Appendix B

Technical Memoranda and Reports

Disclaimer:

Technical memoranda and reports were prepared as independent documents to support the preparation of the Final Environmental Impact Statement (FEIS) for the Dallas CBD Second Light Rail Alignment (D2 Subway). Information from these documents was incorporated into the FEIS to provide information on existing conditions, and in some cases, assess potential impacts to the resources. Information contained in the FEIS is the most current and supersedes information in the technical memoranda and reports.

B-21

Ridership and Capacity Analysis Technical Memorandum

MEMO

Date:	September 25, 2019, Updated September 4, 2020
Project:	DART General Planning Consultant Contract C-2012668 D2 Subway – Downtown Dallas Second Light Rail Alignment
To:	Kay Shelton – DART Assistant Vice President, Capital Planning Ernie Martinez – DART Project Manager, Capital Planning
From:	Adam Socki – GPC6 Transit Planner Vijay Mahal – GPC6 Transit Modeling Manager
Subject:	DART TO39 D2 Subway Project Development SDEIS – Ridership and Capacity Analysis

1.0 INTRODUCTION

Dallas Area Rapid Transit (DART) is conducting Project Development, including Preliminary Engineering (PE) and development of a Supplemental Draft Environmental Impact Statement (SDEIS) for a second Central Business District (CBD) light rail alignment, known as the D2 Subway. The purpose of this memorandum is two-fold:

1. To document the assumptions and approach to travel demand forecasting which will provide the basis for ridership estimates and other transportation performance information in the SDEIS; and
2. To document the ridership analysis and results for inclusion in the SDEIS.

DART uses the North Central Texas Council of Governments (NCTCOG) Regional Travel Demand model with approved demographic forecasts for projecting ridership. Forecasts will be conducted for two years, 2024 and 2045. Year 2024 will represent "opening year" conditions, while Year 2045 will represent long term forecasts. DART uses the assumed NCTCOG roadway networks associated with each of these years. However, DART does make some refinements to the transit network to more accurately reflect physical and operating conditions of the system and includes only those transit projects that are funded and programmed by transit agencies.

Two alternatives are documented in the SDEIS, the No Build Alternative and the Build Alternative. The No Build Alternative also includes two transit network sensitivity test scenarios based on DART headway policy discussions and regional rail program considerations. Both scenarios have the potential to impact the need and timing for the D2 Subway project. **Table 1** summarizes the model forecasts that were done to support the SDEIS analysis.

Table 1 - Summary of D2 Subway Travel Demand Forecasts

Alternative	Year 2024	Year 2045
No Build Alternative		X
No Build Sensitivity Test Scenarios		
1. Enhanced LRT System Headways (10/20)		X
2. Regional Rail Expansion		X
Build Alternative	X	X

Source: DART

The following sections describe each alternative and the transit network assumptions in more detail.

2.0 NO BUILD ALTERNATIVE

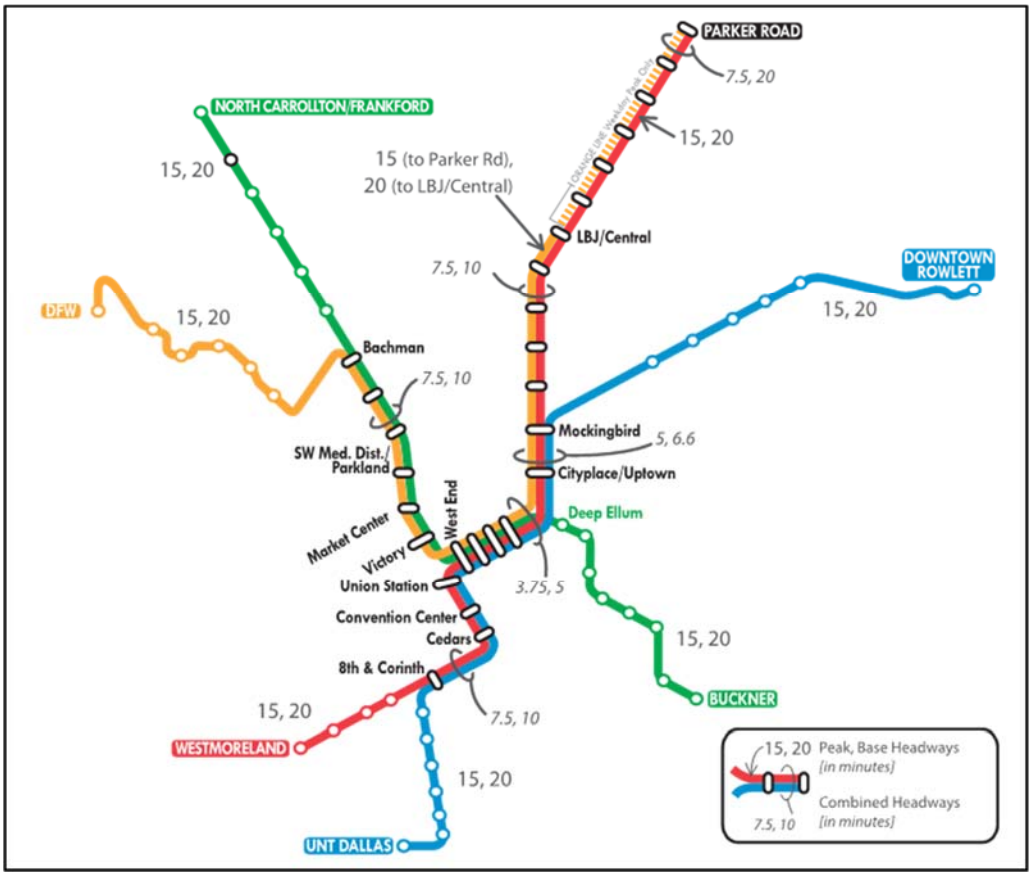
2.1 2024 No Build

The 2024 No-Build Alternative transit model network includes existing and committed rail in downtown and the region, including:

- Existing LRT system at 15/20-minute headways (see **Figure 1**)
- Existing regional rail at 30/60-minute headways (TRE, A-Train, TEXRail)
- DART Silver Line regional rail line at 30/60-minute headway (opens 2022)
- Existing Dallas Streetcar system including future Central Link project at 20-minute headway (opening date assumption 2024 concurrent with D2 Subway)
- Existing M-Line operations
- Existing DART bus transit network including recent August 2019 service changes
- Hidden Ridge Station on Orange Line (opens 2020)

While DART has other transit improvements in progress that are part of the 2024 No Build definition, including CBD rail replacement and Red/Blue line platform extensions, these projects do not affect ridership forecasts.

Figure 1 – No Build LRT Network and Headways



Source: DART

2.2 2045 No Build

Since the DART 2045 Transit System Plan is in development, there are no additional major programmed DART rail expansion projects or service level improvements defined at this time to include in the 2045 No Build scenario. Future bus improvements are being defined through a Bus Service Plan during fiscal year 2020. Minor changes to the 2045 No Build network include:

- Limited bus network adjustments to keep up with growth
- Loop 12 Station on Orange Line

2.2.1 Year 2045 No Build Sensitivity Test Scenarios

For year 2045, DART analyzed two additional scenarios based on local policy discussions and regional plans. These are described below in more detail.

Enhanced LRT Headway Scenario

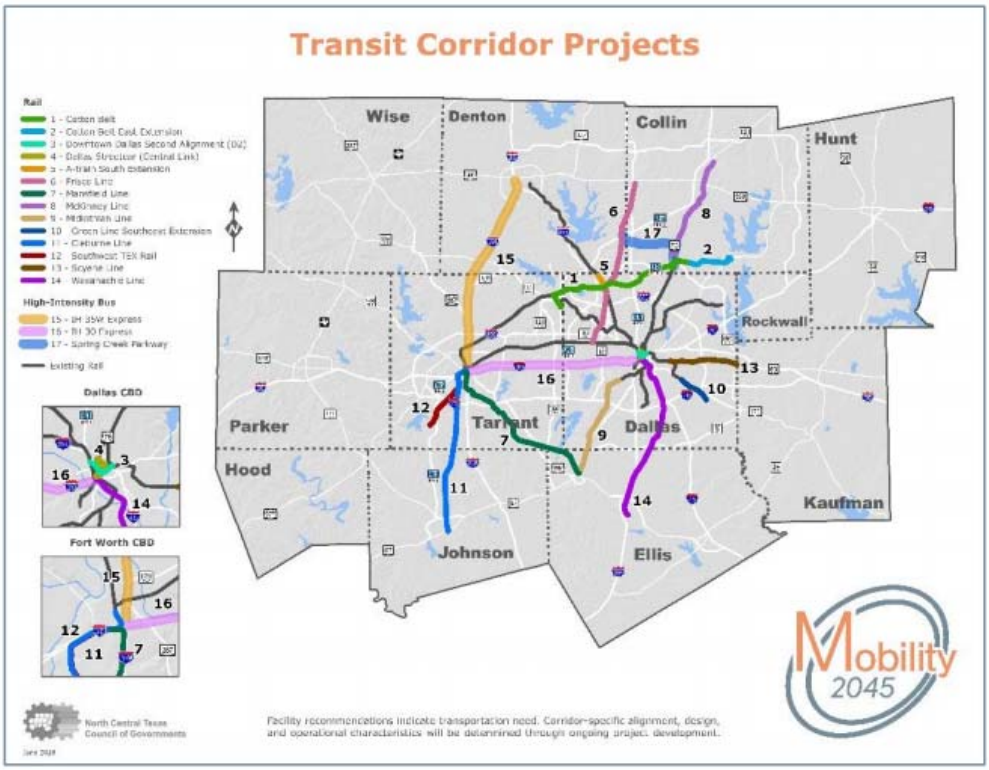
The DART Board has discussed a desire to enhance LRT system headways and return to 10-minute peak service in the future. While enhanced service is not yet included in the 20-year Financial Plan, it could be advanced as a long-range recommendation in the Transit System Plan. Understanding the capacity needs of a more frequent network is needed to determine if the No Build system could accommodate increased passenger loads. Thus, this scenario will modify the 2045 No Build Alternative to reflect:

- 10-minute peak headways on the LRT network
- 20-minute peak headways on the Silver Line
- 15-minute service on the Dallas Streetcar system

Regional Rail Expansion Scenario

The NCTCOG Metropolitan Transportation Plan Mobility 2045 includes recommendations for several regional rail corridors that would directly interface or be interlined with DART rail lines, or that could terminate in downtown Dallas (see **Figure 2**). **Table 2** summarizes the regional rail lines and one high intensity express bus service in this scenario.

Figure 2 – Regional Rail Project Map



Source: DART

Table 2 – Regional Rail Expansion Scenario Assumptions

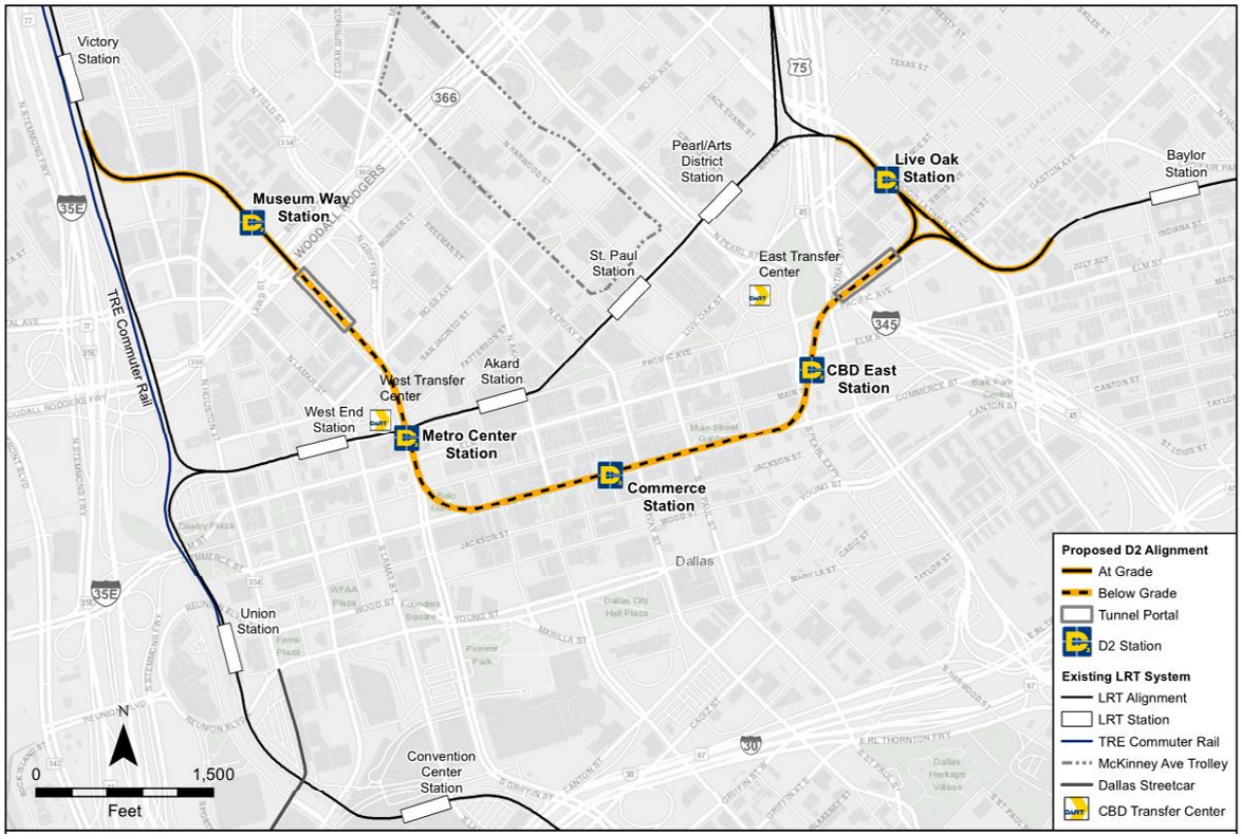
Corridor	From-To	Headway	System Interface
2 – Silver Line (Cotton Belt) extension	Shiloh Road to Downtown Wylie	20/60	Extension of Silver Line from Shiloh Road
5 – A-Train Extension	Trinity Mills to Downtown Carrollton	20/60	Adds transfer point at Downtown Carrollton (Green Line, Silver Line)
6 – Frisco Line	South Irving to Frisco	20/60	Peak direction headways with interface with Green, Orange and TRE lines
7 – Mansfield Line	Fort Worth to Mansfield	20/60	Peak direction headways
8 – McKinney Line	Parker Road to McKinney North	20/60	Transfers to DART Rail at Parker Road Station
9 – Midlothian Line	Westmoreland to Midlothian	20/60	Transfers to DART Rail at Westmoreland Station
10 – Green Line Extension	Buckner to South Belt Line	15/20	Extension from existing Buckner Station
11 – Cleburne	Fort Worth to Cleburne	20/60	Peak direction headways
12 – Southwest TEXRail	Fort Worth to McPherson		Extension of TEXRail to southwest
13 – Scyene Extension	Downtown Dallas to Masters Drive	15/20	MTP shows Masters to CBD East Station. DART will model as extension of Orange Line (DFW to Masters) with Red Line infill service to replace Orange Line in North Central Corridor
14 - Waxahachie	Dallas to Waxahachie	20/60	Peak direction headways with interface at Union Station
16 – IH 30 Express Bus	Fort Worth to Dallas	30/30	High intensity bus service directly into downtown Dallas

Source: NCTCOG Mobility 2045 Plan; DART

3.0 BUILD ALTERNATIVE

The Build Alternative will include the D2 Subway project in both the year 2024 and 2045 scenarios. The assumptions will be the same for both No Build years except for the addition of the D2 Subway. The Build Alternative consists of a new LRT corridor, four new stations, and one relocated station as shown in **Figure 3.**

Figure 3 – Proposed Build Alternative (D2 Subway)

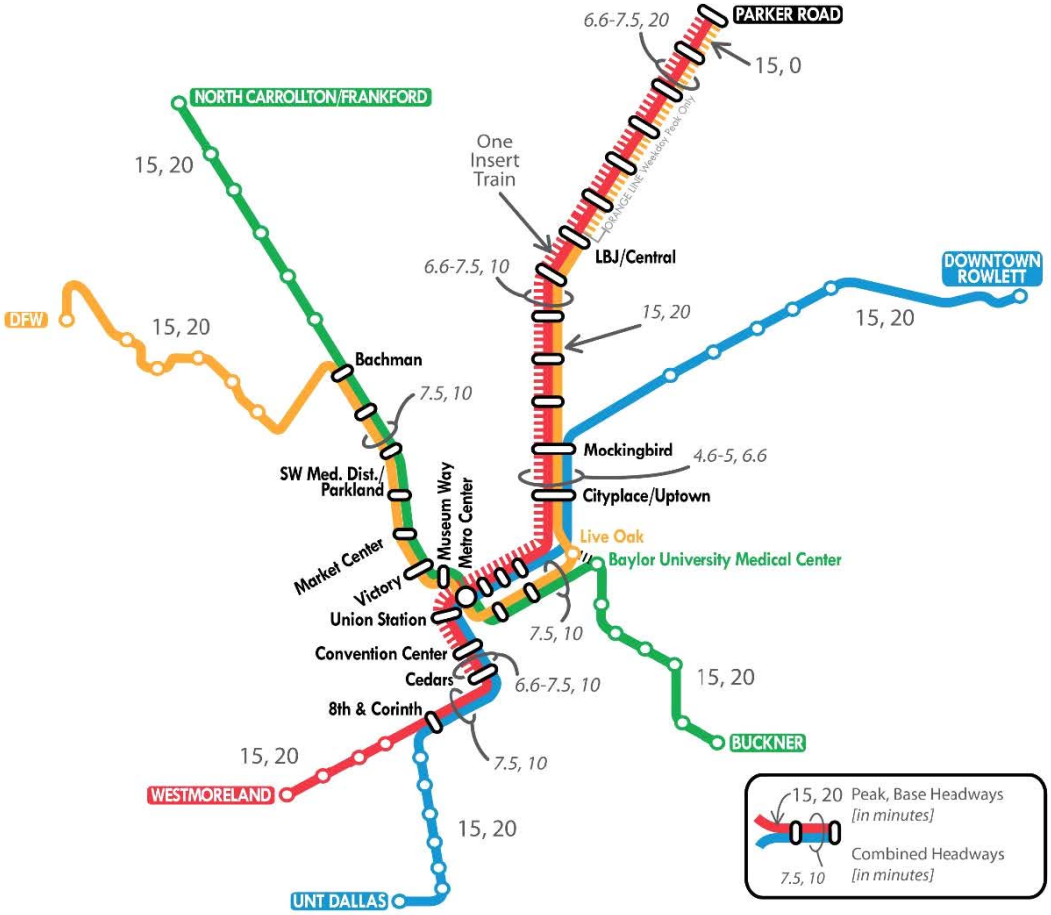


Source: DART

The following network changes would occur under the Build Alternative:

- The Green and Orange Lines would shift from the existing transit mall to the D2 Subway Corridor. Red and Blue would continue to operate on the existing transit mall. The LRT system would continue to operate at a 15/20-minute headway. **Figure 4** illustrates the operating concept.
- Based on the core capacity needs, the equivalent of one train would be inserted on the Red Line from Cedars to Parker Road in the peak hour to address crowding.

Figure 4 – Build Alternative LRT Network and Headways



Source: DART

4.0 MODEL OUTPUT AND PERFORMANCE REPORTS

The travel demand model was run for all the scenarios described above and forecasts of rail ridership including station level data were extracted directly from the model outputs. The model was run for two forecast years: 2024 and 2045. Performance reports were generated for year 2045 to understand and compare the No Build versus Build Alternatives effects on system-wide transportation performance for the region, the DART Service Area, and the downtown Dallas area (based on the Dallas 360 Plan area). Some statistics that quantify system wide impacts include Vehicle Miles of Travel (VMT), hours of congestion delay, linked and unlinked transit trips.

5.0 RIDERSHIP RESULTS AND ANALYSIS

The following sections document the results of the analysis comparing the No-Build to the Build Alternative for year 2045. Sensitivity test and performance measure information is also described.

The following sections describe ridership changes that are forecast to occur with the D2 Subway in place. System, corridor and station information are discussed. Forecasts are based on approved year 2045 demographics and utilize the NCTCOG Regional Travel Demand model. Since D2 Subway is a core capacity project and primarily shifts service from one corridor to another with targeted service level increases, ridership changes are minimal. Its primary purpose is to add capacity and flexibility to the system to sustain the region into the future and open up new markets for enhanced economic development opportunities.

The NCTCOG model generates trips between zones for various trip purposes using approved regional demographics and assigns those trips to the roadway and transit network based on anticipated travel patterns. In many cases, recent development within the last few years and future development opportunities are not yet realized in long range demographic forecasts that were updated in 2017. For example, year 2045 forecasts do not account for the Epic Development, which includes a 23-story office tower, residential tower and hotel, or recent East Quarter projects including an office and residential tower. There is also no or very minimal development forecast for several vacant parcels surrounding the CBD East Station. Based on City of Dallas input, site specific demographic data for the Dallas 360 Plan area was provided as input to NCTCOG in 2017 but has not yet been incorporated into any future official demographic dataset.

The model also incorporates elasticities related to changes in travel time or transfers. Within downtown Dallas, direct walk access is important and is the primary mode of access. However, without up to date demographics representing existing and planned development at a station level, which influences the model estimate of how many people can easily walk to a station (direct walk access), the model is somewhat limited and may underestimate station level activity, especially in the southeast part of downtown.

5.1 Year 2045 No-Build vs. Build Comparison

Ridership analysis for system-wide, corridor level and station level changes are discussed below.

5.1.1 System-wide Ridership Impacts

Table 3 shows the 2045 daily regional system ridership for the No-Build and Build Alternatives.

Table 3 Year 2045 Daily Regional System Ridership for the No-Build and Build Alternative

Local Bus	257,200	257,000	0%
Express Bus	7,400	7,300	-1%
Streetcar	4,600	4,500	-1%
Light Rail	147,300	143,900	-2%
Regional Rail	38,200	38,500	+1%
Total Regional System	**454,600**	**451,200**	**-1%**

Source: DART, 2019

When looking at the entire transit system, changes between the No-Build and Build Alternative are minimal. The largest changes are generally within downtown Dallas relative to how riders will access and transfer between existing and new stations. The entire system would have a daily ridership of 454,600 under the No Build Alternative. Under the Build Alternative the system ridership drops by less than 1 percent. At the systems level a reduction of 3,500 trips is not very significant and it may be due to a few different factors which may include some inherent noise in the model as well as some multi-transfer trips in the No Build becoming either single transfer or no-transfer trips in the Build alternative. For all practical purposes, one can conclude the D2 ridership at the systems level is about the same as the No Build.

In terms of total linked transit trips in the region, the 2045 No Build Alternative is projected to have 278,500 daily trips. In the Build Alternative, the daily linked trips are about 277,700, about 800 trips fewer than the No Build. Again, at the systems level, a reduction of 800 trips is not significant and it may be attributable to a few different factors which may include some inherent noise in the model as well as some transit paths being slightly longer in the Build alternative than in the No Build alternative. For all practical purposes, one can conclude the total demand in the Build Alternative is about the same as in No Build.

Table 4 summarizes the linked and unlinked trips, which provides an indication of overall transfer rate difference for the No Build and Build Alternatives.

Table 4- Linked Trips, Unlinked Trips and Transfer Rate Analysis

Trips	No-Build	Build	Percent Change
Linked Transit Trips	278,500	277,700	-0.3%
Unlinked Transit Trips	454,600	451,200	-0.7%
Transfer Rate (Ratio of Unlinked versus Linked transit trips)	1.63	1.62	-0.6%

Source: DART, 2019

5.1.2 Corridor-Level Impacts

Table 5 shows the 2045 daily ridership for the total LRT system for the No-Build and Build Alternatives. The light rail system in the No Build Alternative is projected to carry 147,200 trips in the year 2045. In the Build Alternative, the LRT ridership reduces slightly by about 3,300 trips when compared to the No Build alternative.

Table 5 - 2045 Daily LRT System Ridership for No-Build and Build Alternative

LRT Line	No-Build	Build	Percent Change
Red Line + Red Insert	35,200	37,500	+6%
Blue Line	30,900	30,400	-2%
Green Line	42,400	40,600	-4%
Orange Line	38,700	35,400	-9%
Total LRT	**147,200**	**143,900**	**-2%**

Source: DART, 2019

Under the Build Alternative, changes in overall LRT ridership are primarily associated with the Green and Orange Lines moving to a new route in a less dense corridor. The Green Line would no longer serve the Deep Ellum Station, and the Orange Line would have a slightly longer travel time, which affects model output. In addition, an analysis of zones along the existing Bryan-Pacific Mall and the Commerce Corridor shows that population and employment in the existing corridor is about 20 percent higher based on 2045 demographics. With continuing land use changes that may not be included in the 2045 projections, and increasing density, it is anticipated that system ridership would be higher than that associated with year 2045 demographics. The D2 Subway Project frees up capacity on the transit mall, allowing additional Red Line service to be added during the peak hour to increase Red Line ridership by 6%.

5.1.3 Station Level Impacts

Table 6 summarizes year 2045 daily ridership for stations within the D2 Study Area, including the estimated percentage by mode of access. This gives an indication of which stations would emphasize direct walk access versus a focus on bus and/or rail transfer. D2 Subway stations are highlighted in bold. A more detailed breakdown of transfer trips for the Build alternative is presented in Table D1 in Appendix D.

Table 6 - Year 2045 Daily LRT Station Ridership within D2 Study Area

Station	Year 2045 Average Weekday Ridership	Mode of Access		
		Bus	Rail[1]	Walk
Victory Station	5,400	3%	75%	23%
Museum Way Station	**1,400**	**27%**	**8%**	**65%**
Convention Center Station	800	0%	2%	97%
Union Station	3,800	7%	46%	46%
West End Station	6,100	22%	30%	48%
Metro Center Station	**5,600**	**14%**	**33%**	**53%**
Akard Station	4,200	6%	1%	93%
Commerce Station	**3,800**	**16%**	**0%**	**83%**
St. Paul Station	3,300	4%	0%	96%
Pearl/Arts District Station	3,400	12%	5%	84%
CBD East Station	**4,400**	**17%**	**39%**	**44%**
Live Oak Station (former Deep Ellum)	**500**	**7%**	**0%**	**93%**
Baylor UMC	1,000	12%	0%	88%
Total	43,400	12%	26%	62%

Source: DART Capital Planning; NCTCOG Model

Notes: D2 Subway Stations highlighted in **BOLD** type

[1] Rail access includes transfers to/from LRT, TRE commuter rail, and streetcar

As noted previously, NCTCOG demographics do not reflect the most recent development trend, most of which is occurring in the southern part of downtown, so ridership at some stations may be underestimated. The model also does not account for special event ridership associated with concerts, games or museum attendance. Based on prior year special event surveys by DART, direct LRT access can equate to a 15 to 20 percent mode share. Furthermore, the City of Dallas and DART have applied for an FTA Transit Oriented Development (TOD) Pilot Program grant to develop a TOD implementation plan around the Project corridor and stations to maximize development and ridership potential.

Observations relative to specific stations include:

- Victory Station continues to be a strong rail to rail transfer station, allowing TRE riders to transfer to and from the Green and Orange Line.
- Museum Way Station ridership, estimated to be 1,400, does not account for visitors to adjacent attractions such as the Perot Museum, Dallas World Aquarium, and House of Blues. Perot Museum alone has about 1,000,000 visitors per year. A 15 to 20 percent mode share could be 500 to 650 additional riders per day associated with the museum. Walk access is strong, supporting the need for pedestrian linkages in the area as outlined in urban design plans.
- Metro Center and West End Station both generally split mode share between walk access (48 to 53 percent) and bus/rail transfer activity (47 to 52 percent). Sharing the transfer activity between these two stations would help to spread the passenger loads between the two stations. The Metro Center station is designed to facilitate these transfers.
- Akard, Commerce, and St. Paul Stations all have strong walk access of 83 to 96 percent. Of these, Commerce Station has 16 percent bus mode share, indicating strong connections with the Elm and Commerce bus routes.
- The CBD East Station has strong rail transfer activity. This is associated with transfers between the Orange and Green Line. Riders from south Dallas can transfer at this location to the Orange Line to continue north towards Richardson and Plano. Southbound Orange Line riders can transfer at CBD East to continue towards Baylor Medical Center or Fair Park. Station ridership could also be higher given recent development trends in the East Quarter and Farmers Market areas that are not yet included in year 2045 demographics.
- Ridership generally shifts from Deep Ellum Station, which would be relocated to Live Oak Station. The forecast of 500 riders is comparable to existing ridership. Ridership at this station is anticipated to be higher given development trends in that area that are not yet reflected in regional demographic forecasts.

5.2 Sensitivity Test Scenarios and Analysis of Peak Demand Versus Available Train Capacity

As described in **Section 2.2.1,** two sensitivity test scenarios for year 2045 were analyzed to understand future passenger load constraints without D2 Subway in place, enhanced headways and regional rail expansion. It should be noted that LRT passenger loads in year 2045 No-Build Alternative would exceed three-car train capacity (seated and standing) in some corridors. This demonstrates that the Project is needed in the long-term to accommodate growth projections even without scenarios that incorporate enhanced headways or regional rail expansion.

This analysis provides an understanding of potential LRT system capacity constraints under future conditions without D2 Subway. It should be noted that the enhanced system headway scenario assumes 10-minute peak LRT headways which is not possible unless the D2 Subway is in place and lines could be balanced between two corridors. However, the capacity analysis does provide information on whether 10-minute peak LRT service would further burden the system beyond 3-car train capacity.

The charts in the **Appendix A, B** and **C** show LRT seating capacity for 2-car and 3-car train consists – both seated (94 seats per car) and standing using the 1.75 peak hour load factor per DART policy. The peak passenger load was compared against peak available train capacity at each station. This comparison revealed any capacity shortfall that may exist under different train consist assumptions.

5.2.1 2045 No Build

Figures A1 through **A8** (located in **Appendix A**) illustrate the peak demand and available capacity on each of the 4 LRT lines in each direction for the 2045 No Build scenario. **Figures A1** and **A2** illustrate peak hour passenger loads on the Red Line in 2045 at each station along the alignment for the No-Build scenario. The figures also show the peak hour train capacity assuming 2 car and 3 car consists, with and without standees. As shown in the **Figure A2**, at 15 minute peak headway, the Red Line would provide a capacity of 1,316 passengers during the peak hour. Under this condition, the model results indicate in 2045, there would be 5 stations (CityLine/Bush Station to LBJ Central) in the southbound direction that would experience crowding condition during the peak hour, assuming 2-car consists. However, this crowding phenomenon can be alleviated by providing 3-car trains. Likewise, in the northbound direction as shown in **Figure A1**, 5 stations (Dallas Zoo Station to Union Station) would experience passenger crowding during the peak hour. Again, this crowding phenomenon can be alleviated by providing 3-car trains. A similar comparative analysis of peak demand versus capacity in the 2045 No Build indicates:

- Blue line exceeds 3-car train capacity in both directions on some segments – this indicates that additional insert trains will be required and that D2 must be in place to allow this. (**Figure A3 & A4**)
- Green line exceeds 3-car capacity in northbound direction into downtown. This again indicates additional train inserts will be needed to handle the capacity shortfall and D2 would have to be in place to insert more trains. (**Figure A5 & A6**)
- Orange line will require some 3-car trains in peak to serve the projected demand. (**Figure A7 & A8**)

5.2.2 2045 Regional Rail Expansion

Under the regional rail expansion scenario, which is consistent with the Mobility 2045 Metropolitan Transportation Plan, LRT ridership is expected to increase by 20 percent to 177,000 trips a day. Regional rail ridership in this scenario would increase from 38,200 in the No-Build to almost 84,000, an increase of about 120 percent. At the system wide level, transit ridership would increase from 454,500 to 549,400, about 21 percent. Higher passenger loads and transfers to the DART system would necessitate running more service on almost all lines in order to provide enough capacity to handle peak demand. The D2 Subway is essential to serve the projected demand under the regional rail expansion scenario.

Figures B1 through **B8** (located in **Appendix B**) illustrate the peak demand and available capacity on each of the 4 LRT lines in each direction for the 2045 Regional Rail Expansion scenario. As seen from these figures, there are at least 5 stations on the Northbound Red line where peak loads will exceed available capacity even under 3-car scenario. One way to address this crowding condition would be to provide more train service which would require D2 to be in place.

On the southbound Blue Line, there are at least 5 stations where peak loads will exceed available capacity even under 3-car scenario. One way to address this crowding condition would be to provide more train service which would require D2 to be in place. Likewise, in the northbound Green and Orange lines, there are 4 stations where peak loads will exceed available capacity even under 3-car scenario. Again, one possible way to address this crowding condition would be to provide more train service which would require D2 to be in place. This analysis emphasizes the importance of D2 if the region wants to expand regional rail as outlined in Mobility 2045 plan.

5.2.3 Enhanced Headways Scenario

The light rail system in the No Build scenario is projected to carry 147,200 riders in the year 2045. The entire transit system daily ridership is forecast to be 454,600. Under the enhanced headway scenario, LRT system ridership would increase by 9 percent to 162,000 riders a day. All other transit modes would increase by one to five percent over the No Build Alternative as well. The system level ridership would reach 476,000 trips a day, a 5 percent increase from the No Build. Enhanced headways would require the Project be in place given that the current transit mall is at capacity. Prior to 2010, DART operated 10-minute peak LRT headways on the Red and Blue Lines. With the Project in place, DART would have the flexibility to improve headways in the future.

Figures C1 through **C8** (located in **Appendix C**) illustrate the peak demand and available capacity on each of the 4 LRT lines in each direction for the 2045 No Build with Enhanced LRT Headways scenario. A quick analysis of these charts indicate many of the LRT lines could operate fine with 2-car consists at this better frequency. However, there are a few stations on the Blue Line NB and SB and Green Line NB where the projected demand cannot be served with 2 car consists. Deploying 3 car consist will address this problem. Note D2 is required to support a 10-minute peak headways on all the LRT lines.

Table 7 summarizes the crowding issues in the 2045 No Build, Regional Rail expansion and D2 scenarios.

Table 7 – Summary of Capacity Issues in the No Build Alternative and Sensitivity Test Scenarios

Line	2045 No Build Alternative	Regional Rail Expansion Scenario	Enhanced Headways Scenario
Red SB	Peak hour crowding would likely occur at 5 stations under 2-car consist. 3-car consist would resolve the issue.	Peak hour crowding would likely occur at 10 stations under 2-car consist. 3-car consist would resolve the issue.	No crowding with 2-car consist.
Red NB	Peak hour crowding would likely occur at 5 stations under 2-car consist. 3-car consist would resolve the issue.	Peak hour crowding would likely occur at 9 stations under 2-car consist. Crowding would likely occur at 5 stations under 3-car consist. Additional peak service needed.	No crowding with 2-car consist.
Blue SB	Peak hour crowding would likely occur at 7 stations under 2-car and 3-car consist. Additional peak service needed.	Peak hour crowding would likely occur at 8 stations under 2-car consist. Crowding would likely occur at 5 stations under 3-car consist. Additional peak service needed.	Only 1 station would experience slight crowding with 3-car consist.
Blue NB	Peak hour crowding would likely occur at 3 stations under 2-car and 3-car consist. Additional peak service needed.	Peak hour crowding would likely occur at 6 stations under 2-car consist. Crowding would likely occur at 1 station under 3-car consist. Additional peak service needed.	3-car consist resolves all crowding issues.
Green SB	Peak hour crowding would likely occur at 2 stations under 2-car consist.	Peak hour crowding would likely occur at 1 station under 2-car consist. 3-car consist would resolve the issue.	No crowding issues with 2- car consist
Green NB	Peak hour crowding would likely occur at 6 stations under 3-car consist. Additional peak service needed.	Peak hour crowding would likely occur at 11 stations under 2-car consist. Crowding would likely occur at 4 stations under 3-car consist. Additional peak service needed.	3-car consist resolves all crowding issues.
Orange SB	No crowding issues under 2-car consist.	No crowding issues under 2-car consist.	No crowding issues with 2-car consist.
Orange NB	Peak hour crowding would likely occur at 7 stations under 2-car consist. 3-car consist will resolve this issue.	Peak hour crowding would likely occur at 8 stations under 2-car consist. Crowding would likely occur at 4 stations under 3-car consist. Additional peak service needed.	No crowding issues with 2-car consist.
Red Insert SB	N/A	Peak hour crowding would likely occur at 9 stations under 2-car consist. 3-car consist would resolve the issue.	N/A
Red Insert NB	N/A	No crowding issues under 2-car consist.	N/A

Source: HDR Engineering

6.0 PERFORMANCE MEASURES

The following section describes outputs from the model relating to vehicle miles of travel and hours of congestion delay.

6.1 Vehicle Miles of Travel and Hours of Congestion Delay

Building the D2 project is anticipated to result in some trips getting diverted from the automobile mode to transit. This will result in a decrease of Vehicle Miles Traveled (VMT) across the region. For this analysis, three different geographic areas were chosen to illustrate the decrease of VMT – the region, the DART Service Area, and the Dallas 360 Plan area. The D2 project will result in a decrease of VMT of 124,400 at the regional level, a decrease of 46,500 across the DART Service Area, and a decrease of 9,600 across the Downtown Dallas area. **Table 8** summarizes the VMT totals for the different geographies between the No Build and D2 Build scenario. As seen, in the Dallas service area, the D2 project has the potential to reduce about 46,500 vehicle miles of travel each weekday. **Table 9** shows the potential reductions in vehicle hours of travel for three different geographic areas. Within the DART service area, the D2 project has the potential to reduce about 1,200 vehicle hours of travel while that reduction is almost three times more at the regional level. Although transit change is minimal as noted in prior sections and LRT ridership drops slightly, VMT is slightly lower due to additional peak service and service to new areas of downtown. As a percentage of total VMT, most benefits are expected within the 360 Plan area where the Project is located. Vehicle hours of congestion delay are also only slightly lower. Both of these changes could be within the margin of error in the model and are not statistically significant. However, regional model data is the only data available at this time.

Table 8 – VMT for No Build and Build Alternatives

Geographic Area	No Build VMT	Build VMT	Reduction in VMT
Region	340,462,600	340,338,200	124,400
DART Service Area	104,800,800	104,754,400	46,500
360 Plan	7,745,900	7,736,300	9,600

Source: HDR Engineering

Table 9 – Vehicle Hours of Congestion Delay for No-Build and Build Alternatives

Geographic Area	No Build Hours	Build D2 Hours	Reduction in Hours
Region	3,244,200	3,240,800	3,400
DART Service Area	1,259,500	1,258,200	1,200
360 Plan	134,400	134,200	250

Source: HDR Engineering

6.2 Air Quality Impacts and Safety Impacts

With the reduction of VMT from the D2 project, there is a corresponding reduction in both vehicle emissions and vehicular related injuries or deaths. These reductions can be monetized through calculating overall air quality benefits and a monetized value of safety.

For the air quality benefits, 5 different emission factors are used to monetize the VMT reduction impact. Various emission factors are based on the total Kilogram per vehicle mile produced. These emission reductions are based on the reduction of Carbon Monoxide (CO), Nitrous Oxide (NOx), Volatile Organic Compounds (VOC), Particulate Matter (PM), Carbon Dioxide (CO2), and Sulphur Dioxide (SO2).

Monetized value of safety impacts are based on a fatality and injury factor that is reduced relative to the reduction of VMT from the D2 project.

Table 10 summarizes the different monetary value impacts for Air Quality and Safety Benefits based on different geographic extents for the D2 project. As noted above, changes in VMT are minor and likely within the margin of error of the model. However, the regional model data is the only source to estimate potential air quality and safety impacts.

Table 10 – Monetized Air Quality and Safety benefits per VMT Reduction

Geography	VMT Reduction	Total Monetized Value of Air Quality Benefits (Daily/Annual)	Total Monetized Value of Safety (Daily/Annual)
Region	124,400	$4,000/$1,220,141	$26,601/$8,113,276
DART	46,500	$1,495/$455,843	$9,938/$3,031,110
Downtown (360)	9,600	$308/$94,089	$2,051/$625,641

Source: www.catf.us/resources/filings/IAQR/CATF_IAQR_Appendices.pdf & https://www.energy.gov/eere/buildings/appliance-and-equipment-standards-program

With a reduction in VMT of 124,400 miles across the region, the monetized value of Air Quality Benefits is $4,000 per day and $1,220,141 annually. The monetized value of safety is $26,601 per day and $8,113,276 annually[1].

With a reduction in VMT of 46,500 miles across the DART Service Area, the monetized value of Air Quality Benefits is $1,495 per day and $455,843 annually. The monetized value of safety is $9,938 per day and $3,031,110 annually.

With a reduction in VMT of 9,600 miles across Downtown Dallas, the monetized value of Air Quality Benefits is $308 per day and $94,089 annually. The monetized value of safety is $2,051 per day and $625,641 annually.

6.3 Conclusion

In conclusion, the D2 Project is anticipated to have beneficial impacts to the regional transportation system by providing sufficient train capacity to address peak demand and by helping to reduce Vehicle Miles Traveled (VMT) and hours of congestion delay. As indicated above, DART conducted a comparison of VMT and hours of congestion delay in year 2045 with and without the proposed Project. Forecasted VMT with the Project in operation results in a reduction of nearly 46,500 daily (or 14.4 million annual) VMT in the DART Service Area. In terms of hours of congestion delay, the Project would save about 1,200 daily hours of congestion; or 366,000 hours of congestion delay per year in the DART service area.

[1] Based on an annualization factor of 305, which is the number normally used in the industry for high level calculations.

Appendix A – No Build

Figure A1: 2045 No Build Red Line Northbound

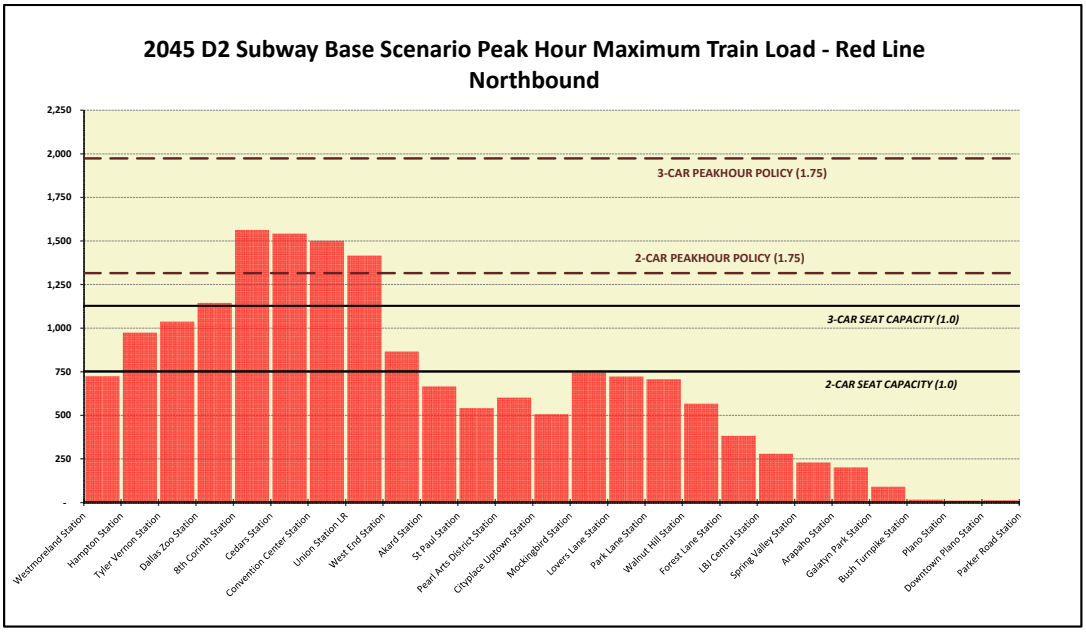


Figure A2: 2045 No Build Red Line Southbound

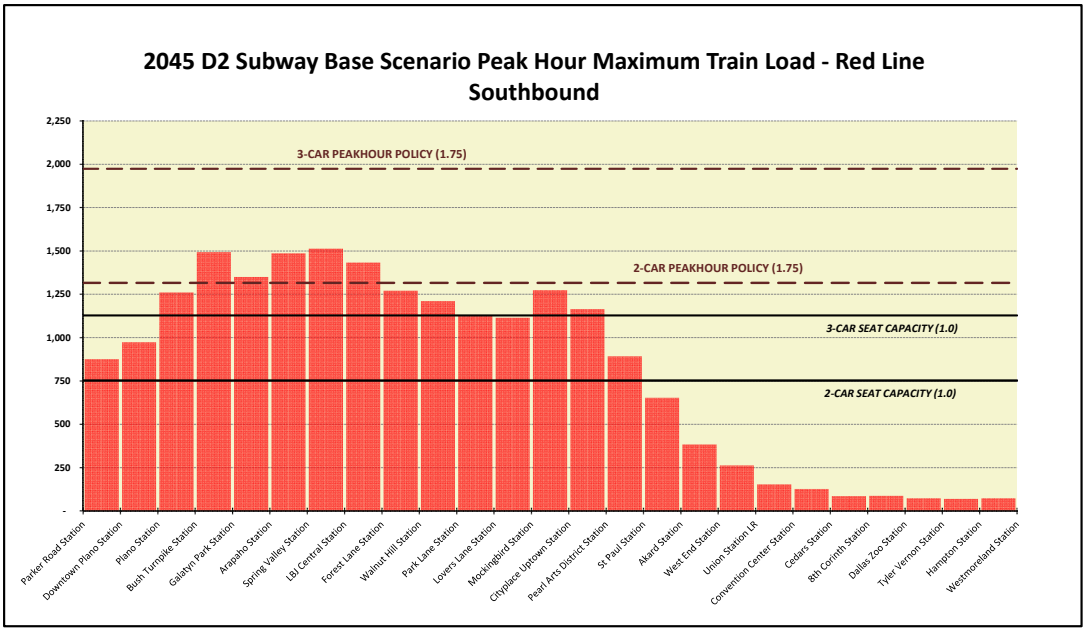


Figure A3: 2045 No Build Blue Line Northbound

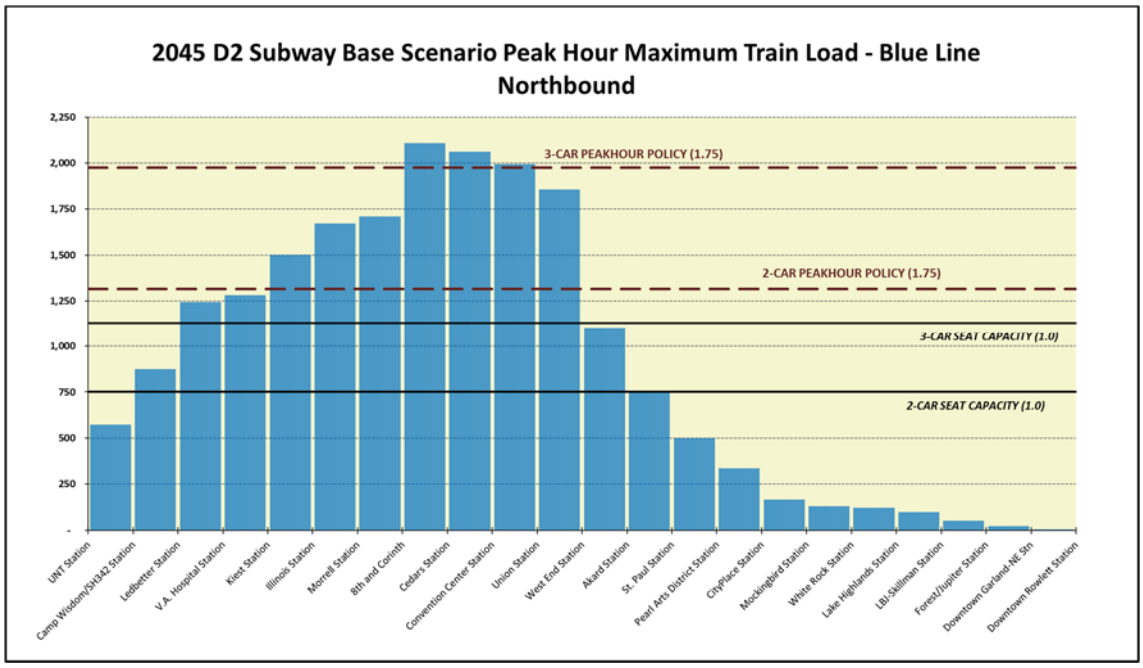


Figure A4: 2045 No Build Blue Line Southbound

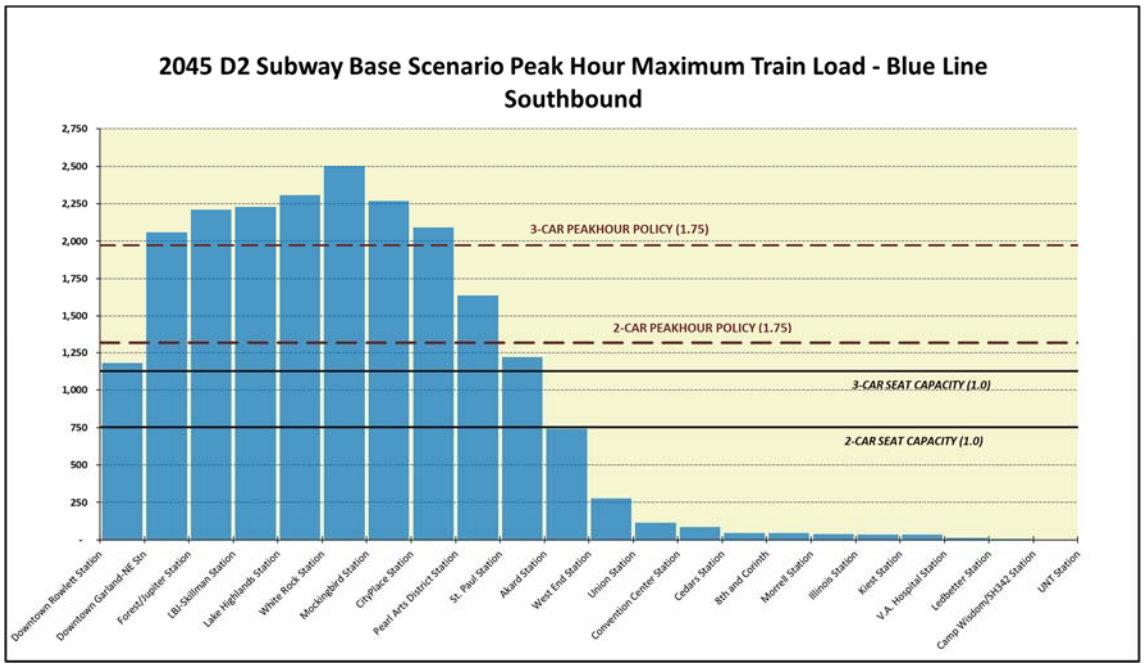


Figure A5: 2045 No Build Green Line Northbound

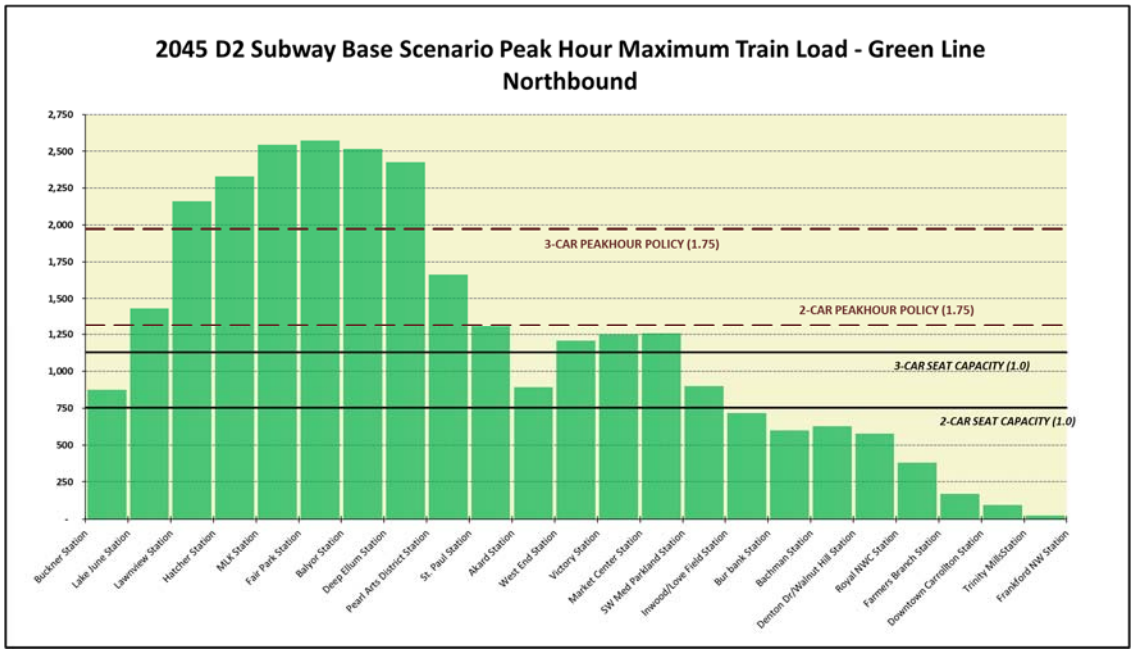


Figure A6: 2045 No Build Green Line Southbound

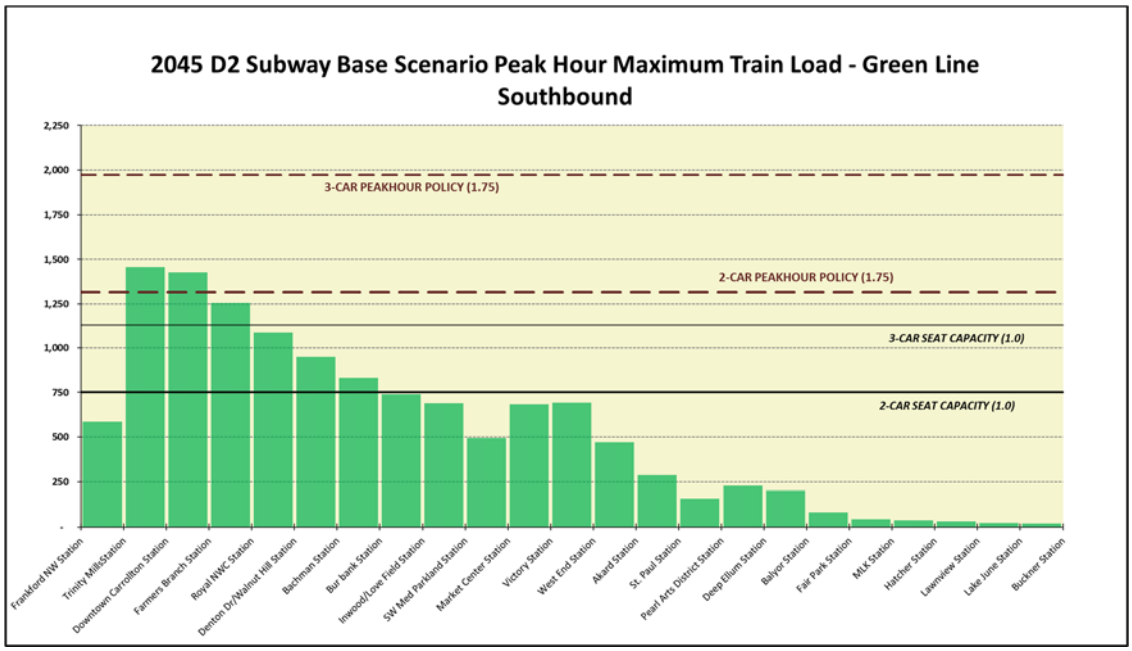


Figure A7: 2045 No Build Orange Line Northbound

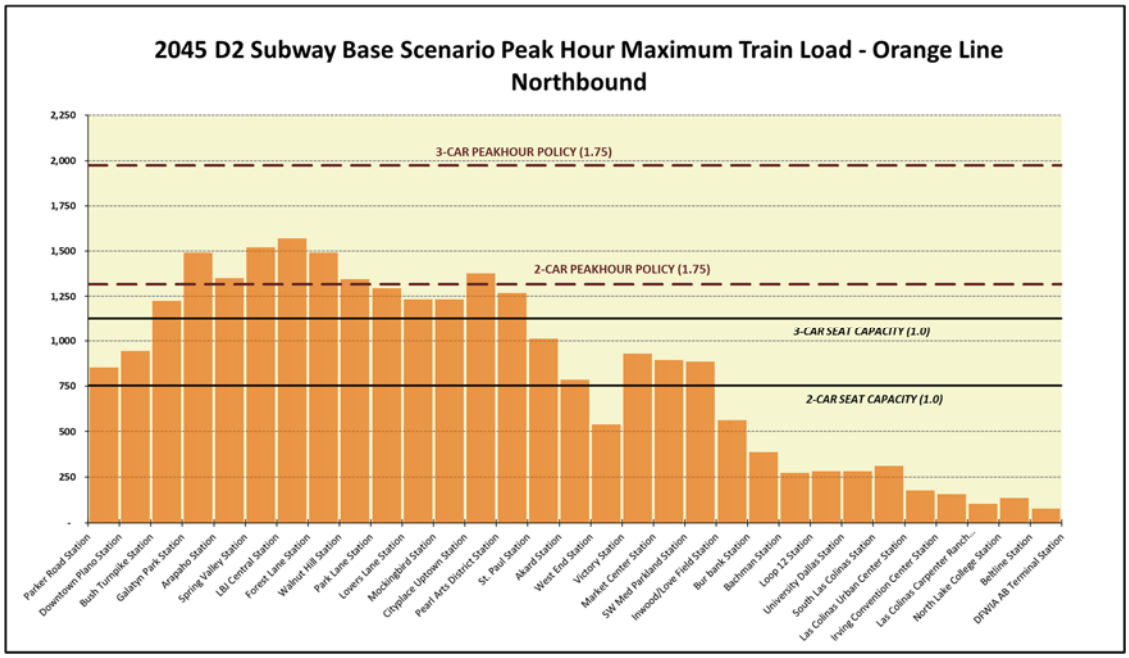
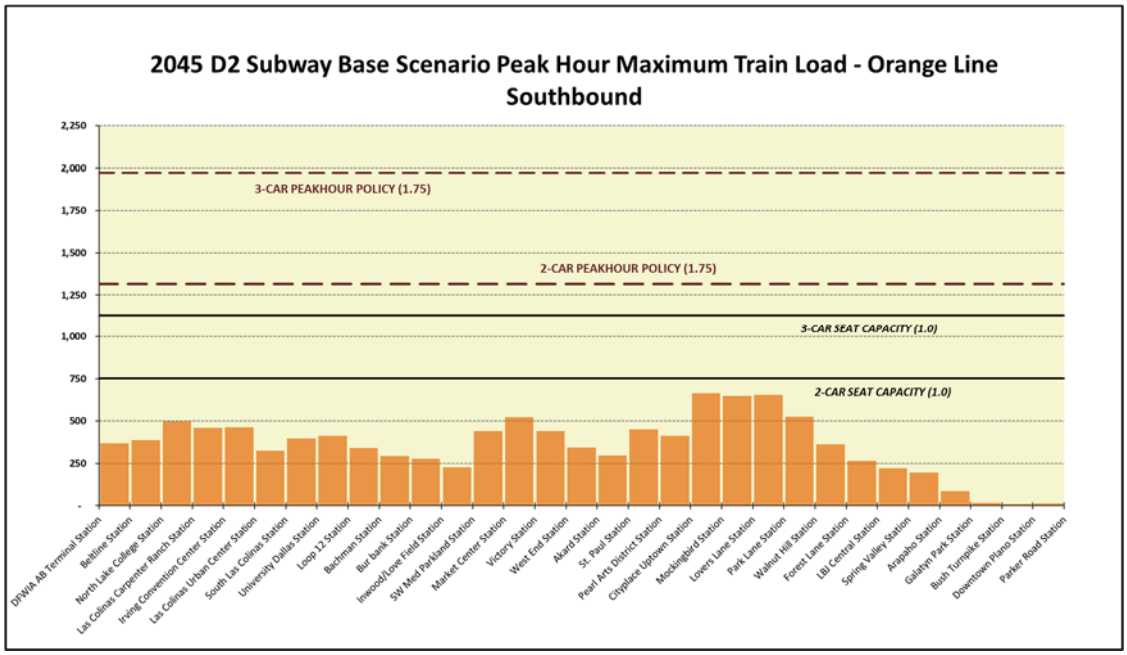


Figure A8: 2045 No Build Orange Line Southbound



Appendix B – Regional Rail Expansion

Figure B1: 2045 Regional Rail Expansion Red Line Northbound

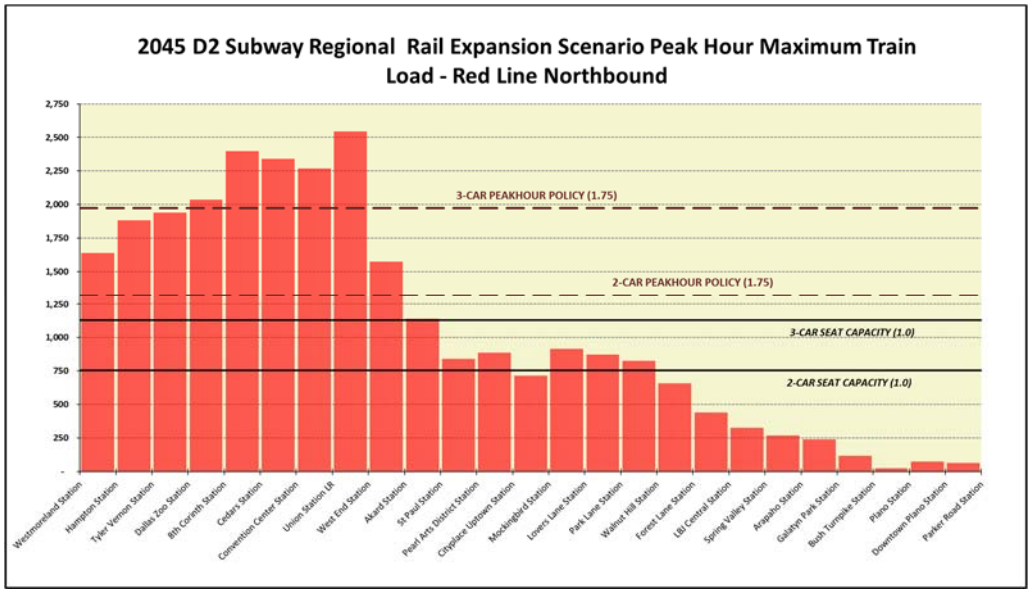


Figure B2: 2045 Regional Rail Expansion Red Line Southbound

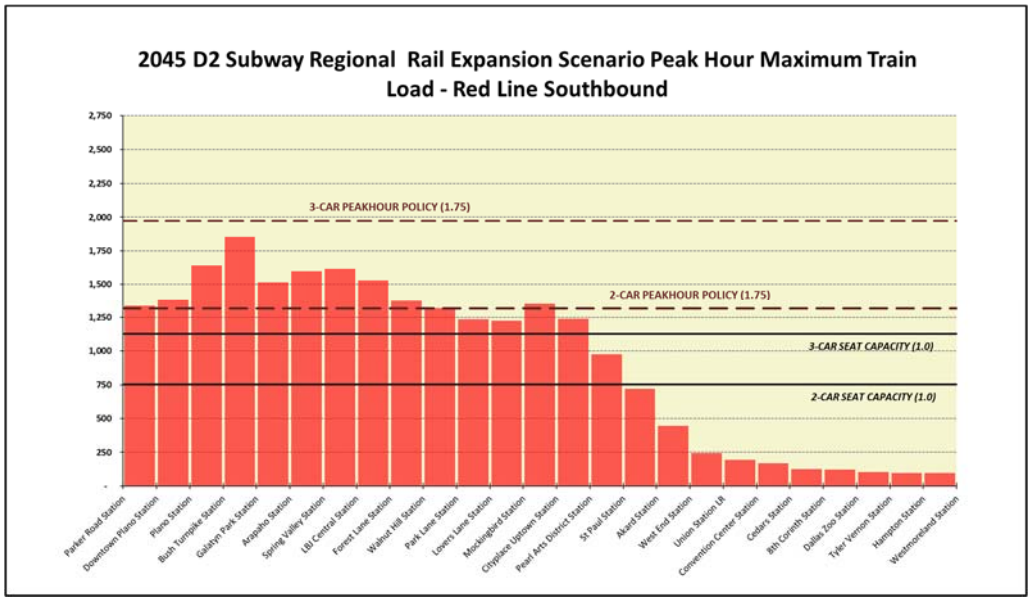


Figure B3: 2045 Regional Rail Expansion Blue Line Northbound

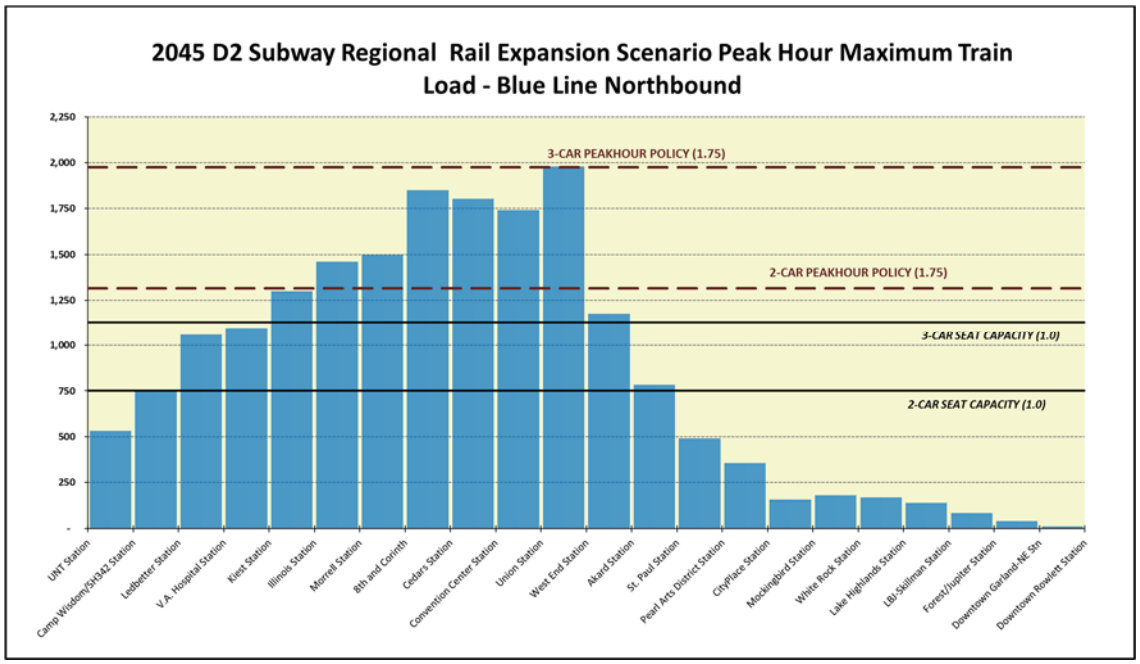


Figure B4: 2045 Regional Rail Expansion Blue Line Southbound

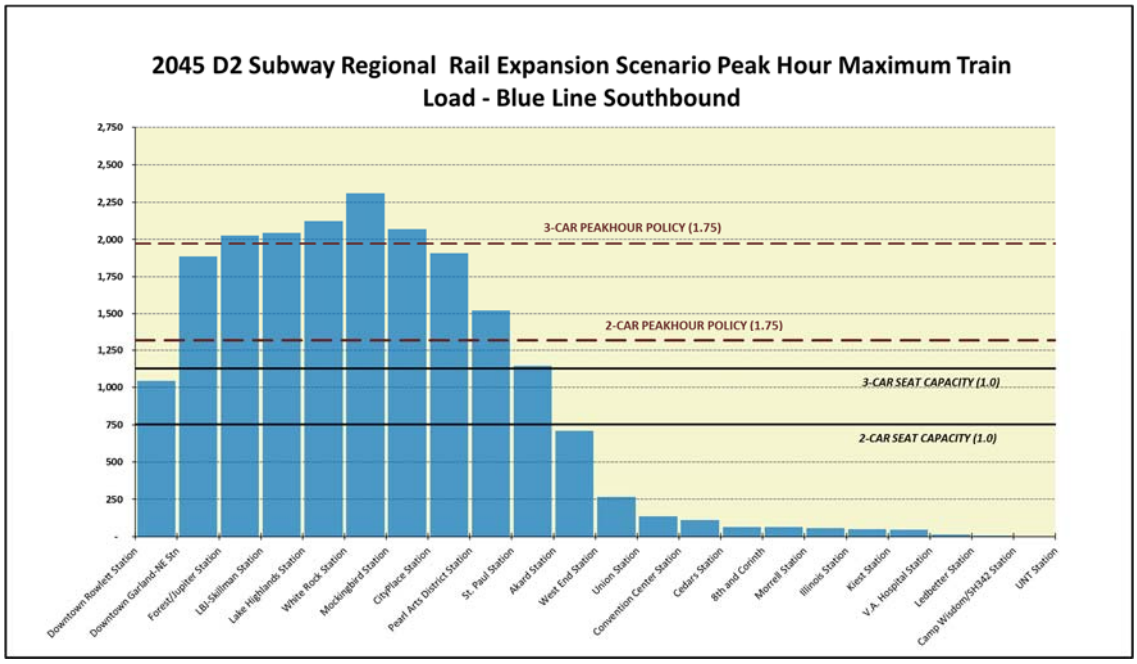


Figure B5: 2045 Regional Rail Expansion Green Line Northbound

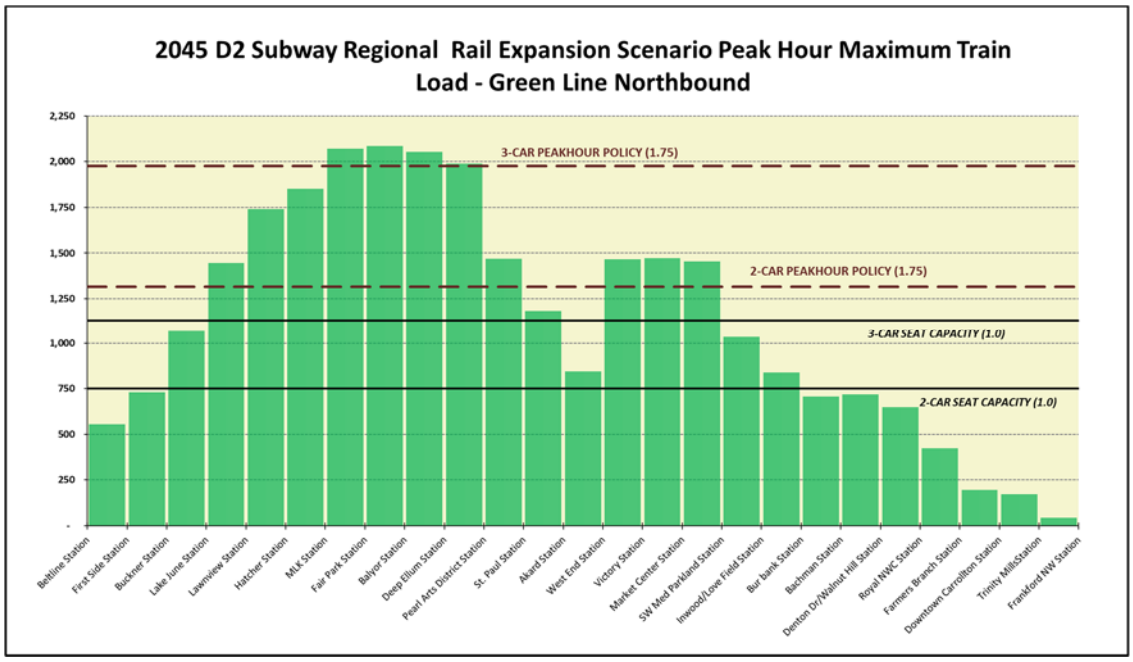


Figure B6: 2045 Regional Rail Expansion Green Line Southbound

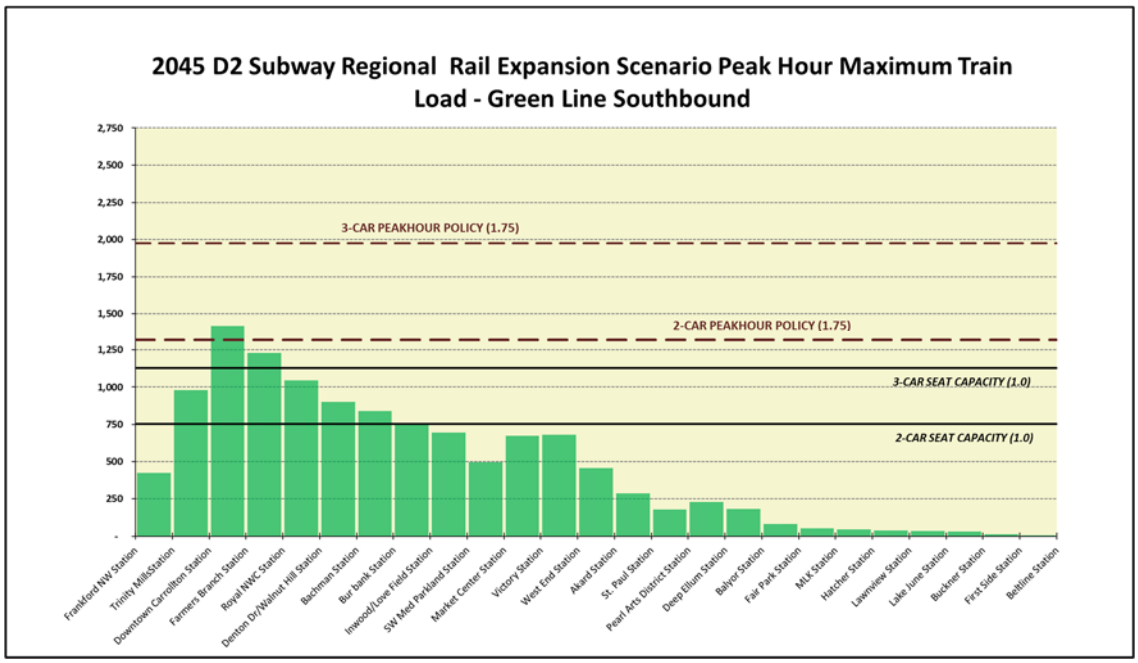


Figure B7: 2045 Regional Rail Expansion Orange Line Northbound

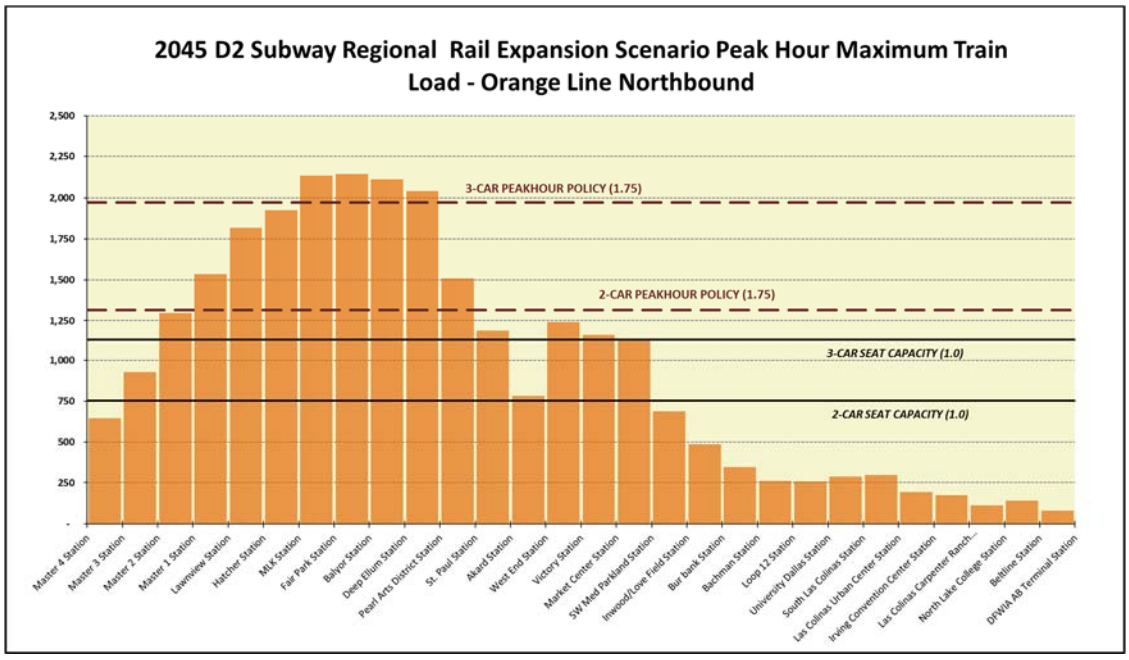
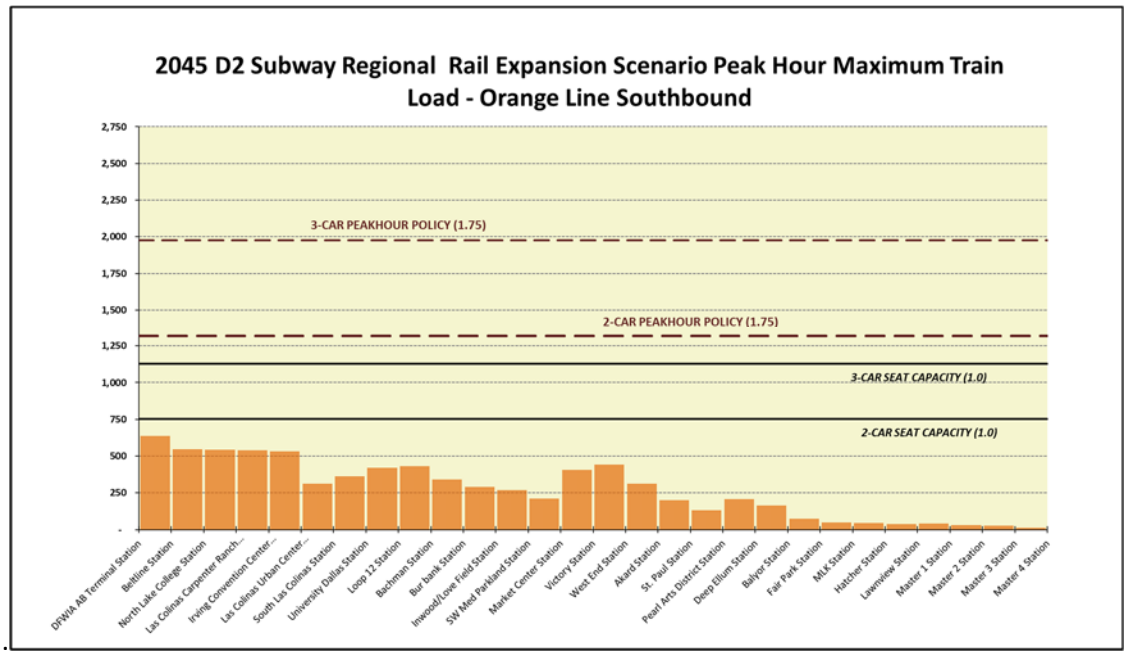


Figure B8: 2045 Regional Rail Expansion Orange Line Southbound



Appendix C – Enhanced Headways

Figure C1: 2045 Enhanced LRT Red Line Northbound

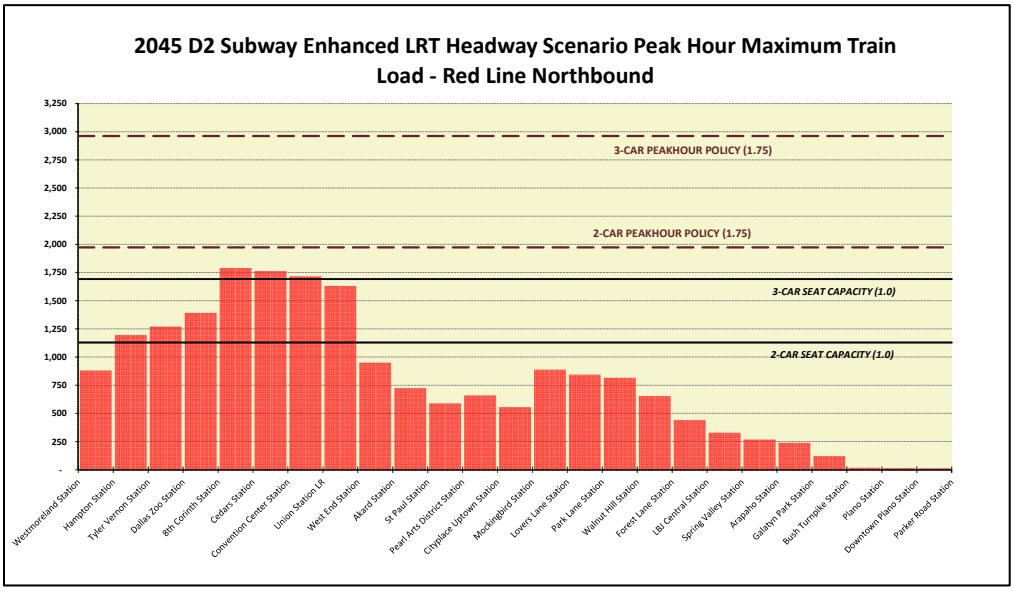


Figure C2: 2045 Enhanced LRT Red Line Southbound

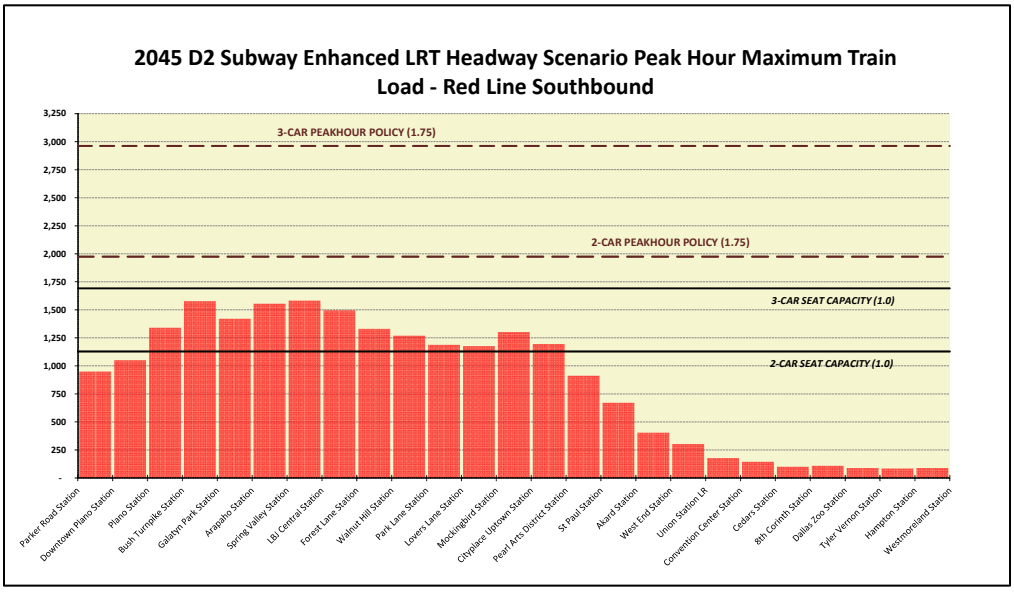


Figure C3: 2045 Enhanced LRT Blue Line Northbound

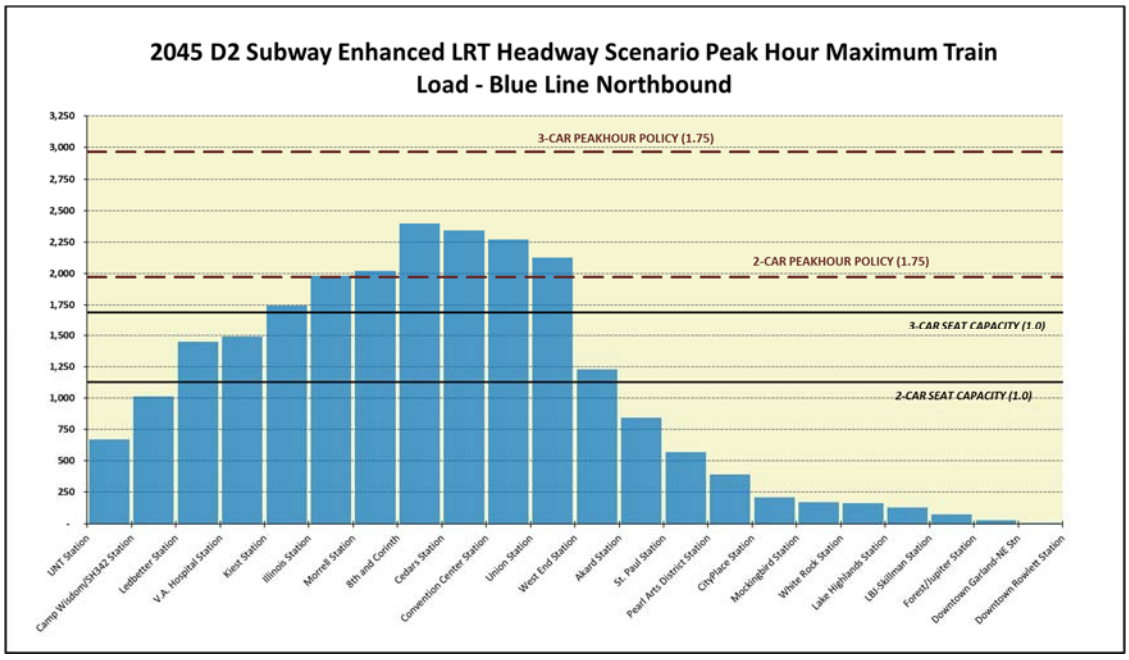


Figure C4: 2045 Enhanced LRT Blue Line Southbound

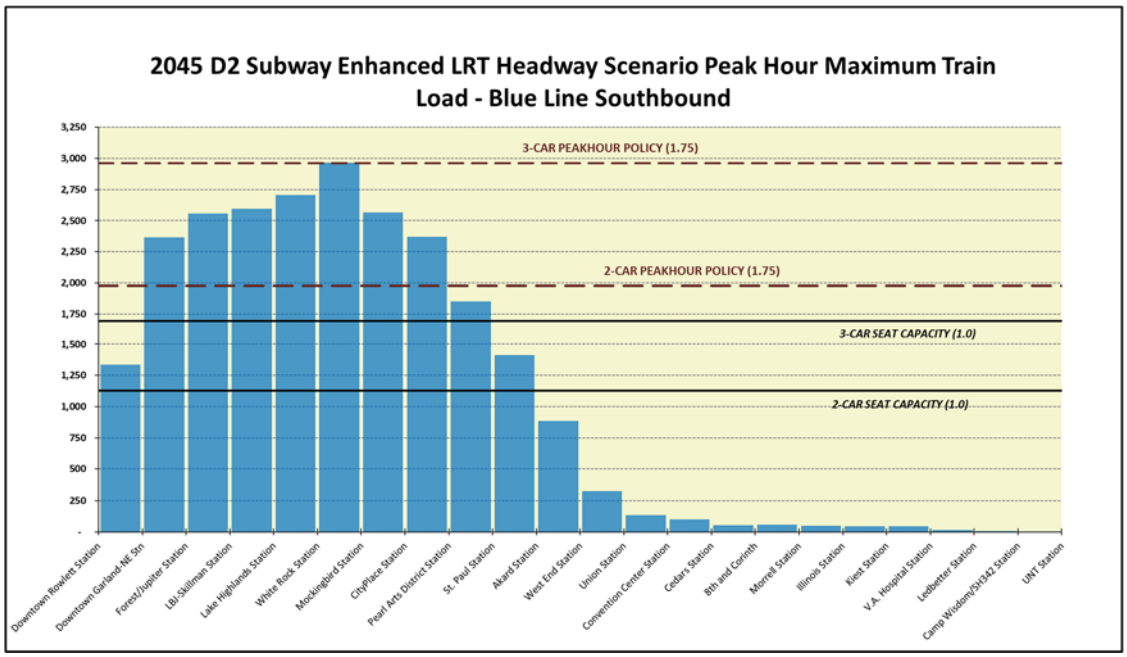


Figure C5: 2045 Enhanced LRT Green Line Northbound

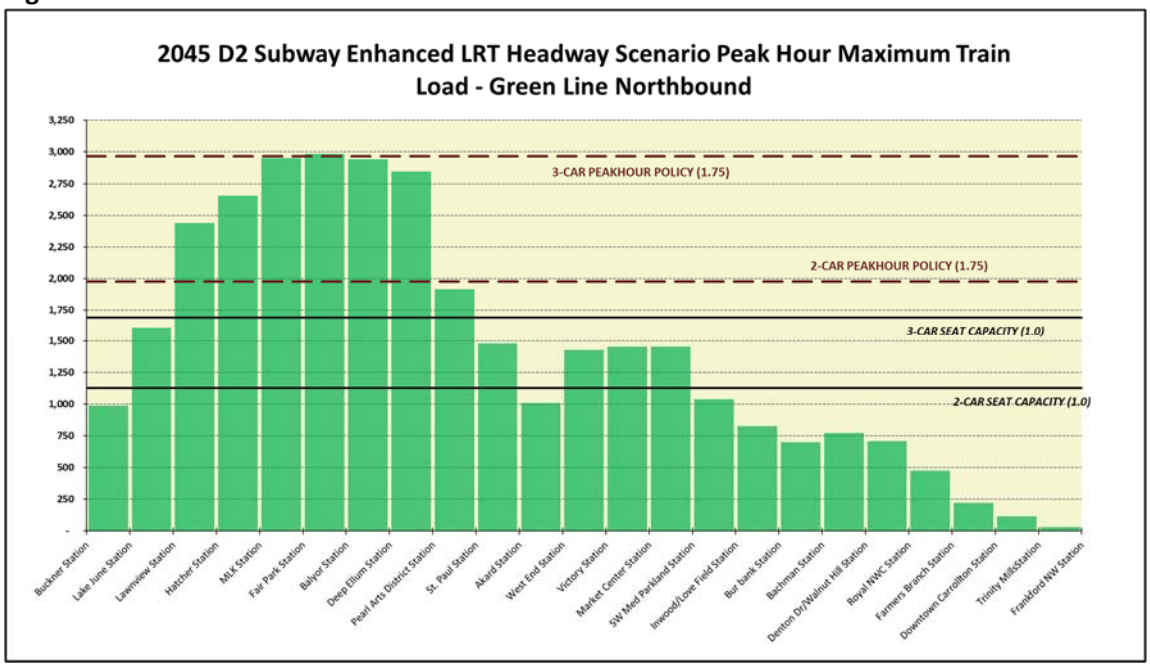


Figure C6: 2045 Enhanced LRT Green Line Southbound

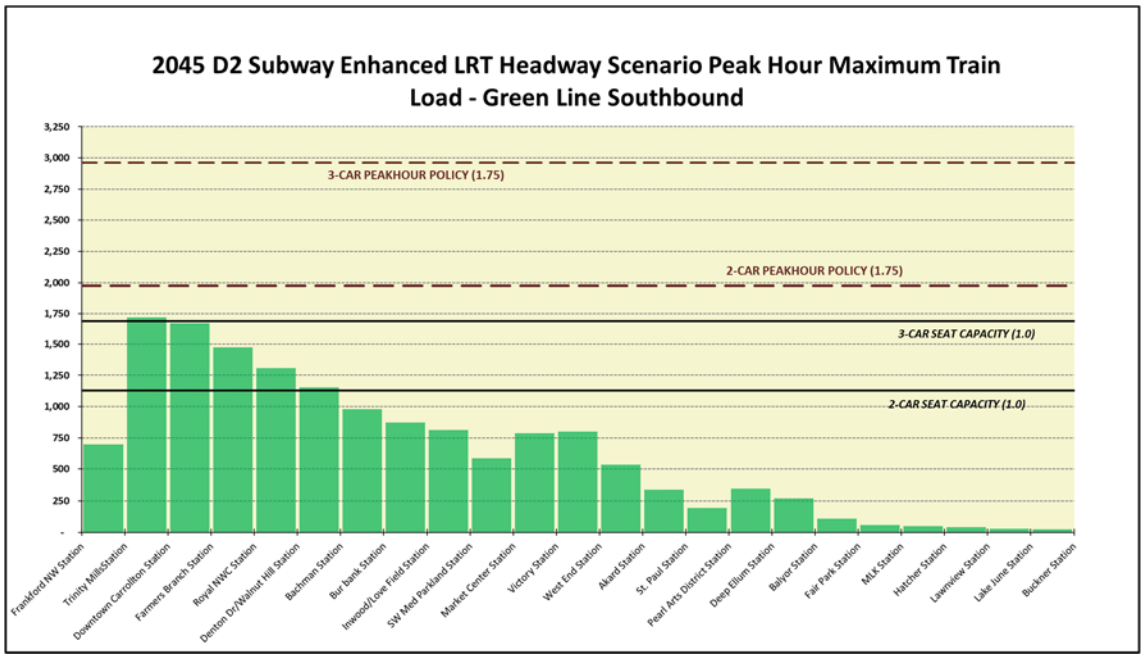


Figure C7: 2045 Enhanced LRT Orange Line Northbound

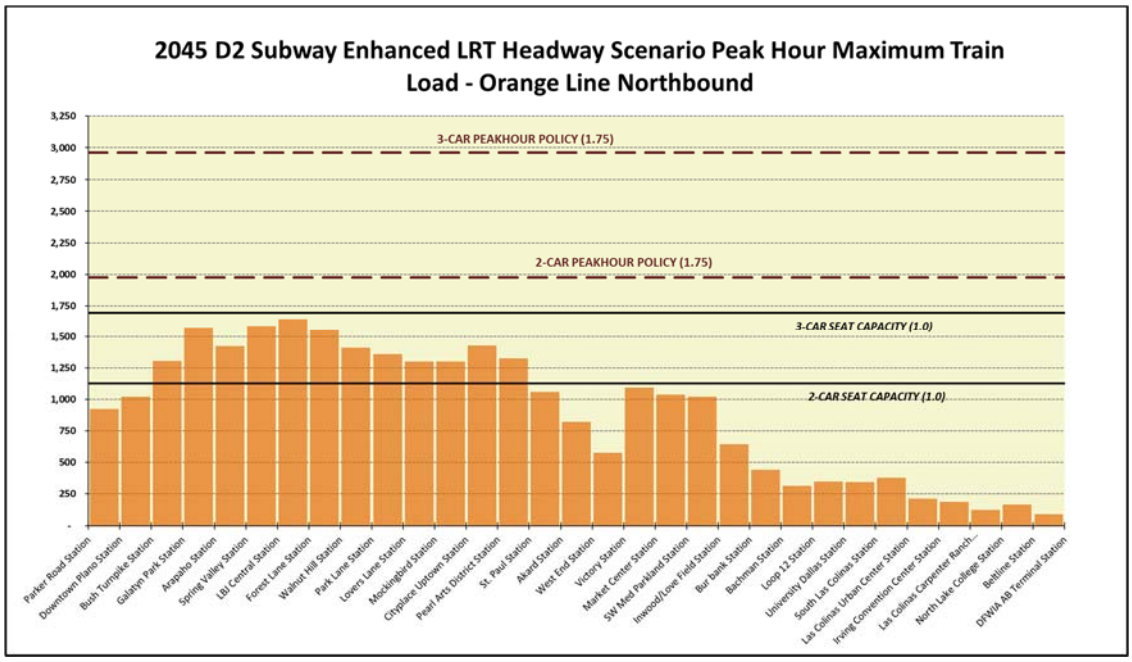
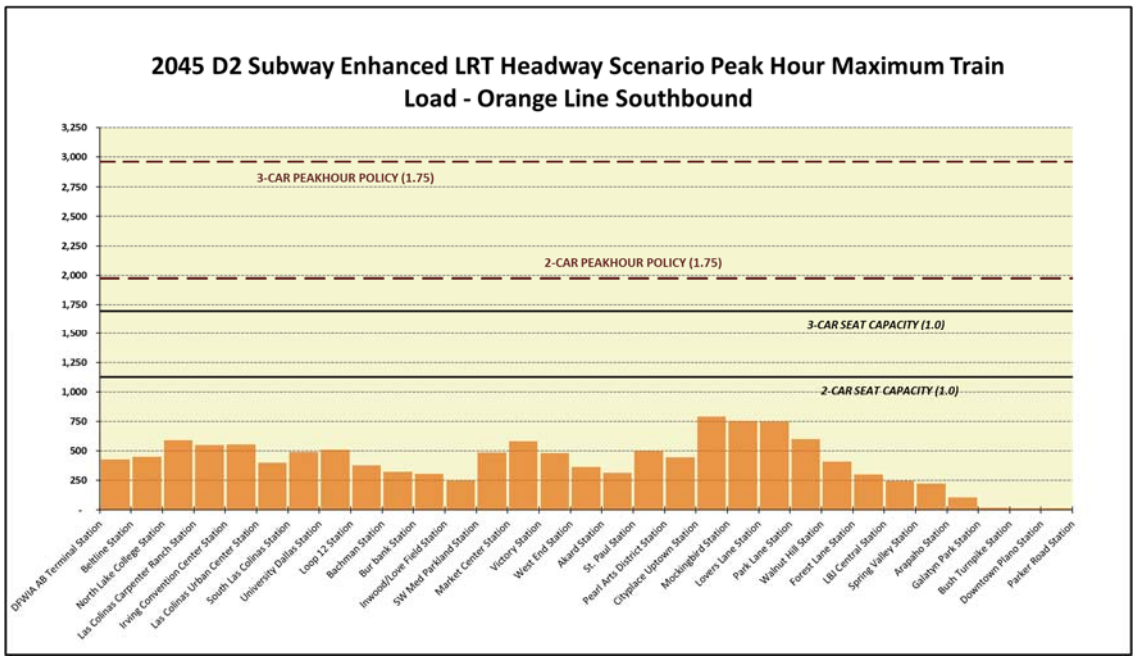


Figure C8: 2045 Enhanced LRT Orange Line Southbound



Appendix D –Mode of Access Data

Table D1 Mode of Access to LRT at CBD Stations

BLD with Red insert	WALK	DRIVE	DCTA	FWTA	DART CBD	DART FEEDER	APM	FWTA EXP	DART EXP	DCTA EXP	LRT	CRT	SC	TOTAL
Victory Station	1,216	0	0	0	121	18	12	0	7	0	1,991	1,986	1	5,353
Museum Way Station	886	0	0	0	371	0	81	0	0	0	35	0	1	1,374
Convention Center Station	672	0	0	0	2	0	0	0	1	0	17	0	0	691
Union Station	1,756	0	0	0	205	0	0	0	77	0	864	862	26	3,790
West End Station	2,924	0	0	0	1,263	73	0	0	0	0	1,804	0	0	6,065
Metro Center Station	2,997	0	0	0	786	0	0	0	7	0	1,856	0	0	5,645
Akard Station	3,904	0	0	0	225	0	0	0	12	0	50	0	0	4,192
City Center/Ervay Station	3,123	0	0	0	559	0	0	0	57	0	16	0	0	3,755
St. Paul Station	3,125	0	0	0	121	0	1	0	4	0	7	0	2	3,260
Pearl/Arts District Station	2,849	0	0	0	221	0	10	0	171	0	143	0	0	3,395
CBD East Station	1,935	0	0	0	738	0	14	0	13	0	1,680	0	0	4,380
LIVE OAK STATION	433	0	0	0	35	0	0	0	0	0	0	0	0	468
Baylor University Medical Center St	885	0	0	0	125	0	0	0	0	0	0	0	0	1,010
Total	**26,707**	**0**	**0**	**0**	**4,771**	**91**	**119**	**0**	**348**	**0**	**8,463**	**2,848**	**30**	**43,377**

Source: DART

Mode of Access	Mode of Access Definition
Walk	Walk
Drive	Drive
DCTA	Denton County Transit Authority
FWTA	Fort Worth Transit Authority (Trinity Metro)
DART CBD	DART Local Busses that serve the Central Business District
DART FEEDER	500 series DART Busses that serve the rail stations
APM	DFW APM, Las Colinas AMP, and the McKinney Ave Trolley
FWTA EXP	FWTA (Trinity Metro) Express Buses
DART EXP	DART Express Buses
DCTA EXP	DCTA Express Buses

Source: DART