Appendix B

Greenway Rail Travel Time and Train Meet Analysis Memorandum

Date: July 31, 2013 (updated October 18, 2013)

To: Mona Elabaddy, Liz Heyman

From: Susan Rosales, Jim Baker

Re: Midtown Corridor Rail Operating Plan Analysis

This memo presents results from an analysis of rail travel times, scheduling and train meets for the Midtown Corridor Alternatives Analysis. The rail alignment that has been analyzed is in the Midtown Greenway, between the proposed West Lake Station on the Southwest LRT Green Line extension, and the existing Midtown Station on the existing LRT Blue Line.

Rail Travel Time Estimates

Station-to-station travel time estimates were developed with alignment drawings provided by Kimley-Horn (alignment drawing file "MG_TRACK_ALIGNMENT 8-16-13"). These drawings identify current proposed locations for stations, and track configuration (single track vs. double track). The drawings do not yet provide stationing or alignment curve radii.

Key assumptions used to generate travel time estimates are as follows:

- Rail vehicle acceleration and deceleration rates are 2.5 mphps
- Station dwell times are 20 seconds
- A maximum operating speed of 45 mph has been assumed
- For segments with at-grade street crossings, a maximum operating speed of 30 mph has been assumed
- A 20 mph speed has been assumed at switch locations between single and double track
- The reduction in speed through switches is presently only assumed for eastbound trains
- Speeds have been reduced at some locations where there are significant alignment curves (e.g., the approach into Midtown Station)

Travel time estimates have been generated for both directions of travel. The first set of travel times, presented in Exhibits 1a and 1b at the end of this memo, reflect streetcar travel times for the alignment drawings referenced above, with two single track segments (between West Lake and Calhoun Beach, and east of the Bloomington Avenue Station). The second set of travel time estimates, presented in Exhibits 2a and 2b, reflect a travel time estimate for a scenario where the entire alignment is double-tracked. Table 1, shown below, presents a summary of the travel time estimates. Speed reductions into and out of single track segments have a minimal impact on the overall travel time estimate.

Table 1
Midtown Greenway Rail
Travel Time Estimates (Preliminary – not including layover)

Direction	w/ Single Track Segments	All Double Track
Eastbound	12:57	12:37
Westbound	12:55	12:39
Total	**25:52**	**25:16**

Train Meet Analysis: 10-minute Frequencies

An example train schedule was developed with the travel times presented in Exhibits 1 and 2 to determine how train meets can be scheduled to avoid single track segments. End-of-line dwell/layover times were adjusted to move scheduled train meets to optimal locations. It was determined that a 10.5-minute layover at Midtown Station produces the best scenario for scheduled train meets. Thus, a train is scheduled to leave Midtown station as soon as an inbound train has arrived. This produces train meets at the 5th Avenue Station, and just west of Hennepin Avenue.

Exhibit 3 presents a stringline analysis for 10-minute frequencies. Blue, red, green and orange lines follow the four individual trains where eastbound train movements are read left to right, and westbound train movements are read right to left. Shaded pink areas represent areas where single track is proposed.

At West Lake Station, there would be 4:18 of time available for dwell/recovery time, resulting in a 40-minute cycle time. It is important to note, however, that the travel times used in this analysis are very preliminary and subject to change as more detailed alignment drawings are developed. Further, the train movements illustrated in Exhibit 3 represent *scheduled* train movements. Station dwell times vary, thus trains will not always be operating on-schedule. Thus, it may be necessary to add a fifth train and operate a 50-minute cycle time. A fifth train would result in a 14:18 dwell/recovery time at West Lake Station.

Train Meet Analysis: 7.5 and 15-minute Frequencies

Train schedules were also developed for 7.5 and 15-minute frequency scenarios, to determine how those frequencies impact train meet locations. Exhibits 4 and 5 present the stringline diagrams for these two scenarios. The 7.5-minute scenario produces three meets along the alignment: east of Chicago Avenue, west of Nicolette Avenue and east of Calhoun Beach. The proposed cycle time is 45-minutes, thus requiring six trains. There would be 11-minutes of layover at West Lake and 8:48 minutes of layover at Midtown Station.

The fifteen-minute scenario produces one train meet along the alignment: west of Nicollet Avenue. The proposed cycle time is 45-minutes, thus requiring three trains. There would be 4-minutes of layover at West Lake and 15:48 minutes of layover at Midtown Station.

Exhibit 1A
Single Track Scenario – Eastbound Travel Times

MIDTOWN CORRIDOR ALTERNATIVES ANALYSIS
RUN TIME ESTIMATE WORKBOOK
Greenway Streetcar
Eastbound Run Time Estimate (assumes single track segments per 8/16/13 alignment drawings without Lyndale or W of Bloomington Single Track Sections)

Sta. No.	Intersection/Station	Coded Speed	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)	Time Between Stations
1	**West Lake Station**			**0.00**		**0:00:00**	**0:00:00**	
		15	0.10		0:00:27			
	Start single track under Lake St. Bridge (15 mph)			0.10			**0:00:27**	
		45	0.30		0:00:30			
	Dean Parkway Bridge			0.40			**0:00:57**	
		40	0.08		0:00:09			
	End single track west of Thomas Ave. (20 mph)			0.48			**0:01:06**	
		20	0.05		0:00:13			
2	**Calhoun Beach Station (at-grade)**			**0.53**		**0:00:20**	**0:01:39**	**0:01:39**
		45	0.38		0:00:41			
	Channel Bridge			0.91			**0:02:20**	
		45	0.08		0:00:07			
	East Calhoun Pkwy Bridge			0.99			**0:02:27**	
	James, Irving, Humboldt at-grade crossings	30	0.30		0:00:42			
3	**Hennepin Ave Station**			**1.29**		**0:00:20**	**0:03:29**	**0:01:50**
		45	0.51		0:01:00			
4	**Lyndale Ave S Station**			**1.80**		**0:00:20**	**0:04:49**	**0:01:20**
		45	0.50		0:00:59			
5	**Nicollet Ave Station**			**2.30**		**0:00:20**	**0:06:08**	**0:01:19**
		30	0.13		0:00:28			
6	**I-35W/Stevens Ave Station**			**2.43**		**0:00:20**	**0:06:56**	**0:00:48**
		40	0.31		0:00:45			
7	**5th Ave S Station (at-grade)**			**2.74**		**0:00:20**	**0:08:01**	**0:01:05**
		45	0.34		0:00:47			
8	**Chicago Ave S Station**			**3.08**		**0:00:20**	**0:09:08**	**0:01:07**
		45	0.50		0:00:59			
9	**Bloomington Ave Station**			**3.58**		**0:00:20**	**0:10:27**	**0:01:19**
		20	0.06		0:00:15			
	Start single track e of Bloomington Ave (20 mph)			3.64			**0:10:42**	
		35	0.27		0:00:31			
	Start curve at approach to 20th Ave S			3.91			**0:11:13**	
		20	0.11		0:00:20			
	20th Ave S (at-grade)			4.02			**0:11:33**	
		25	0.04		0:00:06			
	21st Ave S (at-grade)			4.06			**0:11:39**	
		20	0.10		0:00:18			
	End curve east of 21st Ave S			4.16			**0:11:57**	
		20	0.14		0:00:25			
	End single track n of Midtown Station (20 mph)			4.30			**0:12:22**	
		15	0.05		0:00:15			
10	**Midtown Station (at-grade)**			**4.35**		**0:00:20**	**0:12:57**	**0:02:30**
Totals	**Totals**			**4.35**	**0:09:57**	**0:03:00**	**0:12:57**	**0:12:57**
						Avg. Speed (mph):	**20.15**	

Exhibit 1b
Single Track Scenario – Westbound Travel Times

MIDTOWN CORRIDOR ALTERNATIVES ANALYSIS
RUN TIME ESTIMATE WORKBOOK
Greenway Streetcar
Westbound Run Time Estimate (assumes single track segments per 8/16/13 alignment drawings)
without Lyndale or W of Bloomington Single Track Sections)

Sta. No.	Intersection/Station	Coded Speed	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)	Time Between Stations
10	**Midtown Station (at-grade)**			**0.00**		**0:00:00**	**0:00:00**	
		15	0.05		0:00:15			
	Start single track n of Midtown station (15 mph)			0.05			**0:00:15**	
		20	0.14		0:00:25			
	Start curve at approach to 21st Ave S			0.19			**0:00:40**	
		20	0.10		0:00:18			
	21st Ave S (at-grade)			0.29			**0:00:58**	
		25	0.04		0:00:06			
	20th Ave S (at-grade)			0.33			**0:01:04**	
		20	0.11		0:00:20			
	End curve west of 20th Ave S			0.44			**0:01:24**	
		30	0.27		0:00:33			
	End single track e of Bloomington Ave			0.71			**0:01:57**	
		30	0.06		0:00:13			
9	**Bloomington Ave Station**			**0.77**		**0:00:20**	**0:02:30**	**0:02:30**
		45	0.50		0:00:59			
8	**Chicago Ave S Station**			**1.27**		**0:00:20**	**0:03:49**	**0:01:19**
		45	0.34		0:00:47			
7	**5th Ave S Station (at-grade)**			**1.61**		**0:00:20**	**0:04:56**	**0:01:07**
		40	0.31		0:00:45			
6	**I-35W/Stevens Ave Station**			**1.92**		**0:00:20**	**0:06:01**	**0:01:05**
		30	0.13		0:00:28			
5	**Nicollet Ave Station**			**2.05**		**0:00:20**	**0:06:49**	**0:00:48**
		45	0.50		0:00:59			
4	**Lyndale Ave S Station**			**2.55**		**0:00:20**	**0:08:08**	**0:01:19**
		45	0.51		0:01:00			
3	**Hennepin Ave Station**			**3.06**		**0:00:20**	**0:09:28**	**0:01:20**
	Humboldt, Irving, James at-grade crossings	30	0.30		0:00:42			
	East Calhoun Pkwy Bridge			3.36			**0:10:10**	
		40	0.08		0:00:08			
	Channel Bridge			3.44			**0:10:18**	
		45	0.38		0:00:40			
2	**Calhoun Beach Station (at-grade)**			**3.82**		**0:00:20**	**0:11:18**	**0:01:50**
		25	0.05		0:00:12			
	Start single track w of Thomas Ave			3.87			**0:11:30**	
		35	0.08		0:00:09			
	Dean Parkway Bridge			3.95			**0:11:39**	
		45	0.30		0:00:29			
	End single track under Lake St Bridge			4.25			**0:12:08**	
		15	0.10		0:00:27			
1	**West Lake Station**			**4.35**		**0:00:20**	**0:12:55**	**0:01:37**
Totals	**Totals**			**4.35**	**0:09:55**	**0:03:00**	**0:12:55**	**0:12:55**
						Avg. Speed (mph):	**20.21**	

Exhibit 2a
Double Track Scenario – Eastbound Travel Times

MIDTOWN CORRIDOR ALTERNATIVES ANALYSIS
RUN TIME ESTIMATE WORKBOOK
Greenway Streetcar
Eastbound Run Time Estimate (assumes full line is double-tracked)

Sta. No.	Intersection/Station	Coded Speed	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)	Time Between Stations
1	**West Lake Station**			**0.00**		**0:00:00**	**0:00:00**	
		45	0.40		0:00:42			
	Dean Parkway Bridge			0.40			**0:00:42**	
		45	0.13		0:00:19			
2	**Calhoun Beach Station (at-grade)**			**0.53**		**0:00:20**	**0:01:21**	**0:01:21**
		45	0.38		0:00:41			
	Channel Bridge			0.91			**0:02:02**	
		45	0.08		0:00:07			
	East Calhoun Pkwy Bridge			0.99			**0:02:09**	
	James, Irving, Humboldt at-grade crossings	30	0.30		0:00:42			
3	**Hennepin Ave Station**			**1.29**		**0:00:20**	**0:03:11**	**0:01:50**
		45	0.51		0:01:00			
4	**Lyndale Ave S Station**			**1.80**		**0:00:20**	**0:04:31**	**0:01:20**
		45	0.50		0:00:59			
5	**Nicollet Ave Station**			**2.30**		**0:00:20**	**0:05:50**	**0:01:19**
		30	0.13		0:00:28			
6	**I-35W/Stevens Ave Station**			**2.43**		**0:00:20**	**0:06:38**	**0:00:48**
		40	0.31		0:00:45			
7	**5th Ave S Station (at-grade)**			**2.74**		**0:00:20**	**0:07:43**	**0:01:05**
		45	0.34		0:00:47			
8	**Chicago Ave S Station**			**3.08**		**0:00:20**	**0:08:50**	**0:01:07**
		45	0.50		0:00:59			
9	**Bloomington Ave Station**			**3.58**		**0:00:20**	**0:10:09**	**0:01:19**
		45	0.26		0:00:32			
	Cedar Ave overpass			3.84			**0:10:41**	
		35	0.19		0:00:20			
	20th Ave S (at-grade)			4.03			**0:11:01**	
		30	0.04		0:00:06			
	21st Ave S (at-grade)			4.07			**0:11:07**	
	Cuve, station approach	15	0.28		0:01:10			
10	**Midtown Station (at-grade)**			**4.35**		**0:00:20**	**0:12:37**	**0:02:28**
Totals	**Totals**			**4.35**	**0:09:37**	**0:03:00**	**0:12:37**	**0:12:37**
						Avg. Speed (mph):	**20.69**	

Exhibit 2b
Double Track Scenario – Westbound Travel Times

MIDTOWN CORRIDOR ALTERNATIVES ANALYSIS
RUN TIME ESTIMATE WORKBOOK
Greenway Streetcar
Westbound Run Time Estimate (assumes full line is double-tracked)

Sta. No.	Intersection/Station	Coded Speed	Distance [mi]	Total Distance	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Total Time (hr:min:sec)	Time Between Stations
10	**Midtown Station (at-grade)**			**0.00**		**0:00:00**	**0:00:00**	
	curve, station approach	15	0.28		0:01:10			
	21st Ave S (at-grade)			0.28		0:00:00	**0:01:10**	
		25	0.04		0:00:07			
	20th Ave S (at-grade)			0.32		0:00:00	**0:01:17**	
		35	0.19		0:00:20			
	Cedar Ave overpass			0.51		0:00:00	**0:01:37**	
		45	0.26		0:00:31			
9	**Bloomington Ave Station**			**0.77**		**0:00:00**	**0:02:28**	**0:02:28**
		45	0.50		0:00:59			
8	**Chicago Ave S Station**			**1.27**		**0:00:00**	**0:03:47**	**0:01:19**
		45	0.34		0:00:47			
7	**5th Ave S Station (at-grade)**			**1.61**		**0:00:00**	**0:04:54**	**0:01:07**
		40	0.31		0:00:45			
6	**I-35W/Stevens Ave Station**			**1.92**		**0:00:00**	**0:05:59**	**0:01:05**
		30	0.13		0:00:28			
5	**Nicollet Ave Station**			**2.05**		**0:00:00**	**0:06:47**	**0:00:48**
		45	0.50		0:00:59			
4	**Lyndale Ave S Station**			**2.55**		**0:00:00**	**0:08:06**	**0:01:19**
		45	0.51		0:01:00			
3	**Hennepin Ave Station**			**3.06**		**0:00:00**	**0:09:26**	**0:01:20**
	Humboldt, Irving, James at-grade crossings	30	0.30		0:00:42			
	East Calhoun Pkwy Bridge			3.36		0:00:00	**0:10:08**	
		40	0.08		0:00:08			
	Channel Bridge			3.44		0:00:00	**0:10:16**	
		45	0.38		0:00:40			
2	**Calhoun Beach Station (at-grade)**			**3.82**		**0:00:00**	**0:11:16**	**0:01:50**
		35	0.13		0:00:21			
	Dean Parkway Bridge			3.95		0:00:00	**0:11:37**	
		45	0.40		0:00:42			
1	**West Lake Station**			**4.35**		**0:00:00**	**0:12:39**	**0:01:23**
Totals	**Totals**			**4.35**	**0:09:39**	**0:00:00**	**0:12:39** **20.63**	**0:12:39**

Exhibit 3:
String Line Diagram for Single Track Operations
10-minute Frequencies

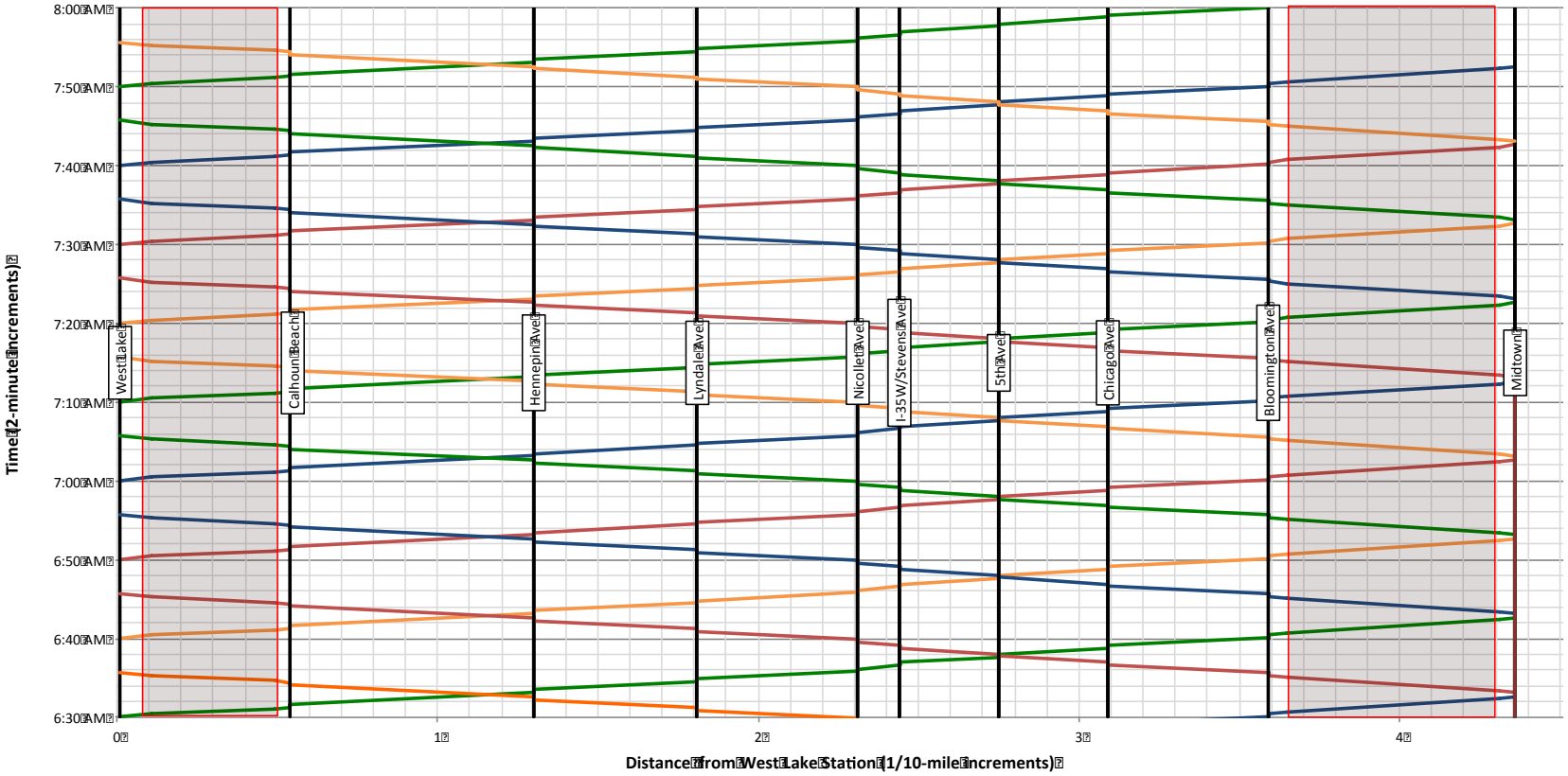

Exhibit 4:
String Line Diagram for Single Track Operations
7.5-minute Frequencies

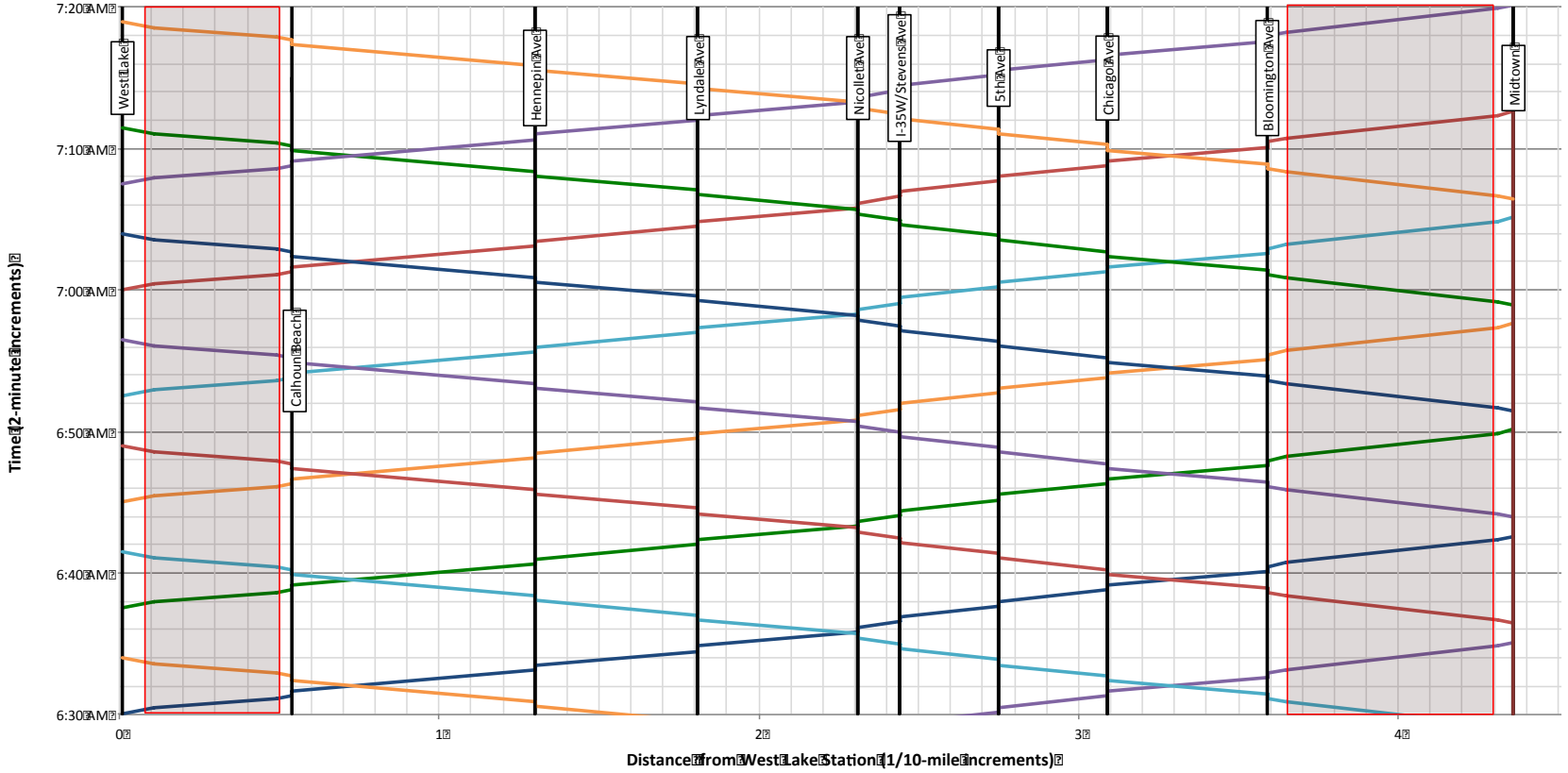

Exhibit 5:
String Line Diagram for Single Track Operations
15-minute Frequencies