

TECHNICAL MEMORANDUM

Balboa Reservoir Supplemental EIR

Responses to Comments Supplementary Memorandum

Transit Delay Analysis and Capital Improvements

Date: March 29, 2020
To: Wade Wietgreffe, Liz White
From: Mike Alston, RSP & Amanda Leahy, AICP
cc: Jeanie Poling

PURPOSE OF MEMORANDUM

This technical memorandum (memo) identifies and analyzes existing sources of transit delay to the 29 Sunset, K/T Third/Ingleside, and 43 Masonic Muni lines in the Balboa Reservoir project study area, and then recommends offsite capital improvements to reduce transit travel times. The results of this analysis further refine and inform Balboa Reservoir Draft Subsequent Environmental Impact Report (DSEIR)'s **Mitigation Measure M-C-TR-4. Monitor Cumulative Transit Travel Times and Implement Measures To Reduce Transit Delay.**

This memo is organized as follows:

- Background
- Analysis Approach
- Findings
- Recommended Improvements
- Secondary Effects of Implementing Improvements

BACKGROUND

The DSEIR presented an analysis of transit delay under existing plus project conditions and under 2040 cumulative conditions. The impacts were determined to be less than significant under existing plus project conditions and significant and unavoidable under 2040 cumulative conditions, with the proposed project contributing considerably. The project would make a considerable contribution, defined as two or more minutes, to cumulative transit delay to the K/T Third/Ingleside; 29 Sunset; and the 43 Masonic Muni lines.^{1,2}

¹ The 8 Bayshore and 8BX Bayshore B Express series buses also travel through the study area; however, as identified in the DSEIR, the proposed project would not considerably contribute to cumulative transit delay on these routes. The 91

ANALYSIS APPROACH

This analysis consists of both quantitative and qualitative approaches to identify and analyze sources of transit delay and quantify how implementation of capital improvements would reduce transit travel times. **Figure 1** presents the study area as it relates to these approaches.

Analysis Approach for K/T Third/Ingleside and 29 Sunset

The analysis approach compares transit travel times during the peak period and nighttime off-peak period. Transit travel times are typically slowest during the p.m. peak period, greatly influenced by vehicle congestion. Off-peak nighttime travel times represent conditions in which transit vehicles do not experience the typical delays related to vehicle congestion in the p.m. peak period. As a result, the off-peak nighttime travel times are a comparison to the p.m. peak period travel times to calculate the differences between individual segments of delay within the study area, and to identify the delay sources for those segments.

Identifying the specific locations, causes, and amount of delay along a transit route provides the ability to estimate delay reductions from capital improvements. In contrast, the data collected for the DSEIR analysis includes existing K/T travel times for the full segment along Ocean Avenue between Jules Avenue and Balboa Park BART, but not for points and subdivided segments along the corridor.

The analysis was conducted for the routes along the following segments:

- K/T Third/Ingleside: Jules Avenue/Ocean Avenue to Balboa Park Bay Area Rapid Transit (BART);
- K/T Third/Ingleside: San Jose Avenue/Geneva Avenue to Dorado Terrace/Ocean Avenue;
- 29 Sunset: Plymouth Avenue/Ocean Avenue to Mission St/Persia Avenue; and
- 29 Sunset: Mission St/Persia Avenue to Plymouth Avenue/Ocean Avenue.

Third Street/19th Avenue Owl and K Owl also travels through the corridor but is an overnight only route and is not included in the analysis.

² The Responses to Comments (RTC) document revised the draft SEIR analysis and Mitigation Measure M-C-TR-4, which incorrectly identified that the proposed project would have a considerable contribution to cumulative transit delay on the 49 Van Ness/Mission line.

Figure 1: Transit Delay Analysis and Capital Improvements Study Area

Field data collection was collected to identify the following:

- Sources of transit delay along the corridor (location and descriptive cause);
- Delay values associated with given locations and bus actions (corridor delay, transit reentry delay, or passenger boarding delay); and
- Qualitative observations of conditions at potential improvement locations.

Based on the data and observations, capital improvements are then recommended to improve transit operations at a fixed point along a service segment (i.e., an intersection and approach direction), with benefits accruing to the segment's travel time.

Analysis Approach for 43 Masonic

The analysis for the 43 Masonic supplements the Synchro corridor analysis from the DSEIR and utilizes the traffic counts and future traffic volumes from the DSEIR to calculate delay to the line at the Ocean Avenue/Frida Kahlo Way/Geneva Avenue intersection.³ The delay associated with the inbound 43 Masonic (i.e., going towards Balboa Park BART station) primarily comes from the signal at Frida Kahlo Way/Geneva Avenue/Ocean Avenue. The delay experienced at this intersection is primarily associated with vehicle congestion. This is different than the delay on Ocean Avenue, which can be attributed to other factors, such as left or right turning vehicles.

As a result, no additional data collection was needed to calculate transit delay because the supplemental Synchro analysis allows the disaggregation of corridor travel time to identify the amount of delay attributable to the specific transit movement at the intersection versus along the segment as a whole.

DATA COLLECTION

The field data collection occurred in two phases to achieve a disaggregate analysis of travel times and delays. The p.m. peak period data collection and observations yielded travel times along and through fixed segments of the transit routes, along with descriptions of operational events at each location. The p.m. peak period data collection was conducted from 5-7 p.m. on Tuesday, December 17, 2019; Wednesday, December 18, 2019; and Thursday, January 16, 2020. The off-peak travel time runs provided a baseline travel time along the lines as well as times along and through the same fixed

³ As part of the DSEIR analysis, transit corridor delay was quantified using Trafficware's Synchro modeling software arterial/corridor delay reports to calculate traffic congestion delays along corridors served by transit. Intersection operations analysis was performed using Synchro software and conducted using the SF Planning Department's *Guidelines for Synchro Intersection LOS Analysis*. Intersection operations were analyzed for Existing Conditions, Existing plus Developer's Proposed Option (which includes reassigned parking trips), and Existing plus Additional Housing Option (does not include reassigned parking trips) for the weekday a.m. and p.m. peak hours.

segments observed in the p.m. peak period collection. The off-peak travel time runs occurred between 8 p.m. and 11:59 p.m. on Thursday, January 9, 2020, and Thursday, January 23, 2020.^{4,5}

P.M. Peak Period Delay Collection and Observation

Travel time data were collected and qualitative observations recorded at the following locations from a fixed vantage point⁶:

- Ocean Avenue and Brighton Avenue (eastbound and westbound)⁷;
- Ocean Avenue and Plymouth Avenue (eastbound and westbound)⁷; and
- Ocean Avenue and Frida Kahlo Avenue (eastbound and westbound)⁸.

At each intersection, both segment travel time and intersection travel time were calculated, both of which are defined below. The number of observations used to establish the averages is provided in each table with the discussion of findings.

Segment travel time is defined as the time required for the transit vehicle to travel from the previous intersection to the subject intersection. The recorded time began when the front of the vehicle cleared the previous intersection and ended when:

- The vehicle stopped at a red light or entered the back of a queue at the light; or
- The front of the vehicle entered the intersection during a green light; or
- The vehicle was within a car length of the back of a queue at the intersection.

Intersection travel time is defined as the time required for the transit vehicle to pass through an intersection. The recorded time began when:

- The vehicle stopped at a red light or entered the back of a queue at the light; or
- The front of the vehicle entered the intersection during a green light; or

⁴ City College was in regular session during all p.m. peak period data collection (December 17, December 18, January 16). City College was in regular session during January 23, 2020, off-peak (8-11 p.m.) data collection but not during January 9 off-peak data collection. As explained, off-peak travel time runs were compared to historical data to check that they were representative.

⁵Field data were collected during typical conditions (i.e., no events, disruptions, or inclement weather).

⁶ These data collection locations were identified in coordination with the SFMTA.

⁷This intersection was observed from public space in front of the McDonald's on the south side of Ocean Avenue between Plymouth and Brighton avenues.

⁸ This intersection was observed from an elevated vantage point on the Ocean Avenue pedestrian bridge.

- The recorded time ended when the front of the transit vehicle cleared the intersection.

Off-Peak Travel Nighttime Time Runs

Kittelsohn conducted onboard travel time runs on the studied segments to establish baseline times in calculating p.m. peak period delay.⁹ These segments included:

- K/T Third/Ingleside
 - Eastbound, Ocean Avenue/Miramar Avenue to Balboa Park BART
 - Westbound, Balboa Park BART to Ocean Avenue/Miramar Avenue
- 29 Sunset
 - Eastbound, Plymouth Avenue/Ocean Avenue to Ocean Avenue/Howth Street
 - Westbound, Ocean Avenue/I-280 onramp to Plymouth Avenue/ Ocean Avenue

FINDINGS

Ocean Avenue/Brighton Avenue

Eastbound

Table 1 provides average observed travel times at Ocean and Brighton avenues in the eastbound direction for the K/T Third/Ingleside and the 29 Sunset.

⁹To ensure these travel times were representative of typical off-peak nighttime conditions, Kittelson compared the stop-to-stop travel times to historical SFMTA travel time data as a cross-check. The SFMTA maintains an internal database of historical travel times; those data points are aggregated as historical travel time between stops. SFMTA provided historical weeknight travel times as a point of reference. The SFMTA data provided includes median and 90th percentile historical travel times between stops. The historical travel time data is included in Appendix D.

Table 1: Transit Travel Time Delays Eastbound at Ocean Avenue/Brighton Avenue

Route/Location	Off-Peak Average Travel Time, Seconds (number of observations)	Nighttime Average Travel Time, Seconds (number of observations)	Peak Average Travel Time, Seconds (number of observations)	Difference, seconds
K/T Third/Ingleside				
Segment travel time: Plymouth to Brighton	14		14	0
Intersection travel time: through Brighton	4		29	26
29 Sunset				
Segment travel time: Plymouth to Brighton	13		17	4
Intersection travel time: through Brighton	12		28	16

Note: Averages based on four K/T off-peak period observations, three 29 off-peak period observations, 16 peak period K/T observations, and 10 peak period 29 observations.

Source: Kittelson, 2020.

Most differences in delay at this location were associated with the intersection: an average of 26 and 16 seconds for the K/T Third/Ingleside and 29 Sunset, respectively. The following observations provide context for peak period travel times at this location in the eastbound direction:

- The segment travel times were relatively similar between peak and off-peak periods, indicating that delay is mostly related to signal timing and intersection queueing rather than conditions along the corridor that would slow transit along the segment.
- The K/T travels in the center-running track lane and is sometimes delayed by left-turning vehicles. The train was frequently observed to be stuck behind left-turning vehicles, at times resulting in missing a green light and incurring additional delay from the red signal.
- The K/T routinely stopped at red lights in the p.m. peak period. In the off-peak period, the line was not observed to experience any travel time delay due to red lights.
- The 29 has the flexibility to operate in either lane and was generally observed in the right travel lane and does not wait directly behind left-turning vehicles (it must be in the right lane traveling through the intersection to be aligned to serve the next passenger stop). However, one observation noted that queuing from a left-turning vehicle affected both lanes and contributed to delay for the 29.
- The 29 was frequently stopped at red lights during the peak period.
- With the center-running track lane serving left-turning vehicles, the right lane serves the 29, a majority of through vehicles, and right-turning vehicles. Drivers turning right must yield to pedestrian movements at the parallel crosswalk, delaying through vehicles behind right-turning vehicles.

In the eastbound direction, much of the delay to the K/T Line and a portion of the delay to the 29 can be attributed to left-turning vehicle delay. This includes frequently waiting behind left-turning vehicles searching for a gap in oncoming traffic.

Westbound

Table 2 provides average observed travel times on Ocean Avenue approaching and through Brighton Avenue in the westbound direction for the K/T Third/Ingleside and the 29 Sunset.

Table 2: Transit Travel Time Delays Westbound at Ocean Avenue/Brighton Avenue

Route/Location	Off-Peak Average Travel Time (seconds)	Nighttime Travel Time (seconds)	Peak Average Travel Time (seconds)	Difference in seconds
K/T Third/Ingleside				
Segment travel time: Lee to Brighton	8		15	7
Intersection travel time: through Brighton	3		23	20
29 Sunset				
Segment travel time: Lee to Brighton	8		19	11
Intersection travel time: through Brighton	2		32	30

Note: Averages based on two K/T off-peak period observations, two 29 off-peak period observations, five peak period K/T observations, and seven peak period 29 observations.

Source: Kittelson, 2020.

Most differences in delay were associated with the intersection: an average of 20 and 30 seconds for the K/T Third/Ingleside and 29 Sunset, respectively. The following observations provide context for the peak period travel times at this location in the westbound direction:

- The segment travel times almost doubled for the K/T and more than doubled for the 29 but represent small portion of each line's travel time compared to the time through the intersection. The differences indicate that p.m. peak period congestion levels affect operating speed through the corridor in the westbound direction.
- The K/T travels in the center-running track lane and is sometimes delayed by left-turning vehicles. The train was not observed to be stuck behind left-turning vehicles such that the train would miss a green light and incur additional delay from the red signal, as was observed in the eastbound direction. However, left turns do contribute to approach delay in this direction, and the K/T was frequently observed to experience delay at red lights in this direction. The p.m. peak hour turning movement counts collected for the project show 122 left-turning vehicles in the p.m. peak hour (see Appendix A); observations indicate that most left-turning drivers must wait until the end of the permissive green phase to turn left.

- The 29 operates in the right travel lane and does not wait directly behind left-turning vehicles. The left-turning delay has less direct influence on 29 operations.
- The 29 was frequently stopped at red lights during the peak period.
- With the center-running track lane serving left-turning vehicles, the right lane serves the 29, and right-turning vehicles, as well as observed to serve the majority of through vehicles. Drivers turning right must yield to pedestrian movements at the parallel crosswalk, potentially delaying through vehicles behind right-turning vehicles.

Ocean Avenue/Plymouth Avenue

Eastbound

Table 3 provides average observed travel times at Ocean and Plymouth avenues in the eastbound direction for the K/T Third/Ingleside.

Table 3: Transit Travel Time Delays Eastbound at Ocean Avenue/Plymouth Avenue

Location	Off-Peak Average Travel Time (seconds)	Nighttime Average Travel Time (seconds)	Peak Average Travel Time (seconds)	Difference in seconds
K/T Third/Ingleside				
Segment travel time: Miramar to Plymouth	16		Not recorded ¹	-
Intersection travel time: through Plymouth	13		27	14

¹Because of limitations from a fixed vantage point, observed p.m. peak period segment travel time was noted between Granada and Plymouth avenues, whereas off-peak period observations noted time between Miramar and Plymouth avenues. Comparison of the two entries would not be commensurate.

Note: Averages based on four K/T off-peak period observations and seven peak period K/T observations.

Source: Kittelson, 2020.

The average p.m. peak hour travel time delay through the intersection was 14 seconds compared to off-peak nighttime conditions. The following observations provide context for peak period travel times:

- The K/T was observed to sit at a red light in almost all p.m. peak hour observations, including as a result of waiting behind a left-turning vehicle and subsequently missing a green phase. Like at the Brighton location, the K/T travels in the center-running track lane and is sometimes delayed by left-turning vehicles.
- The 29 turns right from Plymouth Avenue onto Ocean Avenue at this intersection and does not travel eastbound through the intersection.

Westbound

Table 4 provides average observed travel times at Ocean and Plymouth avenues in the westbound direction for the K/T Third/Ingleside and the 29 Sunset.

Table 4: Transit Travel Time Delays Westbound at Ocean Avenue/Plymouth Avenue

Location	Off-Peak Nighttime Average Travel Time (seconds)	Peak Average Travel Time (seconds)	Difference in seconds)
K/T Third/Ingleside			
Segment travel time: Brighton to Plymouth	7	11	4
Intersection travel time: through Plymouth	4	29	25
29 Sunset			
Segment travel time: Brighton to Plymouth	5	9	4
Intersection travel time: through Plymouth	3	33	30

Note: Averages based on two K/T off-peak period observations, three off-peak period 29 observations, six peak period K/T observations, and 12 peak period 29 observations.

Source: Kittelson, 2020.

The average p.m. peak hour travel time delay through the intersection was 14 seconds compared to off-peak nighttime conditions. The following observations provide context for peak period travel times:

- The travel time difference in segment travel times for each line indicates that the sources of delay are at the intersection rather than due to overall travel speeds on the segment.
- The K/T was observed to sit at a red light in most all p.m. peak hour observations, including as a result of waiting behind a left-turning vehicle and subsequently missing a green phase on multiple occasions. The average delay experienced is largely a result of delay behind left-turning vehicles and subsequent red-light delay. Although the p.m. peak hour average among observations is 30 seconds, the maximum observed intersection travel time was 57 seconds, indicating wide variability. Like at the Brighton location, the K/T travels in the center-running track lane and is sometimes delayed by left-turning vehicles.
- The 29 turns left onto Plymouth Avenue at this intersection, so it is subject to the same operational delay and issues as the K/T. During the p.m. peak hour, the 29 was observed to miss its green phase multiple times, with a maximum intersection travel time of 99 seconds resulting from waiting for left-turning drivers (sitting through two red phases).

Ocean Avenue and Geneva Avenue/Frida Kahlo Way

Eastbound

Table 5 provides average observed travel times in the eastbound direction for the K/T Third/Ingleside and the 29 Sunset.

Table 5: Transit Travel Time Delays Eastbound at Ocean Avenue/Frida Kahlo Way/Geneva Avenue

Location	Off-Peak Average Travel Time (seconds)	Nighttime Travel Time (seconds)	Peak Average Travel Time (seconds)	Difference in seconds
K/T Third/Ingleside				
Segment travel time: Lee to Frida Kahlo	19		18	-
Intersection travel time: through Frida Kahlo ¹	39		53	14
29 Sunset				
Segment travel time: Lee to Frida Kahlo	10		15	5
Intersection travel time: through Frida Kahlo	57		54	-

¹Includes dwell time

Note: Averages based on four K/T off-peak period observations, three off-peak period 29 observations, four peak period K/T observations, and eight peak period 29 observations.

Source: Kittelson, 2020.

As **Table 5** provides, the p.m. peak period travel time delays were relatively small based on the observations and data collection. The following observations provide context for travel times:

- During peak and off-peak periods, the K/T showed consistent travel times between Lee Avenue and the intersection (or back of queue).
- The 29 includes a near side bus stop between Harold and Geneva avenues. Following this stop, the bus driver must reenter the traffic stream to continue along Ocean Avenue. A combination of red lights, associated re-entry delay (with a green or red indication), and slow operating speeds through the intersection resulted in similar peak hour and off-peak average travel times for the 29. Observed p.m. peak hour intersection travel times were widely variable, ranging from 21 seconds to 82 seconds.
- The K/T line shares a travel lane with left-turning vehicles in a left-turn lane with a protected left-turn phase. Although drivers do not share a conflicting phase with crossing pedestrians and do not need to yield to oncoming traffic, the K/T (which continues straight) must wait behind left-turning

vehicles at a red light while adjacent through traffic has a green indication, delaying the line relative to if it was in an exclusive lane or a through lane.

Westbound

Table 6 provides average observed travel times in the westbound direction for the K/T Third/Ingleside and the 29 Sunset.

Table 6: Transit Travel Time Delays Westbound at Ocean Avenue/Frida Kahlo Way/Geneva Avenue

Location	Off-Peak Average Travel Time (seconds)	Nighttime Average Travel Time (seconds)	Peak Average Travel Time (seconds)	Difference in seconds
K/T Third/Ingleside				
Segment travel time: Howth to Frida Kahlo	12		17	5
Intersection travel time: through Frida Kahlo	11		49	38
29 Sunset				
Segment travel time: Howth to Frida Kahlo	15		20	5
Intersection travel time: through Frida Kahlo	8		66	58

Note: Averages based on two K/T off-peak period observations, two off-peak period 29 observations, six peak period K/T observations, and 10 peak period 29 observations.

Source: Kittelson, 2020.

The following observations provide context for travel times:

- In the p.m. peak hour, the K/T experienced an average of 38 seconds of travel time delay compared to off-peak conditions. This delay was mostly a result of red-light delay and of queuing once the K/T left the separated track lane to the east of the intersection. No left turns are allowed from the center-running track lane, so the K/T was not observed to be waiting behind turning vehicles. Rather, the limited green time and the queuing present contributed to higher p.m. peak hour travel times.
- The 29 experienced 58 seconds of relative delay to travel through the intersection in p.m. peak hour conditions compared to in off-peak conditions. Observations noted that the 29 frequently queued in advance of the intersection, in some cases back to Howth Street. As a result of queuing, buses missed green signal phases and waited for an extra signal cycle; the maximum intersection travel time observed in the p.m. peak observations was 213 seconds.
- The 29 was observed to use the center-running track lane to bypass queuing on at least one occasion.

- This intersection is uniquely constrained compared to the other study Intersections:
 - It serves multiple approaches with higher volumes than the Brighton and Plymouth intersections. This includes cross-street volumes and through and turning movement volumes along Ocean Avenue. Much of the delay recorded was observed to be a result of queuing, likely as a result of the allocation of green time to competing intersection approaches.
 - The intersection includes longer pedestrian crossings across Ocean Avenue (in excess of 80 feet) than the other intersections, requiring longer side-street pedestrian crossings phases and a longer signal cycle than the other locations.

These constraints reduce the ability to provide capital improvement solutions compared to the other locations.

Southbound

The 43 Masonic outbound route along Geneva at this location from one of two shared left-through lanes that do not include conflicting pedestrian or vehicle movements. As provided in Table 3.B-18 beginning on Response to Comments Section 4C pp. 4.C-40, project-related increase in vehicle traffic and passenger boarding/alighting activity would be associated with 82 seconds of travel time delay during the p.m. peak hour. Travel time delay is attributable to passenger boarding activity, transit reentry time, and the level of vehicular traffic at the intersection and surrounding the Muni stop approximately 250 feet north of the intersection. The 2000 *Highway Capacity Manual* shows average bus re-entry delay into adjacent traffic streams to increase as a function of the adjacent lane hourly volumes, from an average of zero seconds with 100 vehicles to an average between four and six seconds at volumes between 400 and 600 vehicles per hour.¹⁰ Data collected for this project show a southbound p.m. peak hour volume of 508 vehicles, which corresponds with an estimate of between four and six seconds of reentry delay in addition to delay at the intersection. As explained in the preceding section, this intersection is constrained by vehicle demand and pedestrian crossing lengths that limit possible signal timing solutions.

Combined Delay

Table 7 provides the recorded travel time delays presented above by line, direction, and location.

Table 7: P.M. Peak Hour Transit Travel Time Delays by Line

Location	Eastbound	Westbound
K/T Third/Ingleside		

¹⁰ 2000 *Highway Capacity Manual*, Chapter 27, Exhibit 27-10. Reproduced in the "Public Transit" appendix of the 2019 *San Francisco Transportation Impact Analysis Guidelines* and available at <https://sfplanning.org/project/transportation-impact-analysis-guidelines-environmental-review-update#impact-analysis-guidelines>

Intersection travel time: through Plymouth Avenue	14	25
Intersection travel time: through Brighton Avenue	26	20
Intersection travel time: through Frida Kahlo Way	14	38
Total Combined Delay	54	83
29 Sunset		
Segment Travel Time: Lee to Brighton	n/a	11
Intersection travel time: through Brighton Avenue	16	30
Intersection travel time: through Plymouth	-	30
Intersection travel time: through Frida Kahlo Way	-	58
Total Combined Delay	16	129

Source: Kittelson, 2020.

RECOMMENDED IMPROVEMENTS

The following improvements are recommended to reduce transit travel times in the study area and are displayed in **Construct a** bus boarding island on southbound Frida Kahlo Way.

Figure 2. These proposed improvements require approval by the SFMTA and are subject to review by relevant rail oversight authorities.

- Providing a protected green arrow signal phase for westbound left turns at Ocean Avenue/Brighton Avenue;
- Prohibit eastbound left turns at Ocean Avenue/Brighton Avenue;
- Providing a protected green arrow signal phase for westbound left turns at Ocean Avenue/Plymouth Avenue;
- Prohibit eastbound left turns at Ocean Avenue/Plymouth Avenue; and
- Construct a bus boarding island on southbound Frida Kahlo Way.

Figure 2: Recommended Improvements to Reduce Transit Travel Times



Source: Google Earth.

Ocean Avenue/Brighton Avenue

Eastbound: Prohibit Left Turns

At Ocean and Brighton avenues, prohibiting eastbound left turns would provide dual benefit to transit operations. It would eliminate transit delay for the K/T associated with waiting behind left-turning vehicles, which was observed to result in missing green phases. A left turn prohibition would also provide more through volume capacity and would give through drivers the ability to choose a lane rather than to proceed in the right lane. This would benefit the 29 as well, whose drivers would either travel in a right lane with fewer vehicles or could also use the left lane to travel through the intersection if right-turning vehicles are yielding to crossing pedestrians.

Implementing this improvement would improve reliability for the K/T and 29 and could reduce p.m. peak hour travel time delay compared to off-peak travel times by up to 26 and 16 seconds, respectively. There is no guarantee that the improvement would reduce delay by the full amounts observed, given there are other sources of transit delay.

Westbound: Provide Protected/Permissive Left Turn Phasing

At Ocean and Brighton avenues, providing a protected green arrow left turn phase would allow left-turning vehicles a dedicated portion of the signal phase and would reduce delay for the K/T associated with waiting behind those left-turning vehicles. This improvement would improve reliability for the K/T and could reduce delay by up to 20 seconds. There is no guarantee that the improvement would reduce delay by the full amounts observed, as the K/T line would need to wait for a turning vehicle to clear even though the movement would be more reliable with a protected/permissive phase.

Ocean Avenue/Plymouth Avenue

Eastbound: Prohibit Left Turns

At Ocean and Plymouth avenues, prohibiting eastbound left turns would provide dual benefit to transit operations. It would eliminate transit delay for the K/T associated with waiting behind left-turning vehicles, which was observed to result in missing green phases. A left turn prohibition would also provide more through volume capacity and would give through drivers the ability to choose a lane rather than to proceed in the right lane. This improvement would improve reliability for both lines and could reduce delay for the K/T by up to 14 seconds. There is no guarantee that the improvement would reduce delay by the full amounts observed, given there are other sources of transit delay.

Westbound: Provide Protected/Permissive Left Turn Phasing

At Ocean and Brighton avenues, providing a protected/permissive left turn phase would allow left-turning vehicles a dedicated portion of the signal phase and would reduce delay for the K/T associated with waiting behind those left-turning vehicles. This improvement would improve reliability for the K/T. This benefit would also accrue to the 29, which turns left at the intersection and is subject to the same travel delays. This improvement would improve reliability for both lines and could reduce delay for the K/T by up to 25 seconds and for the 29 by up to 30 seconds. There is no guarantee that the improvement would reduce delay by the full amounts observed, as the K/T and 29 lines would need to wait for a turning vehicle to clear even though the movement would be more reliable with a protected/permissive phase.

Frida Kahlo Way/ Ocean Avenue/Geneva Avenue

Southbound: Transit Boarding Island

The improvement identified to improve transit operations at this intersection is the addition of a transit boarding island along the southbound approach of Frida Kahlo Way. A transit boarding island would be an extension of the sidewalk at the location of the stop that would reduce passenger boarding and re-entry delay associated with accessing the bus stop. The SFMTA Transportation Engineering *Transit Preferential Toolkit* identifies that transit boarding islands typically reduce passenger boarding/alighting

delay by an average of five seconds and reduce re-entry delay by an average of five seconds. This location may be associated with more passenger boarding/alighting delay than five seconds. The boarding island would reduce transit reentry delay, which would in turn allow Muni buses better access to the signal, potentially reducing delay at the intersection by proceeding through on more green signals or getting better position in a queue.

Conclusion

The recommended improvements further refine the capital measures identified as part of **Project Mitigation Measure M-C-TR-4: Monitor Cumulative Transit Travel Times and Implement Measures to Reduce Transit Delay.**

SECONDARY EFFECTS OF IMPLEMENTING IMPROVEMENTS

The following describes the secondary construction and operational effects of implementing the improvements identified above.

Construction

Construction to implement the identified capital improvements would include the following:

- Installation of signage for the prohibited left turns at both Brighton and Plymouth avenues.
- Installation of additional signal heads, possibly including a new mast arm, to provide protected/permissive phasing in the eastbound direction at Plymouth and Brighton avenues.

This level of construction would cause temporary disruption to existing operating conditions and would require a logistics plan to ensure continued service is provided for all travel modes and road users in the interim.

General Effect to Vehicle Traffic

The reliability and delay reduction benefits described for transit vehicles along Ocean Avenue as a result of the proposed changes would also accrue to general traffic along Ocean Avenue. Anticipated effects are discussed below:

- For westbound left-turning drivers at Plymouth and Brighton avenues, a protected/permissive phase provides dedicated time to make the left turn separated from oncoming traffic or pedestrians. It would also provide a safety benefit with the provision of the protected movement.
- The westbound protected left-turn phase would occupy a share of green time and would result in a decrease in green time of a few seconds to other phases.
- For eastbound through drivers along Ocean Avenue, the prohibition of left turns at Plymouth and Brighton avenues would improve travel times and reliability, eliminating instances of delay from waiting behind a left-turning vehicle.

Effects on left-turning drivers at Plymouth or Brighton avenues are discussed in the Circulation section below.

Pedestrian Benefits

The Ocean Avenue/Plymouth Avenue intersection serves many pedestrians in the p.m. peak hour. These pedestrians share a signal phase with the parallel Ocean Avenue movements, including the right-turn, and left-turn movements. The shared vehicle turning movements and pedestrian crossings create a conflict between road users and contributes travel time delay for turning drivers yielding to pedestrians. The two intersections with recommended improvements serve the following number of pedestrians:

- **Ocean Avenue/Brighton Avenue:** 442 pedestrians across north leg, 278 pedestrians across south leg in the weekday p.m. peak hour (5-7 p.m.; see Appendix A)
- **Ocean Avenue/Plymouth Avenue:** 349 pedestrians across north leg, 152 pedestrians across south leg in the weekday p.m. peak hour (5-7 p.m.; see Appendix A)

For pedestrians crossing the north legs of these intersections, conflicting left-turning vehicles would be eliminated. For pedestrians crossing the south legs of these intersections, conflicts with left-turning drivers would be reduced. Separating the left-turning conflicts provides a safety benefit to pedestrians crossing Plymouth and Brighton avenues.

General Effect on Circulation

The identified improvements would have the following anticipated effect on circulation within the study area:

- **The prohibition of eastbound left turns at Ocean and Plymouth avenues.** Prohibiting this movement would redistribute the 11 left-turning drivers currently making this movement in the p.m. peak hour. These drivers would have the following options (see **Construct a** bus boarding island on southbound Frida Kahlo Way.
- Figure 2):
 - Turn left at Faxon, Miramar, or Granada avenues in advance of the Plymouth Avenue intersection; or
 - Turn right at Granada Avenue, left to Holloway Avenue, and then left at Plymouth Avenue, left at Ocean Avenue, and right at Plymouth Avenue, adding approximately 1,700 feet of diversion to their trip.
- **The prohibition of eastbound left turns at Ocean and Brighton avenues.** Prohibiting this movement would redistribute the 39 left-turning drivers currently making this movement in the p.m. peak hour. These drivers would have the following options (see **Construct a** bus boarding island on southbound Frida Kahlo Way.
- Figure 2):

- Turn right at Plymouth, Granada, or Miramar avenues, left at Brighton Avenue, and through at Ocean Avenue, adding approximately 1,700 feet of diversion to their trip. Transit travel time and reliability benefits accrue to general traffic.

Note that Brighton Avenue provides vehicular access to the Whole Foods parking deck and to Avalon Ocean Avenue residential parking.

Both prohibitions would redistribute approximately the number of left-turning trips presented above and would increase the traffic on the relevant local streets by an amount commensurate to the existing eastbound left-turn volumes.

The capital improvements and potential diversions discussed above would not be expected to create conflicts or delays to existing transit operations and would not create safety hazards to people walking, biking, driving, or taking transit. Plymouth, Granada, Miramar, Brighton, and Holloway avenues are low-speed local roads that can accommodate the marginal increase in trips.

APPENDIX A: MULTIMODAL TURNING MOVEMENT COUNTS

APPENDIX B: PEAK HOUR DATA COLLECTION

APPENDIX C: OFF-PEAK (NIGHTTIME) DATA COLLECTION

APPENDIX D: HISTORICAL SFMTA MUNI TRAVEL TIMES