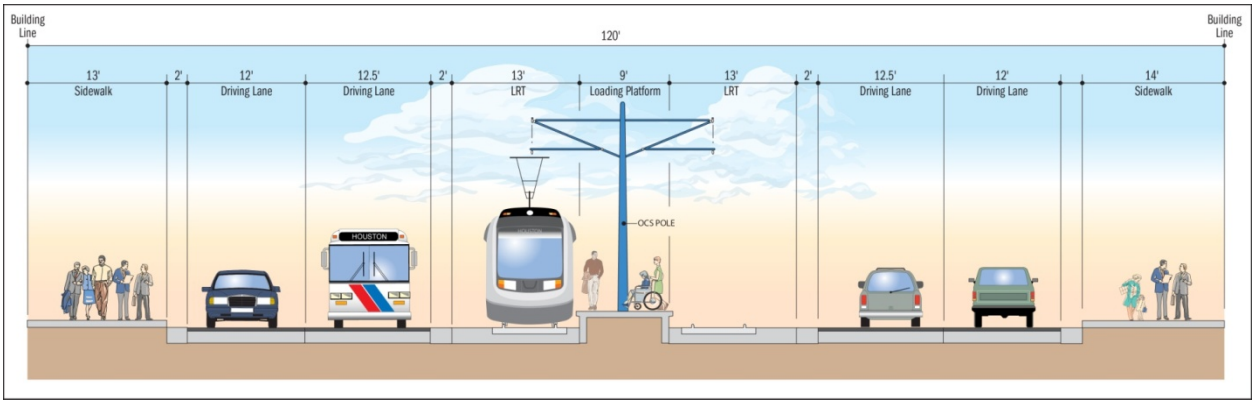

FIGURE 2.2 – EXISTING FANNIN ST. CROSS SECTION WITH TWO-WAY LRT IN MEDIAN

Existing LRT in Median on Fannin

Car Making Left Turn from LRT Trackway

Physical Separation Between LRT Trackway and Traffic Lane at Station

The ridership of the METRO Red Line (see Figure 2.3) indicates that the TMC General Study Area accounts for about half of all passengers using light rail. The most-used station, Dryden, is in the TMC, and the three "TMC Destination" stations are in the top five Red Line stations.

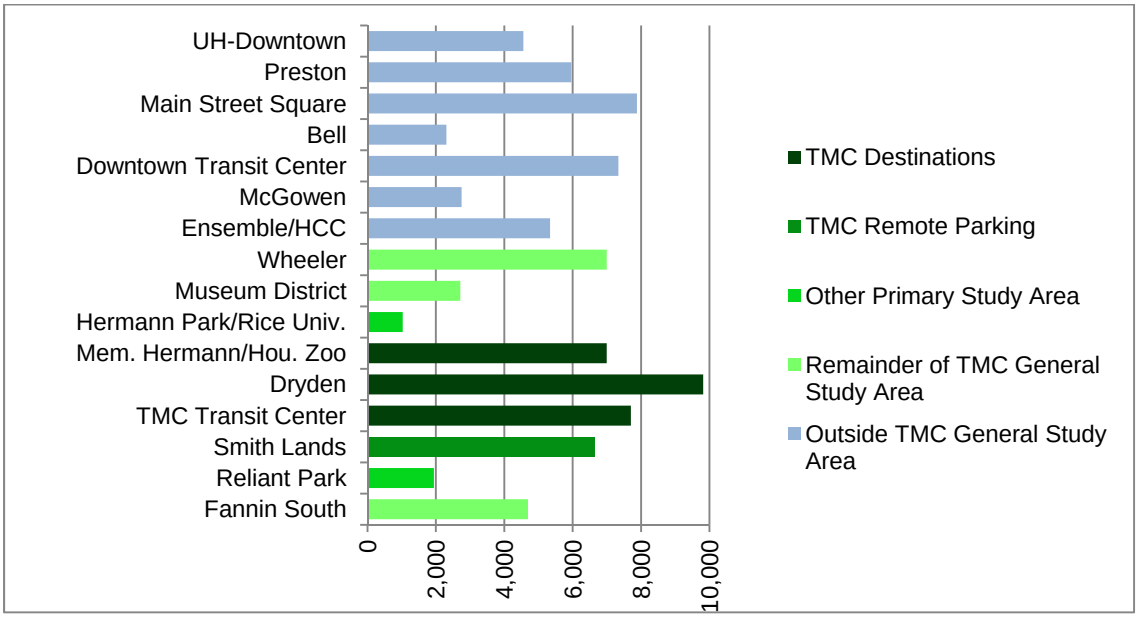

FIGURE 2.3
METRO RED LINE STATIONS WEEKDAY ON AND OFF PASSENGERS

2.2 Adequacy of Station Platform Areas and Pedestrian Crossings

The LRT stations are typically side platform farside of a signalized intersection. The platforms are generally only 10 feet wide to the back railing, with an effective width for passengers as narrow as eight feet with the provision for various passenger amenities such as benches and ticket vending machines. Passenger access to the stations is from a crosswalk at the adjoining signalized intersection, with pedestrian signals provided and timed with cross street traffic to allow passengers to access the median area. There are curb ramps integrated into the adjoining sidewalks to provide ADA access, but several ramps are blocked by fire hydrants and poles which preclude them from fully being utilized

Typical Crowded LRT Station Platform During Peak Hours

Passengers Accessing LRT Station

Obstacles at Pedestrian
Crosswalk/Curb Ramp Location

The TMC area is well served with sidewalks and skybridges to accommodate safe, efficient travel throughout the five campuses. The sidewalks located within the Texas Medical Center (TMC) study area are generally contiguous with little to no gaps; the width of the crosswalks was observed to be 4 feet or less along most public streets. The sidewalks provide convenient access to open spaces and institutions throughout the TMC. Crosswalks are generally located at each signalized intersection within the study area. Pedestrian signals were located at all the study intersections and were observed to be operating in good condition. Figure 2.4 shows the location of sidewalks, skybridges and cross walk locations within the Main Campus.

The following field observations were made related to pedestrian facilities in the primary study area:

- On west side of the Main Street, jogging trail was present between Sunset Blvd and Cambridge.
- On the east side of the Main Street, sidewalk was in good condition throughout the study area.
- At a few intersections the wheel chair ramps were observed to be in bad condition. (Example: At the northeast corner of the intersection of Main at Cambridge, the wheel chair ramp was observed to be in a bad condition)
- The sidewalks along Fannin Street in the study area are in good condition.
- It was observed that the pedestrians were jay-walking across Fannin in the Main campus.
- The sidewalks along Holcombe Blvd. and Cambridge Street were observed to be in good condition.
- Along Braeswood Boulevard, between Greenbriar Drive and Fannin Street, sidewalk was disconnected.
- Also, it was observed that the sidewalk was less than 4 feet wide along south side of Braeswood Boulevard between Fannin Street and Bertner Street.
- Along Cambridge Street, the sidewalk on the east side between Braeswood Boulevard and Hermann Park Drive was of mixed character (partly dirt trail and partly concrete).

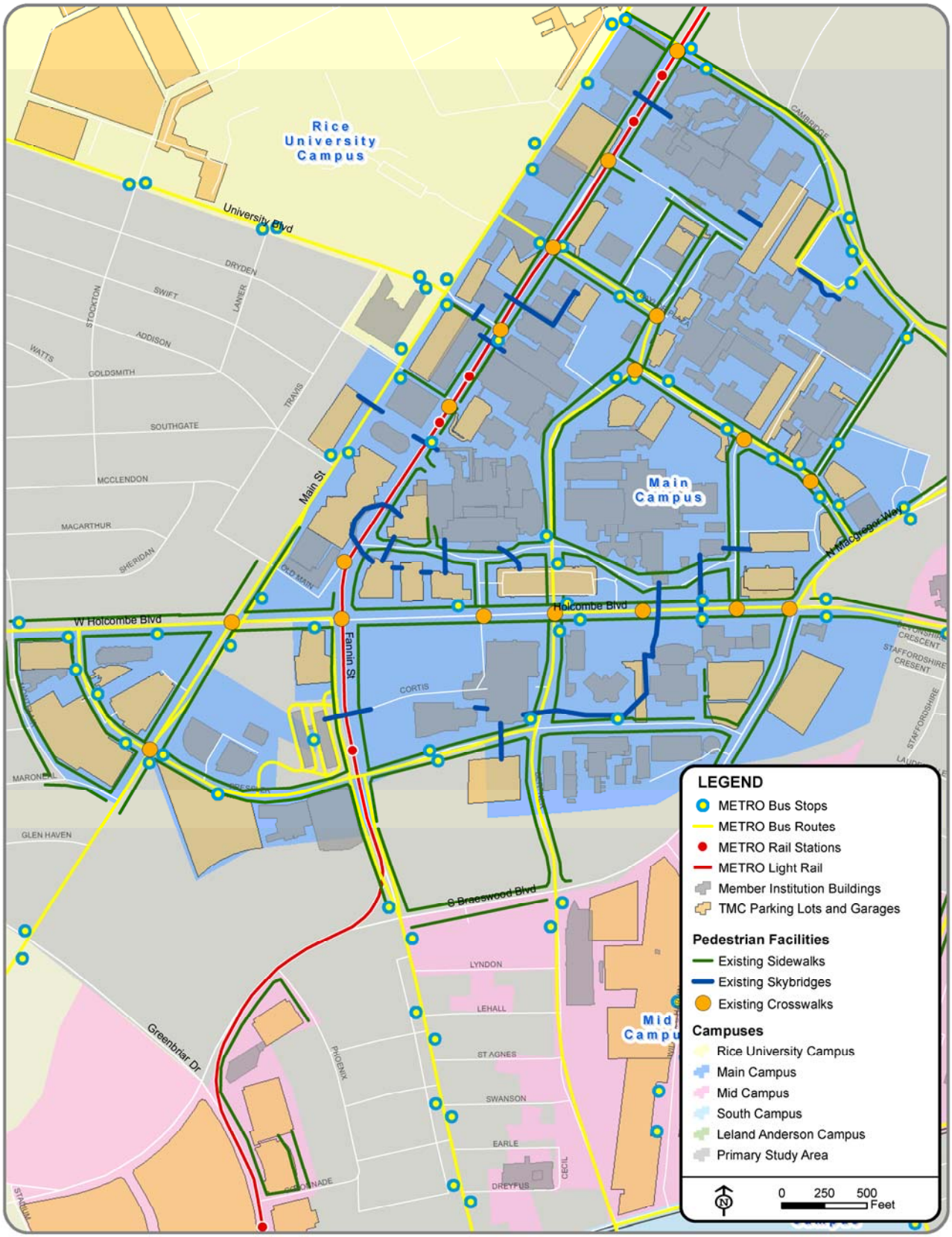

FIGURE 2.4
EXISTING PEDESTRIAN FACILITIES

2.3 General Traffic Bottlenecks

Several thoroughfare street intersections are controlled using traffic signals in the study area. Figure 2.5 shows a map of 67 traffic signal locations in the primary study area. Fannin Street has several closely spaced signalized intersections. Main Street, Fannin Street, and Holcombe Boulevard have signal coordination. All signals in the primary study area are equipped for emergency vehicle preemption.

The Year 2011 bi-directional 24-Hour traffic volumes on the roadways in the study area were obtained from the City of Houston GIMS maps. The 24-Hour traffic counts are summarized in Table 2.1. The lane configurations at selected intersections are illustrated in Figures 2.6 and 2.7.

A traffic counting program was undertaken by study team to obtain the existing weekday AM and PM peak hour traffic data at the analysis intersections. Traffic volumes for all study intersections were compared to determine the study area peak hours within the peak periods. The overall peak hours determined from these counts are as follows:

- AM Peak Hour – 7:15 AM to 8:15 AM
- PM Peak Hour – 4:45 PM to 5:45 PM

The existing AM and PM peak hour intersection traffic data are summarized in Table 2.2 and Table 2.3, respectively.

TABLE 2.1
24-HOUR TRAFFIC COUNTS IN PRIMARY STUDY AREA

Street	Location	ADT
Main St	South of Sunset Blvd	34,599
Main St	South of University Blvd	34,911
University Blvd	West of Main St	14,253
Holcombe Blvd	West of Greenbriar Dr	31,691
Holcombe Blvd	East of Greenbriar Dr	43,509
Greenbriar Dr	North of Holcombe Blvd	15,104
Greenbriar Dr	South of Holcombe Blvd	9,011
Main St	South of Greenbriar Dr	33,957
Main St	South of Dryden	34,911
Holcombe Blvd	East of Bertner Ave	31,265
Braeswood Blvd	East of Fannin St	8,541
Fannin St	South of Braeswood Blvd	25,238
Braeswood Blvd	East of Fannin St	8,541
MacGregor Dr	North of Holcombe Blvd	19,970

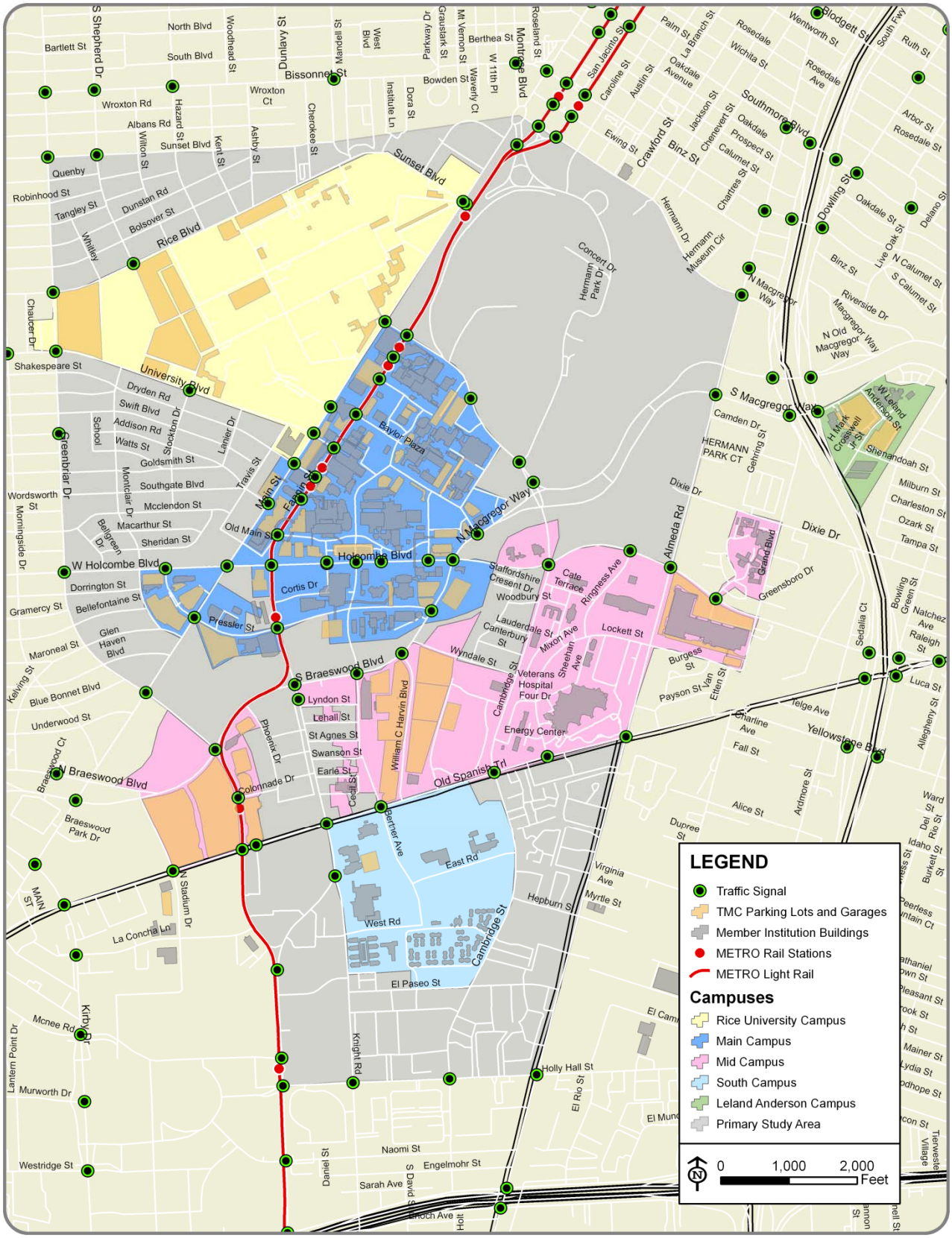

FIGURE 2.5
EXISTING TRAFFIC SIGNAL LOCATIONS

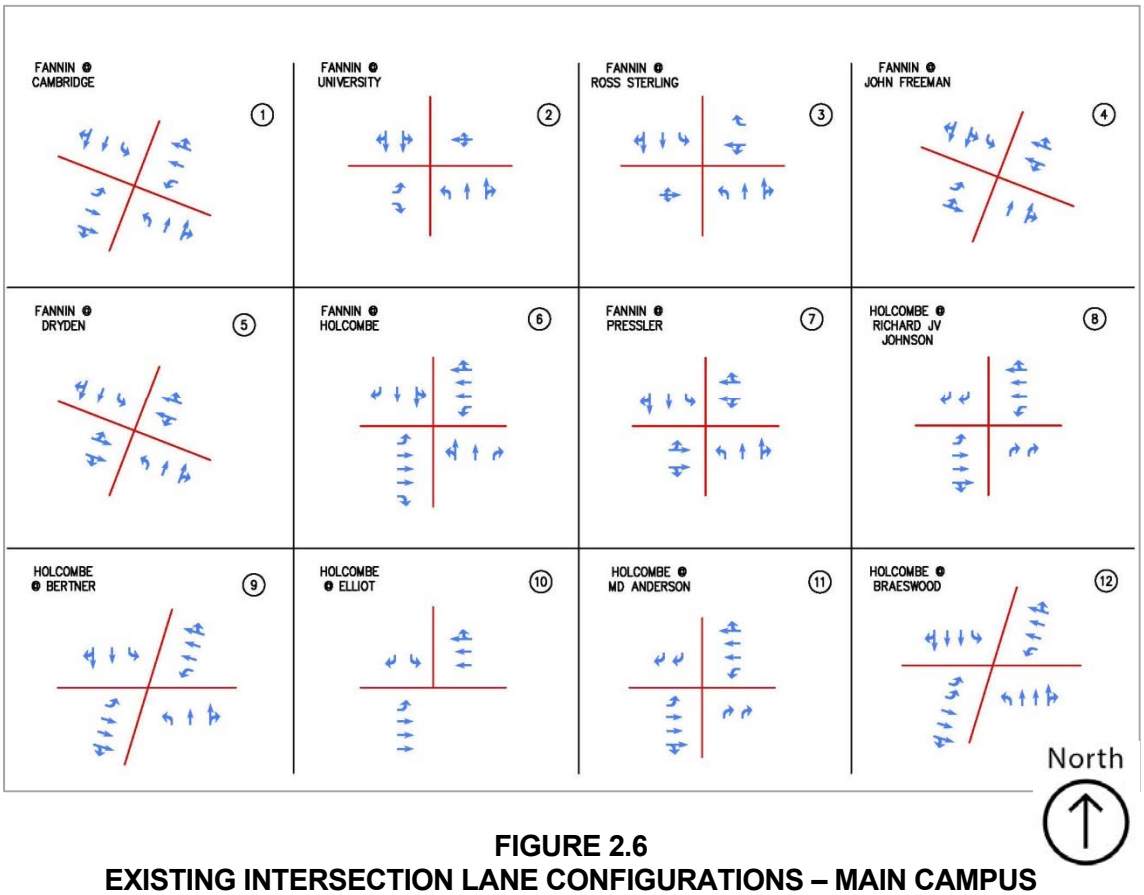

FIGURE 2.6
EXISTING INTERSECTION LANE CONFIGURATIONS – MAIN CAMPUS

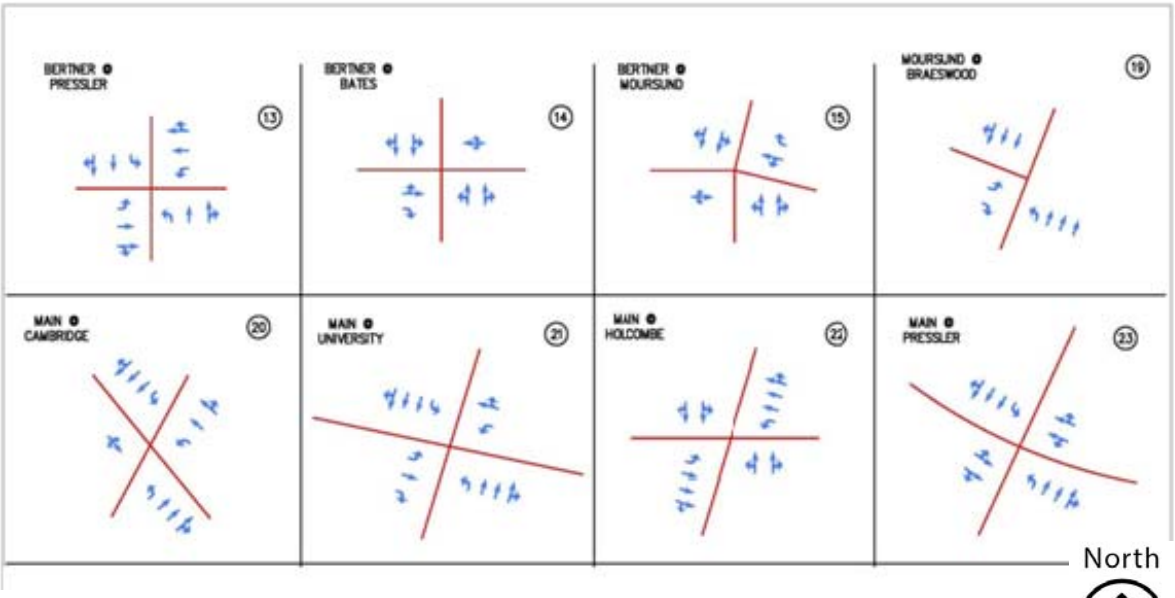

FIGURE 2.7
INTERSECTION LANE CONFIGURATIONS – MAIN CAMPUS contd.

TABLE 2.2
WEEKDAY AM PEAK HOUR TURNING MOVEMENT COUNTS

Intersection	Southbound			Westbound			Northbound			Eastbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Fannin at Cambridge	200	814	39	141	427	66	39	333	87	1	322	75
Fannin at University	-	462	69	6	19	35	127	487	1	135	2	180
Fannin at Ross Sterling	51	701	77	44	6	55	33	411	65	0	0	0
Fannin at John Freeman	79	531	63	85	142	65	2	430	204	13	230	16
Fannin at Dryden	23	570	65	1	94	62	68	528	84	30	73	155
Fannin at Holcombe	95	41	76	209	994	187	122	98	113	207	1617	199
Fannin at Pressler	25	470	44	71	85	33	101	933	108	25	192	189
Bertner at Holcombe	65	185	75	144	741	206	146	195	68	116	897	87
Holcombe at Elliot	131	-	149	-	1,106	126	-	-	-	99	1102	-
Holcombe at MD Anderson	322	1016	9	24	1,099	231	-	-	10	-	-	163
Holcombe at Braeswood	0	2	98	46	792	94	2	0	26	196	802	68
Bertner at Pressler	104	265	57	87	138	67	51	269	113	85	129	69
Bertner at Bates	13	216	57	116	32	33	56	360	70	30	55	67
Moursund at Bertner	0	0	0	119	1	183	1	160	137	135	164	13
Moursund at Braeswood	208	-	151	-	-	-	152	213	-	-	1081	319
Main at Cambridge	140	1358	20	359	16	193	14	1,057	225	2	4	11
Main at University	70	1062	110	44	53	59	86	1,458	103	258	287	81
Holcombe at NB Main	-	-	-	-	926	295	27	70	354	405	1614	-
Holcombe at SB Main	231	16	132	237	723	-	-	-	-	-	1800	15
Cambridge at Braeswood	353	167	153	34	1,258	718	55	292	36	60	397	13

TABLE 2.3
WEEKDAY PM PEAK HOUR TURNING MOVEMENT COUNTS

Intersection	Southbound			Westbound			Northbound			Eastbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Fannin at Cambridge	103	331	57	83	392	105	135	717	139	2	433	68
Fannin at University	-	646	190	15	26	35	70	642	0	174	0	167
Fannin at Ross Sterling	27	542	13	44	2	127	14	858	47	0	0	0
Fannin at John Freeman	81	689	66	102	239	180	0	742	119	27	80	33
Fannin at Dryden	23	792	117	3	130	93	56	609	55	51	13	100
Fannin at Holcombe	144	71	234	147	1,581	148	155	66	72	119	1,063	97
Fannin at Pressler	11	765	45	64	192	68	45	495	38	57	113	124
Holcombe at Elliot	137	-	170	-	986	55	-	-	-	64	1160	-
Holcombe at MD Anderson	118	1047	22	10	837	126	-	-	13	-	-	240
Holcombe at Braeswood	208	811	28	35	585	27	87	187	128	126	214	310
Bertner at Pressler	38	337	72	118	169	147	53	229	38	89	82	73
Bertner at Bates	17	323	71	80	50	40	51	227	20	53	23	169
Moursund at Bertner	4	0	7	100	0	132	1	146	110	121	147	0
Moursund at Braeswood	288	-	117	-	-	-	28	395	-	-	456	100
Main at Cambridge	92	991	20	239	12	376	14	1,584	278	26	28	39
Main at University	30	1289	234	214	170	67	141	1,035	57	147	103	105
Holcombe at NB Main	-	-	-	-	1,777	163	119	57	170	179	967	-
Holcombe at SB Main	196	45	318	445	1,461	-	-	-	-	-	946	35
Cambridge at Braeswood	676	278	95	74	543	270	13	198	74	155	957	54

Through field observation supplemented by a review of traffic counts and level of service analysis, several points of traffic congestion along the Fannin Street corridor have been identified, distinguished by the weekday AM and PM peak hours:

AM Peak Hour

- Westbound traffic along Holcombe Boulevard was observed to be heavy at Fannin Street, but in other directions traffic flow was lower and flowing smoothly.
- All-way stop control intersection of MD Anderson Boulevard at Moursund Street observed some back up, mainly due to parking garage entry traffic.
- Cambridge Street at Hermann Park was observed to be congested during the spring break. Heavy back-ups were observed at Cambridge/Hermann Drive intersection.
- Overall traffic operation at the intersection of Fannin and Pressler was satisfactory in spite of the presence of the METRO transit center and heavy pedestrian activity. However, high delays were observed for the southbound left turn movement of the intersection due to the presence of the METRO Rail LRT station north of the intersection. It was observed that the southbound left turn phase is prohibited when the train is detected in either direction and is not released until the train leaves the station. In the scenario where northbound train checks in before the southbound train checks out of the station the delay for the southbound left turn movement extended up to five minutes.
- The intersection of Fannin at University experiences heavy delays during the AM peak hour.
- The traffic along Main Street in both northbound and southbound directions was observed to be operating at or below capacity.
- The intersections along Main Street at Cambridge and Holcombe Boulevard were observed to be operating with no significant delays.
- Sunset Drive at Main Street was observed to have poor pedestrian operating conditions. The pedestrian ramps need to be reconstructed to meet ADA standards.

PM Peak Hour

- During PM peak hour, Holcombe eastbound traffic flow observed to be smooth; however, westbound traffic spilled back into upstream intersections.
- High delay was observed at the eastbound left turn movement from Holcombe to northbound Fannin.
- Progressive traffic movement was observed along northbound Fannin Street between Holcombe Blvd. and John Freeman Blvd.
- Between John Freeman and Sunset, along northbound Fannin Street, traffic flow was not continuous and delays were observed. The traffic was observed to be stopping at each signal in this segment.
- The level of service at the intersections along Fannin within Main Campus were observed to have slight delay in the field, however the traffic analysis results show heavy delays. The traffic on the

northbound and southbound through movements did not spill back into upstream intersections. Field observations indicated that delay was better than LOS D and no queues were observed.

- The unsignalized intersections within the Main Campus were observed to be operating at acceptable levels of service, and no major back-ups were seen.
- During PM peak hour, northbound Main Street has heavy traffic flow.
- Northbound Main Street traffic was observed to be spilling back into upstream intersections from Cambridge to Southgate.

Table 2.4 identifies the overall intersection peak hour level of service (LOS) along the Fannin Street corridor through the TMC on weekdays. The most congested intersections are at University Blvd., Holcombe Blvd. and Old Spanish Trail, operating at "E" or "F" during the AM and/or PM hours.

TABLE 2.4 - EXISTING FANNIN ST. WEEKDAY INTERSECTION LEVEL OF SERVICE

Intersection	AM Peak Hour	PM Peak Hour
Sunset Blvd.	C	C
Cambridge Street	C	C
Ross Sterling Street	B	C
John Freeman Drive	C	C
University Blvd.	F	E
Dryden Road.	C	C
Holcombe Blvd.	F	F
Pressler Street.	A	C
Old Spanish Trail	E	D

2.4 Traffic Conflicts/Crash Experience

Table 2.5 identifies the crash experience along Fannin Street at major intersections in the TMC area for a 3-year period from 2007 through 2011. The data shows the highest number of crashes at Old Spanish Trail, Dryden Street, Cambridge Street, Pressler Avenue, and Holcombe Blvd.

Two specific conflicts create some level of hazardous operation along Fannin Street: 1) motor vehicles sharing the trackway at signalized intersections and 2) pedestrians crossing into the median to access the LRT stations.

TABLE 2.5 – CRASH EXPERIENCE ALONG FANNIN STREET – 2007-11

Intersection	Number of Crashes
Sunset Blvd.	2
Cambridge Street	28
Ross Sterling St.	11
John Freeman St.	30
University Blvd.	11
Dryden Road	36
Holcombe Blvd.	27
Pressler Street	28
Old Spanish Trail	46

3.0 TRANSIT GUIDEWAY ALTERNATIVES

3.1 LRT Relocation Alternatives

The METRO Red Line, located on Fannin Street passing through the TMC, occupies effectively three lanes (two lanes for the tracks, and one lane between the tracks for stations). This LRT configuration, shown in cross-section sketch below, requires study because of the following issues:

- Chronic traffic congestion on Fannin Street
- Undesirably narrow station platforms and related inadequate pedestrian space
- Conflicts among LRT trains, general traffic and pedestrians

Note that the narrow “center platform” station, because of its limited width, serves only one of the two tracks. Each complete station is comprised of two such platforms, one serving northbound trains, and the other, the southbound trains. The restriction of vehicular traffic to only two lanes in each direction has forced the use of the trackway at one or more locations as a left-turn lane for traffic. This introduces a source of driver confusion and increases exposure to collisions.

As a result, a series of LRT relocation alternatives have been postulated, for consideration as methods to mitigate these problems. They include the following:

1) LRT moved to the west side of Fannin
2) Develop Transit Mall on Fannin
3) Conversion of Main and Fannin to a one-way pair with split at-grade LRT
4) LRT relocated to Main Street
5) LRT realigned in subway on Fannin
6) LRT realigned on elevated structure on Fannin
7) LRT relocated via Cambridge, MacGregor, and Braeswood
8) LRT relocated via Cambridge, MacGregor, and Holcombe

The alternatives are shown in Figure 3.1.

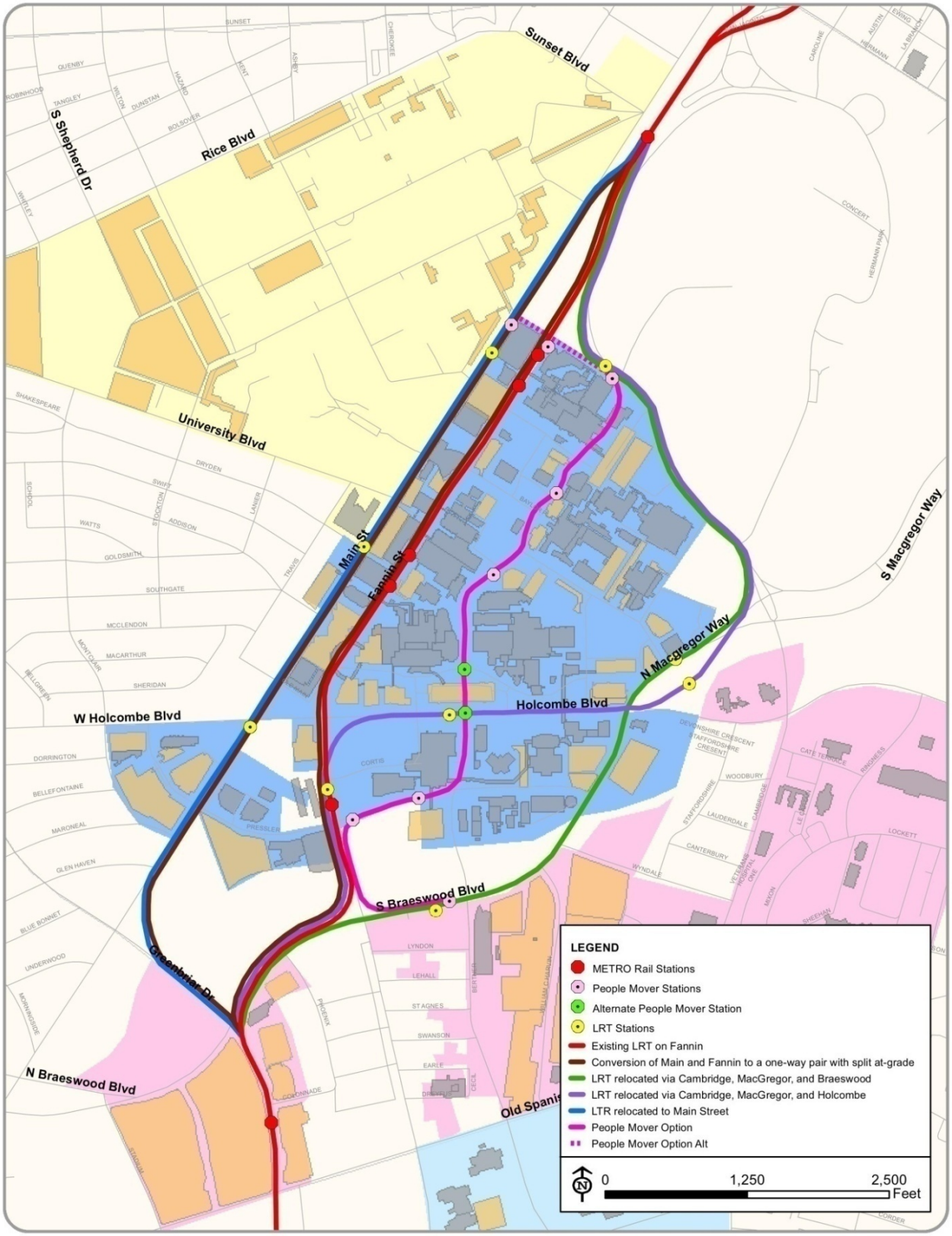

FIGURE 3.1
CONCEPTS FOR LRT RELOCATION AND TMC PEOPLE MOVER ROUTE

3.1.1 LRT Moved to West Side of Fannin

The objective of alternative 1, relocation of LRT to the west side of the street, would be intended to improve access to the many vehicular access points, which are mainly along the east side of Fannin (see Figures 3.2, 3.3 and 3.4 for alignment and cross section concepts). The re-design would seek to improve LRT station platform widths as well as removal of the left-turn barrier formed by the present alignment and inhibiting southbound vehicles seeking to enter access roadways along the east side of Fannin Street. Ideally, this option would include measures to divert traffic away from Fannin, making use of Main Street and Cambridge-MacGregor-Braeswood and other streets to bypass the TMC or as alternate means of vehicular access to TMC parking and drop-off pick-up sites. The alternative requires an awkward transition north of Holcombe, where the light rail tracks would have to cross the southbound traffic lanes, to allow light rail to use its present alignment through the underpass beneath Holcombe. An expensive option would be to re-build the track and street in the vicinity of the intersection, to avoid the traffic/rail at grade crossing.

Both LRT and traffic might benefit in this alternative if Main and Fannin were made a one-way pair, with Fannin Street used for northbound vehicles only. This probably would result in better traffic operations on Fannin, and facilitate design of the intersection of Fannin and Holcombe. This configuration provides four traffic lanes, as in the present design, and wider station platforms, although with some encroachment on the sidewalk along the west side of Fannin. Between stations, the width taken by station platforms becomes available for an added traffic lane and a wide sidewalk. The added traffic lane accommodates various turning lane arrangements. Aside from the narrow sidewalk at stations, this configuration has the disadvantage of restricting access to the entire length of Fannin Street's west side.

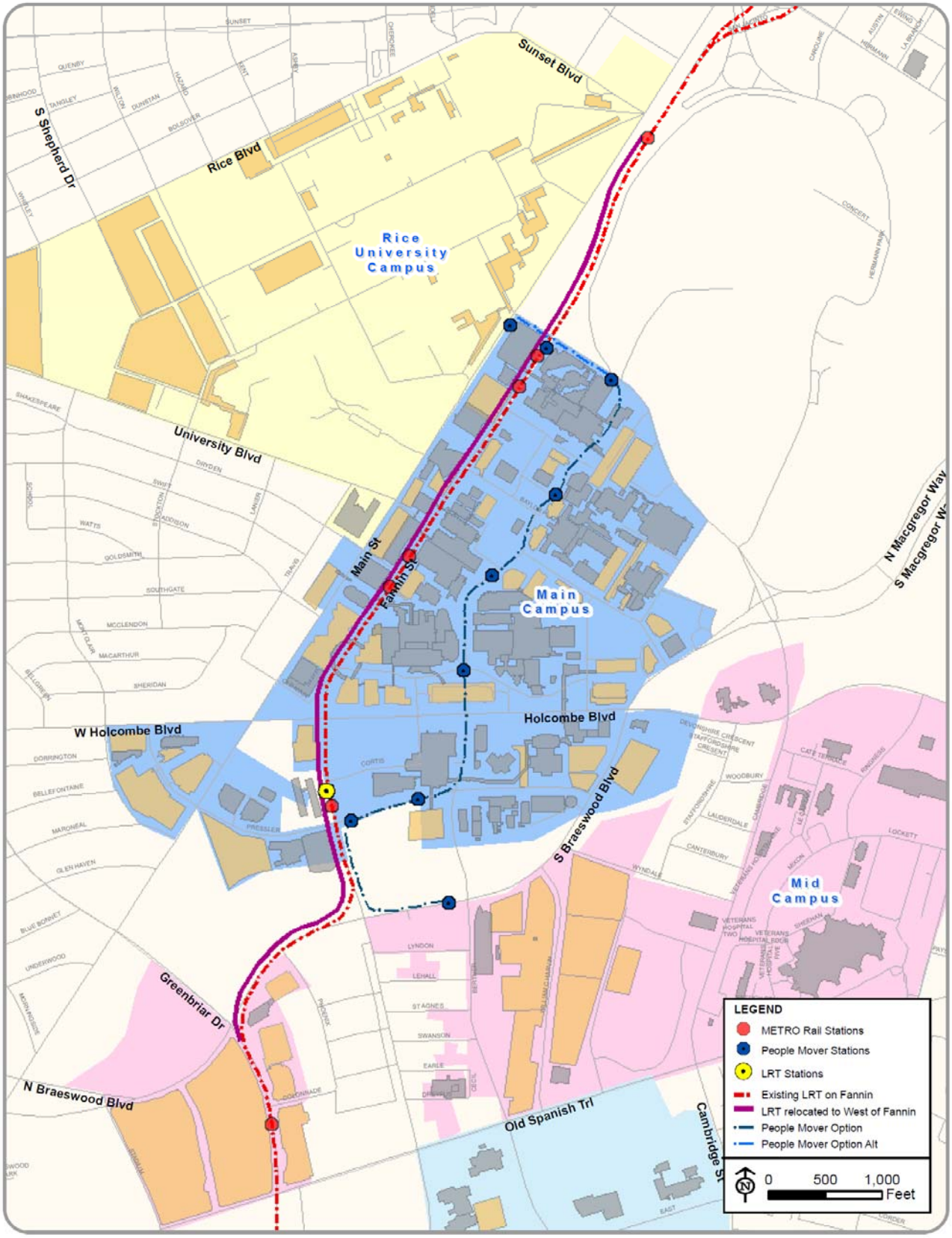

FIGURE 3.2
LRT ALIGNMENT RELOCATED TO WEST SIDE OF FANNIN

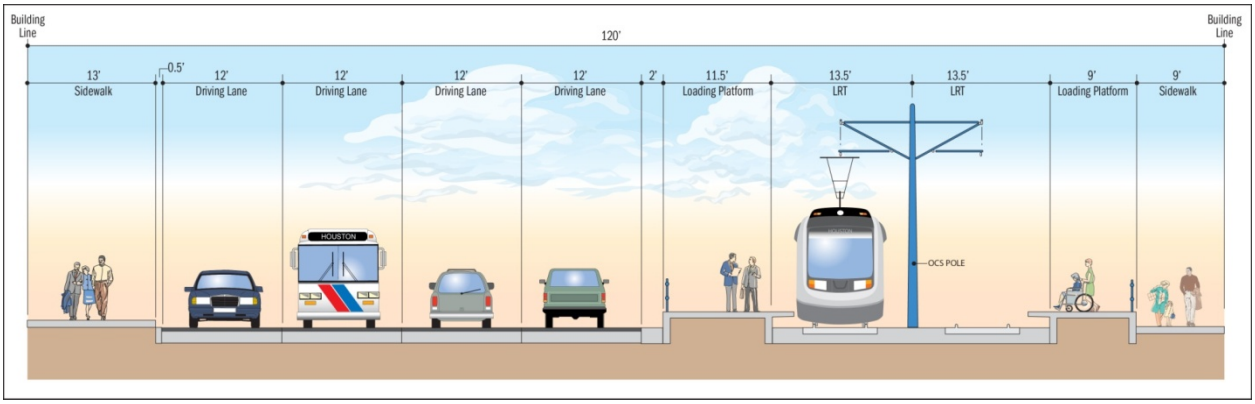

FIGURE 3.3 – FANNIN ST. CROSS SECTION WITH LRT ON WEST SIDE OF STREET (LOOKING SOUTHWEST)

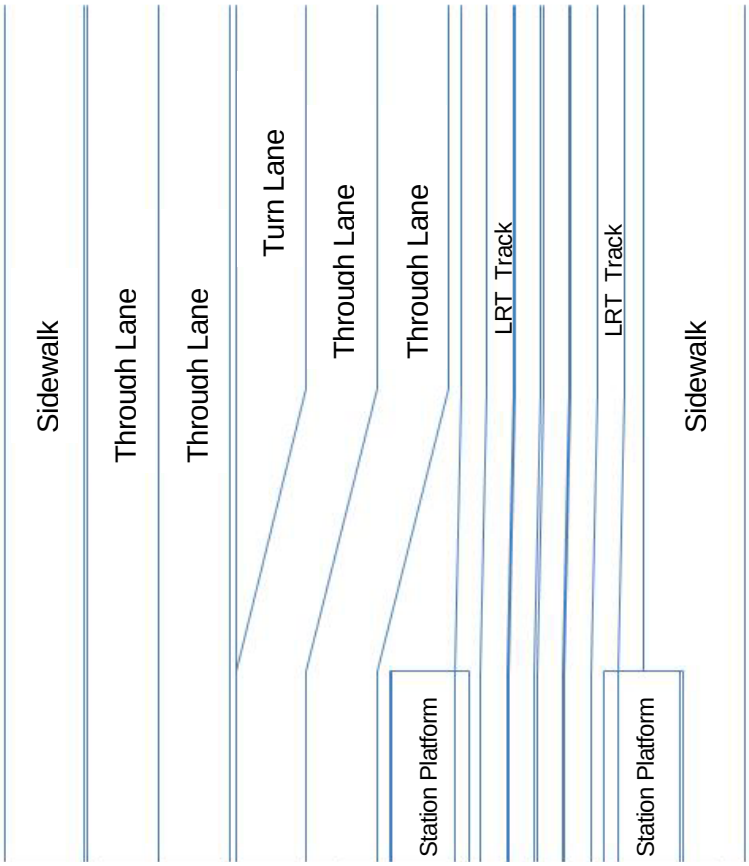

FIGURE 3.4 – PLAN SCHEMATIC OF LRT ON WEST SIDE OF FANNIN ST.

3.1.2 Fannin St. Transit/Pedestrian Mall

A second alternative would be to reduce the through-carrying capacity of Fannin Street for motor vehicles by providing only one traffic lane in each direction, still maintaining the LRT in the median. This would allow more space for pedestrian circulation along the street. The cross section shown in Figure 3.5, with widened 24-foot sidewalks on both sides of the street, is one potential concept for the reallocation of street space under the transit/pedestrian mall concept. Another concept could include widening the LRT platforms to 12-15 feet, and still provide widened sidewalks on both sides closer to 20 feet. Signage would be required to indicate the reduced roadway would be for "Local Traffic" only, for access to parking garage accesses and for emergency and delivery vehicles.

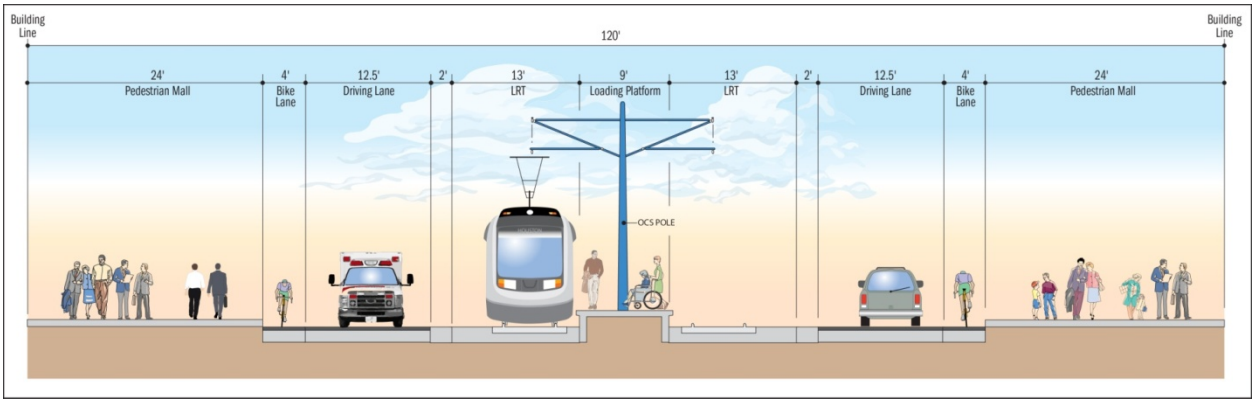

FIGURE 3.5 – TRANSIT/PEDESTRIAN MALL CROSS SECTION ON FANNIN

3.1.3 Fannin/Main One-Way Pair with Split At-Grade LRT

In alternative 3, the improvement of traffic flow on Fannin Street would be achieved by giving vehicular traffic one of the lanes now occupied by LRT, and by operation of both Fannin and Main streets as a one-way pair (see Figures 3.6 and 3.7 for alignment and cross section views). Access to the LRT stations would be less convenient as a result of the split operation, but traffic flow might be enhanced significantly, subject to adequate provision for crossing and u-turn movements between the two streets. The LRT stations could be built to a higher standard, with greater width than is now provided. Access to the TMC Transit Center at the intersection of Fannin and Pressler would be inconvenient for the southbound LRT service on Main Street.

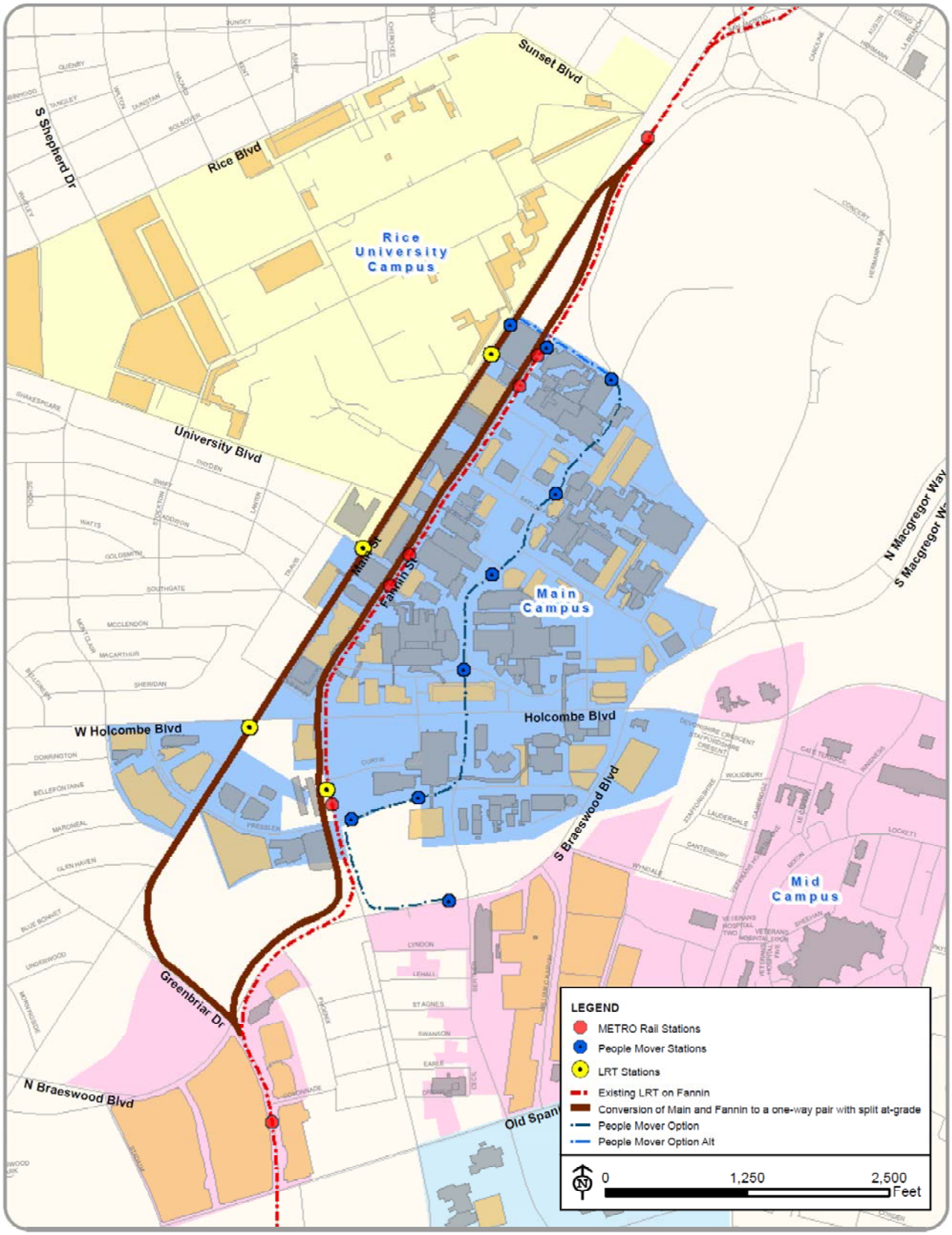

FIGURE 3.6
ONE-WAY COUPLET OPTION FOR LRT USING FANNIN AND MAIN – ALIGNMENT LOCATION

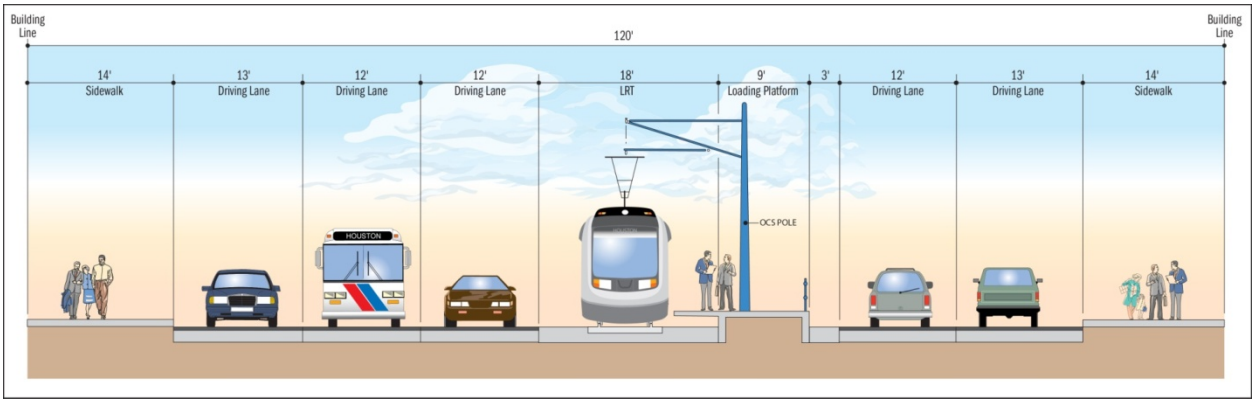

FIGURE 3.7 - FANNIN ST. CROSS SECTION WITH ONE-WAY LRT COUPLET WITH MAIN (LOOKING SOUTHWEST)

3.1.4 LRT Relocated to Main Street

Alternative 4 would relocate LRT entirely to Main Street, where pedestrian activity and traffic turning movements are less intensive. Figures 3.8 and 3.9 show the alignment and a typical mid-block cross section on Main with two-way LRT operation. The realignment would begin north of Cambridge Street and continue south on Main Street to Greenbriar, then following Greenbriar to merge into the existing LRT alignment north of the Smith Lands Station. TMC Transit Center access would be inconvenient for both southbound and northbound LRT service. Like for the existing Fannin Street LRT operation, left turns from Main at signalized intersections would have to be made from the trackway area.

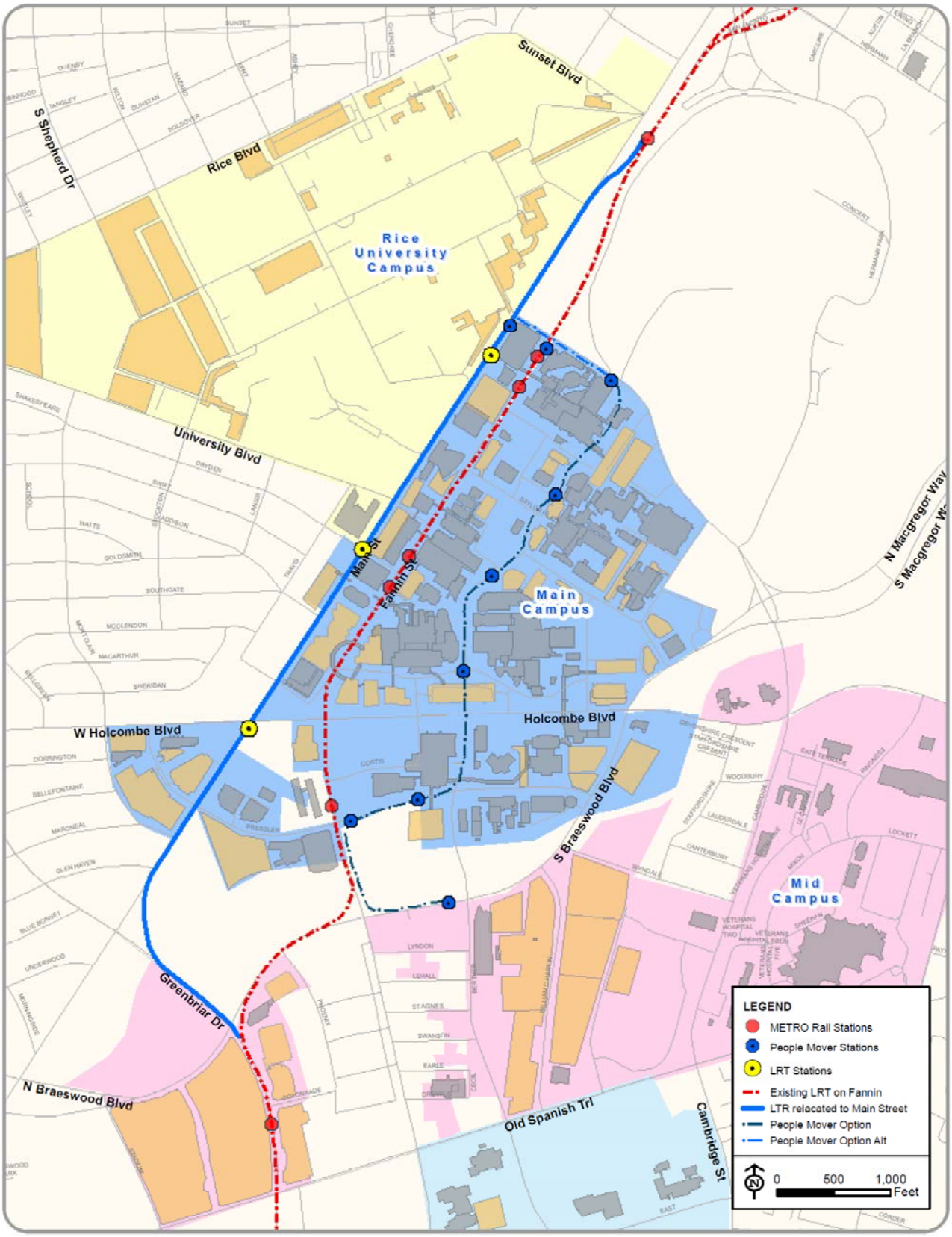

FIGURE 3.8
LRT ALIGNMENT RELOCATED TO MAIN ST.

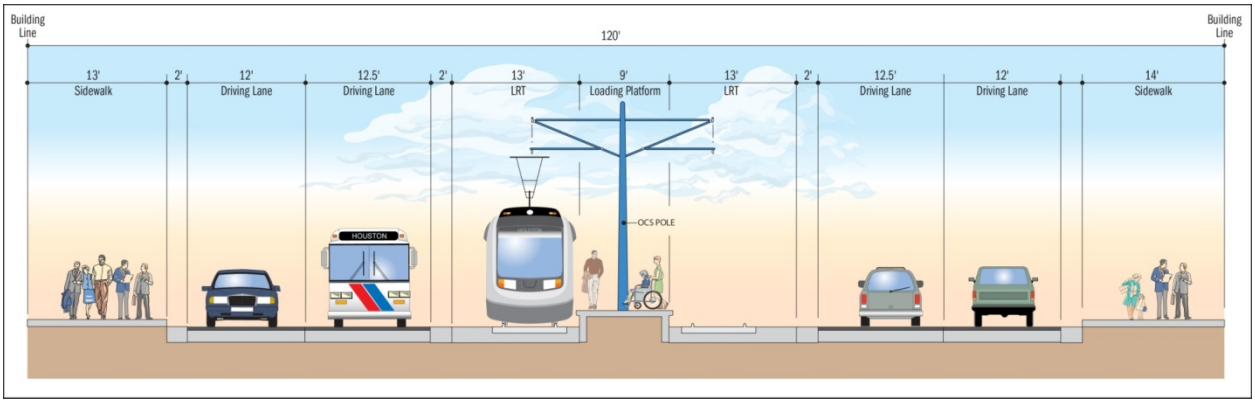

FIGURE 3.9 – MAIN ST. CROSS SECTION WITH TWO-WAY LRT

3.1.5 LRT Vertical Realignment Options on Fannin

LRT alternatives 5 and 6 would provide a transition from the current at-grade alignment to a subway or elevated alignment at a location sufficiently far north of Cambridge Street to pass above or underneath that street. Figure 3.10 shows potential track profiles for both subway and elevated treatments, while Figure 3.11 shows the extent of grade-separated alignment for LRT. At the southern end of the realignment, the transition back to the present at-grade alignment would be completed on Greenbriar just north of Old Spanish Trail.

As a subway, the alignment would be shallow at the Smith Lands Station, but otherwise deep, allowing provision of a mezzanine level above each TMC station, with underground passage to entrances on both sides of the street (see Figure 3.12). These passageways also would allow pedestrians to cross underneath the street, and could accommodate direct entry to TMC buildings on both sides of the street, to the extent this may be desirable. The depth of the guideway tunnel also would be sufficient to pass underneath the existing Holcombe underpass and Brays Bayou immediately to the south. At each end of the subway, the track profile would rise sufficiently above ground level to minimize the risk of flooding during episodes of heavy rain. On-street pedestrian entrances also would be raised above sidewalk level, for the same reason.

The elevated alignment alternative would be designed to interface with and hopefully minimize disruption of or requirements to reconstruct the pedestrian bridges that cross Fannin Street. A pedestrian mezzanine level could be integrated with existing and new pedestrian bridges and might also include a longitudinal pedestrian-way, providing further sheltered distribution of passengers to and from their TMC destinations (see Figure 3.13). The design would seek to minimize the adverse effects of support columns, which can obstruct sight lines and also occupy otherwise-useful right of way. An optimal design combining functionality with visual acceptability would require careful study.

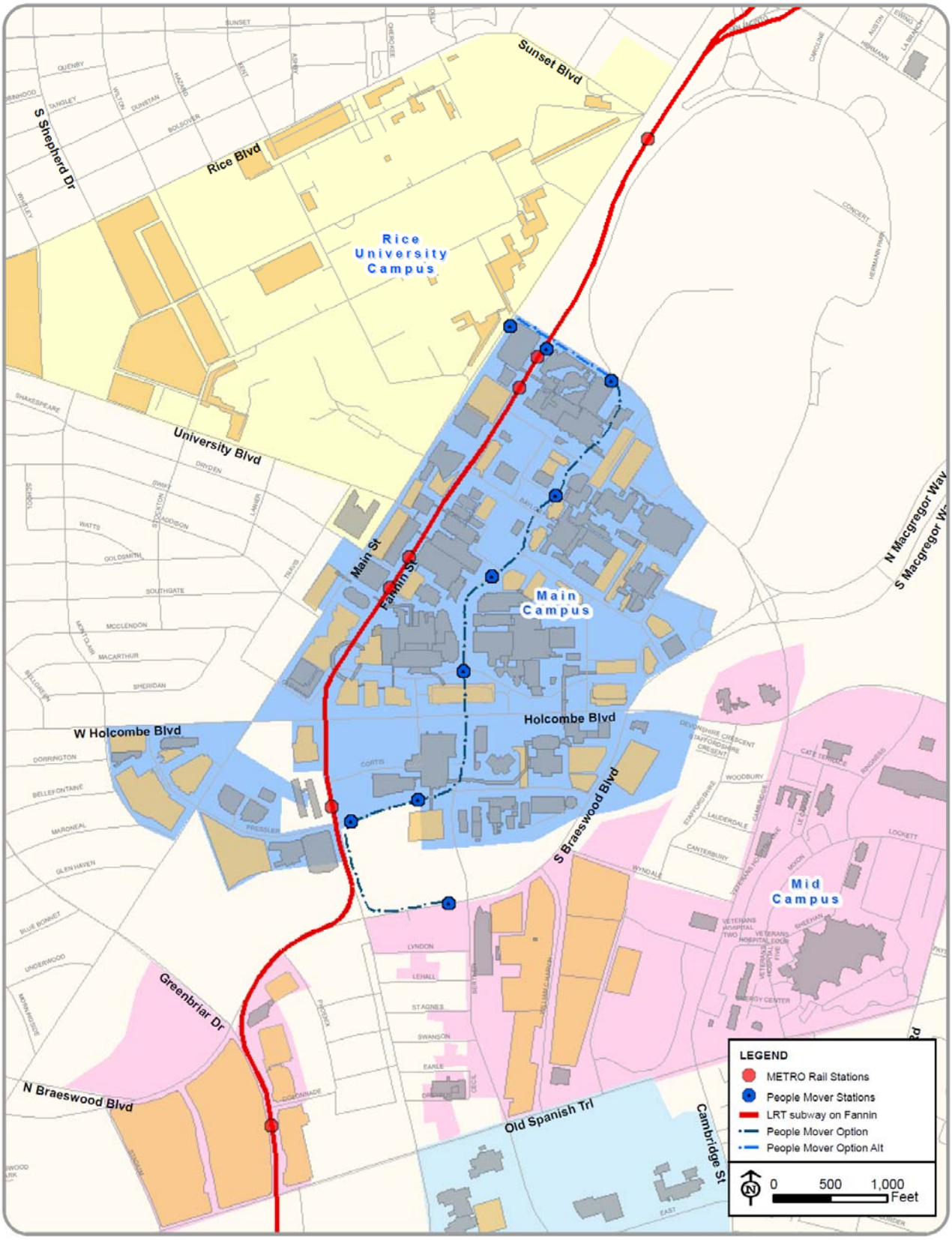

FIGURE 3.10
SUBWAY OR ELEVATED LRT ALIGNMENT OPTIONS ON FANNIN

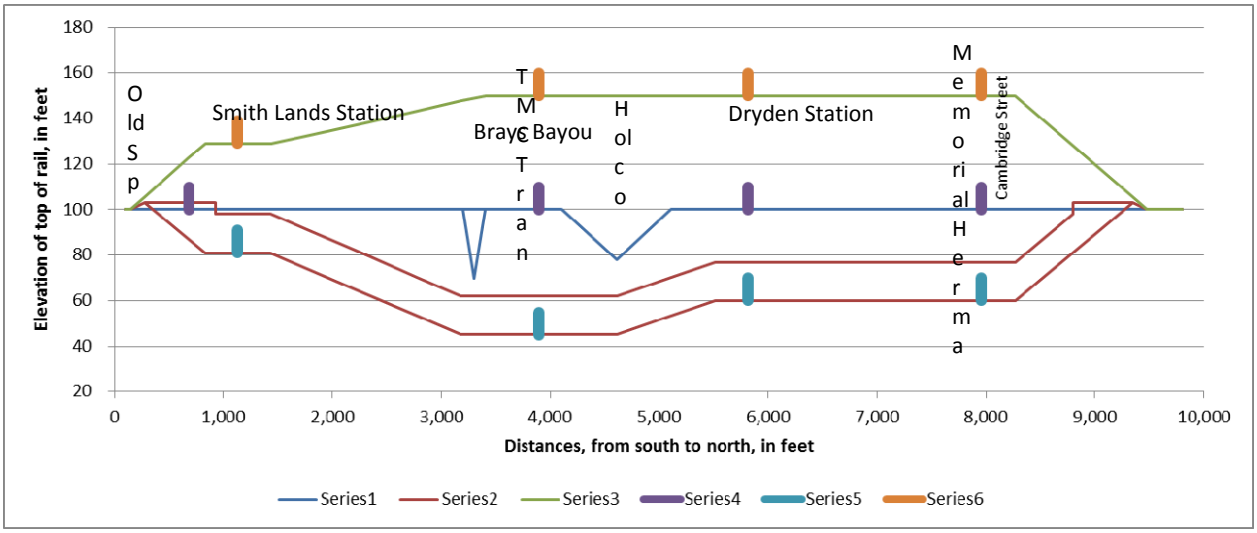

FIGURE 3.11 – CONCEPTUAL TRACK PROFILES FOR SUBWAY AND ELEVATED LRT OPTIONS ON FANNIN ST.

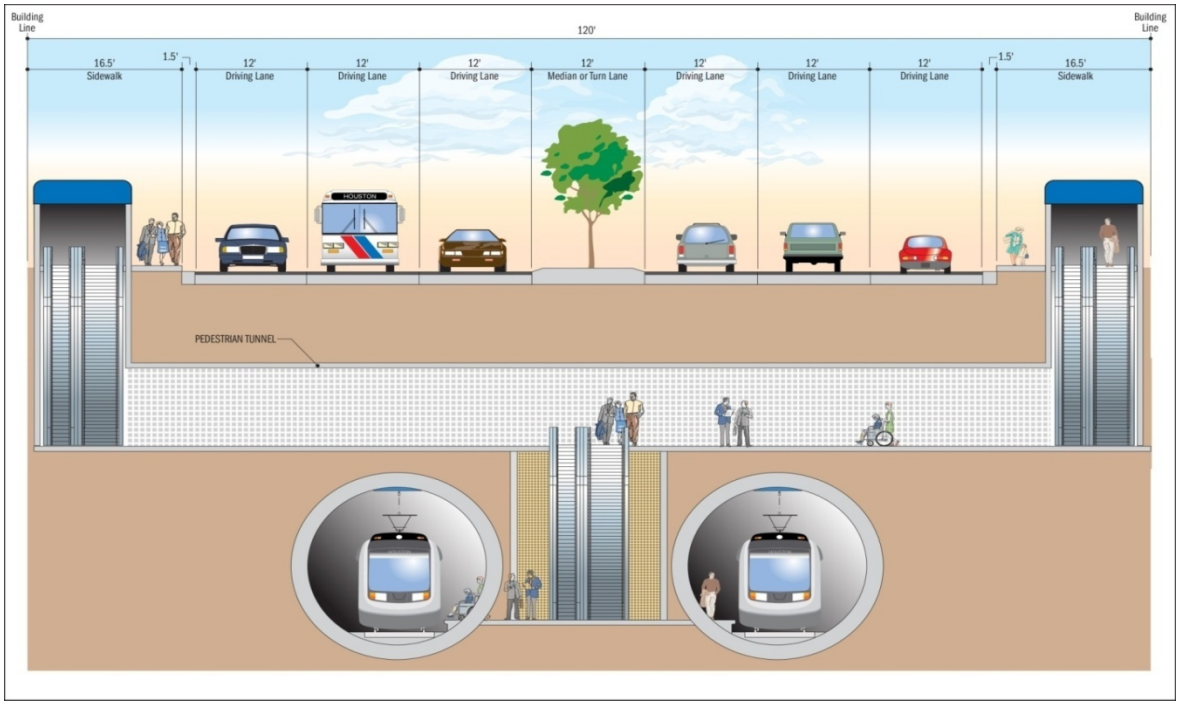

FIGURE 3.12 – SUBWAY LRT CROSS SECTION ON FANNIN ST.

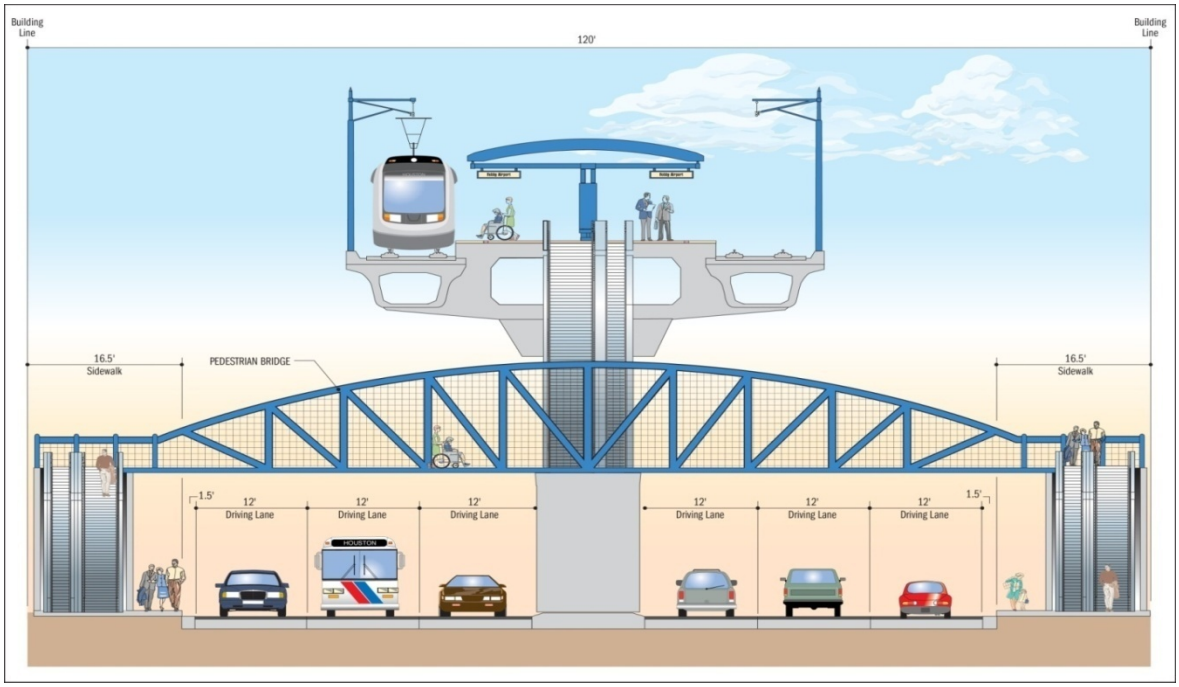

FIGURE 3.13 – ELEVATED LRT CROSS SECTION ON FANNIN ST.

3.1.5 Easterly LRT At-Grade Options

Two other alternative total relocations are considered, again with the objective of maximizing the potential for Fannin Street to carry vehicular traffic and accommodate traffic access to TMC parking or passenger drop-off and pickup locations. Both alternative 7 and alternative 8 would re-route LRT to the east around the TMC main campus, turning from Fannin Street to Cambridge Street and then south onto MacGregor. Typical revised alignments and cross sections to accommodate LRT on these streets is shown in Figures 3.14, 3.15 and 3.16. In alternative 7, the alignment would continue to Braeswood, then following Braeswood to rejoin the present LRT alignment where it turns onto Braeswood just west of Fannin. In alternative 8, the alignment would turn to the west from MacGregor onto Holcombe, returning to Fannin just north of the TMC Transit Center Station. This alternative has geometric and right of way challenges in accommodating the curve from Holcombe to Fannin.

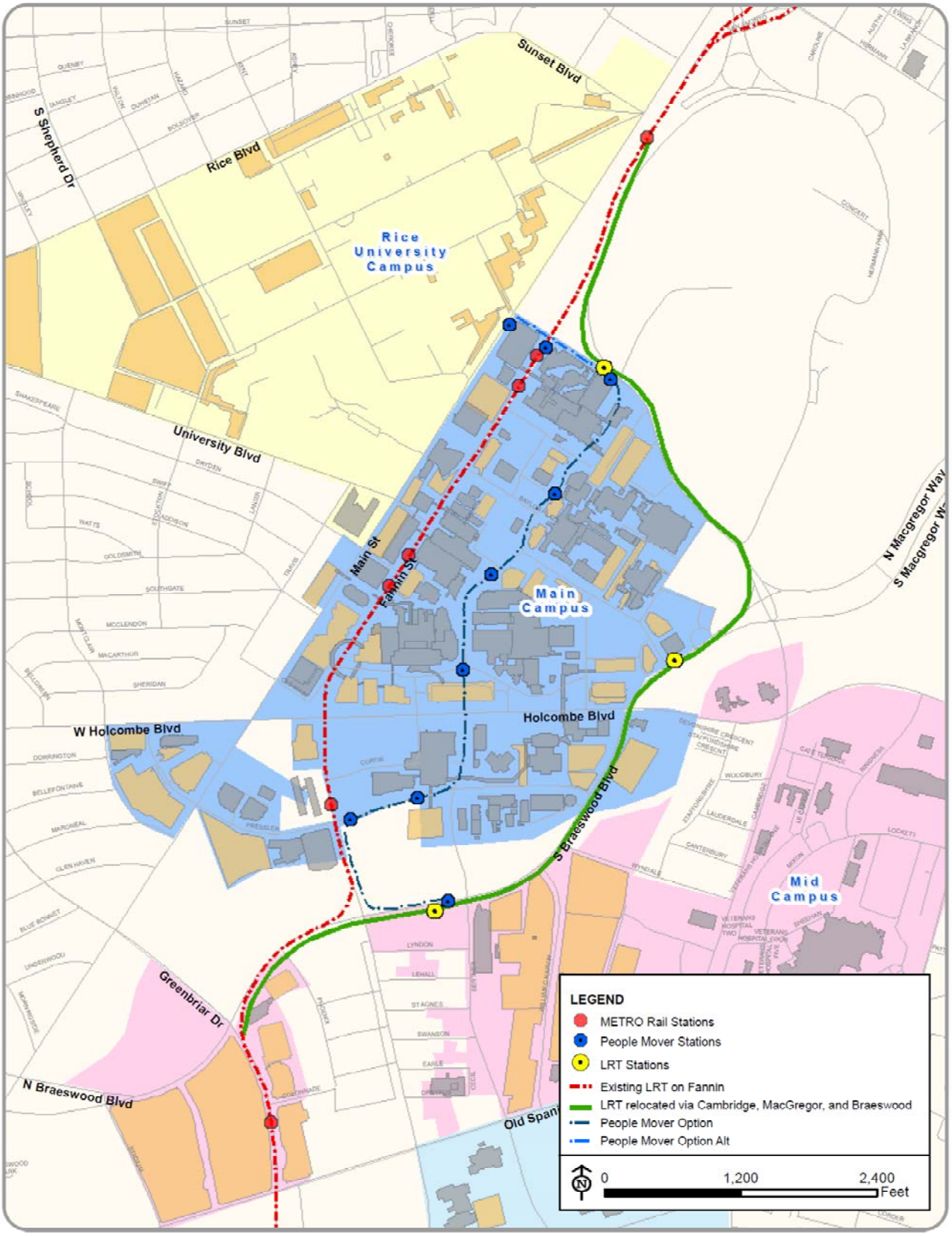

FIGURE 3.14
LRT RELOCATED TO CAMBRIDGE/MACGREGOR/BRAESWOOD ALIGNMENT

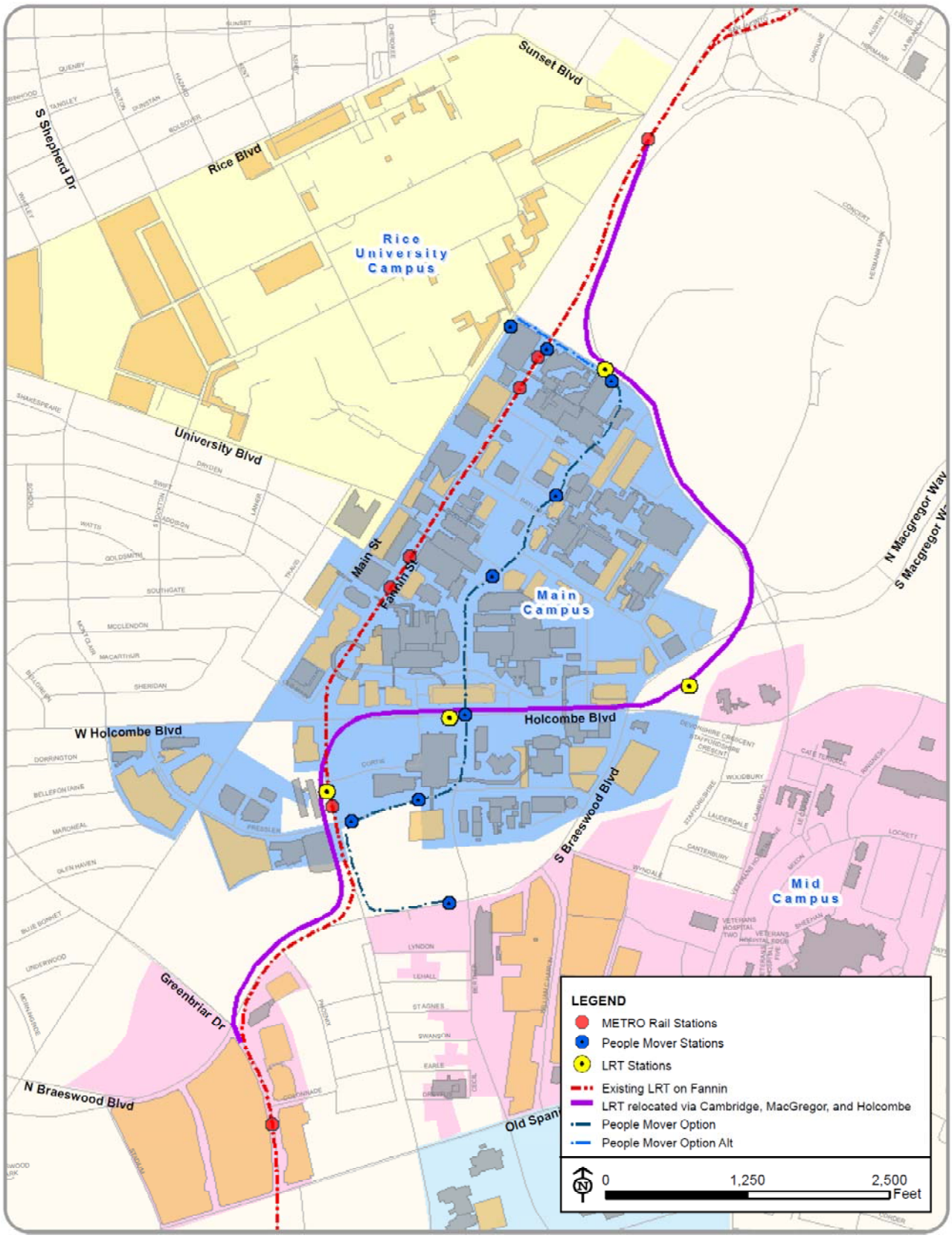

FIGURE 3.15
LRT RELOCATED TO CAMBRIDGE/MACGREGOR/HOLCOMBE ALIGNMENT

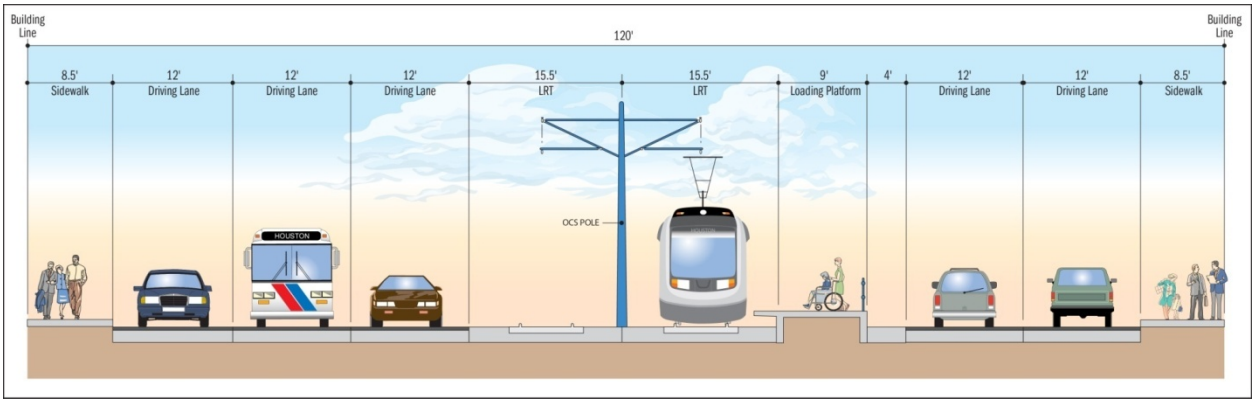

FIGURE 3.16 – CAMBRIDGE AND MACGREGOR ST. CROSS SECTIONS TO INCLUDE TWO-WAY LRT

3.2 People Mover Alternatives

As shown in the evaluation of LRT alternatives, there is no viable alignment better than Fannin Street with respect either to the directness of the LRT route or the convenience Fannin Street stations can provide for access to TMC destinations. Even so, there are access deficiencies for LRT passengers; the stations are not near all of the TMC's activity centers. Aside from the LRT access issues, there are intra-TMC travel needs that entail long walking distances or the use of shuttle buses within the area. An option that has been considered from time to time would be to design and build a people mover to address these needs. A suitable technology might be an automated guideway transit (AGT) system, such as those commonly used for interconnection of airport terminal buildings and less commonly found as activity center distribution systems. An example of the latter application is the Miami Metromover, which performs a circulator function in downtown Miami, Florida. In comparison with LRT, AGT systems typically fit within a smaller clearance envelope, can negotiate tighter curves and steeper grades, and may be integrated more easily with existing structures.

The all-elevated alignment considered in this study (see Figure 3.17) would begin with a passenger interchange station adjoining an LRT station near or on Cambridge Street (at Main Street, at Fannin Street, or on Cambridge east of Fannin), turn into the TMC campus between Memorial Hermann and Ben Taub hospitals, cross above existing buildings, and then make its way on elevated structure along or near East Cullen Street and Bertner Avenue, crossing Holcombe. The alignment would turn west from Bertner onto Pressler Street, south onto Fannin, and then east onto Braeswood, where a terminal station and small maintenance facility could be located near Bertner. The southern portion of the route could vary, ending at Pressler and Fannin in the case of LRT alternatives that retain the existing TMC Transit Center LRT station, extending westward along Pressler Street to Main Street to meet a Main Street LRT alignment, or continuing to the Braeswood-Bertner terminal station to provide passenger interchange with the Cambridge-Braeswood LRT alternative. Imaginative design would be required to optimize access to passenger destinations and interchange points along the route. Six to eight stations are envisioned.

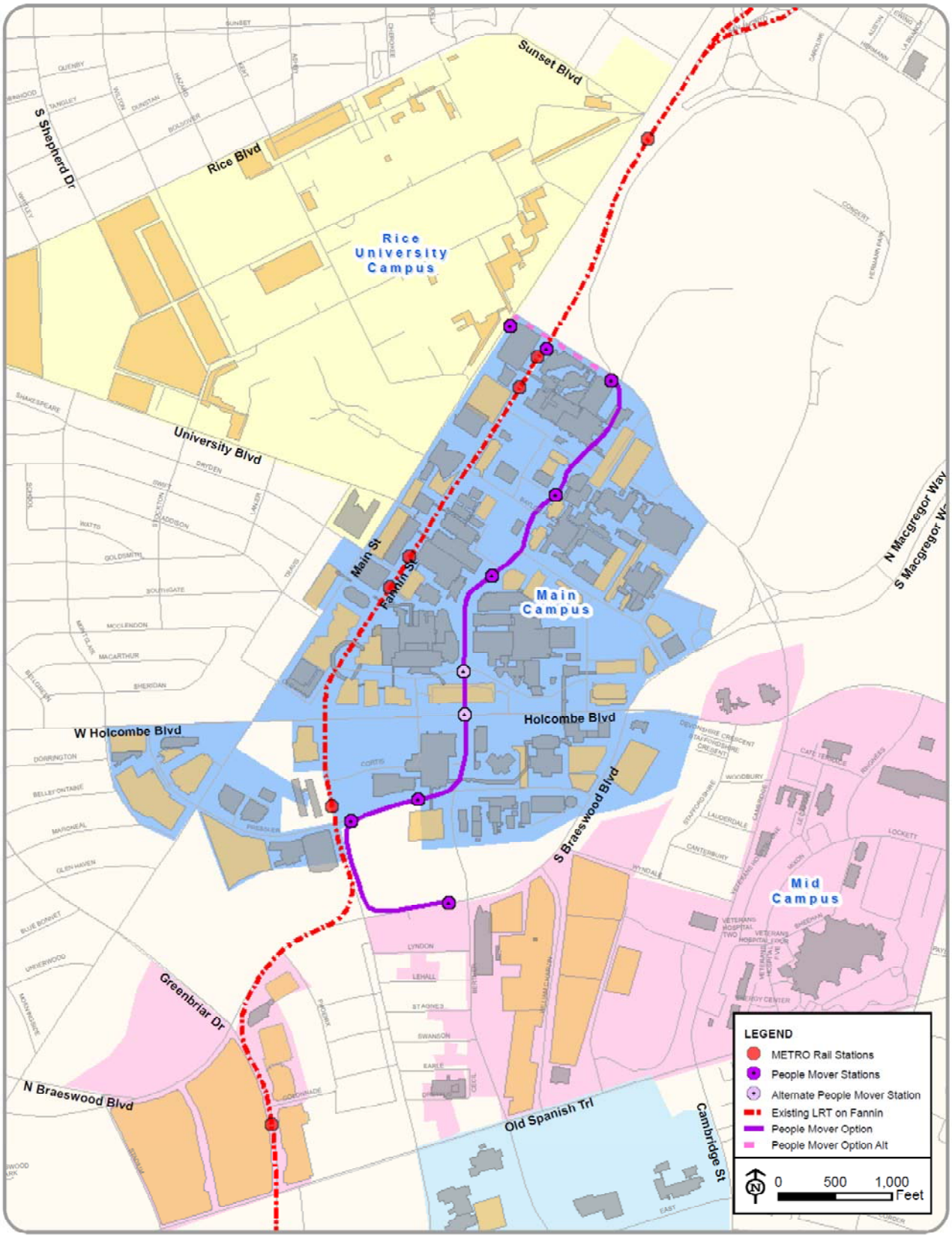

FIGURE 3.17
PEOPLE MOVER ALIGNMENT ALTERNATIVE

3.3 Guideway Alternatives Evaluation

3.3.1 Evaluation Methodology

For the seven LRT alternatives, the following concept-level analyses were undertaken:

- Estimation of LRT train running times through the TMC area
- Estimation of "rough order of magnitude" (ROM) capital costs
- Estimation of operating and maintenance (O&M) costs
- Calculation of TMC main campus access times
    - For current Red Line passenger trips to/from TMC locations
    - For current TMC main campus employment
- Recognition of right of way and environmental issues

Analysis of the people mover alternative is limited primarily to its potential value to LRT passengers under each of the seven LRT route alternatives. Analyses for this purpose mirror those of the LRT route alternatives. Study of the potential time-saving benefit of a people mover found that it would produce only small benefits as a supplement to the existing light rail route, even without considering the benefits already provided by TMC shuttle bus routes. The people mover would be of significant benefit for LRT alignments in other streets, and especially as a supplement to the Cambridge-Braeswood LRT alternative.

3.3.2 Evaluation of Transit Guideway Alternatives

The evaluation of LRT re-routing alternatives considered numerous factors including travel times as they affect transit operations and transit passengers, traffic level of service, traffic delay, traffic access, needs for parking access modifications, traffic and pedestrian safety, TMC accessibility generally, LRT station capacity, right of way availability, environmental effects, constructability, and capital cost.

Some of these factors are addressed in the following:

Light Rail Passenger Travel Time and TMC Accessibility

Figure 3-18 shows the estimated running time for the different LRT relocation alternatives. LRT travel time would be best if the alignment remains on Fannin Street, but placed on aerial structure or in subway through the TMC area. Train running time would be more reliable (predictable) and would save an estimated 3.6 minutes in each direction, reducing vehicle fleet requirements by one train (two light rail vehicles.

The shorter travel time through the TMC area would benefit passengers traveling through the TMC, and, subject to the design of pedestrian access to the aerial or subway stations, would also provide time savings to passengers traveling to or from TMC locations.

LRT travel time for an alignment re-routed via Main Street would be about the same as the current route, but with adverse effects on passengers using the TMC stations. Travel time would be slightly longer for an alignment along Cambridge and Braeswood (estimated to add only 18 seconds), and significantly

longer for an alignment following Cambridge and Holcombe (2.7 minutes longer). Both of the Cambridge alignments would be significantly worse for access to TMC trip origins and destinations.

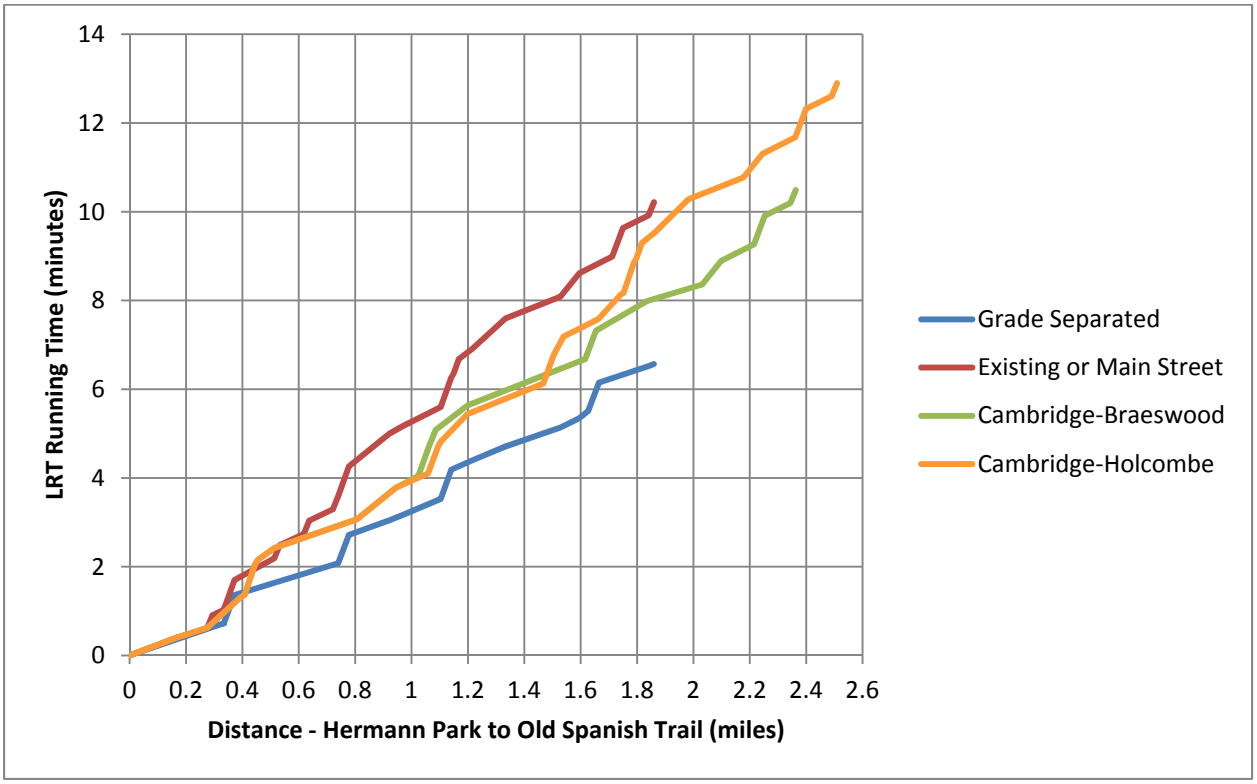

FIGURE 3.18 – ESTIMATED LRT RUNNING TIMES AND DISTANCES FOR TMC ALTERNATIVES

LRT Station Capacity

The design of the narrow existing LRT stations, located between the northbound and southbound tracks, was a compromise intended to leave as much street width as possible for vehicular traffic. This was mitigated to a degree by providing separate station platforms for northbound and southbound trains, but even so, the result is unsatisfactory for passengers, whose access is severely restricted by necessary station furniture such as fare vending equipment. The holding space for passengers leaving trains and waiting for a traffic signal to cross traffic lanes between the station and curbside is also inadequate. The joint use of the northbound trackway by trains and left-turning vehicles at Cambridge Street is another problematic effort to accommodate both LRT and vehicular traffic.

A re-design of the LRT line on Fannin Street would seek to provide more station platform and station access space, while still providing for traffic movement and local TMC access. One approach would be to shift the tracks to the west side of the street, close together, and provide conventional side-platform stations. A controlling feature of the alignment would be to leave adequate sidewalk space adjacent to stations serving southbound trains. Station platforms must be approximately 13 inches above track level, which is about six to eight inches higher than the sidewalks. Consequently sidewalks and station platforms cannot occupy shared space. This sidewalk restriction at stations would extend for approximately 250 feet, but between stations, the sidewalk could be wider than normal. This configuration also would allow a traffic lane to be added between stations. The added lane could be used for southbound traffic right turns, or to allow the southbound lanes to be shifted to the west, permitting provision of a southbound left turn lane.

One might also consider a more extreme re-configuration of Fannin Street, coupled with maximum diversion of traffic from Fannin. Some traffic could gain access to the TMC via Main, Cambridge, and Holcombe, and the effort would be made to divert all through traffic via a counter-clockwise loop using streets that form the TMC main campus perimeter. An optimal configuration satisfying LRT requirements and best accommodating vehicular traffic would require detailed study beyond the scope of this project.

Right of Way Requirements

Re-routing LRT would introduce various right of way requirements. Shifting one or two tracks to Main Street would most likely be accomplished just south of the Hermann Park/Rice University station, where Fannin and Main are very close to one another. The space between the streets is park land, and its use for LRT tracks would have to be negotiated. Farther south of Holcombe, the turn from Main to Greenbriar would require acquisition of land to allow a curve of about 400-foot radius.

Re-routing LRT via Cambridge Street and MacGregor Way requires LRT curves across existing park land, affecting mature oak trees, at the Fannin-Cambridge and Cambridge-MacGregor intersections. The alternative that turns from MacGregor to Holcombe would be accomplished by aligning the track off-street to the south of MacGregor, to provide for the curve westward into Holcombe. The curve from Holcombe westbound to Fannin southbound would cross private right of way, with the alignment complicated by the need to enter Fannin Street where the slope from the Fannin underpass of Holcombe reaches surface level.

Environmental Effects

There are potential adverse noise and vibration effects associated with the LRT re-alignment alternatives, including during construction as well as during subsequent operation. LRT structures, particularly the aerial alternative on Fannin Street, introduce visual intrusion that may be objectionable and require design attention. Flooding hazards actually may be lessened by the aerial and subway alternatives, by avoiding the Holcombe underpass traversed by the present LRT route. Subway stations will require design attention to avoid the risk of introducing flooding from building basement levels that may be subject to flooding during periods of severe rainfall.

Constructability

Because of limited street rights of way, the presence of underground utilities, and intensive urban activity levels, the re-alignment alternatives introduce constructability issues that would require resolution. These issues are likely to be most severe for alignments that remain on Fannin Street (re-building at surface level, and subway or aerial construction). Alignments in Main Street and Holcombe Boulevard are likely to pose the second highest level of constructability issues.

Costs and Benefits

Using very approximate quantities and generic unit costs for guideway transit and street construction, “rough order of magnitude” (ROM) estimates of capital cost have been prepared for the LRT and People Mover alternatives described above, in existing dollars (see Figure 3-19). Estimates of annual operating and maintenance (O&M) costs in existing dollars also have been prepared, using recent Houston METRO Red Line cost experience for light rail, and Miami (Florida) Metromover cost experience for the people mover alternatives.

Understandably, the subway alternative is the most expensive, followed by aerial LRT, then the Fannin/Main split routing, then the alternatives that re-route both tracks, and finally, the least expensive is to re-configure LRT on Fannin Street.

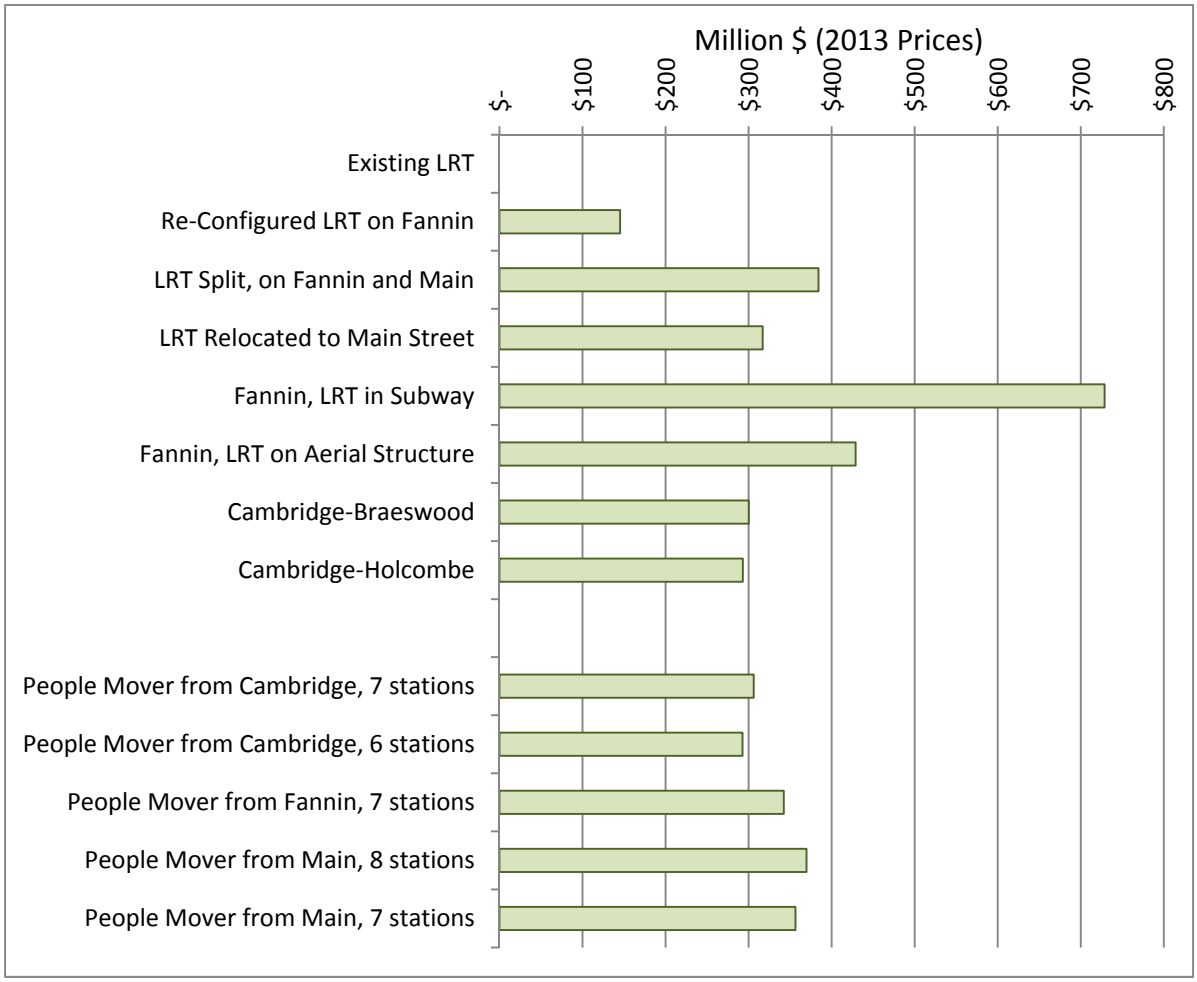

FIGURE 3.19 – RANGE IN CAPITAL COSTS FOR LRT RELOCATION/PEOPLE MOVER ALTERNATIVES

As a means of demonstrating possible comparative justification of these alternatives, the capital costs have been converted to equivalent annualized cost, considering the discounted life span cost of major capital cost elements. These costs have been added together with the annual O&M cost estimates, and the existing O&M cost subtracted, to give the net annual cost of each improvement alternative.

Potential user benefits of the alternatives have been estimated for existing users of the METRO Red Line, treating travel between LRT stations and ultimate passenger origins or destinations within the TMC Main Campus as walk trips. This approach disregards the fact that some LRT passengers use shuttle buses for access to less convenient TMC destinations. In the case of the People Mover alternatives, the link between LRT stations and TMC origin/destination locations was assumed to use the People Mover if its use would save time, compared with walking time. There are also potential LRT passenger benefits or dis-benefits to those traveling through the affected length of the Red Line.

The alternatives also have the intention of improving traffic conditions, so there are possible time savings to those traveling to, from, or through the TMC via motor vehicle (see Figure 3.20). Approximate notional values were selected for time saved by users of the daily 30,000 vehicles on Fannin (also as a proxy for traffic effects on other streets having traffic conditions affected by the guideway transit alternatives). The benefit to motor vehicle users would be greatest in the case of the Fannin Street subway LRT alternative, somewhat less for the Fannin Street aerial LRT alternative, less still for the alternatives routed to the east

of the main campus, and with the least benefit in the case of the surface-transit Main Street and Fannin Street alternatives.

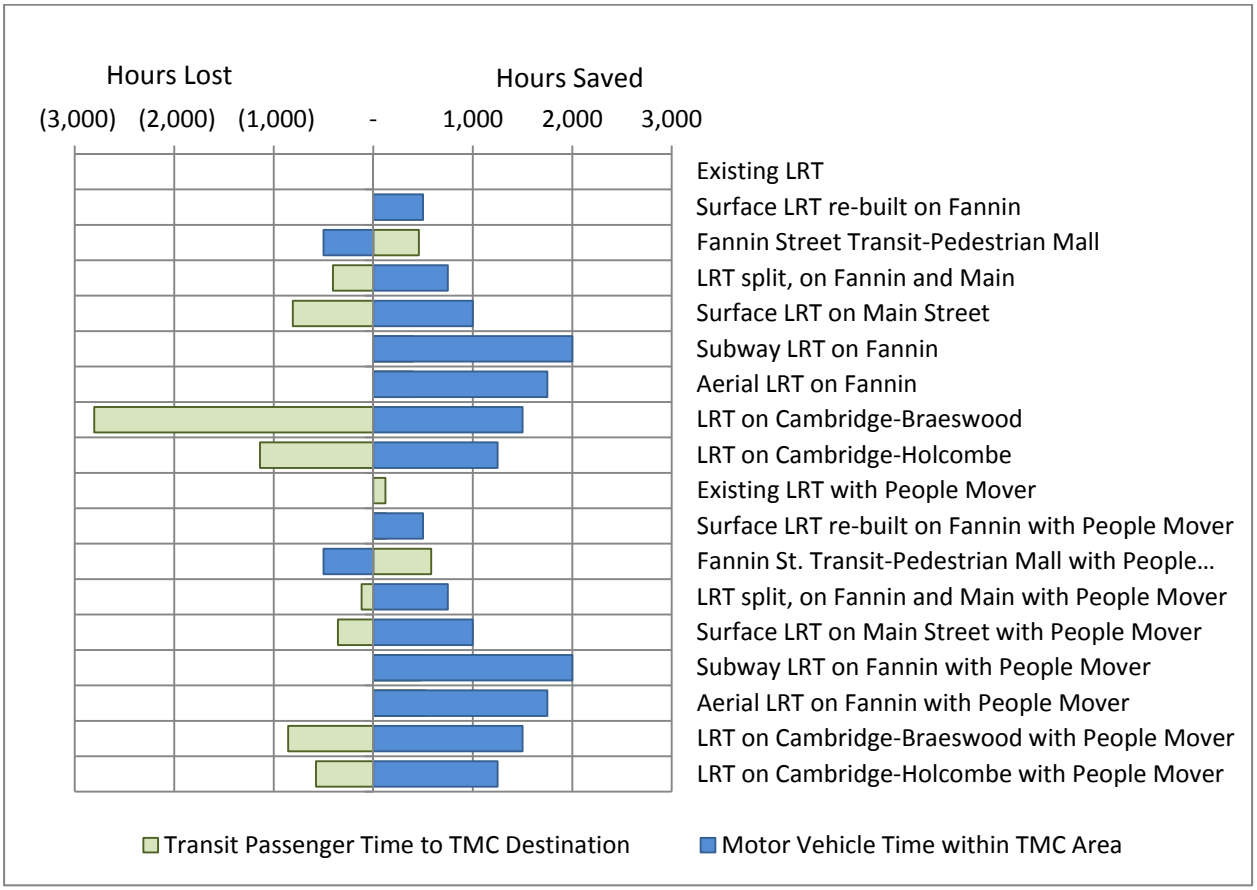

FIGURE 3.20 - WEEKDAY USER TIME SAVINGS OR LOST WITH LRT RELOCATION/PEOPLE MOVER ALTERNATIVES

As will be seen, most of the alternatives result in lost time for LRT passengers. This demonstrates that Fannin Street is well-placed for transit service to the TMC, and that finding is reinforced by the fact that only small further savings would result from providing a connecting people mover routed more within the center of the TMC main campus.

The estimated annual costs and benefits of the alternatives are presented in Figure 3.21. The analysis indicates that none of the alternatives would have benefits exceeding their cost. It should be recognized, however, that there are unquantified user benefits (safety improvements and life-saving reduction in delay to emergency vehicles, for example), and non-user benefits such as reduced flooding risk and a less cluttered visual environment. Considering only the quantified benefits, the benefit/cost ratios of the alternatives are shown and ranked in Figure 3.22.

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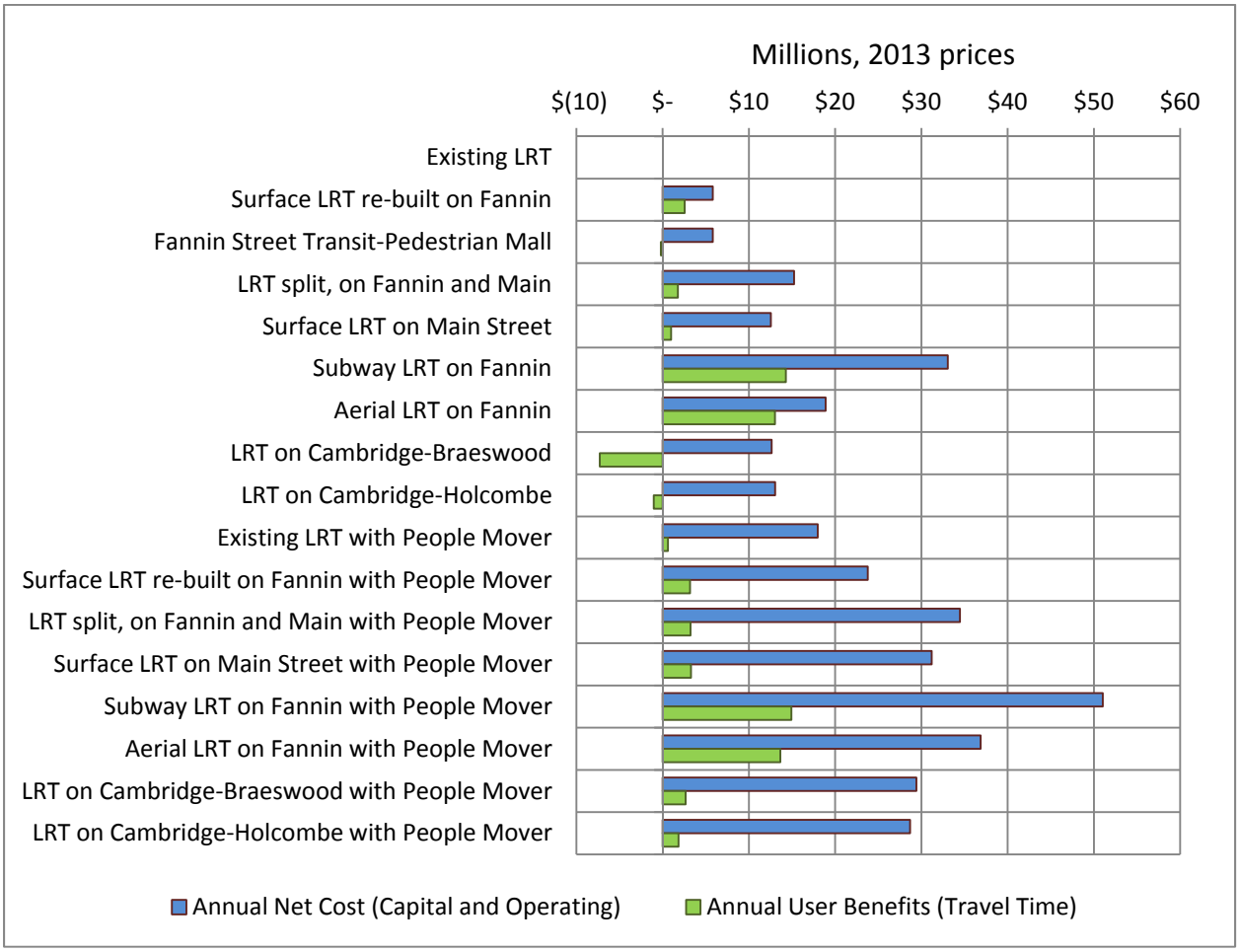

FIGURE 3.21 - ANNUALIZED COST AND USER BENEFITS FOR LRT RELOCATION/PEOPLE MOVER ALTERNATIVES

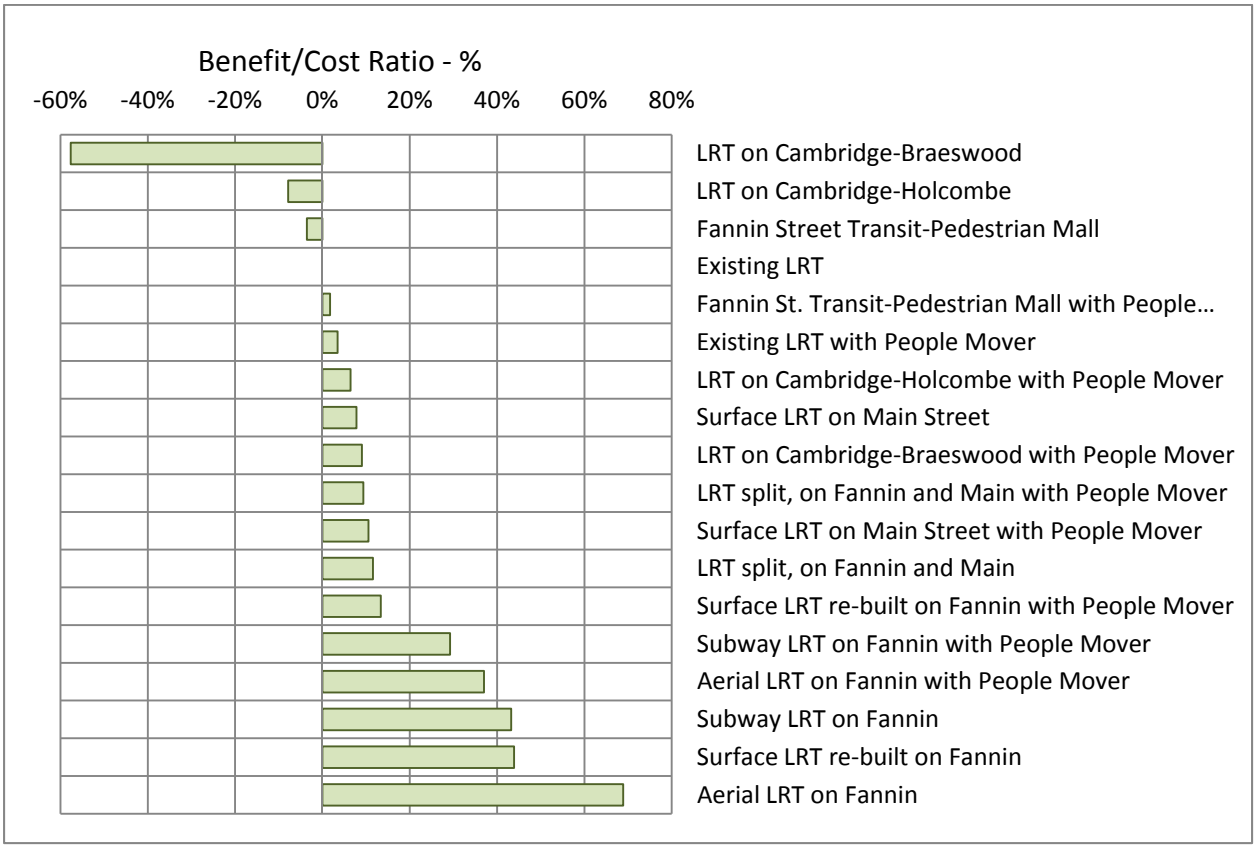

FIGURE 3-22 - BENEFIT/COST RATIO OF LRT RELOCATION/PEOPLE MOVER ALTERNATIVES

Overall

Nine criteria were evaluated to provide a total evaluation of the different LRT relocation alternatives. Each criteria was assigned a % by the study team based on an assumed importance or weight from a total of 100% (see Table 3-1). Each criteria for each alternative was rated on a scale of 1 (lowest) to 5 (highest). Unweighed scores were then tabulated, followed by a tabulation of weighed scores applying the individual criteria % identified (see Table 3-2).

The analysis revealed that the lower cost options – transformation of Fannin into a transit/pedestrian mall and the existing configuration scored the highest. The lowest scores were associated with the LRT relocation alternatives to the east to the Cambridge/MacGregor corridors, primarily because of their poor accessibility and impact on ridership. The grade separated alternatives on Fannin scored lower because of their high cost.

TABLE 3-1: OVERALL LRT EVALUATION CRITERIA WEIGHTS

IMPORTANCE WEIGHTING (Assumed by Study Team)	
LRT Through Passenger Travel Time	2%
LRT TMC Ridership Access	10%
Traffic Operations	13%
Safety	20%
Right-of-Way Required	5%
Environmental Effects	5%
Constructability	10%
Capital Cost	30%
O&M Cost	5%
WEIGHTED SCORE (highest is best)	100%

TABLE 3.2 – LRT EVALUATION CRITERIA SCORES

		Existing	Rebuilt on Fannin	Fannin Transit/ Pedestrian Mall	Split, Fannin and Main	Main Street	Fannin Subway	Fannin Aerial	Cambridge-Braeswood	Cambridge-Holcombe
LRT Through Passenger Travel Time		2	3	4	3	3	5	5	2	1
LRT TMC Ridership Access		5	5	5	4	3	4	4	1	2
Traffic Operations		1	2	3	3	4	5	4	4	4
Safety		1	2	3	2	2	5	4	3	2
Right-of-Way Required		5	5	5	4	4	5	5	2	1
Environmental Effects		3	3	3	3	3	4	4	3	2
Constructability		5	3	3	3	3	1	2	3	3
Capital Cost		5	4	4	3	3	1	2	3	3
O&M Cost		5	5	5	5	5	3	3	5	4
UNWEIGHTED TOTALS:		32	32	35	30	30	33	33	26	22
IMPORTANCE WEIGHTING (judgment-based percent of all criteria)										
LRT Through Passenger Travel Time	2%	0.04	0.06	0.08	0.06	0.06	0.10	0.10	0.04	0.02
LRT TMC Ridership Access	10%	0.50	0.50	0.50	0.40	0.30	0.40	0.40	0.10	0.20
Traffic Operations	13%	0.13	0.26	0.39	0.39	0.52	0.65	0.52	0.52	0.52
Safety	20%	0.20	0.40	0.60	0.40	0.40	1.00	0.80	0.60	0.40
Right-of-Way Required	5%	0.25	0.25	0.25	0.20	0.20	0.25	0.25	0.10	0.05
Environmental Effects	5%	0.15	0.15	0.15	0.15	0.15	0.20	0.20	0.15	0.10
Constructability	10%	0.50	0.30	0.30	0.30	0.30	0.10	0.20	0.30	0.30
Capital Cost	30%	1.50	1.20	1.20	0.90	0.90	0.30	0.60	0.90	0.90
O&M Cost	5%	0.25	0.25	0.25	0.25	0.25	0.15	0.15	0.25	0.20
WEIGHTED SCORE (highest is best)	100%	3.52	3.37	3.72	3.05	3.08	3.15	3.22	2.96	2.69

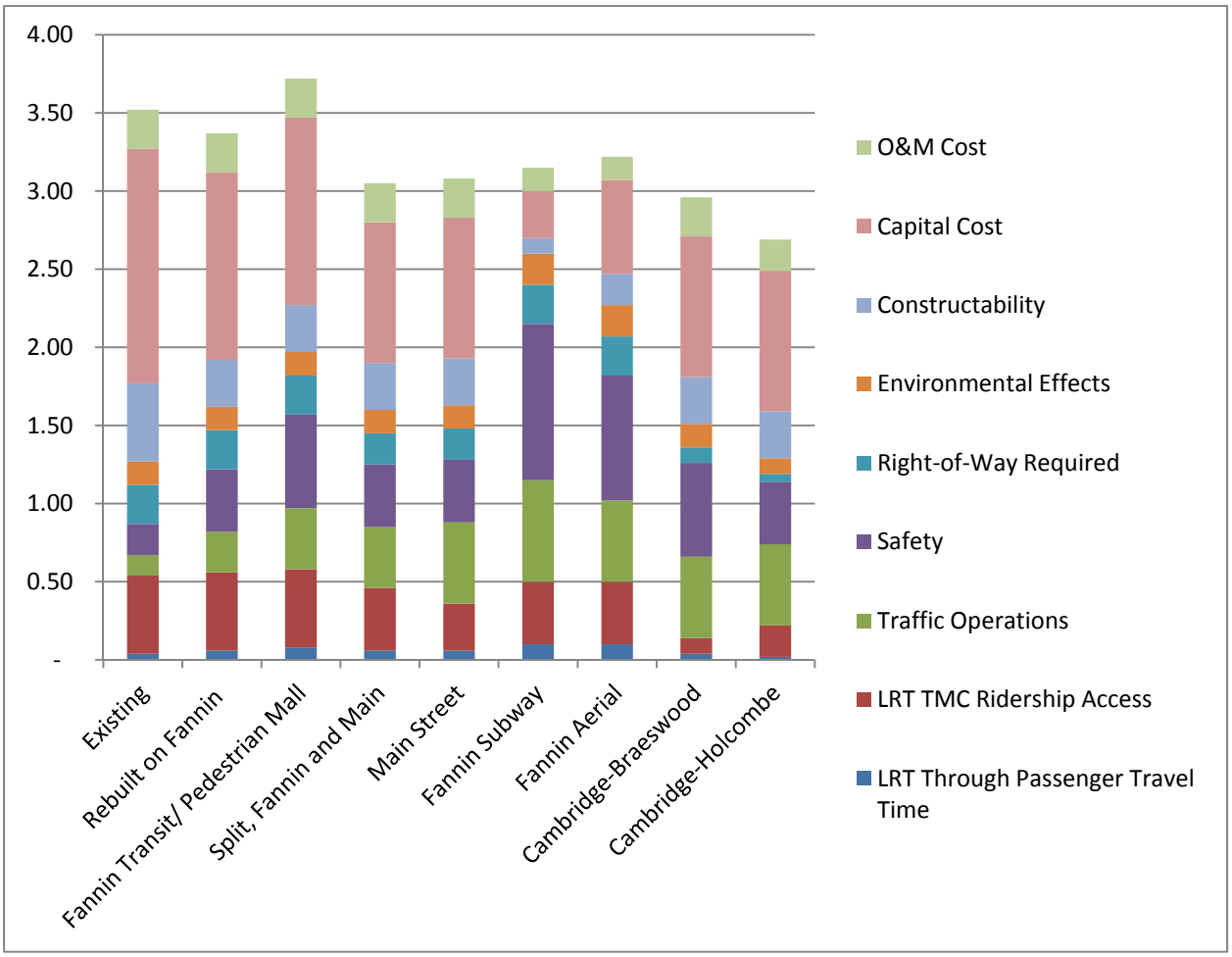

FIGURE 3-23: OVERALL LRT ALTERNATIVES COMPARISON

3.3.3 Conclusions

The evaluation conducted suggests that none of the LRT relocation alternatives would appear to be cost-effective, with or without the people mover, given their high capital cost. This led to the consideration of a set of lower cost modifications to the roadway and signal system in the TMC Central Campus area to improve traffic operations and safety, described in the following section.

4.0 ROADWAY/SIGNAL SYSTEM ALTERNATIVES

4.1 Overview

As a part of the Fannin Street Corridor Analysis, lower-cost roadway and signal improvement options were also studied. These improvements could be accomplished in a shorter timeframe and at a lower cost than options such as light rail transit (LRT) relocation or installation of an automated people mover (APM). The options considered included: improving signal coordination, removal of signals which contribute to poor arterial operation, conversion of University/Dryden to a one-way pair, and station relocations. Of these potential alternatives, three scenarios were studied in detail: 1) conversion of University and Dryden to a one-way pair, 2) removal of signals at Bellows and Ross Sterling intersections, and 3) a combination of both one-way pair conversion and signal removal.

4.2 Alternatives Considered

4.2.1 University/Dryden One-Way Pair

In order to improve operation along Fannin Street by reducing the conflicting movements as well as improving traffic circulation, University Boulevard and Dryden Road were studied as a one-way pair between Fannin Street and Main Street. Dryden Road would be converted to a one-way eastbound road and University Boulevard would be converted to a one-way westbound road.

The following lane configuration modifications would occur at Fannin/Dryden intersection:

- Northbound left movement eliminated
- Westbound thru movement eliminated
- Four lanes on eastbound approach

At University Boulevard, the following lane configuration modifications would occur:

- Eastbound approach converted to four westbound lanes
- North, south and westbound approaches will retain existing lane configuration

Figure 4.1 presents the aforementioned improvements.

FIGURE 4.1 - UNIVERSITY/DRYDEN ONE-WAY PAIR SCENARIO – TRAFFIC REDISTRIBUTION

4.2.2 Ross Sterling and Bellows Signal Removal

The second alternative considered is the removal of the signals at Ross Sterling and Bellows. It is anticipated that, with the removal of these two signals, there will be an improvement in the operation of the Fannin Street Corridor. In this scenario, the medians at both intersections would be closed and only right-in and right-out movements would be permitted at the cross street approaches.

The median closure at these two intersections will result in the redistribution of the traffic. At the Bellows intersection, vehicles currently making southbound left turn would be forced to proceed further south and make a U-turn at Holcombe Street to reach their destinations on the east side of Fannin Street. The vehicles currently making northbound left turn at the intersection would have to use Main Street as an alternative route to access the facilities on the westside of Fannin Street.

At the intersection of Fannin and Ross Sterling, the vehicles currently making southbound left turn would have to make a left turn at John Freeman instead and northbound left turning vehicles would have to continue north and turn left at Cambridge to access the parking facilities from Main Street.

Figure 4.2 presents the aforementioned improvements and redistribution of traffic.

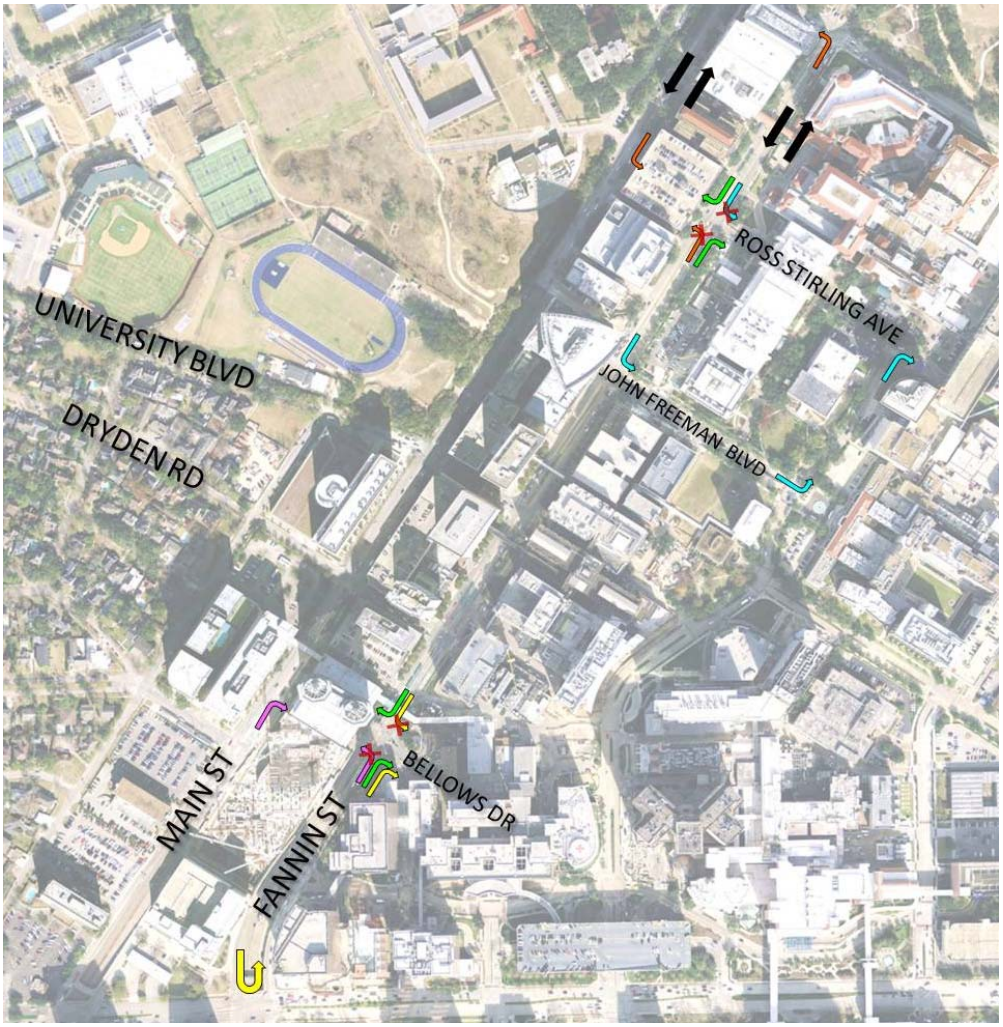

FIGURE 4.2 - BELLOWS AND ROSS STERLING SIGNAL REMOVAL – TRAFFIC REDISTRIBUTION

4.2.3 Composite Improvement

The Composite Improvement alternative is a combination of both the conversion of University and Dryden to a one-way pair and the removal of signals at Bellows and Ross Sterling. In this scenario, all the lane configuration modifications and traffic redistribution which were considered for the individual alternatives were considered and any additional redistribution of traffic was accounted for.

4.3 Evaluation Methodology

The operation of the Fannin Street was analyzed using the VISSIM software. The scope of the study includes VISSIM analysis to reflect vehicle, pedestrian, and transit conditions for the existing conditions as well as the three alternatives as described in section 5.2. The following eight intersections along Fannin Street within the study limits were modeled and analyzed:

- Fannin Street at Cambridge Street
- Fannin Street at Ross Sterling Avenue

- Fannin Street at John Freeman Boulevard
- Fannin Street at University Boulevard
- Fannin Street at Dryden Road
- Fannin Street at Bellows Street
- Fannin Street at Holcombe Boulevard
- Fannin Street at Pressler Street

4.3.1 VISSIM

VISSIM is a microscopic modeling software that can simulate multi-modal traffic flows, including cars, trucks, buses, trams, heavy/light rail transit, bicyclists, and pedestrians. Some of the useful tools of VISSIM software are;

- Coding detailed vehicle parameters and human behavior characteristics to simulate most realistic field conditions
- Evaluating the feasibility and impact of integrating LRT into urban street networks
- Developing, evaluating, and fine-tuning transit signal priority logic
- Evaluating and optimizing a combined network of coordinated and actuated traffic signals
- Three dimensional visual display to observe and fine-tune the model

The following methodology was applied to cover the technical aspects of this study:

- Assemble available data.
  - The data from the existing conditions report such as the traffic volumes, critical intersections etc. was gathered.
  - VISSIM files developed for the previous studies conducted in the project vicinity were collected.
- Updated VISSIM model for the base option to add the intersections of Fannin Street/Bellows Street and Fannin Street/Pressler Street to the model network.
- VISSIM models provided were used as base and traffic volumes gathered for this study were coded to reflect current traffic conditions.
- The train performance and operations (service headways, dwell times) applicable to PM peak periods in the study corridor were gathered and applied.
- Performed several simulation runs of the VISSIM models to refine the model, check for accuracy.
- Developed VISSIM models for the three alternative scenarios.
- Updated the models for alternative scenarios with redistributed traffic volumes at applicable intersections for each scenario.
- Evaluated LRT and traffic operations along the corridor
- Evaluated study network operation by comparing various Measures of Effectiveness for alternative scenarios.

Vehicular turning movement counts were redistributed based on the lane configuration changes for the three alternatives. Additionally, traffic signal operation modifications were made to accommodate the redistributed traffic in all three scenarios. Several simulation runs were completed in order to gain an understanding of the impact that the three alternatives would have on the entire corridor. Finally, measures of effectiveness were compared among the three alternatives as well as the base condition.

4.3.2 Evaluation Criteria

In order to evaluate the impacts of the modifications made to the intersections along Fannin Street corridor for the three alternative scenarios it was determined that the following criteria will be considered:

- Change in general traffic travel time
- Change in LRT travel time

Also, to evaluate the impacts of the modifications on the study network it was determined that the following criteria will be considered:

- Change in average delay per vehicle
- Change in average general traffic speed
- Change in travel time

4.4 Alternatives Evaluation

4.4.1 Corridor Impacts

The travel time sections were created in the model networks and several simulations runs were conducted to observe the traffic operations and the travel times were recorded for the general traffic lanes as well as LRT guide way for both northbound and southbound directions. The results of the simulation runs are summarized and depicted in Figure 4.3.

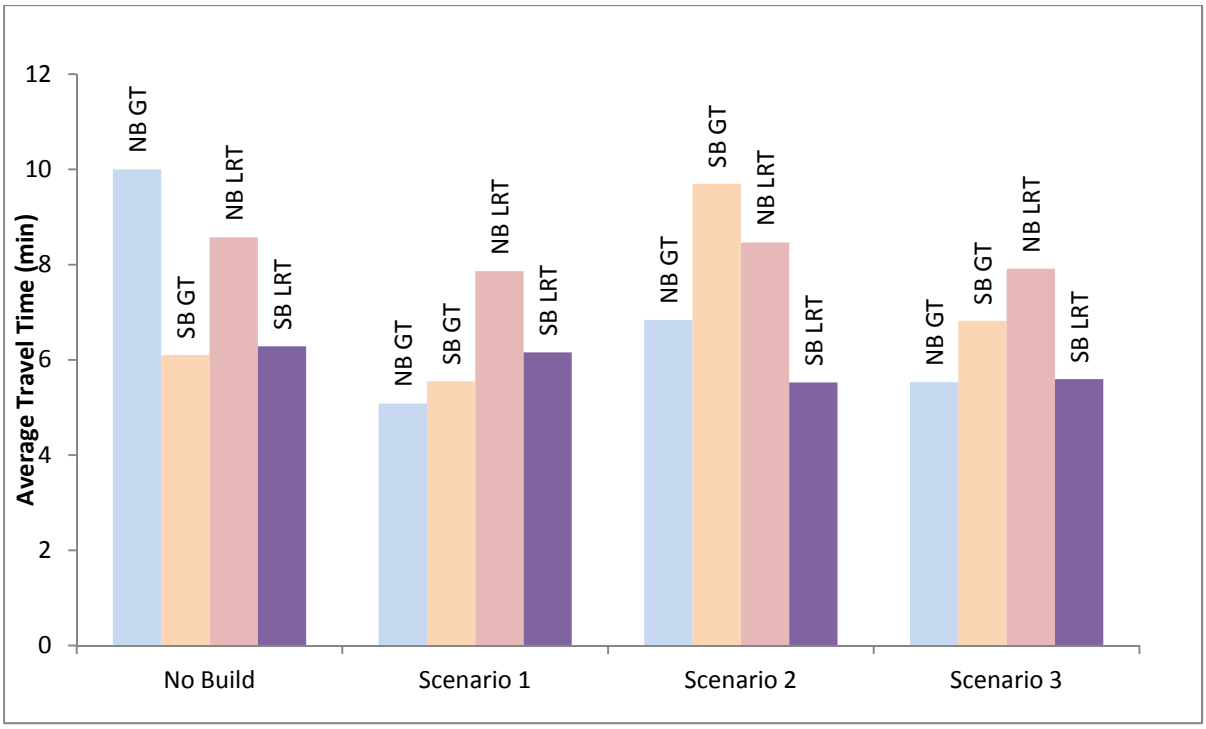

FIGURE 4.3 – NETWORK TRAVEL TIME COMPARISON

As presented in Figure 4.3, it can be seen that there is a significant improvement in the travel time in the northbound general traffic lanes for all three alternative scenarios. However, the southbound travel time along general traffic lanes appears to have decreased slightly for scenario 1 and increased for alternative scenarios 2 and 3. The LRT Travel time in both northbound and southbound directions has remained consistent for all the three scenarios.

4.4.2 System Impacts

As described in Section 4.3 the system impacts were evaluated by comparing the average delay, average speed and average travel time of all the vehicles in the network. The simulations runs were conducted and the abovementioned measures of effectiveness were collected. The comparison of average delay, average speed and average travel time are presented in Figures 4.4, 4.5 and 4.6 respectively.

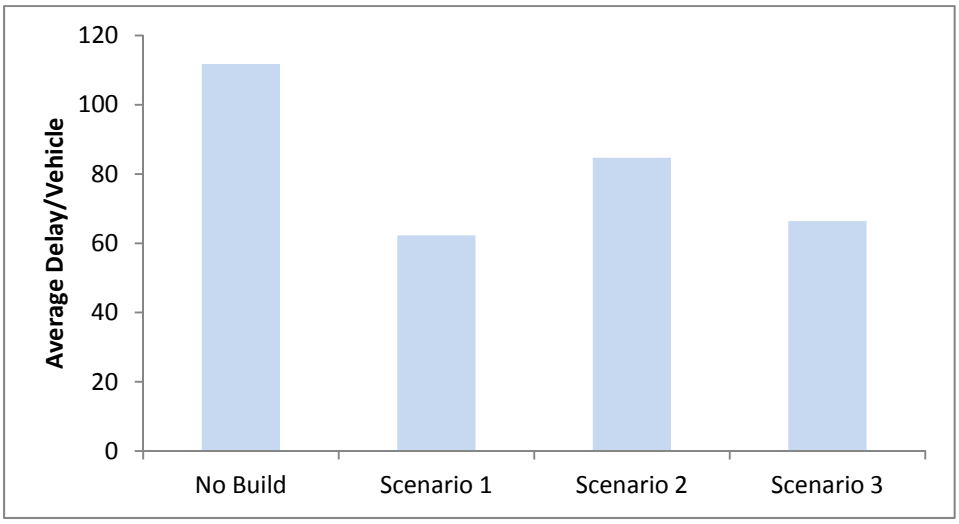

FIGURE 4.4 - NETWORK AVERAGE DELAY/VEHICLE COMPARISON

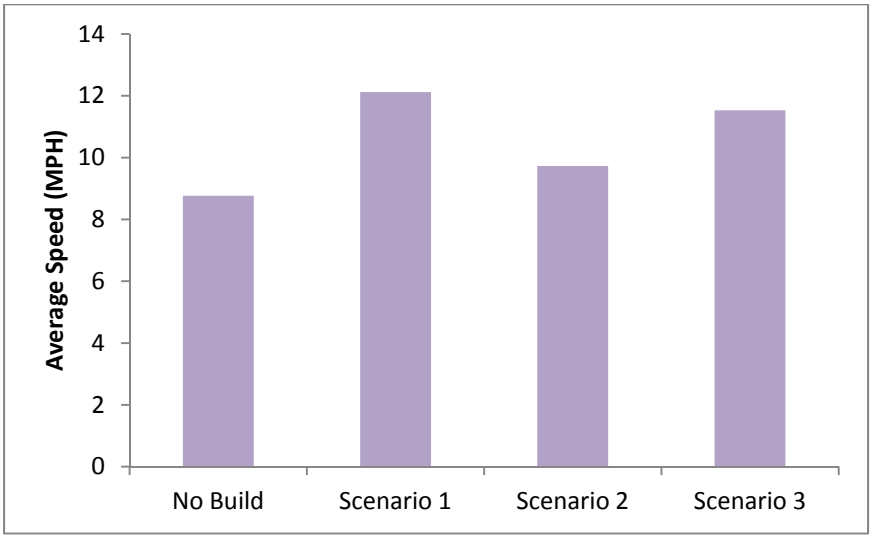

FIGURE 4.5 – NETWORK AVERAGE SPEED COMPARISON

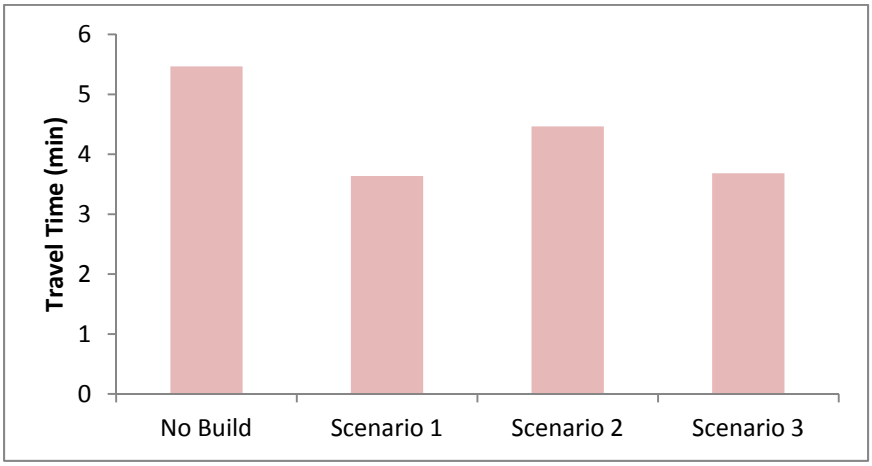

FIGURE 5.6 – NETWORK TRAVEL TIME COMPARISON

The results of the analysis, as presented in the above figures, indicate that the roadway and signal modifications modeled would result in improved traffic operation in the study network. Also, it has been observed that the implementation of the modifications suggested as part of alternative scenario 1 appear to produce the best results.