5.0 COMPARISON OF THE TUNNELING METHOD ALTERNATIVES VERSUS THE PROJECT

This chapter presents a summary of the consequences associated with the construction and operation of the two tunneling method alternatives, Alternatives A and B. Information provided includes an overview of the construction descriptions of the two alternatives, and their resulting construction risk considerations, operational impacts, cost and schedule impacts, and environmental effects as valuated and documented in the SEIS.

5.1 Introduction

A summary discussion of the resulting information from the *Draft Flower Street Tunneling Method Alternatives Report (2014)* and the SEIS is provided to allow for informed decision-making. The viability of a transportation system investment typically is based on the following planning, operational, and environmental factors, which are discussed in the following sections:

- **Purpose and Need** – Meeting the project purpose and need as identified in the project study efforts leading up to the Final EIS and summarized in Chapter 1, Background, Purpose and Scope of the SEIS.
- **Construction and Risk Considerations** – Identifying appropriate construction methods and associated risks, and resulting project schedule impacts.
- **Operational Considerations** – Meeting Metro's operational goals for light rail transit service from a customer and rail system operational perspective.
- **Cost and Funding Considerations** – Developing cost estimates to reflect the construction methods and risks of the two alternatives.
- **Environmental Considerations** – Identifying and assessing environmental and community impacts and benefits.

5.2 Description of the Project And Tunneling Method Alternatives

Within the urban and densely built setting along the Flower Street portion of the Regional Connector project alignment, the Project proposes a combination of cut and cover from the 7th Street/Metro Center Station tail tracks structure to 4th Street, and EPBM tunneling north from 4th to 3rd Street. Two tunneling method alternatives (Alternatives A and B) were identified and evaluated in the SEIS that propose different combinations of underground construction as options to the cut and cover method planned for the Project. These alternatives were developed using a variety of tunneling techniques to assess opportunities to reduce the use of cut and cover.

The SEIS is a limited-scope document that provides additional detail on tunneling methods not selected for construction along Flower Street, specifically Open-Face Shield and SEM tunneling for the Flower Street portion of the Regional Connector project alignment between 4th Street and the 7th Street/Metro Center Station. The two tunneling method alternatives identified and evaluated in the

SEIS propose different combinations of underground construction as options to the cut and cover method planned for the Project:

- Alternative A – a combination of Earth Pressure Balance Tunnel Boring Machine (EPBM), Open-Face Shield, and SEM construction methods; and with similar horizontal and vertical alignment profiles to that of the Project.
- Alternative B – a combination of EPBM and SEM construction methods with a similar horizontal alignment profile, but a lower vertical alignment profile, than that of the Project.

Table 5.2-1 summarizes and compares the descriptions for the Project and Alternatives A and B.

5.3 Effectiveness in Meeting Purpose and Need

As discussed in Chapter 1, Purpose and Need in the Final EIS, the purpose of the Regional Connector project is to improve the region's public transit service and mobility by improving travel times and connecting the light rail transit (LRT) service of the Metro Gold Line and the Metro Blue Line. As identified in the Final EIS, this rail link would serve communities across the region, allowing greater accessibility while serving population and employment growth in downtown Los Angeles. With operation of the Regional Connector, Gold Line service will provide a one-seat ride for travel from East Los Angeles to Santa Monica, and the Blue Line from Azusa to Long Beach.

The Project and tunneling method alternatives would improve the region's public transit service and mobility, and improve service to the growing population and employment in downtown Los Angeles; however, the transit service provided by the Project versus the tunneling method alternatives is superior. Construction and implementation of the Project would result in 55 miles per hour (mph) operations in the Flower Street segment meeting the requirements of Metro Rail Design Criteria (MRDC), Section 10 Operations as discussed below in Section 5.6, Operational Considerations. Alternatives A and B would result in a speed reduction in this key LRT system to 35 mph as discussed in Chapter 2, Alternatives Considered. Due to the slower speeds provided by the tunneling method alternatives, passengers would have a longer travel time of approximately 1.2 minutes per one-way trip over the travel time provided by the Project, and may not be as attractive in encouraging auto travelers to transfer to the Regional Connector project.

5.4 Construction and Risk Considerations

There are a significant number of surface and underground constraints combined with the requirements of the MRDC and desired future operations of the Project that have framed the design and construction of the Flower Street section. Flower Street surface constraints to future subway construction include possible impacts to vehicular, bus, and shuttle traffic, impacts to pedestrian and bicycle circulation, and restricted access to off-street parking and adjacent properties.

As discussed in Section 2.2.1 of the SEIS, underground constraints that the design and construction of a tunnel along the Flower Street segment must address include:

Table 5.2-1: Comparison of Project and Tunneling Method Alternatives

	The Project	Alternative A EPBM/Open-Face Shield/SEM Project Profile	Alternative B EPBM/SEM Low Alignment
Construction Description[1]	• EPBM to south of 4th Street • C&C from 4th Street to 7th Street/Metro Center Station tail tracks	• EPBM to 4th Street • Open-face shield TBM to 5th Street • SEM from 5th to 7th Street/Metro Center Station tail tracks	• EPBM to south of 5th Street • SEM from 5th Street to 7th Street/Metro Center Station tail tracks
Horizontal Alignment	Baseline	Slight shift to west of Project alignment	Slight shift to west of Project alignment
Depth To Top of Rail	40'	40'	40' to 105' (at sag)
Mucking Locations	• Flower Street • Mangrove site in Little Tokyo	• Flower Street (for emergency exit and train control room only) • Mangrove site in Little Tokyo	• Flower Street (emergency exit and train control room only) • Mangrove site in Little Tokyo
Handling of Flower Street Segment Excavation Materials (by location)	Flower Street Site: 81% Mangrove Site: 19%	Flower Street Site: 25% Mangrove Site: 75%	Flower Street Site: 20% Mangrove Site: 80%
Corresponding Excavation Materials/ Construction Trucks Per Day	On Flower Street segment: 32 In Little Tokyo: 8	On Flower Street segment: 18 In Little Tokyo: 22	On Flower Street segment: 8 In Little Tokyo: 32
Construction Shaft	TBM retrieval shaft at 4th Street (part of cut and cover construction)	TBM retrieval shaft south of 4th Street	EPBM removed thru Mangrove portal
Permanent Shafts	• Emergency exit south of 4th Street • Emergency exit south of 5th Street • Train control room vent shaft 7th Street/ Metro Center Station tail tracks structure	• Emergency exit south of 4th Street • Emergency exit south of 5th Street • Train control room shaft 7th Street/ Metro Center Station tail tracks	• Emergency exit south of 5th Street • Train control room shaft 7th Street/ Metro Center Station tail tracks
2nd/Hope Station Depth	96'	96'	128'
Maximum Design Speed	55 mph	35 mph	35 mph
Double Track Crossover Before 7th Street/Metro Center Station	Yes	Yes	Yes
Future 5th/Flower Station	Center platform with mezzanine	Side platform with no mezzanine	Side platform with mezzanine Requires tunnel reconstruction
Project Delivery Duration (months) • Construction • Pre-Construction Activities[2] • Total Duration (difference)	78 -- 78	93 (+ 15 months) 29 122 (44 months or 3.7 years longer)	85 (+ 7 months) 29 114 (36 months or 3 years longer)
Project Cost (Millions, YOE)[3]	$171	$295-332[4] (+$124 to $161 more than the project)	$238-266[4] (+$67 to $95 more than the project)

Notes: [1] **Construction Techniques** include C&C - Cut and cover; EPBM- earth pressure balance tunnel boring machine; SEM- sequential excavation method. [2] **Pre-Construction Activities** include engineering design revisions and re-procurement of the design-build construction contract. [3] **Project Cost YOE** is the year of expenditure using 2017 as the mid-point of construction. [4] **Project Costs** Range for two alternatives provides a low and high cost estimate based on risk. The range does not include increased costs resulting from procurement delay, construction delay, or escalation due to delays.

Metro

- **Physical operational challenges**, including connecting to the existing narrow and shallow rectangular 7th Street/Metro Center Station tail tracks structure, providing a new double track crossover before the tail tracks connection, and accommodating a future 5th/Flower Station.
- **Significant underground constraints**, including: a large number of abandoned steel tie-backs ranging from 30 to 90 feet in length and extending across the street right-of-way from both sides; existing utilities and sewer lines ranging in size up to an 84-inch diameter reinforced concrete pipe approximately 18 feet below the ground surface; and 4th Street Bridge foundations and piles that extend 64 feet below the surface on the west side of Flower Street and 83 feet on the east side.
- **Challenging geologic ground conditions,** which require thorough consideration in the evaluation of tunneling feasibility within acceptable risks. Flower Street geologic conditions include the presence of groundwater, unstable soils, a challenging geologic interface between different soil or rock strata (mixed face), and hazardous gases. Before development of downtown Los Angeles, Flower Street served as a natural drainage path which became a stream during rainfall with seasonal variations of groundwater below ground. Groundwater is anticipated to follow the historic underground water course and pose problems for the stability of open-face tunnel excavation. Borings made for building sites along Flower Street between 5th and 7th Streets have encountered water seepage at relatively shallow depths ranging from 15 to 35 feet, which is close to or within the proposed tunnel envelope. Groundwater within the lower portion of the alluvial deposits, most likely perched above the Fernando Formation, has been reported at depths of 18 to 27 feet on sites adjacent to the Flower Street right-of-way between 2nd and 5th Streets. All of these factors result in conditions that are difficult to tunnel through without risking ground instability, ground loss, and settlement if not addressed by the tunneling construction method and/or ground stabilization techniques. Both alternatives would require the use of jet grouting to stabilize soil conditions in the Flower Street segment to allow for tunneling construction.

The construction methods identified for the Project represent the tunneling methods that best address the significant underground constraints and lessen the construction risk along Flower Street, and have proven to be successful on other Metro projects, such as for the Gold Line Eastside Extension tunneling effort.

5.5 Summary of Impacts of Alternatives versus the Project

The SEIS analysis identified that Alternatives A and B would have the following major impacts when compared to the project:

1. Delay of Regional Connector Project completion;
2. Increased construction impacts to the Little Tokyo community and increased duration of those impacts;
3. Increased risks of excessive settlement, sinkholes and utility service disruption along Flower Street; and
4. Increased construction risks along the Flower Street segment.

Project Completion Delay

It is estimated that both tunneling method alternatives would delay the project completion schedule by a minimum of 3.0 years beyond the Project's schedule. Under the Project, the cut and cover construction along Flower Street would require only minimal ground improvement and could be carried out concurrently with construction of the remainder of the project. The Open-Face Shield and SEM tunneling methods proposed by Alternatives A and B would require a substantial jet grouting program prior to open face TBM and SEM construction due to Flower Street geologic conditions. The grouting activities would delay construction of the project's other underground stations until the tunneling is completed as excavated materials from the Flower Street segment would be transported to the Mangrove site in Little Tokyo using conveyors through the tunnels.

Increased Construction Impacts to Little Tokyo

Under the Project conditions, a majority of excavated materials from the Flower Street segment would be handled through construction sites on Flower Street and only muck from EPBM-bored tunnels would be handled through the Mangrove site. For Alternatives A and B, all of the muck generated from open-face shield and SEM tunneling would be transported to the Mangrove site through the tunnel, and only a minor quantity of excavated materials from shafts along Flower Street would be handled from construction sites on Flower Street. This would result in a significant increase in the quantity of spoils handled through the Mangrove site.

Alternative A would increase excavation-related truck activity in Little Tokyo and would extend the duration of those impacts by 15 months. Alternative B would increase the excavation-related truck activity in Little Tokyo and would extend the duration of those impacts by 7 months. The increased quantity and duration of the muck handling activities would increase construction impacts to Little Tokyo, which is an environmental justice community.

Increased Risks along Flower Street

As discussed in Chapter 2, Alternatives Considered, there are significant underground constraints which pose challenges to the design and construction of the future rail tunnel on the Flower Street segment of the Regional Connector Project. These constraints include: 1) connecting with the existing narrow, shallow rectangular tail tracks structure of the 7th Street/Metro Center Station; 2) numerous abandoned underground tie-backs (used to support the excavation of building foundations) extending into the path of the future rail tunnel from adjacent building foundations along both sides of Flower Street south of 3rd Street; 3) unstable soil conditions; 4) many utilities; and 5) the 4th Street Bridge foundations which restrict the location of a future rail tunnel to a narrow vertical and horizontal corridor between the foundation piers.

The tunneling method alternatives would increase construction risks related to excessive ground surface settlement, sinkholes, and utility service interruption along Flower Street. These risks are mainly associated with the open-face shield and SEM tunneling in an area with significant underground infrastructure constraints and poor ground conditions.

5.6 Operational Considerations

With operation of the Regional Connector project, Gold Line service will provide a one-seat ride for travel from East Los Angeles to Santa Monica, and the Blue Line from Azusa to Long Beach. The Regional Connector will serve as the trunk section for these two Metro LRT corridors. As identified by MRDC operating criteria, the required operational speed for the Flower Street segment is 55 mph. The Project provides a 55 mph operating speed in the Flower Street segment, meeting Metro's operating criteria, while Alternatives A and B would result in a speed reduction in this key LRT system segment to 35 mph, as shown in Table 5.2-1. Reduction of the maximum operating speed in this key system link would decrease rail service headways, operational efficiency, and operating capacity for the entire Metro LRT system. These impacts would be permanently adverse.

Due to the slower speeds provided by Alternatives A and B, passengers would have a longer travel time of approximately 1.2 minutes per one-way trip over the travel time provided by the Project. While this may appear minor based on individual perception, the cumulative impact for the forecast 90,000 daily boardings would be significant – approximately 1,800 hours of daily delay. Slowing rail operations makes rail transit a less attractive option for potential riders and may impact LRT line and system ridership, and reduce air quality and climate change benefits compared to the Project.

This slower speed in the heart of the region's LRT system would result in permanent operational constraints, including slower operations providing less capacity and the need for Metro to operate more trains to provide the same capacity as the Project. For Alternatives A and B, the additional trip time is estimated to require an increase in the fleet size of six vehicles with a corresponding increase in capital and operating costs.

It should be noted that the Project and Alternatives A and B have designed to allow for a future 5th/Flower Station. Construction of this station would result in slower operating speeds in the Flower Street segment for the Project and Alternatives A and B as the closer station spacing would not allow the LRT vehicles to reach the desired 55 mph operational speed. While there currently is no funding for this station, construction funding priorities may change in the future and implementation of this station would be evaluated as a separate project.

For Alternative B, the resulting 5.9 and 4.6 percent gradients due to its "sag" to avoid underground obstructions would result in increased maintenance requirements from the resulting increase in friction between the rail tracks and train wheels. The Flower Street segment of the alignment would require more frequent track maintenance efforts to ensure operations remain below the desired noise threshold.

A key element in designing the Flower Street segment of the project is to allow for future provision of a 5th/Flower Street Station. While Alternatives A and B are designed to accommodate construction of a future station, the resulting stations would be substandard and not as convenient for passengers. Under the Project, a central platform is provided allowing for ease of cross-platform transfers for passengers. For Alternatives A and B there is insufficient room between the twin tunnels to allow for a future center platform, and side platforms would be provided. Under Alternative B, passengers

desiring to travel in the reverse direction would need to circulate up to the mezzanine level, and then take an escalator or elevator down to the platform to complete their transfer. Alternative A would not have a mezzanine and passengers desiring to transfer would need to circulate up to the ground level and then back down again to complete their transfer. Alternatives A and B would result in a significant decrease in passenger convenience, especially for visitors and infrequent users who may not know the Metro LRT system well.

Table 5.6-1: Operational Summary of the Project and the Tunneling Method Alternatives – Flower Street Segment

	The Project	Alternative A	Alternative B
Maximum Speed (miles per hour)	55 mph	35 mph	35 mph
Travel Time[1]	2.1	3.3	3.3
Double Track Crossover	Yes	Yes	Yes
Future 5th/Flower Station	Center platform with mezzanine	Side platform with no mezzanine	Side platform with mezzanine

Note: [1] minutes to travel between 7th Street/Metro Center and 2nd/Hope stations

5.7 Schedule Impacts

A detailed discussion of the Project schedule impacts resulting from the tunneling method alternatives was developed in the *Draft Flower Street Tunneling Method Alternatives Report (2014)*. Table 5.7-1 presents a summary of the resulting implementation schedules for Alternatives A and B.

Table 5.7-1: Comparison of Schedules for the Project and Tunneling Method Alternatives

Alternative	Construction Duration	Change in Construction Duration (Over Project)	Required Pre-construction Activities	Total Project Delivery Duration	Revenue Service Date	Total Project Delivery Delay	
	Months	Months	Months	Months	Date	Months	Years
The Project	78	--	--	78	Mid-2020	--	--
Alternative A	93	15	29	122	Early-2024	44	3.7
Alternative B	85	7	29	114	Mid-2023	36	3.0

Source: *Draft Flower Street Tunneling Method Alternatives Report (2014)*

Table 5.7-2, on the following page, provides an overview of the construction and risk factors that would contribute to the lengthening of the total project delivery schedules for Alternatives A and B and correspondingly the Revenue Service Date (RSD), when compared to the Project.

Table 5.7-2: Overview of Construction and Risk Factors Impacting the Construction Schedules for the Project and Tunneling Method Alternatives

	Project	Alternative A	Alternative B
Construction Factors	• Cut and cover section along Flower Street can occur concurrently with excavation of bored tunnels and other construction activities, including station construction.	• Requires extensive jet grouting along Flower Street between 4th and 6th Streets. • Higher level of muck truck activity in Little Tokyo than the Project • Extends duration of muck truck impacts in Little Tokyo. • Delays station construction. Removal of excavation materials through the tunnel to the Mangrove portal would delay start of station construction work until after tunneling is complete. • With extension of tunneling further south on Flower Street, longer tunnel runs would be required for excavated materials than the Project, and would extend construction duration.	• Requires extensive jet grouting along Flower Street between 5th and 6th Streets. • Higher level of muck truck activity in Little Tokyo than the Project and Alternative A. • Extends duration of muck truck impacts in Little Tokyo. • Delays the start of station construction work and 2nd/ Broadway SEM cavern/cross passages until tunneling is complete. • Removal of excavation materials through the Mangrove portal via the westbound tunnel would continue until SEM work is complete. • SEM can occur concurrently with one of the EPBM tunnels.

Alternative A Schedule Impacts

Implementation of Alternative A would require 44 months over the Project's project delivery schedule. The increased duration is due to: 1) an additional 29 months for pre-construction activities; and 2) a longer construction duration by 15 months. Pre-construction activities for this alternative would include the preparation of detailed engineering design plans; re-procurement activities for the existing design-build contract; and re-permitting efforts. As the Project is currently under construction, implementation of either tunneling method alternative would require stopping current construction activities, and initiation of re-procurement and follow-on-mobilization efforts for the new project configuration using different construction techniques and equipment than the Project. Given the design-build contract currently in place, Metro evaluated what would be required contractually to accommodate the construction changes identified by the two alternatives. Based on the magnitude in the difference of the Flower Street segment construction contract value, ranging between approximately $276 and $403 million for the two alternatives over the awarded Project cost for the same segment (as presented below in Table 5.8-1, re-procurement of the project design-build contract was recommended.

Alternative A would have a longer construction duration as the identified tunneling excavation and construction activities would need to be performed sequentially, rather than concurrently as under the Project. Additional construction time would be required for the jet grouting activities that must be performed prior to and during tunneling efforts to provide needed ground stabilization. The estimated construction duration reflects 12 months of grouting activities with the caveat that grouting work may increase up to 24 months due to unforeseen underground conditions.

In summary, the total project schedule impact for Alternative A would be 44 months or 3.7 years longer than the Project from initiation of construction to start of revenue service. As discussed in Section 2.3.1.1, the duration of construction activities for this alternative along the Flower Street segment would be reduced, while the duration of construction-related activities in Little Tokyo would increase.

Alternative B Schedule Impacts

Implementation of Alternative B would require 36 months over the Project's project delivery schedule. Similar to Alternative A, the increased duration is due to required pre-construction activities and an increased construction duration by seven months over the Project's schedule. Pre-construction activities would include preparation of detailed engineering design plans; re-procurement activities for the existing design-build contract; and re-permitting efforts. During construction of the Project, cut and cover excavation and construction work would occur concurrently with the excavation of the bored tunnels and other construction activities throughout the alignment. For Alternative B, the primarily tunneling work would be performed sequentially as the tunnel boring machine bores one tunnel towards the 7th Street/Metro Center station box, and then is turned back towards Little Tokyo to bore the second parallel tunnel, which would increase the construction schedule. Due to the need to remove all Flower Street segment tunnel spoils through the Mangrove portal, the tunneling operation would continue until the SEM work is complete. This would hold the start of station construction work for the cavern and all cross passages until after the Flower Street segment tunneling is complete. Start of station construction work would be delayed for the 2nd/Hope and 2nd/Broadway stations, and of the 2nd/Broadway SEM cavern and all cross passages until after the Flower Street segment tunneling is complete. Additional construction time would be required for the jet grouting activities that must be performed prior to and during tunneling efforts to provide needed ground stabilization. The estimated construction duration reflects eight months of grouting work with the caveat that grouting work may increase up to 16 months due to unforeseen underground conditions.

In summary, the total schedule impact would be 36 months or 3.0 years longer than the Project from initiation of construction to start of revenue service. As discussed in section 2.3.1.1, the duration of construction activities along the Flower Street segment would be reduced under this alternative, while the duration of construction-related activities in Little Tokyo would increase.

5.8 Cost and Funding Considerations

Capital cost estimates for the Flower Street portion of the two tunneling method alternatives were identified based on the efforts discussed below and documented in the *Draft Flower Street Tunneling Method Alternatives Report (2014)*. Capital costs are the expenses associated with the design and construction of a proposed transit system, with the project costs falling in one of two areas:

1. Construction Costs – including track and guideway elements, stations, and vehicle control and power system equipment.

2. Non-construction Costs – including engineering, environmental, agency, and construction management services; permits; surveying, geotechnical, and other testing; vehicles; and insurance.

Capital cost estimates were developed for the two tunneling method alternatives using cost information identified for the Project as documented in Metro Contract No. C0980 Design Build contract as it represented the most current cost information available from a design-build project similar in scope and location. Construction of the two alternatives would be substantially similar to the Project, except for the Flower Street segment south from 4th Street to the 7th Street/Metro Center Station. New cost information was developed for the revised tunneling construction techniques proposed by each alternative by estimating the quantities for the individual line items required to build the two alternatives along the Flower Street segment. The costs applicable to the estimated quantities were derived from the bid information in Contract C0980. New construction costs, such as for SEM tunnel construction and grouting activities, were identified and alternative-specific quantities and costs were developed. Non-construction costs, similar to those identified for the Project, were included in the cost estimates for the two alternatives.

The resulting cost estimates were compiled in the Standardized Cost Categories (SCC) analytical format developed by the FTA. The SCC format identifies total project costs through nine project line item categories with the first five (10-50) detailing construction costs; the second set (60 ROW, Land, Existing Conditions; 70 Vehicles; and 80 Professional Services) delineating non-construction costs; and Line Item 90 identifying the Unallocated Contingency provision. Each line item has separate allocated contingency amounts.

The cost estimates for the two tunnel method alternatives included contingency factors similar to those identified for the Project. Contingency is a necessary part of the budget for this type of project in order to account for unknowable costs, based on project construction experience on similar projects. Contingency addresses risks including market volatility, unforeseen conditions, and outside influences to the successful progression and completion of a project within the forecasted budget and schedule. It is expected that a portion of the budgeted contingency will be required to cover costs incurred during construction of the project. Contingency factors (percentages) were identified by Metro based on agency experience on similar tunneling projects. Similar to the Project cost estimate, allocated contingencies were applied to each of the SCC construction cost line items based on the risk profile associated with each SCC classification. An overall project cost provision for unallocated contingency was captured in SCC Line Item 90. The unallocated contingency percentages used for the two tunneling method alternatives were the same as those identified for the Project in the C0980 cost estimate.

The cost estimating effort for the two alternatives took into consideration schedule delays and higher risks related to the tunneling methods proposed by the two alternatives. As the Project is currently under construction, implementation of either tunneling method alternative would require stopping current construction activities and pursuing a new contract procurement process to incorporate the new tunneling construction techniques.

Construction of either tunneling method alternative would require new pre-construction services, including preparation of detailed engineering design plans for the selected tunneling method alternative, revised environmental documentation based on the final plans, re-permitting, and re-mobilization of construction staff and equipment. These pre-construction activities were estimated to delay re-initiation of construction activities by approximately 29 months for either tunneling method alternative. The increased construction duration for the two alternatives is due to the identified tunneling excavation and construction method activities having to be performed sequentially, rather than concurrently, as included in the Project's construction plan described in detail in Section 2.1.2 and summarized above in Section 5.7. The increased construction duration would have related delay and escalation costs due to the suspension of construction activities and the typical inflationary increase in construction costs during the extended project period.

In addition, as presented above in Table 5.7-2, the construction methods proposed by the two tunneling alternatives would have higher risks related to the significant number of underground constraints and the unstable geologic conditions along Flower Street. Underground constraints include tunneling activities encountering the hundreds of tie-backs that anchor existing building and parking structure foundations which form a "mesh" within the proposed Flower Street segment tunnel alignment. The geologic conditions include the presence of groundwater, unstable soils, a challenging geologic interface between different soil or rock strata (mixed face), and hazardous gases, which would present less risk with cut and cover construction for the Project.

The cost estimates for each alternative, presented in Table 5.8-1, were prepared taking into account the tunnel construction method changes and related schedule delays and risks. Cost adjustments addressed the proposed SEM and Open Face Shield construction methods, which would require extensive jet grouting for ground stabilization. A schedule analysis was performed to identify the construction schedule for each alternative, with extended construction for Alternatives A and B taking into account the proposed construction techniques, along with pre-construction activities. An initial risk assessment resulted in the re-assessment of allocated and unallocated contingency percentages to address increased risk conditions presented by the two alternatives. A range of costs was identified for the two alternative, with a low and high cost estimates, to reflect the higher risk associated with construction of the two alternatives due to challenging subsurface conditions and obstructions.

Costs related to the identified pre-construction and construction schedule delays resulting from implementation of either of the two alternatives were identified and included in the project cost estimates presented in Table 5.8-1:

1. Additional Construction Duration Cost – reflecting the design-build contractor's increased overhead costs due to an extended construction duration by a minimum of 3.0 years.
2. Cost of Procurement Delay – costs for the engineering re-design, environmental review, re-procurement, re-permitting, and re-mobilization activities required for the two alternatives.
3. Escalation Costs due to Redesign and SEIS Delay – escalation costs for construction materials, equipment, and labor due to a minimum of a 3.0 year delay from the current Project schedule.

4. Construction Delay Cost to Overall Project – agency costs for the added delay to complete the overall project.

The cost estimating effort resulted in the identification of both baseline construction only and total project cost estimates for the two tunneling method alternatives. The total Flower Street segment cost ranges between $510 and 575 million for Alternative A, and $447 and 503 million for Alternative B, as compared to $171 million for the Project.

Table 5.8-1: Year of Expenditure[1] Dollar Cost Estimate for the Flower Street Segment for the Tunneling Method Alternatives ($Million)

SCC Category	SCC Line Item	Project	Alternative A		Alternative B	
			Low	High	Low	High
10.06	Guideway – Underground Cut and Cover	93.1	9.9	9.9	7.0	7.0
10.07	Guideway – Underground Tunnel SEM	--	50.0	68.3	57.1	77.9
10.07	Guideway – Underground EPBM	31.5	46.6	46.6	50.1	52.5
10.07	Guideway – Underground Tunnel Open Face TBM	--	41.8	56.9	--	--
20.03	Underground station, stop, platform	--	--	--	30.6	32.0
40.02	Site Utilities, Utility Relocation	9.6	7.5	7.5	7.5	7.5
40.04	Environmental mitigation	0.1	0.4	0.4	0.5	0.5
40.07	Auto, bus, van access, including roads, parking lots	0.6	0.2	0.2	0.2	0.2
40.08	Temporary Facilities and other indirect costs during construction	0.4	0.1	0.1	0.1	0.1
	Total SCC 10-50	135.3	156.5	189.9	153.1	177.7
80.02	Final Design	11.2	19.0	19.4	15.4	15.7
80.04	Project & Construction Management	6.8	11.5	11.7	9.3	9.5
80.06	Legal Permits, Survey, Testing, Inspection	1.3	2.3	2.3	1.8	1.9
	Total SCC 10-80	154.7	189.3	223.3	179.6	204.8
90.00	Unallocated Contingency	16.7	20.5	24.2	19.5	22.1
	Total SCC 10-90	171.4	209. 8	247.5	199.1	226.9
	Additional Construction Duration Cost (Contractor's extended overhead)	--	84.7	84.7	39.0	39.0
	Subtotal[2]	**171.4**	**294.5**	**332.2**	**238.1**	**265.9**
	Cost for Procurement Delay	--	47.0	47.0	47.0	47.0
	Escalation Costs due to Redesign/SEIS Delay	--	139.9	139.9	134.2	134.2
	Construction Delay Cost to Overall Project	--	27.8	55.7	27.8	55.7
	Total	**$171.4**	**$509.2**	**$574.8**	**$447.1**	**$502.8**

Notes: [1] YOE – Year of Expenditure: 2017, as the mid-point of construction for the Project, was used to calculate the SCC 10- 50 line item costs

[2] Range for two alternatives provides a low and high cost estimate based on risk. The range does not include increased costs resulting from procurement delay, construction delay, or escalation due to delays.

Source: *Draft Flower Street Tunneling Method Alternatives Report, Appendix B: Cost Risk Analysis Model for Baseline and Each Alternative (2014)*

5.9 Environmental Consequences

Based on guidance provided in NEPA, this SEIS provides an analysis of the environmental consequences associated with construction and operation of the tunneling method alternatives. The following environmental impact areas were studied in the SEIS:

- Transportation and Circulation
- Visual Quality
- Air Quality
- Climate Change
- Noise and Vibration
- Geotechnical
- Energy Resources
- Historic Resources
- Environmental Justice
- Cumulative

In summary, the environmental analysis documented in the SEIS shows that construction of either of the two tunneling method alternatives would have adverse environmental effects, many of which could not be mitigated. These include shifting of a majority of the truck handling of tunnel excavation materials from the Flower Street segment, a high-rise commercial district with wide streets, to Little Tokyo, a low to mid-rise, mixed use district with visitor and cultural destinations, and identified as an environmental justice community. Implementation of Alternatives A and B would extend the duration of construction impacts in Little Tokyo by a minimum of 3.0 years over the Project.

Construction of Alternatives A and B would require the use of jet grouting for ground stabilization with extensive equipment requirements, including jet grouting rigs and mixing plants more than 100 feet in height, along with mixers, compressor, generators, and related support equipment. The grouting equipment would require use of the two travel lanes on the east side of Flower Street between 4th and 6th Streets for Alternative A, and between 5th and 6th Streets for Alternative B, for the duration of the grouting activities. Grouting efforts would require the use of two travel lanes for eight to 16 months further reducing street capacity. The construction impacts on Flower Street would result in significant traffic and circulation, visual, air quality, climate change, and noise impacts that would be difficult to mitigate or could not be mitigated. Alternatives A and B do not provide reduced environmental impacts during construction to those identified for the Project. In addition, the tunneling method alternatives would have higher and longer construction-related adverse environmental justice effects on Little Tokyo, as shown in Table 5.9-1.

Table 5.9-1: Comparison of Environmental Effects During Construction in Little Tokyo

Impact	The Project	Alternative A	Alternative B
Hauling of Excavated Materials from Flower Street			
- On Flower Street • Percentage of total Flower Street materials • Duration of hauling activities	 81% 9 Months	 25% 1 Month	 20% 1 Month
- In Little Tokyo • Percentage of total excavation activities • Duration of hauling activities	 19% 2.5 Months	 75% 19 Months	 80% 17 Months
Excavation/Construction Trucks Per Day			
- On Flower Street	32	18	8
- In Little Tokyo	8	22	32
Duration of Truck Impacts (for hauling excavated materials)	9 Months	19 Months 10 months longer	17 Months 8 months longer

Source: *Draft Flower Street Tunneling Method Alternatives Report (2014)*

5.10 Summary of Findings

Based on the environmental analysis in the SEIS and the engineering analysis documented in the *Draft Flower Street Tunneling Methods Alternatives Report*, the construction method alternatives would not perform as well as the Project in meeting purpose and need, would impact Metro operations, would pose construction and safety risks, and would result in environmental impacts, as summarized below, and presented in Table 5.10-1.

- **Purpose and Need** – Alternatives A and B would not perform as well as the Project in meeting the purpose and need identified for the Regional Connector project. While they would provide an improved regional connection, implementation of these options would result in reduced operating speeds on the Flower Street segment – 35 mph compared to 55 mph provided by the Project. There would be a corresponding increase in travel times for Gold, Blue, and Exposition Line passengers, as well as for passengers transferring from the Red and Purple Lines. The speed reduction resulting from the tunneling method alternatives would have permanent adverse operational effects over the Project due to increased travel times for the operational life of the Regional Connector project.

- **Construction and Risk Considerations** – Construction along the Flower Street segment must address significant challenges including physical operational challenges, difficult surface and underground conditions, and challenging geologic conditions. The geologic conditions include the presence of groundwater, unstable soils, a challenging geologic interface between different soil and rock strata (mixed-face), and hazardous gases. The Project was defined to address those constraints given the segment's high risk and challenges. The tunneling methods proposed by Alternatives A and B would result in significantly higher construction risks, a longer construction schedule, and a higher project cost. The higher construction risks include increased risks of ground instability, loss, and settlement which could threaten public and worker safety.

Table 5.10-1: Overview of Environmental Impacts Due to Construction of the Tunneling Method Alternatives

Resource Area	The Project	Alternative A	Alternative B
Transportation/ Circulation Flower Street Impacts Little Tokyo Impacts	• 3 to 4 travel lanes available on Flower Street during construction • Even with mitigation, the intersections of 4th, 5th and 6th and Flower Streets would be adversely affected during the AM peak hour. With mitigation, the resulting effect would not be adverse under NEPA.	• 2 travel lanes available on Flower Street during grouting and construction. • Longer duration of traffic lane closure due to 12 months (possibly up to 24 months) of grouting activities. • Increases and extends construction truck impacts on Little Tokyo by 15 months.	• 3 travel lanes available on Flower Street: 4th to 5th Streets; 2 travel lanes 5th to 6th Streets. • Longer duration of traffic lane closure due to 8 months (possibly 16 months) of grouting activities. • Increases and extends construction truck impacts on Little Tokyo by 7 months.
Visual Quality	• Construction staging area along the east side of Flower Street would have negative impacts on the visual quality/character that can be screened.	• Construction and grouting staging areas along east side of Flower Street would have adverse impacts on visual quality/character. • Impacts cannot be mitigated due to size of grouting and plant equipment (over 100 feet tall). • With two grouting areas, this alternative would have a more adverse effect than Alternative B.	• Construction and grouting staging areas along east side of Flower Street would have adverse impacts on visual quality/character. • Impacts cannot be mitigated due to size of grouting and plant equipment (over 100 feet tall). • With only one grouting area, this alternative would have less impact than Alternative A, but more than the Project.
Air Quality Peak daily emissions	• During construction, regional construction emissions of VOC, NO_x, and CO will be adverse, significant and unavoidable under NEPA. With mitigation, localized construction emissions will be reduced to less than significant.	• Higher emissions during construction due to use of grouting equipment. • Longer duration of construction emissions by 12 months (up to 24 months) on Flower Street; and by 15 months over the Project.	• Higher emissions during construction due to use of grouting equipment. • Longer duration of construction emissions by 7 months (up to 16 months) on Flower Street; and by 7 months in Little Tokyo over the Project. • With only one grouting area, this alternative would have less impact than Alternative A.
Climate Change MTCO2e/year	• 2017[1] GHG emissions would be 4,870.	• 2017[1] GHG emissions would be 8,040. • Higher GHG emissions than the Project due to use of grouting equipment.	• 2017[1] GHG emissions would be 4,950. • Higher GHG emissions than the Project due to use of grouting equipment. • Less GHG emissions than Alternative A due to need for only one grouting area.
Noise and Vibration Flower Street Impacts	• Noise may inadvertently exceed FTA significance criteria during construction; mitigation measures will control exceedances.	• Results in increased construction noise level over the Project due to use of grouting equipment. • Possible minor increase in vibration impacts due to TBM use further south on Flower Street.	• Results in some noise level increases over the Project due to use of grouting equipment. • Results in lower noise level than Alternative A due to need for only one grouting area.

Note: [1] Mid-point of construction

- **Operational Considerations** – The speed reduction resulting from Alternatives A and B would have negative impacts on rail service headways, run times, and operations over the Project. With a slower operating speed – one-third slower than Metro operational requirements – Alternatives A and B would negatively impact passengers using the Gold, Blue, and Exposition Lines, as well as passengers transferring from the Red and Purple Lines at the 7th Street/Metro Center Station. Metro would be required to operate additional trains and increase the fleet size by approximately six vehicles with a corresponding increase in capital and operational costs. It should be noted that the Project and Alternatives A and B have been designed to allow for a future 5th/Flower Station. Construction of this station would result in slower operating speeds in the Flower Street segment as the closer station spacing would not allow the LRT trains to reach the desired 55 mph speed. While both alternatives would allow for a future 5th/Flower Street Station, the resulting station configuration for Alternatives A and B would not allow for cross-platform transfers negatively impacting passenger convenience, especially for visitors and infrequent users. Implementation of Alternatives A and B would result in a permanent, substandard operating segment in the heart of the region's LRT system.

- **Schedule Impacts** – Implementation of Alternatives A and B would delay start of revenue service by a minimum of 3.0 years beyond the Project's schedule. The increase in schedule is partially due to longer construction timeframes – 15 and 7 months for Alternatives A and B respectively. In addition, both alternatives would require an additional 29 months over the Project's schedule for pre-construction activities required to revise the engineering design and re-procure the design-build construction contract. A longer construction time would increase the project cost and delay operation of this much needed segment in the region's LRT system.

- **Cost and Funding Considerations** – Based on a cost analysis similar to that performed for the Project, the higher risk for Alternatives A and B translates to $67 to $123 million more for the baseline Year of Expenditure (YOE) cost for the Flower Street segment beyond the cost identified for the Project. Given the higher risk level along this segment, a range of total project costs identified an additional $276 to $403 million would be required for the construction of Alternatives A and B beyond that identified for the Project. Funding for these additional costs will need to be identified among limited federal, state, and local sources.

- **Environmental Considerations** – The two tunneling method alternatives shift a majority of the effects resulting from the handling of excavation materials from the Flower Street segment, a high-rise commercial district with wide streets, to Little Tokyo, a low to mid-rise mixed use district with visitor and cultural destinations, and identified as an environmental justice community. Use of grouting equipment, required for Flower Street segment ground stabilization for construction of the two alternatives would result in adverse visual, noise and vibration, air quality, and traffic effects that may not be mitigated.

Based on the above conclusions, it was determined that the proposed tunneling method alternatives in Alternatives A and B would result in a higher safety risk, would cost more money, would take longer to construct, and would result in additional adverse environmental effects than the Project. Even with the proposed methods to reduce construction risk associated with tunneling in the weak ground conditions under Flower Street, the tunneling method alternatives have a high chance of ground

settlement problems and thus, were not carried forward as part of the Regional Connector project. While implementing Alternatives A and B may be technically possible, for the reasons stated in this paragraph and above, those alternatives were considered infeasible as a matter of sound public policy, and thus were withdrawn from further consideration.[i]

[i] *See Res. Ltd. v. Robertson, 35. ,3d 1300, 1307 (9th Cir. 1997)*