Route 51 Service and Reliability Report

December 19, 2008

Service Development, Planning Department

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1. INTRODUCTION

Line 51 has operated in the Cities of Berkeley, Oakland, and Alameda in various forms since 1928 (when the Posey Tube was first opened[1]). The 51 route originates from AC Transit's predecessor- the Key System. Routes 1 through 50 were reserved for streetcar operations, and 51 was the first route operated by bus[2]. The route has changed minimally since then, and has continued to serve the Cities of Berkeley, Oakland and Alameda. Two segments that have been discontinued were a variant that served the City of Albany (51A), and a variant that served the Berkeley Marina (51M).

In 2006, AC Transit began a study of Line 51 in order to evaluate its levels of service and reliability. Carrying nearly 19,000 passengers a day[3], Line 51 is the most used public bus route in the (San Francisco) East Bay. The route travels along major roads through the cities of Alameda, Oakland and Berkeley. However, service on Line 51 has been unreliable, with such operational problems as bus bunching, late vehicles and crowded buses. With increasing customer complaints and performance concerns expressed by AC Transit Staff, a formal effort began to identify problems and craft solutions to improve the quality of service provided on Line 51. The first step in studying Line 51 was the creation of a Task Force to assess the operational issues that have plagued the route and impacted passenger riding experiences.

In February 2007, the first meeting of the Line 51 Task Force was held. The aim of the group was to develop a method of evaluating the route, identifying problems and their causes, and developing recommendations to improve route performance. With such broad responsibility, the composition of the Line 51 Task Force also needed to be varied and inclusive. As such, The Task Force included members from several departments within AC Transit, as well as a representative from each of the Cities of Alameda, Berkeley and Oakland.

To date, The Task force has met four times. The initial meeting of The Task Force covered the purpose and scope of the Line 51 Study, as well as a discussion of operational impacts and recent investments that AC Transit had made in the route. The second meeting of The Task Force included a stop by stop overview of existing conditions, a detailed look at on-time performance (OTP), and an analysis of operations. At the third meeting the Task Force examined data collected by Planning Department Staff that sought to identify and quantify existing delays on Line 51. At the fourth meeting the group reviewed all recommendations and service design options that were made as a result of the analysis segment of The Study.

After The Task Force had defined the purpose and scope of the Line 51 Study, Planning Department staff assumed responsibility for the research, data collection, and analysis aspects of The Study. This work by AC Transit Planners was a complete technical analysis of the route, including: a baseline analysis of existing conditions on the route, data collection regarding passenger counts, ridership patterns, route speed, route dwell time, route running time, route alignment, and causes of delay, analysis of all data collected, a comparative examination of peer routes, and the formulation of recommendations for route improvement.

This paper will follow the Line 51 Study through each phase of information gathering and analysis, and will reveal the key causes of service and reliability issues on Line 51 that came to light as a result of this work. The recommendations and conclusions presented by Planning Department Staff will address such issues as on time performance, delays caused by unsequenced traffic signals, fare media, and bus stop design. This report will detail the recommendations and their proposed applications and, in so doing, will demonstrate the achievement of The Task Force's initial goals of: evaluating the route, identifying problems and their causes, and developing recommendations to improve route performance.

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[1] AC Transit Retirees Newsletter September 2008
[2] Conis, Elena, "From Horses to Hybrid: A Century of East Bay Transport", Fall 2002. http://journalism.berkeley.edu/projects/actransit/conis_feature.html
[3] APC data, Operating year 2007

2. GENERAL CHARACTERISTICS

2.1 Route Structure

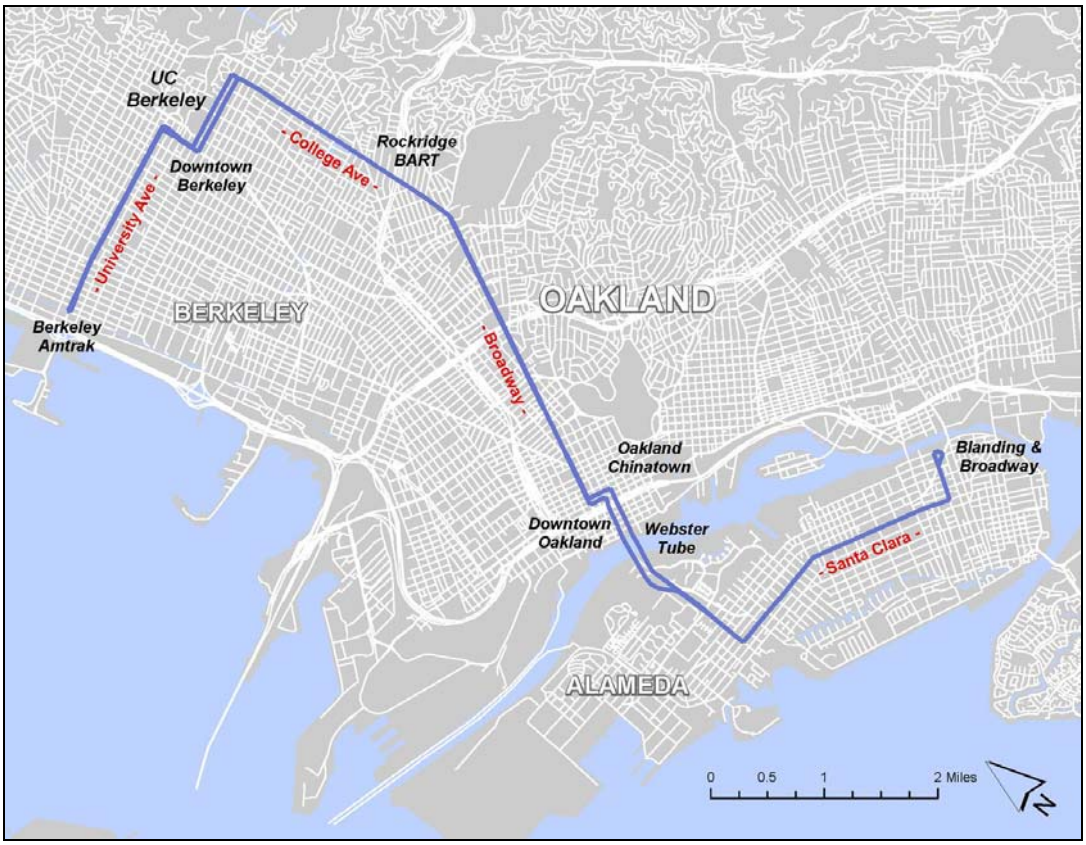
Line 51 is a 12.7 mile route with a northern terminus at the Berkeley Amtrak and a southern terminus on Blanding Avenue at Broadway in Alameda.

The southbound route operates via University Avenue, right Shattuck Avenue, left Durant Avenue, right College Avenue, right Broadway, left 7th Street, right Webster Street into the Webster Street tube, into Webster Street, left Santa Clara Avenue, left Broadway, right Tilden Way, left Blanding Avenue to the southern terminus.

The northbound routes operates via Blanding Avenue, left Broadway, right Santa Clara Avenue, left Webster Street into Posey Tube, into Harrison Street, left 8th Street, right Broadway, left College Avenue, left Bancroft Way, right Shattuck Avenue, left University Avenue to the northern terminus.

There are 79 stops in the southbound direction and 77 stops in the northbound direction. Figure 2.1 provides a graphical depiction of the route.

Figure 2.1 – 51 Route Map



2.2 Service Headway

The line runs on a 7 to 8 minute headway during peak travel times on weekdays, a 10-minute headway throughout the middle of the day and a 20 minute headway at night.

Table 2.1 –Line 51 Headway (Weekday)

	Northbound		*Southbound*	
Time Period	**# of Buses Leaving**	**Max Scheduled Headway (min)**	**# of Buses Leaving**	**Max Scheduled Headway (min)**
	first bus	*4:53 AM*	*first bus*	5:17 AM
4 AM- 5 AM	1	37		
5 AM-6 AM	3	15	4	15
6 AM-7 AM	6	11	7	10
7 AM-8 AM	8	8	7	8
8 AM-9 AM	7	10	6	10
9 AM- 10 AM	6	10	6	10
10 AM-11 AM	6	10	7	10
11 AM-12 PM	6	10	6	10
12 PM-1 PM	6	10	6	10
1 PM- 2PM	6	10	6	10
2 PM-3PM	6	10	6	10
3 PM-4 PM	7	8	7	10
4 PM-5PM	8	8	7	8
5 PM- 6 PM	6	10	5	14
6 PM- 7 PM	6	10	4	15
7 PM- 8 PM	5	15	3	20
8 PM – 9 PM	3	20	3	20
9 PM- 10 PM	3	20	3	20
10 PM- 11 PM	3	20	3	20
11 PM -12AM	2	28	3	20
	last bus	*11:47 PM*	*last bus*	*11:40 PM*

Weekend service differs from that of weekdays, operating on 15-minute headways between 5 AM and 7 PM and on 20-minute headways after 7 PM.

In addition to the local service, an “all-nighter” service is provided daily along various segments of the route by routes 800, 802 & 851, operating from midnight until 5AM.

2.3 Revenue Hours and Miles

Each weekday, Line 51 makes 104 southbound trips and 101 northbound trips. The line operates a total of 262 revenue-hours and 2609 revenue-miles per day.

2.4 Fleet Requirement

During the afternoon peak period, the round-trip cycle time (southbound running time + layover + northbound running time + layover) reaches 197 minutes. 25 vehicles are required to run the service at 8-minute headways.

The District currently assigns 40 foot Van Hool buses (32 seats) and 40 foot N.A.B.I. buses (40 seats) on line 51. AC Transit Board Policy 550 establishes thresholds to measure service effectiveness and quality. One measure of service quality is the standard for the number of standees.

For trunk and major corridor local bus service, Policy 550 sets a threshold of 25 percent standees. This equates to 8 standees on the Van Hool (40 total passengers) and 10 standees on the N.A.B.I. buses (50 total passengers). The Van Hool buses are designed with fewer seats and provide more room for standees. This is not yet reflected in Board Policy 550.

2.5 Bus Stops

The route serves 79 bus stops in the southbound direction and 77 bus stops in the northbound direction. Bus stops are the locations where bus passengers access the AC Transit system and therefore should be convenient to the places where passengers wish to go. They are ideally and typically paired so that a passenger may board a bus for a return trip relatively close to where they exited the bus.

Stops should generally be placed on the far side of signalized intersections in order to get through the traffic signal prior to loading and unloading passengers. At uncontrolled intersections, the preferred location is also far side, as passengers getting off the bus will cross the street behind the bus. Near side stops are preferred at stop sign controlled intersections, allowing the bus to only have to stop once at the intersection to load or unload passengers. Of the current Line 51 bus stops, less than 60% are placed at the preferred location.

Most of AC Transit bus stops are off-line- meaning the bus pulls out of traffic into the bus stop. Stops that keep the bus in the lane of traffic are considered on-line. The operational advantage of an on-line bus stop is that it eliminates the need to pull back into traffic after stopping, reducing delay. There are ten bus stops along line 51 that are on-line. See Appendix 1 and Appendix 2 for a complete list of each bus stops, their location relative to the nearest intersection (Near side/Far Side/Attractor), the type of stop control near the stop (Signal/Stop Sign/Uncontrolled) and the stop type (On-Line/Off-Line).

2.6 Stop Spacing

Excluding the Alameda/Oakland tunnels and downtown areas, stops are spaced, on average, about 730 feet apart. Bus stops along University Avenue, Bancroft Way and Durant Avenue in Berkeley have an average spacing of under 700 feet apart. Table 2.3 below illustrates stop spacing on the primary segments of Line 51.

AC Transit stop spacing guidelines suggest that local bus stops be placed 800 to 1300 feet apart Outside the downtown areas, AC Transit generally seeks to have bus stops 1,000 feet apart. This target has been set with the goal of increasing travel speed for AC Transit buses. Along Line 51, 87 bus stops are spaced less than 800 feet from the next stop.

Table 2.2 shows average spacing on segments of the route. Most segments on the route are below stop spacing guidelines and are less than 800 feet apart. See the Appendix for complete stop spacing detail.

Table 2.2 - Average Stop Spacing per Segment

Segment	Northbound - Average Spacing (ft)	Southbound -Average Spacing (ft)
Berkeley Amtrak to Shattuck Ave at University Ave	657	654
Bancroft/Durant between College Ave and Shattuck Ave	648	633
College Avenue Ave	726	726
Broadway (College to 40th)	921	718
Broadway (40th to 20th)	798	786
Webster St	692	738
Santa Clara Ave. (Webster. to Grand)	842	862
Santa Clara Ave (Grand to Broadway)	933	956
Santa Clara Ave & Broadway to Broadway & Blanding Ave	719	674

2.7 Roadway and Traffic Signal Configurations

Line 51 operates in mixed-flow traffic with cars, trucks & bicycles along the entire route. The route operates on arterial roadways with varying street widths, lane configurations, traffic controls and turning conditions.

The line runs along University Avenue in Berkeley for 1.76 miles. University Avenue has two travel lanes in each direction with “pockets” that reduce the conflict between left-turning vehicles and buses. There are 12 traffic signal controlled intersections, one stop sign controlled intersection, and 9 uncontrolled intersections along this stretch of the route. Even with multiple travel lanes and turn pockets, congestion can still be an issue on University Avenue, especially in the afternoon peak period and on weekends.

By comparison, College Avenue (2.22 miles), a narrow street that connects Berkeley and Oakland, has only one travel lane per direction, with minimal turning pockets. This configuration slows down bus operations, as vehicles turning onto side streets stop in the travel lane, slowing traffic (including the bus) and frequently causing queues of cars that keep buses from accessing the stops. Parallel parking and double parking are also issues affecting bus operations along this segment. Of the 33 intersections along this segment of the route, 9 have traffic signals, three have stop signs and 21 are uncontrolled.

Line 51 operates along Broadway in Oakland for 2.81 miles. Broadway is a wide, multi-lane street (2-3 lanes per direction). Line 51 crosses 34 traffic signals along Broadway. There are no uncontrolled intersections or stop signs along Broadway where the 51 operates. One of the most significant features of this corridor is that traffic signals along certain segments of Broadway are not coordinated or actuated and are the cause of delays.

The Posey/Webster Tubes, with two lanes in each direction, pose a sometimes difficult passage between Alameda and Oakland. In the morning, peak commute period, vehicles traveling to Oakland queue up past Atlantic Avenue/Ralph Appezzato Memorial Parkway while attempting to enter the Tube, a distance of over a half-mile. During the off-peak hours, vehicles do not experience this type of delay and can be found traveling in excess of 50 miles per hour. The tube segments prove to be a challenge as the actual running times through the tube can be up to 10 minutes more than scheduled.

Within Alameda, Webster Street (.41 miles), and Santa Clara Avenue (2.27 miles), differ greatly from each other. Webster Street has 2 lanes with 6 traffic signals, and modern bulb-out bus stops with well

placed amenities. Santa Clara Avenue is one wide lane in each direction, with parallel parking on either side. There are five signalized intersections and two stop sign controlled intersections along this street but the majority are uncontrolled intersections.

The differences in these roadways highlight the variety of the segments along the route. A list of all the streets that line 51 travels along and the number of lanes available on each street segment can be found in the Appendix.

Line 51 crosses 73 signals in the northbound direction, and 71 signals in the southbound direction. A list of the locations of all signals along the Line 51 can be found in the Appendix. .

3. EXISTING CONDITIONS

An analysis of existing service delivery on Line 51 was conducted. Information was collected on ridership trends, loads, scheduled running time, dwell, speeds, and schedule adherence. The analysis is presented in the following section.

3.1 Data Sources

An initial investigation of existing conditions on Line 51 was the first goal of the Line 51 Task Force. The data was obtained from the following sources

- Running Time Analysis via Automatic Passenger Counters (APC)
- Customer Service Database
- Ridership Data APC
- On Time Performance (OTP)
- Passenger Loads by Segment via APC
- Average Speed by Segment via AVL
- Point Checks

3.2 Passenger Feedback

Many complaints were received from passengers regarding the reliability of Line 51. Concerns were raised about bus bunching, driver behavior, overcrowding, long wait times, and on time performance. The nature and quantity of customer complaints relating to Line 51 are shown in Table 3.1.

Table 3.1 - Complaints Related to the Line 51 (June 2006-June 2007)

Nature of Complaint	Number Received	Percent of Total
Overloads/Pass-by/Boarding/Alighting/Carry By/Refusal to Allow Board/Improper Stop	91	27%
No Shows/Late/Sharp/Bunched Buses	59	18%
Accidents/Hazardous	56	17%
Conduct/Cell Phone	45	14%
ADA	37	11%
Fare Dispute	14	4%
Equipment/Untidy Bus or Stop	6	2%
Insufficient Run Time/Request New Route/Route Changes	4	1%
Other (Radios, Vandalism, Eating, Cell Phone, End of Line (EOL) Violation, Idling, General, Other)	20	6%
Total	332	100%

3.3 Ridership

Latest ridership data shows 18,747passengers ride the 51 route each day, making it the most heavily traveled local transit service in the East Bay[4].

[4] Anthony Bruzzone and Howard Der, GM Memo 08-033(a), February 27, 2008.

On average, the route serves 72 passengers for every hour in service. This rate of passengers per service hour makes Line 51 not only the most heavily traveled, but also one of the most productive routes in the AC Transit Service Area.

Ridership patterns vary throughout the route, as shown by Table 3.2 below. The segment between 40th Street & Broadway and 7th Street and Broadway is the most productive

Table 3.2 - Boardings by Segment

Segment	Distance (in miles)	Northbound Boarding Activity	Northbound Average Passengers/ mile
Broadway & Blanding to 7th & Franklin	4.71	2610	554
7th & Franklin to 40th & Broadway	2.24	1833	818
40th & Broadway to Rockridge BART	1.22	433	354
Rockridge BART to Berkley BART	2.58	1850	717
Berkeley BART to 3rd & University	1.97	750	380

Segment	Distance (in miles)	Southbound Boarding Activity	Southbound Average Passengers/ mile
3rd & University to Berkeley BART	1.97	1658	842
Berkeley BART to Rockridge BART	2.58	2231	865
Rockridge BART to 40th & Broadway	1.22	481	394
40th & Broadway to 7th & Franklin	2.24	2238	999
7th & Franklin to Broadway & Blanding	4.71	839	178

In contrast to the variations in ridership by route segment, ridership is distributed moderately across all bus stops. Few stops have low ridership (defined as less than 50 passenger boardings or alightings per day), and ridership nears or exceeds 100 passengers at many stops. Table 3.3 illustrates the stops on Line 51 that have the highest average daily ridership (boarding and alighting combined).

Table 3.3 - Highest Activity Stop Locations

Location	Northbound Ridership Activity	Southbound Ridership Activity	Attractors / Generator
Downtown Berkeley BART	997	889	BART Transfer location
Broadway at 14th	653	1101	BART/Transfer location
Bancroft/Durant at Telegraph	643	648	U.C Berkeley
University at San Pablo	532	428	Transfer location
Bancroft/Durant at College	429	427	U.C Berkeley

In addition to variation by route segment and bus stop, ridership patterns were analyzed by time of day. This examination revealed that Line 51 ridership varies greatly by time of day. Though the line moves many commuters to and from work during the traditional commute hours, its ridership also has multiple peaks throughout the day.[5]

For example, northbound data (from Alameda to Oakland to Berkeley) shows heaviest ridership on trips departing from Broadway at Blanding (the beginning of the line) between 7AM-8AM. It was observed that northbound ridership spikes again from 12PM-5PM, when the route carries over 600 passengers per hour (approximately 6-8 trips per hour).

[5] Automatic Passenger Counters, June 2006-March 2007

Southbound trips experience peaks as well, with heaviest ridership between 1PM-4PM, and almost 800 passengers between 4PM and 5PM.[6] It is significant to note that heavy ridership during the 12PM-4PM period may impact the PM Peak Commute service from 5PM-7PM. Since operators are moving the heaviest loads just prior to the PM peak commute, this could impact other drivers being able to leave the terminus on schedule and thus affect bus spacing and headway adherence.

3.4 Passenger Load Analysis

Staff used APC data to construct a load profile for both directions on line 51. This shows us where the maximum load points are along the route as well as when the buses are most used.

Line 51 carries heavier loads during the AM in the northbound direction. During the PM, loads are heaviest heading southbound. The max load occurs northbound on the 7:43 AM trip. In the southbound, the max load occurs on the 2:56 PM trip.

Figure 3.1a details the load profile for trips heading northbound. The profile includes the heaviest trips as well as the average for trips during the AM peak period, the midday and the PM peak periods.

In the northbound direction, loads build throughout Alameda, peaking by the time the bus gets to the Posey Tube. Passengers get dropped off throughout Chinatown and up to 14th & Broadway. The loads build up once again starting at 14th & Broadway and are maintained up to MacArthur Blvd. This segment along Broadway is the most utilized portion of the route. Loads pick up once again heading toward UC Berkeley. The loads peak once again near the campus as passengers alight throughout Downtown Berkeley and University Ave.

[6] Automatic Passenger Counts by trip, Jun 2006-March 2007.

Figure 3.1a – Bus Load Profile (Northbound)

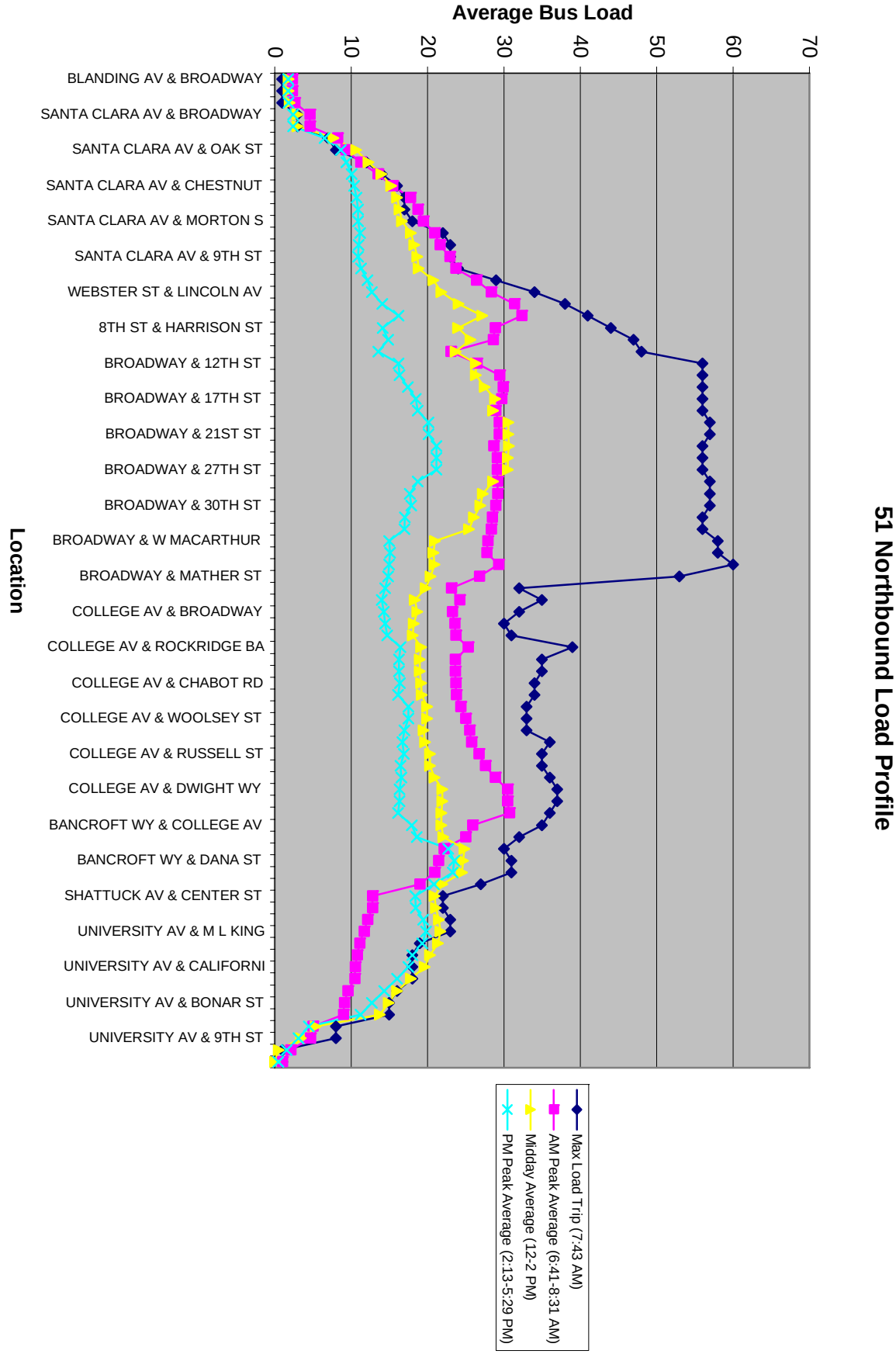


Figure 3.1b – Bus Load Profile (Southbound)

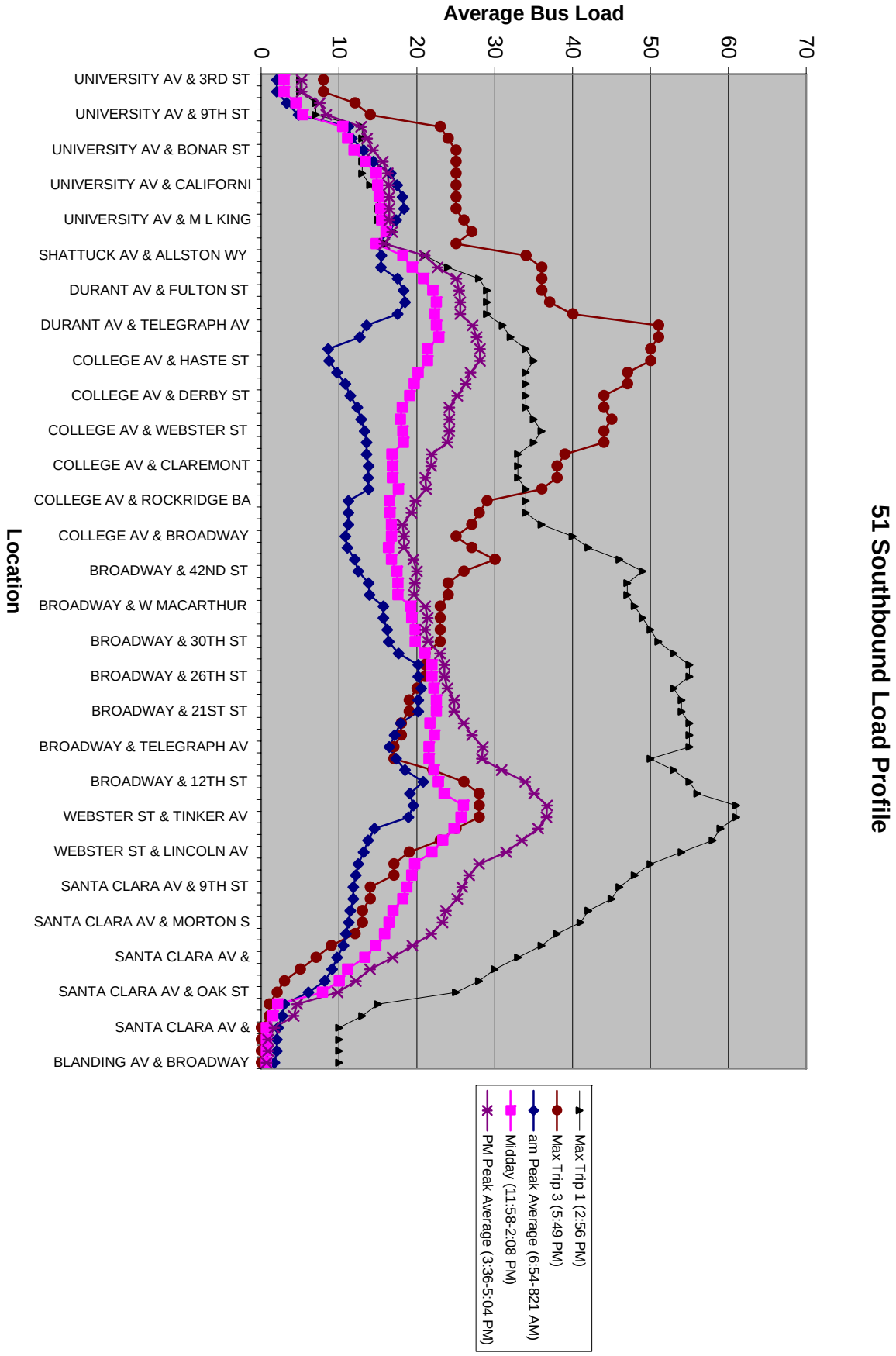


Figure 3.1b details the load profile for trips heading southbound. The profile includes the heaviest trip as well as the average for trips during the AM peak period, the midday period and the PM peak periods.

In the southbound direction, loads are fairly light along University Avenue. Once buses get past Downtown Berkeley, the loads get heavier, peaking along the northern section of College Avenue near the UC campus. The loads continue to decrease until the bus gets to Broadway. Along Broadway (with particularly high boarding in Downtown Oakland), the bus fills up once again as it heads toward Alameda.

3.5 Running Time Analysis

Scheduled Running Time

Line 51 is scheduled to have increasingly more running time as the day goes on. The most running time is scheduled during the afternoon peak when Line 51 has a one-way running time of 87 minutes in the southbound direction and 86 minutes in the northbound direction.

In June 2007 AC Transit added nine minutes (approximately 10% of the total running time) to the southbound direction of Line 51's scheduled running time (Depicted in Table 3.4 below); up to seven minutes were added in the northbound direction. The time was added in order to maintain service levels, and the additional running time required two additional vehicles to service the route. Adding buses to maintain existing levels of service is costly and is something that that AC Transit can not continue to do. Moving forward, the District would rather look at ways to speed up service, allowing for higher levels of service with the same resources, Table 3.4 below reflects the changes made in Line 51's scheduled running time.

Table 3.4 - Total Scheduled Operating Time in Minutes (NB/SB)

Time Period	June 2007	May 2007
8 AM	79 min/ 71 min	73 min/ 67 min
10 AM	79 min/ 73 min	74 min/ 72 min
1 PM	83 min/ 83 min	76 min/ 75 min
5 PM	86 min/ 87 min	79 min/ 78 min

Using running time data from almost 12,000 observations, a consultant was able to identify the running time for each trip within a given time period. The data indicated significant variability in the running time for various segments of the route, even during the same time periods (Spring 2006/Fall 2007). This means that the amount of time it takes to travel between the same two points vary. These factors make it difficult to schedule the route.

This data was used to develop the revised schedule in 2007. The new schedule was developed to keep the buses moving quickly- a tight schedule early on in the route and more time toward the end of the route. Schedules were altered to ensure 95% of all trips would be able to depart on a trip on time.

Data indicates that there is a high degree of variability in running time on all segments. The time it takes to travel between the same two points vary. Running time on the same trip on different days will vary. See Appendixes 7a and 7b for detailed information on northbound and southbound trips.

Segment Running Time

The median running times for the nine time point segments (3rd & University to San Pablo, San Pablo & University to Center & Shattuck, Center & Shattuck to Bancroft/Durant & Telegraph, Bancroft/Durant & Telegraph to Rockridge BART, Rockridge BART to 40th & Broadway, 40th & Broadway to 14th & Broadway, 14th & Broadway to Atlantic & Webster, Atlantic & Webster to Park & Santa Clara, Park & Santa Clara to Broadway & Blanding), were examined during six time periods (6-9 AM, 9-Noon, Noon-2 PM, 2-4 PM, 4-7 PM, 7-MID). Some segments have large variations in running times between time periods. Figure 3.2a and 3.2b depict the changes in the average running times for the time point to time point segments. Each line in the figure represents one of the segments. The segment between Telegraph to Rockridge BART showed a significant increase in running time as the day went on. The section between Downtown Oakland and Alameda showed an increase in running time during the peak periods.

Figure 3.2a – Segment Running Time (Southbound)

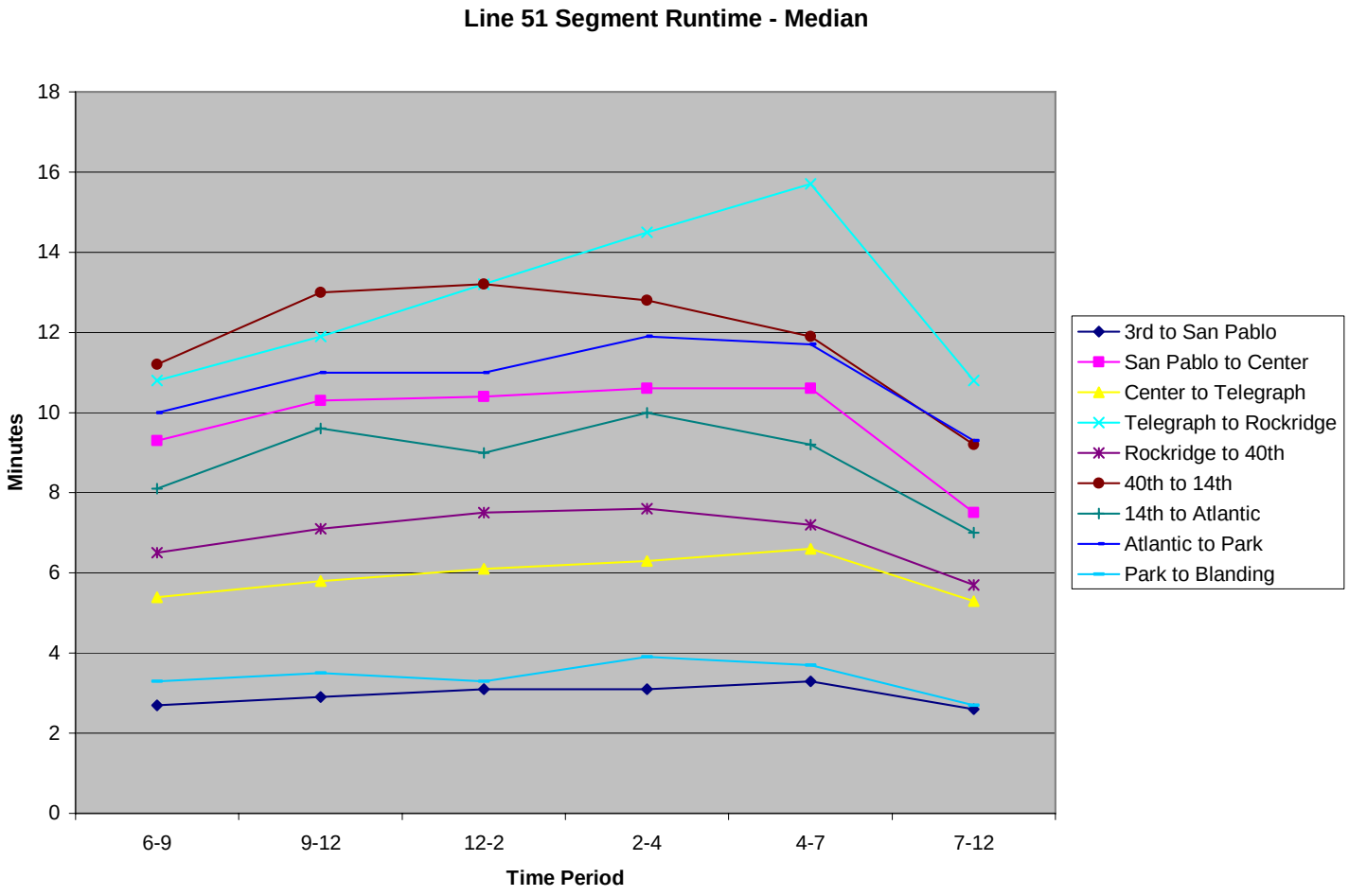
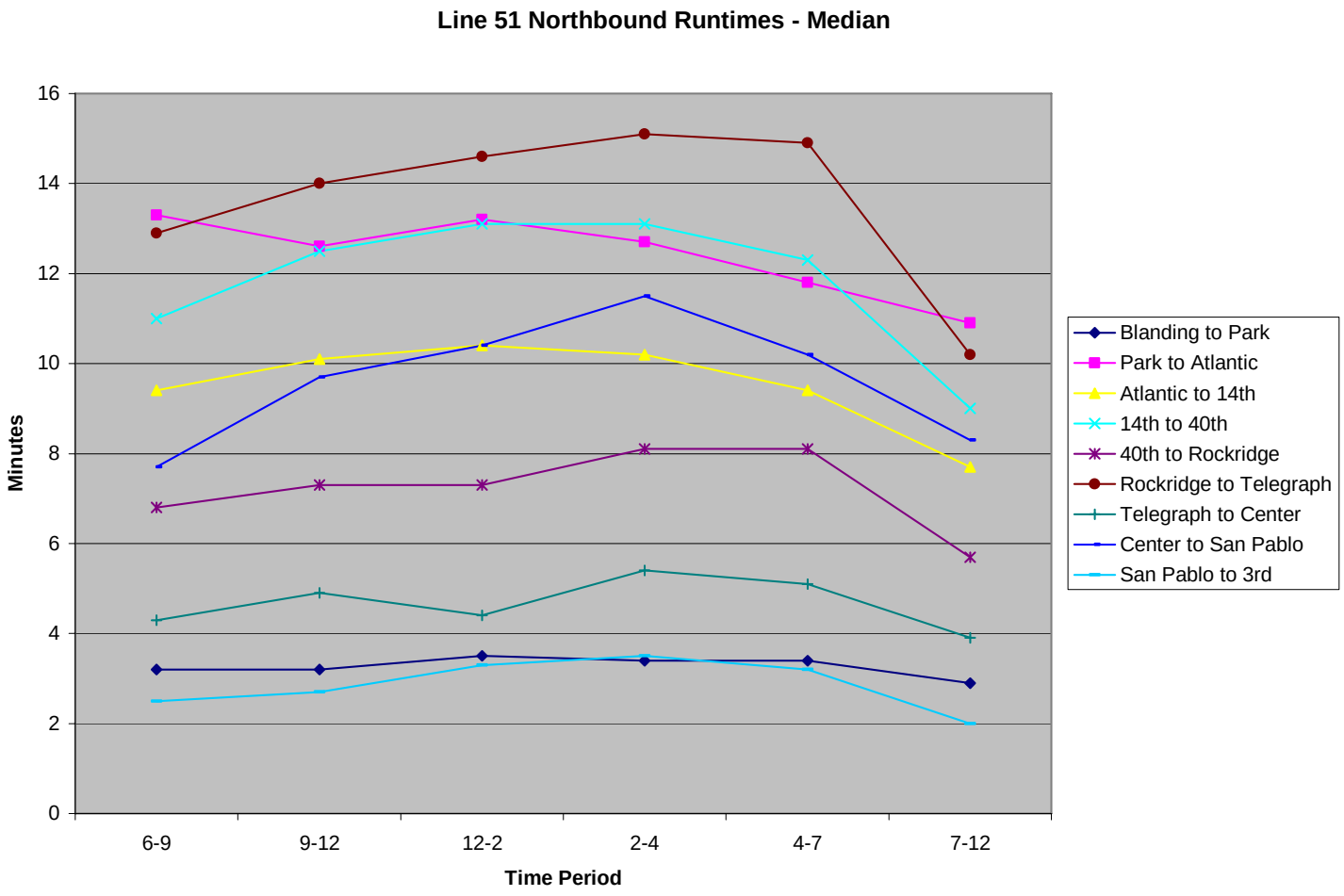


Figure 3.2b – Segment Running Time (Northbound)



The northbound direction trends differently than the southbound direction. The afternoon peak period includes increases in running time along University Avenue as well as along College Avenue.

3.6 Speed

The speed of the bus can influence a passenger's decision to choose to ride. Slow vehicle speeds and longer running time makes using the bus a significantly less attractive travel option.

In addition to increasing route running time, slow speeds also have an impact on operating costs. As speeds decrease along a route, more vehicles are required to maintain the existing frequency.

Using APC data, staff was able to identify the running time for each trip within a given time period. During the afternoon peak period, the average bus operating speed in both the northbound and southbound directions is 9 miles per hour - 25% slower than the AC Transit system average.

Figure 3.3a details the average bus speed by time of day for segments of the route for northbound trips; figure 3.3b details the southbound trips. The Southbound segment with the slowest speed consistently is Downtown Berkeley. In the Northbound direction, the segments from Rockridge to Telegraph, and Telegraph to Downtown Berkeley are the segments with the slowest speeds. Segments in Alameda were consistently the faster.

Heading northbound, the segment between Rockridge BART and Bancroft Way at Telegraph Ave is the slowest segment, averaging less than 8 mile per hour.

In the southbound direction, the segment between Shattuck Avenue at Center Street and Durant at Telegraph Avenue is the slowest segment, operating at just over 6 miles per hour during the PM peak period.

Figure 3.3a – Average Bus Speed by Segment by Time of Day (Northbound)

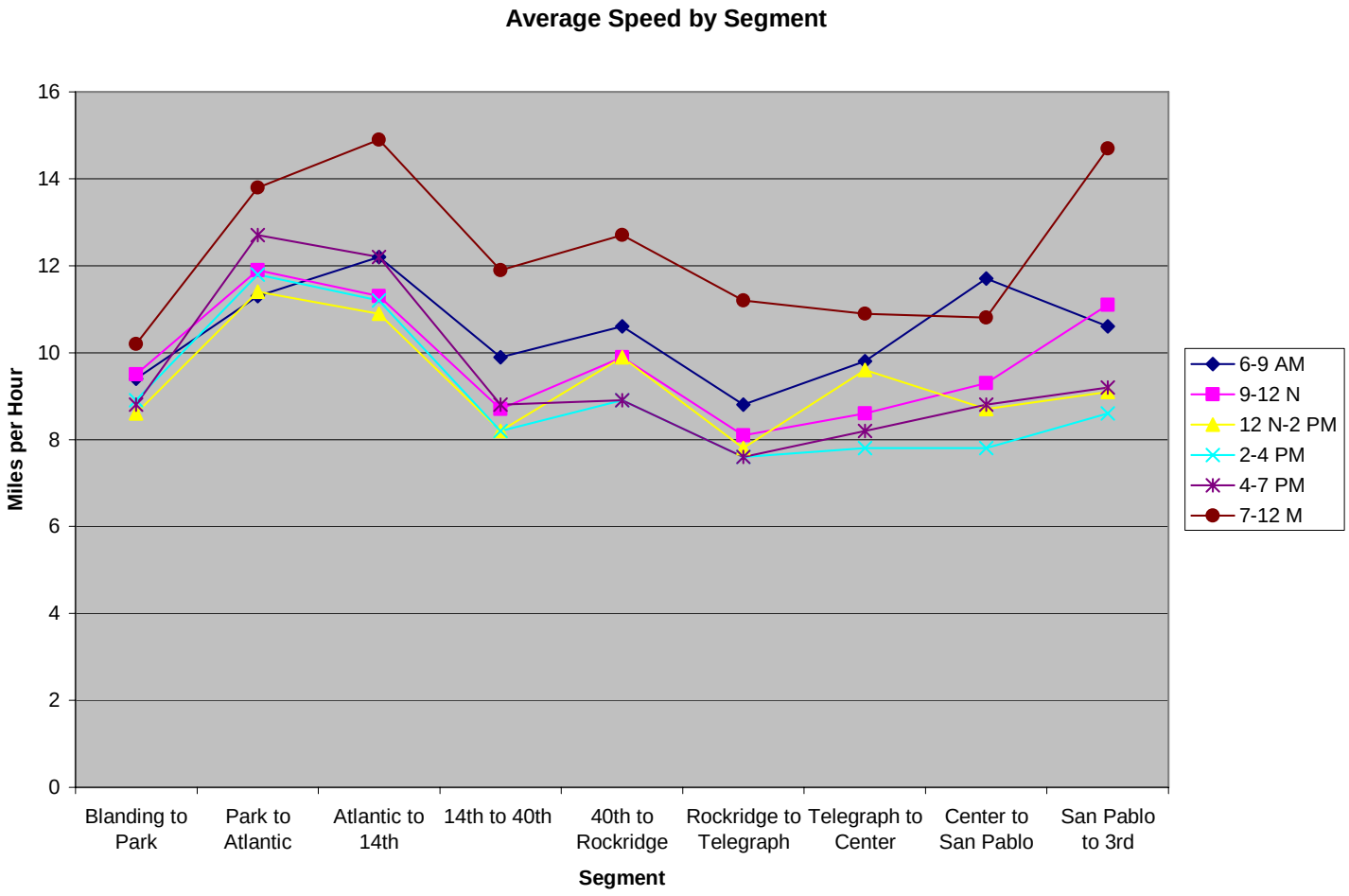
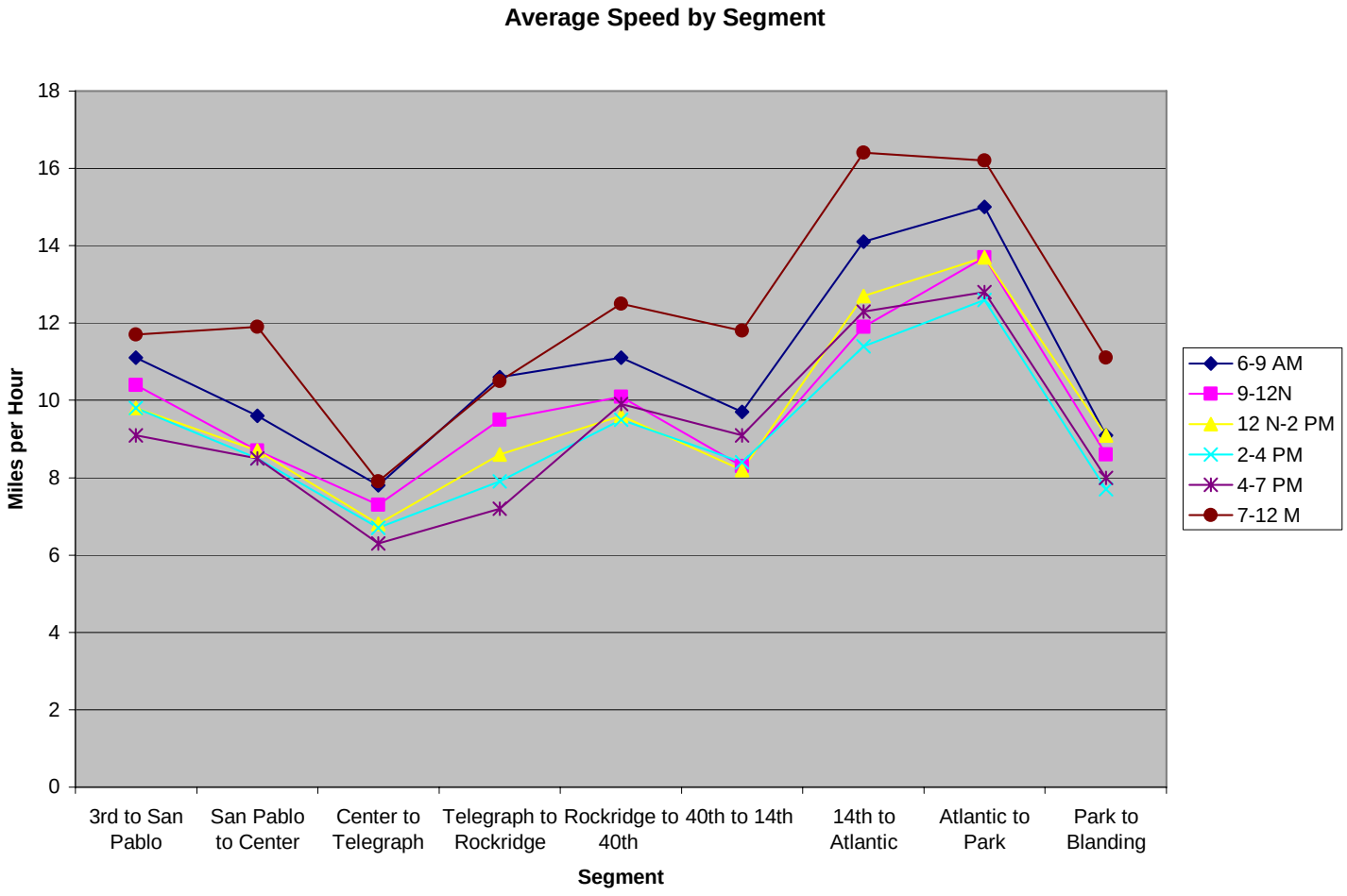


Figure 3.3b – Average Bus Speed by Segment by Time of Day (Southbound)



Automobile travel time runs were made along the 51 route in order to compare the speed of the buses to that of an automobile. Five runs were made in each direction between the hours of 10 AM and 5 PM. The car runs averaged 12.8 miles per hour. Therefore, the average speed of the bus is 1.6 times slower than traveling the same route in a car.[7]

3.7 Schedule Reliability

Most people consider waiting time to be more onerous than in vehicle travel time[8]. During most of the day on the Line 51, wait times should average between 4-5 minutes (half the headway). However, lengthier wait times are commonly reported. These lengthy wait times are attributed to "bus bunching" (or platooning) and off schedule vehicles.

Bus bunching, occurs when buses travel immediately behind one another instead of the scheduled number of minutes apart. Due to bus bunching, passengers are often forced to wait longer for the bus to

[7] Staff initiated and performed end to end car runs and bus rides, Fall 2007.

[8] Lam, William, and John Morrall. *Transportation Quarterly* 36 "Bus Passenger Walking Distances and Waiting" 1982.

arrive. For example, if Bus A and Bus B are scheduled to leave the end of the line 8 minutes apart, and Bus A starts to fall behind schedule, it will pick up passengers who were waiting for Bus B. The additional passengers onboard Bus A will cause further delay to the schedule by increasing the bus's dwell time at stops. Bus A will get further behind schedule, and with heavier loads on Bus A, and lighter loads on Bus B, the two buses will eventually start operating alongside each other because Bus B will make fewer stops. By policy, AC Transit operators are instructed not to pass the leader bus-even to reduce buses operating ahead of schedule- and buses will continue to be off schedule until they can reset at the end of the route. As a result, maintaining a consistent headway is an important objective.

In the Transit Capacity and Quality of Service Manual, headway adherence is based on a relationship between the coefficient of headway variation and the probability (P) that a vehicle's headway deviation hd (actual headway minus scheduled headway) will be off by more than one-half the scheduled headway h. The coefficient of variation is calculated by dividing the standard deviation of headway deviation by the mean scheduled headway deviation. The proposed standard for this measure is Level of Service B (LOS B). Table 3.5 lists the Level of Service standards for Headway Adherence and the type of service associated with each LOS.

In order to quantify the level of bus bunching and headway adherence problems on Line 51, staff conducted point checks at six locations (Santa Clara at Park, Atlantic and Webster, 14th & Broadway, Rockridge BART, College at Ashby, and Center and Shattuck) during the months of May and June in 2007. These point checks were conducted between the hours of 2-7PM, and were used to verify the actual headways between buses versus their scheduled headways. The results of the data collection are listed in Table 3.6.

Table 3.5 Fixed-Route Headway Adherence LOS

LOS	Coefficient of Headway Variation	$P(h_d>.5h)$	Comments
A	0.00-0.21	1%	Service provided like clockwork
B	0.22-0.30	10%	Vehicles slightly off headway
C	0.31-.039	20%	Vehicles often off headway
D	0.40-0.52	33%	Irregular headways, with some bunching
E	0.53-0.74	50%	Frequent bunching
F	>0.75	>50%	Most vehicles bunched

Table 3.6 – Headway Adherence Results

Location	Dir.	Mean Sch. Headway (sec)	Std. Dev. For Headway Adherence (sec)	Coefficient of Headway Variation	Level of Service
Park & Santa Clara	North	528	241	.456	D
Atlantic & Webster	North	526	253	.482	D
14th & Broadway	North	529	267	.506	D
Rockridge BART	North	525	397	.757	F
College & Ashby	North	531	336	.633	E
Center & Shattuck	North	526	400	.760	F

Location	Dir.	Mean Sch. Headway (sec)	Std. Dev. For Headway Adherence (sec)	Coefficient of Headway Variation	Level of Service
Center & Shattuck	South	589	255	.433	D
College & Ashby	South	581	337	.580	E
Rockridge BART	South	581	364	.626	E
14th & Broadway	South	580	402	.693	E
Atlantic & Webster	South	555	454	.819	F
Park & Santa Clara	South	540	463	.858	F

As expected, some buses arrived very close together and others were far apart. The analysis showed that 33% of the time headways between buses were more than 4 minutes off the scheduled 8 minute headway.[9] Due to this variability, it is not uncommon for passengers to wait 15-20 minutes for a Line 51 bus to arrive. Towards the latter part of the route, the buses tend be more unreliable irregardless of direction.

[9] AC Transit-Point Check May 2007

4. RIDE CHECK & DELAY DATA ANALYSIS

4.1 Methodology

While data collected from Automated Vehicle Location (AVL) software is useful for delay analysis, it only provides the results of delays and not the causes, duration, or precise locations of them. This detailed information is critical in order to be able to address the causes of delay and thus reduce delay time. To inform this effort, Planning Department Staff rode 21 trips spanning 27 service hours, and identified all causes of delay. Data was collected between 1PM-7PM on Tuesdays, Wednesdays and Thursdays, when operational issues were most severe and service was least predictable. All data was collected in late September and October 2007.

While some delays are inevitable in on-street bus operations, the goal is to reduce these delays and to make them more predictable. Planning Department Staff rode round trip runs of the Line 51 and collected data on all incidents of delay on the bus using laptop computers. Data was collected on the arrival and departure times at each stop, as well as the duration and location of each delay incident. Delays were coded to the stop segment (the space between two stops) they occurred within in order to have the most accurate information possible regarding delay location.

Staff associated each delay with one of the following categories:

- Traffic Signals
- Blocked Bus Zones
- Re-entering Traffic
- Obstructed by Turning vehicles
- Automobile Parking
- Yielding to Pedestrians
- Yielding to Cyclists
- Schedule delay from too much time
- Other delays

4.2 Components of Run Time

After quantifying and categorizing each type of delay observed on Line 51, a break-down of scheduled operating time, by activity, was formulated, and is reflected in Table 4.1 below. Only half of the scheduled running time is spent in motion. The other components, dwell time at stops and delay along the route, make up the balance of the running time components.

Table 4.1 - Breakdown of Running Time

Component of Running Time	Average Distribution (minutes)	Proportion of Run Time
Travel Time	44.5	50%
Dwell Time	17.5	20%
Delay Time	24.0	30%
Total Run Time	86.0	100%

4.3 Types of Delay

Of the 30% of time spent being delayed, 80% of it was found to be due to traffic signals or stop signs. See Table 4.2 below for the break down.

Table 4.2 - Delay Time Components

Type of Delay	Percent of Overall Delay
Traffic signals	80%
Blocked Bus Zones	3%
Reentering Traffic	2%
Obstructed by Turning Traffic	1%
Automobiles Parking	2%
Yielding to Cyclists/Peds	4%
Schedule Delay from too much time	5%
Other delays	3%
Total	100%

Planning Department Staff also analyzed signal delay as it relates to stop placement. When a signal delay occurred within a few seconds of pulling out of a near side stop, the delay was flagged as being related to stop placement. Twice as much time was attributed to waiting at a near side stop as waiting to enter a far side stop, and the bus was more likely to experience two signal cycles with near side stops. Near side stops were associated with 29% (or 108 minutes, over the course of the study) of signal delay, while far side stops were associated 16% (or 60 minutes, over the course of the study).

4.4 Locations of Delay

Delay by Segment

Delays were analyzed by segment along the route. Each segment was approximately one mile in length, allowing for observations of delays that were unevenly distributed over the length of the route. Table 4.3 below illustrates this segmented delay analysis.

Table 4.3 - Delay by Mile Segments

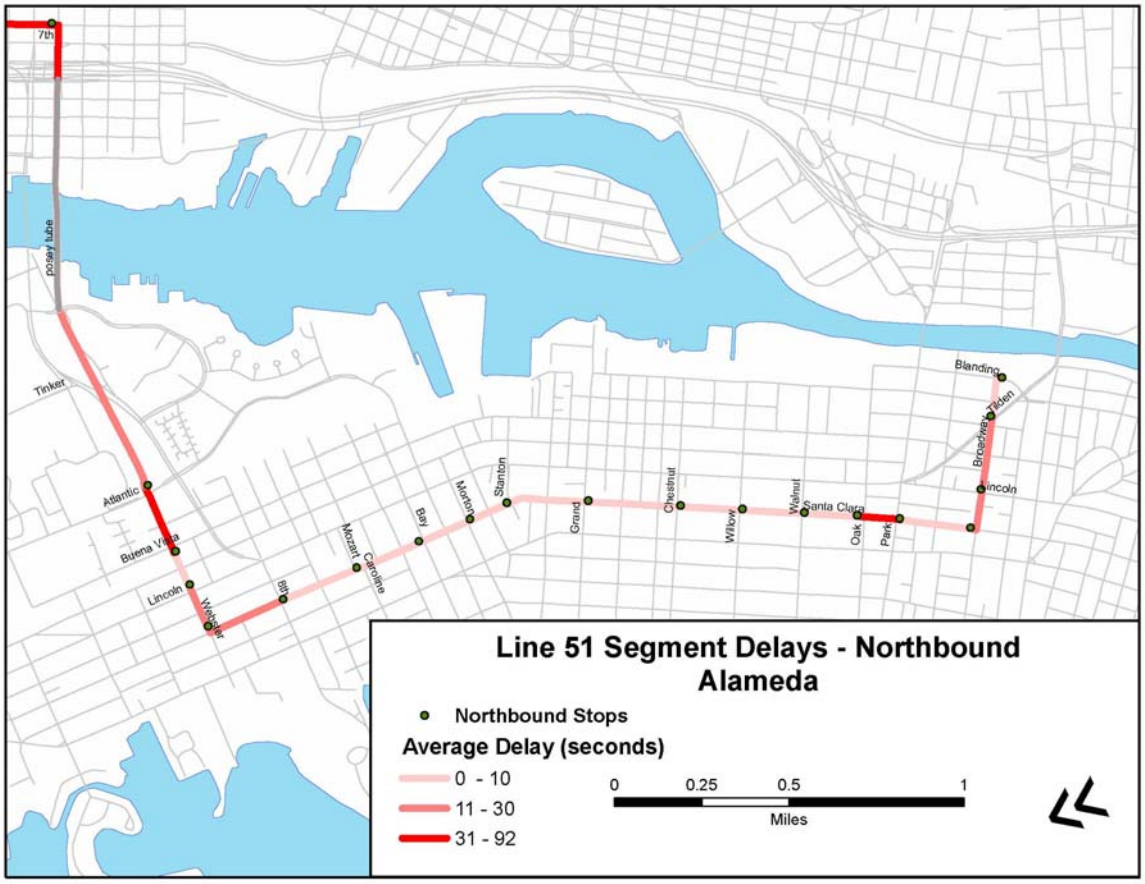
Point A	Point B	City	Distance	NB Delay (min)	SB Delay (min)
University/3rd	University/Sacramento	Berkeley	1.1	3.52	1.78
University/Sacramento	Shattuck/Durant	Berkeley	1.0	2.57	2.63
Shattuck/Durant	College/Durant	Berkeley	1.0	3.13	1.37
College/Durant	College/Woolsey	Berkeley	1.0	1.95	1.82
College/Woolsey	College/Manila	Oakland	1.0	1.57	1.95
College/Manila	Broadway/40th	Oakland	0.9	2.07	1.77
Broadway/40th	Broadway /25th	Oakland	1.0	2.08	2.45
Broadway/25th	Broadway /12th	Oakland	0.9	3.05	2.60
Broadway/12th	Atlantic/Webster	Oakland	1.8	2.25	1.80
Atlantic/Webster	Santa Clara/Caroline	Alameda	0.9	1.10	0.92
Santa Clara/Caroline	Santa Clara/Chestnut	Alameda	1.0	0.13	0.42
Santa Clara/Chestnut	Santa Clara/Broadway	Alameda	1.0	0.70	0.48
Santa Clara/Broadway	Blanding/Broadway	Alameda	0.5	0.67	1.33
Totals			**13.1**	**24.78**	**21.32**

As can be seen from the table above, the majority of delay takes place within the Cities of Oakland and Berkeley. Much of the route through the City of Alameda is along a roadway with minimally controlled

intersections, and thus there are fewer opportunities for the bus to encounter the signal delays that were so prevalent in Oakland and Berkeley. Strategic improvements in Oakland and Berkeley may help to reduce these types of signal induced delay.

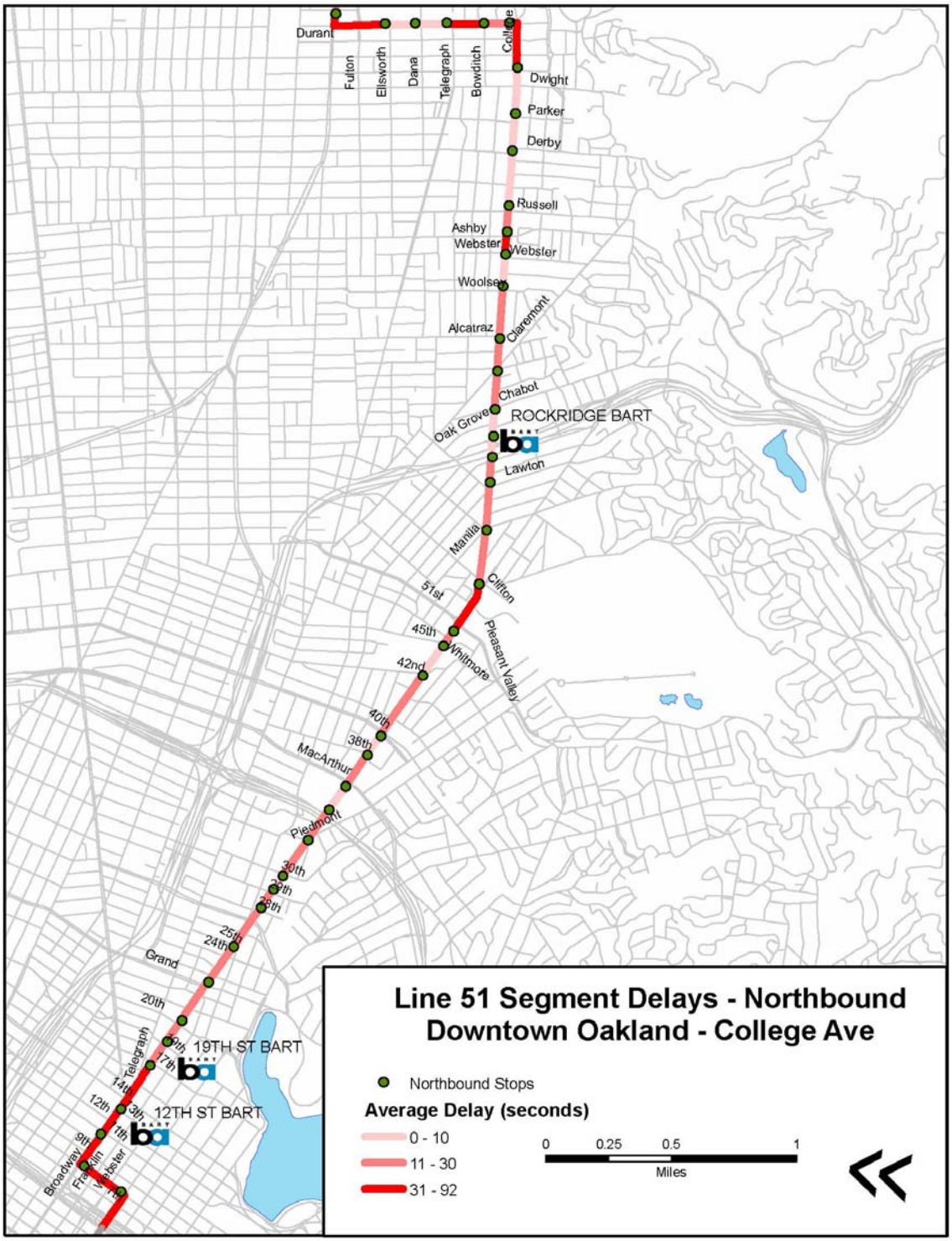
Below are a series of maps which geographically display the amount of delay experienced between each set of bus stops.

Figure 4.1a - Delay Results by Segment Alameda Northbound



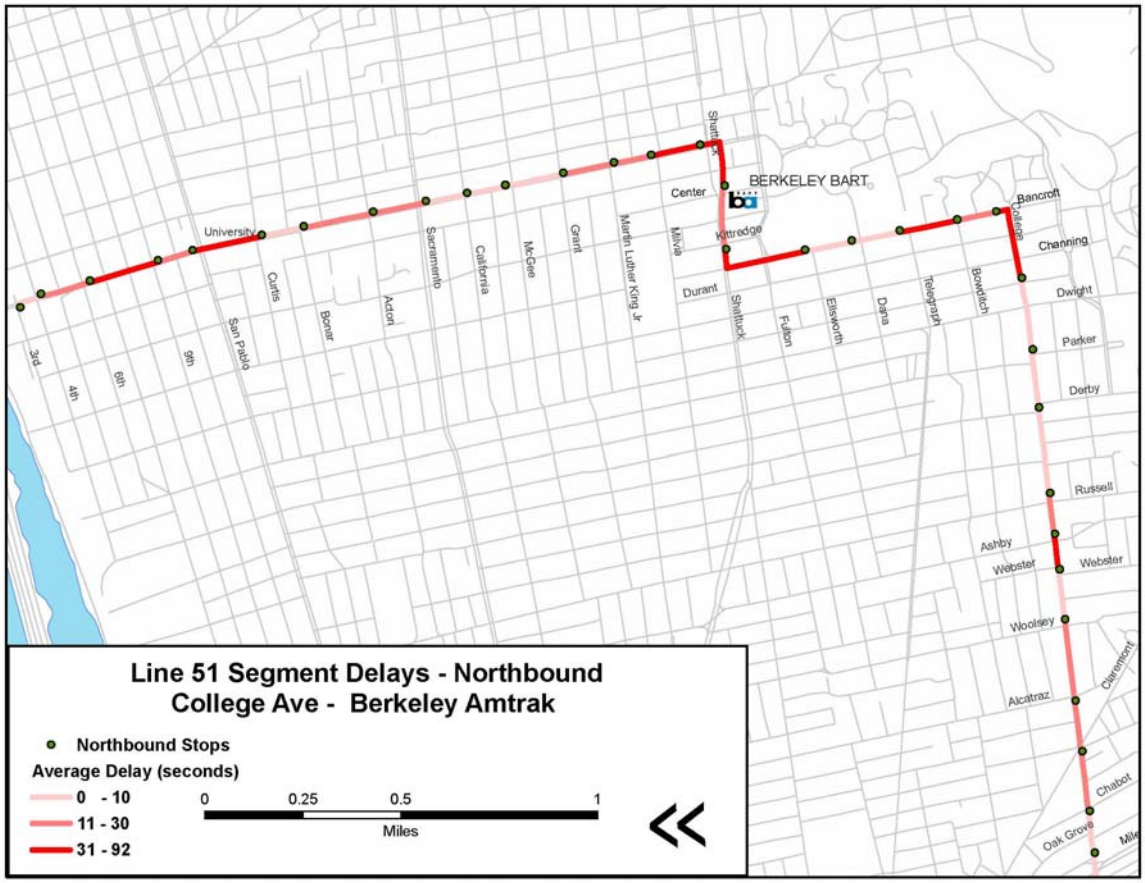
The Northbound delay data captured in Alameda showed significant delay at the Posey Tube and between Oak Street and Park Street. Queuing sometimes backed up past Atlantic, which caused heavy delays from Buena Vista.

Figure 4.1b - Delay Results by Segment Oakland Northbound



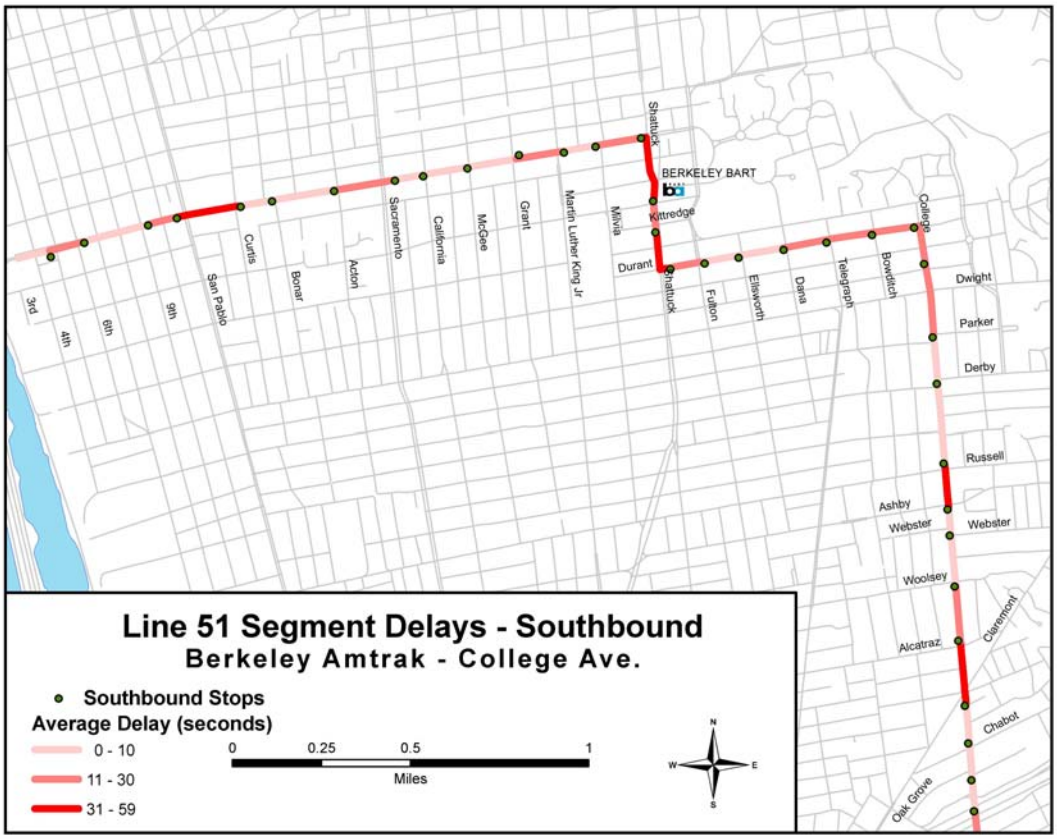
The Northbound delay data captured from Downtown Oakland to College at Bancroft showed significant delay in Downtown Oakland, between Ashby and Russell Street, at Pleasant Valley/51st Street and around the UC Campus. The most significant delays were recorded at Russell, Webster and at Ashby.

Figure 4.1c - Delay Results by Segment Berkeley Northbound



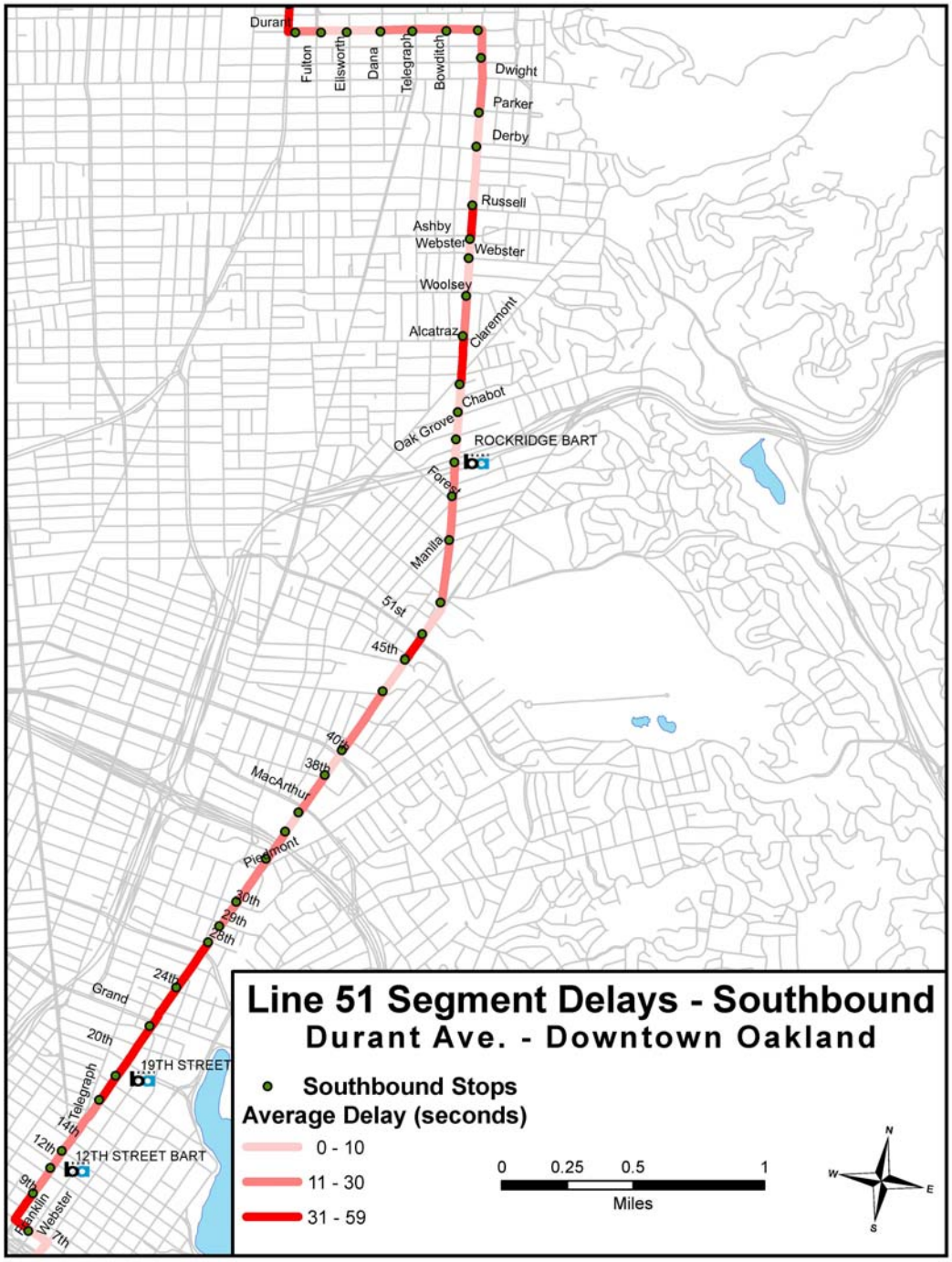
The Northbound delay data captured in Berkeley showed significant delay Downtown Berkeley, between Curtis and San Pablo, and between 9th and 6th. The most significant areas of delay were entering and exiting Downtown Berkeley, approaching San Pablo Avenue, at Bancroft and College, and at Ashby at Webster.

Figure 4.2a - Delay Results by Segment Berkeley Southbound



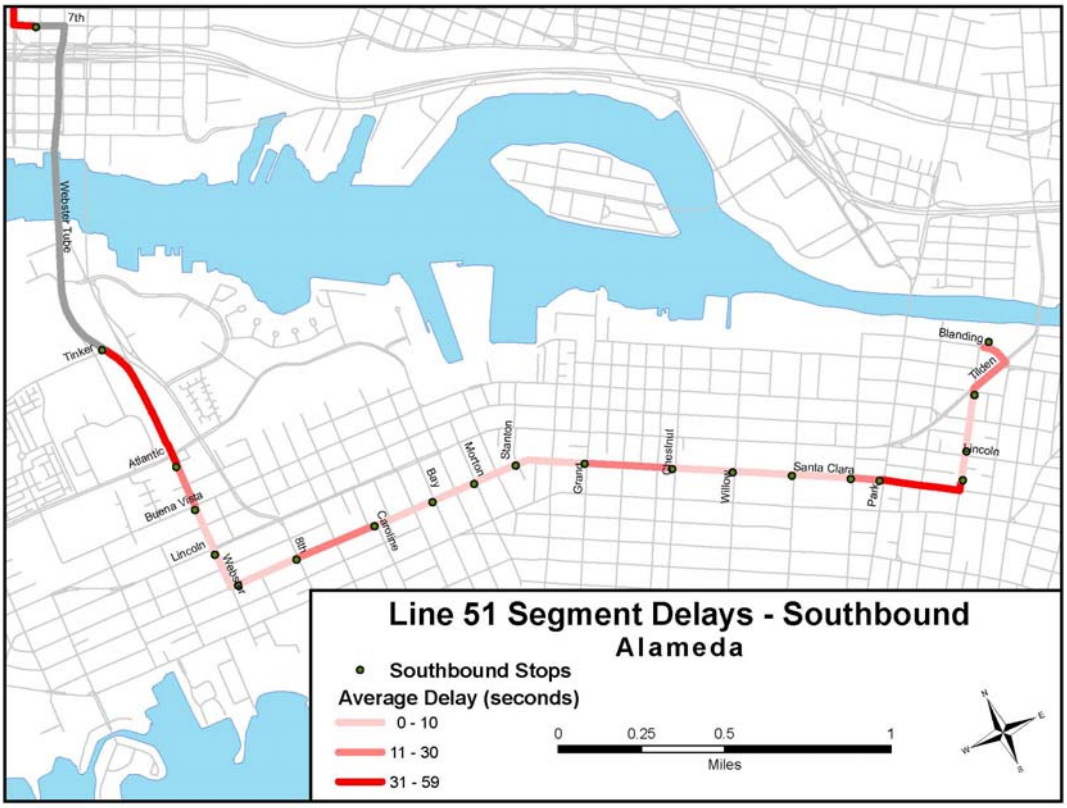
The Southbound delay data captured in Berkeley showed significant delay from San Pablo to Curtis, Downtown Berkeley, from Russell to Ashby, and from Alcatraz to Claremont.

Figure 4.2b - Delay Results by Segment Oakland Southbound



The Southbound delay data captured in Oakland showed significant delay from Pleasant Valley to 45th, in Downtown Oakland, and in Oakland Chinatown.

Figure 4.2c - Delay Results by Segment Alameda Southbound



The Southbound delay data captured in Alameda showed significant delay in the Webster Tube and from Park Street to Broadway.

Regularly Delayed Locations

Stop locations with the heaviest delay are noted in Table 4.4 below. Average delay was calculated using data from every observation, including incidents where zero seconds of delay occurred. Most of the locations listed below involved nearly a minute and half of delay per location. The variability between the average and the maximum delay illustrates the difficulty of scheduling this route to maintain on-time performance. The most delayed areas in the maps above are identified in Table 4.4 with the average amount of delay noted and the maximum delayed also noted. Using this information, our recommendations are aimed both at reducing the amount of delay, and also reducing the variability so that designing scheduled operating times can be more predictable.

Table 4.4 - Twenty Most Regularly Delayed Locations

Rank	Direction	Segment Name	Average Total Delay	Max Total Delay	Recommendation	Time Saving
1	N	shattuck/ university: center to milvia	92	184	Active Management, Signal Adjustments	11
2	N	college: webster to ashby	51	107	Signal Adjustment; Stop Sign Removal; Stop Relocation or Bus Bulb	25
3	S	college: alcatraz to claremont	59	108	Signal Adjustment; Parking Adjustment; Alter Driveways to Safeway/Access from Claremont	20
4	N	8th St: harrison to broadway	48	76	Loading Zones/Double Parking Enforcement	7
5	N	broadway: pleasant valley to college	60	111	Que Jump; Signal Adjustment; Bus Island; Stop Relocation to FS	40
6	N	college: channing to bancroft	56	153	channing Removed; Signal at Bancroft to safely control turn movements & ped	17
7	N	bancroft / Shattuck: ellsworth to kittridge	55	93	No Recommendation at this Time	NA
8	N	university: curtis to san pablo	70	159	Que Jump Using Parking Lane	35
9	S	Shattuck: university to berkeley bart	57	219	Pedestrian Enforcement; Clearing Bus Zones	3
10	S	Broadway: 51st to 45th	43	124	Signal Adjustment; Que Jump; Bus Island; Stop Alteration	40
11	S	Webster: tinker to atlantic	41	104	Readjust Signal Timing/Move Preference to Atlantic and alter Pedestrian Preference	12
12	N	Broadway: 8th to 11th	43	103	NA	NA
13	N	Broadway: 13th to 17th	53	131	NA	NA
14	S	university: san pablo to curtis	33	86	Que Jump Using Parking Lane ; Stop Relocation	12
15	S	Shattuck: kittridge to durant	36	126	Improve Left Turn Movement/Extend Green Arrow (BRT?)	4
16	S	college: russell to ashby	42	105	Replace Stop Sign at Russell with Signal	21
17	S	college: manila to broadway	28	70	Relocate Stop to FS; Side Street Detectors	1
18	S	broadway / 7th St: 9th to franklin	34	88	Improve Left Turn Movement/Install Turn Arrow	12
19	N	broadway: 11th to 13th	38	68	No Recommendation at this Time	NA
20	S	santa clara: park to broadway	46	104	Signal Timing; Adjust Stop to Farside	9

4.5 Dwell Time

Data collected during the ride check recorded dwell time from the time that the doors opened for passenger boarding and alighting, until the time that the doors closed. Dwell times were found to account for about 20% of the total running time. Dwell time is factor of number of boardings, method of fare payment, lift requests, and the ease of boarding and alighting (i.e. crowded buses have increased dwell because of the added difficulty to board and alight). Our ride check did not record the variables contributing to dwell. However, a recent UC Berkeley report studied the components of dwell time. Components of dwell are discussed later in this report in this report.

Dwell Time by Stop

On average, dwell times on Line 51 are 30-34 seconds per stop. A significant percentage of the total running time of a route is attributable to dwell time. Figures 4.3a, 4.3b, 4.3c, 4.3d, 4.3e and 4.3f show the range of average dwell time for each stop.

Figure 4.3a – Dwell Time – Southern Portion (Northbound)

Figure 4.3a shows the range of the average dwell for northbound stops on line 51 within Alameda. The two stops with dwell time in the 31-47 range are Santa Clara Avenue at Park Street and Webster Street at Atlantic Ave.

Figure 4.3b – Dwell Time – Central Portion (Northbound)

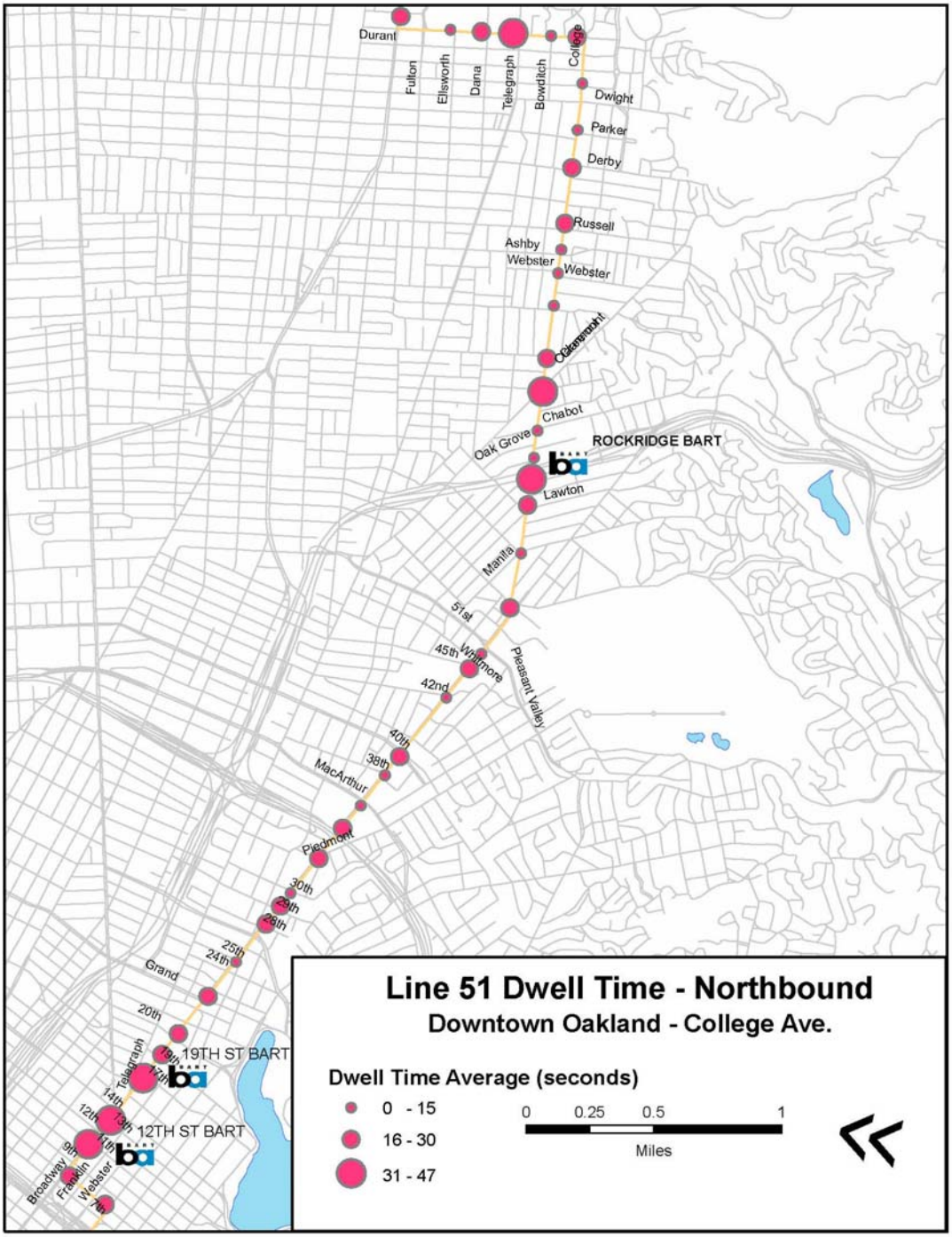


Figure 4.3b details the Broadway –College portion of line 51. Large dwell occurs in Downtown Oakland, at Rockridge BART, on College at Claremont Avenue, and on Bancroft at Telegraph.

Figure 4.3c – Dwell Time – Northern Portion (Northbound)

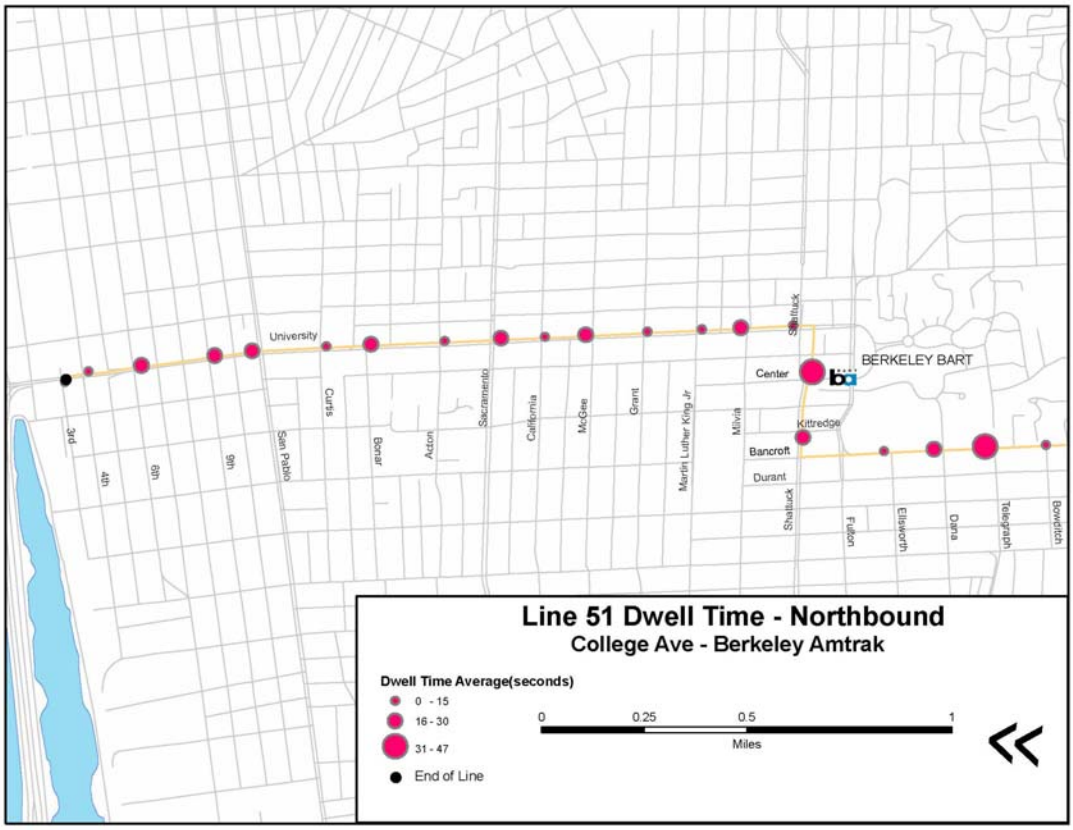
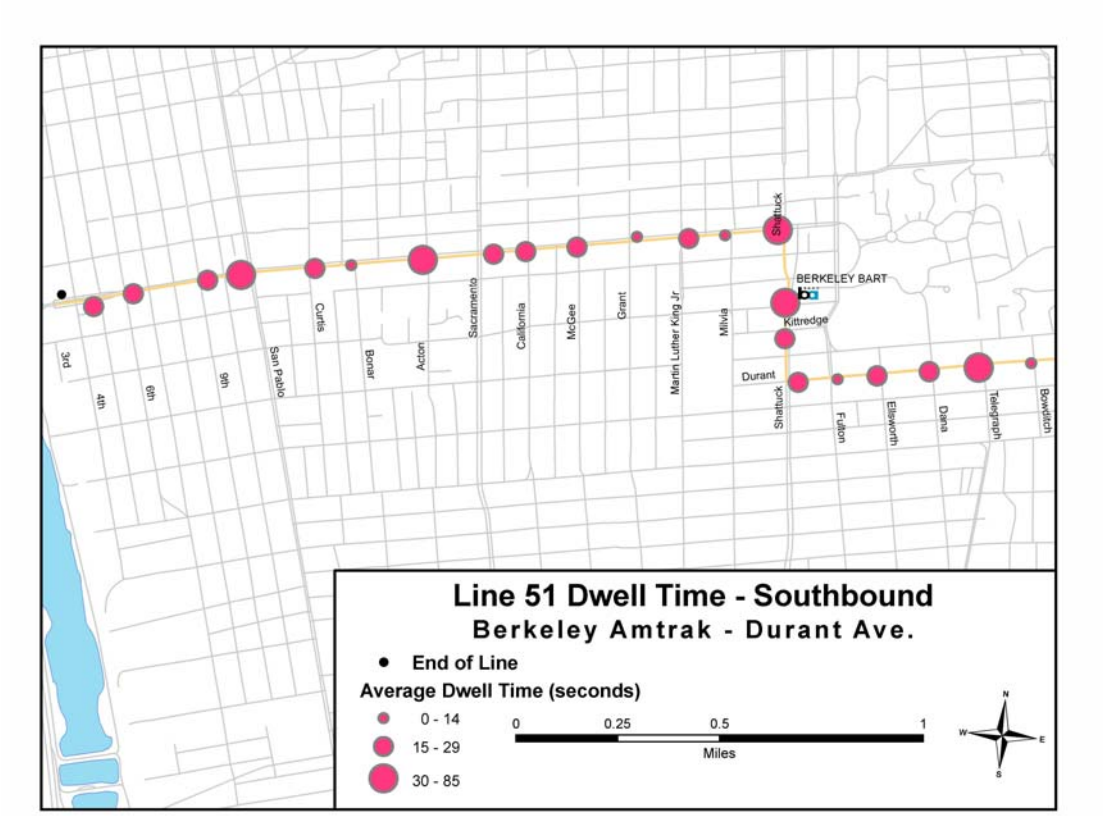


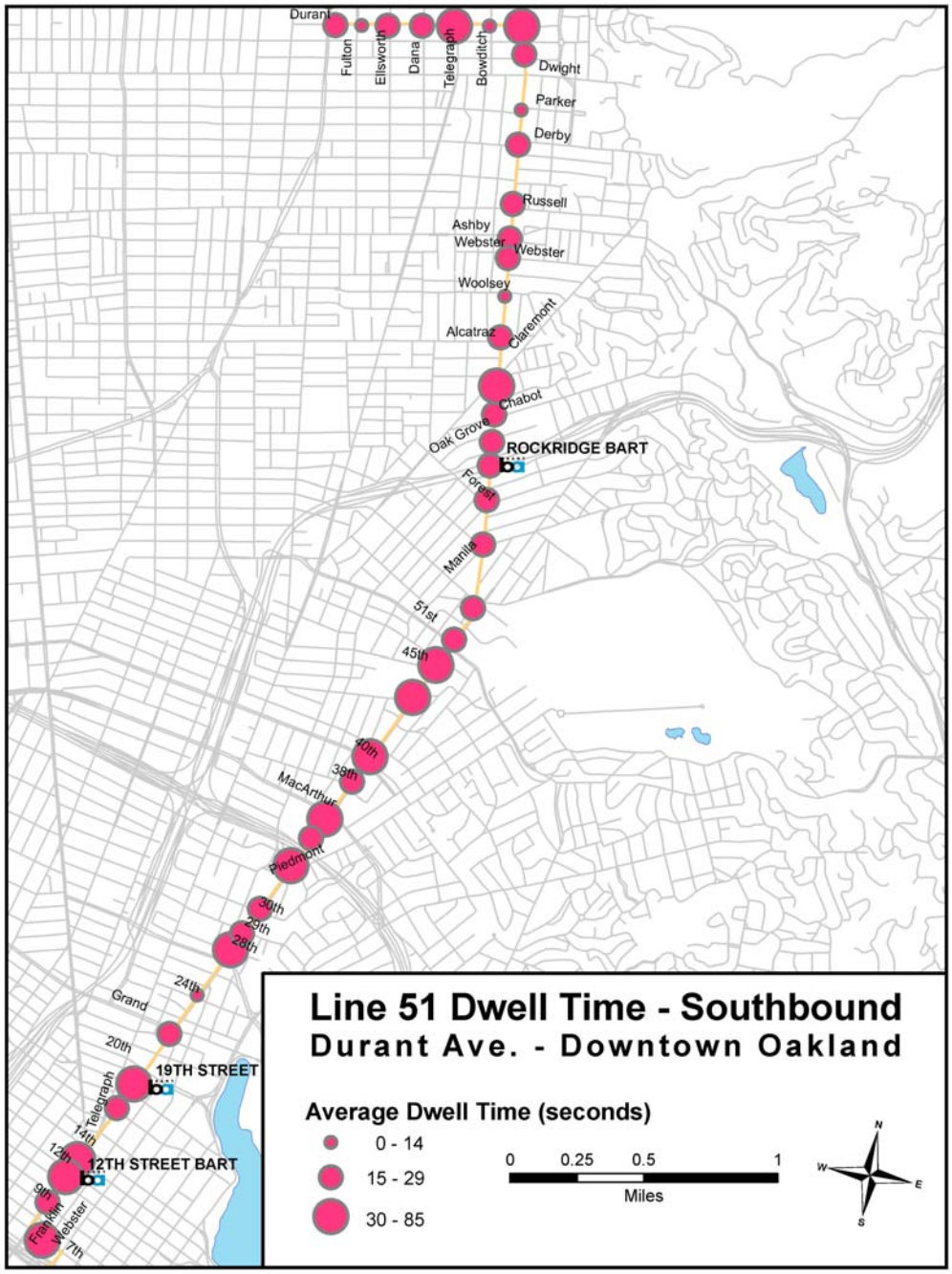
Figure 4.3c displays the large dwell on Bancroft Way at Telegraph and on Shattuck Avenue at Center Street.

Figure 4.3d– Dwell Time – Northern Portion (Southbound)



Heading south, higher dwell time occurs at University Avenue at San Pablo Avenue, University Avenue at Shattuck, Shattuck Avenue at Allston Way and at Durant Avenue at Allston Way.

Figure 4.3e– Dwell Time – Central Portion (Southbound)



Through the College- Broadway portion of the route, long dwell occurs at Durant Avenue at College Avenue, College at Claremont, as well as the majority of stops along Broadway.

Figure 4.3f – Dwell Time – Alameda Portion (Southbound)

Within Alameda, the stops on Webster Street at Buena Vista and on Santa Clara Avenue at Webster Street experienced dwell time over 30 seconds, on average.

Components of Dwell Time

While the delay study conducted by Planning Department Staff did not look specifically at the components of dwell time (but rather dwell as a whole), students at U.C. Berkeley under the guidance of Dr. Betty Deakin, recently (2007) recorded and analyzed the variants and span of dwell time on Line 51[10]. This study looked at passenger fare payments, alighting patterns, and other factors that contributed to the dwell time at each stop.[11] The group developed a model that weighed factors contributing to dwell. Data collected on the Line 51 was entered into the model. The model is statistically significant and explains more than half (52.9%) of the variation in dwell.

The full set of variables observed during dwell, as well as the number of occurrences, is displayed in Table 4.5 below.

[10] Investigating the Contributors to Bus Dwell Time for an Urban University Context by Ryan Greene-Roesel, Junhee Kang, Maria Catalina Ochoa, and Wendy Tao.
[11] Investigating the Contributors to Bus Dwell Time for an Urban University Context by Ryan Greene-Roesel, Junhee Kang, Maria Catalina Ochoa, and Wendy Tao.

Table 4.5 - Variables Observed During Dwell

Variables	Number of Occurrences
Front Door boardings	196
Front Door alightings	121
Back door alightings	159
Number paying with cash	80
Number Paying with "flash type"	125
Number paying with insert card	66
Number of standees	82
Standees > 20	4
Peak period	164
Bus Driver Talking with Passenger	5
Inclement weather /rain	112
Disabled person boarding or alighting	2
Elderly person boarding or alighting	6
Door opens twice	10
Payment Delay	3
Bicycle Loading/unloading	1
Any disturbance	36

The most frequent variable affecting dwell time was fare payment. The U.C. student study determined that passengers who used magnetic striped passes that needed to be “dipped” into the fare box, verified, and then returned to the passenger, took the most time and contributed 6.22 sec/pass to total dwell. Cash payment was only marginally faster, at 5.59 seconds per passenger. Flash pass payment, identified as the variable “N_pass”, took only 2 seconds per passenger boarding. These findings are reflected in Table 4.6 below.

Table 4.6 - Dwell Time Model Parameters

Variables with Significant Effect on Model	Unstandardized Coefficents (B)	T-Value	Significance
Boarding using cash	5.59	5.73	0.00
Boardings using insert card payment	6.22	6.9	0.00
Boardings using flash-pass type payment	1.97	6.39	0.00
Front door alighting	2.15	4.33	0.00
Disabled person boarding or alighting	41.33	5.45	0.00
Door opening twice	13.68	3.94	0.00
Senior person boarding or alighting	10.13	2.3	0.02
Number of standee greater than 20	21.05	3.91	0.00

Cash payments were observed to take slightly less time than, "dipped" fare media, and passengers using flash/contactless passes were able to board in the least amount of time. AC Transit's own APC data supports that flash passes are indeed faster than cash, 10-day and 31-day passes.

The U.C. Berkeley dwell study also revealed that the dwell time increased when large groups of standees were present, as the standees tended to stand near the front of the bus and blocked the aisle for those

waiting to board. Front door alighting also increased dwell time, because the passengers getting off the bus interfered with the boarding process, losing an estimated 2 seconds per passenger. Doors opening twice for passengers added a 13.68 seconds toward dwell. Some variables with less frequent occurrences, such as elderly and disabled boardings or bicycling loading were noted, though more data are needed to adequately assess these variables.

Pre-paid transit flash passes (i.e. Class Pass) can have both a positive and negative influence on dwell time; the passes reduced the boarding times per passenger, but encouraged more riders to use the bus for short trips (that could otherwise be completed by walking) since there is not a per ride fare paid.

Fares and Pass Programs

Several methods exist to pay bus fare on all AC Transit routes, including Line 51:

- Cash Fare (Discounted for Seniors and Youth)
- Ten Ride and Monthly Magnetic Stripe Passes
- Translink (contactless)
- University Flash Pass
- Various Employer Based Pass Programs

In addition to the above-mentioned fare media, AC Transit's fare structure includes the use of transfers. All fares, including cash, ten ride, transfers and monthly passes must be entered or dipped into the fare box. The breakdown of passengers paying with each type of fare medium was discussed in the AC Transit On-Board Rider survey released in 2003[12]. According to the survey, approximately 30% of passengers in Alameda and Central Oakland pay with cash fares. Monthly or ten ride passes accounted for 34% of riders in Alameda, and nearly 40% of riders in Central Oakland.

The Berkeley/Albany area has different fare payment patterns because of the large student population and the variety of pass programs available. Cash fare in Berkeley is the lowest in AC Transit, at 24%. According to the survey, pass instruments were used by 24% of surveyed Berkeley riders; 35% of those were UC Berkeley passes. There are three pre-paid bus pass programs within the Berkeley area serviced by Line 51: City of Berkeley staff (1,400 participants), University of California students (26,000 participants), and University of California staff (all three are pre-paid fares). These programs are important because pre-payment, flash type passes have been shown to improve bus operations by reducing boarding time and dwell at bus stops.[13] Pre-paid fare passes reduce boarding times and dwell because there is no magnetic verification, but rather the driver is shown the pass. This reduces the boarding time by two thirds (from an average of 6 seconds to 2 seconds per passenger).

[12] 2002 Onboard Riders Survey System Wide Results produced by AC Transit
[13] Investigating the Contributors to Bus Dwell Time for an Urban University Context by Ryan Greene-Roesel, Junhee Kang, Maria Catalina Ochoa, and Wendy Tao.

5. INPUT FROM OTHER BUS AGENCIES

5.1 Peer Routes

Once the main problems on Line 51 had been identified, an effort was made to contact transit systems with reliability issues on peer routes. AC Transit Planning Department staff interviewed planning and operations staff from four transit agencies nationwide, via telephone and email, and information was gathered concerning routes with similar characteristics to AC Transit's Line 51.

Peer routes were defined as those meeting criteria in the following areas of similarity: service area, ridership relative to other routes, service to multiple attractors (such as a university and a commercial district), current or past concerns with schedule adherence, a portion of route operated on a one lane roadway, and participation in a no-cost at boarding University pass program. Appendix XYZ contains a table which details a variety of characteristics that form a basis for inter-agency comparison, including travel time, average speed, passengers per hour, headways, and fare collection methods.

In addition to collecting data from other agencies, Planning Department Staff obtained information on two other AC Transit routes which share characteristics similar to the Line 51; Lines 40 and 18. One characteristic that these lines share with Line 51 is that portions of the routes operate on a one lane roadway, which contributes to "bottleneck," or slower traffic conditions. On Line 51, the one-lane portion of the route falls on College Avenue. For Line 18, the one-lane portion is on Solano Avenue, and on Line 40, on Foothill Boulevard. Common to all three routes was poor on time performance. Line 40 had especially poor schedule adherence with a large portion of the route operating on a narrow one lane road, and with larger articulated vehicles. Lane configurations contribute to operational issues.

5.2 Best Practices

A list of best practices was developed in conjunction with the Peer Review, help to define creative ways to fix irregularly performing routes. In our interviews with agencies about their highly used, irregularly performing routes, staff asked what practices were used to improve their system and recapture reliability in their service. Some of the responses included changes made on alternative routes to shift riders. Many agencies indicated the need to invest more resources, such as supervision, in order to provide reliable service and retain or grow ridership.

Table 5.1 outlines some of the practices, as well the how the practice was implemented, and by which agency or agencies.

Table 5.1 - Best Practices

Practice	Impact	Agency Implemented
Short Turn	Madison Metro Transit incorporated short turns on their route, decreasing frequencies at either end to one in every second or third trip.	Madison Metro Transit
Split Route	Metro Transit in Seattle split their route, making two shorter routes (and has since experienced better OTP). This however, was in reaction to a significant loss in ridership due to reliability issues. Reportedly, ridership is recovering. Staff at Metro Transit noted a significant cost increase to operate a split routes service at the same frequency.	Metro Transit (Seattle)
Coupled Service	Several different approaches were used to provide underlying service. • Madison Metro Transit added underlying commuter services during peak hours. • Metro Transit (Minnesota) added a complete limited route service to its underlying local service. The agency experienced healthy ridership distribution between local and limited service. • Metro Transit in Seattle added service using different line numbers, which still served most, but not the entire corridor. • Sacramento Area Regional Transit uses a limited stop which stops 15 times, rather than the 50 on the local service.	• Madison Metro Transit • Metro Transit (Minnesota) • Metro Transit (Seattle) • Sacramento Area Regional Transit
Extra Running Time	Built in extra running time to accommodate for variation in travel time. Added hold time later in route, which has been used to allow drivers to catch up.	Metro Transit (Minnesota)
Extra Recovery Time	Increased recovery time by more than necessary to absorb lateness and reduce late departures from terminal.	Metro Transit (Minnesota)
Stop Spacing Changes	Phased in stop changes and removals. Increasing stop spacing reduced underutilized stops and improved route efficiency.	Metro Transit (Minnesota)
Transfer Hubs	Madison Metro Transit changed their system from a cross town radial service area to a hub and spoke system. OTP is measured at the pulse point, so passengers can make transfers at pulse release points. Transfers are offered at no cost. With heavy use at the University, the agency built in more recovery time for those routes.	Madison Metro Transit
Fare Media	Agencies have shown preference to flash passes, over magnetic stripe passes. The added delay to passenger loading compromises OTP and end to end travel time.	Madison Metro has noted the delay with magnetic stripe passes and is advocating to moving towards a flash pass.

6. ANALYSIS & RECOMMENDATIONS

The final goal of The Line 51 Task Force was to develop recommendations to improve route performance. Throughout the course of The Line 51 Study, Planning Department Staff collected and analyzed a variety of data in order to characterize and quantify the service and reliability problems that had been identified on the route. As this data collection and analysis took place, an emphasis was placed on obtaining data that could lead to feasible solutions to the challenges observed on the route. The cities along the line have participated in this process and plan to work cooperatively with AC Transit to implement these recommendations.

Improvements presented in this section are grouped in three categories; larger, route level recommendations, more detailed segment level proposals, and service design options. The recommendations put forth address issues that are in the control of the affected Cities as well as AC Transit; travel time, reliability and stop accessibility. This collaborative approach was designed to maximize the benefit to all transit users, and insure that the implementation of suggestions made in this report will result in a positive effect on general traffic and congestion.

Route Level Recommendations

While many improvements in this report are specific to a route segment, there are some improvements that can be applied to Line 51 as a whole. These route level recommendations include the following:

- Stop removals and re-spacing
- Lengthening bus stops
- Defined clear areas (ADA compliance)
- Encourage Translink Usage
- Schedule Refinements
- UC Berkeley Area Services
- Signal Coordination/Signal Actuation
- Active Line Management
- Real-Time Passenger Information Systems/Passenger Amenities
- Rear Door Alighting
- Supplemental Service
- Scheduled Dwell Point
- Operator and Dispatch Procedures

Each of the above mentioned recommendations will be explained in this section.

Stop Removals and Re-Spacing

Bus stop spacing has a major effect on transit vehicle and route performance. The closer stops are placed along the route, the slower the speed of the bus. This slowing of the bus happens because closely spaced stops require constant acceleration and deceleration; reducing the speed of the route. If stops are placed farther apart on the route, then higher speeds can be achieved for longer durations of time, thus decreasing the running time of the trip[14].

AC Transit Board Policy 508 states:

> *"Outside the downtown areas, AC Transit generally seeks to have bus stops 1,000 feet apart. This target has been set with the goal of increasing travel speed for AC Transit buses, and means that some existing stops will be eliminated. Passenger usage of bus stops is an important factor when considering bus stop placements or removals."*

[14] TCRP 19- Guidelines for the location and Design of Bus Stops (Part B)

The Policy goes on to state that "stops should be close enough that passengers can walk to them easily, but far enough apart to help buses move quickly". The policy recommends bus stop to be spaced between 800-1300 feet apart. However, if appropriate, but does allow for stops to be closer than 800 feet or farther than 1300 feet.. Adequate spacing of bus stops on Line 51, in accordance with the AC Transit Board Policy, would help to reduce the running time of buses on this route and thus speeds up the route.

In order to achieve appropriate spacing, bus stops need to be removed on Line 51. Bus stop removals follow a process outlined in Board Policy 509. AC Transit does not own or maintain bus stops, and so the local jurisdiction controls the final placement of the stops and works with AC Transit to determine the best location. In order to remove a bus stop, AC Transit must work closely with the cities to follow Board directed processes.

Staff has made recommendations for bus stop removals in several areas of Line 51. The recommended stop removals and the justifications for them follow. The estimated time savings is in Table 6.1.

City of Berkeley Stop Removals

- Bancroft at Bowditch NB
- Durant at Bowditch SB
- College at Webster SB/NB
- University at Milvia SB/NB
- Durant at Fulton SB

Bancroft at Bowditch is poorly placed between two crosswalks. The bus stops both to the north and south of the stop at Bowditch are in better condition, are more highly used (with almost twice the ridership), and are within reasonable walking distance (1556 and 536 feet respectively) of this stop.

College at Webster is a poorly designed stop with inadequate curb space in both directions. The northbound stop is located between two residential driveways, and the southbound stop has inadequate curb space and no pull-out area. In addition, this stop is very close to the stop at Ashby. Once a bus operator pulls over to this stop, it is difficult to re-enter traffic because of the significant volume of traffic queuing along College Avenue. Ridership is low at this location.

The stop at University and Milvia is proposed for removal. Recently, a bus stop was added at University at Shattuck, 674 feet east of the stop at Milvia, which serves as a similar transfer point and is a reasonable walking distance away.

The stop at Durant and Fulton is also recommended for removal. This location has no companion stop for passengers to board. This stop is closely spaced (about 500 feet) to neighboring bus stops at Durant at Ellsworth and Durant at Shattuck.

The stop at University at Curtis is proposed to be removed. The stop is not well utilized and is easy walking distance to both stops both at San Pablo and at Bonar. Removing this stop will save an estimated 20 seconds of running time, and all buses will be able to remain in the travel lane; eliminating the need to pause while waiting to re-enter traffic.

The stop at University at California is proposed to be removed. The resulting stop spacing allows for easy walking distance to the next stop.

City of Oakland Stop Removals

- Broadway at 45th/Whitmore NB/SB
- Broadway at 38th NB/SB
- Broadway at 30th NB
- Broadway at 29th SB
- Broadway at 19th NB

The stop at Broadway and 45th/Whitmore is proposed for removal. In the southbound direction, the removal of the stop at 45th causes the remaining stops, at 51st and 42nd, to be more than 1300 feet apart. This problem can be resolved by moving the stop at 51st to the far side of the intersection, which subsequently reduces the spacing to 1150 feet. In the northbound direction, the removal of the stop at Whitmore creates stop spacing of 1144 feet between Mather and 51st. With the removal of 45th/Whitmore, the bus stop at 42nd/Mather will be the main stop in front of Oakland Technical High School. It is further proposed that the bus stop at Mather be relocated to the far side in order to further improve distance, to provide a larger waiting area for students and to create a more accessible stop.

The bus stop at Broadway and 38th is poorly utilized and has very few cross streets nearby that would allow passengers to access the bus stop. Also, the stop is located in an uncontrolled intersection which can cause unsafe walking conditions for those wishing to cross the street. Improved and upgraded bus stops are being developed as part of the Kaiser development and passengers will be able to access a bus stop at 40th or MacArthur. This stop is not recommended to be removed until construction of the Kaiser Center is completed.

The bus stops at Broadway and 30th Street Northbound, and 29th Street Southbound, are proposed to be removed. Since these stops are so closely spaced, taking one from each direction will create a pair of slightly off-set stops and retain the better of both stops. The bus stop at 30th Street has a limited landing area due to large curb cuts in the sidewalk. The curb cuts are utilized by the neighboring auto dealership to showcase cars, which limits the bus from accessing the stop. 29th Street Northbound is a well utilized stop and provides access to a grocery store. 29th Street Southbound is often blocked by automobiles being serviced at a nearby repair shop, since part of the bus stop is a driveway and there is not a means to regulate it. The stops at both 29th and 30th Streets serve medical facilities and grocery stores, but providing service to two stops on the same block proves to have a negative impact on bus service. Crosswalks and signal controls allow for easy movement between the stops in this area.

The stop at Broadway and 19th Street, Northbound, is proposed for removal. There is no companion stop at this location, and sufficient stops with amenities exist at both 20th Street and 17th Street (with easy access to the 19th Street BART station). The revised stop spacing between 17th and 20th Streets is 1159 feet.

City of Alameda Stop Removals

- Santa Clara at 9th NB/SB
- Broadway at Lincoln NB/SB
- Broadway at Tilden relocated to Buena Vista NB/SB

Two sets of stop removals are recommended for Alameda. Santa Clara at 9th Street is proposed for removal due to the particularly short stop spacing, and reasonable walking conditions to nearby stops. Broadway at Lincoln is proposed to be removed, and Broadway at Tilden is proposed to be relocated to Buena Vista. These two removals would close the gap between stops and service the residential area surrounding the stops. Broadway at Lincoln has particularly low ridership.

Estimated Time Savings

Planning Department staff proposes to remove 22 bus stop locations (approximately 15% of total stops) along the route, pushing the average spacing closer to the AC Transit policy, and, in turn, speeding up the service. Planning Department Staff estimate that running time would be reduced 10-35 seconds per stop elimination; depending on the placement and context of the stop. The estimated cumulative time savings for Line 51 would be eight minutes per round trip, as outlined in Table 6.1 below.

Table 6.1 - Estimated Time Savings from Stop Removals

Northbound Stops	Time Savings (sec)
University at California	35
University at Curtis	35
University at Milvia	20
Bancroft at Bowditch	20
College at Webster	20
Broadway at Whitmore	35
Broadway at 38th	20
Broadway at 30th	10
Broadway at 19th	20
Santa Clara at 9th	20
Broadway at Lincoln	15
Northbound Subtotal	**250 (4+ minutes)**

Southbound Stops	Time Savings (sec)
University at Curtis	20
University at California	35
University at Milvia	30
Durant at Fulton	20
Durant at Bowditch	35
College at Webster	35
Broadway at 45th	15
Broadway at 38th	20
Broadway at 29th	20
Santa Clara at 9th	20
Broadway at Lincoln	15
Southbound Subtotal	**265 (4+ minutes)**

The total time savings from the proposed bus stop removals (Northbound and Southbound) is estimated at 8.5 minutes. Bus stop reductions and relocations are an important step because they increase the time savings of other improvements; including moving stops from near to far side and the installation of bus bulbs. The reduction in the overall number of stops also allows the bus to travel more quickly between stops and eliminates the time it takes the bus to slow down, pull out of traffic (into the stop), and re-enter traffic to depart. Stop removals have only been proposed in areas where walking conditions are good, spacing to the next stop is not cumbersome, and, generally, the stops were not well utilized. The dwell time at a stop is not included in the time savings listed above, as riders will likely board at the next closest stop, and the overall number of passengers on the route (and the time it takes them to board) will not change.

Lengthening Bus Stops

Staff surveyed all bus stops on Line 51. The majority of stops surveyed are curbside and out of the travel lane. However, many bus stops have insufficient red curb space for the bus to pull out of traffic and into the bus stop.

AC Transit has developed standards for bus stop lengths pertaining to stop location and vehicle size, which allow for free flow of traffic and facility of passenger boarding. These standards can be found in AC Transit's handbook, "Designing with Transit." For example, the minimum length of a bus stop on the near

side of an intersection is the length of the bus plus 30 feet. Line 51 typically uses 40 foot long buses, so the minimum bus stop length for a near side stop on Line 51 is 70 feet. Far side stops, at a minimum, should be the length of the bus plus 20 feet (Far side stops tend be shorter than near side stops, as the intersection is used to pull into the stop). This standard dictates a minimum length of 60 feet on Line 51 far side bus stops.

A final important note on bus stop lengths, involves the ramifications of short bus stops on Line 51, considering the equipment being used on this route. The wheel chair, low floor ramp on Van Hool buses used on Line 51 is deployed from the middle door The wheel chair ramp on other AC Transit buses is located at the front door. A short bus stop makes it very difficult to safely deploy the wheelchair ramp on Van Hool coaches.

Defined Clear Areas (ADA compliance)

Stop area amenities, including newspaper racks, trash receptacles, landscaping, benches, etc., can enhance the experience of waiting for the bus. However, if there are poorly placed objects along the sidewalk operators, may have to adjust their position to make sure that the doors open onto a clear space and the wheel chair ramp can be deployed. The added movement of the bus as it repositions itself increases the time it takes to board and alight passengers, and creates further accessibility issues for passengers waiting for the bus who require the lift.

Cities and AC Transit must cooperate in the design and implementation of a bus stop layout in order to maintain access from all doors and ramps. Using the bus pole as the point where the bus will stop, the first 5 feet (by 8-ft deep) prior to the pole need to be clear. The middle door wheelchair ramp also requires a landing area; an 8-ft by 8-ft landing area, starting 16-ft from the bus pole, is required.

Encourage Translink Use

Boarding time is an area of service that AC Transit has some control over. Staff recommends increasing Translink use as a fare medium, eliminating or reducing cash fares at major stops (by offering pay stations; pilot program at the highest ridership stops). All passes should be converted to Translink in order to eliminate dipping the passes for magnetic verification.

A second way to address delay and dwell related to fare payment is to add ticket machines at bus stops. Adding ticket machines at all bus stops is cost-prohibitive. A more cost effective way to do this, would be to only require pre-payment at the bus stops that have the highest ridership (i.e., major transfer locations/BART Stations). This way, multiple routes could benefit from the reduced dwell time. Passengers should still be required to board through the front door and show their ticket as proof of payment to the driver.

Both the BRT and Transbay Terminal projects offer the opportunity to demonstrate proof of payment technologies. These projects use proof of payment as key parts of their service. Issues that may need to be addressed include ticket machines, transfer policies, and passenger training.

Schedule Refinements

Planning Department Staff recommends further redistribution of scheduled running time on this route in order to optimize travel time. The scheduled run time is too long in the early morning (6AM-7:15AM) and in the evening (after 6PM). The extra running time necessitates drivers to operate slower than traffic conditions allow. Drivers will adjust their driving practice to use the extra time by driving slowly. APC data captures incidents when running time is too short by recording late arrivals at time points; however APC data does not identify excessive running time because drivers are not allowed to arrive at a time point early. Run times should encourage drivers to operate as quickly as circumstances and traffic will safely allow, providing passengers with the quickest trip and using AC Transit resources efficiently.

Schedules should also accommodate for surges in ridership. Ridership data shows that AM ridership on Line 51 follows a more dispersed pattern between 7AM-9AM, with northbound service carrying heavier loads than southbound. Conversely, southbound trips carry heavier loads in the afternoon between 3-4:30PM. Ridership spikes should be accommodated with the appropriate service level or with vehicles with greater capacity.

UC Berkeley Area Services

UC Berkeley operates a campus oriented shuttle program. The P-Line on this service (operating along the perimeter of the campus) offers service every 12 minutes from 7AM to 7PM. Many destinations, such as Sather Gate and Downtown Berkeley BART Station, are common to both the Line 51 and Line P. An appropriate level of service should be maintained to provide transit for the dense area surrounding the campus. AC Transit will work with UC Parking and Transportation to conduct more analysis on whether additional service on the P-Line is needed.

In addition to increased service in Berkeley, AC Transit recommends installing way-finding signage at major stops like Bancroft and Telegraph. This signage should indicate the campus bus and AC Transit bus lines that serve Downtown Berkeley BART and other major destinations. Increasing passenger awareness of all the options available for a particular trip can promote ridership, reduce confusion, and reduce questions asked of the driver.

Signal Coordination/Signal Actuation

Coordinated signals along the major arterials, like Broadway and University Avenue, would significantly improve travel speeds on Line 51. The current, "fixed-timing," system gives green phases to both side streets and the main street. The fixed signals can be better coordinated so that buses will be able to travel through a series of green lights instead of continually stopping and going through signals that are not coordinated. Side street detectors and actuated signals along University Avenue and Broadway are recommended. Side street detectors will provide green time to side streets only when a car approaches the intersection, and thus reduce signal cycling and maximize green time along the main corridor. Pedestrian actuated technology can maintain the integrity of safe pedestrian crossings by turning signal lights to allow for pedestrian cycle. Both of these technologies would improve the corridor for transit, pedestrian and general traffic.

Active Line Management

AC Transit has put together a team of supervisors (Line Management Team) to manage problematic routes throughout the district. One supervisor is placed at each end of the route while one supervisor is placed near the middle. In this recommendation, we aim to further develop this management concept.

In order to better understand reliability issues on Line 51, Planning Department Staff conducted On-Time Performance (OTP) data collection both with and without the Line Management Team. Tests were done on similar days, with consistent traffic conditions and weather. The data showed that having the Line Management Team monitoring the line resulted in an improvement for on time departures and OTP throughout the route.

Further strategies can be implemented to improve schedule adherence, overcrowding and improper spacing. For routes that perform unpredictably, like the Line 51, active management (not only monitoring) is required. At a minimum, supervision should instruct operators to:

- Operate closed door (Improves spacing between buses)
- Deadhead to the terminus (Ensures the bus leaves on time for the next trip)
- Pass their leader ("help out" with heavy loads and to reduce bunching)

A better utility of the District's investment in technology should also be encouraged, such as remote supervision and management. Automatic Vehicle Location (AVL) information can be used to help supervisors monitor bus locations in real-time in order to better manage the route. Additional tools and standardized responses would empower supervisors to respond to situations like bus bunching, crowding, and poor headway adherence.

Operator and dispatchers procedures can also be improved. Currently, the agency is gathering information on strategies to address active management procedures from other agencies.

Real-Time Predicative Arrival Information

Real-time passenger information was added to Line 51 in June 2007. This service, known as Nextbus, provides passengers with an estimate of when the next bus should arrive at the bus stop. The information can be accessed online or on a Personal Data Assistant (PDA). The next step in providing this type of information would be to have electronic signs at each bus stop providing similar information to that discussed above. However, electronic signage is costly. Information on how to access NextBus via cell phone or PDA can be posted on the flag or pole, indicating to passengers that arrival information is available

Rear Door Alighting

Front door alighting can delay other passengers from boarding[15] and increase dwell times for the bus. In order to reduce dwell, AC Transit should encourage passengers to move toward the rear of the bus and exit through the rear doors. The improved circulation would result in passengers being able to board as quickly as possible, eliminating the conflict between boarding and alighting passengers. Many other transit agencies, such as SFMTA, achieve this communication of boarding etiquette through signage and AVA messages that state, "Please exit the rear."

Supplemental Service

Additional supplemental service will prevent over crowding and reduce delays to local service on Line 51. Currently, supplemental service is offered at Oakland Technical High School and Claremont Middle School. School related overloads affect basic schedules into the afternoon commute. Delay data shows excessive delay due to large numbers of boardings at Shattuck at Kittridge in the afternoon. Similar patterns of heavy boardings in the afternoon occur at other schools. To prevent continued impact on local service into the commute hour, Planning Department Staff recommends using articulated buses for the supplemental service that begins at Oakland Technical High School and heads Southbound towards Downtown Oakland. There also is a need for supplemental service at Berkeley and Alameda High Schools and both of these schools have sufficient demand to use articulated vehicles.

[15] Investigating the Contributors to Bus Dwell Time for an Urban University Context by Ryan Greene-Roesel, Junhee Kang, Maria Catalina Ochoa, and Wendy Tao.

Scheduled Dwell Point

A final route level recommendation is the proposed insertion of a “dwell point” at Rockridge BART Station. A dwell point, is a mid-route location where a few extra minutes are added to a schedule for arrival and departure times. This added time buffer allows a late bus the opportunity to recover and helps keep buses evenly spaced to reduce bus bunching. Dwell points are typically no more than 3-4 minutes long, in order to reduce possible delay to the passenger. Creating a 3-4 minute dwell point at Rockridge BART during the afternoon and evening peak would help reduce bus bunching south of Rockridge. A bus running a few minutes late could regain proper headway spacing with the bus ahead by holding at this dwell point.

6.1 Segment Level Recommendations

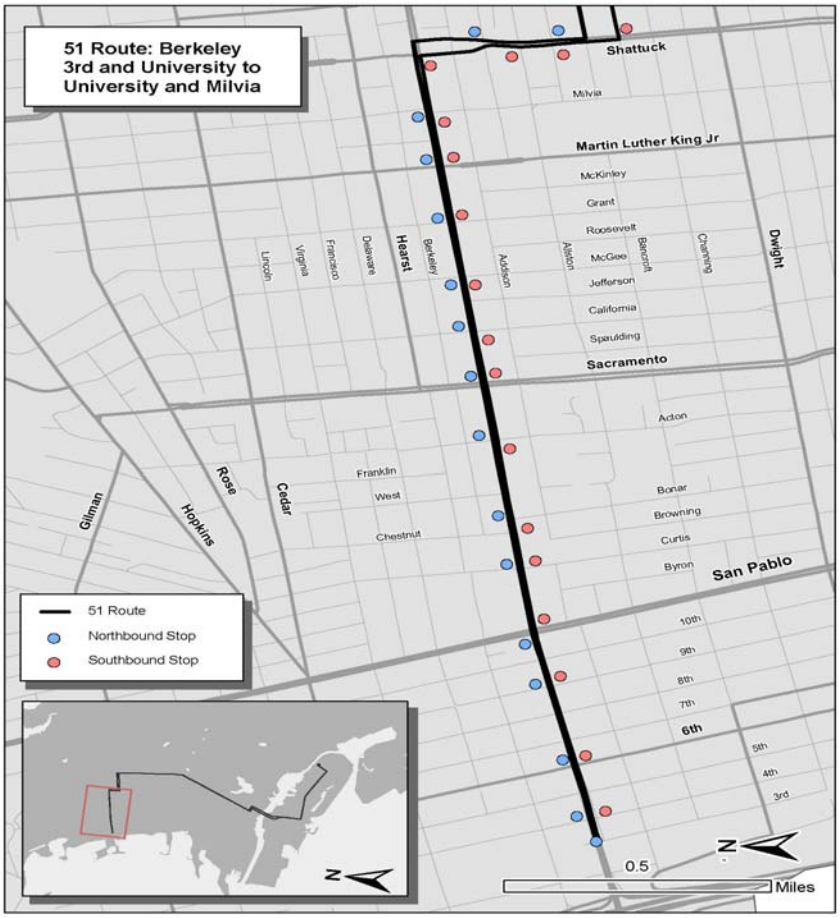
A segment-specific improvement plan has also been developed for Line 51. These recommendations for improvement and their associated time savings estimates are included. Each segment on the route presented is considered individually, although cumulative time savings would occur as a result of these recommendations. The northbound recommendations are estimated to save over 13.5 minutes of running time, while the southbound recommendations are estimated to save 12.5 minutes. Together, these recommendations would save an estimated 26 minutes on a round trip of 173 minutes.

The following recommendations are largely low cost and can be implemented with City approval. These recommendations focus on improving transit within the framework of existing mixed-flow bus operations. More transformative transit measures and alternatives, along with a more complete list of estimated time savings, are discussed in the SFMTA Transit Effectiveness Program Tool Kit located in the Appendix. The three common roadway treatments considered for this report are:

- Queue Jump: Consists of a lane, sometimes made from a parking lane or a right turn lane, where designated vehicles may bypass the queue of cars at an intersection. A Queue Jump creates a non-exclusive lane for the bus to proceed straight. A far side bus stop acts as a receiving zone, which improves efficiency, access into the bus stop, and reduces travel time. Without a far side stop, a continuous lane or additional signal phase is necessary.
- Bus Lanes: Dedicates a travel lane for use by transit vehicles (though some exceptions, namely emergency vehicles, may apply). Bus lanes vary in length, and shorter distances are useful for getting transit vehicles around a single congested area. Longer bus lanes can create a system for buses to travel along entire stretches of roadway.
- Peak Hour Parking Restriction: Creates an additional lane of travel during peak travel times by converting continuous parking stalls into a lane of travel. Typically, this extra capacity along the roadway is for all vehicles and is not limited to transit vehicles.

3rd and University to Downtown Berkeley BART

Figure 6.1 – 51 Route Map



This segment of the route serves several destinations, including Amtrak, grocery stores, recreational activities and transit transfer points. Passenger boardings exceed 2,965 per day, with 675 of those occurring at the Downtown Berkeley BART Station. Delays along this segment are lengthy (exceeding 30 seconds) with a low degree of predictability (the location and duration of delay varies greatly). This variability in delays makes scheduling the running time for this segment difficult.

In the southbound direction, delays were observed at 6th Street (25 seconds) and San Pablo Avenue (30 seconds). In the northbound direction, delays were excessive leaving Berkeley BART, approaching San Pablo Avenue, and between San Pablo and 6th Street. The delay associated with the left turn movement from Shattuck Avenue to University Avenue, westbound, approached 90 seconds, on average. The traffic signal at San Pablo Avenue and University Avenue added one minute of delay. The signal delay from San Pablo Avenue to 4th Street averaged 90 seconds. Buses heading west on University Avenue are also delayed due to heavy traffic going to I-80.

Southbound:

1. Create a queue jump on University Avenue from 4th to 6th streets by eliminating 4 parking spaces during the peak periods. This would allow the bus to bypass the queue of cars at the signal. The sidewalk on the south-side of University Avenue near side of 6th Street may need to be narrowed to accommodate the additional lane up to the intersection.
2. Create tow-away lane from 6th to 9th from 4 to 7 pm daily, increasing roadway capacity. This would reduce random delays that result from heavy weekday commute and weekend general traffic. This recommendation affects 20 parking spaces.
3. Create a queue jump from 10th to San Pablo by removing 4 parking spaces; relocate existing nearside stop to existing far-side stop.
4. Remove the bus stop on University Avenue at Curtis Street.
5. Remove the bus stop on University Avenue at California Street.
6. Relocate the bus stop on University Avenue at McGee Avenue to the far side.
7. Create queue jump on University Avenue at MLK Jr. Way using the existing right-turn pocket; add “Right turn only, Bus Excepted” signage.
8. Remove bus stop on University Avenue at Milvia Street.

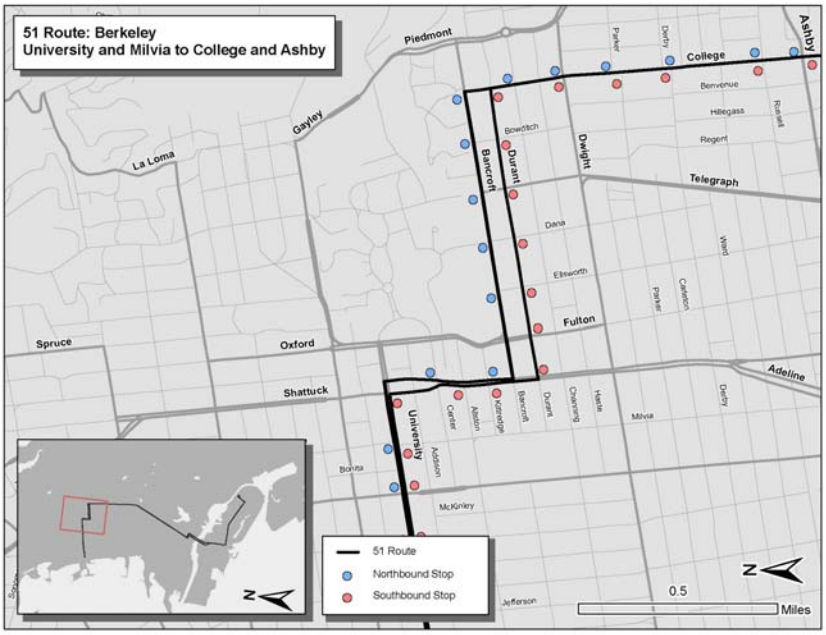
9. Maintain clear bus zones in Downtown Berkeley and around BART Stations to reduce delay entering stops.
10. Pedestrian enforcement in Downtown Berkeley in order to reduce mid-block delay and improve safety.
11. Coordinate and upgrade the signals on University Avenue to improve flow of traffic, reduce queuing and give priority based on demand.

Northbound:

1. Pedestrian and bus stop enforcement in Downtown Berkeley in order to reduce mid-block delay and improve safety.
2. Improve signals phasing at Shattuck Avenue/University Avenue intersection to facilitate move of vehicles through intersection.
3. Remove bus stop on University Avenue at Milvia Street.
4. Relocate bus stop on University Avenue at MLK Jr. Way to the far side. Leave near side stop in as a queue jump/right turn pocket; add “Right turn only, Bus Excepted” signage.
5. Remove bus stop on University Avenue at California Street.
6. Relocate bus stop on University Avenue at Sacramento Street to the far side; use near side stop as a queue jump lane.
7. Relocate bus stop on University Avenue at Acton Street to the far side.
8. Create a queue jump lane on the near side of San Pablo Avenue by removing 4 parking spaces. In addition, move the existing 52L bus stop onto San Pablo Avenue in order to remove conflicts between two buses.
9. Create a queue jump from 7th to 6th by eliminating 2 parking spaces and creating a bus lane.
10. Relocate bus stop on University Avenue 9th Street to the far side.
11. Create a tow-away lane from Curtis to 6th Street, from 12 noon to 7 pm daily. This would reduce random delays that result from heavy weekday commute and weekend visitor traffic. This affects 33 parking spaces.
12. Create a tow-away lane from Ohlone Greenway to Curtis Street from 12-7PM daily. This would reduce random delays that result from heavy weekday commute and weekend visitor traffic. This affects 17 parking spaces.
13. Coordinate and upgrade the signals on University Avenue to improve flow of traffic reduce queuing and give priority based on demand.

Berkeley BART to Telegraph Avenue to Rockridge BART

Figure 6.2 – 51 Route Map



Portions of this segment are tied to the future Bus Rapid Transit (BRT) alignment, and so recommended improvements to bus stops and routes are aligned with that project. This segment experiences nearly 3,500 boardings daily, and speeds are extremely slow (*8 to 9 mph northbound, below 7 mph southbound*). College Avenue is the most congested portion of the route, with speeds between 7 and 8 mph in each direction. The street is narrow, rarely has room for passing, and is highly congested because of the large number of destinations *(including residential neighborhoods, commercial districts, freeway access and BART*). There are several factors that contribute to this congestion: traffic controls which do not favor traffic movement or volumes, multiple curb cuts that allow left and right turns at poor locations, and closely spaced bus stops.

In the southbound direction, service on this segment is delayed at the Shattuck/Durant traffic signal by 30 seconds per trip. However, Planning Department Staff recorded worst case delay at this location to be two minutes. The route between Alcatraz and Claremont was also found to experience excessive delay; one minute of delay due to signals (with uncoordinated signals at Alcatraz and Claremont), right turns into the bank parking lot, pedestrian movements, and automobile parking delays. In addition, previous studies have identified the left turn from College into the Safeway parking lot as a cause of delay. Delays also occurred between Russell Street and Ashby Avenue, caused by both the stop sign at Russell and the signal at Ashby. The total delay southbound on this segment is three minutes.

In the northbound direction, where Line 51 operates on Bancroft Way, delay at several intersections ranged between 40 and 60 seconds. These delays were primarily due to traffic signals and stop placement, but they were also influenced by pedestrian activity at non-signalized intersections. Both directions of this segment experienced automobiles blocking access to bus zones.

Southbound:

1. Extend “green time” for left turn from Shattuck Avenue onto Durant Avenue to better accommodate turning movements.
2. Remove bus stop on Durant Avenue at Fulton Street.
3. Install pedestrian controls for mid-block crossing on Durant Avenue between Dana Street and Telegraph Avenue to group and control pedestrian movement and vehicle traffic.
4. Relocate bus stop on Durant Avenue at Telegraph Avenue to the far side and install bus bulb to create a receiving zone for the bus with adequate sidewalk space for a shelter.
5. Remove bus stop on Durant Avenue and Bowditch Street.
6. Create queue jump lane into bus stop at Russell Street by removing 3 parking spaces.
7. Replace stop sign at Russell Street with signal; coordinate with signal at Ashby Avenue to reduce queue and more adequately control traffic demand.
8. Remove bus stop on College Avenue at Webster Street.
9. Coordinate the signals between Alcatraz Ave and Claremont Avenue to improve traffic flow. This will require coordination between Oakland and Berkeley.
10. Move Northbound stop from nearside to farside (coordinate with future Safeway project).

11. Prohibit left turns from College Avenue into Safeway parking lot near Claremont Avenue; close driveways to reduce delays to through movements on College Avenue.
12. Eliminate driveway on College Avenue into bank parking lot to reduce delays to through movements on College Avenue.

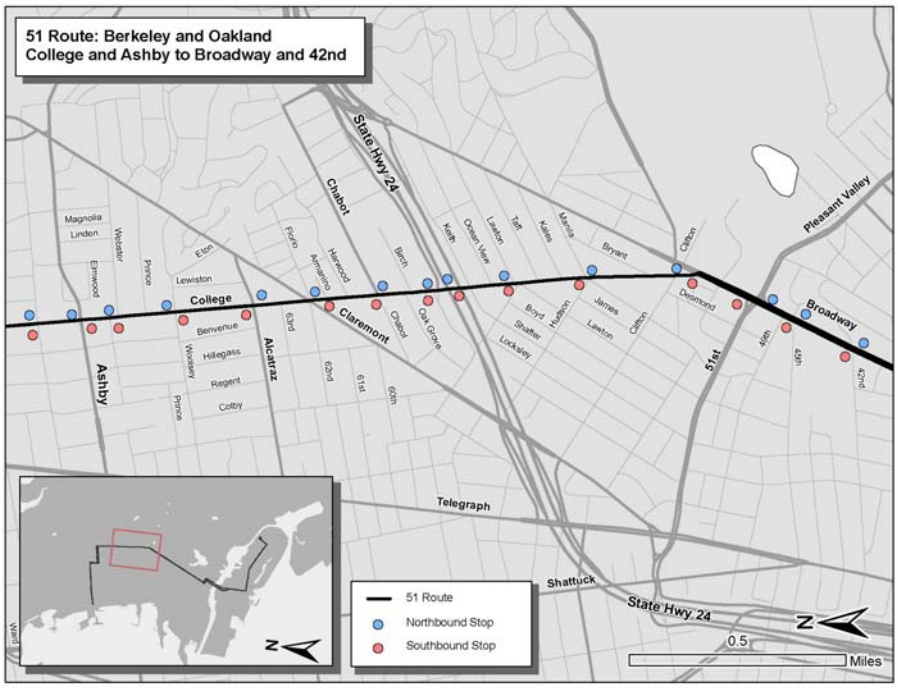
Northbound:

1. Relocate bus stop at Claremont Avenue to far side.
2. Prohibit left turns from College Avenue into Safeway parking lot near Claremont Avenue; close driveways.
3. Eliminate driveway from College Avenue into bank parking lot.
4. Coordinate the signals between Claremont Avenue and Alcatraz Avenue to improve traffic flow. This will require coordination between Oakland and Berkeley..
5. Remove bus stop at on College Avenue at Webster Street.
6. Create left turn pocket at Ashby Avenue to allow through traffic to bypass turning vehicles and cross intersection.
7. Replace stop sign at Russell Street with signal; coordinate with signal at Ashby Avenue to reduce queue and more adequately control traffic demand.
8. Install traffic signal at Bancroft Avenue & College Avenue intersection to separate pedestrian and vehicle movements.
9. Remove bus stop on Bancroft Avenue at Bowditch Street.

Rockridge BART to Broadway at 40th Street

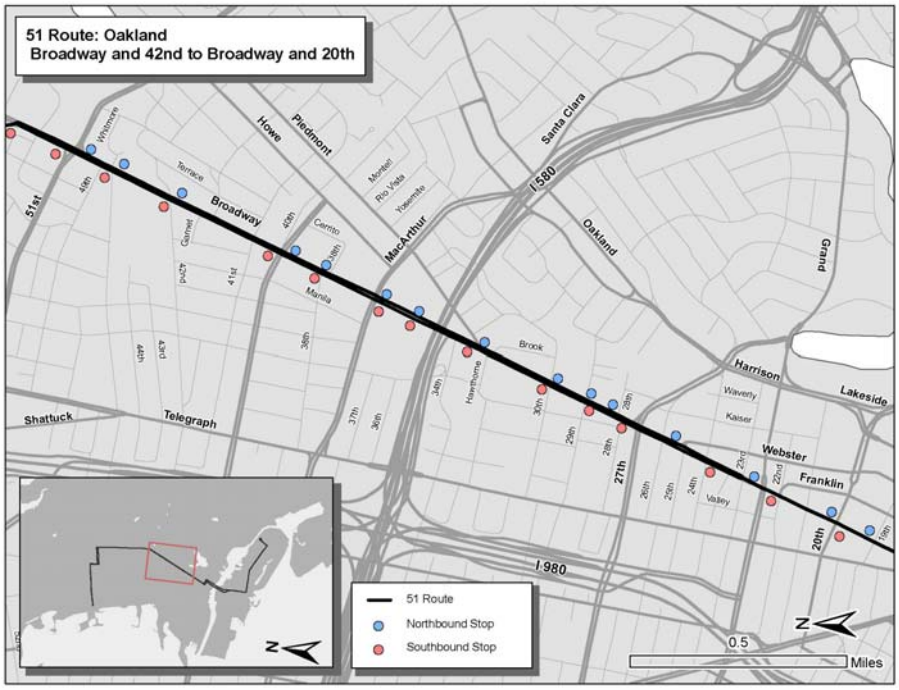
This segment includes the balance of College to Broadway, and then Broadway to 40th. This portion of the route serves Oakland Technical High School, California College of the Arts, Rockridge Shopping Center (Pleasant Valley & Broadway) and also intersects other AC Transit bus lines. Most of the delay in this segment is due to signal delay in both directions at Pleasant Valley, which ranges from 45 to 60 seconds; with maximums of more than two minutes. Reentry into traffic was also seen as an issue along the College Avenue corridor.

Figure 6.3 – 51 Route Map



The following list of improvements provides nearly 2 minutes (115 seconds) of bus travel time savings in the southbound direction and 2 minutes (120 seconds) of saving in the northbound direction.

Figure 6.4 – 51 Route Map



Southbound:

1. Create queue jump into bus stop on College Avenue at Broadway by removing a loading zone and one parking space.
2. Relocate the bus stop College Avenue at Manila Avenue to the far side.
3. Coordinate the signals along Broadway between College Avenue and 40th Street.
4. Relocate bus stop on Broadway at 51st Street to far side.
5. Remove bus stop on Broadway at 45th.

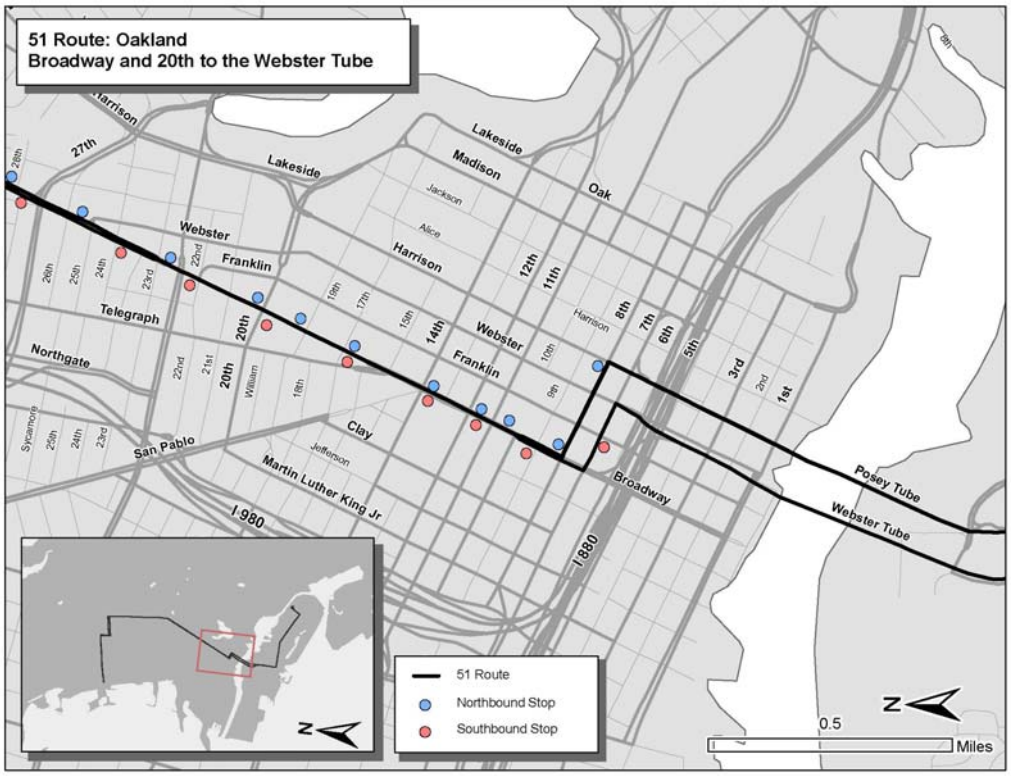
Northbound:

1. Coordinate the signals along Broadway between 40th Street and College Avenue; add side street detectors.
2. Relocate the bus stop on Broadway at Mather Street to the far side.
3. Remove the bus stop on Broadway at Whitmore Street.
4. Relocate the bus stop on College Avenue at Manila Avenue to the far side.

Broadway & 40th to 7th Street & Franklin Street

This route segment includes Downtown Oakland, Kaiser Hospital, Auto Row, and senior facilities. Daily boardings in this segment average 4,164 passengers. The primary cause of delay on this route segment is ineffective traffic signals. There are also delays associated with automobiles parked illegally in bus zones and double parked vehicles in Chinatown along 7th & 8th Streets. Southbound savings on this segment are estimated at 117 seconds, and northbound savings are estimated at 125 seconds.

Figure 6.5 – 51 Route Map



Southbound:

1. Lengthen bus stop on Broadway at 40th per *Designing with Transit* guidelines to provide safe space for operator relief without bus obstructing traffic lane.
2. Remove bus stop on Broadway at 38th Street.
3. Remove bus stop on Broadway at 29th Street.
4. Lengthen bus stop on Broadway at 28th per *Designing with Transit* guidelines by removing on parking space and creating take off zone.
5. Enforce double parking violations at 40th Street, in Downtown Oakland and Chinatown to reduce delays from double parking. Provide alternative loading facilities.

Northbound:

1. Extend "green time" at Harrison Street/8th Street intersection to allow through traffic to clear from Tube.
2. Remove Line 51 from stopping on Broadway at 19th Street.
3. Enforce double parking violations at 40th Street, in Downtown Oakland and Chinatown/provide additional loading facilities to reduce delays from double parking.
4. Create queue jump lane on Broadway at Grand by adding, "Right turn only, Bus Excepted," signage to existing right turn lane.
5. Remove bus stop on Broadway at 30th Street.
6. Move stop at 3506 Broadway out of crosswalk.
7. Relocate bus stop on Broadway at MacArthur Boulevard to the far side.
8. Remove bus stop on Broadway at 38th Street.

Webster Tube to Broadway at Blanding

This segment of the route operates relatively well and has nearly 3,200 daily boardings. Delays are minimal, with a few exceptions, such as on Webster Street at Atlantic Ave, and entering the Webster Tube. The delay analysis showed lengthy and unpredictable delays for this segment. Traffic on Santa Clara Avenue is primarily uncontrolled. Several minor improvements (far side stops, stop reductions) have been identified for this segment in order to increase travel time. For example, creating a queue jump from Webster Street at Atlantic to the Tube would be a major improvement. Southbound savings on this segment are estimated at 162 seconds, and northbound savings are estimated at 165 seconds.

Figure 6.6 – 51 Route Map

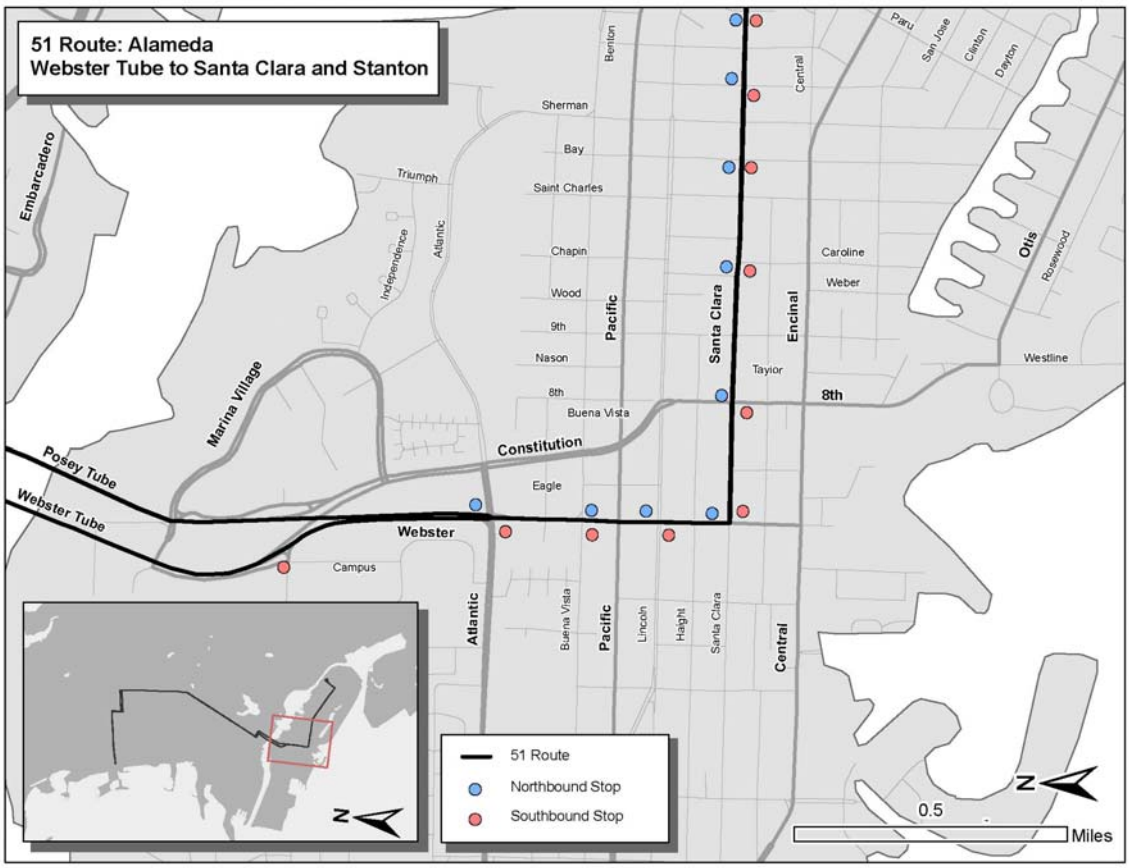
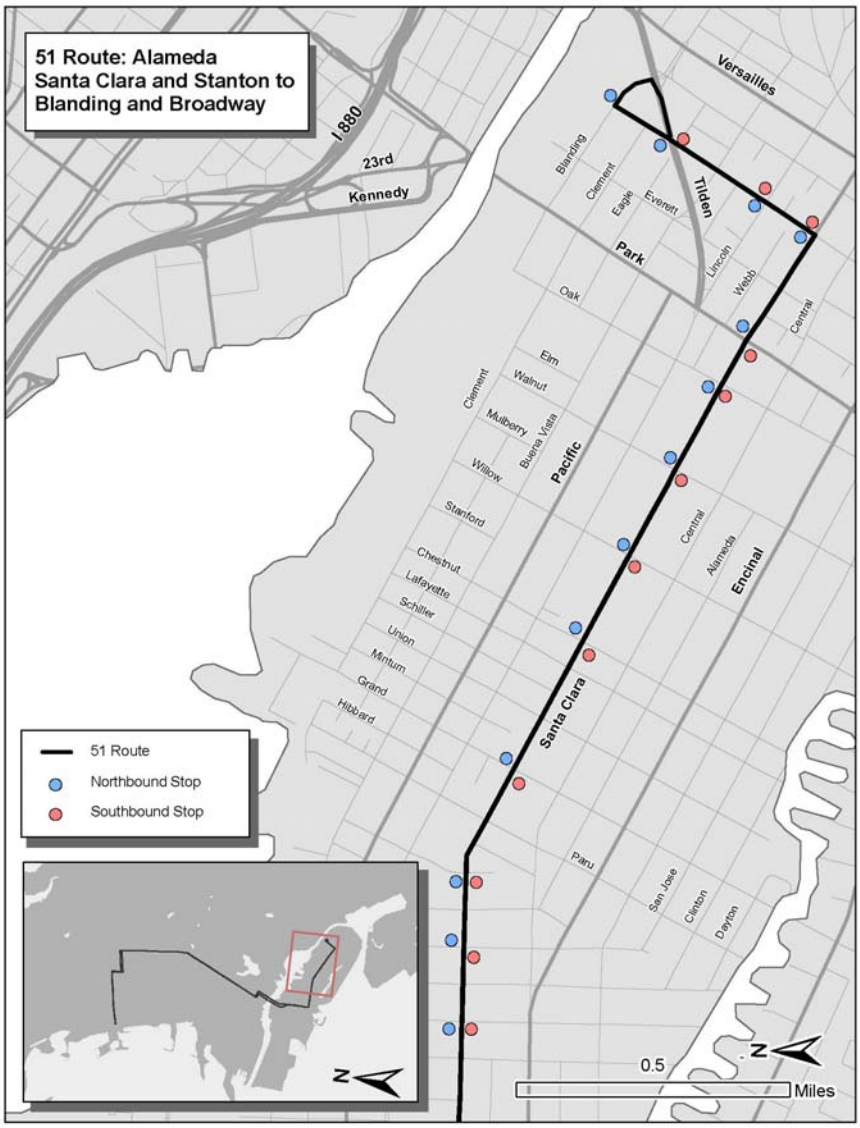


Figure 6.7 – 51 Route Map



Southbound:

Remove bus stop on Santa Clara at 9th.

1. Relocate bus stops to far side of traffic signal at:
   - 8th Street
   - Grand Street
2. Relocate bus stops to far side of uncontrolled intersection.
   - Bay Street
     - add crosswalk
   - Morton Street
   - Willow Street
3. Remove bus stops on Broadway at Tilden and Broadway at Lincoln. Install bus stop on Broadway at Buena Vista Avenue.

Northbound:

1. Remove bus stops on Broadway at Tilden Way and Broadway at Lincoln Avenue. Install bus stop on Broadway at Buena Vista Avenue.

2. Lengthen bus stop on Santa Clara Avenue at Oak Street per *Designing with Transit* guidelines; creates adequate area for bus to pull out of traffic.

3. Relocate bus stops to far side of traffic signal at:
    i. Grand Street
    ii. 8th Street
4. Relocate bus stops to far side of uncontrolled intersections at the following locations:
    a. Walnut Street
        i. add crosswalk
    b. Willow Street
    c. Morton Street
5. Remove bus stop on Santa Clara Avenue at 9th Street.
6. Create a queue jump from Webster Street at Atlantic to the Tube.

6.2 Service Design Options

The recommendations presented earlier in this report will greatly improve transit reliability and bus travel time. A number of options are being considered to redesign the service. This section focuses on options, without making a recommendation for one option. Receiving public comment will be an important factor to determine if a service design change is suitable. For this reason, the service design for the route will have a separate planning and (if deemed necessary) implementation schedule. In all of the service design scenarios, the recommendations presented earlier in this report will improve transit service by reducing travel times. A recommendation will be implemented once the public and Cities have an opportunity to comment.

Three major service redesigns have been considered. They are as follows:

- Split Route
- Limited Service overlaid with Local Service
- A/B Stops

Split Route

Briefly, a split route option is characterized by taking an existing route and breaking it into two routes that run independently of each other. An example would be splitting the 51 Line at Rockridge BART and having one route operate from 3rd/University to Rockridge BART, and a second route from Rockridge BART to Alameda. There are several benefits to this type of service, including flexibility with service levels and the operational benefit of isolating delays.

Limited Service overlaid with Local Service

A limited service option is created by overlaying a local bus service (serving all stops) with a limited bus stop service (serving a selected number of stops). Both routes would travel the entire length of the route, and would likely operate at different frequencies. This type of service provides a faster trip for some passengers.

A/B Stops

An A/B service option is essentially two routes that operate the entire length of the route and only service every other stop. Stops are alternating A or B, with major stops (i.e. transfer points, downtown areas, etc) common A and B stops. The Line 51A route would service only stops designated as A stops, and the Line 51B route would service only stops designated as B stops. The benefit of this type of route is that trip travel time is faster because the bus stops at only about half the bus stops.

Each service design option is explained in greater detail.

Split Route Service Option

A split route service would separate Line 51 into two routes that operate independent of each other. Each route would continue to serve every stop under a local service pattern. Splitting the route in two separate routes offers a number of benefits operationally. Different service levels and vehicle types can be assigned to more appropriately cater to heavy loads, slow speeds, etc.

Another benefit of a split route service is to isolate the delays on one portion of the route and stop them from upsetting the schedule of the rest of the route.

Dividing the route provides flexibility for vehicle type. Line 51 currently operates using 40 foot buses. One of the constraints to using larger buses is the narrowness of this roadway. It does not allow for 60 foot buses to be assigned, as buses would not be able to pull even slightly out of the roadway when accessing a stop. If the route was divided south of College, AC Transit could assign larger buses to the, "A," route; allowing for increased capacity. Splitting the route also allows for flexibility of service levels. Currently, the frequency of the route is tied to the area with the highest demand. By splitting the route, AC Transit can tailor the frequency of service to the specific demand along each new route.

Generally, the cost to operate two separate routes is higher than the cost to operate one. This is due to two factors: increased layover time and increased running time. Instead of having layover at the two terminals of one route, there are now four, "end of line," locations between the two routes. Depending on the length of each route, this may cause an added layover expense, as it did with dividing the routes in Downtown Oakland.

The split route option creates two routes out of the existing lengthy route. Staff considered three points at which to split the route: options have been considered to split the route at three points:

- Downtown Oakland
- Rockridge BART
- MacArthur BART

Each variation of the split route forces a certain number of passengers who otherwise ride through the location to disembark from the bus and transfer. There are ways to mitigate the impact of transferring, such as with conveniently timed schedules (i.e., pulse points). However, with two routes it is inevitable that some passengers will be inconvenienced. The number of passengers who ride through each proposed split location are noted in Table 6.2 below. The MacArthur BART (options 3) includes an overlap of service between MacArthur BART and Downtown Oakland, thusly the number of through riders is estimated, but is likely far less. The numbers below represents the worst case scenarios. APC data was used to formulate the number of passengers impacted.

Table 6.2 - Passengers Riding Through For Split Service Scenarios

Break Point	Number of Ride Through Passengers
Downtown Oakland	1639
Rockridge BART	2439
MacArthur BART	1639 (estimated worst case)

Splitting Line 51 could affect up to 2400 passenger trips a day. While this is a significant number of trips, it is less than 10 percent of the total trips on Line 51. The other 90% of passengers will benefit from a more reliable service that could potentially operate with larger vehicles to provide extra comfort and reduce crowding. The frequency of Line 51 is often enough that transfers between 51's could be made easily.

Of the three split route options, the most cost effective option is Option #1; splitting the route at Rockridge BART Station. This option keeps the layover location along the route and only requires four minutes to turn around. Table 6.3 below illustrates the comparative differences in vehicle demand among the split route options.

Table 6.3 - Vehicle Demand Split Route Comparison

Period	Vehicle Demand Existing Service	Option #1	Option #2	Option #3
AM Peak	21	26	23	30
PM Peak	25	28	27	33

A cost has been estimated for each option by including the number of additional vehicles required to run the new service. The estimated operation cost per vehicle, including all associated costs, is $400,000 per bus. Although altering the service design will add costs, the improvements suggested in this report can mitigate some of that cost—by reducing travel time, and thusly the vehicle demand.

Vehicle demand is done in a worst-case scenario, though it is likely that a number of improvements can be made to achieve a reduced running time. Round trip running time in our base scenario can be reduced by the implementation of any number of the recommendations listed in the improvement plan. Service design changes are only cost feasible if significant run time savings can be achieved with the active and intentional effort of each city.

Split Route Option #1 Route A-Alameda to Downtown Oakland/Route B- Berkeley Amtrak to Downtown Oakland

Staff looked at dividing line 51 into two routes that both terminated in the Downtown Oakland area. The, "A," route, starting in Alameda, would terminate along 21st Street, near Franklin Street. The, "B," route, starting at 3rd and University in Berkeley, would terminate at Lafayette Park just west of Broadway on 11th Street. This would allow access to Downtown Oakland for passengers of both routes. The, "B," route would be slightly over one hour each way while the, "A," would be just over half an hour. Due to contractual obligations, the percentage of recovery time to in-service time would increase from 13% to 20%.

Dividing the route in Downtown Oakland would eliminate the affects of any delays north of Downtown Oakland on the Alameda portion of the route, and vice versa. This would increase reliability on the route.

The existing PM Service on Line 51 uses 25 vehicles. Operating two routes at the same frequency would utilize 28 buses during the PM peak. The increase in running time is due to routing each line through Downtown and then on to an appropriate layover location (adding roughly 3-5 minutes to each route per direction). Table 6.4 below illustrates the vehicle requirements for this option.

Table 6.4 - Vehicle Requirement -Split Route Option #1 Service Plan at 8 minute headway

Period	Vehicle Demand Existing Service: Alameda to Berkeley	Vehicle Demand Route "A": Alameda to Downtown Oakland	Vehicle Demand Route "B": Berkeley to Downtown Oakland	Split Route Total
AM Peak	21	9	17	26
PM Peak	25	9	19	28

Split Route Option #2 Route A -Alameda to Rockridge BART/Route B- Berkeley to Rockridge BART

Another potential "split" point for Line 51 is Rockridge BART Station. From a scheduling standpoint, splitting the route at this point is very efficient. The two, "new," routes would both have one-way running times of less than one hour, keeping the required layover down to a minimum. This splitting scenario

would also alleviate the need to extend either route away from the existing route in order to layover. The added time to loop around the BART station adds minimal time and would increase the bus requirement by one bus. This additional cost can be eliminated by reducing the round trip running time of the route north of Rockridge by 8 minutes, or by taking 8 minutes off the round trip running time of the route south of Rockridge. In addition, the frequency of either route could be reduced; lowering the coach requirements by an additional 2-3 buses each. Table 6.5 below illustrates this option.

Table 6.5 - Vehicle Requirement -Split Route/Option #2 Service Plan at 8 minute headway

Period	Existing Service: Alameda to Berkeley	Split Route Broadway/Blanding to Rockridge	Split Route 3rd/University to Rockridge	Combined Vehicle Allocation after changes
AM Peak	21	13	10	23
PM Peak	25	15	12	27

Split Route Option #3 Route A-Alameda to MacArthur BART/Route B- Berkeley Amtrak to Downtown Oakland

Another option for Line 51 would be to split the route at Macarthur BART, with both routes overlapping between MacArthur BART and Downtown Oakland. This option would serve Kaiser Hospital. The increase in vehicles is largely due to the overlapping segments of the two routes along Broadway between 14th & 40th streets. However, in this option the fewest passengers would be affected because of the overlap in service. Any time savings between 14th & Broadway and 40th & Broadway would be shared by both routes. This vehicle allocation plan is outlined in Table 6.6 below.

Table 6.6 - Vehicle Requirement - Split Route/Option #3 Service Plan at 8 minute headway

Period	Existing Service: Alameda to Berkeley	Vehicle Demand Route A Berkeley Amtrak to Downtown Oakland	Vehicle Demand Route B Broadway/ Blanding to MacArthur BART	Combined Vehicle Allocation after changes
AM Peak	21	17	13	30
PM Peak	25	19	14	33

Local-Limited Service Option

In order to provide a faster ride for our passengers, Planning Department staff looked into adding a limited stop service on top of the existing service. Line 51 operates under a local service pattern where all bus stops along the route are served. A limited service covering the entire length of the existing route would stop every-half mile along all segments (except for College Avenue). In this service design, Line 51 would operate 2 services; one limited and one local. Both services would operate from the current start point to the current end of line. However, limited buses are expected to operate more quickly, and would pass local buses. It should be noted that the College Avenue corridor reduces the operational benefits of a limited route because it is narrow, heavily traveled and offers only a minimal number of locations where the limited buses may pass local buses. A possible alteration on this option could be to end the limited service at Rockridge BART and provide local only service in the Berkeley area.

The major benefit of a limited service is to provide a faster trip for passengers, and the drawback of such a system is that not all passengers are directly served by a limited bus (since it will not serve all stops).

For those passengers not served by the limited route, the wait time for the local bus or the walking distance to a limited stop is increased. Typically, when a limited service is overlaid with a local service, the combined frequency meets an appropriate service level. Previous examples of similar route treatments by AC Transit include the 72R, operating a Rapid bus every 12 minutes and a local bus every 15 minutes, and the 1R; operating a Rapid bus every 12 minutes and a local bus every 15-20 minutes.

Table 6.7 below displays the vehicle requirement for a Limited-Local service. The assumptions include a local bus operating at a 15-minute frequency, and a limited bus operating at a 12-minute frequency.

Table 6.7 - Vehicle Requirement - Limited/Local Service

Period	Existing Service	Vehicle Demand Limited Service	Vehicle Demand Local Service	Combined Vehicle Allocation
AM Peak	21	12	12	24
PM Peak	25	14	14	28

A/B Stop Service

The final operating scenario studied by the Task Force is skip stops, also referred to as A/B service. Skip Stop service would have every bus serve every other stop. In this service design, Line 51 would operate two routes; an A and a B. One set of stops would be identified a, “A,” stops, and only the 51A would serve them. Another set of stops would be identified as, “B,” stops, and only the 51B would serve those stops. Major destinations, like BART Stations, downtown areas or transfer points, would be designated both A and B and would be served by both routes. This scenario would effectively reduce the number of stop on each route by nearly half and allow for improved speed. However, this option is not well suited for a route like Line 51, as passengers would be forced to transfer routes or walk significant distances between bus stops. The vehicle requirements for this option are shown in Table 6.8 below.

Table 6.8 - Vehicle Requirement - A/B Service Plan at 8 minute headway

Period	Existing Service: Alameda to Berkeley	Vehicle Demand Route “A”	Vehicle Demand Route “B”	Combined Vehicle Allocation
AM Peak	21	18	18	36
PM Peak	25	22	22	44

No Change Option

The current bus route operates on a ‘local’ service design. The bus services all stops, with average spacing between stops of 700-1300 feet. Line 51 operates 18 hours a day, between 5AM and 12AM. Service runs on 8-minute headways throughout the route during the AM and PM peak periods. Service is reduced to 10-minute headways during the mid-day. The PM peak vehicle requirement to operate Line 51 on 8-minute headways is 25 vehicles.

Under this scenario service would continue to operate as it currently does. However, with improvements, service would operate faster and more time could be given to recovery. If the running time were reduced by 22 minutes (round trip), headways could decrease from 8-minutes to 7-minutes in the peak periods, easing loads throughout the day. The service remains local to all stops and will not include an express or limited overlay.

7. FUTURE DEVELOPMENT AND PLAN TRACKING

AC Transit is concurrently tracking projects, plans and developments along the Line 51 corridor to ensure that transit can operate without impairing service or increasing travel times. Although these projects are in different phases, AC Transit area planners are involved to review the project or plans developed and to act as a resource to the parties involved. Some of these projects have created opportunities to improve bus operations, including improving stop locations. Planning Department Staff will strive to stay abreast of City project and development plans that may affect Line 51.

AC Transit is involved in the following projects:

- Kaiser Hospital on Broadway at MacArthur (Oakland)
- Upper Broadway Plan (Oakland)
- Trader Joe's on University (Berkeley)
- West Berkeley Circulation Study (Berkeley)
- Safeway Redevelopment on College Avenue (Oakland)
- Downtown Area Plan (Berkeley)

8. CONCLUSION

In 2006, the Alameda-Contra Costa Transit District (AC Transit) began a study of Line 51(The Study) in order to evaluate its levels of service and reliability. The Line 51 Task Force had three goals for the Line 51 Study; to develop a method of evaluating the route, to identify problems and their causes, and to develop recommendations to improve route performance. After The Task Force had defined the purpose and scope of the Line 51 Study, Planning Department Staff assumed responsibility for the research, data collection, and analysis aspects of The Study.

AC Transit will work with the Cities of Alameda, Berkeley and Oakland, as well as soliciting the input of interested community groups, to evaluate and implement the recommendations of this report. Meetings with the affected Cities will take place January and March 2009.

A public process will be conducted in February 2009, consisting of three open houses. The three open houses will be presented in each City so that the public may review recommendations and service design options presented in this report. Feedback and comments will be recorded and presented to the AC Transit Board of Directors April/May of 2009. Revisions will be made to this document to include the final onboard survey and to reflect public comments communicated throughout the public process.

This paper has followed the Line 51 Study through each phase of information gathering and analysis, and revealed the key causes of service and reliability issues on Line 51 that came to light as a result. The recommendations and conclusions presented by Planning Department staff address such issues as on time performance, delays caused by unsequenced traffic signals, fare media, bus stop design, and other issues. These recommendations and their proposed applications achieve The Task Force's initial goals and complete the necessary work prior to the beginning of implementation.

APPENDIX

Appendix 1 – Bus Stop Inventory (Northbound)

Stop No.	Location	Location	Control Type	Type
Northbound				
1	BLANDING AV: BROADWAY	Nearside	Stop Sign	Off-Line
2	BROADWAY: TILDEN WY	Nearside	Signal	Off-Line
3	BROADWAY: LINCOLN AV	Nearside	Uncontrolled	Off-Line
4	SANTA CLARA AV: BROADWAY	Farside	Signal	Off-Line
5	SANTA CLARA AV: PARK ST	Nearside	Signal	On-Line
6	SANTA CLARA AV: OAK ST	Farside	Signal	Off-Line
7	SANTA CLARA AV: WALNUT ST	Nearside	Uncontrolled	Off-Line
8	SANTA CLARA AV: WILLOW ST	Nearside	Uncontrolled	Off-Line
9	SANTA CLARA AV: CHESTNUT ST	Nearside	Stop Sign	Off-Line
10	SANTA CLARA AV: GRAND ST	Nearside	Signal	Off-Line
11	SANTA CLARA AV: STANTON ST	Farside	Uncontrolled	Off-Line
12	SANTA CLARA AV: MORTON ST	Nearside	Uncontrolled	Off-Line
13	SANTA CLARA AV: BAY ST	Farside	Uncontrolled	Off-Line
14	SANTA CLARA AV: MOZART ST	Nearside	Uncontrolled	Off-Line
15	SANTA CLARA AV: 9TH ST	Farside	Uncontrolled	Off-Line
16	SANTA CLARA AV: 8TH ST	Nearside	Signal	Off-Line
17	WEBSTER ST: SANTA CLARA AV	Farside	Signal	On-Line
18	WEBSTER ST: LINCOLN AV	Farside	Signal	On-Line
19	WEBSTER ST: BUENA VISTA AV	Nearside	Signal	Off-Line
20	WEBSTER ST: ATLANTIC AV	Farside	Signal	Off-Line
21	8TH ST: HARRISON ST	Farside	Signal	Off-Line
22	8TH ST: BROADWAY	Nearside	Signal	Off-Line
23	BROADWAY: 11TH ST (12TH ST BART STATION)	Nearside	Signal	Off-Line
24	BROADWAY: 13TH ST (12TH ST BART STATION)	Farside	Signal	On-Line
25	BROADWAY: 17TH ST	Nearside	Signal	Off-Line
26	BROADWAY: 19TH ST (19TH ST BART STATION)	Farside	Signal	Off-Line
27	BROADWAY: 20TH ST (19TH ST BART STATION)	Farside	Signal	Off-Line
28	BROADWAY: GRAND AV	Farside	Signal	Off-Line
29	BROADWAY: 25TH ST	Nearside	Signal	Off-Line
30	BROADWAY: 28TH ST	Farside	Signal	Off-Line
31	BROADWAY: 29TH ST	Farside	Signal	Off-Line
32	BROADWAY: 30TH ST	Nearside	Signal	Off-Line
33	BROADWAY: PIEDMONT AV	Nearside	Signal	Off-Line
34	BROADWAY: #3506	At	Signal	Off-Line
35	BROADWAY: W MACARTHUR BLVD	Nearside	Signal	On-Line
36	BROADWAY: 38TH ST	Farside	Uncontrolled	Off-Line
37	BROADWAY: 40TH ST	Nearside	Signal	Off-Line
38	BROADWAY: MATHER ST	Nearside	Signal	Off-Line
39	BROADWAY: WHITMORE ST (45TH ST)	Nearside	Signal	Off-Line
40	BROADWAY: PLEASANT VALLEY AV	Nearside	Signal	Off-Line
41	COLLEGE AV: BROADWAY	Farside	Signal	Off-Line
42	COLLEGE AV: MANILA AV	Nearside	Signal	Off-Line
43	COLLEGE AV: LAWTON AV	Farside	Uncontrolled	Off-Line

Stop No.	Location	Location	Control Type	Type
Northbound				
44	COLLEGE AV: KEITH AV (Rockridge BART)	Farside	Signal	Off-Line
45	COLLEGE AV: MILES AV	Farside	Signal	Off-Line
46	COLLEGE AV: CHABOT RD	Nearside	Uncontrolled	Off-Line
47	COLLEGE AV: CLAREMONT AV	Nearside	Signal	Off-Line
48	COLLEGE AV: ALCATRAZ AV	Nearside	Signal	Off-Line
49	COLLEGE AV: WOOLSEY ST	Farside	Uncontrolled	Off-Line
50	COLLEGE AV: WEBSTER ST	Farside	Uncontrolled	Off-Line
51	COLLEGE AV: ASHBY AV	Farside	Signal	Off-Line
52	COLLEGE AV: RUSSELL ST	Farside	Stop Sign	Off-Line
53	COLLEGE AV: DERBY ST	Nearside	Stop Sign	Off-Line
54	COLLEGE AV: PARKER ST	Farside	Uncontrolled	Off-Line
55	COLLEGE AV: HASTE ST	Farside	Signal	Off-Line
56	BANCROFT WY: COLLEGE AV	Farside	Stop Sign	Off-Line
57	BANCROFT WY: BOWDITCH ST	op	Stop Sign	Off-Line
58	BANCROFT WY: TELEGRAPH AV	Farside	Signal	Off-Line
59	BANCROFT WY: DANA ST	Farside	ped crossing	Off-Line
60	BANCROFT WY: ELLSWORTH ST	Farside	Uncontrolled	Off-Line
61	SHATTUCK AV: KITTREDGE ST	Nearside	Signal	Off-Line
62	SHATTUCK SQ: CENTER ST	Farside	Signal	Off-Line
63	UNIVERSITY AV: SHATTUCK AV	Farside	Signal	Off-Line
64	UNIVERSITY AV: MILVIA ST	Farside	Signal	Off-Line
65	UNIVERSITY AV: MARTIN LUTHER KING JR WY	Nearside	Signal	Off-Line
66	UNIVERSITY AV: GRANT ST	Nearside	Uncontrolled	Off-Line
67	UNIVERSITY AV: MC GEE AV	Farside	Uncontrolled	Off-Line
68	UNIVERSITY AV: CALIFORNIA ST	Nearside	Signal	Off-Line
69	UNIVERSITY AV: SACRAMENTO ST	Nearside	Signal	Off-Line
70	UNIVERSITY AV: ACTON ST	Nearside	Signal	Off-Line
71	UNIVERSITY AV: BONAR ST	Nearside	Signal	Off-Line
72	UNIVERSITY AV: CURTIS ST	Nearside	Signal	Off-Line
73	UNIVERSITY AV: SAN PABLO AV	Farside	Signal	Off-Line
74	UNIVERSITY AV: 9TH ST	Nearside	Signal	Off-Line
75	UNIVERSITY AV: 6TH ST	Nearside	Signal	Off-Line
76	UNIVERSITY AV: 4TH ST	Nearside	Stop Sign	Off-Line
77	UNIVERSITY AV: 3RD ST			Off-Line

Appendix 2 – Bus Stop Inventory (Southbound)

Stop No.	Location	Location	Control Type	Type
Southbound				
1	UNIVERSITY AV: 3RD ST			Off-Line
2	UNIVERSITY AV: 4TH ST	Farside	Stop Sign	Off-Line
3	UNIVERSITY AV: 6TH ST	Farside	Signal	Off-Line
4	UNIVERSITY AV: 9TH ST	Farside	Signal	Off-Line
5	UNIVERSITY AV: SAN PABLO AV	Nearside	Signal	Off-Line
6	UNIVERSITY AV: CURTIS ST	Farside	Signal	Off-Line
7	UNIVERSITY AV: BONAR ST	Nearside	Signal	Off-Line
8	UNIVERSITY AV: ACTON ST	Farside	Signal	Off-Line
9	UNIVERSITY AV: SACRAMENTO ST	Farside	Signal	Off-Line
10	UNIVERSITY AV: CALIFORNIA ST	Nearside	Signal	Off-Line
11	UNIVERSITY AV: MC GEE AV	Nearside	Uncontrolled	Off-Line
12	UNIVERSITY AV: GRANT ST	Farside	Uncontrolled	Off-Line
13	UNIVERSITY AV: MARTIN LUTHER KING JR WY	Farside	Signal	Off-Line
14	UNIVERSITY AV: MILVIA ST	Nearside	Signal	Off-Line
15	UNIVERSITY AV: SHATTUCK AV	Nearside	Signal	Off-Line
16	SHATTUCK AV: ALLSTON WY	Nearside	Signal	Off-Line
17	SHATTUCK AV: KITTREDGE ST	Farside	Signal	Off-Line
18	DURANT AV: SHATTUCK AV	Farside	Signal	Off-Line
19	DURANT AV: FULTON ST	Farside	Signal	Off-Line
20	DURANT AV: ELLSWORTH ST	Nearside	Signal	Off-Line
21	DURANT AV: DANA ST	Nearside	Signal	Off-Line
22	DURANT AV: TELEGRAPH AV	Nearside	Signal	Off-Line
23	DURANT AV: BOWDITCH ST	Nearside	Signal	Off-Line
24	DURANT AV: COLLEGE AV	Nearside	Signal	Off-Line
25	COLLEGE AV: HASTE ST	Nearside	Signal	Off-Line
26	COLLEGE AV: PARKER ST	Nearside	Uncontrolled	Off-Line
27	COLLEGE AV: DERBY ST	Nearside	Stop Sign	Off-Line
28	COLLEGE AV: RUSSELL ST	Nearside	Stop Sign	Off-Line
29	COLLEGE AV: ASHBY AV	Farside	Signal	Off-Line
30	COLLEGE AV: WEBSTER ST	Opposite	Uncontrolled	Off-Line
31	COLLEGE AV: WOOLSEY ST	Farside	Uncontrolled	Off-Line
32	COLLEGE AV: ALCATRAZ AV	Nearside	Signal	Off-Line
33	COLLEGE AV: CLAREMONT AV	Farside	Signal	Off-Line
34	COLLEGE AV: CHABOT RD	Nearside	Uncontrolled	Off-Line
35	COLLEGE AV: OAK GROVE AV (OPP. CLAREMONT MID. SCH.)	Farside	Uncontrolled	Off-Line
36	COLLEGE AV: MILES AV (ROCKRIDGE BART)	Farside	Signalized	Off-Line
37	COLLEGE AV: FOREST ST	Nearside	Uncontrolled	Off-Line
38	COLLEGE AV: MANILA AV	Nearside	Signal	Off-Line
39	COLLEGE AV: BROADWAY	Nearside	Signal	Off-Line
40	BROADWAY: 51ST ST	Nearside	Signal	Off-Line
41	BROADWAY: 45TH ST	Nearside	Signal	Off-Line

Stop No.	Location	Location	Control Type	Type
Southbound				
42	BROADWAY: 42ND ST (OAKLAND TECHNICAL HIGH SCHOOL)	Nearside	Signal	Off-Line
43	BROADWAY: 40TH ST	Nearside	Signal	Off-Line
44	BROADWAY: 38TH ST	Nearside	Signal*	Off-Line
45	BROADWAY: W MACARTHUR BLVD	Farside	Signal	Off-Line
46	BROADWAY: #3505 (MOSSWOOD PARK)	At	Signal	Off-Line
47	BROADWAY: PIEDMONT AV	Nearside	Signal	Off-Line
48	BROADWAY: 30TH ST	Nearside	Signal	Off-Line
49	BROADWAY: 29TH ST	Farside	Signal	Off-Line
50	BROADWAY: 28TH ST	Farside	Signal	Off-Line
51	BROADWAY: 24TH ST	Nearside	Uncontrolled	Off-Line
52	BROADWAY: W GRAND AV	Farside	Signal	Off-Line
53	BROADWAY: 20TH ST	Farside	Signal	On-Line
54	BROADWAY: 17TH ST	Nearside	Signal	Off-Line
55	BROADWAY: 14TH ST (12TH ST BART STATION)	Farside	Signal	Off-Line
56	BROADWAY: 12TH ST (12TH ST BART STATION)	Farside	Signal	Off-Line
57	BROADWAY: 9TH ST	Nearside	Signal	Off-Line
58	7TH ST: FRANKLIN ST	Nearside	Signal	On-Line
59	WEBSTER ST: TINKER AV	At	Stop	Off-Line
60	WEBSTER ST: ATLANTIC AV	Farside	Signal	Off-Line
61	WEBSTER ST: BUENA VISTA AV	Farside	Signal	Off-Line
62	WEBSTER ST: LINCOLN AV	Farside	Signal	On-Line
63	SANTA CLARA AV: WEBSTER ST	Farside	Signal	On-Line
64	SANTA CLARA AV: 8TH ST	Nearside	Signal	Off-Line
65	SANTA CLARA AV: 9TH ST	Nearside	Uncontrolled	Off-Line
66	SANTA CLARA AV: CAROLINE ST	Nearside	Uncontrolled	Off-Line
67	SANTA CLARA AV: BAY ST	Nearside	Uncontrolled	Off-Line
68	SANTA CLARA AV: MORTON ST	Nearside	Uncontrolled	Off-Line
69	SANTA CLARA AV: STANTON ST	Nearside	Uncontrolled	Off-Line
70	SANTA CLARA AV: GRAND ST	Nearside	Signal	Off-Line
71	SANTA CLARA AV: CHESTNUT ST	Nearside	Stop Sign	Off-Line
72	SANTA CLARA AV: WILLOW ST	Nearside	Uncontrolled	Off-Line
73	SANTA CLARA AV: WALNUT ST	Nearside	Uncontrolled	Off-Line
74	SANTA CLARA AV: OAK ST	Nearside	Signal	Off-Line
75	SANTA CLARA AV: PARK ST	Nearside	Signal	On-Line
76	BROADWAY: SANTA CLARA AV	Farside	Signal	Off-Line
77	BROADWAY: LINCOLN AV	Farside	None	Off-Line
78	BROADWAY: TILDEN WY	Nearside	Signal	Off-Line
79	BLANDING AV: BROADWAY	Nearside	Stop Sign	Off-Line

Appendix 3 – Number of Travel Lanes

Road Segment	Number of Lanes (one direction)
Northbound	
Blanding Av between Tilden Way and Broadway	1
Broadway between Blanding Av and Santa Clara Ave	1 w/bike
Santa Clara Ave between Broadway and Grand St	1
Santa Clara Ave between Grand St and Webster St	1 w/bike
Webster St between Santa Clara Ave and Atlantic Ave	2
Webster St between Atlantic Ave and Posey Tube	2
Posey Tube	
Harrison St between Posey Tube and 8th St	3
8th St between Harrison St and Franklin St	3
8th St between Franklin St and Broadway	4
Broadway between 8th St and 25th St	2
Broadway between 25th St and 3547 Broadway	2 w/bike
Broadway between 3547 Broadway and Coronado Ave	3
Broadway between Coronado Av and College Ave	2
College Ave between Broadway and Bancroft Way	1
Bancroft Way between College and Barrow Lane	2
Bancroft Way between Barrow Lane and Dana St	3
Bancroft Way between Dana St and Fulton St	2
Bancroft Way between Fulton St and Shattuck Ave	1
Shattuck Ave between Bancroft Way and Allston	2
Shattuck Way between Allston Way and University Ave	3
University Ave between Shattuck Av and 6th St	2
University Ave between 6th St and 4th St	1
Southbound	
University Ave between 4th St and 6th St	1
University Ave between 6th St and Shattuck Ave	2
Shattuck Ave between University Ave and Center St	3
Shattuck Ave between Center St and Durant Ave	2
Durant Ave between Shattuck Ave and Fulton St	2
Durant Ave between Fulton St and Bowditch St	3
Durant Ave between Bowditch St and College Ave	2
College Ave between Durant Ave and Broadway	1
Broadway between College Ave and 40th St	3
Broadway between 40th and 3565 Broadway	2
Broadway between 3565 Broadway and 25th St	2 w/bike
Broadway between 25th St and 20th St	2
Broadway between 20th St and 19th St	3
Broadway Between 19th St and 7th St	2
7th St between Broadway and Franklin St	4
7th St between Franklin St and Webster St	3
Webster St between 7th St and Santa Clara Ave	2
Santa Clara Ave between Webster St and Grand St	1 w/bike
Santa Clara Ave between Grand St and Broadway	1
Broadway between Santa Clara Ave and Tilden Way	1 w/bike
Tilden Way between Broadway and Blanding Ave	1
Blanding Ave between Tilden Way and Broadway	1

Appendix 4 – Signalized Intersections

Northbound		***Southbound***	
Route Segment	**Cross Street**	**Route Segment**	**Cross Street**
BROADWAY	TILDEN WY	**UNIVERSITY AVE**	6TH ST
SANTA CLARA AV	BROADWAY		9TH ST
	PARK ST		10TH ST
	OAK ST		SAN PABLO AV
	GRAND ST		CURTIS ST
	8TH ST		BONAR ST
WEBSTER ST	SANTA CLARA AV		ACTON ST
	HAIGHT AV		SACRAMENTO ST
	LINCOLN AV		CALIFORNIA ST
	BUENA VISTA AV		MARTIN LUTHER KING JR WY
	ATLANTIC AV		MILVIA ST
HARRISON ST	7TH ST		SHATTUCK AV
8TH ST	HARRISON ST	**SHATTUCK AVE**	ADDISON
	FRANKLIN ST		ALLSTON WY
	BROADWAY		KITTREDGE ST
BROADWAY	9th ST		DURANT AV
	10TH ST	**DURANT AVE**	FULTON ST
	11TH ST (12TH ST BART STATION)		ELLSWORTH ST
	12TH ST		DANA ST
	13TH ST (12TH ST BART STATION)		TELEGRAPH AV
	14th ST		BOWDITCH ST
	15TH ST		COLLEGE AV
	LATHAM SQ	**COLLEGE AVE**	CHANNING WY
	17TH ST		HASTE ST
	19TH ST (19TH ST BART STATION)		ASHBY AV
	20TH ST (19TH ST BART STATION)		ALCATRAZ AV
	21ST ST		CLAREMONT AV
	22nd ST		MANILA AV
	GRAND AV		BROADWAY
	25TH ST	**BROADWAY**	51ST ST
	26th ST		45TH ST
	27TH ST		42ND ST
	28TH ST		41ST ST
	29TH ST		40TH ST
	30TH ST		**38TH ST**
	PIEDMONT AV		W MACARTHUR BLVD
	#3506 BROADWAY		#3505 (MOSSWOOD PARK)
	W MACARTHUR BLVD		PIEDMONT AV
	38TH ST		30TH ST
	40TH ST		29TH ST
	41ST ST		28TH ST
	MATHER ST		27TH ST
	WHITMORE ST		26TH ST
	PLEASANT VALLEY AV		25TH ST
COLLEGE AVE	BROADWAY		W GRAND AV
	MANILA AV		22ND ST
	KEITH AVE		21ST ST
	MILES AV		20TH ST
	CLAREMONT AV		17TH ST
	ALCATRAZ AV		LATHAM SQ.
	ASHBY AV		TELEGRAPH
	HASTE ST		13th ST
	CHANNING WY		14TH ST
BANCROFT WY	TELEGRAPH AV		12TH ST
	MID BLOCK CROSSING		11th ST

Northbound		***Southbound***	
Route Segment	**Cross Street**	**Route Segment**	**Cross Street**
SHATTUCK AVE	KITTREDGE ST		10th ST
	ALLSTON WY		9th ST
	CENTER ST	**7TH ST**	FRANKLIN ST
	ADDISON WY		WEBSTER ST
	UNIVERSITY AV	**WEBSTER ST**	ATLANTIC AV
UNIVERSITY AVE	SHATTUCK AV		EAGLE AV
	MILVIA ST		BUENA VISTA AV
	MARTIN LUTHER KING JR WY		LINCOLN AVE
	CALIFORNIA ST		HAIGHT AV
	SACRAMENTO ST	**SANTA CLARA AVE**	WEBSTER ST
	OHLONE GREENWAY		8TH ST
	ACTON ST		GRAND ST
	BONAR ST		OAK ST
	CURTIS ST		PARK ST
	SAN PABLO AV	**BROADWAY**	SANTA CLARA AV
	10TH ST		TILDEN WAY
	9TH ST		
	6TH ST		

Appendix 5 – Interagency Best Practices

	SEATTLE				SACRAMENTO	MADISON	MINNEAPOLIS/ ST PAUL	AC TRANSIT		
	Metro Transit				Regional Transit	Madison Metro Transit	Metro Transit			
Route Number	48	7 *(Before split in 2005)*	7 *(After split in 2005)*	49 *(After split in 2005)*	82	2	Route 16	Route 40	Route 43	Route 51
Length of Route	17.2 miles	15.48 miles	10.18 miles	5.3 miles	12.5	11 miles	10.55 miles	19.2 miles	18.1 miles	13.5 miles
Average Speed	11.7 mph	9.29 mph	10.53 mph	7.23 mph	13.9 mph	peak: 12 mph, off peak: 16 mph	11 mph	12.7 mph	11.4 mph	11.3 mph
Travel Time	peak 1 hr 28 m, off-peak 1 hr 20 m	peak 1 hr 40 m, off-peak 1 hr 23 m	peak 58 min, off-peak 53 min	peak 44 min, off-peak 38 min	50 min – 54 min	50 min – 55 min	peak 65 min off-peak 43 min	peak 1 hr 37m off-peak 1 hr 10 m	peak 1 hr 20m off-peak 1 hr 9 min	peak 1 hr 5m off-peak 55 min
Ridership	51.08 pass/ /hr	44.79 pass /hr	42.51 pass /hr	46.11 pass /hr	27 pass /hr	38.5 pass /hr	67 pass /hr	52 pass /hr	43 pass /hr	60 pass /hr
Fare Collection Method	Pay As You Board	To CBD: Pay As You Board, From CBD: Pay As You Exit	To CBD: PAYB, From CBD: Pay As You Exit	To CBD: PAYB, From CBD: Pay As You Exit	PAYB	PAYB	Stored Value Card (prepaid) $ Cash	Pay As You Board	Pay As You Board	Pay As You Board
Fare	$1.50	$1.50	$1.50	$1.50	$2.00/$1.00	$1.50/$1.00?$.75	$1.50(off-peak)-$2.00 (peak)	$1.75/ $.80	$1.75/ $.80	$1.75/ $.80
Percent OTP	25.58%	48.1 % (S) 53.8 % (N)	46.8%	65.38%	94%	Reaction Driven: No OTP Available	92%	37.4%	71%	67.8%
OTP Standard	-1/+5	-1/+5	-1/+5	-1/+5	-1/+5	>-5 and <=0 (1997 standard)	-1/+5	-1/+5	-1/+5	-1/+5

	SEATTLE				SACRAMENTO	MADISON	MINNEAPOLIS/ ST PAUL	AC TRANSIT		
	Metro Transit				Regional Transit	Madison Metro Transit	Metro Transit			
Lane Config-uration	varies	varies	four-lane	varies	part one lane, rest 2-3 lanes	varies: 1 lane to 3 lanes	two lane	varies from 1 lane to 3 lanes	varies from 1 lane to 3 lanes	varies from 1 lane to 3 lanes
Peak Headway	10	10	10	15	30 min	30m	12 min	15	15	8
Off-Peak Headway	15	10	10	15	30 min	30m	8 min	20	30	20
Bus Pass Program	Yes (U-PASS)	Yes (U-PASS)	Yes (U-PASS)	Yes (U-PASS)	yes (student sticker)	yes, magnetic stripe pass	Tyes (UPASS)	Yes	Yes	Yes
Vehicle Type & Size	Artics (New Flyer High Floor D60HF, New Flyer Low Floor D60LF) and Standards (New Flyer Low Floor D40LF)	Artic Trolley buses (Breda Trolley 350, MAN SG-T310)	Artic Trolley buses (Breda Trolley 350, MAN SG-T310)	Artic Trolley buses (Breda Trolley 350, MAN SG-T310)	40 FT Orion CNGs	40 FT Gillieg and New Flyer	40 FT Gillieg	60FT. Van Hool Artic	40 Ft. Van Hool	20 40ft Van Hools 6 40 ft NABI 3000
Vehicle Capacity	New Flyer Artic HF (64 seats), New Flyer Artic LF (58 seats), New Flyer Standard LF (38 seats)	Breda (56 seats), MAN (64 seats)	Breda (56 seats), MAN (64 seats)	Breda (56 seats), MAN (64 seats)	42 seated	38/39 seated (2 wheelchair) 2/3 bicycles front rack	42 Seats	45 Seats	32 Seats	Van Hool-32 seats NABI- 40 seats 30 standees

	SEATTLE				SACRAMENTO	MADISON	MINNEAPOLIS/ ST PAUL	AC TRANSIT		
	Metro Transit				Regional Transit	Madison Metro Transit	Metro Transit			
Average Stop Spacing	1108 feet	834 feet	827 feet	848 feet	1000-1500 feet	800 feet	varies but goal 1/4 mile	823 feet	786 feet	828 feet
Bus Stop Configuration (bulb outs, cutouts, pull ins?	Pull Ins, In-Lane mixture	Pull Ins, In-Lane mixture	Pull Ins, In-Lane mixture	Pull Ins, In-Lane mixture	bus cutouts	Curb traffic lane, curb parking lane, limited cut-outs	cutouts			
Limited and Local Service?	Local	Local	Local	Local	no	Local service	Yes peak only (but uses alt line number)	Yes	No	No
Serves Commercial Corridor?	Yes several secondary	Yes Seattle CBD, several secondary	Yes Seattle CBD, several secondary	Yes several secondary	yes	Yes	Yes	Yes	Yes	Yes
Serves University?	Yes	Yes	No	Yes	Yes	Yes-UW Madison campus, MATC Downtown campus	Yes	Yes	Yes	Yes

Appendix 6a – Bus Stop Locations and Spacing (Northbound)

Northbound Bus Stop Spacing	
Bus Stop Location	**Distance (feet)**
BLANDING AV: BROADWAY	0
BROADWAY: TILDEN WY	610
BROADWAY: LINCOLN AV	1129
SANTA CLARA AV: BROADWAY	719
SANTA CLARA AV: PARK ST	1078
SANTA CLARA AV: OAK ST	628
SANTA CLARA AV: WALNUT ST	794
SANTA CLARA AV: WILLOW ST	935
SANTA CLARA AV: CHESTNUT ST	930
SANTA CLARA AV: GRAND ST	1406
SANTA CLARA AV: STANTON ST	1232
SANTA CLARA AV: MORTON ST	601
SANTA CLARA AV: BAY ST	842
SANTA CLARA AV: MOZART ST	1009
SANTA CLARA AV: 8TH ST	1209
webster st: santa clara ave	1302
WEBSTER ST: LINCOLN AV	692
WEBSTER ST: BUENA VISTA AV	544
WEBSTER ST: ATLANTIC AV	1111
8TH ST: HARRISON ST	7359
8TH ST: BROADWAY	826
BROADWAY: 11TH ST (12TH ST BART STATION	1013
BROADWAY: 13TH ST (12TH ST BART STATION	683
BROADWAY: 17TH ST	1101
BROADWAY: 19TH ST (19TH ST BART STATION	595
BROADWAY: 20TH ST (19TH ST BART STATION	770
BROADWAY: GRAND AV	808
BROADWAY: 25TH ST	894
BROADWAY: 28TH ST	1017
BROADWAY: 29TH ST	457
BROADWAY: 30TH ST	345
BROADWAY: PIEDMONT AV	907
BROADWAY: #3506	787
BROADWAY: W MACARTHUR BLVD	602
BROADWAY: 38TH ST	821
BROADWAY: 40TH ST	490
BROADWAY: MATHER ST (OAKLAND TECHNICAL	1542
BROADWAY: WHITMORE ST (45TH ST)	797
BROADWAY: PLEASANT VALLEY AV	360
COLLEGE AV: BROADWAY	1045
COLLEGE AV: MANILA AV	1249
COLLEGE AV: LAWTON AV	1020
college ave: keith ave	522
COLLEGE AV: MILES AV (CLAREMONT MIDDLE	444
COLLEGE AV: CHABOT RD	564

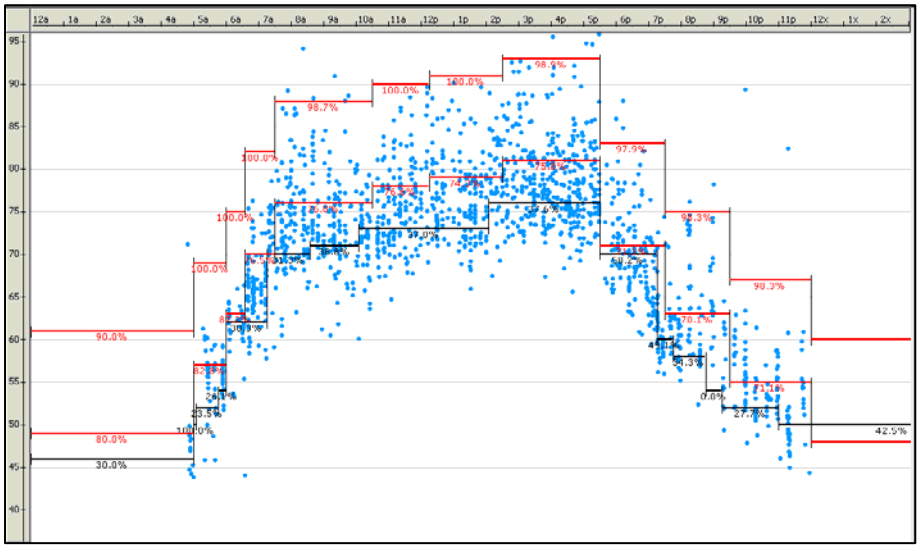
Northbound Bus Stop Spacing (Continued)	
Bus Stop Location	**Distance (feet)**
COLLEGE AV: CLAREMONT AV	811
COLLEGE AV: ALCATRAZ AV	688
COLLEGE AV: WOOLSEY ST	1110
COLLEGE AV: WEBSTER ST	666
COLLEGE AV: ASHBY AV	486
COLLEGE AV: RUSSELL ST	565
COLLEGE AV: DERBY ST	1146
COLLEGE AV: PARKER ST	788
COLLEGE AV: HASTE ST	973
BANCROFT WY: COLLEGE AV	1097
BANCROFT WY: BOWDITCH ST	541
BANCROFT WY: TELEGRAPH AV	771
BANCROFT WY: DANA ST	656
bancroft wy: ellsworth st	639
SHATTUCK AV: KITTREDGE ST	1338
shattuck sq: center st	850
university ave: shattuck ave	857
UNIVERSITY AV: MILVIA ST	669
UNIVERSITY AV: MARTIN LUTHER KING JR WY	501
UNIVERSITY AV: GRANT ST	713
UNIVERSITY AV: MC GEE AV	780
UNIVERSITY AV: CALIFORNIA ST	526
UNIVERSITY AV: SACRAMENTO ST	543
UNIVERSITY AV: ACTON ST	741
UNIVERSITY AV: BONAR ST	955
UNIVERSITY AV: CURTIS ST	567
university ave: san pablo ave	972
UNIVERSITY AV: 9TH ST	455
UNIVERSITY AV: 6TH ST	956
UNIVERSITY AV: 4TH ST	688
UNIVERSITY AV: 3RD ST	402

Appendix 6b – Bus Stop Locations and Spacing (Southbound)

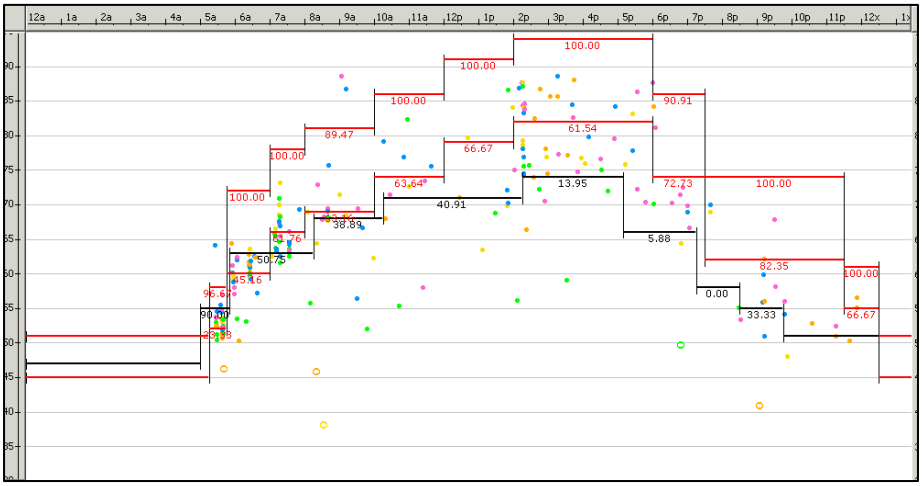
Southbound Bus Stop Spacing	
Bus Stop Location	**Distance (feet)**
UNIVERSITY AV: 3RD ST	0
UNIVERSITY AV: 4TH ST	477
UNIVERSITY AV: 6TH ST	511
UNIVERSITY AV: 9TH ST	947
UNIVERSITY AV: SAN PABLO AV	471
UNIVERSITY AV: CURTIS ST	955
UNIVERSITY AV: BONAR ST	385
UNIVERSITY AV: ACTON ST	1023
UNIVERSITY AV: SACRAMENTO ST	924
UNIVERSITY AV: CALIFORNIA ST	412
UNIVERSITY AV: MC GEE AV	658
UNIVERSITY AV: GRANT ST	732
UNIVERSITY AV: MARTIN LUTHER KING JR WY	720
UNIVERSITY AV: MILVIA ST	459
UNIVERSITY AV: SHATTUCK AV	650
SHATTUCK AV: ALLSTON WY	1095
SHATTUCK AV: KITTREDGE ST	428
DURANT AV: SHATTUCK AV	756
DURANT AV: FULTON ST	507
DURANT AV: ELLSWORTH ST	510
DURANT AV: DANA ST	685
DURANT AV: TELEGRAPH AV	633
DURANT AV: BOWDITCH ST	684
DURANT AV: COLLEGE AV	633
COLLEGE AV: HASTE ST	642
COLLEGE AV: PARKER ST	1104
COLLEGE AV: DERBY ST	692
COLLEGE AV: RUSSELL ST	1171
COLLEGE AV: ASHBY AV	695
COLLEGE AV: WEBSTER ST	489
COLLEGE AV: WOOLSEY ST	662
COLLEGE AV: ALCATRAZ AV	812
COLLEGE AV: CLAREMONT AV	988
COLLEGE AV: CHABOT RD	550
COLLEGE AV: OAK GROVE AV (OPP. CLAREMON	539
college ave: miles ave	462
COLLEGE AV: FOREST ST	670
COLLEGE AV: MANILA AV	911
COLLEGE AV: BROADWAY	1337
BROADWAY: 51ST ST	664
BROADWAY: 45TH ST	639
BROADWAY: 42ND ST (OAKLAND TECHNICAL HI	771
BROADWAY: 40TH ST	1434
BROADWAY: 38TH ST	612

Southbound Bus Stop Spacing (Continued)	
Bus Stop Location	**Distance (feet)**
BROADWAY: W MACARTHUR BLVD	908
BROADWAY: #3505 (MOSSWOOD PARK)	470
BROADWAY: PIEDMONT AV	664
BROADWAY: 30TH ST	1064
BROADWAY: 29TH ST	537
BROADWAY: 28TH ST	404
BROADWAY: 24TH ST	1165
BROADWAY: W GRAND AV	937
broadway: 20th st	999
broadway: 17th st	798
BROADWAY: 14TH ST (12TH ST BART STATION	1215
BROADWAY: 12TH ST (12TH ST BART STATION	463
broadway: 9th st	621
7TH ST: FRANKLIN ST	1001
WEBSTER ST: TINKER AV	5859
WEBSTER ST: ATLANTIC AV	2259
WEBSTER ST: BUENA VISTA AV	738
webster st: lincoln ave	770
SANTA CLARA AV: WEBSTER ST	707
SANTA CLARA AV: 8TH ST	998
SANTA CLARA AV: CAROLINE ST	1345
SANTA CLARA AV: BAY ST	988
SANTA CLARA AV: MORTON ST	718
SANTA CLARA AV: STANTON ST	717
SANTA CLARA AV: GRAND ST	1115
SANTA CLARA AV: CHESTNUT ST	1386
SANTA CLARA AV: WILLOW ST	973
SANTA CLARA AV: WALNUT ST	938
SANTA CLARA AV: OAK ST	937
SANTA CLARA AV: PARK ST	452
BROADWAY: SANTA CLARA AV	1457
BROADWAY: LINCOLN AV	453
broadway: tilden way	894
BLANDING AV: BROADWAY	1206

Appendix 7a – Actual Running Time (Northbound)



Appendix 7b – Actual Running Time (Southbound)



Appendix 8 – MUNI Tool Box

Tool Box

In 2001, Muni issued its *Vision for Rapid Transit in San Francisco.* This document provides a good description of various measures, procedures and improvements that can improve transit service. Muni referred to these as the "Toolbox" and they serve the discussion of the various improvements to the 51 line well. The Toolbox description includes (from Muni's *Vision*):

> This toolbox describes potential incremental steps for transit improvements. All corridors discussed here need basic improvements, such as Transit Preferential Street treatments described below, but some conditions justify a more robust, higher capacity mode. Costs are expressed as general, per-mile estimates and do not include companion projects such as new storage and maintenance facilities, new vehicles, and ongoing operating and maintenance costs.

Transit Preferential Street (TPS) Treatments

The TPS tool consists of a variety of low-to-medium cost treatments that speed transit vehicle flow. These can also be implemented individually but are more effective taken together.

- Signal Timing for Transit Vehicle Flow
- Signal Priority Systems
- Bus Bulbs (sidewalk extensions at bus stops)
- Boarding Islands
- Transit Lanes
- Exclusive Transit Right-of-Way
- Transit Stop Respacing and Relocation

Cost per mile: $200,000

Conversion to Trolley Coach/Trolley Coach Extension

Electric trolley coaches are rubber-tired coaches that are powered electrically from fixed overhead wires……Trolley coaches produce zero emissions and are particularly effective on steep grades….Conversion of more lines to trolley coach operation is desirable because they are quiet, clean vehicles that enhance the quality of life in an urban setting.

Cost per mile: $6.6 Million

Bus Rapid Transit (BRT)
BRT is rubber-tired vehicle operation configured to offer speeds and capacity similar to rail transit, with exclusive travel lanes, limited stops, and signal pre-emption. Other characteristics include the use of low-floor transit vehicles, a prepaid fare system that expedites boarding, and stations that provide shelter and passenger information. Because BRT vehicles are separated from other vehicles and stop less frequently, travel time decreases. BRT is appropriate in corridors with high ridership where there is sufficient ROW to provide dedicated lanes. BRT does not require as much capital infrastructure as surface light rail transit (LRT), and may serve as the first phase of implementing light rail transit.

Cost per mile: $28 Million

Surface Light Rail Transit (LRT)
LRT on surface streets operates most efficiently in exclusive rights-of-way, where traffic is prohibited (possibly by a physical barrier) from traveling in the same lane as the transit vehicle but is allowed to cross at intersections. LRT ideally operates with signal preempts, allowing vehicles to travel relatively unimpeded from station to station…….

Cost per mile: $59 Million

Subway Light Rail Transit (LRT)
In addition to running on the surface, light rail can operate in subways in congested areas. LRT operation is most efficient in an exclusive right-of-way with no conflicts with other vehicles and pedestrians, where speed is maximized and train control can be automated. This is only possible in a grade-separated right-of-way, such as a subway……...The cost of building a subway is justified where there is a high density of population, destinations, and traffic, such as downtown.

Cost per mile: $366 Million

Other Tools

This document focuses on physical infrastructure investments, but there are other tools that would help reduce travel time and provide a higher level of service to riders.

- Proof of Payment
- Express, limited, or skip-stop service
- Low-floor vehicles
- Real-time passenger information systems.

Appendix 9 – Ridership Data (Dir 1B & A Weekday)

ROUTE	DAYTYPE	DIR	ADIR	STOP NO	LOCATION	ON	OFF
51	WEEKDAY	1	NB	1	BLANDING AV & BROADWAY	312	0
51	WEEKDAY	1	NB	2	BROADWAY & TILDEN WY	1	1
51	WEEKDAY	1	NB	3	BROADWAY & LINCOLN AV	18	0
51	WEEKDAY	1	NB	4	SANTA CLARA AV & BROADWAY	98	2
51	WEEKDAY	1	NB	5	SANTA CLARA AV & PARK ST	363	11
51	WEEKDAY	1	NB	6	SANTA CLARA AV & OAK ST	141	4
51	WEEKDAY	1	NB	7	SANTA CLARA AV & WALNUT S	125	10
51	WEEKDAY	1	NB	8	SANTA CLARA AV & WILLOW S	127	16
51	WEEKDAY	1	NB	9	SANTA CLARA AV & CHESTNUT	120	24
51	WEEKDAY	1	NB	10	SANTA CLARA AV & GRAND ST	119	32
51	WEEKDAY	1	NB	11	SANTA CLARA AV & STANTON	55	25
51	WEEKDAY	1	NB	12	SANTA CLARA AV & MORTON S	43	11
51	WEEKDAY	1	NB	13	SANTA CLARA AV & BAY ST	99	40
51	WEEKDAY	1	NB	14	SANTA CLARA AV & MOZART S	42	23
51	WEEKDAY	1	NB	15	SANTA CLARA AV & 9TH ST	77	33
51	WEEKDAY	1	NB	16	SANTA CLARA AV & 8TH ST	48	23
51	WEEKDAY	1	NB	17	SANTA CLARA AV & WEBSTER	252	112
51	WEEKDAY	1	NB	18	WEBSTER ST & LINCOLN AV	108	31
51	WEEKDAY	1	NB	19	WEBSTER ST & BUENA VISTA	189	32
51	WEEKDAY	1	NB	20	WEBSTER ST & ATLANTIC AV	273	88
51	WEEKDAY	1	NB	21	8TH ST & HARRISON ST	126	349
51	WEEKDAY	1	NB	22	8TH ST & BROADWAY	169	127
51	WEEKDAY	1	NB	23	BROADWAY & 11TH ST	166	481
51	WEEKDAY	1	NB	24	BROADWAY & 12TH ST	376	277
51	WEEKDAY	1	NB	25	BROADWAY & 13TH ST	156	66
51	WEEKDAY	1	NB	26	BROADWAY & 17TH ST	106	87
51	WEEKDAY	1	NB	27	BROADWAY & 19TH ST	65	74
51	WEEKDAY	1	NB	28	BROADWAY & 20TH ST	151	94
51	WEEKDAY	1	NB	29	BROADWAY & GRAND AV	85	79
51	WEEKDAY	1	NB	30	BROADWAY & 25TH ST	38	30
51	WEEKDAY	1	NB	31	BROADWAY & 28TH ST	86	193
51	WEEKDAY	1	NB	32	BROADWAY & 29TH ST	65	125
51	WEEKDAY	1	NB	33	BROADWAY & 30TH ST	26	28
51	WEEKDAY	1	NB	34	BROADWAY & PIEDMONT AV	21	66
51	WEEKDAY	1	NB	35	3506 BROADWAY	8	32
51	WEEKDAY	1	NB	36	BROADWAY & W MACARTHUR BL	141	294
51	WEEKDAY	1	NB	37	BROADWAY & 38TH ST	48	15
51	WEEKDAY	1	NB	38	BROADWAY & 40TH ST	111	120
51	WEEKDAY	1	NB	39	BROADWAY & MATHER ST	29	67
51	WEEKDAY	1	NB	40	BROADWAY & WHITMORE ST	48	90
51	WEEKDAY	1	NB	41	BROADWAY & PLEASANT VALLE	61	89
51	WEEKDAY	1	NB	42	COLLEGE AV & BROADWAY	90	87
51	WEEKDAY	1	NB	43	COLLEGE AV & MANILA AV	52	40
51	WEEKDAY	1	NB	44	COLLEGE AV & LAWTON AV	42	32

ROUTE	DAYTYPE	DIR	ADIR	STOP NO	LOCATION	ON	OFF
51	WEEKDAY	1	NB	45	COLLEGE AV & ROCKRIDGE BA	178	91
51	WEEKDAY	1	NB	46	COLLEGE AV & MILES AV	30	30
51	WEEKDAY	1	NB	47	COLLEGE AV & OAK GROVE AV	4	0
51	WEEKDAY	1	NB	48	COLLEGE AV & CHABOT RD	29	18
51	WEEKDAY	1	NB	49	COLLEGE AV & CLAREMONT AV	49	47
51	WEEKDAY	1	NB	50	COLLEGE AV & ALCATRAZ AV	131	57
51	WEEKDAY	1	NB	51	COLLEGE AV & WOOLSEY ST	30	14
51	WEEKDAY	1	NB	52	COLLEGE AV & WEBSTER ST	34	37
51	WEEKDAY	1	NB	53	COLLEGE AV & ASHBY AV	87	70
51	WEEKDAY	1	NB	54	COLLEGE AV & RUSSELL ST	83	39
51	WEEKDAY	1	NB	55	COLLEGE AV & DERBY ST	61	46
51	WEEKDAY	1	NB	56	COLLEGE AV & PARKER ST	88	50
51	WEEKDAY	1	NB	57	COLLEGE AV & DWIGHT WY	147	105
51	WEEKDAY	1	NB	58	COLLEGE AV & HASTE ST	4	2
51	WEEKDAY	1	NB	59	COLLEGE AV & CHANNING WY	71	73
51	WEEKDAY	1	NB	60	BANCROFT WY & COLLEGE AV	159	270
51	WEEKDAY	1	NB	61	BANCROFT WY & BOWDITCH ST	104	87
51	WEEKDAY	1	NB	62	BANCROFT WY & TELEGRAPH A	353	290
51	WEEKDAY	1	NB	63	BANCROFT WY & DANA ST	67	59
51	WEEKDAY	1	NB	64	BANCROFT WY & ELLSWORTH S	23	48
51	WEEKDAY	1	NB	65	SHATTUCK AV & KITTREDGE S	118	343
51	WEEKDAY	1	NB	66	SHATTUCK AV & CENTER ST	368	629
51	WEEKDAY	1	NB	67	SHATTUCK SQ & ADDISON ST	6	2
51	WEEKDAY	1	NB	68	UNIVERSITY AV & MILVIA ST	118	122
51	WEEKDAY	1	NB	69	UNIVERSITY AV & M L KING	65	63
51	WEEKDAY	1	NB	70	UNIVERSITY AV & GRANT ST	15	45
51	WEEKDAY	1	NB	71	UNIVERSITY AV & MCGEE AV	19	68
51	WEEKDAY	1	NB	72	UNIVERSITY AV & CALIFORNI	24	46
51	WEEKDAY	1	NB	73	UNIVERSITY AV & SACRAMENT	66	123
51	WEEKDAY	1	NB	74	UNIVERSITY AV & ACTON ST	23	125
51	WEEKDAY	1	NB	75	UNIVERSITY AV & BONAR ST	5	96
51	WEEKDAY	1	NB	76	UNIVERSITY AV & CURTIS ST	6	74
51	WEEKDAY	1	NB	77	UNIVERSITY AV & SAN PABLO	27	505
51	WEEKDAY	1	NB	78	UNIVERSITY AV & 9TH ST	2	99
51	WEEKDAY	1	NB	79	UNIVERSITY AV & 6TH ST	6	156
51	WEEKDAY	1	NB	80	UNIVERSITY AV & 4TH ST	0	61
51	WEEKDAY	1	NB	81	UNIVERSITY AV & 3RD ST - EOL	0	1

Appendix 10 – Ridership Data (Dir OB & A Weekday)

ROUTE	DAYTYPE	DIR	ADIR	STOP NO	LOCATION	ON	OFF
51	WEEKDAY	0	SB	1	UNIVERSITY AV & 3RD ST	394	0
51	WEEKDAY	0	SB	2	UNIVERSITY AV & 4TH ST	0	0
51	WEEKDAY	0	SB	3	UNIVERSITY AV & 6TH ST	142	1
51	WEEKDAY	0	SB	4	UNIVERSITY AV & 9TH ST	82	3
51	WEEKDAY	0	SB	5	UNIVERSITY AV & SAN PABLO	400	28
51	WEEKDAY	0	SB	6	UNIVERSITY AV & CURTIS ST	39	1
51	WEEKDAY	0	SB	7	UNIVERSITY AV & BONAR ST	88	10
51	WEEKDAY	0	SB	8	UNIVERSITY AV & ACTON ST	104	21
51	WEEKDAY	0	SB	9	UNIVERSITY AV & SACRAMENT	114	23
51	WEEKDAY	0	SB	10	UNIVERSITY AV & CALIFORNI	38	9
51	WEEKDAY	0	SB	11	UNIVERSITY AV & MCGEE ST	52	21
51	WEEKDAY	0	SB	12	UNIVERSITY AV & GRANT ST	31	17
51	WEEKDAY	0	SB	13	UNIVERSITY AV & M L KING	53	66
51	WEEKDAY	0	SB	14	UNIVERSITY AV & MILVIA ST	46	41
51	WEEKDAY	0	SB	15	UNIVERSITY AV & SHATTUCK	75	178
51	WEEKDAY	0	SB	16	SHATTUCK AV & ALLSTON WY	557	332
51	WEEKDAY	0	SB	17	SHATTUCK AV & KITTREDGE S	158	39
51	WEEKDAY	0	SB	18	DURANT AV & SHATTUCK AV	187	38
51	WEEKDAY	0	SB	19	DURANT AV & FULTON ST	58	15
51	WEEKDAY	0	SB	20	DURANT AV & ELLSWORTH ST	49	30
51	WEEKDAY	0	SB	21	DURANT AV & DANA ST	75	79
51	WEEKDAY	0	SB	22	DURANT AV & TELEGRAPH AV	304	384
51	WEEKDAY	0	SB	23	DURANT AV & BOWDITCH ST	75	110
51	WEEKDAY	0	SB	24	DURANT AV & COLLEGE AV	120	307
51	WEEKDAY	0	SB	25	COLLEGE AV & HASTE ST	3	1
51	WEEKDAY	0	SB	26	COLLEGE AV & DWIGHT WY	146	207
51	WEEKDAY	0	SB	27	COLLEGE AV & PARKER ST	59	101
51	WEEKDAY	0	SB	28	COLLEGE AV & DERBY ST	64	72
51	WEEKDAY	0	SB	29	COLLEGE AV & RUSSELL ST	54	74
51	WEEKDAY	0	SB	30	COLLEGE AV & ASHBY AV	126	74
51	WEEKDAY	0	SB	31	COLLEGE AV & WEBSTER ST	22	21
51	WEEKDAY	0	SB	32	COLLEGE AV & WOOLSEY ST	15	25
51	WEEKDAY	0	SB	33	COLLEGE AV & ALCATRAZ AV	53	135
51	WEEKDAY	0	SB	34	COLLEGE AV & CLAREMONT AV	43	59
51	WEEKDAY	0	SB	35	COLLEGE AV & CHABOT RD	11	24
51	WEEKDAY	0	SB	36	COLLEGE AV & OAK GROVE AV	52	36
51	WEEKDAY	0	SB	37	COLLEGE AV & ROCKRIDGE BA	60	193
51	WEEKDAY	0	SB	38	COLLEGE AV & FOREST ST	29	35
51	WEEKDAY	0	SB	39	COLLEGE AV & MANILA AV	38	41
51	WEEKDAY	0	SB	40	COLLEGE AV & BROADWAY	73	78
51	WEEKDAY	0	SB	41	BROADWAY & 51ST ST	108	70
51	WEEKDAY	0	SB	42	BROADWAY & 45TH ST	87	27
51	WEEKDAY	0	SB	43	BROADWAY & 42ND ST	86	21
51	WEEKDAY	0	SB	44	BROADWAY & 40TH ST	166	141
51	WEEKDAY	0	SB	45	BROADWAY & 38TH ST	19	9
51	WEEKDAY	0	SB	46	BROADWAY & W MACARTHUR BL	267	96

ROUTE	DAYTYPE	DIR	ADIR	STOP NO	LOCATION	ON	OFF
51	WEEKDAY	0	SB	47	3505 BROADWAY	21	5
51	WEEKDAY	0	SB	48	BROADWAY & PIEDMONT AV	54	23
51	WEEKDAY	0	SB	49	BROADWAY & 30TH ST	43	25
51	WEEKDAY	0	SB	50	BROADWAY & 29TH ST	131	46
51	WEEKDAY	0	SB	51	BROADWAY & 28TH ST	148	38
51	WEEKDAY	0	SB	52	BROADWAY & 26TH ST	7	2
51	WEEKDAY	0	SB	53	BROADWAY & 24TH ST	55	43
51	WEEKDAY	0	SB	54	BROADWAY & W GRAND AV	55	50
51	WEEKDAY	0	SB	55	BROADWAY & 20TH ST	120	180
51	WEEKDAY	0	SB	56	BROADWAY & 19TH ST	71	36
51	WEEKDAY	0	SB	57	BROADWAY & TELEGRAPH AV	110	136
51	WEEKDAY	0	SB	58	BROADWAY & 14TH ST	551	550
51	WEEKDAY	0	SB	59	BROADWAY & 12TH ST	240	102
51	WEEKDAY	0	SB	60	BROADWAY & 9TH ST	180	214
51	WEEKDAY	0	SB	61	7TH ST & FRANKLIN ST	259	135
51	WEEKDAY	0	SB	62	WEBSTER ST & TINKER AV	10	35
51	WEEKDAY	0	SB	63	WEBSTER ST & ATLANTIC AV	115	248
51	WEEKDAY	0	SB	64	WEBSTER ST & BUENA VISTA	52	167
51	WEEKDAY	0	SB	65	WEBSTER ST & LINCOLN AV	48	148
51	WEEKDAY	0	SB	66	SANTA CLARA AV & WEBSTER	97	264
51	WEEKDAY	0	SB	67	SANTA CLARA AV & 8TH ST	33	70
51	WEEKDAY	0	SB	68	SANTA CLARA AV & 9TH ST	30	82
51	WEEKDAY	0	SB	69	SANTA CLARA & CAROLINE ST	14	53
51	WEEKDAY	0	SB	70	SANTA CLARA AV & BAY ST	47	117
51	WEEKDAY	0	SB	71	SANTA CLARA AV & MORTON S	16	45
51	WEEKDAY	0	SB	72	SANTA CLARA AV & STANTON	19	57
51	WEEKDAY	0	SB	73	SANTA CLARA AV & GRAND ST	36	122
51	WEEKDAY	0	SB	74	SANTA CLARA AV & CHESTNUT	28	132
51	WEEKDAY	0	SB	75	SANTA CLARA AV & WILLOW S	15	152
51	WEEKDAY	0	SB	76	SANTA CLARA AV & WALNUT S	3	118
51	WEEKDAY	0	SB	77	SANTA CLARA AV & OAK ST	5	192
51	WEEKDAY	0	SB	78	SANTA CLARA AV & PARK ST	9	451
51	WEEKDAY	0	SB	79	SANTA CLARA AV & EVERETT	2	41
51	WEEKDAY	0	SB	80	SANTA CLARA AV & BROADWAY	1	117
51	WEEKDAY	0	SB	81	BROADWAY & LINCOLN AV	0	25
51	WEEKDAY	0	SB	82	BROADWAY & BUENA VISTA AV	0	8
51	WEEKDAY	0	SB	83	BLANDING AV & BROADWAY - EOL	0	23