SFMTA
Municipal Transportation Agency

San Francisco County Transportation Authority

Seal of the City and County of San Francisco

San Francisco Planning Department

T-Third – Phase 3 Concept Study

FINAL

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SUSTAINABLE STREETS DIVISION – Strategic Planning and Policy

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Executive Summary

In early 2019 the T-Third Phase 2 (Central Subway) will be complete and light rail transit (LRT) service between the Caltrain Station at 4^{th} and King Streets and Chinatown will begin. The new service will serve approximately half of the North Beach corridor identified in the existing San Francisco long range transit expansion plan (the Four Corridor Plan) that was completed in 1994.

The T-Third Phase 3 Concept Study assesses the general feasibility of an extension of Light Rail Transit (LRT) service to North Beach and the Fisherman's Wharf area in San Francisco.

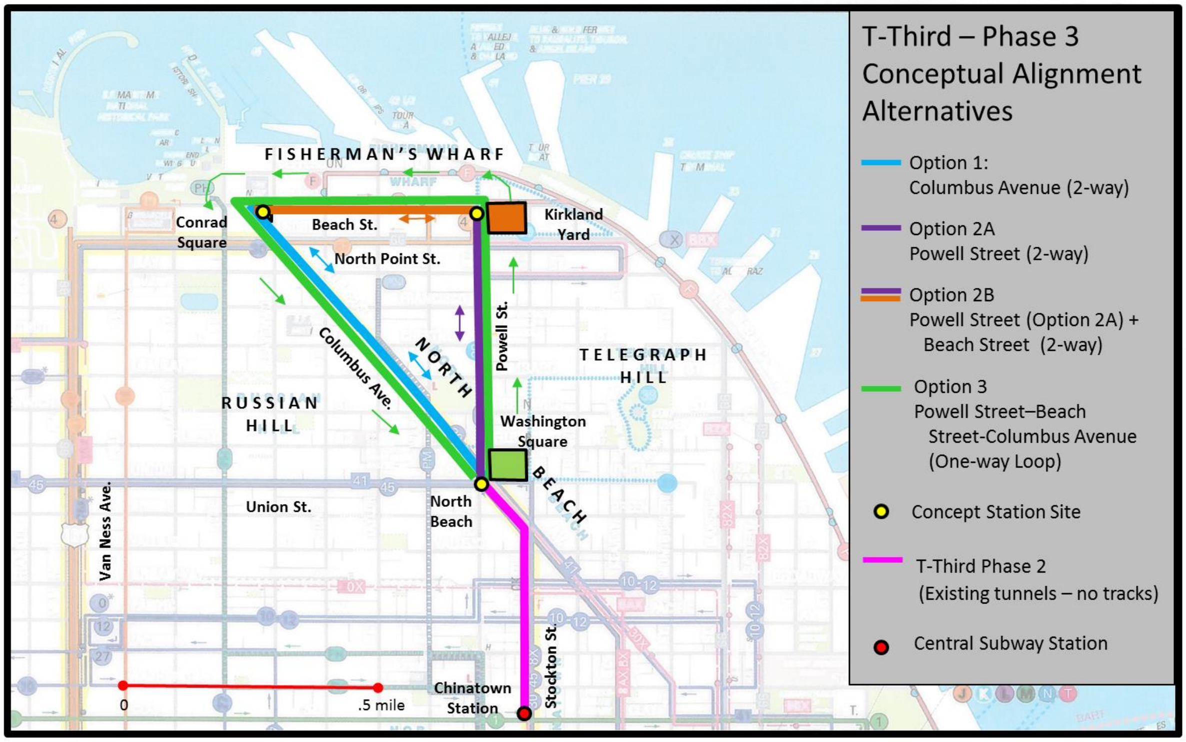
The T-Third Phase 3 Concept Study is a joint effort between the San Francisco County Transportation Authority (Transportation Authority), the San Francisco Municipal Transportation Agency (SFMTA), and the San Francisco Planning Department (The Planning Department), with SFMTA as the lead agency. The scope of work for the study was approved by the Transportation Authority, along with $173,212 in funds to support the effort.
The scope called for a report that included the following elements and sections:

- Alignment
- Grade Options
- Construction Methods
- Transit & Traffic Analysis
- Costs & Funding
- Land Use and Economic Development

The goal of the concept study is to show preliminary technical strengths and weaknesses of sample alignments, for consideration by stakeholders, governing bodies, and the public during any future planning efforts. Four general alignments were suggested by earlier Phase 2 studies and a 2013 charrette, including two-way service along Columbus Avenue (Option 1), two-way service along Powell Street (Option 2A), two-way service along Powell Street and Beach Street (Option 2B), and a one-way loop along Powell Street, Beach Street, and Columbus Avenue.

All alignments included a North Beach station near the current terminus of the Central Subway tunnel at Columbus Avenue and Union Street. Depending on the alignment, Fisherman's Wharf station options were considered near the SFMTA's Kirkland Yard at Powell Street and Beach Street; at Conrad Square near Columbus Avenue and Beach Street; or at both locations. (See figure.)

Figure: T-Third Phase 3 Study Conceptual Alignments



For each horizontal alignment, variations of station location and of vertical alignment were considered, resulting in 14 concept alignments for study. Both surface and subway vertical alignments were analyzed, and initial analysis on tunnel issues (ground types, utilities, etc.) was performed. Use of a tunnel boring machine (TBM) appears feasible and economical, with tunnel depths of approximately 50' to 60' below ground. A launching pit and turn-back or retrieval pit would be required for this method.

Some areas, including the stations and the connection to the existing Central Subway tunnels, would require additional excavation. This work could be performed using either sequential excavation method (SEM) or cut-and-cover construction. Cost considerations and availability of staging areas will factor into choosing a construction method at each site. SEM is considered less disruptive to the surface environment, but is more expensive and requires a nearby staging area. The current TBM retrieval site (Pagoda Palace) would be feasible to use as staging for the tunnel connection; other sites are also possible. Cut-and-cover is cheaper but must be staged directly on the alignment; for stations under streets (as North Beach is likely to be, due to the tunnel connection), cut-and-cover construction would be significantly disruptive.

Estimated one-way travel times from the Chinatown station to either a station at Conrad Square or a station at Kirkland Yard ranged from 3-3.5 minutes by subway to 4.5-5 minutes by surface LRT. Service plans assumed train service every 2.5 minutes during the peak period. A representative transportation model run, using the Columbus Avenue subway concept alignment, estimated ridership of 40,000 trips per day and significant relief of overcrowding on other Muni lines in that area. Using current FTA "New Starts" guidelines, an extension is likely to receive a "high" cost-effectiveness rating for the range of costs estimated in the study.

The current 2-car trains and platforms of the Central Subway are adequate to carry projected ridership peaks, but only if the planned service levels are maintained. Some configurations could help maintain the frequent headways by adding loops or additional crossover tracks to facilitate turn-around performance. An additional 6-14 Light Rail Vehicles (LRVs, 3-7 train sets) would be needed to maintain project service levels.

Several configurations are possible for long-term future expansion past Fisherman's Wharf to neighborhoods that lie to the west - including Russian Hill and the Marina. However, expansion into these areas may require line renovations because the 2-car-length Central Subway stations may be too small to handle ridership increases.

Preliminary cost estimates of the concept alignments ranged from a low of $367 million (subway and surface to Kirkland), to a high of $1.400 billion (subway connecting all three locations) in 2014 dollars. Ten alignments were under $1.0 billion and two were over $1.0 billion (two were found to be infeasible in a constructability assessment).

Initial land use and economic development analysis showed a potential for value capture funding that could pay for 10%-30% of the capital cost via use of a community finance district or infrastructure finance district.

The representative alignments studied show that an extension is feasible and carries ridership benefits. To aid discussion of potential alignment options and trade-offs for different choices, staff evaluated the concept alignments within seven areas of consideration. (See table below.)

- Passenger Experience
- Operational Efficiency
- System Performance
- Local Operations Considerations
- Infrastructure Resiliency
- Construction Disturbance
- Capital Construction Cost & Risk

The study does not recommend a particular alignment, nor is it intended to limit alignments to the samples here. That said, the best scoring concepts were all-underground alignments, which supply greater passenger, operations, system, and resiliency benefits, but which cost approximately twice as much as surface alignments.

Table: Evaluation Matrix

Evaluation Matrix														
	1-1	1-2	2A-1	2A-2	2A-3	2A-4	2A-5	2A-6	2B-1	2B-2	2B-3	2B-4	3-1	3-2
Evaluation Elements	Evaluation of Concept Alternatives													
	Columbus Ave. Subway-Surface	Columbus Ave. Subway	Powell St. Subway-Surface	Powell St. subway	Powell St. Subway-Surface w/ surface short loop	Powell St. Subway w/ surface short loop	Powell St. Subway-Surface w/surface F-Line loop	Powell St. Subway w/ surface F-Line loop	Powell St + Beach St. Subway-Surface	Powell St.+ Beach St. Subway	Powell St. + Beach St. Surface-Subway	Powell St. + Beach St. Subway-Surface	One-Way Loop (Powell-Beach-Columbus) Subway-Surface	One-Way Loop (Powell-Beach-Columbus) Subway
Passenger Experience	0	+	0	+	-	-	-	-	-	+	NF	NF	0	+
Operational Efficiency	-	+	-	+	-	0	-	-	-	+	NF	NF	+	+
System Performance	0	+	0	+	0	+	-	-	0	+	NF	NF	+	+
Local Operations Considerations	-	+	-	+	-	0	-	-	-	+	NF	NF	-	+
Infrastructure Resiliency	+	+	0	+	0	-	0	-	0	+	NF	NF	0	0
Construction Disturbance	-	0	-	0	-	-	-	-	-	-	NF	NF	-	-
Capital Construction Cost and Risk	+	0	+	0	+	0	+	0	+	-	NF	NF	+	0
Total	-1	5	-2	5	-3	-2	-4	-6	-3	3	NF	NF	1	3
Capital Cost ($ millions in 2014 Dollars)	407-482	848-933	367-442	837-912	406-480	875-950	454-529	924-999	443-518	1,333-1,408	NF	NF	496-571	1,087-1,139
Constructability Rating	4	5	3/4	4	3/4	2	3/4	2	3/4	4	1	2	3	3/4

An extension beyond the current terminal station at Chinatown scheduled to open in 2019 will require a new environmental review effort. The SFMTA lease to use the Pagoda Palace property as a TBM retrieval site expires on May 10, 2015. The SFMTA has a 60 day "right of first refusal" if the property owner were to place the property up for sale on the real estate market. The owner has obtained entitlement from the San Francisco Planning Commission to build a 19-unit residential structure on the site.

This study is to be incorporated into the San Francisco Bay Area Core Capacity Transit Study that is to begin in 2015.

Section 1 – Introduction

1-1 PURPOSE OF CONCEPT STUDY

The purpose of this study is to assess general feasibility of possible options for an extension of Light Rail Transit (LRT) service to the Fisherman's Wharf area in San Francisco. The assessment will utilize existing information, including information on current conditions, historical data, and new data collected for use on this project. The LRT extension will be referenced as the T-Third Phase 3 extension. This report will be referenced as the T-Third Phase 3 Concept Study. This study will not recommend a best concept alignment.

The format of the study is based upon a project scope of work that was approved by the San Francisco County Transportation Authority (Transportation Authority) in Spring 2014. The scope of work called for a joint effort between the Transportation Authority, the San Francisco Municipal Transportation Agency (SFMTA), and the San Francisco Planning Department (The Planning Department), with SFMTA to be the lead agency. The scope called for a report that included the following elements and sections.

- Alignment
- Grade Options
- Construction Methods
- Land Use & Economic Development
- Transit & Traffic Analysis
- Costs & Funding

A total of $173, 212 was allocated by the Transportation Authority to pay for staff and consultant costs to complete this project. Proposition K Sales Tax dollars were the funding source. The T-Third Phase 3 Concept Study was completed within budget.

1-2 BACKGROUND INFORMATION

In early 2019 the T-Third-Phase 2 (Central Subway) project will be complete and new LRT service between the Caltrain Station at 4th and King Streets and Chinatown will begin. The new service will be joined to service on the T-Third Phase 1 segment which operates between Caltrain and the Sunnydale station in the southeastern part of San Francisco. For purposes of this report, existing T-Line service along the Embarcadero and into the Muni Metro Market Street Subway is not considered part of the line, because it duplicates service provided by other Muni LRT lines, and the T-Line designation will be dropped from this segment when the Central Subway to Chinatown opens. The opening of the T-Third-Phase 2 service will mark the completion of the initial T-Third light rail project that was first conceptualized in the 1980s, and which has been in construction for over fifteen years.

Although the station at Chinatown represents the northern end of the initial project, the LRT line is designed so that it can be extended to serve the northern / northeastern neighborhoods with a connection to the San Francisco LRT system. Between the Chinatown station and the Pagoda Palace site, the T-Third Phase 2 project completed two bored tunnels without tracks and systems (power, signals and communication) to allow for removal of the tunnel boring machines (TBMs) without disruption to Columbus Avenue or Washington Square Park. Two transportation corridors, Columbus Avenue and Powell Street, exist north and northwest from North Beach to the Fisherman's Wharf area, and it is the recommendation of staff from all agencies involved in this study that possible future extensions focus on these existing transit corridors.

This report will also briefly address a future possible extension to neighborhoods to the west including Russian Hill, northern Van Ness Avenue, the Marina, Cow Hollow / Lower Pacific Heights and the Presidio that currently have high ridership on existing SFMTA bus and trolley bus transit service.

1-2-1 Bayshore Transit Study (1993)

The background for this study reaches back over 30 years. In the mid-1980s the Bayshore/Third Street Corridor, North Beach Corridor, Van Ness Corridor and Geary Corridor were all identified as possible project concepts for improved transit service prior to the placement of Proposition B Sales Tax measure on the ballot in 1989.

In 1993 the San Francisco Municipal Railway (Muni) hired consultants to analyze future transportation improvement options on the east side of San Francisco along 3rd Street. The completed series of documents named The Bayshore Transit Study (1993) included concepts that eventually led to the implementation of LRT service along 3rd Street as part of the T-Third Phase 1 project.

1-2-2 The Four Corridor Plan (1994) and the North Beach Corridor

A year after completion of the Bayshore study and five years after the passage of Proposition B, the Transportation Authority and SFMTA developed a long range plan, titled The Four Corridor Plan (1994). The plan prioritized future capital transit improvements in the aforementioned four corridors. Of the four corridors, the T-Third LRT project was initiated first, and within a few years the Van Ness and Geary Corridor plans had transformed into bus rapid transit (BRT) projects in an effort to stretch limited funds, and to implement transit improvements sooner than would be possible with an

LRT project. Simultaneously, SFMTA continued to proceed with the outline of the Four Corridor Plan by initiating a second phase of the T-Third project, which would both complete work on the Third Street Corridor and initiate work on the southern segment of North Beach Corridor.

The North Beach Corridor, which extends from Market Street through North Beach to Fort Mason and the Marina District, is one of the busiest transportation corridors in one of the densest areas of population within San Francisco. In the Four Corridor Plan Technical Summary Report on page 1-3, the corridor is described in the following manner.

> "The North Beach Corridor serves north-south travel through the northeast quadrant of San Francisco. It is generally focused along Kearny, Stockton and Columbus extending from Market Street to the San Francisco Bay between Pier 39 and Aquatic Park."

1-2-3 T-Third LRT Implementation Phases 1 and 2

The T-Third LRT line opened in April 2007 as the first new rail line in the eastern part of San Francisco in over 50 years. The new rail line extended 5.1 miles from the San Francisco County Line near Visitacion Valley to the Caltrain Station at 4th and King Streets, and was built at a cost of $748 million dollars.

The T-Line Phase 2 (Central Subway) will extend the line 1.7 miles from 4th and King Streets to Stockton and Clay Streets in Chinatown. The extension will include four new stations and address transit needs and congestion in a busy north-south corridor in the heart of downtown San Francisco. Phase 2 has received a full funding grant agreement (FFGA) from the Federal Transit Administration (FTA). The extension is expected to open for service in 2019. The total program cost of the T-Line Phase 2 (Central Subway) is projected at $1.5 billion dollars. Construction includes two tunnel "shells" (without tracks or rail systems) between Chinatown and the Pagoda Palace construction shaft site in North Beach to facilitate removal of the tunnel boring machines TBMs from below ground near the intersection of Powell Street, Columbus Avenue and Union Street.

With a terminal station at Chinatown, the Central Subway Phase 2 project represents a first step toward completion of a high capacity rail transit service through the North Beach corridor. An extension of LRT service further north in this corridor to a terminal near Aquatic Park, or to meet a terminal at the end of Van Ness Avenue served with high capacity transit service would complete a program of transportation improvements to the corridor that were identified in the Four Corridor Plan twenty years ago.

1-2-4 Environmental Review Summary

The T-Third Phase 1 (Third Street) project was initiated in November 1998, following completion and approval of an Environmental Impact Statement (EIS) as required by the National Environmental Policy Act (NEPA), and an Environmental Impact Report (EIR), as required by the California Environmental Quality Act (CEQA) in November, 1998.

The T-Third Phase 2 (Central Subway) project was initiated following completion and approval of a Supplemental Environmental Impact Statement (SEIS), and a Supplemental Environmental Impact Report (SEIR) in September, 2008.

The modification to the alignment of the T-Third Phase 2 (Central Subway) that allowed for TBM removal to be relocated from Columbus Avenue to the Pagoda Palace site in North Beach was completed after supplemental environmental clearance documents were approved by the Federal Transit Administration (FTA) and the City of San Francisco. The supplemental documents are an Addendum to the Supplemental Environmental Impact Statement (SEIS) and Addendum to the Supplemental Environmental Impact Report (SEIR) in January, 2013.

The three projects followed a mandatory environmental review process for transit projects that meet requirements for review as spelled out in the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).
A summary of the environmental review process for NEPA/CEQA reviewed projects is provided below. The information is copied from The FINAL DRAFT of the Conceptual Alternative Downtown Rail Alignment Study – Volume 1 Summary Report (March 2006), produced for the T-Third – Phase 2 Central Subway project with minor edits.

Preparation of the EIS/EIR

This component includes four tasks. The definition of existing conditions, evaluation of transportation impacts, and assessment of environmental impacts are preliminary tasks that need to be completed to produce the environmental document. This effort includes the collection of air quality, vibration, hazardous materials and geotechnical samples, as well as detailed information about the transportation network, and an assessment of rail impacts on the system. The results of these tasks would be integrated into chapters of the EIS/EIR.

The preparation of the EIS/EIR includes administrative draft EIS/EIR documents; 1) a DRAFT EIS/EIR that is published and distributed to the public – followed by a draft and final "Response to Comments" documenting public input received during the 45-day review period, and 2) a DRAFT and FINAL EIS/EIR. The latter is made available to the public, but does not require agency responses to public comments. These preliminary and final environmental documents are reviewed by the San Francisco Planning Department and by the Federal Transit Administration (FTA). This process also includes at least two San Francisco Planning Commission public hearings: review of the DRAFT EIS/EIR and certification of the FINAL EIR by the San Francisco Planning Department and a final Record of Decision (ROD) by the FTA.

Per NEPA and CEQA regulations, transit extensions beyond the original project boundary, or implementation of changes to the transit alignment that are more significant than a simple revision to a previously considered alignment, typically require a new environmental evaluation. The T-Third Phase 2 (Central Subway) project included analysis on an extension beyond North Beach via Columbus Avenue, and made a provision for the tail tunnel beyond the terminal station that would be useful for TMB retrieval, as well as for the future rail extension to the north. The tunnel to extract the boring machines that could be used by a future LRT subway extension was constructed as part of the T-Third Phase 2 project between the Chinatown station and the Pagoda Palace site at Washington Square. However, it does not appear possible to perform an additional supplemental environmental study to continue the Phase 1 / Phase 2 project work on a future phase. Based on initial discussions with staff at the San Francisco City Attorney's office, any future plans to extend LRT service north from the Chinatown station will require initiation of a new environmental review and analysis effort to meet NEPA and CEQA needs.

1-3 FUTURE GROWTH PROJECTIONS FOR SAN FRANCISCO

The population of San Francisco in 2010 surpassed 800,000 for the first time in city history. The current population is roughly 20% larger than it was only 40 years ago in the mid-1970s, which was the post- World War II low point. Association of Bay Area Governments (ABAG) and Metropolitan Transportation Commission (MTC) projections estimate San Francisco will grow by another 20%, or more to nearly 1,000,000 by 2040. The need for public transit is great today, and it will continue to grow in the future. The need for improved LRT service in many areas of San Francisco will be an important ongoing element of transportation planning for the next several decades.

1-4 SFMTA RAIL LONG RANGE PLANNING

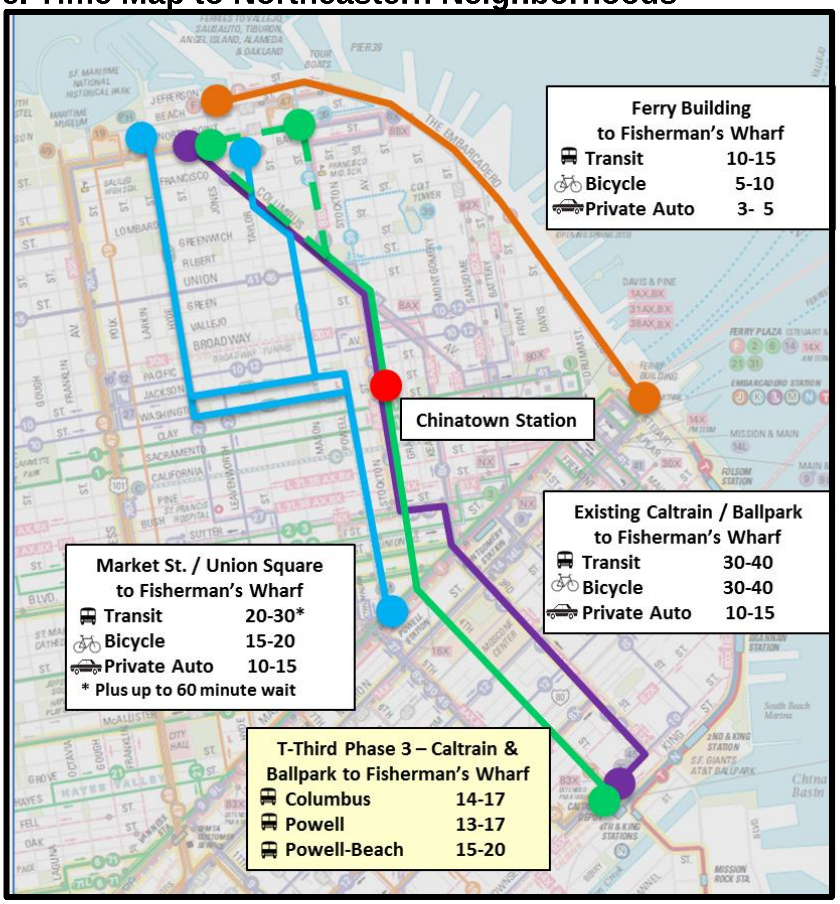
In early 2014 the SFMTA initiated the SFMTA Rail Capacity Strategy; a larger study to analyze opportunities for optimization of existing Muni rail service, and to plan for future rail transit improvements and expansion. The report which will analyze multiple project concepts in several transportation corridors, including the North Beach Corridor, is expected to be completed in early 2015. On the horizon in 2015, a regional transit study titled the San Francisco Bay Area Core Capacity Transit Study will begin. This project will be led by MTC and will focus on concept development and engineering of high priority investments for future transit services. It will be a joint effort involving SFMTA, the Transportation Authority, BART and AC Transit. The information developed in the T-Third Phase 3 Concept Study will be utilized in both forthcoming studies.

Section 2 - Transportation

2-1 OVERVIEW

The northeast neighborhoods of San Francisco including North Beach, Fisherman's Wharf, Telegraph Hill and the northern waterfront along the Embarcadero are some of the oldest and most densely populated areas of the City. In the last half century some parts underwent a dramatic transformation as maritime based business has declined and tourist oriented business
has increased. This area has the highest number of tourism focused sites of interest and tourism focused businesses than any other area within the city limits. While it has excellent service by public transit, travel times are slower than most other modes to access other parts of San Francisco. Transit travel times from Downtown, South of Market and Civic Center to the Fisherman's Wharf area are often two or three times longer than travel times by private automobile. See Figure 2-1. The opening of the T-Line Phase 2 (Central Subway) service will provide competitive transit travel times as far as Chinatown, but for the remainder of the area, the status quo will remain.

Figure 2-1 Travel Time Map to Northeastern Neighborhoods



SFMTA operates five modes of transit in the study area: motor buses, electric trolley buses, light rail vehicles (LRTs), historic streetcars and cable cars. See Figure 2-2. Historically, the primary transit corridors in the North Beach and Fisherman's Wharf areas have been Columbus Avenue, Stockton Street and Powell Street for north-south transit; and the Embarcadero, Beach Street, North Point Street, and Union Street for east-west transit. These corridors continue to remain the primary transit corridors, and are recommended as the likely alignment options for future service improvements.

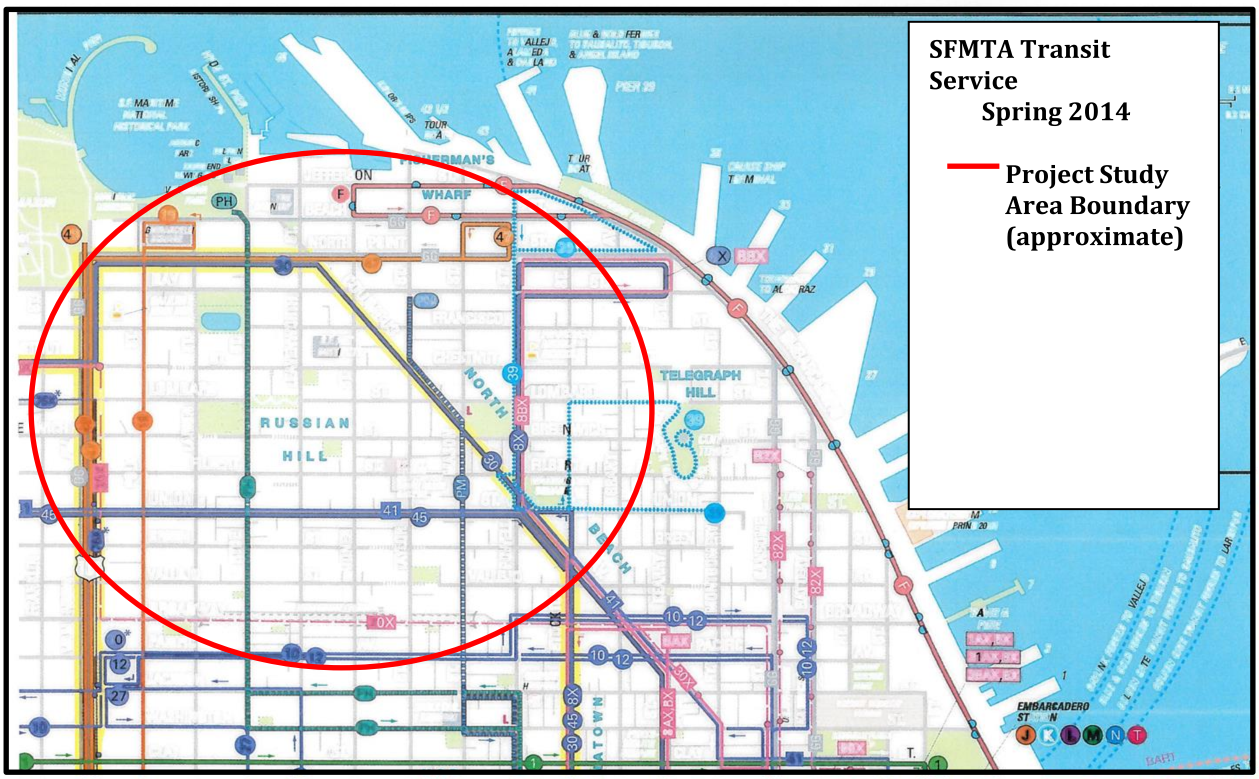
2-2 SUMMARY OF EXISTING TRANSPORTATION

The next several sub-sections provide information on the many different modes of travel present in the project study area.

2-2-1 Existing Transit Service

Although it is abundant, transit service in the North Beach and Fisherman's Wharf area has been in a constant state of change for over a decade.

Figure 2-2 – Concept Study project area



The largest changes were implementation of the F-Embarcadero streetcar service along the waterfront which started in 2001, and elimination of the 15-Third Street motor bus route when the T-Third LRT line began service in 2007. Although T-Third service did not extend into the neighborhoods north of Market Street, the 15-Third Street line did extend all the way into the Fisherman's Wharf area, and after removal it was replaced by revised bus transit service into the area. A consistent group of the general public has sought to restore the one-seat ride between eastern San Francisco and the Fisherman's Wharf area.

2-2-1-1 TRANSIT VEHICLE CAPACITY

Passenger capacity is a critical component to help determine future equipment needs when projected passenger volumes are calculated. Table 2-2 shows three capacity measurements: seats, the 85% load factor (the point where a crowded transit vehicle theoretically becomes uncomfortable), and the planning capacity, which is the maximum capacity of a transit vehicle when it is totally full with passengers. The planning capacity level of a transit vehicle can be exceeded, but only with a very high level of discomfort to passengers and great difficulty in boarding and alighting of passengers.

Table 2-1 Load Factors for Transit Vehicles

Transit Vehicle Type	Seats - Standard (Standard) bus, trolley bus / LRV / hist. streetcar / cable car	Seats Low Floor (Low Floor) bus / trolley bus)	85% Load Factor	100% Planning Capacity
30' – motor bus / trolley bus	See Low Floor	27	38	45
40' – motor bus / trolley bus	See Low Floor	35	54	63
60' – motor bus / trolley bus	55	46	80	94
Light Rail Transit Vehicle (LRT) (Breda)*	60	See standard	101	119
Historic Streetcar (PCC / Milan)	47-60 / 29	See standard	51	60
Cable Car (Powell / California)	30 / 34	See standard	54	63

***** LRTs can operate in multiple units of up to 4 cars, but on this corridor, 2 car trains are required due to platform lengths at stations. All other modes only operate as single unit vehicles. Specifications for future Siemens cars are not finalized, except for length, which will be the same as the Breda cars.

2-2-1-2 EXISTING (2014) TRANSIT SERVICE IN THE NORTH BEACH AND FISHERMAN'S WHARF AREA

Transit service in the North Beach Corridor is provided by several routes. See Appendix A for greater detail on frequency and span of service. The most frequent service is present on the following routes: 8X, 8AX, 8BX, 30, 30X, 41, and 45. During the AM and PM peak hour these routes have a planning capacity of approximately

4,250 passengers in each direction. Rail service is present on the F-Market & Wharves (Embarcadero); the Powell-Mason and Powell-Hyde cable car lines. During the AM and PM peak hour these routes have a planning capacity of approximately 1,350 passengers in each direction. Less frequent transit service, or service that only covers part of the corridor is present on Routes: 10, 47, 12, 27, 39 and 82X. During the AM and PM peak hour these routes have a planning capacity of approximately 1,600 passengers in each direction.

Although the North Beach Corridor is essentially a north-south corridor, east-west transit service is present at the southern end of the corridor on Route 1 and the California cable car line. During the AM and PM peak hour these routes have a planning capacity capacity of approximately 1,500 passengers in each direction. In addition, Golden Gate Transit operates bus service between Marin County and downtown / Transbay Terminal via Battery and Sansome Streets on the eastern edge of the corridor, and on the Embarcadero, North Point and Beach Streets on the northern edge of the corridor.

2-2-1-3 BUS SERVICE CHANGES FOLLOWING T-THIRD PHASE 1

Phase 1 of the T-Third LRT line opened for full service in April, 2007 between the Sunnydale Station in Visitacion Valley near the San Mateo County Line and the Caltrain San Francisco Terminal station at 4th and King Streets. The T-Third line replaced the 15-Third Street motor bus service that had provided transit on the Third Street corridor since it replaced streetcars in 1941.

North of Caltrain, transit service that had formerly been provided by the 15-Third Street bus is presently being served by new or revised bus routes 9X, 9AX and 9BX. These routes were all part of an improved limited stop service along the former routes that 15-Third Street service: 3rd Street / 4th Street, Kearny Street, Columbus Avenue, Powell Street, and the one-way loop on Bay Street, Kearny Street and North Point Streets to the northern route terminal. A new route, the 20-Columbus bus was added to help out the very busy 30-Stockton route, but it was discontinued in 2009.

In 2010, the Route 9 group of routes was slightly revised and renamed to be Routes 8X, 8AX and 8BX bus service. See Figure 2-2. Service on the newly designated routes continued south of Market to Harrison Street and Bryant Streets before using the US 101 and I-280 freeways to reach the southeastern part of the City along San Bruno Avenue in the Portola District. After all three routes serve Visitacion Valley, the 8X and 8BX routes turn west to operate along Geneva Avenue to a terminal at the combined Balboa Park BART and Muni Metro station at Geneva and San Jose Avenues adjacent to I-280.

2-2-2 Summary of T-Third Phase 1 and Phase 2 Projects

The T-Third Light Rail Transit (LRT) line opened in April 2007 as the first new rail line in the eastern part of San Francisco in over 50 years. The new rail line extended 5.1 miles from the San Francisco County Line near Visitacion Valley to the Caltrain Station at 4th and King Streets, and was constructed at a cost of $748 million dollars.

Phase 2 of the T-Third LRT line is tentatively scheduled to begin service in early 2019. The new service will extend the line 1.7 miles via a surface line and subway from 4th and King Streets to Stockton and Clay Streets in Chinatown. The subway portion will take place north of Bryant Street. New stations will open at Brannan Street (surface), Moscone Center (subway), Union Square / Market Street (subway) and Chinatown (subway). The extension will address transit needs and street congestion in a busy north-south corridor in the heart of downtown San Francisco. Phase 2 received a Full Funding Grant Agreement (FFGA) from the Federal Transit Administration (FTA). The total program cost of the Phase 2 extension is projected at $1.5 billion dollars. Phase 2 construction extended into North Beach where the tunnel boring machines (TBMs) were retrieved from the ground near the intersection of Powell Street, Columbus Avenue and Union Street (Pagoda Palace site). At the planned horizon service year of 2030, the LRT service is projected to operate at 2.5 minute frequency during the AM and PM peak hours, which would equate to a planning capacity capacity of approximately 5,700 passengers in either direction.

Plans to modify surface Muni transit service, to enhance the rail line extension, and avoid service duplication once the new extension opens are in preliminary stages of development. Implementation will be challenging due to the heavy ridership on multiple routes and the tight and limited space available for bus stops, layover locations, and general operations in the area that will receive the greatest impacts from the service changes.

2-2-3 Summary of ‘E’ and ‘F’ Line Transit Project Plans

In addition to the planned Central Subway improvements, other service changes that have been environmentally reviewed include the E Line -Embarcadero service between Fisherman’s Wharf and Mission Bay, and F- Line – Market and Wharves extension north from Fisherman’s Wharf through the Fort Mason rail tunnel to Fort Mason. The former is a planned service that would use historic streetcars to serve a new route on existing tracks, while the latter would be a new service using historic streetcars on new tracks that would be built between the current F-Line terminal on Jones Street and a northern terminal on the north side of the Fort Mason rail tunnel in Lower Fort Mason. The E-Line is likely to begin operations within 1-3 years, while the F-Line Extension is several years away as capital funds to build the new line are not currently available, nor expected to be available for a decade or more.

2-2-4 Summary of Existing Traffic and Parking Conditions

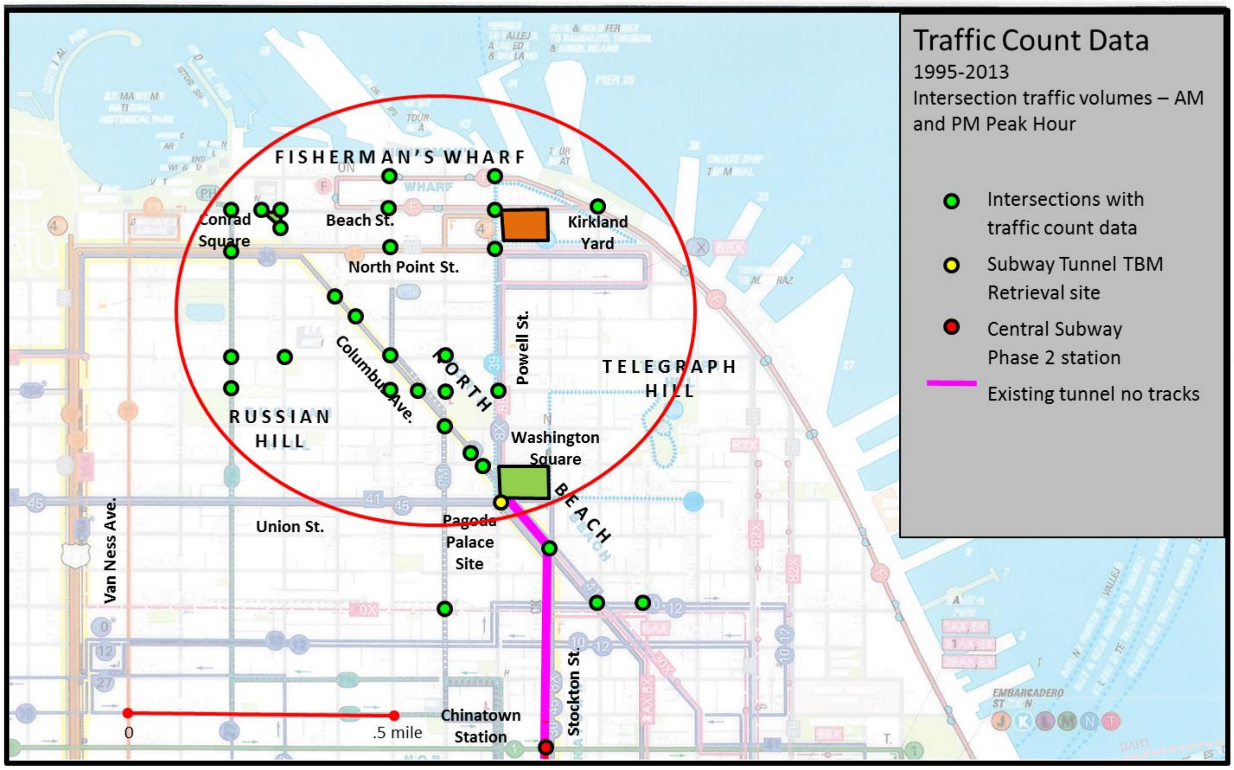
The neighborhoods of North Beach and Fisherman's Wharf primarily feature a grid pattern of north-south and east-west streets, but with major non-conforming geographic features and non-grid arterial streets. The largest grid disruptions are Telegraph Hill on the east side of North Beach; Columbus Avenue, which bisects North Beach at a 45 degree angle for fourteen blocks; and the edge of San Francisco Bay. Along the bayside waterfront The Embarcadero, a major transit and traffic corridor, gradually turns from a north-south corridor at the southeastern edge of the study area to an east-west corridor at the northwestern end. In addition, many small one to two block alleys exist in seemingly random locations.

Although the area is well known for an abundance of narrow streets and a scarcity of on-street parking, traffic congestion is generally limited to major corridors, and occurs more often on weekends at non-peak period times, because it is tied to tourism related activities.

Due to their orientations, and the fact they are some of the widest streets in the study area, both Columbus Avenue and The Embarcadero are major arterial streets and travel corridors. Other major arterial streets on the south side of the study area include north-south routes Stockton Street and Kearny Street, both of which directly feed into Columbus Avenue. They act as extensions to funnel traffic and transit to and from downtown and Market Street, and the east-west arterial Broadway. On the north side, closer to Fisherman's Wharf, major east-west arterials include Chestnut Street, Bay Street, North Point Street and Beach Street. Powell Street is the primary north-south transit corridor on the eastern edge of Fisherman's Wharf. On the far western edge, Van Ness Avenue (US 101) is also a major north-south arterial.

The compilation of recently-recorded traffic conditions information in the entire study area - and especially along the three primary transit corridors (Columbus Avenue, Powell Street, Beach Street) that are the source of most transit alignment options - is not extensive. Streets and intersections with traffic counts less than ten years old are shown in Figure 2-3. In general traffic counts are often within 25% of traffic present on any given day. Variations can be due to weather, accidents, road work, etc. All count totals listed below are rounded slightly up or down (e.g. less than 10%).

Figure 2-3 Traffic Count Data in Concept Study project area



Columbus Avenue is the busiest north-south street in the study area north of Chinatown. At 80 feet, it is the widest north-south street in the study area, and it is the flattest. It is the primary "through" route from downtown to North Beach and Fisherman's Wharf. All intersections are signalized, except Francisco / Leavenworth / Beach at Conrad Square, which are controlled by stop signs. The sidewalks in this area are 10 feet wide on each side of the street, leaving 60 feet of roadway space. The street is striped for four traffic lanes (two in each direction), with a narrow median along most of the seven blocks between the Washington Square and Conrad Square. A short five lane section with an exclusive northbound left turn lane exists on the block between Jones Street and Bay Street. Parallel parking extends along most of the seven block area.

However, because Columbus Avenue crosses the street grid at a 45 degree angle, it has several complex, odd-shaped intersections that create challenging traffic issues. It is further complicated by the presence of the Powell-Mason cable car line, which operates on the street for two blocks between Mason and Taylor Streets. The single busiest intersection is Columbus and Bay Streets, the site of the only double left turn lane (northbound) on Columbus Avenue in the study area.

Traffic volume counts are available for five Columbus Avenue intersections in the AM and PM peak hour: Jones and Bay; Francisco, Greenwich and Mason, Stockton and Green; and Grant and Broadway. The volumes range from 200-700 vehicles southbound, although one count at Broadway recorded 1,200. Volumes range from 175-600 vehicles northbound. With one exception, PM peak hour traffic was heavier than AM peak period traffic in either direction. East-west traffic volumes at four intersections were a few dozen or less during the AM and PM peak hour, but at Bay Street, volumes were 400-1,300 vehicles in both directions during both the AM and PM peak hour. The limited data available showed much higher eastbound traffic in the AM peak hour and westbound traffic in the PM peak hour. The three streets adjacent to Conrad Square (Beach / Leavenworth / Columbus) had PM peak volumes of 250-400 vehicles per hour, with the heaviest traffic on Beach Street and the lightest traffic on Columbus Avenue.

North of Washington Square Powell Street is the quietest street of the three likely alignment streets. At 68 feet it is narrower than Columbus, but carries much less “north-south” traffic. It has two blocks of 6.5%-7.5% grade, but otherwise is fairly flat. Sidewalks measure 12-13 feet on each side of the street, leaving 41-44 feet of street roadway space. Currently all blocks allow parallel parking on both sides of the street (16’), which leaves 25-28 feet for two lanes of mixed traffic (one lane in each direction). Central Subway – Phase 2 drawings show a width of 26 feet for LRT track areas, which is slightly wider than two standard traffic lanes.

Traffic volume counts are available on four Powell Street intersections in all directions for the PM peak hour: Embarcadero and Jefferson; Beach, North Point and Lombard; and at one intersection, Powell and Lombard in all directions for both the AM and PM peak hours. North-south traffic on Powell was recorded at 120-200 vehicles in each direction during the PM peak hour at all intersections, and at 120-140 vehicles in each direction on Powell at Lombard Street during the AM peak period. East-west traffic totaled only a few dozen vehicles (less than 100) on Lombard Street, but was much higher on the three streets close to the waterfront. Traffic counts range from 200-250 vehicles on Beach and North Point, 500-750 vehicles westbound on The Embarcadero; and 400-500 vehicles on Beach and North Point, and 200-300 vehicles eastbound on The Embarcadero.

Beach Street is the most likely “east-west” street that would be a focus of alignment options. It is also 68-69 feet wide between Powell and Columbus, and is almost perfectly flat as it is mostly built on fill. Four of five intersections on Beach Street between Powell Street and Conrad Square are signalized. Only the triangular intersections at Conrad Square are controlled using stop signs. Beach Street is striped

for one lane of traffic in each direction, with parallel parking on the north side (facing west), and a semi-exclusive transit lane for F-Line historic streetcars on the south side (facing east) between Jones and Powell Streets. In the two blocks between Jones and Conrad Square, the street is striped for two lanes of eastbound traffic. Sidewalks are present on both sides of the street, and range from 8-15 feet in width.
Traffic volume counts are available on four Beach Street intersections in all directions for the PM peak hour: Hyde, Taylor, Powell and The Embarcadero. Volumes range from about 200-400 vehicles in each direction with the heaviest traffic volume being at Powell Street. Cross traffic in the north-south direction on Taylor Street is about equal to the Beach Street east-west traffic, and the north-south direction on Powell Street is lower than the Beach Street east-west traffic. On the western edge of the study area, south traffic on Hyde exceeds 430 vehicles at the Beach Street intersection. Part of this high traffic volume is likely due to Hyde S treet being the last north-south street available for traffic driving west on Jefferson Street to turn south and remain connected to the larger street network.

As part of a series of “complete street” improvements, proposals are in place to reduce the width of Columbus Avenue between Broadway and Washington Streets from two traffic lanes in each direction to one lane with a buffered bike lane, and to implement exclusive transit lanes on Columbus Avenue between Filbert and Stockton Streets near the Washington Square area. Although these changes are within the project study area, as currently envisioned subway tracks would not rise to a surface portal until a location north of Filbert Street on any of the concept alignments.

2-2-5 Summary of Existing Bike Conditions

The SFMTA approved a completely revised Bicycle Plan in 2009 which is the source of most of the information in this sub-section. Within the project study area, Columbus Avenue is a signed bicycle route (Class III), while the Embarcadero between North Point Street and Broadway, and North Point Street between Van Ness Avenue and the Embarcadero are streets with a bicycle lanes (Class II). Powell Street and Beach Streets which are listed as study corridors for possible T-Third Phase 3 extensions are not streets that are presently on the San Francisco bicycle route network.

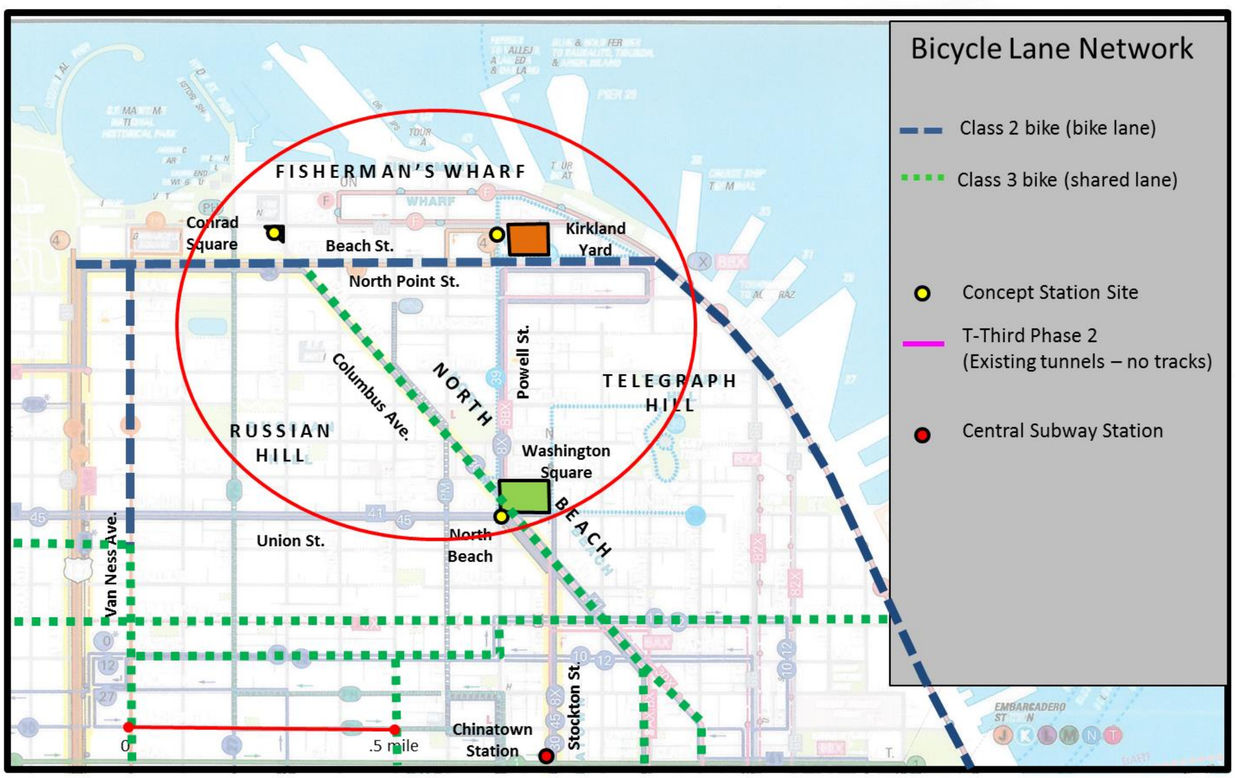
Three bicycle routes are present in the North Beach and Fisherman’s Wharf area.

- Route #11 connects Fisherman’s Wharf with North Beach, the Financial District and SOMA. The route starts at the corner of North Point Street and Columbus Avenue and proceeds via Columbus Avenue to Washington / Clay Street, where it proceeds east into the Financial District before turning south and crossing into SOMA.

- Route 5 starts at the corner of North Point Street and the Embarcadero and runs along the Embarcadero and the east side of San Francisco all the way to the San Mateo County line on Bayshore Blvd.
- Route 2 starts at the corner of North Point Street and the Embarcadero and runs along North Point Street to Van Ness Avenue before continuing on through Fort Mason, the Marina and the Presidio to the Golden Gate Bridge.

Within the Bicycle Plan a sub-section addressed the issue of bicycle facilities on transit routes and provided a preliminary framework to guide the SFMTA and other city agencies to resolve issues and conflicts. Key issues include ensuring bicycle rider safety and ensuring minimal degradation to transit service performance.

Figure 2-4 Existing Bicycle Lane Network



2-2-6 Summary of Existing Pedestrian Conditions

Columbus Avenue is designated a "Commercial Throughway" per the San Francisco Better Streets Plan. The recommended sidewalk width on Commercial Throughways is 15' and the minimum is 12'. Existing sidewalks on Columbus Avenue are only 10' and do not meet the minimum standards. Pedestrian conditions along the street are generally considered to be crowded, with insufficient space for movement and street life.

A series of "complete street" actions have been proposed to make Columbus Avenue a safer and more neighborhood oriented street. In January 2010 the Transportation Authority completed a Columbus Avenue Neighborhood Transportation Study. The study analyzed a variety of pedestrian-oriented improvements to the street, such as road diets, corner bulb outs, expanded medians, and sidewalk widening, All proposals are currently conceptual.

The portion of Powell Street in the study area is designated "Neighborhood Commercial" except for the portion between Chestnut and Greenwich streets which is designated "Neighborhood Residential." The San Francisco Better Streets Plan recommended sidewalk widths are 15' for Neighborhood Commercial and 12' for Neighborhood Residential. Sidewalks on Powell are currently 12' wide and thus do not meet recommended widths for the majority of the street in the study area.

Columbus Avenue and Bay Street are "Walk First" Safety streets identified as a part of the Walk First pedestrian safety program. The Walk First program was developed in response to Mayoral Executive Order 10-03 in 2010, which called on the City to reduce fatal and serious injuries to pedestrians by 25% in 2016, and 50% in 2021 (compared to a 2008 baseline). The Directive also called for development of a Pedestrian Strategy, which would examine current conditions and make recommendations for near and long term actions and funding sources to improve safety and walkability. An existing conditions report was created which identified key walking streets and recommended criteria to prioritize and improve pedestrian safety and walking conditions, encourage walking, and enhance pedestrian connections to key destinations. Additionally, the intersections of North Point and Taylor Streets and Hyde and Beach Streets have been identified as top collision locations in need of changes to improve pedestrian safety.

A subway extension should have minimal impacts on proposals to improve these streets for pedestrians. However, surface alignments could potentially complicate and add expense to "complete streets" improvements. If a decision is made to proceed on a T-Third Phase 3 extension, the conflict between these concepts and an extension of surface-level LRT service along Columbus Avenue and/or Powell would be analyzed in future planning and environmental review work.

2-3 T-THIRD PHASE 3 LRT EXTENSION CONCEPT ALIGNMENTS

To develop a list of concept alignments, consultations and interviews were held internally with SFMTA staff affiliated with the Central Subway Phase 2 project, and SFMTA staff located in the following divisions and groups: Livable Streets, Traffic Engineering, Transit Operations, and Capital Projects and Construction. Existing documents were reviewed including:

The Bayshore Transit Study (1993)

The Four Corridor Plan (1995)

Third Street Light Rail Project FINAL EIS/EIR (October, 1998)

A Vision for Rapid Transit in San Francisco (2001)

Third Street Light Rail – Phase 2 – Conceptual Alternative Downtown Rail Alignment Study (vols. 1 & 2) (2006)

Third Street Light Rail Project – Central Subway FINAL Supplemental EIS/EIR (September 2008)

Third Street Light Rail – Phase 2 – New Starts Criteria Report (September 2010)

Fisherman's Wharf Public Realm Plan Project (August 2011)

Third Street Light Rail Phases 1 & 2: 2018-2030 Service Integration (March 2011)

Third Street Light Rail Project – Central Subway Addendum to the Supplemental EIS/EIR (January 2013)

SPUR Charette Report: Connecting San Francisco's Northeast Neighborhoods – Discussion Paper (August 2013)

2-3-1 Concept Alignments – Background Assumptions

The first assumption is the target destination terminal for a T-Third Phase 3 extension is the Fisherman's Wharf area. Fisherman's Wharf is located on the northern waterfront of San Francisco. The neighborhood covers approximately twenty square blocks north of North Point Street. To the west it stretches for several blocks to Ghirardelli Square and the National Maritime Museum at Polk Street. To the east it extends to Pier 39, which is located on the Embarcadero at the north end of Grant Street.

Several possible alignments are available for an extended T-line light rail line to reach the Fisherman's Wharf area, and the alignments include options for surface LRT, subway LRT and a combination of subway and surface LRT. The second assumption is potential alignments follow existing transit routes on Columbus Avenue, Powell Street and Beach Street that have been in constant use during the past several decades to maintain general continuity of travel patterns and infrastructure. Exceptions to second assumption were made for segments of one to two blocks to allow for alignment options to be complete at some key locations. Other basic assumptions listed below refined the basic elements set out in the first two assumptions.

2-3-1-1 T–THIRD PHASE 2 TAIL TRACK TUNNEL

The third assumption is that the Washington Square area is the origin point for analysis of future service alignments to the Fisherman's Wharf area. Although the Chinatown station is the northern terminal of future LRT service (to begin once the T-Third Phase 2 project is completed), subway tunnels extend seven blocks north of the Chinatown station to the former Pagoda Palace site on Powell Street and Columbus Avenue at Washington Square in North Beach. The tunnels were built to allow for easier extraction of the TBMs, but will almost certainly be utilized as a part of any future northern LRT service extension.

2-3-1-2 PAGODA PALACE SITE AS NORTH BEACH AREA STATION

Although the third assumption includes utilization of the tunnel between Chinatown and Washington Square for a northern LRT service extension, the Pagoda Palace site is not automatically assumed to be the North Beach station location, although the Pagoda Palace site is considered a potential location of station ancillary facilities (entrances, emergency egress, ventilation shaft location). The larger issue of the North Beach station site is addressed later in this section, but as a starting point for the concept study, a fourth assumption should be that a station will be constructed in the Washington Square area that will be identified as a "North Beach" station.

2-3-1-4 STATION AND TERMINAL LOCATIONS NEAR FISHERMAN'S WHARF

Three station locations are identified in different concept alignments being analyzed. A station in North Beach at or near Washington Square is present in all concept alignments. Different concept alignments also propose a station at Conrad Square, located at Columbus Avenue and Beach and Leavenworth Streets, or a station at the Kirkland Division SFMTA bus yard at Powell and Beach Streets. A few concept alignments propose stations both at Conrad Square and at Kirkland Yard.

Most concept alignments propose terminal and track turnaround facilities that stand alone separate from existing SFMTA facilities, but in an effort to complete a broad look at many options, a few concept alignments propose to utilize tracks used by the current F-Line historic streetcar to facilitate a turnaround. The assumption for these alignments would be to serve existing F-Line stations (likely four surface platform stations) in the Fisherman's Wharf area in addition to the North Beach and Kirkland stations. See Figure 2-1.

Conrad Square is a small triangular shaped park of less than ½ acre in size located at the end of Columbus Avenue at Beach Street. It is landscaped with a small lawn, trees and shrubs, and park benches. It was named for the novelist Joseph Conrad in 1979, and is the only publicly owned open space near the end of Columbus Avenue.

Any actions involving Conrad Square as a station or as an access point to subway construction would likely result in an action involving federal Department of Transportation (DOT) Section 4f regulations applicable to parkland protection. The space is too small to fit a surface terminal / station without using additional space on at least one of the adjacent surface streets. A draft plan to narrow Columbus Avenue was a part of the Fisherman's Wharf Public Realm Plan (2011). It may be possible to close the last block of Columbus Avenue adjacent to Conrad Square to through-traffic.

The Kirkland Division (Kirkland Yard) is an SFMTA motor coach division located on a 2.3 acre parcel in North Beach that is bounded by North Point, Powell, Beach and Stockton Streets. Kirkland Yard opened as an S.F. Municipal Railway division in 1950 at a time when industrial uses were very common in the North Beach area. The facility currently has a capacity of 100 40-foot buses. It is not a "full service" facility, as it only performs fuel, wash and minor "running repair" on the fleet stored onsite. Heavy duty repairs for the Kirkland Yard fleet are done at the Woods Division in the southeastern part of San Francisco. Kirkland Yard has been identified as a facility in need of a rebuild or substantial improvements in documents that date back to 1967, but has not seen significant changes or renovations at any time in the past fifty years.

Kirkland represents the largest, and initially, the only non-parkland property under City of San Francisco ownership in the greater Fisherman's Wharf area. It could be utilized as an area where station ancillary facilities (entrances, emergency egresses, ventilation shafts and other station facility systems could be located, or it could be utilized as an equipment and contractor staging area. If the Kirkland Yard is not used, private property would need to be purchased or leased to build a station in this area.
Any action scenario with Kirkland as a station or as an access point to subway construction would likely require the existing bus fleet to relocate to new or temporary division facility for the duration of the construction, or permanently. This scenario would currently be in conflict with the SFMTA Facilities Vision Plan which calls for all SFMTA vehicle facilities to be maintained, because currently vehicle storage and maintenance capacity is constrained, and future projections indicate that population and transit ridership growth will require additional facilities. To that point, Kirkland Yard is not being analyzed as a Transit Oriented Development (TOD) opportunity in this study.

Conceptual layouts of a surface station and terminal at Kirkland have not been drafted, because the property is believed to be more than adequate to accommodate a stub end design terminal and station. The property size may be adequate for a loop turnaround design. A multiple level facility has also been discussed as an option for this site.

2-3-2 Concept Alignments for LRT Service

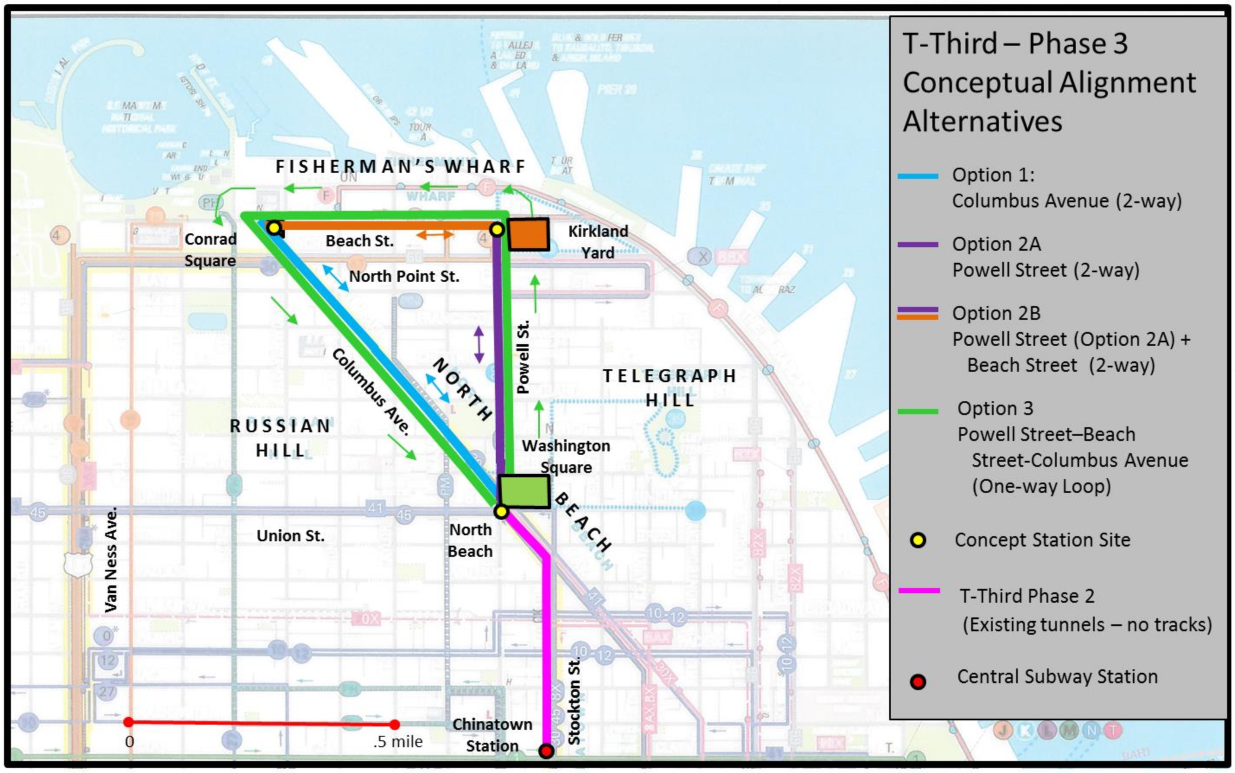
Using previous work from the Four Corridor Report (1994), The Third Street Light Rail – Phase 2 – Conceptual Alternative Downtown Rail Alignment Study (vols. 1 & 2) (2006), and the San Francisco Planning and Urban Research (SPUR) Charette (2013) as starting points, two corridors are the focus for analysis as routes to the Fisherman's Wharf area: Columbus Avenue and Powell Street. Specific alignment concepts must include both the geographic route issue, and the elevation issue (surface, subway or combination).

The alignment options are listed below. A decision was made to limit corridors to existing transit corridors, but a large number of possible concept alignments were analyzed, because this concept study is focused on the development of information. However, alignments found to be infeasible during an initial analysis are briefly mentioned – and then listed as screened out. The screening of alignments and alternatives found to be initially feasible would be the focus of a future document to be drafted if a decision is made to proceed with advanced planning on a T-Third Phase 3 extension. Greater detail on all of the alignment concepts is present in Appendix C.

All concept alignments assume that the existing tunnels between the Chinatown station and Washington Square would be used for the first segment of a larger extension to the Fisherman's Wharf area, and that the extension would include a subway station in North Beach. Therefore, all concept alignments originate from North Beach at Washington Square. See Figure 2-5. All concepts assume 2-car train operations with terminal stations that can store at least two 2-car trains. The three transit corridor options where the concept alignments are located are:

- 1) Columbus Avenue (two-way) – with a station at Conrad Square,
- 2A) Powell Street (two-way) – with a station at Kirkland Yard
- 2B) Powell Street (two-way) with a station at Kirkland Yard (option 2A) + Beach Street (two-way) with a station at Conrad Square
- 3) Powell Street / Beach Street / Columbus Avenue (one-way loop) with stations at Kirkland Yard and Conrad Square

Figure 2-5 Concept Alignments (Detailed maps located in Appendix C)



The Columbus Avenue (two-way) alignment (Option 1) includes two concepts:

- 1-1: Subway / surface alignment with a surface station and off-street turnaround at Conrad Square
- 1-2: All subway alignment with a station and an underground turnaround below Conrad Square.

The Powell Street one-segment / one station alignment (Option 2A) includes six concepts:

- 2A-1: Subway / surface alignment with a surface station and off-street turnaround at Kirkland Yard.
- 2A-2: All subway alignment with a station and underground turnaround below Kirkland Yard.
- 2A-3: Subway-surface alignment with a surface station at Kirkland Yard and a short surface loop turnaround on Powell, Jefferson, Mason and Beach Streets
- 2A-4: All subway alignment and subway station at Kirkland Yard and a short surface loop turnaround on Powell, Jefferson, Mason and Beach Streets
- 2A-5: Subway-surface alignment with a surface station at Kirkland Yard and a short surface loop turnaround via Powell Street to existing F-Line tracks for several blocks on Jefferson, Jones and Beach Streets

- 2A-6: All subway alignment with a station at Kirkland Yard with a surface loop turnaround via Powell Street to existing F-Line tracks for several blocks on Jefferson, Jones and Beach Streets

The Powell Street - Beach Street two segment / two station alignment (Option 2B) incorporates the Powell Street single segment – one station concept at Kirkland, but the line extends further via Beach Street to Conrad Square, where a second station and a turnaround would be located. This group includes four concepts:

- 2B-1: Subway / surface alignment with a surface station at Kirkland Yard; a Beach, Jones, North Point, and Columbus surface alignment with a surface station and an off-street turnaround at Conrad Square
- 2B-2: Subway alignment and subway station at Kirkland Yard, and a Beach Street subway alignment with a subway station and underground turnaround below Conrad Square
- 2B-3: Subway / surface alignment with a surface station at Kirkland Yard; a Beach Street subway alignment with a subway station and underground turnaround below Conrad Square
- 2B-4: Subway alignment and subway station at Kirkland Yard, and a Beach, Jones, North Point, Columbus surface alignment with a surface station and off-street turnaround at Conrad Square

The Powell Street / Beach Street / Columbus Avenue one-way loop two station alignment (Option 3) would only have a single tunnel bore and track. For initial planning purposes, a train storage and terminal appears more likely to be at or near a Kirkland Yard station than at a Conrad Square station. The terminal station must have a center platform that can accommodate two 2-car trains on each side, as well as a pocket track to move non-service trains out of the way from regular service trains. The one-way loop alignment includes two concepts:

- 3-1: Subway / surface loop alignment via Powell Street with a surface station at Kirkland Yard; a surface alignment via Beach Street, with a surface station at Conrad Square; and a surface alignment via Columbus Avenue to north of Taylor Street, with a subway back to Washington Square
- 3-2: All subway loop alignment via Powell Street with a subway station at Kirkland Yard, a subway alignment via Beach Street, with an underground station under Conrad Square, and a subway alignment back to Washington Square

2-4 T-THIRD PHASE 3 TRANSIT OPERATIONS ISSUES

Many operations issues differ among the concept alternatives, and the information in the next sub-section briefly addresses some of the issues. Objective data exists on some issues that provide definite comparisons between the alignments, but other issues do not yet have data available, so the comparison is more subjective in nature.

2-4-1 Surface Alignments vs. Subway Alignments

Both surface and subway alignments have large scale pros and cons that make it very challenging to select a preferred alignment profile. As a general rule surface alignments can be built more quickly, and at a much lower initial capital cost than a subway, apart from utility relocations that can take significant time to accomplish. Surface alignments are much less likely to encounter ground problems (e.g. sand, rock, high water table, poor soil formations, etc.) than subways, but they are prone to larger permanent environmental impacts (noise, vibration, traffic congestion, safety issues, lower residential values along the immediate corridor, visual impacts, etc.).

Surface options impact limited street right-of-way, taking up valuable space that might otherwise be used for sidewalks, parking, or travel lanes. Surface options also create potential conflicts with pedestrians, bicyclists and other modes of transit. As stated above, subways are more expensive and require longer construction time, but once in place, they are usually immune to mixed traffic congestion, and service can operate at higher speeds with greater on-time reliability – for a century or longer. Over the lifetime of a transit facility, lower operations and maintenance costs due to quicker and more efficient service eventually will offset the higher capital costs associated with subway construction. Additionally, subways are “out of sight” below ground, so the constant challenge of impacts due to surface LRT tracks and train operations in neighborhoods is a challenge that isn’t present with a subway alignment. In dense neighborhoods, subway alignments are usually a better long-term investment that pays many times over not only in terms of improved efficiency of the transit operations, but in terms of improved environmental benefits (improved aesthetics, lesser noise and vibration, lower pollution levels, etc.).

2-4-1-1 RELIABILITY – CONFLICT / CONGESTION WITH MIXED TRAFFIC / TRANSIT

Transit service that is reliable (on-time with even spacing between buses or trains) is a top desire of transit passengers. Reliability is the ability of transit vehicles to arrive and depart a station at the time they are scheduled to do so. Reliability should not be equated with speed or travel time, which is a separate issue.

Even with exclusive right-of-way over much of a service area, surface alignments generally result in slower transit service than subway alignments because they must cross intersections with mixed traffic, and usually have closer spaced stations than subways. Each intersection is a potential interruption with planned service operations, and an each interruption results in lower reliability. Closer spaced stations offer improved passenger access, but that gain is offset by the aforementioned loss of speed and performance.

LRT service that operates in mixed traffic without signal priority at signalized intersections has the lowest level of reliability, because it has the greatest opportunity to be delayed by outside influences (e.g. traffic congestion, unfavorable signal timing, etc.). LRT service that has conflicts with other rail transit service (e.g. two LRT lines sharing the same track) must endure similar challenges as service that has conflicts with mixed traffic, and therefore is likely to have lower reliability than if it was the sole transit service on a segment of track.

At the high end of the spectrum the type of service with the highest reliability is single line subway service where trains have no interaction with intersections and mixed traffic.

The streets in the concept study area were categorized as arterial, commercial, or residential, and the number of intersections assumes a two-way trip, plus layover in the extended segment, excepting the one-way loop concept, which was a single loop trip.

Table 2-2 Traffic Conflicts – Intersections and Signals

Alignment	intersections	traffic signals
Columbus Avenue 1-1 - subway-surface	9	4
Columbus Avenue 1-2 - subway	0	0
Powell Street 2A-1– subway /surface	12	4
Powell Street 2A-2 - subway	0	0
Powell Street 2A-3 - subway/surface + short loop	17	9
Powell Street 2A-4 - subway + short loop	5	4
Powell Street 2A-5 - subway/surface + F-Line Loop	21	13
Powell Street 2A-6 - subway + F-Line Loop	9	9
Powell / Beach Streets 2B-1 – subway/surface	22	12
Powell / Beach Streets 2B-2 – subway	0	0
Powell / Beach Streets 2B-3 – subway/surface + subway	N/A	N/A
Powell / Beach Streets 2B-4 – subway + surface	N/A	N/A
One-Way Loop: Powell / Beach / Columbus 3-1 – subway/surface	14	8
One-Way Loop: Powell / Beach / Columbus 3-2 – subway	0	0

2-4-1-2 LRT TURNAROUND AND TERMINAL STORAGE CAPACITY

The ability of transit vehicles to turn around to allow a return trip in service to their point of origin, and allow for operator breaks (layover) is a key issue in transit system design. Inadequate space, or poor design for turnaround actions or transit vehicle layover hamper transit performance by causing problems and slowing service down.

Track designs that use a loop are the preferred design for a turnaround, but they require a lot of space. In tighter spaces (e.g. small parcels or subways) "X" crossover tracks are most often used. Redundancy of "X" crossover locations near a terminal (two or more crossovers versus a single crossover), and adequate storage track to allow LRT vehicles and operators to layover prior to returning to service can significantly increase turnaround performance. Problems with turnarounds have a ripple effect on other issues, such as reliability, travel time, passenger experience, etc. Turnaround locations for the concept alignments assume known design elements, or are listed as a TBD (to be determined) if a clear design element does not yet exist. The primary locations considered for turnaround actions are:

- Conrad Square Park (six concept alternatives, both surface and subway),
- Kirkland Division Yard (two concept alternatives, one surface and one subway),
- The Short Loop near Kirkland Yard (two concept alternatives, both surface),
- The F-Line Loop (two concept alternatives, both surface).

The Short Loop and F-Line Loop concepts need terminal storage capacity and layover space at the Kirkland Yard area, even though the trains don't turnaround at the site. The One-Way Loop concept alignment options do not utilize a turnaround, as both follow an alignment that turns the vehicles around while in active service.

Table 2-3 Turnaround Design

Alignment	turnaround type	number
Columbus Avenue 1-1 – subway/surface	X crossover	1*
Columbus Avenue 1-2 - subway	TBD	TBD
Powell Street 2A-1 – subway/surface	TBD	TBD
Powell Street 2A-2 - subway	TBD	TBD
Powell Street 2A-3 - surface + short loop	surface loop	1
Powell Street 2A-4 - subway + short loop	surface loop	1
Powell Street 2A-5 - surface + F-Line Loop	surface loop	1
Powell Street 2A-6 - subway + F-Line Loop	surface loop	1
Powell / Beach Streets 2B-1 – surface	X crossover	1*
Powell / Beach Streets 2B-2 – subway	TBD	TBD
Powell / Beach Streets 2B-3 – surface + subway	N/A	N/A
Powell / Beach Streets 2B-4 – subway + surface	N/A	N/A
One-Way Loop: Powell / Beach / Columbus 3-1 – subway/surface	surface loop	1
One-Way Loop: Powell / Beach / Columbus 3-2 – subway	subway loop	1

* The number of X crossovers represents the minimum required, but multiple crossovers provide redundancy and resiliency that would help to ensure reliability.

2-4-2 Concept Alignments - Estimated Travel Times

Rail transit service is generally quicker than bus transit service, and vehicles generally can carry higher volumes of passengers. Travel time ranks as a top desire of transit passengers. Faster travel time also saves transit vehicle capital money and operations / maintenance money, because fewer vehicles operating at a higher average speed can provide the same service as a larger fleet.

Run time assumptions for different concept alternatives are based on the following sources:

- surface / subway scheduled travel times of existing (2014) SFMTA LRT service,
- modeled run times for the T-Third-Phase 2 (Central Subway) project (Systra Operations Analysis Report (2013),
- surface scheduled run times of existing (2014) F-Line streetcar service for the concept alternatives with a surface loop turnaround.

Based on these information sources, the average speed of surface LRT on the T-Third Phase 1 service is about 9.0 mph, the average speed in the Market Street Subway is 18.0 mph, and the average projected speed in the T-Third Phase 2 (Central Subway) service is 20.0 mph. The data shows the average SFMTA subway LRT speed is twice as fast as the average surface LRT speed. The average surface F-Line streetcar speed in the Fisherman's Wharf area is 5.2 mph. Note that these times do not reflect any additional surface stops besides the three stations, although concept alignments 2A-5 and 2A-6 used scheduled F-Line travel time in the loop, which includes stops, to achieve a turnaround time.[1]

The distance between the Chinatown Station and the Pagoda Palace site (assumed North Beach station location) is approximately 2,200 feet. The distance between a North Beach Station and a Conrad Square station is approximately 3,400 feet. The distance between a North Beach station and a Kirkland Yard station is approximately 2,500 feet. The distance between a Kirkland Yard station and a Conrad Square station is approximately 2,200 feet. The distance around the surface line Short Loop north of the Kirkland Yard (Powell St.-Jefferson St.-Mason St.-Beach St.-Powell St.) is approximately 1,800 feet. The distance around the F-Line Loop (Powell St.-Jefferson St.-Jones St.-Beach St.-Powell St.) is 3,750 feet.

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[1] Travel time estimates used in the CHAMP travel demand model correspond to the estimates for Chinatown Station to North Beach Station subway (C) and North Beach Station to Station 2 (Conrad Square) subway (X2), and vary slightly from those listed here. Both were prepared using estimated travel times from Systra Operations Analysis Report (4/24/13). The SFCTA derived an average travel speed of 19 mph based on the average Systra simulated travel speed of T-Third Phase 2 (Central Subway) Union Square to Chinatown segment in each direction in the AM and PM peak periods. This estimate made no additional effort to estimate dwell time at stations because the CHAMP model simulates dwell time as a function of passenger boards and exits. The estimated travel times in this section are more conservative. The difference between the estimates is too small to substantially affect ridership in CHAMP.

The following building block distance / time segments were used to build travel time estimates for each concept alignment. See Table 2-4 and Figures 2-6 and 2-7. Note that because T-Third Phase 2 (Central Subway) assumes an "X" crossover turnaround in existing run time estimates, T1, T2, and T3 represent the difference in turnaround time between an "X" crossover and conceptual Phase 3 turnaround options.

Table 2-4 Travel Time Estimates – Concept Alignments Route Segments

C = Chinatown Station to North Beach Station subway =	1 min	10 secs
D = Dwell time at a station =		20 secs
X1 = North Beach Station to Station 2 (Conrad Sq.) surface + subway	3 mins	00 secs
X2 = North Beach Station to Station 2 (Conrad Square) subway =	1 min	40 secs
Y1 = North Beach Station to Station 2 (Kirkland) surface* =	2 mins	45 secs
Y2 = North Beach Station to Station 2 (Kirkland) subway =	1 min	15 secs
Z1 = Station 2 (Kirkland) to Station 3 (Conrad Square) surface =	2 mins	45 secs
Z2 = Station 2 (Kirkland) to Station 3 (Conrad Square) subway =	1 min	10 secs
T1 = "X" Crossover Turnaround =	0 mins	00 secs
T2 = Short Loop Turnaround =	2 mins	00 secs
T3 = F-Line Loop Turnaround =	6 mins	30 secs

*includes subway segment under Washington Square to Greenwich Street

Figure 2-6 Travel Time Estimates Concept Alignments Route Segments

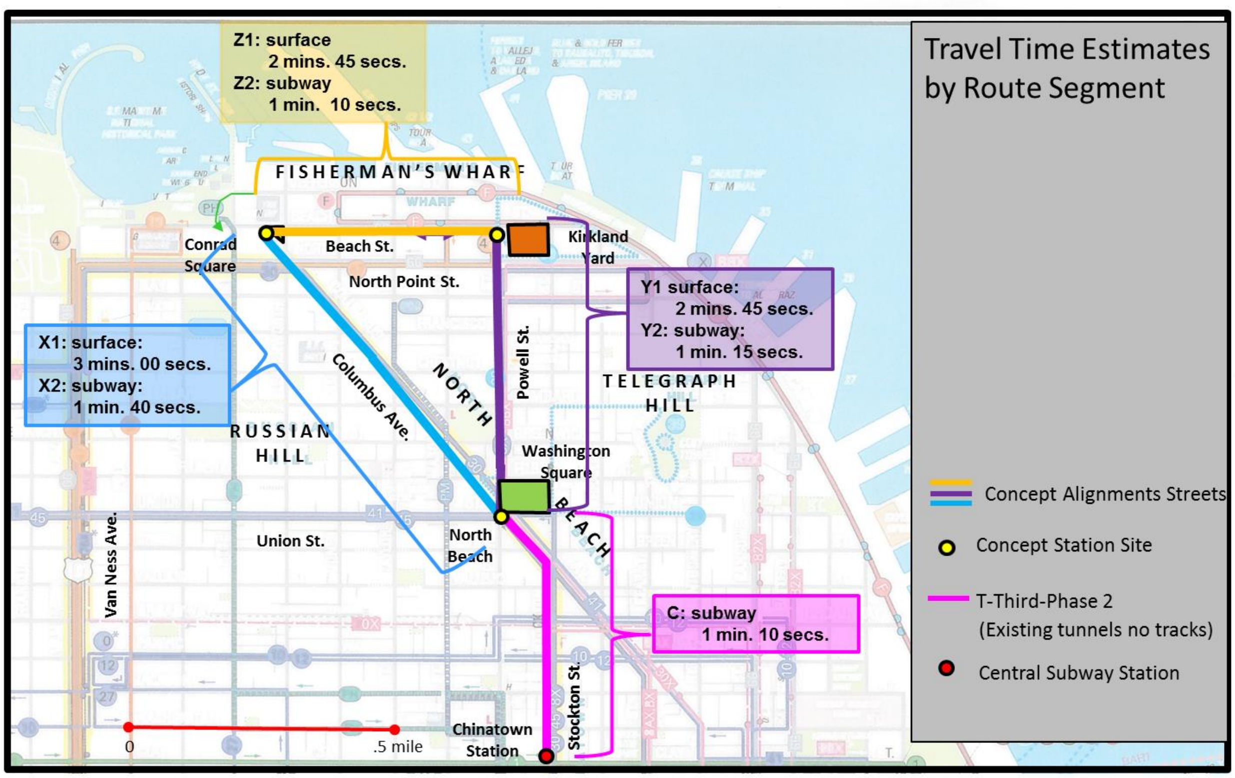
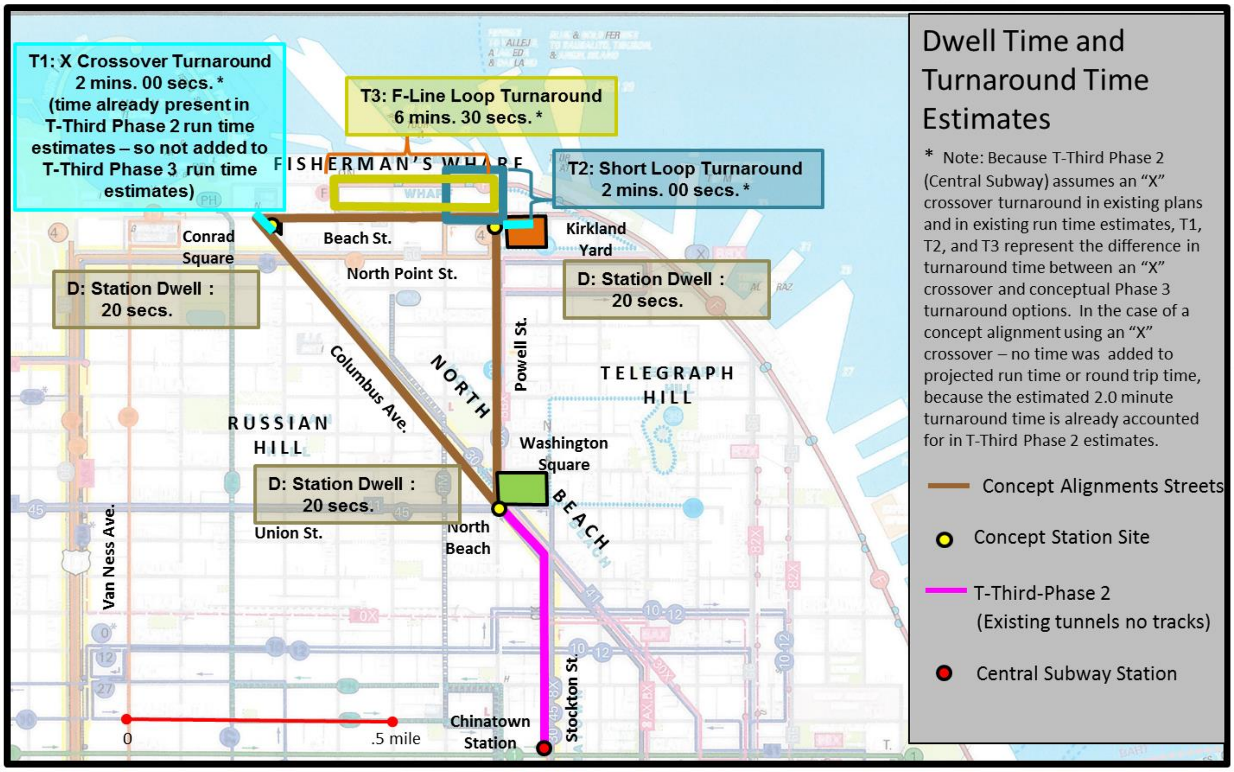


Figure 2-7 Dwell time and Turnaround Time Estimates



Round Trip Time = Chinatown station to terminal and back (not including layover / recovery).

An example of the calculation is shown for Concept Alignment 1-1 (Columbus Avenue – surface to Conrad Square station).

Formula: C + D + X1 + D = One-way Total	=	4 mins	50 secs
Cycle Time = One-way total X 2 + T1	=	9 mins	40 secs

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Table 2-5 Travel Time Estimates Concept Alignments (One-Way and Round Trip)

Concept Alignment	One-Way Travel Time	Round Trip Time (Cycle Time w/o layover)
1-1 Columbus subway-surface	4 minutes 50 seconds	9 minutes 40 seconds
1-2 Columbus subway	3 minutes 30 seconds	7 minutes 00 seconds
2A-1 Powell subway-surface	4 minutes 35 second s	9 minutes 10 seconds
2A-2 Powell subway	3 minutes 05 seconds	6 minutes 10 seconds
2A-3 Powell subway-surface + short loop	4 minutes 35 seconds	11 minutes 10 seconds
2A-4 Powell subway + short loop	3 minutes 05 seconds	8 minutes 10 seconds
2A-5 Powell subway-surface + F Line loop	4 minutes 35 seconds	15 minutes 40 seconds
2A-6 Powell subway + F-Line loop	3 minutes 05 seconds	12 minutes 40 seconds
2B-1 Powell & Beach subway-surface	7 minutes 35 seconds	15 minutes 10 seconds
2B-2 Powell & Beach subway	4 minutes 35 seconds	9 minutes 10 seconds
2B-3 Powell subway-surface & Beach subway	Not feasible	Not feasible
2B-4 Powell subway-surface & Beach surface	Not feasible	Not feasible
3-1 One-Way Loop subway-surface-subway	N/A	12 minutes 30 seconds
3-2 One-Way Loop subway	N/A	8 minutes 05 seconds

2-4-3 Ridership Estimates / Passenger Crowding

The Transportation Authority prepared ridership and transit crowding estimates for the purpose of analyzing potential ridership, crowding effects, and to develop an FTA New Starts rating. The methodology and results are summarized in the memo titled: Output Summary Central Subway Extension to Fisherman's Wharf; 2040 CHAMP 4.3 Fury. See Appendix F. The analysis used forecasts produced by SF-CHAMP, the Transportation Authority's regional travel demand mode, which compared a representative T-Third Phase 3 extension scenario against the no-build scenario (T-Third Phase 2 (Central Subway) only. Both of these scenarios were modeled for the horizon year 2040. The scope of this particular study limited the number of model runs and analysis to a single representative T-Third Phase 3 scenario: extension from Chinatown to North Beach and Fisherman's Wharf via Columbus Avenue to a station / terminal at Conrad Square. Land use data suggests that ridership would be similar if an alternate routing (e.g. Powell Street) with a similar transit travel time were used, or if two stations were located in the Fisherman's Wharf area instead of one station. This subject requires additional research if further study of a T-Third Phase 3 extension is undertaken.

The Transportation Authority's future baseline model analysis (which includes T-Third Phase 2 service, but not T-Third Phase 3 service) estimates that total T-Third ridership will be 74,000 daily passengers by 2040. The maximum load point (MLP) is projected to be between the Brannan Street and Moscone Center stations. The PM peak period is projected to have slightly heavier ridership than the AM peak period, and the heaviest ridership will be in the PM peak in the northbound direction. In 2040 at the MLP during the PM peak hour in the northbound direction, which represents the MLP for the entire day, ridership is estimated to be 3,812 passengers.

The SF-CHAMP based forecasts for the representative T-Third Phase 3 scenario predict daily ridership to increase by over 50% from 74,000 passengers per day to 115,000 passengers per day. The PM peak period remains the busiest time, and the projected maximum load point (MLP) remains between the Brannan Street and Moscone Center stations. In 2040 at the MLP during the PM peak hour in the northbound direction, ridership is estimated to be 4,196 passengers. The high level of projected ridership on this extension is not surprising given that several of the slower surface transit lines serving this corridor are currently at or above their current capacity and are forecast to be worse by 2040 (i.e. 30-Stockton, 45-Union, 8X-Bayshore, and F-Market & Wharves streetcar).

The potential for crowding on the T-Third LRT can be calculated by dividing the passenger volume at the MLP by capacity. A standard LRT train unit has a planning capacity of 119 passengers per car, or 238 passengers per 2-car train. SFMTA uses a "peak load standard" of 85% of the planning capacity as a measurement standard, so the peak load standard for a single LRT vehicle is 101 passengers, and 202 passengers for a 2-car train.

Table 2-6 shows the calculation of load factors for both the T-Third Phase 2 (baseline) and T-Third Phase 3 (baseline + Fisherman's Wharf extension) scenarios. With T-Third Phase 2 (Central Subway) in operation – and assuming 2.5 minute service (headway) in

2040, trains will be at 87% of SFMTA peak load standards, or 73% of total planning capacity at the MLP.

Table 2-6 LRT Passenger Capacity – 2.5 minute service (headway)

Peak Direction – Peak Hour 2040 Service Year	**Train Service (Headway) (Planned 2040) 24 trains / 2.5 minute service**	
Service Phase Estimated Ridership and Capacity at peak hour at Max Load Point (MLP)	Peak Load Standard (SFMTA standard) (101 passengers per car) 4,848	Planning Capacity (119 passengers per car) 5,712
Phase 2 (Central Subway)	3,812 **79% Peak Load Standard**	3,812 **67% Planning Capacity**
Phase 2 (Central Subway) + Phase 3 (North Beach / Fisherman's Wharf)	3,812 + 384 = 4,196 **87% Peak Load Standard**	3,812 + 384 = 4,196 **73% Planning Capacity**

Plans to operate peak period service with 2.5 minutes between trains using a single X crossover track located before the terminal station are aggressive, and will require a very high level of supervisory and management skill by the SFMTA. Failure to provide consistent and reliable service at a scheduled interval of 2.5 minutes would likely create crush level crowds and passenger frustration.

Table 2-7 shows the calculation of load factors for both the T-Third Phase 2 (baseline) and T-Third Phase 3 (baseline + Fisherman's Wharf extension) scenarios. With T-Third phase 2 (Central Subway) in operation – and assuming 3.0 minute service (headway) in 2040, which is only a 30 second decrease in frequency from the planned service, capacity decreases by 16% from 24 trains to 20 trains per hour. Estimated ridership levels climb to 104% of the SFMTA peak load standards, or 88% of total planning capacity at the MLP

Figure 2-7 LRT Passenger Capacity – 3.0 minute service (headway)

Peak Direction – Peak Hour 2040 Service Year	**Train Frequency (Headway) (Planned 2040) 20 trains / 3.0 minute service**	
Service Phase Estimated Ridership and Capacity at peak hour at Max Load Point (MLP)	Peak Load Standard (SFMTA standard): 4,040	Planning Capacity: 4,760
Phase 2 (Central Subway)	3,812 **94% Peak Load Standard**	3,812 **80% Planning Capacity**
Phase 2 (Central Subway) + Phase 3 (North Beach / Fisherman's. Wharf)	(3,812 + 384) = 4,196 **104% Peak Load Standard**	(3,812 + 384) = 4,196 **88% Planning Capacity**

While crowding is not projected to be completely eliminated from the SFMTA surface transit routes with the construction of a T-Third Phase 3 extension, it does remedy the overcrowding north of Market Street on three of the four significantly overcrowded transit routes. Crowding is still projected to exist on these routes south of Market Street.

2-4-4 LRT Vehicle Requirements

Transit service passenger capacity is determined by a combination of LRT vehicle passenger space and travel time. Quicker transit service requires fewer transit vehicles to provide the same level of service and passenger capacity, because vehicles complete more trips while in service. Therefore, quicker service will have lower capital costs for vehicles at the time of purchase, and will have ongoing lower operations and maintenance costs, because passenger ridership is being carried on a smaller number of vehicles.

As explained in Section 2-4-1, surface LRT service is generally slower than subway service because it must cross traffic intersections, serve stations that are closer spaced than subway stations, and possibly operate in mixed traffic with non-exclusive right-of-way. Due to these operations issues, surface LRT requires a higher number of LRT vehicles to carry the same amount of passengers

In 2015 the SFMTA is purchasing new LRT vehicles for T-Third-Phase 2 (Central Subway) service. The projected cost of each LRT vehicle is $3.66M. A 2-car train costs $7.32M.

Service assumptions to determine the number of LRT trains needed for Phase 3 service is based on the 2030 service frequency listed in the T-Third-Phase 2 (Central Subway) SEIS/R. The 2030 plan calls for 2.5 minute frequency during the AM and PM peak period and 5 minute frequency during the mid-day and early evening time periods. This analysis is focused on transit vehicle requirements in the peak period.

Using the round trip times in Table 2-5 and adding a layover / recovery time results in an incremental increase in “cycle time” over the Phase 2 cycle time. Because the baseline service plan accounts for turnaround and layover time, the incremental cycle time needs to account for additional run time, the difference in turn-around time based on the turn-around type, and additional layover and slack due to the increased run time. Using the incremental cycle time figure, a preliminary schedule can be calculated to determine the number of additional transit vehicles that would be needed to provide T-Third Phase 3 service. The formula is shown below. All partial minute figures are rounded up to the nearest tenth of a minute. All partial numbers of trains are rounded up to the next whole number.

Formula to achieve "cycle time" increment over baseline cycle time

Incremental Cycle Time = Travel Time (both directions) +
Layover / Recovery (10% of Travel Time)

Number of trains = Incremental Cycle Time / Frequency

LRT vehicles = Number of trains X 2

Example: (Concept Alignment 1-1)
(9.67 minutes (travel time) + .97 minutes (layover / recovery) = 10.64 minutes

10.64 minutes / 2.5 minutes (frequency) = 4.25 trains (round up to 5)

5 trains X 2 = 10 LRT vehicles

Table 2-8 LRT Vehicle Requirements – T-Third-Phase 3 – Peak Period

Alt.	Analysis Summary
1-1	Cycle Time = 10.60 minutes = 5 trains = 10 LRT vehicles
1-2	Cycle Time = 7.70 minutes = 3 trains = 6 LRT vehicles
2A-1	Cycle Time = 10.10 minutes = 4 trains = 8 LRT vehicles
2A-2	Cycle Time = 6.80 minutes = 3 trains = 6 LRT vehicles
2A-3	Cycle Time = 12.30 minutes = 5 trains = 10 LRT vehicles
2A-4	Cycle Time = 9.00 minutes = 4 trains = 8 LRT vehicles
2A-5	Cycle Time = 17.20 minutes = 7 trains = 14 LRT vehicles
2A-6	Cycle Time = 13.90 minutes = 6 trains = 12 LRT vehicles
2B-1	Cycle Time = 16.70 minutes = 7 trains = 14 LRT vehicles
2B-2	Cycle Time = 10.10 minutes = 4 trains = 8 LRT vehicles
2B-3	Cycle Time = N/A - Route engineering is not feasible
2B-4	Cycle Time = N/A - Route engineering is not feasible
3-1	Cycle Time = 16.00 minutes = 7 trains = 14 LRT vehicles
3-2	Cycle Time = 10.50 minutes = 5 trains = 10 LRT vehicles

The number of LRT vehicles required for implementation of a T-Third-Phase 3 service extension during the peak period is estimated at 6-14 vehicles. Using the LRT vehicle capital cost shown above, the added equipment for a T-Third-Phase 3 extension would range from $21.96 million to $51.24 million in 2014 dollars.

2-4-5 Operations Costs

All concepts for extension will increase operational costs, as any extension is a pure increase in service when no other service cuts are assumed. Costs are proportional to vehicle miles, vehicle hours, and number of peak vehicles. Increases in operational cost may be justified by increased ridership and fare collection, as well as improvement of system performance by improving connections and lessening crowding.

Cost estimates for service, or operations costs were estimated using the Transportation Authority modeling that included using planned 2040 peak service levels (2.5 minute service), modeled and scheduled run time, and standard operating costs (2014 dollars). Due to time and budget constraints, only concept alignment 1-2 (Subway to North Beach and along Columbus Avenue to Conrad Square) was projected. The projection included application of increased operating costs per added vehicle service hour, added vehicle mile, and added vehicles required per day. The estimate for an added day of service on the T-Third Phase 3 extension is $22,051. A multiplier of 320 was applied to the daily total to achieve an annual total of approximately $7.1 million dollars.

Given the vehicle requirement estimates in Table 2-9, the highest vehicle need was for concept alignments 2A-5, 2B-1and 3-1 which would require four more trainsets (eight LRTs) than concept 1-2, so annual operations costs for all alternatives plus LRV acquisition costs should be less than $9.7 million dollars. This is an area that requires additional analysis if a decision is made to proceed further with a T-Third Phase 3 project.

2-5 NORTH BEACH STATION ANALYSIS

The issues present with a potential LRT station in North Beach are a unique subset of this larger concept study. The Chinatown station is the northernmost station of the T-Line Phase 2 (Central Subway) project, and will be the terminal of the T-Line when the Central Subway opens in 2019. If the T-Line is to be extended north, a station in North Beach would be the first station built, and the assumption is the station would be located at or near Washington Square.

Unlike any other part of a T-Third Phase 3 extension, the North Beach station straddles the Phase 2 project that is under construction, and a potential future Phase 3 project. The TBMs used to bore the T-Third Phase 2 (Central Subway) tunnels between 4th Street and Harrison Street and Chinatown, were routed north from the Chinatown station along Stockton Street and Columbus Avenue to the Pagoda Palace site for retrieval from the ground. As a result twin tunnels that would be used by possible future LRT service already exist between Chinatown and North Beach. These tunnels are relatively shallow in this area (70 feet below the surface), and their alignment turns toward the Pagoda Palace site and away from Columbus Avenue between Union Street and Powell Street at the corner of Washington Square. The Pagoda Palace site was selected to allow for retrieval of the TBMs without causing disruption to Washington Square Park, or traffic disruption on Columbus Avenue, which were two earlier locations that were considered for TBM retrieval sites.

For this report, cost estimates were developed for construction of a North Beach Station and turnaround only using FTA guidelines in a manner similar to cost estimates developed for the concept alignments. The estimates range from $343-$500 million dollars. The largest differences in the estimates were the type of construction: use of tunnel boring machines (TBMs) and full “cut and cover” construction versus the use of sequential excavation (mining) and limited “cut and cover” construction. The TBM’s and full cut and cover construction were estimated to have lower costs, allow for quicker construction, but result in a higher impact and disruption during construction. The use of mining and limited cut and cover construction was estimated to have the higher costs and a longer construction duration, but with an overall lower impact and disruption. The cost estimates did not only include a new station, but completion of the tunnels between Chinatown and North Beach (tracks, lighting, operating systems, etc.), and a tail track and turnaround crossover north of the North Beach Station. The last item would not be present in estimated station costs for North Beach if the line were extended to the Fisherman’s Wharf, because they would be located at the end of the line.

2-5-1 Pagoda Palace Site

The Pagoda Palace Theater site is one possible option for a future subway station access location, but other locations nearby must also be considered as options, because no planning or environmental review documents have been completed that allow for a station to be built at the Pagoda Palace site. If the SFMTA were to pursue action to build a North Beach station either at the Pagoda Palace site, or at another as yet undetermined location, a new environmental review process would need to be completed. An initial staff analysis of environmental review work completed for Phases 1 and 2 of T-Line LRT construction concluded that it did not appear sufficient to allow for approval of construction of a North Beach station at the Pagoda Palace site or anywhere in the vicinity. The review included a consultation with staff at the San Francisco City Attorney’s office. Based on the timeline for recent large transit capital projects in San Francisco, an environmental review process followed by design and engineering work for a North Beach Station would likely take 3+ years to complete, unless an expedited effort is undertaken.

The SFMTA has a lease with the property owner on the Pagoda Palace to allow its use as a TBM retrieval site. The lease will expire on May 10, 2015. The SFMTA has the option of early termination. If early termination is chosen, the earliest lease expiration date would be December, 29, 2014. The SFMTA also has a 60-day "right of first refusal" if the property owner decides to place the property up for sale. Prior to a purchase action the property must be appraised in accordance with FTA regulations, if the property is to be used for any future transit related activities that would utilize federal funds. FTA requirements include a mandatory peer reviewed second appraisal before the purchase could proceed. The property owner has obtained entitlement from the San Francisco Planning Commission in 2013 to construct a 19-unit residential structure on site after the SFMTA has vacated the site. The entitlement is valid for the term of the Central Subway Tunnel Boring Machine Extraction Site Special Use District (Planning Code Section 249.7). The owner is currently in the process of securing permits from the San Francisco Department of Building Inspection to begin construction.

While preservation of future station opportunities is very important, access via a vacant parcel during construction is important as well. Analysis performed as part of the Constructability Study concluded that sequential excavation method (SEM) is possible at the North Beach station. However, without a vacant parcel to access station construction using SEM, such construction would need to be accessed from Columbus Avenue / Union Street or via Washington Square Park at a cost of disruption to public areas. SEM for station construction would likely require lowering the existing tunnel profile to increase the available ground cover over the crown of the future excavated station opening, and is generally more expensive than a cut and cover method of construction. Any cut and cover station excavation would require a station box construction beneath Columbus Avenue under the traffic deck, which would be provided to maintain pedestrian and street traffic. Access to under-the-deck cut and cover construction could be provided via an access shaft place either within the street limits or within an available private parcel, or a combination of both.

Due to the high "project value" of the existing Pagoda Palace site for a possible future North Beach station construction, either as an access / staging site, or as a site where station permanent facilities would be placed, several approaches are possible with a primary purpose of assuring the site availability to serve the future station. The site could be purchased or leased, with or without joint development. Whichever option is chosen, there is a clear sense of urgency to secure the Pagoda Palace site to allow for the North Beach station construction to take place considering the scarcity of available properties in the neighborhood for this purpose. Further assessment of the feasibility of the Pagoda Palace site as a station location is recommended as an element of analysis of different alternatives for a North Beach station construction methodology (SEM and cut and cover construction). See Figure 2-8.

Figure 2-8 Plan View of Construction Concepts for North Beach Station

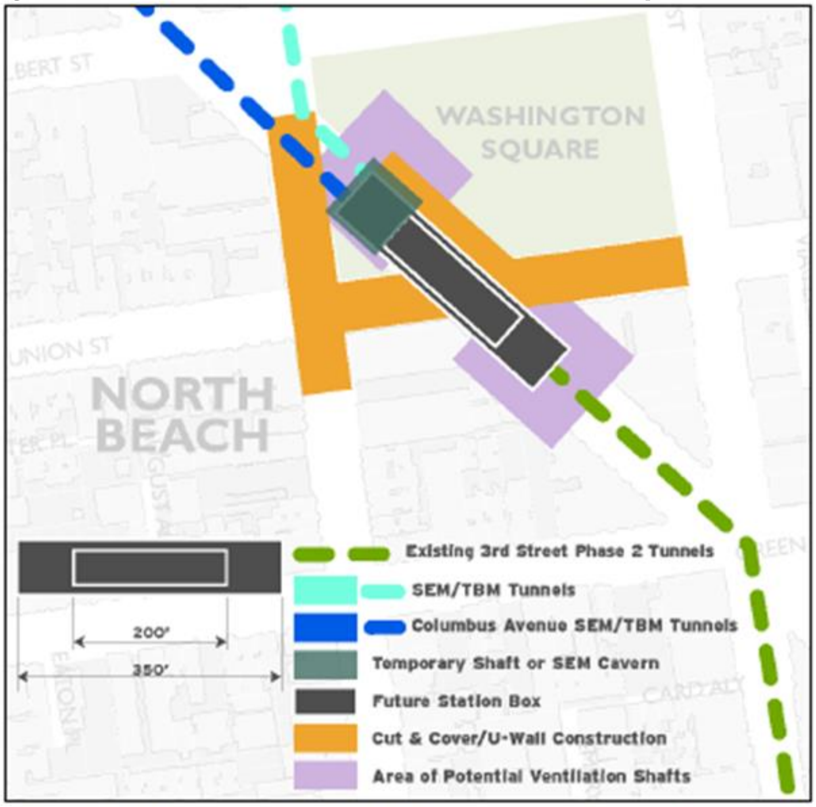


Figure 4.2.20: Potential North Beach Station location beneath Columbus Avenue*

***Note:** *Areas indicated for Cut and Cover/U-wall construction (orange color) and for Potential Ventilation Shafts (purple color) are indicative of the right of way (ROW) requirements in the North Beach Station vicinity in case that the alternative sites are not provided for such purposes (Pagoda Palace Site or any other available neighboring property). Entrances, head house and ventilation shafts could be incorporated into the future transit development if desired. Ventilation stacks if stand-alone could become a part of public art (their exhaust/intake components are usually placed minimum 10 feet above street level).*

It is likely that the station construction would use sequential excavation method (SEM) or a decked cut-and-cover construction approach (See Figure 4.2.21). Existing Pagoda Palace shaft site could be used for construction staging, as a temporary construction shaft and for housing the station permanent facilities (entrance, ventilation shafts, head house and emergency egress). Ground water level is possibly 10 to 15 feet beneath the street surface.

2-6 FUTURE WEST EXTENSION – T-THIRD PHASE 4

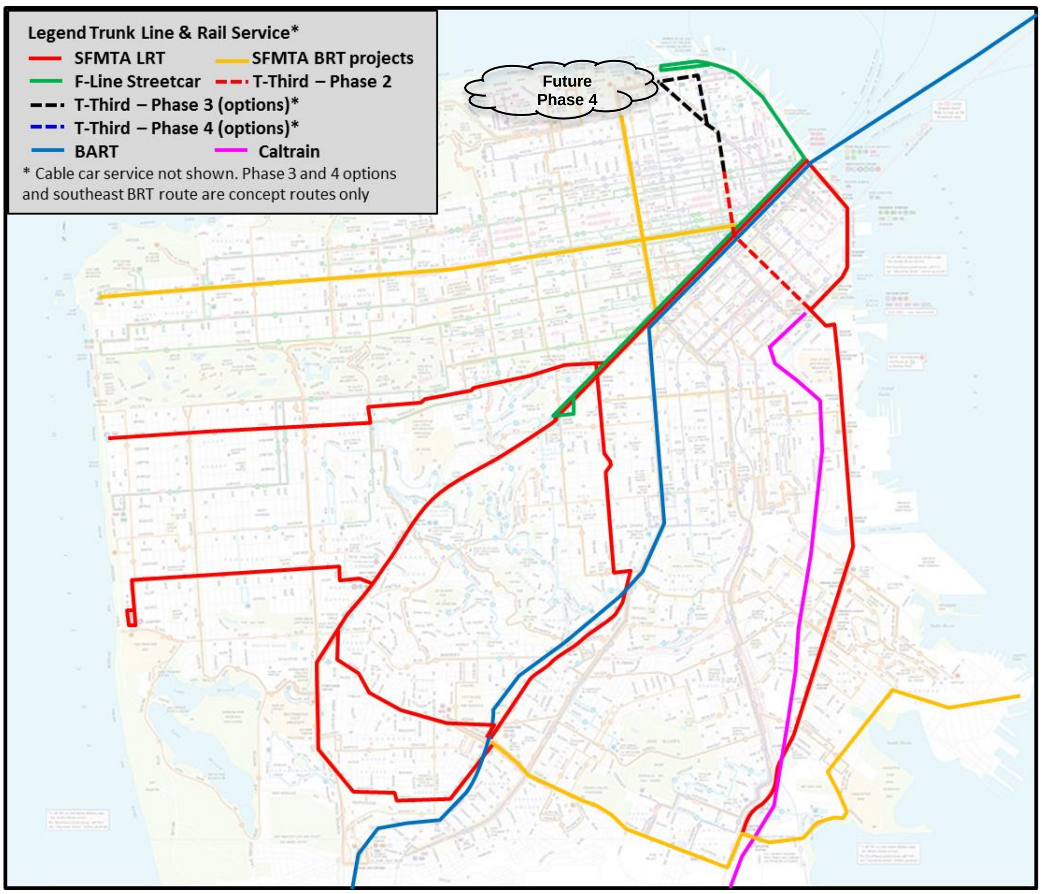
If the T-Third Line is extended to serve part or all of the North Beach Corridor, a new question arises almost immediately. Should the new service be the final extension of the LRT service on this route, or should the line be further extended to serve additional neighborhoods in San Francisco? The most likely extension would be to serve several neighborhoods and points of interest west of North Beach and Fisherman's Wharf, including Russian Hill, northern Van Ness Avenue, Fort Mason, Union Street / Lower

Pacific Heights, the Marina, and the Presidio. Any options with a surface terminal in the Fisherman's Wharf area would increase the difficulty and decrease the likelihood of

westward expansion, because the tracks would need to go back into subway to go through Russian Hill toward Van Ness Avenue.

Although a further extension would likely be several years in the future, initial assessment of issues, opportunities and challenges to such an extension should impact the analysis of alignment concepts of a T-Third Phase 3 extension, which is why this section is present in this concept study.

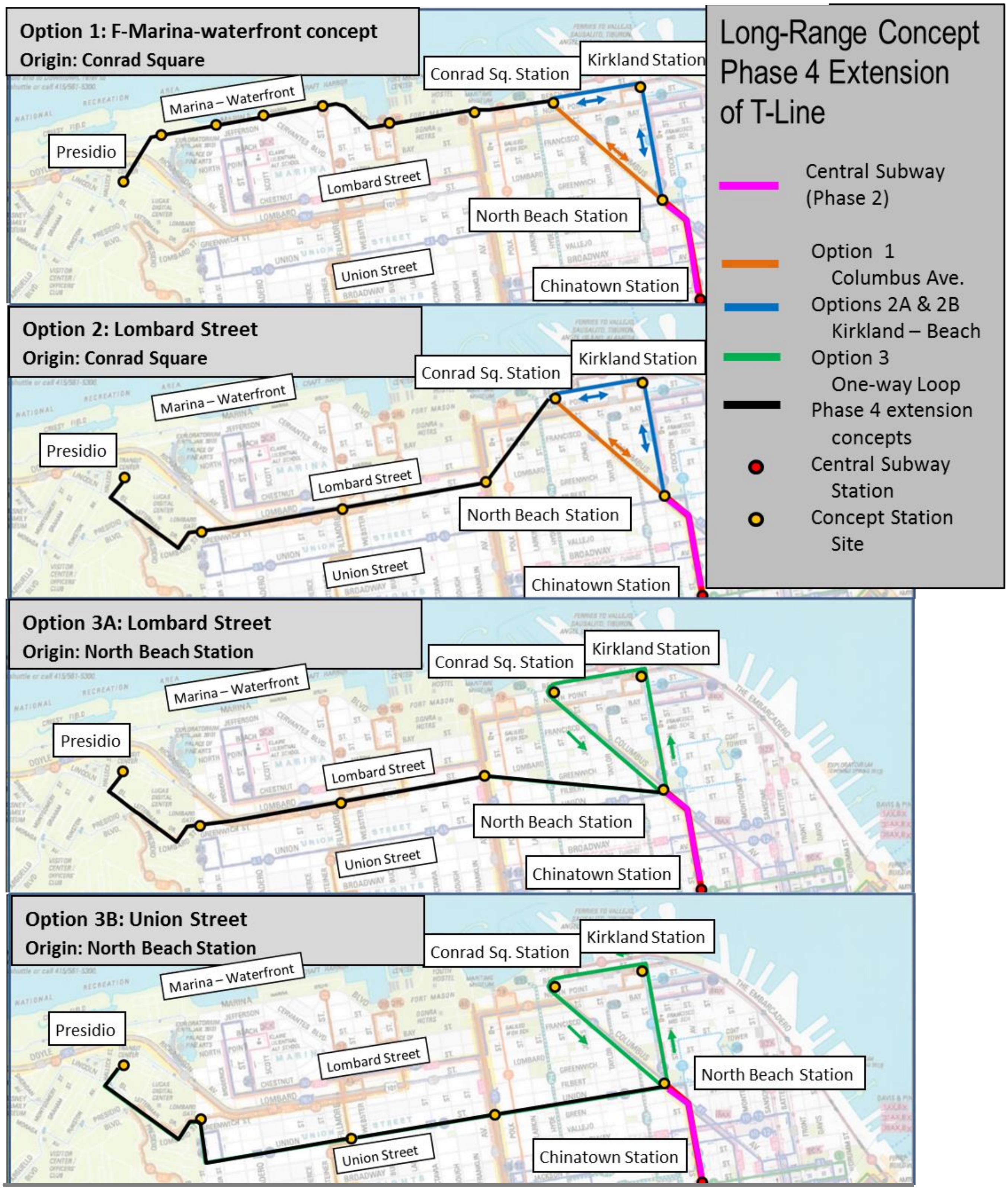
Figure 2-9 Existing and Conceptual Rail + Planned and Proposed BRT Service in San Francisco



2-6-1 Future West Extension - Phase 4 Concept Alignments

Three possible alignments are identified as candidates for a westward expansion from either a station in North Beach or at Conrad Square: the Marina Waterfront alignment, the Lombard Street alignment, and the Union Street alignment. See Figure 2-10.

Figure 2-10 Future Long-range Concept Phase 4 Extension of T-Line



Subway based service would offer faster travel times and higher reliability than surface service operating in exclusive right of way all or part of the time. Both subway and surface – exclusive right of way service would offer faster travel times and better reliability than surface based service in mixed traffic right of way. Each of these options would require additional study of constructability issues which would address practical routes, subsurface construction risks, locations of access shafts and any potential fatal flaw which could affect the concept alignments.

Option 1 – the Marina Waterfront alignment - would extend west from Conrad Square via the route analyzed in the F-Line Extension EIS (2012) to Fort Mason. Selection of this route would most likely preclude a further west expansion of the F-Line. A second tunnel bore under Fort Mason would be required to go under the National Park Service buildings above. West of Fort Mason the line would continue as a surface route along the Marina Green to the Presidio following the route of the State Belt Railroad, which operated freight service on this corridor from 1913 to1969. This route would serve residents of the Marina and the major open spaces and attractions on the north waterfront, but would be less attractive as a transit option to residents in Cow Hollow and Lower Pacific Heights. However, this route presents a poorer connection to Van Ness BRT.

Option 2 – the Lombard Street alignment - would turn southwest from Conrad Square to pass through Russian Hill in a tunnel, and proceed west via the Lombard Street or Chestnut Street corridors. This option would also better serve Marina residents than residents of Cow Hollow and Lower Pacific Heights, unless the route was located on or Lombard Street, where it would be equidistant from both neighborhoods. A Chestnut Street routing could either be surface or subway, but a Lombard Street routing would most likely be a subway, because of the presence of US 101. This alignment could provide a strong a connection to Van Ness BRT.

Options 3A – the Lombard Street alignment - and 3B – the Union Street alignment - would originate from a North Beach Station. These options would appear to work best with T-Third-Phase 3 One-Way Loop alignments 3-1 or 3-2, because the route to the western neighborhoods is shorter, while the loop provides maximum coverage to the Fisherman's Wharf area. The route would pass through Russian Hill in a tunnel and proceed west via the Lombard Street corridor (option 3A), or the Union Street corridor (option 3B). Option 3A would serve neighborhoods north and south of Lombard Street equally well, while option 3B would directly serve Cow Hollow and Lower Pacific Heights, but be less attractive to Marina District residents. A Lombard Street routing would most likely be in a subway, because of the presence of US 101, while a Union Street routing could be either be a surface or subway design. A deep subway under

Union Street should negate the issue of pedestrian access via a hill from Lombard to Union Streets if lateral access tunnels are part of a future design. This alignment could provide a strong connection to the Van Ness BRT.

A westward expansion line routed via Conrad Square and Kirkland would serve two more stations and have a longer path of travel than a westward expansion line that joined the T-Line at the North Beach station, while a direct Conrad Square route would shorten the path of travel in this direction. One-way loop concepts may suggest an obstacle or a redundancy if further western expansion is pursued, but such facilities could still be useful under certain conditions. For example, a westward branch that emanated from the loop would have the flexibility of turnbacks in either direction. A westward branch that split south of a loop would allow two lines of service—one western and one northern—to merge in the central subway tunnel.

2-6-2 Future West Extension - Phase 4 Passenger Capacity

All of the westward expansion route options would result in an increase of several thousand passengers per day on the T-Line LRT service as many passengers moved to use the LRT line and stopped using service provided by bus Routes 30, 41 and 45. Assuming passenger travel patterns present on these routes were to remain in place, the ridership increase would overload the existing T-Line system infrastructure to beyond planning capacity levels, because the 2-car platforms and 2-car trains are too small. The overloading of the system would occur “downstream” in the T-Line-Phase 2 (Central Subway) portion of the line closer to Market Street and Caltrain where the existing MLP is located. To build a T-Third Phase 4 extension will require T-Line infrastructure to be rebuilt to accommodate longer 3-car or 4-car trains, or a second parallel rail line will need to be built.

The technical and practical feasibility of future western expansion should be given serious consideration, and will require additional study and analysis beyond the scope of this report.

Section 3 – Land Use Analysis

3-1 OVERVIEW

The two neighborhoods of North Beach and Fisherman's Wharf are among the most iconic neighborhoods in San Francisco. North Beach is well known for its Italian-American heritage that has been in place for over a century. It is a neighborhood of quiet residential streets adjacent to the vibrant commercial corridor of Columbus Avenue and a cluster of commercial and entertainment activity in the southern part of the neighborhood. It is home to numerous restaurants, bakeries and small shops, many of which are still operated by longtime residents or their descendants. Fisherman's Wharf is one of the most popular commercial areas visited by tourists within the city. Although fishing related activities remain, including the famous fishing fleet at Pier 45, the neighborhood has transitioned during the past couple of generations from a mixed industrial / commercial area to a commercial area with a focus on tourist related activities. Fisherman's Wharf is also home to Aquatic Park, a large, popular waterfront open space that serves both visitors and locals.

Any program of improved transit service, especially a project that could be equal in scope of the T-Third Phase 2 project, would have a large impact on these areas.

As a part of the T-Third Phase 3 Concept Study, the Planning Department analyzed land use, demographic conditions, and development potential within the project area. Future development potential was studied under existing zoning regulations, and under two scenarios that include hypothetical zoning revisions. An economic consultant was engaged to evaluate the potential for land-based value capture mechanisms to help pay for the capital costs of the T-Third Phase 3 project.

3-2 EXISTING DEVELOPMENT PATTERN AND ZONING

The analysis studied parcels within a quarter- mile radius of potential transit stations near Washington Square in North Beach, at Conrad Square at the north end of Columbus Avenue, and at SFMTA's Kirkland Yard near the north end of Powell Street. A significant body of research has demonstrated that the introduction of new transit service typically results in increased local property values and new development, with the effects most concentrated within a quarter to half-mile around the transit stations. (See Appendix E for more information). For the purposes of this study, the more conservative quarter-mile radius was chosen. This allows a focus on areas with easy and direct access to potential stations, and excludes areas were distance combines with topography to form a barrier to access, such as the eastern side of Telegraph Hill or the western side of Russian Hill. In total, approximately 2,343 parcels fall within a quarter-mile of one or more of the three potential stations (“station areas”). Geographic context, parcel size, land use, and zoning for each station area are briefly summarized on the next several pages in a series of land use maps and information tables.

Figure 3-1 Topography of T-Third Phase 3 Concept Study Area

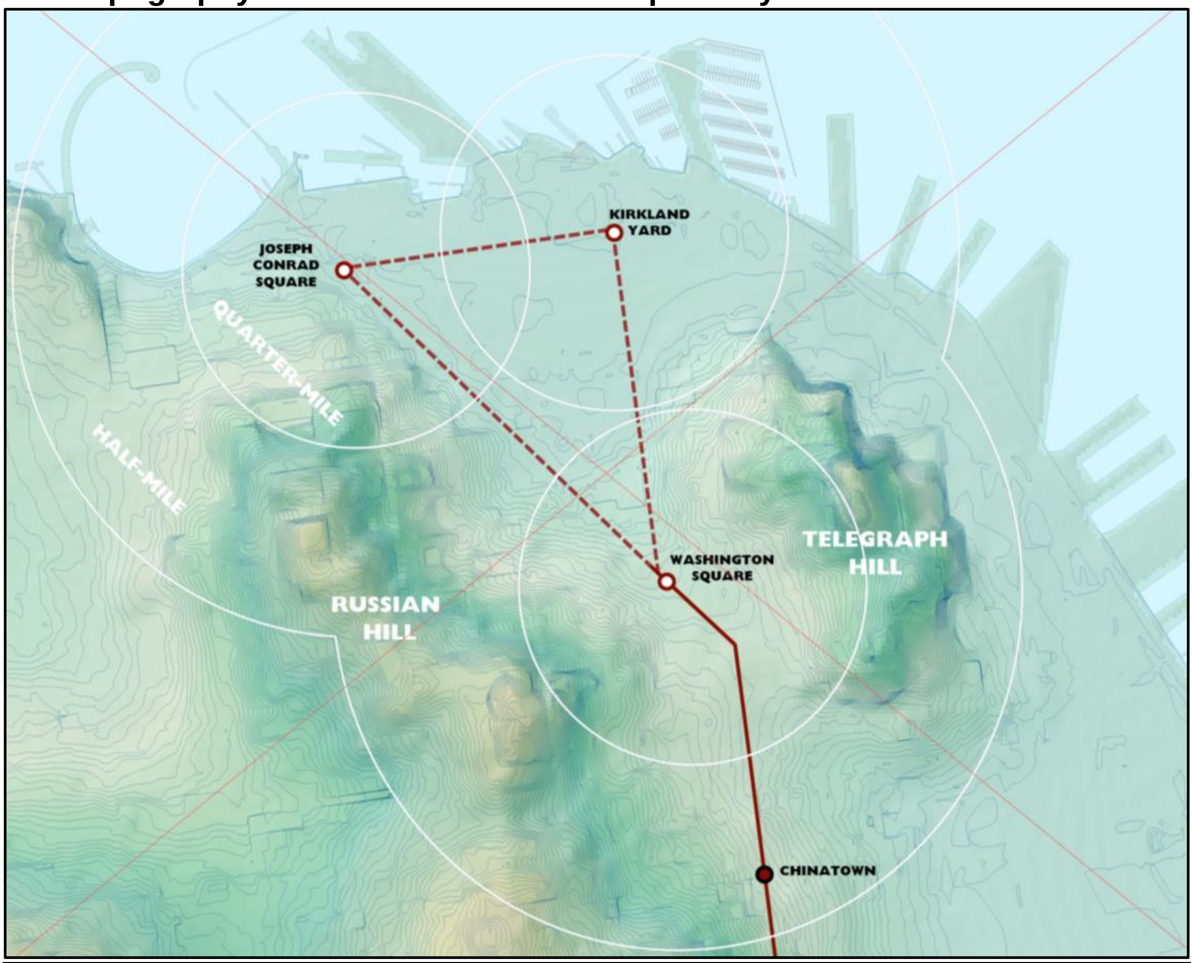


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Figure 3-2 Zoning Map of T-Third Phase 3 Concept Study Area

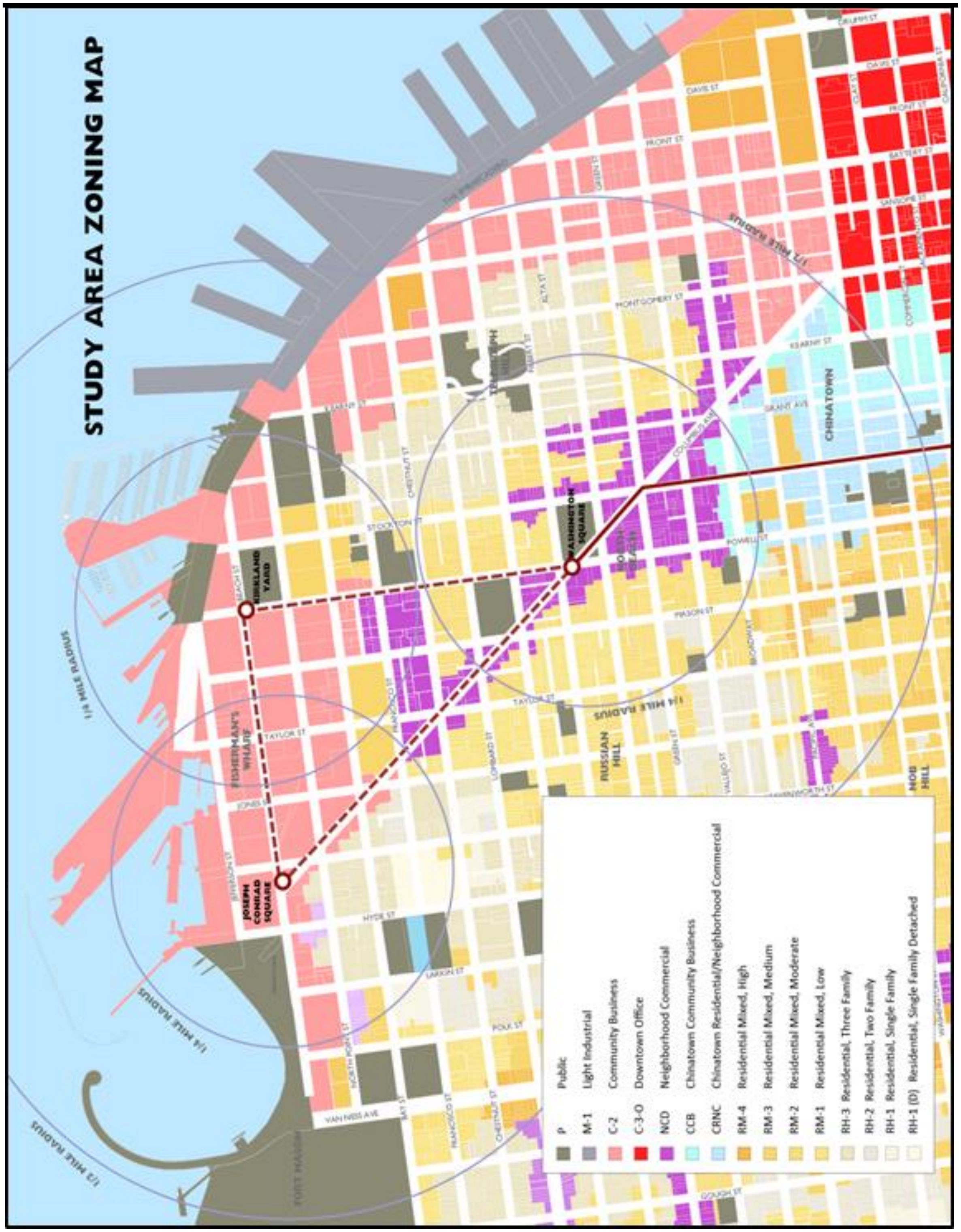


Figure 3-3 Height Limits of T-Third Phase 3 Concept Study Area

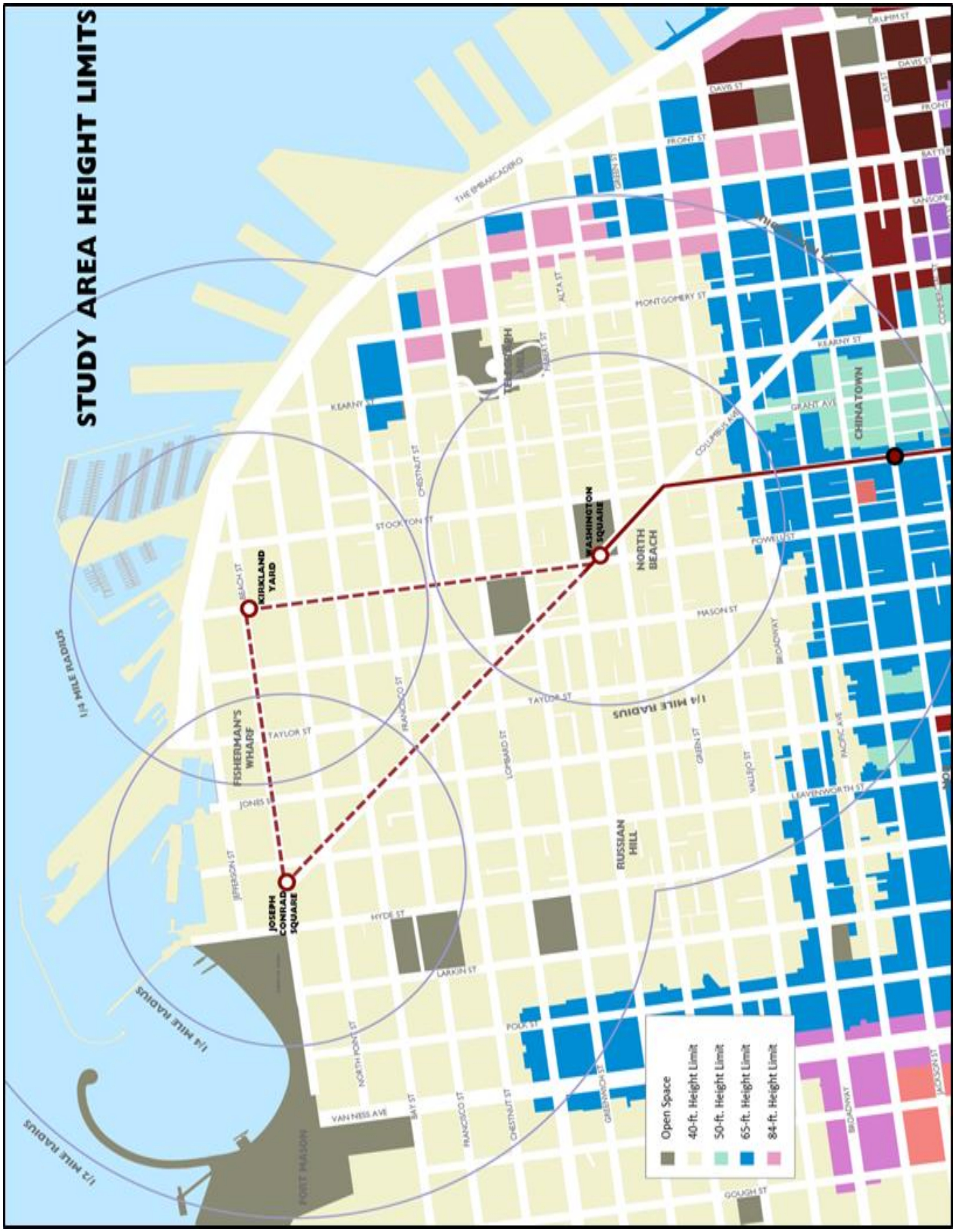


Figure 3-4 Existing Land Use in T-Third-Phase 3 Concept Study Area

3-2-1 North Beach Station Area Land Use

North Beach is located in a valley framed by the slopes of Russian Hill on the west and Telegraph Hill on the east. The potential North Beach station location is in the

Figure 3-5 North Beach Neighborhood

in the heart of the neighborhood's commercial core which surrounds Washington Square and extends along Columbus Avenue. Approximately 1,714 parcels fall within a quarter- mile of the potential station. These parcels average 3,110 square feet each. The station area has a higher number of parcels compared to the other two potential station areas, which is an indication of the dense, fine grained character of North Beach with many small parcels. Parcels fall into 13 different zoning districts; the highest number (479 parcels) fall within the RM-2 (Residential Mixed, Moderate) zoning district. Most parcels (91%) fall within the 40-X height and bulk district. Parcels nearest the potential station are zoned Neighborhood Commercial.

3-2-2 Conrad Square Station Area Land Use

Conrad Square (official name is Joseph Conrad Square) is located on the western edge of Fisherman's Wharf at the northern base of Russian Hill. Located at the terminus of Columbus Avenue, the square serves as a gateway between Fisherman's Wharf and North Beach. A total of 492 parcels fall within the station area. The average parcel size is 9,764 square feet. Major attractions such as Aquatic Park, the San Francisco Maritime National Historic Park, and Ghirardelli Square are within walking distance of the station area. The relatively lower number of parcels compared to North Beach speaks to both the location near the edge of the bay, and larger parcels east of

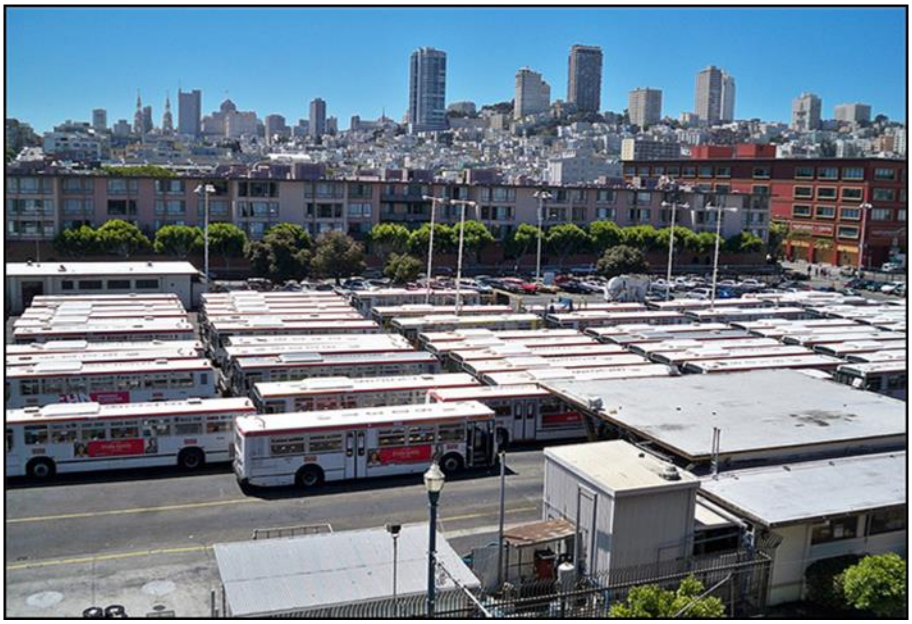
Columbus Avenue. Parcels fall into 11 zoning districts; the highest number (182) fall within the RH-3 (Residential, Three-Family) zoning district. Parcels immediately surrounding the potential station are within the C-2 (Community Business) zoning district. Excluding public open space, all but one parcel is covered by the 40-X height and bulk district.

Figure 3-6A and Figure 3-6B Conrad Square Park

3-2-3 Kirkland Yard Station Area Land Use

SFMTA's Kirkland Yard is located on the eastern edge of Fisherman's Wharf near Pier 39. The area immediately surrounding the potential Kirkland Yard station lacks the fine grained character of the other two potential station areas. A total of 309 parcels fall within quarter-mile of the potential station. The average parcel size is 12,548 square feet. The relatively low number of parcels compared to North Beach area speaks to both the location near the edge of the bay and the larger parcels north of Bay Street. The station area is notable for having blocks dominated by a single utilitarian use, such as Pier 39's parking garage, SFPUC's North Point Facility, and the Kirkland Yard itself. Parcels fall into nine zoning districts; the highest number (79) fall within the C-2 (Community Business) zoning district. Excluding public open space, all parcels are covered by the 40-X height and bulk district.

Figure 3-7 Kirkland Division Yard



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3-3 T-THIRD PHASE 3 CONCEPT STUDY AREA AT A GLANCE

The study area falls within six US Census Tracts. These tracts generally encompass an area slightly larger than the quarter- mile station area radius used in other portions of this study. Demographic data for the combined census tracts is summarized below:

DEMOGRAPHICS

Total Population	25,760
Group Quarter Population	35
Percent Female	50%

Households	13,930
Family Households	36%
Households w/ Children	10%
Non-Family Households	65%
Single Person Household	51%
Avg. Household Size	1.8
Avg. Family Size	2.8

Race Ethnicity	
Black/African American	2%
Asian	42%
White	51%
Native American Indian	0.2%
Hawaiian/Pacific Islander	0.2%
Other/Two or More Races	4%
% Latino (Of Any Race)	5%

Age	
0-4 years	3%
5-17 years	6%
18-34 years	33%
35-59 years	32%
60 and older	27%

Educational (Residents 25 years+)	
High School or Less	33%
Some College/Associate Degree	14%
College Degree	31%
Graduate/Professional Degree	21%

Nativity and Language	
Foreign Born	42%

Language Spoken at Home	
English Only	50%
Spanish Only	4%
Asian/Pacific Islander	39%
Other European Language	6%
Other Languages	0%
(Residents 5 years and older)	

Linguistic Isolation (Households)	
% of All Households	25%
% of Spanish-Speaking	32%
% of Asian Language Speaking	69%
% of Other European-Speaking	18%
% of Speaking Other Languages	0%

Data-2010 Census, Summary File 1.
2010 Census tracts area: 010100, 010200, 010300, 010400, 010600, 010700

HOUSING CHARACTERISTICS

Total Number of Units	15,770
Median Year Structure Built	1913
Occupied Units	36%
Owner occupied	20%
Renter occupied	80%
Vacant Units	12%
For rent	37%
For sale only	5%
Rented or sold, not occupied	4%
For seasonal, rec. or occ. Use	30%
Other vacant	24%
Structure Type	
Single Family Home	7%
2-4 Units	29%
5-9 Units	18%
10-19 Units	11%
20 Units or more	36%
Other	0%
Housing Prices	
Median Rent (month)	$1,346
Median Home Value	$915,262
Rent as % of Household Income	26%
Households with Vehicles	9,790
Homeowners	35%
Renters	65%
Vehicles Per Capita	0.37
Households with no vehicle	6,510
Homeowners with no vehicle	17%
Renters with no vehicle	55%

INCOME, EMPLOYMENT & JOURNEY TO WORK

Income	
Median Household .	$63,051
Median Family	$69,107
Per Capita	$51,182
Percent in Poverty	16%
Employment	
Unemployment Rate	8%
Employed Residents	14,970
Managerial and	50%
Professional Svc.	20%
Sales and Office	21%
Constr. / Maintenance	3%
Production / Transp.	6%
Journey to Work	
Workers 16 yrs. & older	14,660
Car – drive alone	25%
Car - carpool	4%
Transit	25%
Bike	2%
Walk	29%
Other	2%
Work at Home	12%

Data-2010 Census, Summary File 1.
2010 Census tracts area: 010100, 010200, 010300, 010400, 010600, 010700
Note: Numbers from the American Community Survey are estimates and are subject to sampling and non-sampling errors. For more information, see
http://www.census.gov/acs/www/Downloads/handbooks/ACSGeneralHandbook.pdf

3-4 LAND USE DEVELOPMENT SCENARIOS

In order to assess potential for land use change, particularly for the purpose of capitalizing on transit investment and raising revenue, three development scenarios were developed and studied, as summarized below.

> **Scenario A – Current Zoning:** Current zoning and height regulations remain in place.
>
> **Scenario B – Moderate Height Increase:** Height limits are increased from 40 to 55 to 65 feet around the potential Conrad Square and Kirkland Yard stations. (See Figure 3-9-left).
>
> **Scenario C – Maximum Height increase:** Height limits are increased from 40 to 65 to 85 feet around the potential Conrad Square and Kirkland Yard stations, with additional height increases to 55 feet for selected blocks on south side of Jefferson and Beach Streets. (See Figure 3-9-right).

It is important to emphasize that the height increases studied in Scenarios B and C are not recommendations or proposals. Their primary purpose is to understand how strategic height increases on select parcels might result in additional development, and thus, increased opportunities to employ value-capture tools to fund a transit extension to the area as well as provide opportunities for more transit-accessible housing and jobs. Any future rezoning would be developed through a public community planning process.

The hypothetical height increases studied in Scenarios B and C were developed with the guidance of the San Francisco General Plan's Urban Design Element. Both scenarios adhere to the following guidelines, derived from principles within the Urban Design Element:

> Maintain Existing Heights in North Beach
>
> The Urban Design Element encourages building heights that reflect and emphasize the natural topography of San Francisco, stating that "low, smaller-scale buildings on the slopes of hills, at their base and in the valleys between complement topographic forms and permit uninterrupted views." North Beach is nestled in a valley between Telegraph Hill and Russian Hill, which are both identified as "Outstanding and Unique Areas" in the Urban Design Element. Given the unique topography of North Beach, as well as the historic, fine-grained scale of existing development, height increases were not considered near the potential North Beach station.

Concentrate Height near Potential Stations

The Urban Design Element states that "clustering of larger, taller buildings at important activity centers (such as major transit stations) can visually express the functional importance of these centers." In adherence to this principle, the greatest height limits in both Scenarios B (65-feet) and Scenario C (85-feet) are clustered in small areas immediately adjacent to the potential Joseph Conrad Square and Kirkland Yard stations. North Beach station was excluded, for reasons stated above. Increased height may be especially appropriate near the potential Conrad Square station, given its prominent location at the terminus of Columbus Avenue, one of the city's major civic and transportation corridors. The station area has the potential to serve as an important activity node that connects Fisherman's Wharf, Russian Hill, and North Beach.

Step Heights Down to the Waterfront

The Urban Design Element states that "low buildings along the waterfront contribute to the gradual tapering of height from hilltops to water that is characteristic of San Francisco and allows views of the Ocean and the Bay." Both height increase scenarios maintain 40-foot height limits on waterfront parcels north of Jefferson Street and on all Port of San Francisco properties within quarter- mile of potential stations. South of Jefferson Street, height increases step down as they move away from potential stations and closer to the water. Scenario C (Maximum Height Increase) includes an increase to 55-feet on select parcels south of Jefferson Street to Beach Street. This height limit was chosen to roughly correspond with the height of several existing historic buildings in this area, namely the Argonaut Hotel, The Cannery, and Ghirardelli Square., which are all taller than the existing 40-foot height limit.

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**Figure 3-8 Development Scenario B – Moderate Height Increase (Left)
Development Scenario C – Maximum Height Increase (Right)**

3-5 LAND USE – SOFT SITE ANALYSIS

Very few vacant properties currently exist within quarter- mile of the three potential stations. Most development is likely to take the form of redeveloping low-intensity, outdated buildings with higher-intensity uses. The Planning Department identified parcels that are under-developed relative to their total potential capacity – known as “soft sites” – under the zoning and height regulations in each scenario. For the purposes of this analysis, soft sites were defined as sites that are currently developed to less than 40 percent[2] of their total capacity under the zoning and height regulations in each respective scenario. For example, a parcel that could accommodate a 30,000 square foot building under existing zoning, but is currently occupied by a 10,000 square foot building, would be considered a soft site under Scenario A because it is developed at 33 percent of its total capacity. The majority of soft sites are located within the Fisherman’s Wharf area. In comparison, soft sites near the potential North Beach Station are relatively small and scattered, offering limited potential for new development.

[2] A 30% standard is routinely used by the Planning Department to determine whether a building has enough development potential to warrant the expenditure of attaining entitlements and redeveloping the building. However, given the limited number of soft sites in the study area and the potential appeal of new development near a Fisherman’s Wharf-serving subway line, it was decided to use a 40% threshold, which would assume more sites would potentially develop.

Soft site analysis excludes parcels with the following characteristics:

- Officially designated historic landmarks
- Properties under Port of San Francisco jurisdiction
- Properties zoned as Public*
- Muni operations facilities (Kirkland Yard)*
- Properties with over 10 residential units**
- Residential properties that already contain more than 40% of their potential unit count

* SFMTA's Real Estate and Facilities Vision for the 21st Century report states that due to the projected growth and increased demand for transit and a larger transit fleet, the SFMTA will continue to need Kirkland as bus yard. Although it is developed to less than 40% of its development capacity, it was excluded from soft-site analysis per the request of SFMTA.

**A portion of the North Point Centre – a 1968 commercial center occupying the entire block bounded by Taylor, North Point, Mason and Bay Streets was included as a soft site. The portion of the complex fronting Powell Street includes a six-story office building that was converted into 74-dwelling units in the early 2000s. The non-residential portion of the property was included as a soft site to take into account the potential redevelopment of its large single-story parking garage.

Soft site analysis does not take into account political or personal reasons which may influence whether a site is redeveloped or not. Some of the sites identified as "soft" may remain unchanged for the foreseeable future, while others not identified as "soft" may redevelop due to age or other factors. The goal of this analysis is to paint a rough picture of potential development within the area, and is not meant to be a precise prediction for the future of individual parcels.

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Table 3-1 Development Scenarios for North Beach and Fisherman's Wharf

Summary of Land Use Scenarios (Thousands of Square Feet)

	Scenario A	Scenario B	Scenario C
Alignment 1 - Washington Square/Conrad Square Station Areas			
Existing Development, 2014	8,997	8,997	8,997
Maximum Development Capacity	1,662	2,169	2,661
Total New Development, 2015-2047	1,467	1,915	2,349
Redevelopment, 2015-2047	-271	-361	-410
Total (Net) Building Area, 2047	10,193	10,550	10,936
Alignment 2 - Washington Square/Kirkland Yard Station Areas			
Existing Development, 2014	8,585	8,585	8,585
Maximum Development Capacity	1,812	2,086	3,183
Total New Development, 2015-2047	1,577	1,816	2,771
Redevelopment, 2015-2047	-347	-359	-607
Total (Net) Building Area, 2047	9,815	10,042	10,748
Alignment 3 - Washington Square/Kirkland Yard/Conrad Square Station Areas			
Existing Development, 2014	11,046	11,046	11,046
Maximum Development Capacity	2,127	2,705	3,952
Total New Development, 2015-2047	1,851	2,354	3,440
Redevelopment, 2015-2047	-403	-492	-740
Total (Net) Building Area, 2047	12,494	12,908	13,745

Figure 3-9 Fisherman's Wharf Area

3-6 VALUE CAPTURE AS A GENERATOR OF CAPITAL FUNDS

As part of the T-Third Phase 3 Concept Study a decision was made to evaluate the potential for value capture mechanisms to help pay for the capital costs of a potential subway extension to Fisherman's Wharf. The following sections provide a discussion of the transit alignments and land use scenarios tested, the value capture tools that have the greatest potential to contribute to the subway extension financing strategy, the methodology used to calculate value capture revenues, and results of the analysis. Additional information about potential value capture mechanisms and a description of the methodology and key assumptions are provided in the appendices.

The Planning Department, with consultant assistance, projected new residential, hotel, retail, and office development on soft sites within a quarter-mile of the potential stations (the "station areas"), based on local real estate market trends and the Planning Department's analysis of development capacity in the station areas. New development was assumed to reflect the approximate land use mix in the Kirkland Yard and Conrad Square (where the majority of soft sites are located) by building area:

- 40 percent residential
- 30 percent hotel
- 15 percent retail
- 15 percent office

Of the residential development, 80 percent was assumed to be rental apartments and 20 percent was assumed to be for-sale condominiums, based on the existing mix of renters and owners in the Fisherman's Wharf / North Beach area according to the 2010 U.S. Decennial Census.

The consultant's analysis focused on three potential alignments that are under consideration; all would be below ground:

> **Alignment 1:** Columbus Avenue, with stations at Washington Square Park (Columbus Avenue and Powell Street) and Conrad Square (Columbus Avenue and Beach Street).
>
> **Alignment 2A:** Powell Street, with stations at Washington Square and the Kirkland Bus Yard (the intersection of Powell and Beach Streets).
>
> **Alignment 2B:** Powell and Beach Streets, with stations at Washington Square, Kirkland Yard, and Conrad Square.

Alignment 3: One Way Loop concept. The outcome for this concept is not shown separately, but approximates the outcome for Alignment 2B.

The table on the following page summarizes projections for each development scenario by alignment.

3-6-1 Identification of Potential Value Capture Financing Tools

State law authorizes local governments to use a variety of property-based financing mechanisms to help pay for capital projects by capturing a portion of the increased property values expected to result from the provision of new infrastructure. Given the scarcity of state and federal funding for transit projects, local governments and transit operators are increasingly interested in using property-based financing mechanisms, or "value capture" tools, to capture some portion of this increased property value to help pay for transit infrastructure. An evaluation of the potential to use value capture tools to help pay for a T-Third Phase 3 extension was performed by a third-party consultant under oversight of staff at the SF Planning Department. The analysis conducted the following tasks:

1) Evaluated a range of potential value capture mechanisms to identify financing tools that might be used to capture value from the Central Subway extension project;
2) Projected future development and estimated future assessed property values near potential stations; and
3) Estimated the amount that might be "captured" using specific funding mechanisms, including the total revenues generated over time as well as the estimated bonding capacity associated with those revenue streams.

In an effort to determine which tools have the greatest potential to contribute to the capital costs required to build the T-Third Phase 3 extension, the consultant reviewed the full range of value capture mechanisms available to the City. These mechanisms are listed below in Table 3-2 (next page). Each tool has specific voting requirements and other limitations that are discussed in detail in Section 5 – Costs and Funding Sources.

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Table 3-2 Value Capture Concepts

Summary of Value Capture Mechanisms

Mechanism	Revenue Source	Applicable to Central Subway Extension?
Infrastructure Finance District (IFD)	Future increases in revenues from the existing property tax (tax increment)	Likely
Mello-Roos Community Facilities District (CFD)	Special tax on property	Likely
Special Assessment District	Assessment, usually of property	Likely
Community Benefit Districts and Property & Business Improvement Districts (CBDs/PBIDs)[a]	Assessment of business licenses or property	Unlikely; another type of Special Assessment District is more likely to be appropriate
Development Impact Fee	One-time fee on new development	Possible project would likely be eligible for the TSF Expenditure Expenditure Plan, however funds generated in the vicinity of the Central Subway cannot be dedicated to the project
Parcel Tax	Special tax on property	Unlikely; CFDs are more typically used for this type of project and parcel taxes present no clear advantage over a CFD
Sale or Ground Lease of Public Land	Sale or ground lease of publicly owned land for new development	Unlikely; limited City-owned land in study area
Property Transfer Fees/Benefit Covenant	Fee on future sales of new units in development on land sold by a public agency	Unlikely; limited City-owned land in study area

Infrastructure Finance Districts (IFDs), Mello-Roos Community Facilities Districts (CFDs), and special assessment districts have the greatest potential to help fund the construction of the Central Subway extension. An IFD would divert a portion of future General Fund revenues generated within a defined geographic area around the stations from the existing property tax rate in order to help fund the project. IFDs do not add any new fee or tax obligations to property owners, but instead divert money from the City's General Fund and allow the City to bond against this revenue stream. A CFD or special assessment district would create a new, additional annual charge on property within a defined boundary.

Development impact fees can also be used to capture value created within a district in order to pay for a local improvement. However, San Francisco is in the process of studying a citywide Transportation Sustainability Fee (TSF) that would replace or serve as a credit against existing transportation-related impact fees. TSF revenues are projected to fund a $1.4 billion expenditure program over 20 years. A T-Third Phase 3 extension would likely be eligible for the TSF Expenditure Plan. However, funding under TSF revenues are not tied to specific projects or geographic areas; revenues will flow into a citywide fund and be used to pay for eligible projects throughout San Francisco. The City could also consider creating an additional transit-related impact fee in the study area to help fund the Central Subway, although the TSF would serve as a credit against any such fee.

3-6-2 Estimation of Value Capture Revenue

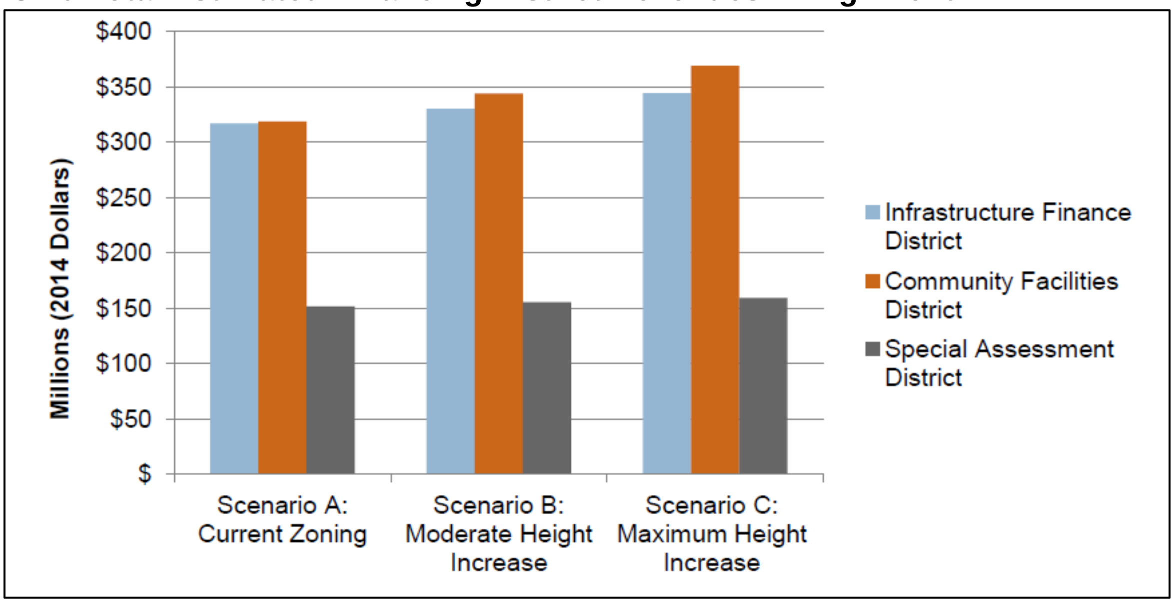
For the three district-based tools with the greatest potential to contribute to the Central Subway extension financing strategy – IFDs, CFDs, and special assessment districts – the consultant worked in conjunction with City staff to develop reasonable assumptions about how the districts would be structured, based on existing City policy and past precedents where available. In order to compare the magnitude of funds associated with different tools, the analysis assumed that each would generate revenues from all properties located within a quarter-mile radius around the potential Central Subway extension transit stations (the “study area”). A quarter-mile radius around the proposed stations was selected as the study area, because research has shown property value benefits from new transit service are typically greatest within a short distance from the stations. (See Appendix E for more information). The analysis also assumed that the districts would generate revenues over a period of 30 years beginning in 2017 (i.e., through 2047), and that those revenues would be used to issue bonds in order to finance the construction of a T-Third Phase 3 extension.

For comparison and informational purposes the analysis also estimated revenues that could be generated within the study area from the City’s proposed Transportation Sustainability Fee. However, these revenues would flow into a citywide fund and could be used to pay for projects throughout San Francisco, while revenues generated elsewhere in the city could be used to help pay for the Central Subway extension. The detailed assumptions used to model the financing mechanisms are described in Appendix E. <u>Note that all values presented below are preliminary estimates based on the assumptions described, and are intended to represent the general magnitude of funds that could be raised using different tools</u>. Additional analysis would be required in order to select and implement the appropriate tool or tools to help pay for the T-Third Phase 3 extension.

For the sake of simplicity, the following findings discuss detailed results for **<u>Alignment 1</u>**, which includes the North Beach and Conrad Square stations. Full results for all three alignments are provided in Appendix E.

Assessed values in the study area are expected to increase by more than 200 percent over 30 years, with upzoning resulting in additional increases**.** The majority of assessed value increase is generated by appreciation and turnover of existing development. The 2047 assessed values reflect a one-time, 5 percent increase in market values associated with the introduction of transit. Five percent is a conservative estimate of the property value premium conferred by proximity to a new transit investment, based on a review of recent literature. Because the development opportunities in the study area are relatively limited, new development contributes a relatively small share (25 to 40 percent, depending on the alignment and land use scenario) of the total increase in assessed value between 2017 and 2047. Higher intensity land use scenarios allow for more new development and therefore result in greater increases in assessed value over time.

Figure 3-10 Total Estimated Financing District Revenues – Alignment 1

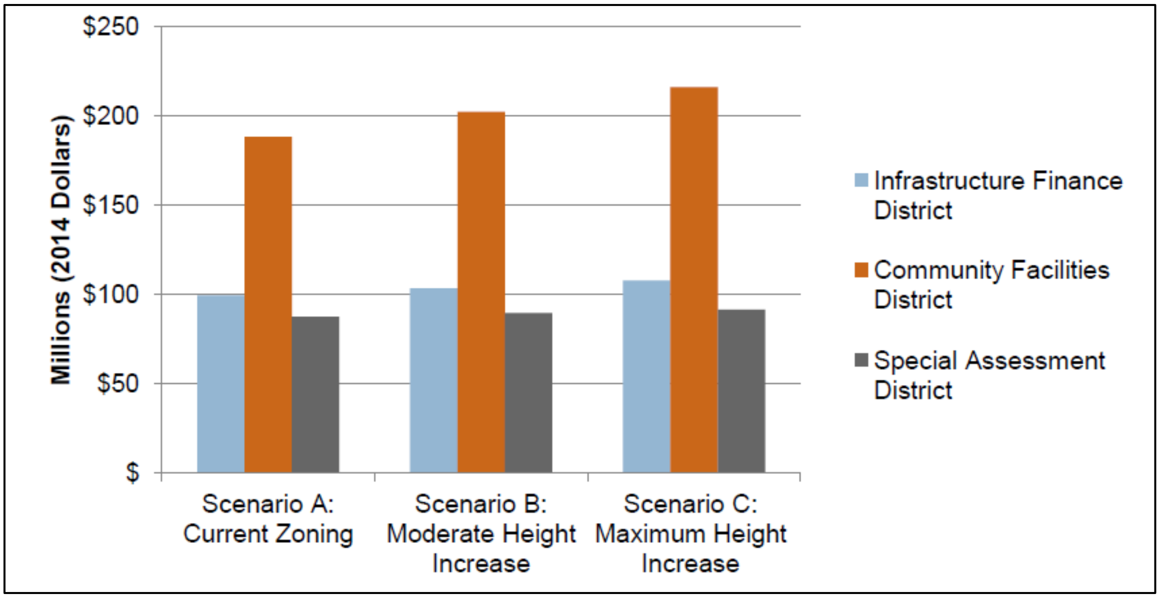


The CFD and IFD might be expected to generate between $320 and $370 million over thirty years, while a special assessment district would generate approximately $150 million (in 2014 dollars). Figure 3-12 compares the total projected revenues in 2014 dollars for the three types of financing districts for Alignment 1; impact fee revenues are discussed separately below. As shown, the CFD results in slightly higher revenues than the IFD. The special assessment district is expected to generate significantly lower revenues than either the CFD or IFD, because assessment districts may only be used to pay for the portion of an improvement that provides a direct “special benefit” (as distinct from general, community-wide benefits) to property owners. In general, the higher intensity land use scenarios result in higher revenues.

Of the three mechanisms, the CFD is expected to support the highest bond proceeds and is therefore likely to pay for the largest share of the project**.**

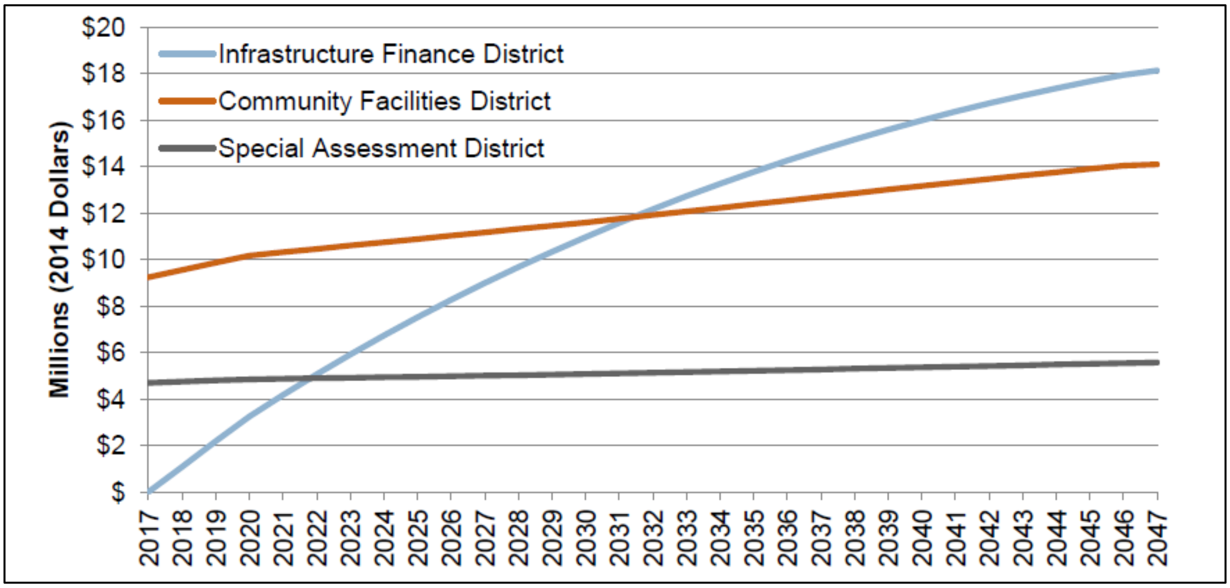
Chart 3-12 shows the estimated bonding capacity of the various financing tools for Alignment 1. The CFD could support bond proceeds of approximately $190 to $215 million. The IFD is expected to support significantly lower bond proceeds, in the range of $99 to $107 million. The special assessment district would support a $87 to $91 million bond.

Figure 3-11 Estimated Bonding Capacity 2017 – Alignment 1



The significant difference in bonding capacity between the IFD and CFD reflects differences in the revenue flows for the respective tools. Both tools generate a similar amount of total revenue over a 30-year period. However, the IFD revenues accrue slowly in the early years, increasing in later years as the size of the tax increment grows. Bonding capacity of the IFD could be somewhat increased by increasing the share of the tax increment that flows to the IFD in early years. The Board of Supervisor's Policy Guidelines for IFDs allows for this type of "front-loading" of increment. Since front-loading the increment would require a policy decision by the Board, this analysis assumed that the share of increment captured by the IFD remains steady over time. In contrast, the revenues from the CFD are more consistent over time, resulting in a greater capacity for financing upfront capital improvements. The bonding capacity estimates are also affected by differences in the bond financing assumptions; because IFDs are an untested tool with which investors are unfamiliar, the interest rates for the first several IFDs issued in the state are anticipated to be higher than current interest rates for more established types of financing districts.

Figure 3-12 Annual Financing Revenue – Alignment 1, Scenario C - 2017-2047



An IFD could potentially be combined with a CFD, special assessment district, or a new impact fee to leverage funds. Because IFDs divert part of the existing property tax rate rather than creating additional taxes or fees for property owners, they have the potential to be combined with other tools such as a CFD, special assessment district, or additional impact fee. Combining multiple tools that create new taxes or fees (such as CFDs and special assessment districts) may be more challenging because property owners would essentially be charged twice for the same transit improvement.

Each of the financing district tools has particular requirements that present challenges for financing a major transit project in an infill context. CFDs require approval by a two-thirds majority of voters if more than 12 registered voters live within the boundaries of the proposed district. Following the passage of Senate Bill 628 (Beall) IFDs had their approval requirement lowered from a two-thirds majority to a 55% majority in California. The change takes effect on January 1, 2015. As a result of the difficult voter approval process and other restrictions, IFDs were rarely used for any purpose before California eliminated redevelopment tax-increment financing (TIF) in 2011. San Francisco's Rincon Hill IFD is one of the only IFDs that has been established to date.

CFDs are much more common, but are typically used to finance improvements in places with a small number of property owners who intend to develop or redevelop their land and/or subdivide it for sale. While there are some limited examples of CFDs that include numerous property owners – including a CFD that voters in downtown Los Angeles approved in 2012 in order to fund the development of a downtown streetcar – such districts are unusual and may require significant community outreach in order to build support among both voters and the property owners who will ultimately pay the special tax.

Special assessment districts only require approval by a simple majority of property owners. However, under Proposition 218, an amendment to the California constitution passed in 1996, assessment revenues may only be used to pay for the portion of an improvement that provides a direct “special benefit” to the property owners paying the assessment. There are no known examples of special assessment districts that have been created in order to pay for large-scale transit capital projects in California since Proposition 218 was passed.

New development in the Alignment 1 study area could generate up to $23 million in Transportation Sustainability Fee revenues over the time horizon of the study. These revenues would flow into a citywide fund that will pay for projects throughout San Francisco that are eligible for the TSF Expenditure Plan. A T-Third-Phase 3 extension is expected to qualify as an eligible project, but TSF revenues generated in this area would not be tied to this specific project, and TSF revenues generated elsewhere in the City could be used here.

In general, Alignments 1 and 2 would serve a smaller land area and are therefore associated with lower revenue projections (as well as lower expected construction costs) compared to Alignment 3. However, as a percentage of total estimated maximum project cost, revenues for Alignments 1 and 2 perform slightly better.

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Section 4 – Constructability Analysis

4-1 OVERVIEW

The T-Third Phase 3 Concept Study was initiated with a goal to develop information to understand opportunities for optimization of existing Muni LRT service and a potential for future rail transit expansion to serve northern San Francisco neighborhoods, including North Beach and Fishermen's Wharf. To achieve the goal, it is necessary to understand constructability issues related to the study alignments and potentially eliminate concept alignments deemed non-constructible, non-practical or with major constructability or feasibility flaws.

The study area is limited to a zone in northeast San Francisco bordered by Beach Street to the North, Powell Street to the East, and Columbus Avenue, intersecting both streets and straddling the area in northwest-southeast direction. Three potential station locations are being considered: North Beach at Washington Square area, Conrad Square and Kirkland Yard stations. Multiple potential alternatives initially identified by SFMTA planning efforts were assessed considering:

- Tunneling methodology through historical records and current experiences primarily from the ongoing projects in the area (e.g. Central Subway)
- Feasibility of potential surface and subsurface concept alignments
- Feasibility of station locations at the areas of North Beach, Conrad Square and Kirkland Yard
- Strategic value of Pagoda Palace site and the existing underground shaft for future northern transit expansion considering both temporary and permanent uses (during construction and in active transit service, respectively)

Special attention was paid to identification of potential underground guideways along the study corridors in terms of finding practical and constructible solutions that would minimize temporary and permanent impacts (utilities, noise, vibration, visual, air quality, traffic congestion, etc.). Such impacts were not quantified since the study was broad and at a conceptual level. However, non-practical or non-feasible concept alignments to the corridor extension were labeled along with those that may have a potential to be further developed as part of a future more detailed study. The concept alignments development in plan and profile and their subsequent evaluation for constructability aspects included the following factors:

- Location of the existing connecting tunnels at the Washington Square area
- Maximum track grades
- Topography and geologic profiles along the study route

- Major underground obstacles including existing tunnels and piles (supporting existing or abandoned utilities)
- Major surface obstacles (including existing cable car infrastructure)
- Major constructability risks with emphasis on subsurface risks
- Operational limitations of tunnel boring machine including minimum feasible horizontal radius (500 feet) and vertical grade (3% to 4%)

4-2 GEOTECHNICAL ASSESSMENT

The information presented herein is preliminary and based primarily on a review of the subsurface information provided within available record and historical documentation relevant to the area of the study. Primary sources of information are: Geotechnical Baseline Reports (GBRs) for tunnels and station contracts prepared for the T-Third-Phase 2 (Central Subway) project, record drawings and reports the N1 and N2 North Shore Outfalls Consolidation Wastewater projects completed by the City of San Francisco (1980s), the United States Geological Survey (USGS) bedrock surface map, State of California Seismic Hazard map (liquefaction), and the United States Coast Survey of the City of San Francisco map (1853).

The available information was extrapolated for the purpose of this study. General assumptions are made to provide basis for potentially feasible alignments as extensions of the tunnels built as part of the T-Third Phase 2 (Central Subway) program.

The study area is located in northeast San Francisco bounded approximately by Beach Street (north), Powell Street (east), and Columbus Avenue (west), which intersects both streets as it travels in a northwest –southeast direction. Three potential station locations have been identified: North Beach station at the Washington Square area, Kirkland Yard station at the corner of Powell and Beach Streets near Fisherman's Wharf, and the Conrad Square station at the corner of Leavenworth and Beach Streets and Columbus Avenue near the western end of Fisherman's Wharf. See Figure 4-1. See Section 2 for concept alignment alternatives.

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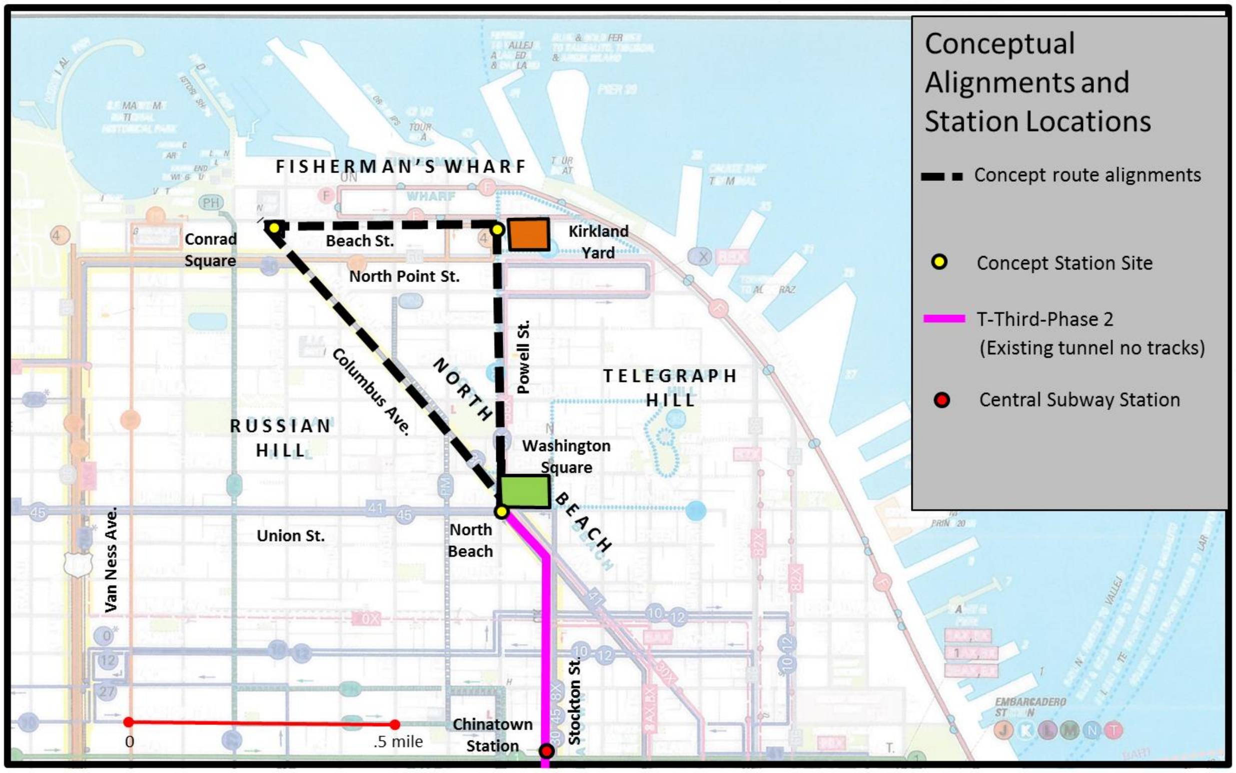
Figure 4-1 Conceptual Alignments and Station Locations



4-2-1 Geologic Setting

The City of San Francisco is located in the central Coast Ranges of the greater Coast Ranges Geomorphic Province of California. The concept study area lies east of the San Andreas Fault, underlain by rocks of the Franciscan Complex, which are strongly deformed (faulted, fractured and folded). In the Coast Ranges, Franciscan bedrock generally comprises three predominant rock types: sandstone (usually referred to as greywacke), shale, and mélange. The sandstones and shales are highly variable in their degrees of fracturing, strength, hardness and weathering. The mélange unit is characterized by a chaotic, heterogeneous mix of small to large (miles in size) masses of different rock types, including sandstone (greywacke), shale, claystone, greenstone, chert and various metamorphic rocks.

The geology of the San Francisco North Quadrangle is characterized by recent (historical)artificial fills and Quaternary sediments (i.e. deposits up to 1.6 million years old) overlying bedrock of the Franciscan Complex.

4-2-1-1 SOIL AND ROCK UNITS

Based on the geotechnical information reviewed for this study, potential subsurface alignments would encounter eight subsurface rock units. These include seven units of

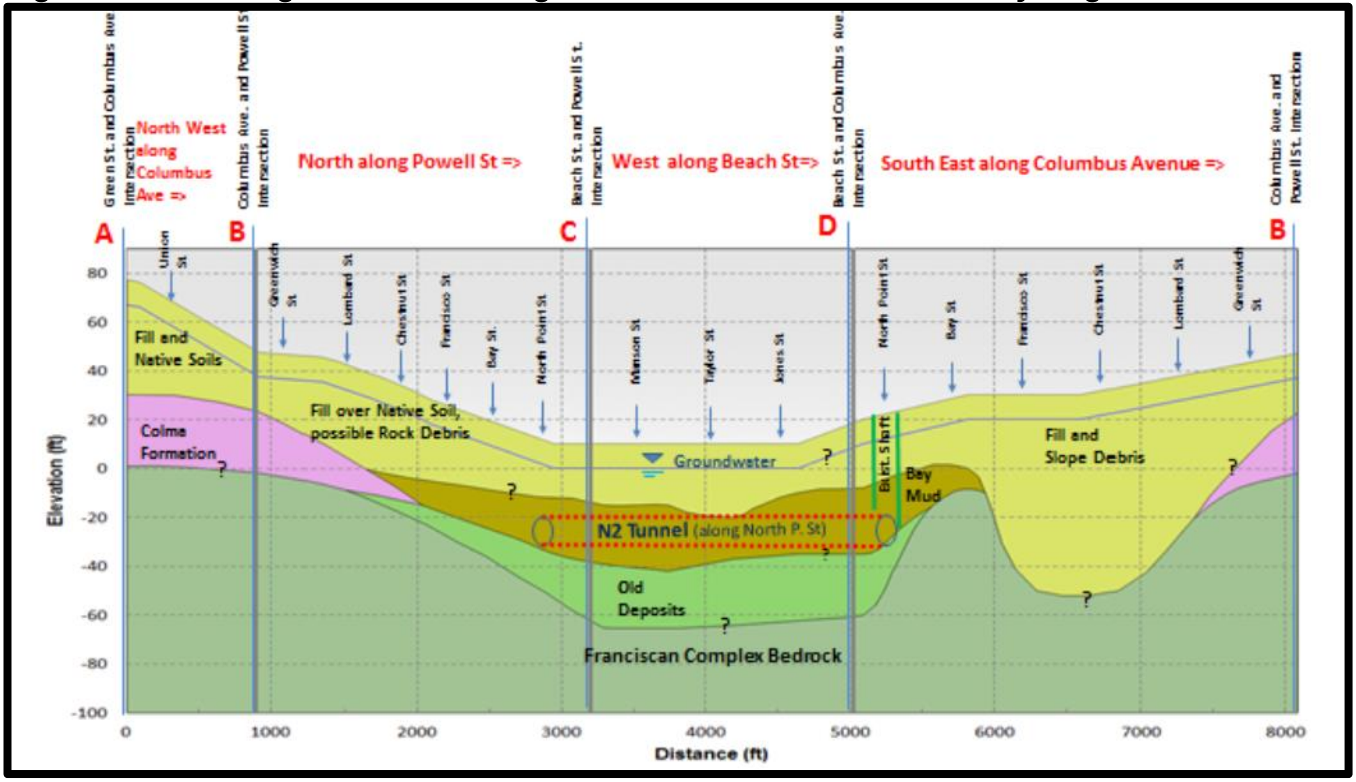
Quaternary surficial deposits and one unit of Jurassic and Cretaceous bedrock. Not all may be present within the investigated alignments. See Table 4-1.

Table 4-1 Soil and Rock Units

Artificial Fill (Qaf)	Very loose to medium dense sand (SP), silty sand (SM), and medium stiff sandy clay (CL); locally with miscellaneous debris (bricks, wood, metal glass, etc.). Much of the deposit originates from the underlying dune sand (Qd).
Dune Sand (Qd)	Loose to medium dense, poorly graded fine to medium grained aeolian sand
Bay Mud / Marsh Deposits (Qm)	Very soft to soft dark green gray to black organic rich Clay and sandy clay (CL to CH)
Undifferentiated Deposits (Qu)	Medium to stiff to stiff brown sandy clay (CL) and medium dense to dense brown Clayey Sand (SC). The unit may comprise colluvium, alluvium, or Colma Foundation. Undifferentiated is used to classify because some soils found don't have distinguishing characteristics.
Colma Foundation (Qc)	Colma Foundation is composed of a complex, interbedded sequence of estuarine and near shore sediments. It consists of very dense sand (SP or SM) with interbedded stiff to very stiff clay and sandy clay (CL)
Undifferentiated Old Bay Deposits (Qo)	Interbedded dense to very dense sand (SP), silty sand (SM) and very stiff clay (CL). This unit also contains older Bay Clay and Mud, which typically are stiff clays and silts that are gray to greenish in color.
Colluvium (Qcol)	Very stiff brown to gray sand clay (CL) to Clayey Gravel (GC) – appears to be decomposed bedrock / residual soil.
Franciscan Complex Bedrock (KJf)	This unit is highly variable in composition, hardness and strength, ranging from soft to hard and friable to moderate strong. This unit primarily includes sandstone, meta-sandstone, sandstone breccia, shale, shale breccia, siltstone, and mélange, along with claystone and mudstone. It can also contain serpentine, chert and greenstone.

An approximate geological profile along the study alignment is shown in Figure 4-2. To read this two-dimensional graph – assume you start at the former Pagoda Palace site at the intersection of Green Street and Columbus Avenue in North Beach and proceed along the streets as described in the red text. When you reach the last section to the right, you will have completed three legs of the triangle – as shown in Figure 4-1 and returned to a start point. Note that not all eight soil and rock units have been identified in the presented geologic profile due to a general lack of specific geological and geotechnical data in the study area, primarily along Columbus Avenue and Powell Street.

Figure 4-2 - Geological Profile along Powell-Beach-Columbus Study Alignment



4-2-1-2 GROUNDWATER CONDITIONS

The primary subsurface water-bearing materials of the study area occur in the Artificial Fill close to the Bay, Dune Sands and the Colma Formation sediments, which overlie the Undifferentiated Old Bay deposits. Drainage is generally controlled by bedrock topography, and the three-dimensional orientation of the overlying sediments. The regional groundwater flow generally follows the bedrock surface and is directed toward the northeast (i.e. towards San Francisco Bay). Based on existing information, the groundwater levels could be within ten feet of the ground surface in the vicinity of the Central Subway receiving pit, and will likely be relatively shallow for the entire area. For the purposes of this study, groundwater levels are shown 10-15 feet below street surface. This is an area where the preliminary assessment requires further study if a decision is made to move forward with more work on the project.

4-2-1-3 SEISMICITY AND RELATED HAZARDS

The San Francisco Bay Area is one of the most seismically active regions in the world. The high rates of seismic activity in the region are associated with the San Andreas Fault system, which comprises several active strike-slip faults, including the Calaveras, Hayward, San Andreas and San Gregorio faults. The closest to the study area are the San Andreas Fault (8 miles southwest) and Hayward Fault (12 miles northeast). Both faults have been the source of moderate to large magnitude earthquakes, including the 1906 m7.8 earthquake which ruptured the ground surface for over 290 miles.

Seismic hazard of fault offset and lateral spreading are not anticipated in the study area. Liquefaction is a phenomenon in which earthquake shaking reduces the strength and stiffness of a soil resulting in a decrease in ground mass volume and reduction of the ground ability to support loads imposed by a structure. Liquefaction may also result in ground settlement or subsidence in addition to soil strength loss. Liquefaction normally occurs in saturated, loose sand and silts. Within the study area, considering the above mentioned seismic risks, surface structures would generally be subjected to the ground excitations and may experience amplification of the shaking motions during an earthquake event depending on their own vibratory characteristics. The shaking motion could be further exacerbated by the area's liquefaction potential. Bridges and overpass structures could be exposed to excitations by resonant effects if the predominant vibratory frequency of these structures is similar to the natural frequency of the ground motions.

In contrast, underground structures and tunnels are constrained by the ground that surrounds them, and it is highly unlikely that they could move to any significant extent independently of the ground around them, or be exposed to vibration amplification. In comparison to surface structures which are generally unsupported above their foundations, underground structures and tunnels exhibit significantly greater redundancy when ground support is considered. Traditionally, they have better earthquake performance history than their aboveground counterparts. The USFS Bay Area liquefaction map identifies a good part of the study area as having a “high liquefaction hazard level”. See Figure 4-3.

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Figure 4-3 Zones of High Liquefaction Potential

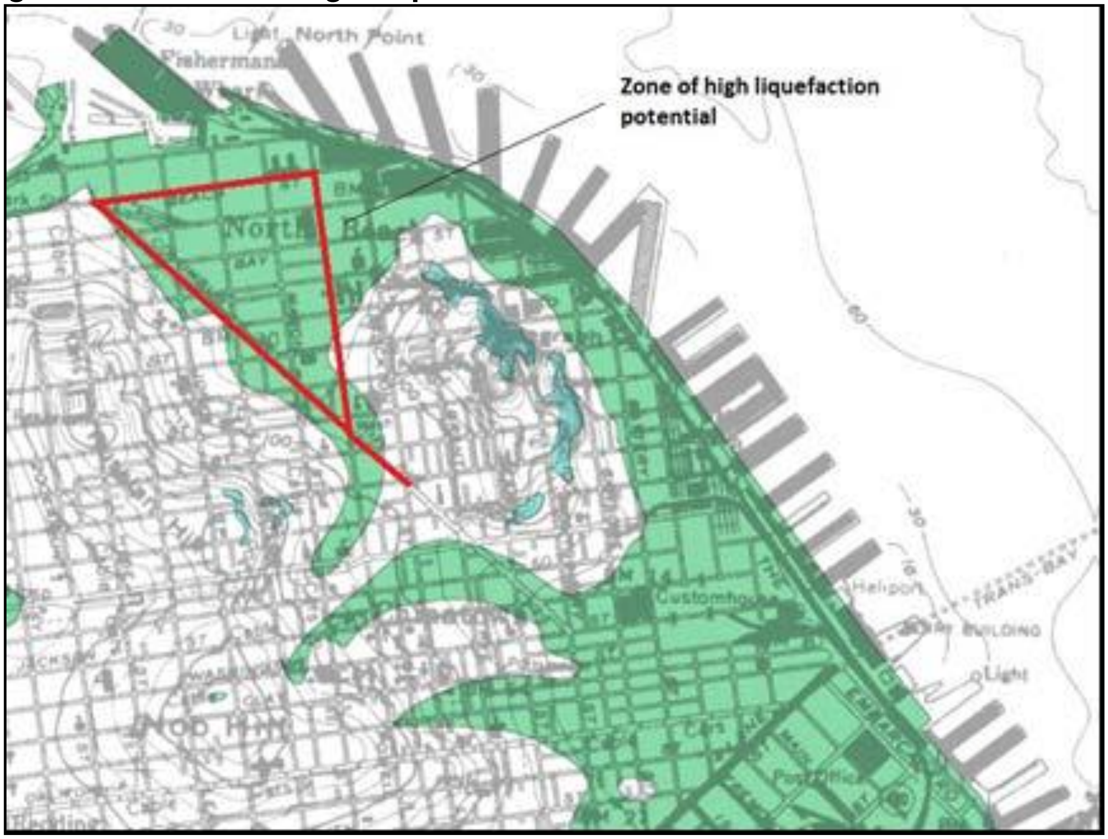

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Table 4-2 Concept Matrix of Subsurface Risks
(5 = very high, 4 = high, 3 = moderate, 2 = low, 1 = very low, 0 = none)

RISKS	PROBA-BILITY	COST IMPACT	SCHED-ULE IMPACT	CONSEQUENCES	MITIGATION STRATEGY
Seismic hazard during service life	4	4	3	Tunnels and stations damaged due to high level of seismic ground motion causing human and economic losses and operational and service delays.	Design tunnels and stations for high level of seismic ground motion. Consider seismic loads during design of the final concrete liners for the tunnels and stations.
Encountering sewer tunnels (N2 Tunnel) as a major existing underground utility that resides beneath North Point Street.	5	5	5	Impact on tunnel and station profiles causing deep positioning of underground structures below street level.	Provide tunnel and station configuration that considers sufficient distance between the existing tunnel (N2 Tunnel) and new proposed structures. Consider ground improvement between the existing (N2 Tunnel) and the new underground structures.
Mixed face excavation of tunnels along Columbus Ave. and Powell St. and soft ground tunneling along Beach St. This occurs when the alignment passes or transitions through soil material and the Franciscan Complex Bedrock.	5	3	3	Potential for ground loss due to tunneling and uncontrolled surface settlements affecting streets, buildings and utilities.	Select an appropriate methodology of excavation such as use of closed face or pressurized face (PF) tunnel boring machine (TBM) or sequential excavation method (SEM).
Relatively high groundwater levels	5	3	3	Groundwater entering the excavated openings causing unstable excavation, ground loss, settlements, and human and material damage / economic loss.	Requires watertight retaining structures for the construction of stations, the TBMs face pressure control to maintain face stability, and avoid ground loss, and may require ground improvement during SEM excavation of tunnel (as grouting or ground freezing)
Potentially liquefiable soils (potential issue for both underground and surface stations / tracks	3	3	3	Structures / utilities damage / collapse due to high ground motion levels / strong earthquakes	Estimate potential of ground liquefaction impacts on final structures. Provide ground improvement if needed.
Ground settlement due to excavation which could impact existing structures, streets and utilities	4	3	3	Impacts / damages to existing structures, streets and utilities, causing material damage and operational and service delays.	Use FP, TBM, consider ground improvement during excavation of the tunnels by TBM and / or SEM, plan on detailed instrumentation and monitoring program, plan on relocating and / or supporting utilities in place.

Leakage of methane gas and other types of hydrocarbons into the tunnels (Central Subway Tunnels were classified as "Potentially Gassy with Special Conditions")	2	3	3	Condition causing explosion (methane) or hazardous conditions in the tunnel.	Consider gas-proofing features of waterproofing membrane, use appropriate gaskets to seal tunnel joints.
Sea level rise during service life impact along Beach St. and northern ends of Powell St. and Columbus Ave.	5	3	3	Flooding of the tunnels and stations.	Considering flood walls or hardening of the portals, stations entrances and openings.
Hazardous Materials within groundwater and excavated soil	3	2	2	Condition causing hazardous conditions.	Investigation needed for mitigation purposes.
Boulders and rock debris(possibility in soil materials along Columbus Avenue near Russian Hill).	3	3	3	Cost and schedule impacts.	Selecting an appropriate type of excavation such as PF TBMs or SEM.
Encountering underground utility supports (deep piles) along the alignment. See Appendix D for wooden piles along Taylor Street.	5	4	4	Impact on tunnel and station profiles causing obstructions for tunnel construction.	Obtain record drawings and provide subsurface exploration (test pits). Identify obstructions and remove / design to encounter for their presence.

4-3 CONSTRUCTABILITY EVALUATION

The analysis and understanding of potential constructability issues is very important. Analysis of constructability issues related to the study alignments, including the potential elimination of concepts deemed non-constructible, non-practical, or with major constructability or feasibility flaws is a key element of the entire report. This information on constructability issues in the North Beach Corridor is expected to be used by SFMTA at a later time when evaluation of rail service expansion concepts in different corridors across the city is undertaken.

Considering that additional studies are required to examine detailed constructability issues related to a potential T-Third Phase 3 extension, either above ground or in subway to serve the Fisherman's Wharf area, the following could be concluded from initial observations at a broad pre-conceptual level of analysis. The multiple potential alternatives identified required a broad-brush assessment through several categories listed below from a constructability standpoint. Since underground alternatives / tunnels entail more efficient transit service while bearing larger constructability risks, the emphasis in constructability evaluation is placed on those options in order to understand such risks and eliminate alternatives that may not be practical.

4-3-1 Tunneling Considerations

The objectives of any potential tunnel option consideration for extension of the existing T-Third Phase 2 (Central Subway) tunnels must continue meeting owner/user requirements as well as good tunneling practice considering specific geologic conditions. It must provide for the appropriate tunnel size (likely same or similar to T-Third Phase 2 tunnels), meet standard industry construction tolerances and durability requirements for service life (usually for 100 to 120 years), and should generally minimize long-term operational costs and maintenance. Tunnels must be safe and stable during construction and impacts to surrounding buildings, infrastructure and local communities must be minimized. In terms of tunneling options along Powell and Beach Streets corridor, as well as along Columbus Avenue, two tunneling methods are possible: mechanically bored tunnel by tunnel boring machine (TBM) or sequentially excavated tunnel by sequential excavation method (SEM). See Figures 4-4 and 4-5.

Figure 4-4 Tunnel Boring Machine (TBM)

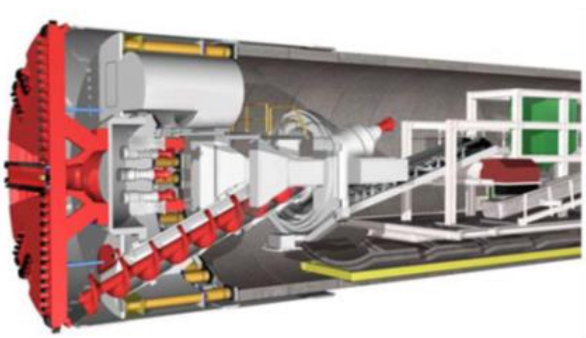


Figure 4-5 Sequential Excavation Method (SEM)

At this early point in time neither of these options should be eliminated. However, based on the assumed geological conditions it is possible that along the middle and northern portion of the alignment beneath Columbus Avenue, northern portion of the alignment along Powell Street, and possibly entire alignment beneath Beach Street, tunnels may need to be constructed in fill or Bay Mud. This is a condition which when combined with a high groundwater elevation, would likely cause assessment of SEM tunnel option non-practical. This assumption is due to potentially extensive ground improvement work that would be necessary to control the groundwater inflow into the excavation to keep the excavation stable at all times so as to minimize impacts to the overlying streets, utilities and buildings. SEM tunnels within a fill or Bay Mud accompanied with high ground water level would require ground improvement (such as jet grouting, to control the groundwater inflow and overall stability of the excavation including ground settlements. Generally, this method may be more expensive to execute and may produce larger overall impacts if needed ground improvements would be initiated form the street (traffic, utility impacts).

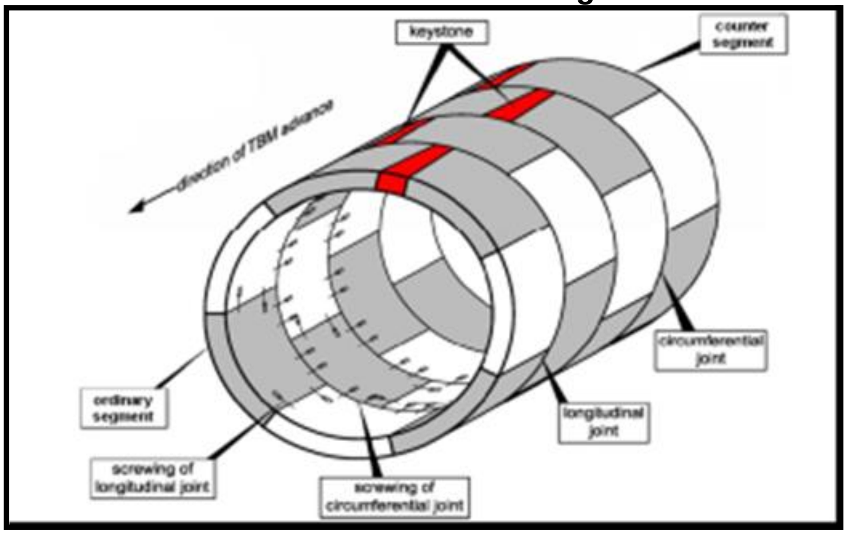
Although the study is dealing with short length of the tunnels for approximately 0.5 miles length for each for Powell and Beach alignments, and 0.7 miles for Columbus Avenue alignment, TBM use is considered more practical. This would be the case from ground control perspective, accounting for the recent advances in the TBM technology as well as the recent experiences related to T Third Phase 2 (Central Subway) construction. From machine utilization standpoint industry-wide, due to relatively short alignments, this might not be the most economical use of the TBM; however, this aspect could be improved if potential further extension of the tunnels is anticipated for some future segments (in this case additional tunnel length could be constructed and then capped to await future use).

4-3-2 Tunnel Lining System

The lining system for the tunnels is required for operational purposes to provide a functional underground opening and environment appropriate to the operation of the tunnel as a light rail transit tunnel. Precast concrete segmental lining will support the surrounding ground initially as well as for the design service life of the structure thus providing and maintaining the required operational cross-section and to control groundwater inflow, generally via special gaskets installed along radial and circumferential segment joints as single-gaskets or double-gaskets depending generally on ground corrosiveness and gas and hydrocarbons presence.

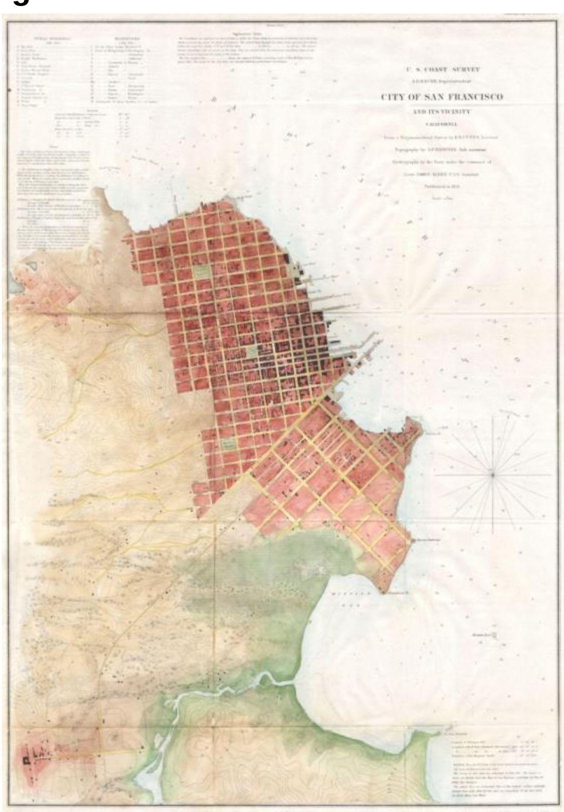
The final precast concrete segmental lining will have the strength and flexibility to resist overburden earth pressures, hydrostatic pressures, and seismic deformations, as well as additional loads due to segment fabrication, storage, handling, demolding, and transportation loadings and related construction imposed loadings to ensure lining section adequacy during construction. See Figure 4-6.

Figure 4-6 Cross-Section of Pre-Cast concrete Segmented Tunnel Liner



4-3-3 Potential Tunnel Profiles Along Study Corridors

Figure 4-7 San Francisco Shoreline Map (1853)



Considering the assumed geological profile and the above constructability considerations, the following provides an assessment of potential tunnel and station profiles along the study area. As noted, the study area is bordered by Powell Street on the east, Beach Street on the north, and Columbus Avenue running northwest from Green Street to Beach Street; it is a triangular area adjoined by Telegraph Hill on the east, the Fisherman's Wharf area on the north and Russian Hill to the west. The 1853 map of San Francisco indicates that Francisco Street was the original shoreline and that the area north of Francisco Street (Bay, North Point and Beach Streets) was filled with material that is primarily dune sand. See Figure 4-7. The area north of Columbus would encounter varying thicknesses of such fill.

For all underground guideways along the study corridor, the vertical alignment, and consequently the selection of the method of construction are dependent upon the following factors:

- Location of the existing connecting tunnels at the Washington Square area
- Maximum track grades (maximum 5% grade preferred, 7% to 9% grades possible for short lengths per Central Subway design criteria)
- Topography and geologic profiles along the study route
- Major underground obstacles including existing tunnels and piles (supporting existing or abandoned utilities)
- Major surface obstacles (including existing cable car infrastructure)
- Major constructability risks with emphasis on subsurface risks
- Operational limitations of tunnel boring machine including minimum feasible horizontal radius (500 feet) and vertical grade (3% to 4%)

Considering the above information, general subsurface profiles have been developed for study alignments as follows:

a. Columbus Avenue (Stockton/Green to Beach Street)
b. Powell Street (Green Street to Beach Street)
c. Beach Street (Powell to Columbus)

The figure below represents a flat cross-section - or an “unwrapped” view - of potential tunnel alignments for the entire triangular LRT route concept area. The right edge and left edges of the figure meet each other. The first segment shows a cross-section of concept alignment 2A, the second segment shows concept alignment 2B, and the third segment shows concept alignment 1. Concept alignment 3 would travel through all segments as it completed a loop.

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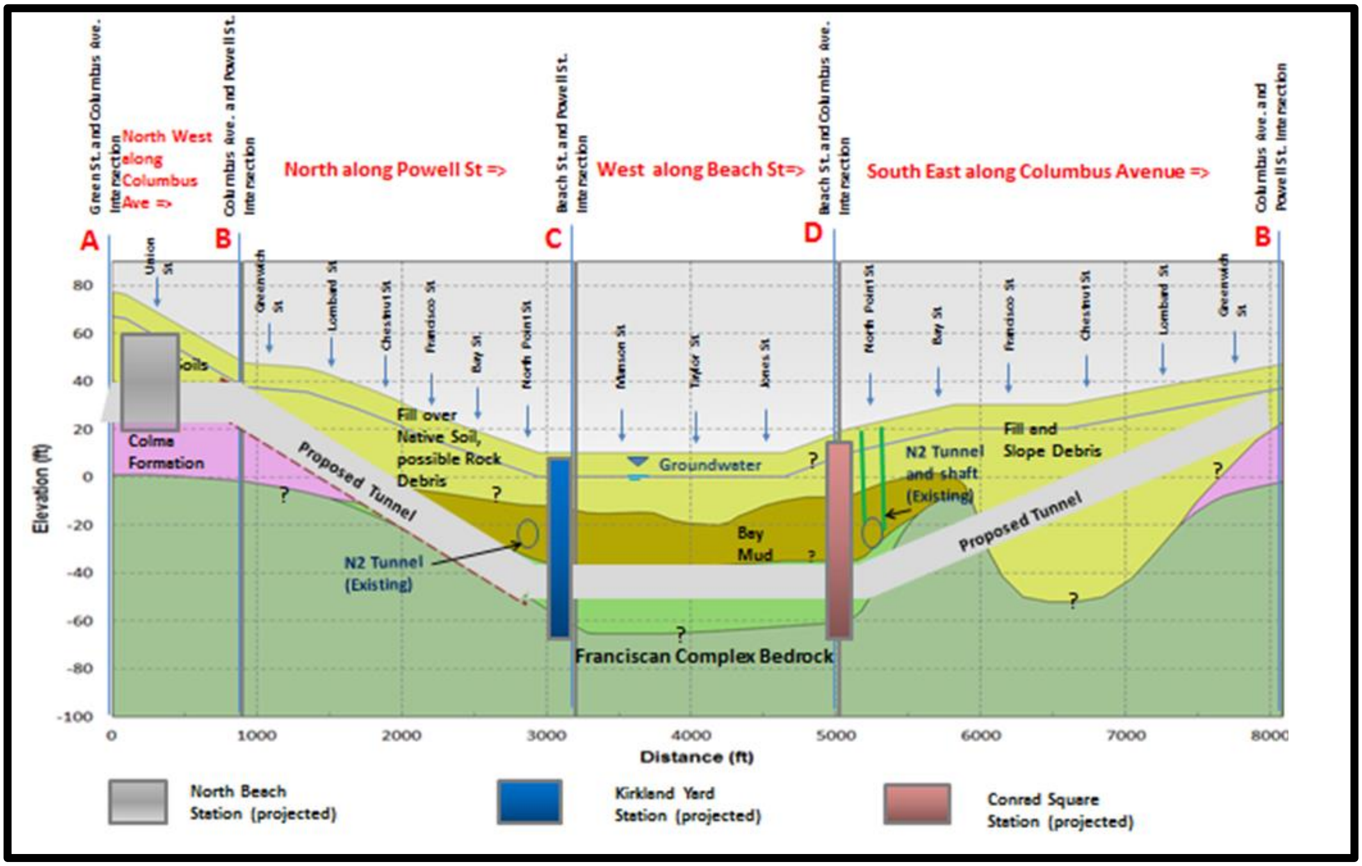
Figure 4-8 Geologic Profile of Subway and Possible Station Locations



4-3-3-1 COLUMBUS STREET ALIGNMENT

Based on the historic maps, most of the Columbus alignment has soil varying in thickness from approximately 20 feet at Filbert Street to over 70 feet at Chestnut. The soil is likely fill at the surface with undifferentiated deposits and colluvium (the street is close to the toe of Russian Hill). In addition in the vicinity of Green Street to Filbert some of the dense Colma material may also be present, to the north of Francisco some native dune sand and Bay Mud might also underlie the fill. Along Columbus the groundwater may be within 10 to 15 feet of the ground surface. The bedrock is Franciscan Complex.

As the third segment in Figure 4-8 shows, the tunnel profile would extend to the northeast from the existing Phase 2 tunnels beneath Union Street, at first through the station box limits then further beneath Columbus Avenue following the descending grade of approximately 3% toward the Conrad Square Station. The tunnel would likely encounter fill and Colma formation at the outset, and then encounter bedrock north of Francisco Street. Further north Bay Mud and Old deposits might be encountered as well contributing to an undefined length of mixed face condition TBM would likely go through;

it would possibly stay beneath the ground water table along the entire path. The tunnel would need to keep a minimum 8 to 10 feet distance beneath the sewer tunnel N2.

4-3-3-2 POWELL STREET ALIGNMENT

As the first segment in Figure 4-8 shows, at the very south end of the alignment the subsurface materials are anticipated to be undifferentiated deposits and possibly Colma formation. To the north from Union Street to Lombard Street the Franciscan Complex bedrock is anticipated to be relatively shallow overlaid with some Colma formation and fill (depth of Colma formation is unclear). North of Lombard Street the rock dips and the materials could be a combination of undifferentiated deposits, dune sand and possible some colluvium. At Francisco Street the materials transition to fill over Bay Mud. In the areas of fill the groundwater may be within 10 to 15 feet of the ground surface and north of Francisco Street the groundwater level will be at or close to sea level. The TBM would encounter mixed face condition for an undefined length while descending at an approximate grade of approximately 4% from North Beach Station to Kirkland Yard Station and passing beneath N2 tunnel beneath North Point Street.

4-3-3-3 BEACH STREET ALIGNMENT

Based on the historic information regarding the exploration performed for the N2 sewer tunnel the entire alignment is underlain by fill overlying about 20 to 40 feet of Bay Mud. In this area the groundwater will be at sea level. The Franciscan Complex bedrock is likely over 60 feet below sea level. As the second segment in Figure 4-8 shows, the tunnel beneath Beach Street would possibly encounter Bay Mud, fill mixed and old deposits. The tunneling would need to control face pressure of the TBM in order to avoid potentially losing ground and causing settlements. It is possible that ground improvement including grouting may need to be implemented to control the impact of settlements on buildings, street and utilities at certain locations.

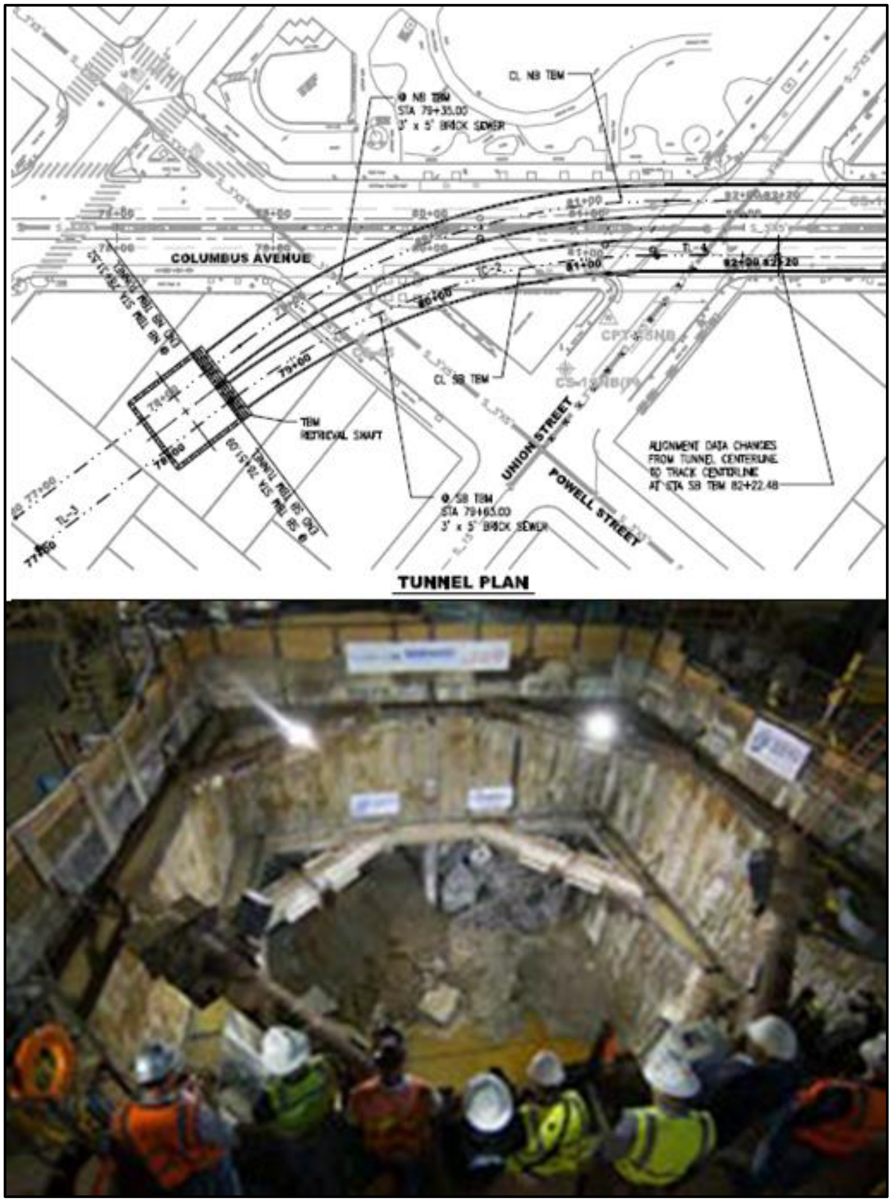
4-3-4 North Beach Station Constructability Issues

An analysis of a potential station in North Beach is somewhat different than analysis of general T-Third Phase 3 issues, because of the existence of the twin tunnels that were built between the Chinatown station and the Pagoda Palace site.

4-3-4-1 PAGODA PALACE SITE AND ACCESS SHAFT TO TUNNELS

The Central Subway project (T-Third-Phase 2), provided for the tunnel boring machine (TBM) removal at the Pagoda Palace site in North Beach instead of the initial approved plan which called for the machine removal in the middle of Columbus Avenue. See Figure 4-9.

Figure 4-9 T-Third-Phase 2 TBM Retrieval Plan and Site Photo at Pagoda Palace site



Any future northern and/or north-eastern extension of the existing LRT alignment towards Fishermen's Wharf must connect to the existing tunnels under Columbus Avenue that are currently terminating at the Pagoda Palace shaft. It is likely the extension of the Central Subway underground guideway would take place along Columbus Avenue, fully or partially. It is also likely that such extension considerations would be coupled with a need to construct new tunnels under Columbus Avenue to replace the existing 'curved' tunnel alignment leading into the existing retrieval shaft (the existing tunnels would be partially backfilled).

Considering proximity of Washington Square, the existing Pagoda Palace site and the existing shaft would continue to be instrumental as a staging site and/or temporary construction shaft for construction crew access and for storing and staging construction materials and equipment. In light of a very limited available right of way (ROW) in the Washington Square area it is highly probable that the existing Pagoda Palace site would become a crucial part of a real estate providing an opportunity for placement of permanent station facilities including ventilation shafts, entrance and emergency egress.

It is possible that this site may house a future transit development over the station permanent transit facilities; therefore, securing this site for the future transit uses should be strongly considered by transit extension stakeholders. The Pagoda Palace site would have an important function in both cases, considering the full transit corridor extension towards the Fishermen's Wharf, as well as in a case that North Beach Station could be constructed first as a possible initial operating segment. Connecting the existing T-Third Phase 2 tracks with future alignment would be different for surface versus subsurface alternatives.

4-3-4-2 ISSUES AFFECTING A STATION AT NORTH BEACH

A North Beach Station could be placed along Columbus Avenue as conceptualized in the previous studies provided as part of the T-Third Phase 2 alternative alignment considerations. Station location would likely reside within the area bordered by Filbert Street at the north and Green Street at the south, generally beneath Union Street and south-west corner of the Washington Square. Such station position would allow tunnel alignment to be extended either beneath Columbus Avenue or with slight reverse curves beneath Powell Street. See Figure 4-10. It appears that bottom of the station would be in Colma formation or within the bedrock overlaid by alluvial sediments and fill. It also appears that rock seems to drop down rather sharply from Filbert Street north beneath Columbus Avenue and that Columbus Avenue grade generally follows this trend.

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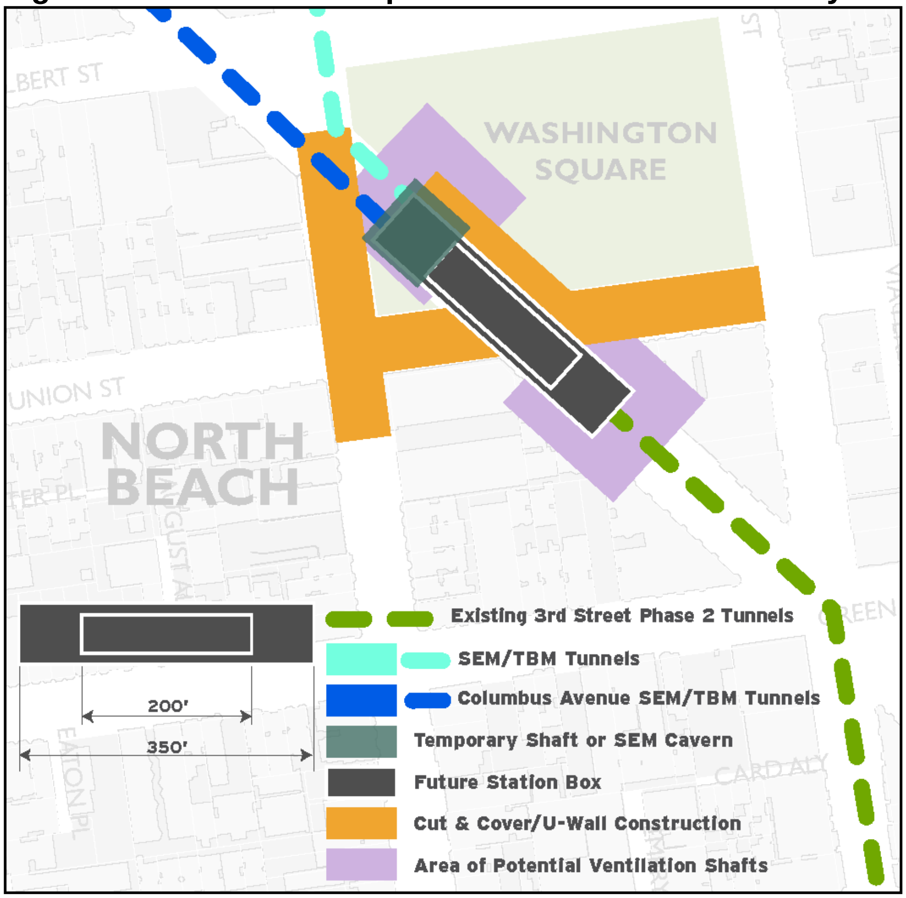
Figure 4-10 Plan view of potential North Beach subway station



***Note: Areas indicated for Cut and Cover/U-wall construction (orange color) and for Potential Ventilation Shafts (purple color) are indicative of the right of way (ROW) requirements in the North Beach Station vicinity in case that the alternative sites are not provided for such purposes (Pagoda Palace Site or any other available neighboring property).**

Entrances, head house and ventilation shafts could be incorporated into the future transit development if desired. Ventilation stacks if stand-alone could become a part of public art (their exhaust/intake components are usually placed minimum 10 feet above street level).

4-3-4-3 SUBWAY TO SURFACE ALIGNMENT CONNECTION

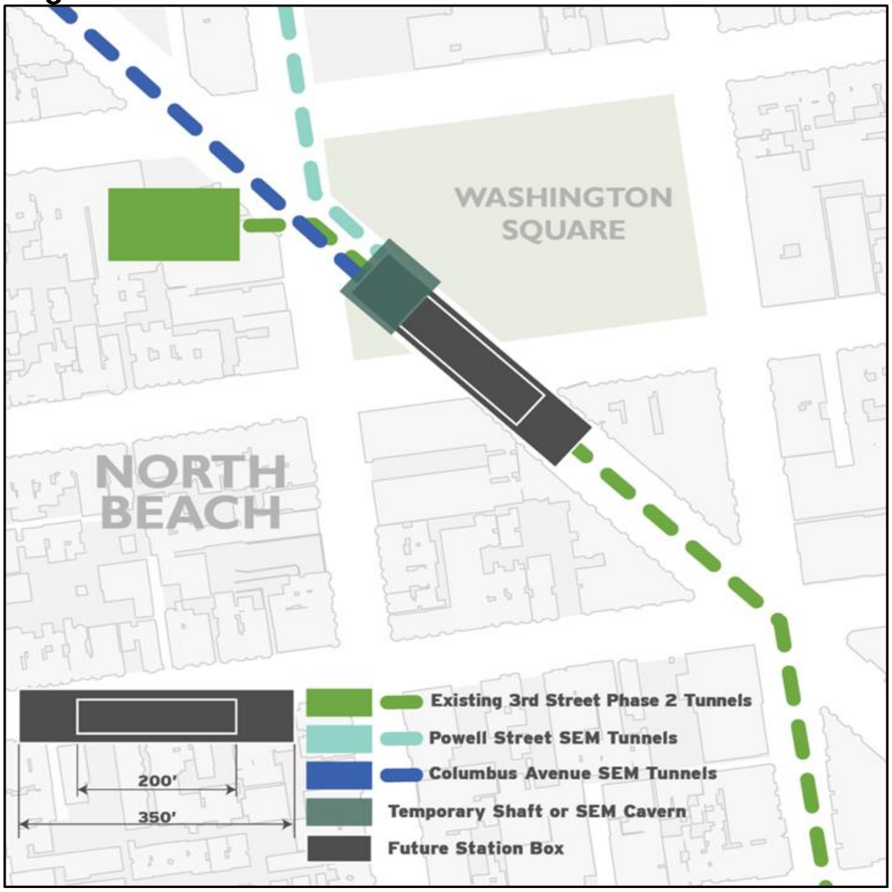
Extending T-Third Phase 2 tracks to meet a surface alignment on Columbus Avenue would likely entail permanent backfilling of the portion of the curved tunnels approaching Pagoda Palace shaft site and demolishing the tunnels within the future station limits. However, contractors could elect to use the shaft along with the portion of the connecting tunnels as temporary access to the excavations beneath Columbus Avenue. Construction of a North Beach Station could utilize cut and cover construction for the future station box. See Figure 4-10. Once built, such a shaft could be decked over for maintenance and protection of traffic and served via Pagoda Palace site.

Alternatively and similarly to deep tunnel alignment options along Columbus Avenue and Powell Street, if a station box construction at North Beach is delayed for any reason, or it is not a preferred construction method, a sequential excavation method (SEM) cavern could be provided in lieu of the Columbus Avenue shaft, without opening Columbus Avenue. This cavern would be constructed and serviced through the existing

Pagoda shaft and the existing or new service tunnels. From this cavern, the individual SEM tunnels would be extended northward.

The existing tunnels would connect to the station box or SEM cavern beneath Union and Filbert Streets. The new tunnels could be constructed from the northern station box (or SEM cavern) wall where a sequential excavation method (SEM) would be implemented for starting new SEM tunnel excavations further north along Columbus Avenue or Powell Street. Due to a relatively short length of these tunnels use of tunnel boring machine (TBM) is not considered practical since procuring the machine would likely take 9 to 12 months and by such time SEM tunnel construction could be well advanced. See Figure 4-11.

Figure 4-11 Plan View of Connection of Existing Tunnels to Extension Alignments and Creation of a North Beach Station Box



The SEM tunnels would continue into cut and cover and U-section construction at the portal locations, for either Columbus Avenue or Powell Street routes. The Columbus Avenue shaft or SEM cavern within a future station could be positioned to meet any northern extension route, either along Powell Street or Columbus Avenue. The station positioning should include generally 200-foot long platforms tangentially placed along the track alignment with sufficient approaching track lengths. It is likely that SEM cavern option would entail deepening the existing tracks to achieve the sufficient cover for the SEM construction.

Portal locations could vary depending on the adopted grades and/or to minimize street traffic and community impacts. In order to avoid the impacts to the existing cable car route along Columbus Avenue, it seems possible to place the tunnel portal north of Chestnut Street and complete the U-section construction south of Francisco Street using maximum ascending track grades within the portal zone. Along Powell Street, the portal is possible north of Filbert Street due to sharply descending street grade. Instead of constructing the SEM tunnels from the north station wall, cut and cover construction for the tunnel portions is possible. This would entail decked, staged construction for maintenance and protection of traffic. The utilities would have to be either protected, relocated, or supported in place.

<u>4-3-4-4 SUBWAY TO SUBWAY ALIGNMENT CONNECTION</u>

Extending T-Third-Phase 2 (Central Subway) tracks to meet the subsurface, or subway alternatives along Powell Street and Columbus Avenue would also entail permanent backfilling of the portion of the curved tunnel alignment approaching Pagoda Palace shaft site and demolishing the tunnels within the limits of the future station box or SEM cavern. Similarly to the surface alternatives, constructing another shaft or SEM cavern beneath Columbus Avenue at the location of potential North Beach Station is possible, where the TBM would be assembled and then launched to undertake either the Columbus Avenue or the Powell Street route. Use of the TBMs would result in the use of the Pagoda Shaft site as a staging and access area if possible.

Alternatively, in case the station construction is delayed, the existing tunnels could be used as approach tunnels to a future excavation of an enlarged SEM tunnel (cavern), from where the machines could be launched after they have been lowered in manageable parts from either Pagoda Palace shaft site or the adjacent station and assembled within this SEM area. Similar logistics would apply if the TBMs are launched from other locations, (e.g. Conrad Square or Kirkland Yard access shafts). Construction of an enlarged SEM tunnel (cavern) would need to be constructed such that the TBMs could be received within the constructed enlargements. In another alternative, in the case of north-south TBM route(s), the machines would be received at a potential shaft constructed within the limits of the future North Beach Station.

The Columbus Avenue shaft or SEM cavern within a future station limits could be positioned to meet any deep northern extension route, either along Powell Street or Columbus Avenue. The station positioning should include generally 200-foot long platforms tangentially placed along the track alignment with sufficient approaching track lengths. It is likely that SEM cavern option would entail deepening the existing tracks to achieve the sufficient cover for the SEM construction and may include ground improvement.

4-3-5 Conrad Square and Kirkland Station Constructability Issues

Constructability issues at the potential Conrad Square and Kirkland Yard station locations have some similarities to those present in North Beach, but these site also have issues unique to their locations.

4-3-5-1 ISSUES AFFECTING STATIONS AT CONRAD SQUARE AND KIRKLAND

The existing subsurface conditions and the fact that the existing North Shore Consolidated Outfalls tunnel (N2) runs beneath North Point Street between Conrad Square (Leavenworth and Columbus) and the Embarcadero, would generally impact the location of both Kirkland Yard and Conrad Square Stations, as well as the final selection of feasible tunnel profiles. N2 sewer tunnel has an invert at approximately 36 feet below grade and 12.3 feet excavated diameter.

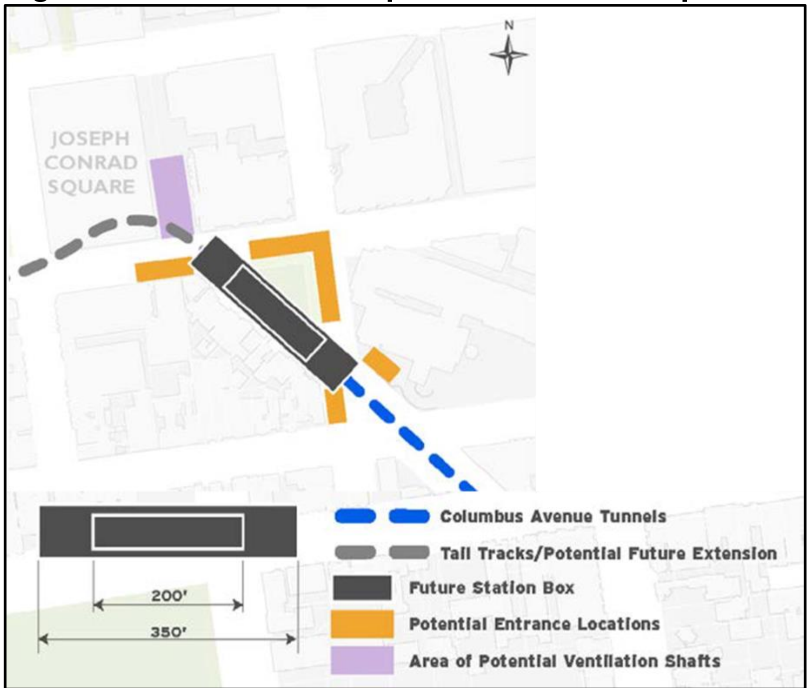
Any potential tunnel option beneath Powell Street and Columbus Avenue will need to have a descending profile in order to connect with the existing T-Third Phase 2 tunnels beneath Columbus Avenue at Washington Square, and pass beneath the N2 tunnel allowing for a minimum clearance generally of 8-10 feet, the elevation at which the tracks would meet the Kirkland Yard or Conrad Square Stations would be approximately 60 feet below street level for Kirkland Yard Station and possibly 70 feet below street level for Conrad Square Station. Both Stations are close to the bay shore line with high groundwater level elevation possibly close to a sea level.

Construction methods would be similar as described for North Beach station box. Watertight and braced support of excavation would need to be installed mostly through the fill and Bay Mud and may encounter old deposits at the bottom of the excavation underlain by Franciscan Complex bedrock. In case of deeper Bay Mud layer it is likely that the invert stability of the excavation would be an issue and in such case ground improvement methods would need to be implemented such as jet grouting to close the excavation box and provide for its stability. Constructability consideration is likely that a cut and cover decked and braced top-down or bottom up excavation would be implemented followed by permanent structures build-out after invert stabilization was achieved. The selection of top down or bottom up will be a potential future study.

4-3-5-2 ISSUES AFFECTING A STATION AT CONRAD SQUARE

Conrad Square Station location would face similar constrains as Kirkland Yard Station in terms of impacts of N2 tunnel. The station would need to be placed along Columbus Avenue north of North Point Street and would possibly encroach into the Beach street right of way. See Figure 4.12.

Figure 4-12 Plan view of potential Conrad Square subway station



***Note: Areas indicated for entrances (Cut and Cover/U-wall construction--orange color) and for Potential Ventilation Shafts (purple color) are indicative of the right of way (ROW) requirements for such purposes in the station vicinity and subject to change.**

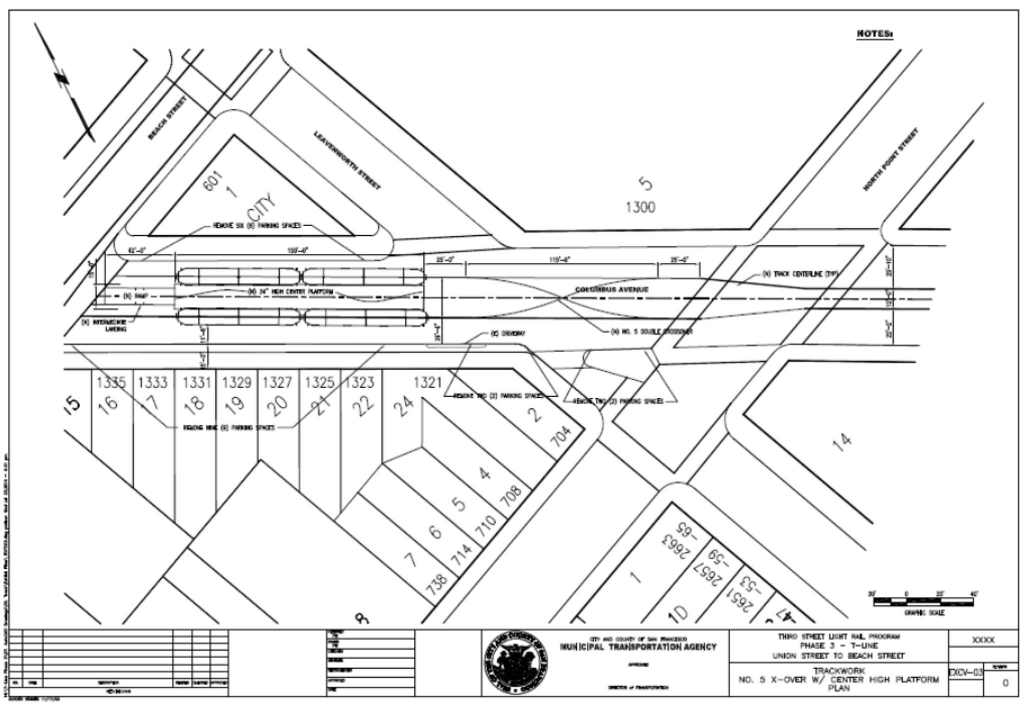
Entrances and ventilation shafts could be incorporated into the future transit development. Ventilation stacks if stand-alone could become part of the public art (their exhaust/intake components are usually placed minimum 10 feet above street level). Ventilation stacks location on this figure is indicative only; the stacks would need to be located on both sides of the station box and placed on available public or private parcel (additional right-of-

The station would need to be placed beneath Beach Street to the north for any deep alternative alignment extending from Powell Street to Conrad Square along Beach Street. It is likely that any of these two potential locations would utilize Conrad Square park or any available right of way to position ventilation shafts while entrances could reside along the sidewalks or at locations where parallel parking exist. As ventilation shafts are not desirable in public rights-of-way, consideration would be given to work with private property owners to locate shafts away from the park area. Any consideration of Conrad Station positioning would need to contemplate on potential improvements to Conrad Square as portrayed in Final Amended Mitigated Negative Declaration, Fisherman's Wharf Public Realm Plan Project, and aim to meet the final improved configuration of the square while potentially allowing for temporary construction impacts during the station construction.

If Conrad Square is contemplated as a terminal station, it would be possible to construct tail tracks beyond the station box to align with potential track extension layouts in the future to the west or the south-west. Similarly, any consideration of a cross-over prior to terminal station would extend the station box for 200-300 feet, depending of the cross—over size, which would be hard to accomplish beneath Columbus Avenue due to N2 tunnel constraint. In such case it is possible that an SEM cavern construction, or an additional cut and cover construction, would be assessed beneath Columbus Avenue between Washington Square and Conrad Square to allow for a cross-over. For SEM cavern, such construction would be possibly accompanied with the ground improvement to control the groundwater during the excavation, depending on actual geological conditions at a selected location.

A draft of a conceptual stub end layout for a surface station / terminal at Conrad Square for service via Columbus Avenue was prepared by SFMTA staff to assess feasibility. See Figure 4-13. A surface loop terminal is not feasible. Neither a stub end nor a loop terminal is feasible via direct access Beach Street. The only viable surface option terminal for service via Beach Street requires the surface tracks to access Conrad Square via Jones Street and North Point Streets to allow a stub end terminal and station that is the same as the design utilized by access from service on Columbus Avenue. Although it appears feasible, the tight space constraints and single cross-over track provide a less than optimal station and terminal. The design also does not allow for additional storage track to accommodate more than two trains at one time unless additional roadway is taken from mixed traffic use in the Conrad Square area.

Figure 4-13 Plan view of potential Conrad Square surface station



4-3-5-3 ISSUES AFFECTING A STATION AT KIRKLAND

Kirkland Yard Station would likely be positioned along Powell Street north of North Point Street and might reach the right of way of Beach Street. See Figure 4.14.

Figure 4-14 Plan view of potential Kirkland Yard subway station

***Note: Areas indicated for entrances (Cut and Cover/U-wall construction--orange color) and for Potential Ventilation Shafts (purple color) are indicative of the right of way (ROW) requirements for such purposes in the station vicinity and are subject to change.**

Entrances and ventilation shafts could be incorporated into the future transit development. Ventilation stacks if stand-alone could become part of the public art (their exhaust/intake

Convenience of Kirkland Yard to house the station appurtenant structures (entrances, ventilation shafts, station ancillary services including electrical, mechanical and systems) could be utilized to a great extent and would benefit the station constructability. An access shaft could be placed in the yard next to the station box allowing the easier maintenance and protection of traffic during the station box construction beneath the traffic deck.

Depending on different alignment alternatives considered, tail tracks could be extended beyond Powell Street if the station is to be considered a terminal station with no future extension. Alternatively, tail tracks could curve toward Beach Street for allowing for potential future extension. This option will require underground easements under private properties. It should be noted that any terminal station consideration should plan for a cross-over. Generally, placing the cross-over before or after the station platform would extend the station box for a minimum 200 to 300 feet, depending on the type of the cross-over and desired operational speeds. Multiple crossovers at the terminal are desirable to ensure service reliability on a very busy LRT line.

In case of Kirkland Yard Station and considering geometric and subsurface constraints, it is possible that an SEM cavern construction, or an additional cut and cover construction, would be assessed beneath Powell Street between Washington Square and Kirkland Yard to allow for a cross-over. For SEM cavern, such construction would be possibly accompanied with the ground improvement to control the groundwater during the excavation, depending on actual geological conditions at a selected location.

A draft of a conceptual stub end layout for a surface station / terminal at Kirkland Yard for service via Powell Street was not prepared by SFMTA staff to assess feasibility, because it is believed the space constraint issues present at Conrad Square are not present at Kirkland.

4-3-6 National Fire Protection Association (NFPA) 130 Compliance

Then National Fire Protection Association (NFPA) has been in existence since 1896. The mission of the international nonprofit NFPA, established in 1896, is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research training and education.

The T-Third Phase 3 Concept Study ‘screening corridor’ includes running tunnels, single or double, depending on the option considered, and at least two stations located at North Beach, Kirkland Yard or Conrad Square that are connected by adjoining tunnels. Tunnel and station ventilation and smoke extraction systems as well as provision for fire life safety egress are essential elements of underground system and need to comply with NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems. General NFPA compliance for all components: tunnels, stations, vehicles and any storage/maintenance areas are required and should be subject of later studies.

The ventilation systems requirements for an underground guideway depend on many variables, including the cross sectional area, length, provision of cross passages or dividing wall, and design fire load. The tunnel environment is mainly driven by the aerothermodynamics features of trains, passengers, ambient and ground conditions, electromechanical equipment, as well as station and tunnel interfaces. This interaction

shows cyclic patterns on three timescales: yearly seasonal, daily peak/off-peak, and train headways. These factors need to be studied to arrive at a successful ventilation system that addresses the build-up within the tunnels of smoke and heat from fires during emergency conditions, the build-up of rejected heat from the trains during normal and congested operating conditions, and maintenance (diesel) vehicle exhaust (if any) during maintenance operations. The airflow rate capacity for the tunnels is determined by the train configuration, fire load, and tunnel geometry (area, height, and grade).
as set by international standards and best practices.

The tunnel safety passenger egress from the train on fire would entail construction of cross-passages or exits to the street as follows:
For a twin (double) running tunnels scheme, considering NFPA 130 requirements:

- Between North Beach Station and Kirkland Yard Station/Safety Egress and Kirkland Yard Station/Safety Egress and Conrad Square Station, no cross passages would be required if the distances between the surface egress points are less than 2500 feet.
- Between North Beach Station and Conrad Square station along Columbus Avenue one cross-passages at a minimum would be required since the distance between these two surface egress points exceeds 2500 feet. If two cross-passages are constructed they should not be spaced closer than 800 feet.

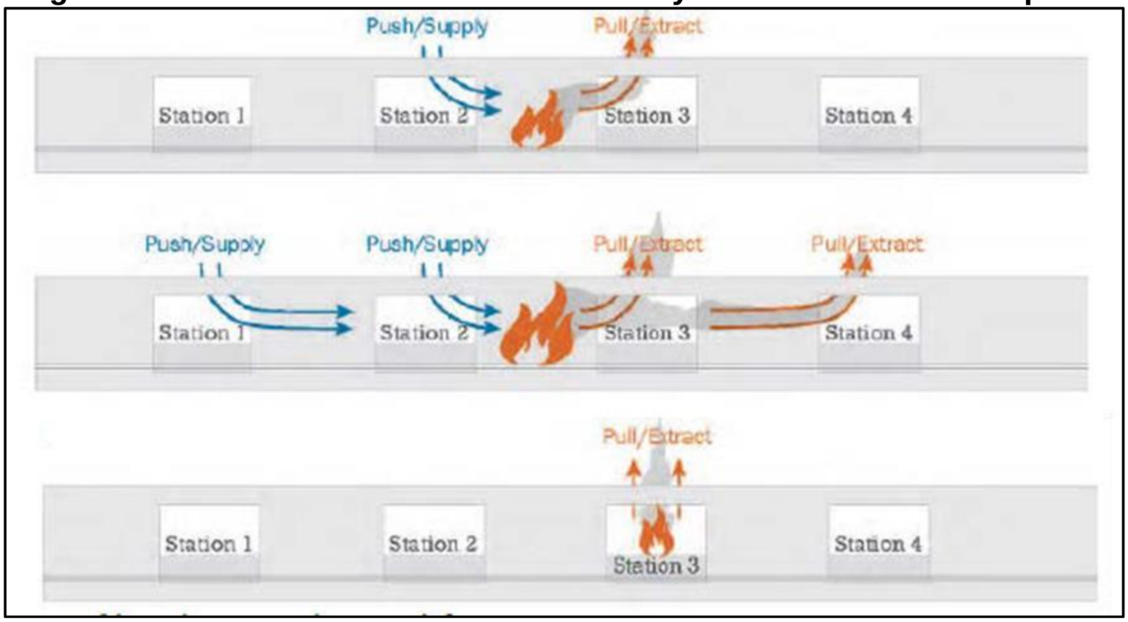
Considering the cross-passage pattern construction for T Third Phase 2 (Central Subway) project, it appears that more stringent requirements are adopted by Central Subway design criteria requiring cross-passage construction between the bored tunnels at distances not larger than 800 feet. This approach has been used herein for cost estimating purposes as well.

For One-Way Loop options (or any potential consideration of single track ‘shuttle’ options) emergency egress to the surface would be required at all three points of the ‘screening triangle’ at a minimum; also, an additional egress would likely be required between Conrad Square and North Beach Stations/egress points.

The fire and smoke control strategy for the stations — types of fire scenarios, integration of existing and new stations into a system that is able to control smoke exhaust flow rates, location of entrances, stairs and escalators, as well as fresh air paths in relation to egress paths for evacuating passengers — both informs and is impacted by the station architecture. Therefore, a station configuration needs to be studied to properly respond to all these factors. Also, existing and new stations ventilation need to be integrated into a system that can respond to emergency situation within the underground guideway, tunnels and stations and manage the heat and smoke originating from a design fire event in accordance with NFPA 130 using either push-pull or pull-pull system. See Figure 4-15.

The outcome of these standards is that only one train at a time in each direction is allowed between Central Subway stations – even if more could be operated using advanced train control, because of fire safety regulations. This does not appear to be an issue when trains are on schedule, but when a train is late inadequate spacing between trains would result in trains backing up at the northbound tunnel portal. The Market Street Subway is not impacted by the NFPA standards, because it was built before the most recent standards were adopted.

Figure 4-15 Push-Pull and Pull-Pull Subway Fire Ventilation Examples



Within each station, facilities need to be provided to assure fan plant capacities, and ventilation shafts and ducts need to be sized for optimum capacities required to manage the most critical ventilation and fire life safety scenario-- usually emergency conditions of a train on fire; they would need to be brought to the surface within the designated right of way within the station area.

The previous sub-section, Section 4-3-4, presents potential station locations for general feasibility screening purposes along with general area that could be designated for station ventilation appurtenances (ducts, shafts) and entrances; these need to be subject of a further study where available right of way would be confirmed.

4-4 UTILITIES INFORMATION

Three primary alignments along with station locations were reviewed for their impacts to the existing utility infrastructure. To obtain the information necessary to evaluate the various impacts to the existing utilities, a Notice of Intent (NOI) was sent to all public and private utility agencies. A list of agencies that were contacted to obtain utility drawings and information is included in Appendix D.

A total of six utilities were analyzed: 1) Low Pressure Water System, 2) Auxiliary Water Supply System, 3) Combined Storm / Sewer System, 4) Electrical System, 5) Telecommunication / Data systems, and 6) Gas System. The utilities were reviewed and analyzed to determine how they might be affected from the proposed track alignment options, and proposed track construction methods. Each utility was assessed for three main categories and risk evaluations which were, cost, schedule and constructability.

4-4-1 Utilities Evaluation – Surface Track and Shallow Track

In general, all utility agencies will require their utility systems be relocated outside the track alignment when surface or shallow track is being proposed. This is to facilitate maintenance or emergency repairs to the utility systems without interrupting the transit service. If there is no separation between utilities system and LRT tracks, it may be very costly and have significant impact to the operations of both the utility agencies and the SFMTA.

Some dry utility systems may allow for their facilities to be buried underneath surface tracks, as long as their utility structures and vaults are located outside the limits of the tracks.

4-4-2 Utilities Evaluation – Subway Track – 20' + Below Ground

For subway track segments that are more than 20' below ground, individual utility systems should be evaluated on the options to remain protected in place, modified or relocated. Construction method can greatly impact and determine how a utility system will be affected. The two main construction methods being evaluated for the below ground subway track are tunneling and cut and cover (or open cut) construction.

If a subway track is being constructed by means of tunneling, the impact to utilities is greatly reduced. Although other factors can still trigger relocation of the utilities, however, the main concern will be vibrations and ground settlement during tunneling construction. If cut and cover (or open cut) construction method is used, each utility system will need to be evaluated for possibility of the following options: a) remain and protected in place, b) modified and protected in place, c) relocate.

Protection of utilities in place is the easiest approach with the least impact on the overall utility system. However keeping utilities in place may require additional construction sequencing, scheduling and costs to work around the utility. Utilities that require modification should undergo the modification if possible prior to being allowed to remain in place during construction. Relocation is generally the most expensive and difficult, and is generally limited to utilities that will interfere with the construction or be in conflict with future improvements.

The decision for protection options is often based on the following issues: vibration, interruption to service laterals, and operations and maintenance. Older utility facilities and structures are more susceptible to vibrations and may need replacement, repair or reinforcement in order to withstand the vibrations incurred. In other situations the utility may be able to withstand the vibrations, but will need to be monitored for any substantial movement in order to proactively anticipate any potential damage to the utility system. Of particular concern are old cast-iron water mains or clay pipes that are susceptible to vibrations. The number of service laterals that are involved with a utility system and require to be interrupted during construction all will directly impact the cost of the utility system as well as the schedule. The more utility laterals that are affected, the more construction phasing will be required, and the greater coordination with individual property owners will be required to allow for service interruptions. The operation and maintenance of an individual utility system will depend on the type of material used and age of the utility system, sensitivity to construction vibration and the flexibility available within the utility system to allow for construction phasing. Evaluating each of the above criteria will directly impact the cost, schedule and constructability.

4-4-3 Utility Systems Evaluation

The six utility systems were evaluated from a general constructability, cost and schedule feasibility study based on the various methods of construction. In order to determine the risk associated with each option, as they relate to the different utility systems, they were evaluated based on the following five criteria: 1) age and type of material, 2) sensitivity, 3) construction method, 4) flexibility of existing system, and 5) building service laterals.

Table 4-3 Low Pressure Water System

Age and Material	Age varies, but some are over 100 years old. Ductile iron, welded steel, cast iron materials.
Sensitivity	Pressurized – sensitive to large vibrations and settlements – watch closely during construction for leaks.
Construction Method	Suspended in place with significant supports when needed.
Flexibility	Very flexible, easily relocated without greatly impacting system, also serves fire hydrants, so plans to relocate must be reviewed by SFFD.
Building Service Laterals	Numerous building laterals, requires significant sequencing, property owner coordination, and phased construction to maintain services. These actions will impact schedule and cost.

Figure 4-16 Low Pressure Water System Map

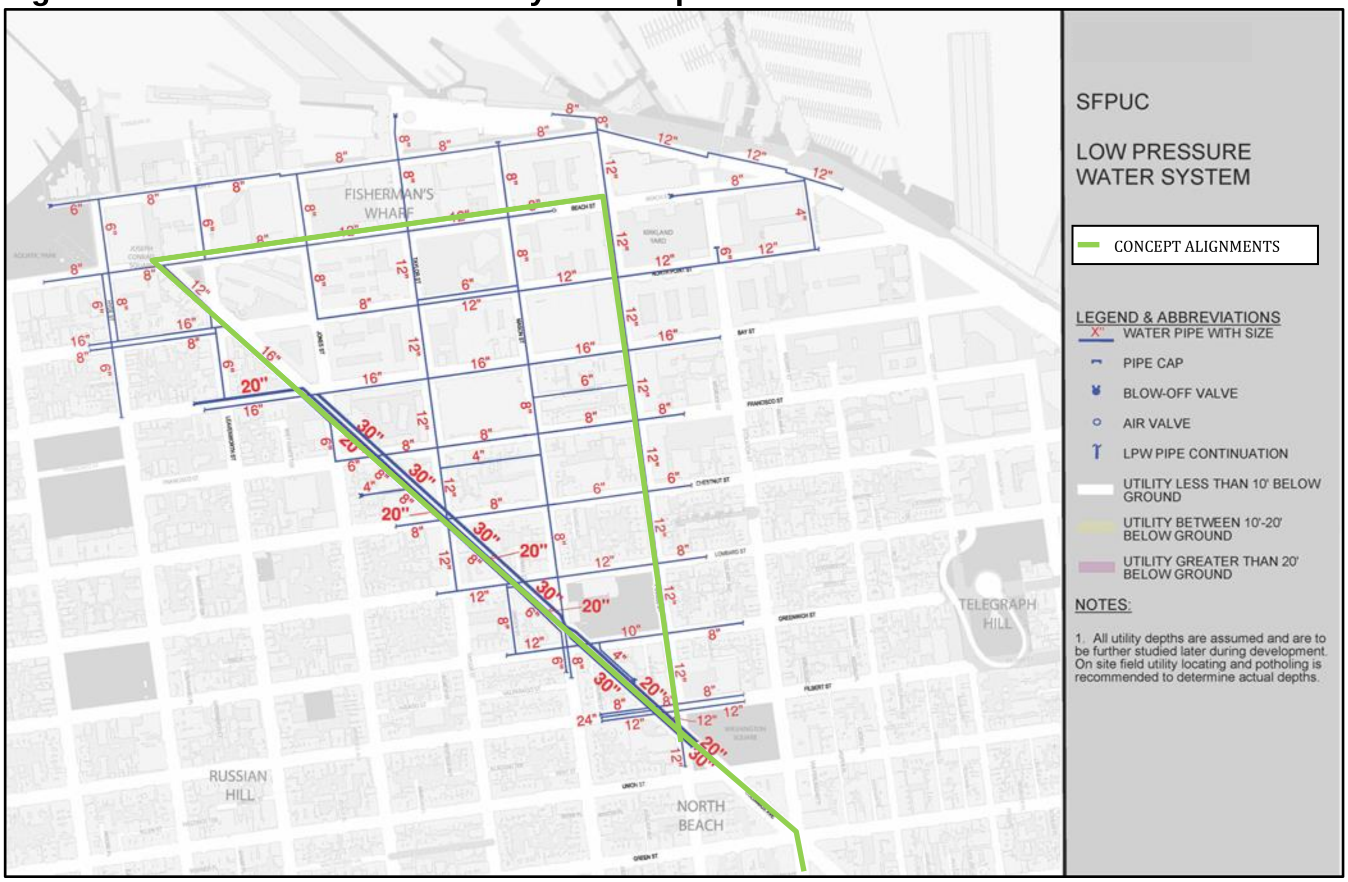


Table 4-4 Auxiliary Water Supply System

Age and Material	Age varies, but much built before 1920. Ductile iron, cast iron materials.
Sensitivity	High pressure - Highly sensitive to vibrations. Typical large transit projects have replaced a portion of the system. Replacement is expensive and slow.
Construction Method	Cannot be suspended during construction– requires access from surface streets, so it cannot be built under tracks, also there are cisterns and valves that require access.
Flexibility	Partially flexible, but not easily relocated without compromising the system, special fire hydrants, etc. require working with SFFD to ensure fire coverage is maintained.
Building Service Laterals	Zero building laterals – no sequencing or coordination required.

Figure 4-17 Auxiliary Water Supply System Map

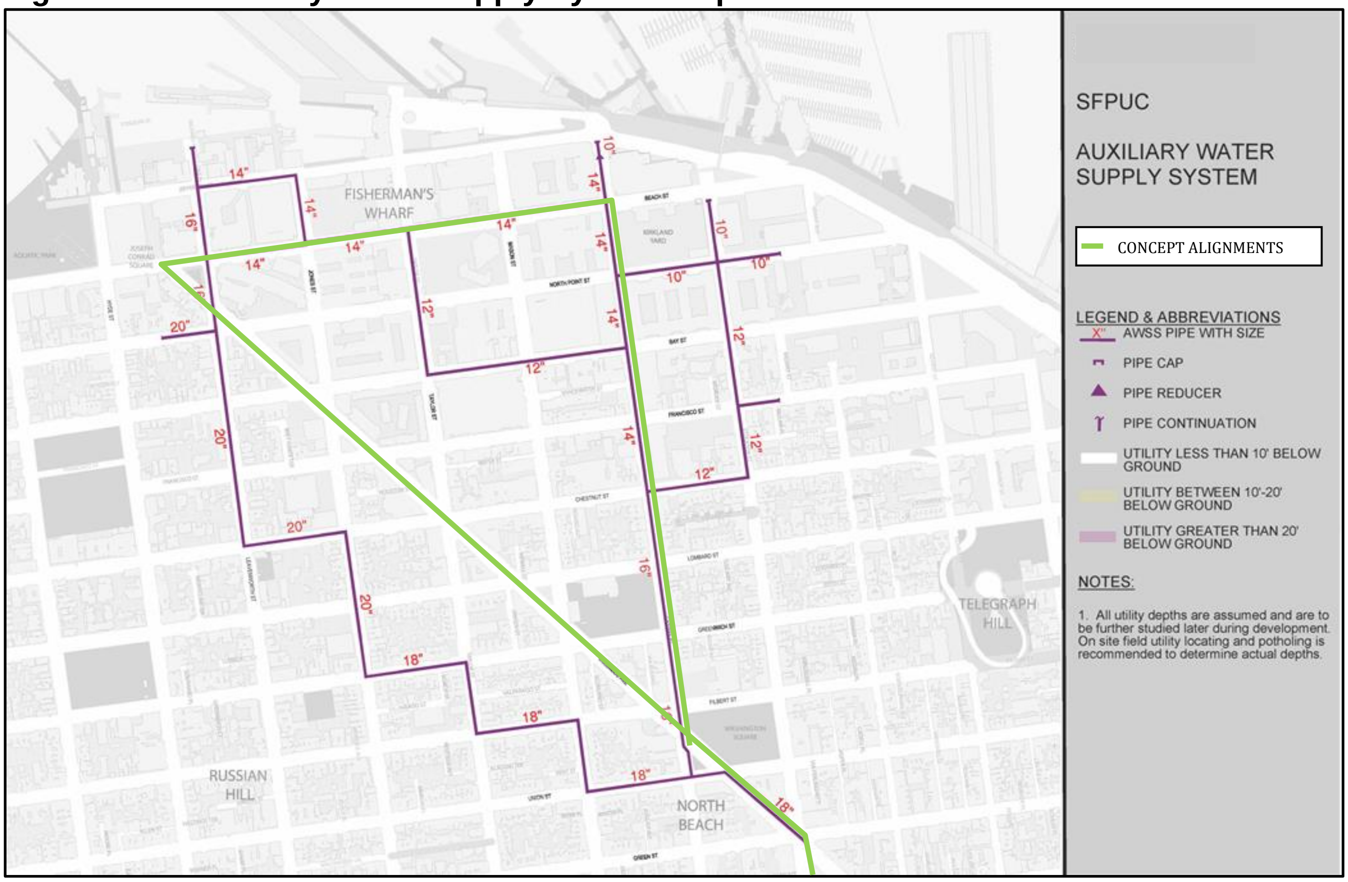


Table 4-5 Combined Storm and Sewer System

Age and Material	Age varies from very old to modern. Clay pipe (VCP), concrete, brick, ironstone pipe (ISP).
Sensitivity	High sensitivity, much of clay pipe is brittle, brick pipe is brittle, joints are a concern.
Construction Method	Gravity lines are difficult to suspend in place if needed, sometimes placed into a steel sleeve, temporary bypass lines are sometimes used, cannot relocate. sewers to be located under sidewalks, pipes can be above subway tunnels, and preferred to be located outside the limits of surface tracks to allow access.
Flexibility	Not easy to relocate, gravity system has different issues than a pressurized system, so vertical alignment is an issue, drainage considerations are important when relocating catch basins or drainage structures.
Building Service Laterals	Numerous laterals, significant challenges requiring sequencing, coordination with property owners, and phased construction to maintain services. There will be impacts to schedule and cost due to temporary shut-downs and reconnections of service.

Figure 4-18 Combined Storm and Sewer Map

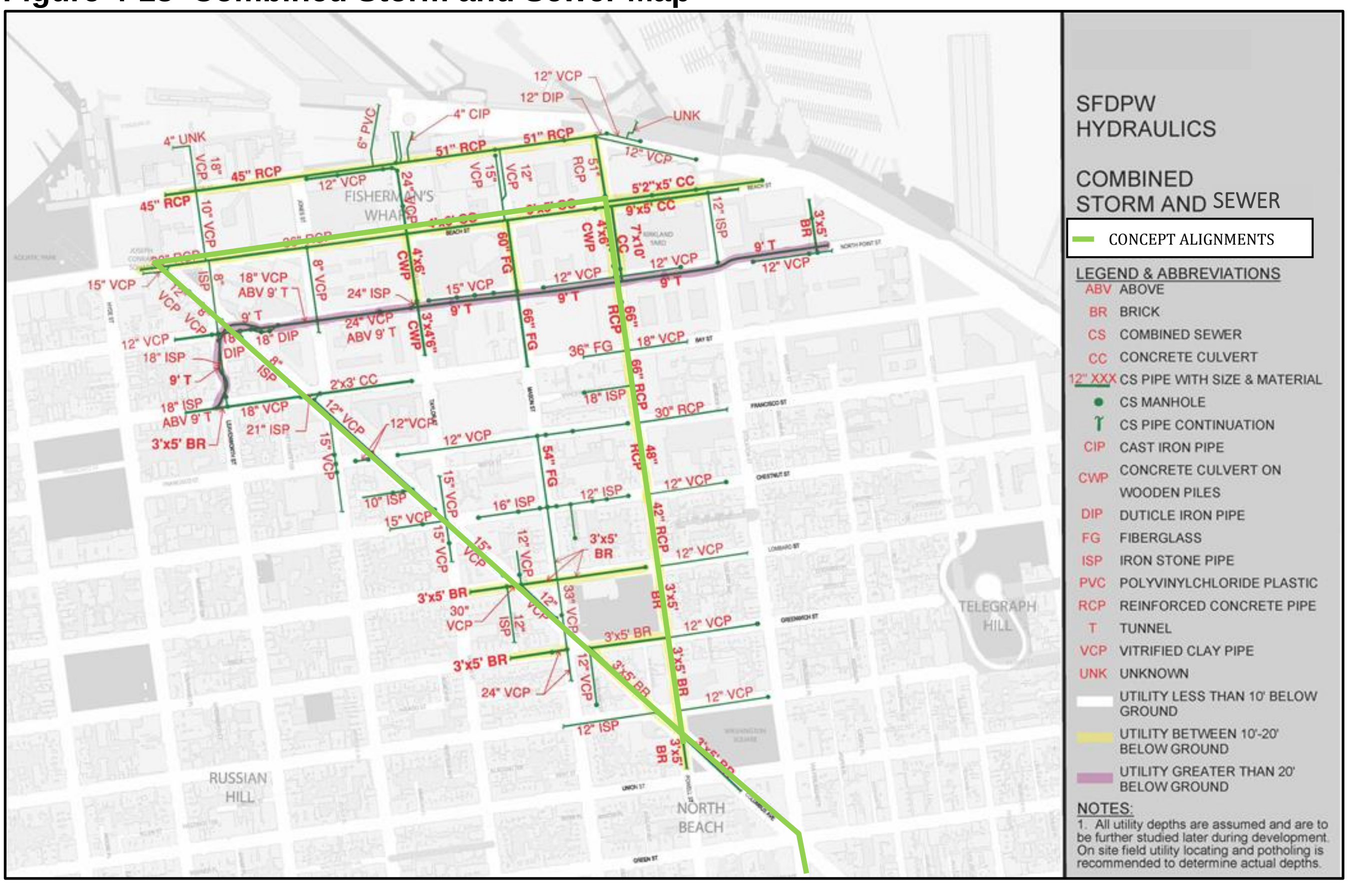


Table 4-6 Electrical System

Age and Material	Combination of PG&E and municipal (street lights) Electrical systems installed in PVC or HDPE conduits, older conduits in concrete, steel, or even wooden duct banks.
Sensitivity	Newer conduits are generally flexible, older conduits are less flexible and may need to be replaced.
Construction Method	Easy to modify to relocate outside of track limits, but care must be taken to keep entire electrical network maintained, which requires temporary shutdowns. Conduits can be suspended in place, electrical systems can be installed in sidewalk area, and in some areas under track installation is allowed. All work must be reviewed on a case by case basis with PG&E.
Flexibility	Easy to modify or relocate, but time required to perform work (cutovers, placement of new wires, conduit, etc.) can be lengthy.
Building Service Laterals	Numerous laterals because all building are connected for electricity. Significant time required to coordinate shut-downs and reconnections to system.

Figure 4-19 Electrical System Map

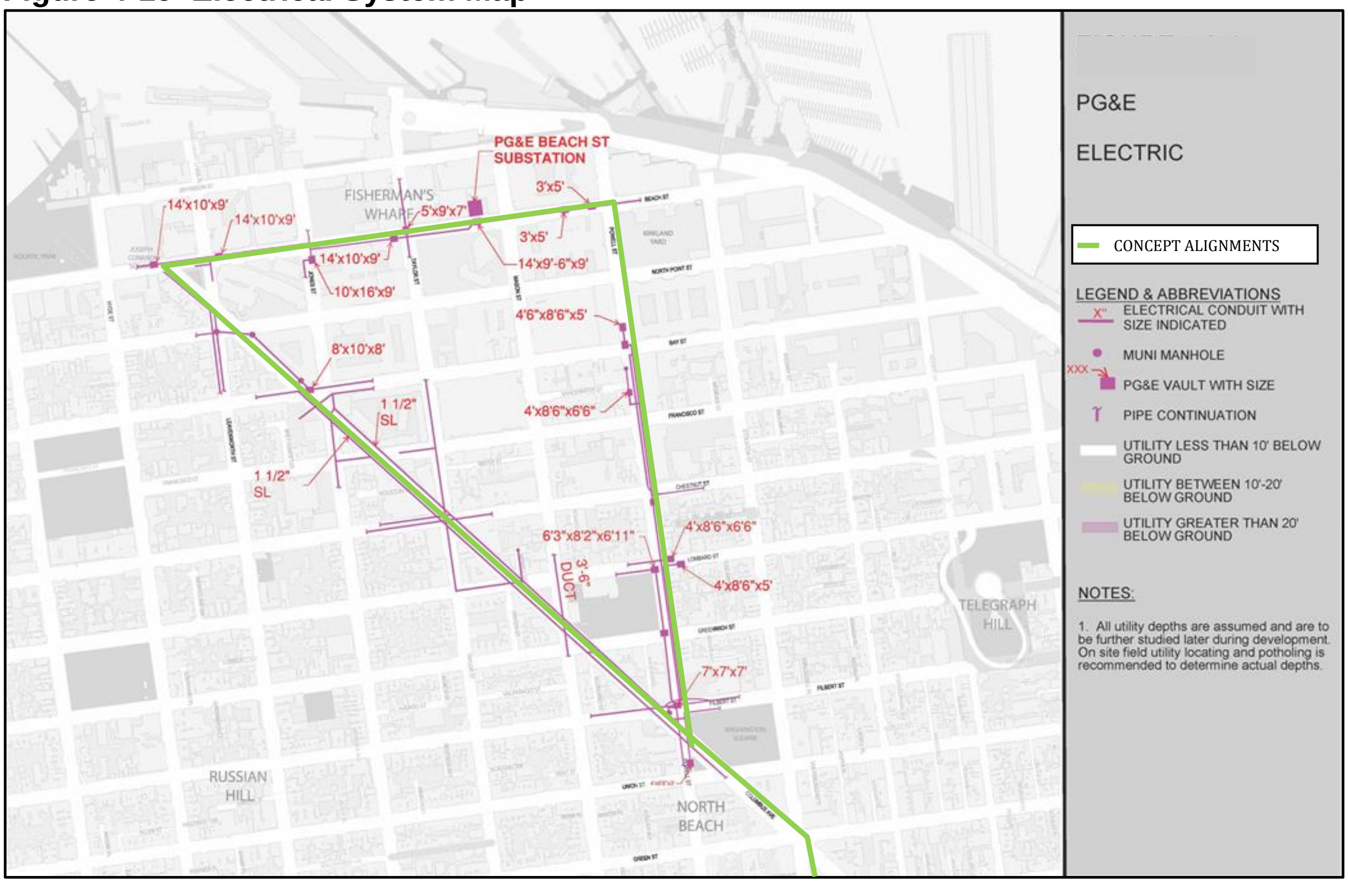


Table 4-7 Telecommunications / Data System

Age and Material	Companies with facilities in study area = AT&T and Comcast. Data systems installed in PVC or HDPE conduits, older conduits in concrete.
Sensitivity	Newer conduits are generally flexible, older conduits are less flexible .
Construction Method	Easy to modify to relocate outside of track limits, but care must be taken to keep entire Tel/Data network maintained, which can require long cutover times. Conduits can be suspended in place, Tel/Data systems can be installed in sidewalk area, and in some areas under track installation is allowed. All work must be reviewed on a case by case basis with the parent utility company.
Flexibility	Not easy to modify or relocate due to very long time (months) a cut-over and reconnection can require. Time to perform work can impact schedule and costs.
Building Service Laterals	Numerous laterals because all building are connected for Tel/Data. Significant time required to coordinate shut-downs and reconnections to system.

Figure 4-20 Telecommunications / Data System Map

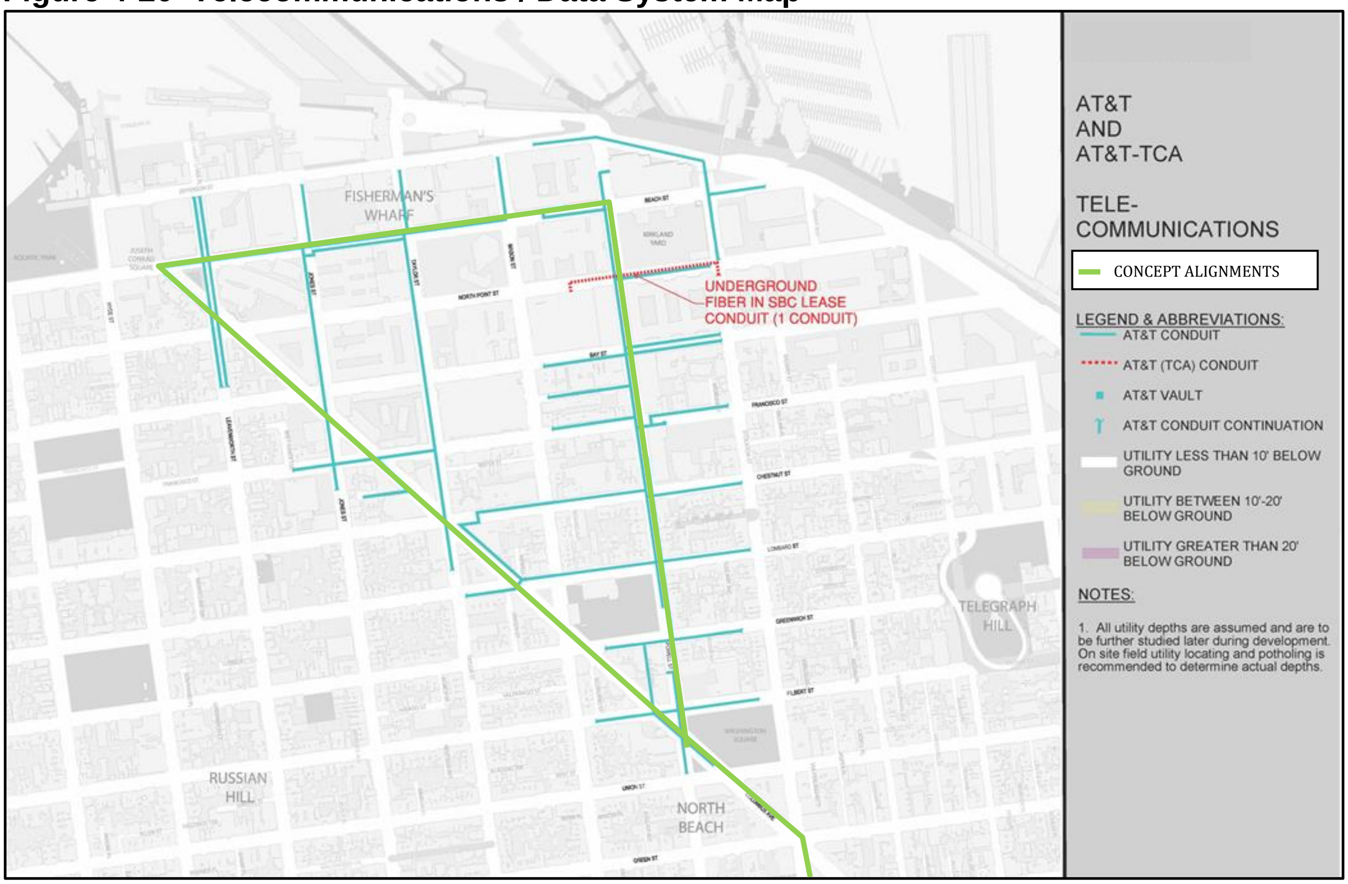
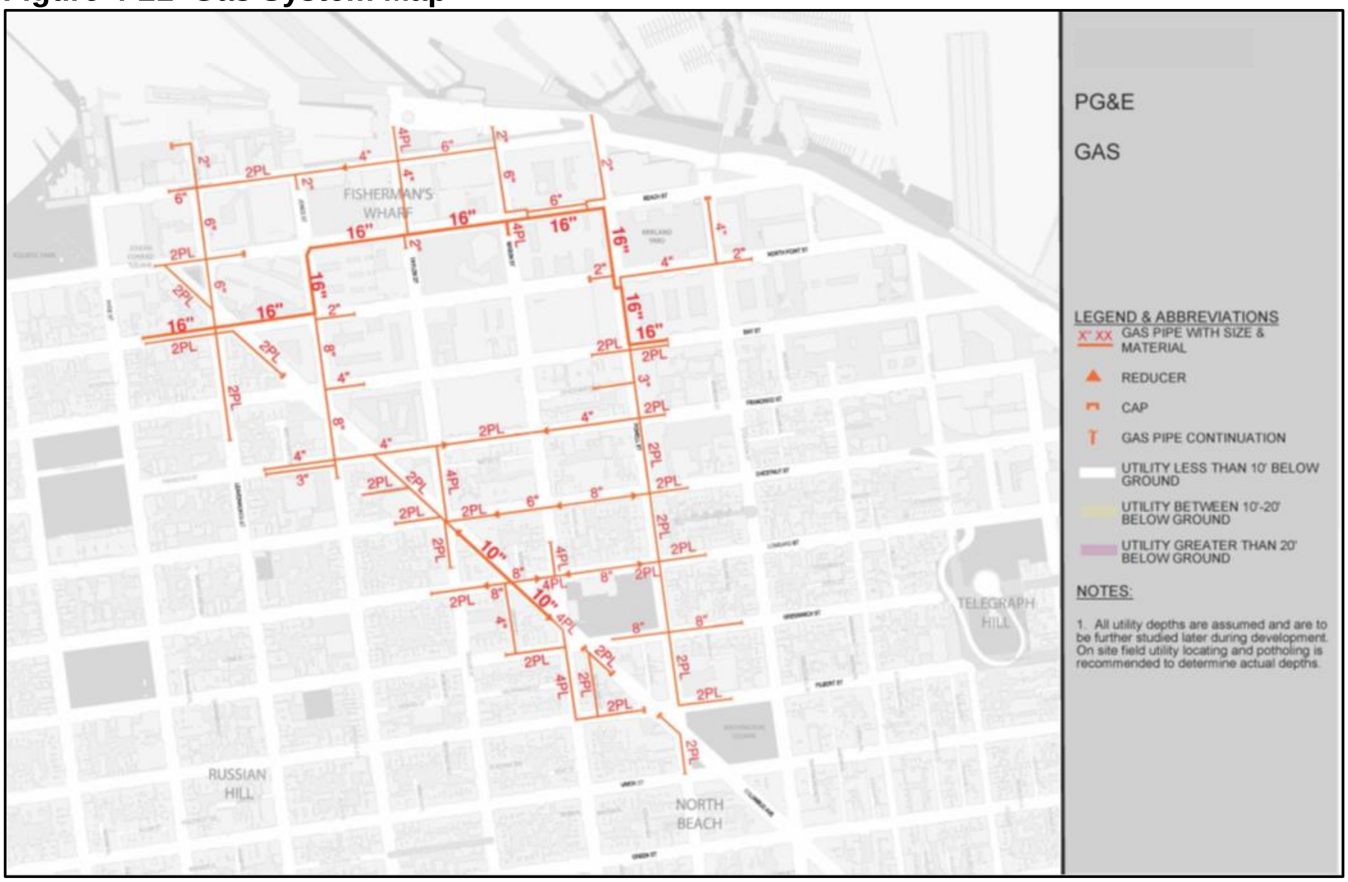


Table 4-8 Gas System

Age and Material	Owned and maintained by PG&E. One main pipe of note is routed via North Point, Beach and Powell. Gas pipes are general installed in MDPE pipe, and sometimes in black steel pipe
Sensitivity	High pressure and very flammable- requires extreme caution. Plastic and steel pipes are flexible and allow for vibrations without impact to system. PG&E should be involved at all steps of process during planning and construction.
Construction Method	Easy to modify to relocate outside of track limits, but care must be taken for safety. Short cut-over times. Gas lines can be suspended in place with adequate support .
Flexibility	Easy to modify or relocate without large impacts to system.
Building Service Laterals	Numerous laterals because all building are connected for Tel/Data. Significant time required to coordinate shut-downs and reconnections to system.

Figure 4-21 Gas System Map



4-4-4 Utility Issues and Concept Alignments Matrix

A summary assessment analysis of utility impacts to concept alignments was performed, although a much more detailed analysis would be necessary in any future planning / design phases of work. Generally, surface alignments had lower cost impacts, constructability issues, and potential schedule impacts than subway alignments. Two pieces of utility infrastructure that impacted multiple concept alignments were the North Point (N2) tunnel sewer pipe, and the 16 inch gas main that runs along Beach, North Point and Powell Streets. The matrix is located in Appendix D.

4-5 SEA LEVEL CHANGE IMPACTS

Over the past century, sea level has risen nearly eight inches (.2 meters) along the California coast, and general circulation model scenarios suggest very substantial increases in sea level as a significant impact of climate change over the coming century. Sea level rise is not expected to result in a high level of permanent inundation in the subject area of this study, but would still increase the risk of coastal flooding and storm surge, increase the size of floods and expand erosion zones.

According to the research from California Climate Change Center, under the medium to medium-high greenhouse-gas emissions scenarios, mean sea level along the California coast is projected to rise from 3.5 to 4.5 feet (1.0 to 1.4 meters) by the year 2100. The amount of sea-level rise will put 480,000 people at risk of a 100-year flooding event. In addition, critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and more will also be at increased risk of inundation.

4-5-1 Flood Impacts

The length of railway mileage in San Francisco vulnerable to a 100-year flood has been estimated to increase by 84% with a sea level rise of 4.5 feet (1.4 meters). The risk of flooding for the T-Third-Phase 3 alignments under consideration includes flooding of surface right of way, flooding of portals and ensuing inundation of the underground facilities, tunnels and stations.

Flooding of street level alignments, resulting in minor damages and temporary disruption of service may be considered as a nuisance rather than serious impairment. However, as the frequency and height of such flooding increase, service interruptions become more frequent, and repairs more costly. Conversely, flooding of underground facilities by water runoff through portals or other openings may present serious consequences in terms of material damages to the structures and systems, and may even present life threatening conditions if adequate precautions are not taken.

The obvious remedy to this type of events is to incorporate into the design tunnels and station hardening measures and an effective drainage system. The hardening measures would include high walls extending out from the portals, flood protection gates, raising ventilation shafts and openings above the flood lines, watertight emergency exits, flood gates at station entrances, etc.

Flooding risk for a given facility is expressed in terms of the probability of occurrence of a design flood, such as a flood level with a 100-year recurrence during the selected lifetime of the facility. The referenced study points to some evidence that in San Francisco the intertidal range was also widening, and the frequency of storminess was also increasing. The former, if confirmed by further studies, could expand the flood zones to be considered, whereas the latter may cause a revision of the design basis flood level.

Assuming that no preventive measures would be taken city-wide to mitigate flooding, such as construction of seawalls or a raised promenade along the Embarcadero, similar to one envisioned for lower Manhattan, the flood prone areas are significant. The impacts of a 100-year flood event combined with a 4.5 foot (1.4 meter) sea level rise show flooding along the entire Embarcadero waterfront area. See Figure 4-22.

Figure 4-22 Projected Sea Level Rise Flooding along The Embarcadero

Based on the distribution of the flooding, it is suggested that Powell Street, having total length of 2900 feet in the project area, is approximately 10 % to 15 % flooded (i.e., at the corner between Beach street and Powell street). Beach street (2500feet) is approximately 50% flooded and Jefferson Street (1900 feet) is mostly flooded. Columbus Ave. (3300 feet) will not be impacted by flooding. The Kirkland Yard Station is exposed to flooding, while the other two potential stations at Conrad Square and North Beach are not impacted by the 100-year flood events.

4-5-2 Groundwater Level Rise Impacts

The permanent state of raised sea level can be expected to affect the depth of groundwater in the coastal areas. This aspect should be taken into consideration for the design of underground tunnels and stations. In summary, the effect of postulated sea level rise does not present an unmanageable condition for the proposed alignments. There is, however, a need to incorporate this aspect into the design of portals and the Kirkland Yard station to positively prevent the inundation of the tunnels and underground stations.

Section 5 – Costs and Funding

5-1 OVERVIEW

The approved Scope of Work required an initial analysis of the capital costs present with a T-Third Phase 3 extension to Fisherman's Wharf, and a listing of potential funding sources that could be considered in the future to pay for the project. A cost-benefit analysis was also required. A special focus on the funding element was analysis of potential "value capture" options present in project study area. The value capture analysis was addressed in section 3, but several value capture concepts are included in the listing of funding concepts in this section.

5-2 CONCEPTUAL COSTS

The FTA Capital Cost Database (CCD) was utilized to generate general Order of Magnitude (GOM) estimates for each concept alignment alternative. The FTA CCD contains "as-built" costs for a sample of light and heavy rail projects, with project costs and unit quantities recorded at the Standard Cost Categories (SCC) level of detail (See Appendix D for SSC definitions).

It should be noted that in addition to the three concept alignment alternatives, a fourth cost estimate was added to capture the costs of North Beach station so it can be analyzed independently. As such, a North Beach station is estimated both as a cut and cover box construction (includes opening the street), and as a cavern construction using segmental excavation method (SEM), a tunneling method performed without opening the street similar to Chinatown Station of T Third Phase 2 project.

All costs are in 2014 dollars, adjusted locally to San Francisco, CA, and to size and scope of each concept alignment. In addition, some of the unit costs were adjusted manually to reflect recent bid prices for tunnel work in the San Francisco area. All costs are based on the total lineal miles of surface or underground guideway, as applicable, including necessary tail tracks as required. Soft costs were added at 49% to account for Professional Services. Finally, a range of values was generated based on FTA guidelines of Probable Accuracy.

Cost estimates for the following concept alignments are based on the following assumptions:

- The yellow rows labeled "C&C" and the green rows labeled "SEM" list designations that refer to the method of construction of the North Beach Station only – and reflect whether the station cost was estimated assuming cut--and-cover box construction, or construction by sequential excavation method.

- The concept alignment stations proposed at Kirkland and Conrad Square are assumed to be constructed using C&C, because use of SEM at these sites would be overwhelmingly impractical, very expensive and risky considering the local ground conditions.
- All deep (subway) options have bored tunnel segments estimated as constructed by tunnel boring machine (TBM).
- All shallow (surface) options have tunnel segments estimated as cut-and-cover box construction.

In the spreadsheet numbers shown below, the following values are shown:

- the first figure shows a value 30% LOWER than the point estimate
- the second figure shows THE POINT ESTIMATE
- the third figure shows a value 50% HIGHER than the point estimate

All cost figures cited in text in the next section are point estimate cost figures. All figures are rounded up to the next million dollar increment. See Appendix D for guidelines and more information.

As a general rule, in the last decade San Francisco construction costs have consistently been in a range between the point estimate and the high estimate.

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5-2-1 Columbus Avenue Alignments to Conrad Square

The cost estimates for the Option 1 Columbus Avenue alignments are shown below. These alignments assume a subway station at North Beach and either a surface or subway station at Conrad Square. The Columbus Avenue alignments range in cost from a low of $407 million for a surface line with cut and cover construction of a station in North Beach, to a high of $933 million for a subway with SEM construction of a station in North Beach.

Figure 5-1 Columbus Avenue (Option 1-to Conrad Square) Concept Alignments Map

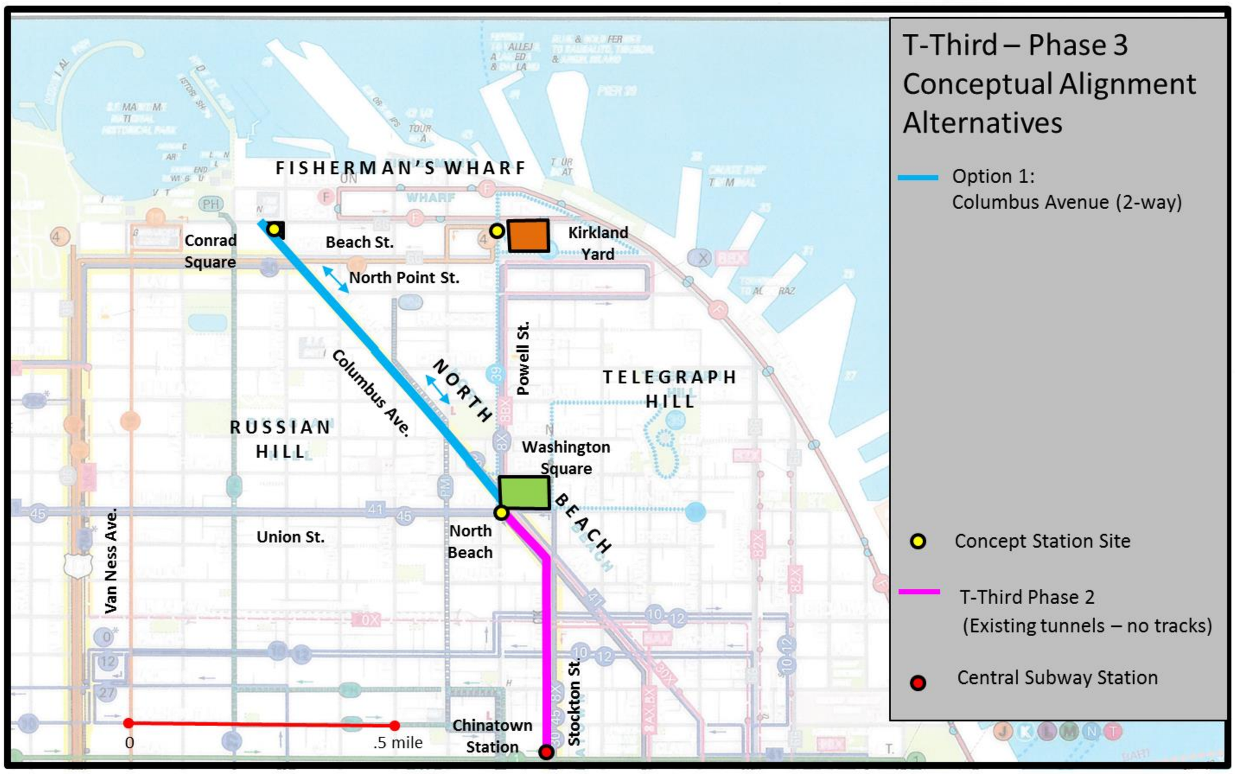

Table 5-1 Columbus Avenue (Option 1-to Conrad Square) Concept Alignment Cost Estimates

Description	Guideway Length in Feet	# of Stations	Low Estimate (-30% from Point) ($000)	Point Estimate ($000	High Estimate (+50% from Point) ($000)
1-1: Surface C&C	4,072	2	312,955	406,841	610,262
1-1: Surface SEM	4,072	2	370,422	481,549	722,323
1-2: Subway C&C	4,072	2	652,232	847,902	1,271,852
1-2: Subway SEM	4,072	2	717,386	932,601	1,398,902

5-2-2 Powell Street Alignments to Kirkland Yard

The costs estimates for the five Powell Street alignments are shown below. These alignments assume a subway station at North Beach and either a surface or a subway station at or near the Kirkland Yard. The first group of Option 2A alignments and costs below are for an alignment that achieves a turnaround on or under the Kirkland Yard site to the greatest extent possible. These alignments range in cost from a low of $368 million for a surface line with cut and cover construction of a station in North Beach, to a high of $912 million for a subway with SEM construction of a station in North Beach.

Figure 5-2 Powell Street (Option 2A-to Kirkland) Concept Alignments Map

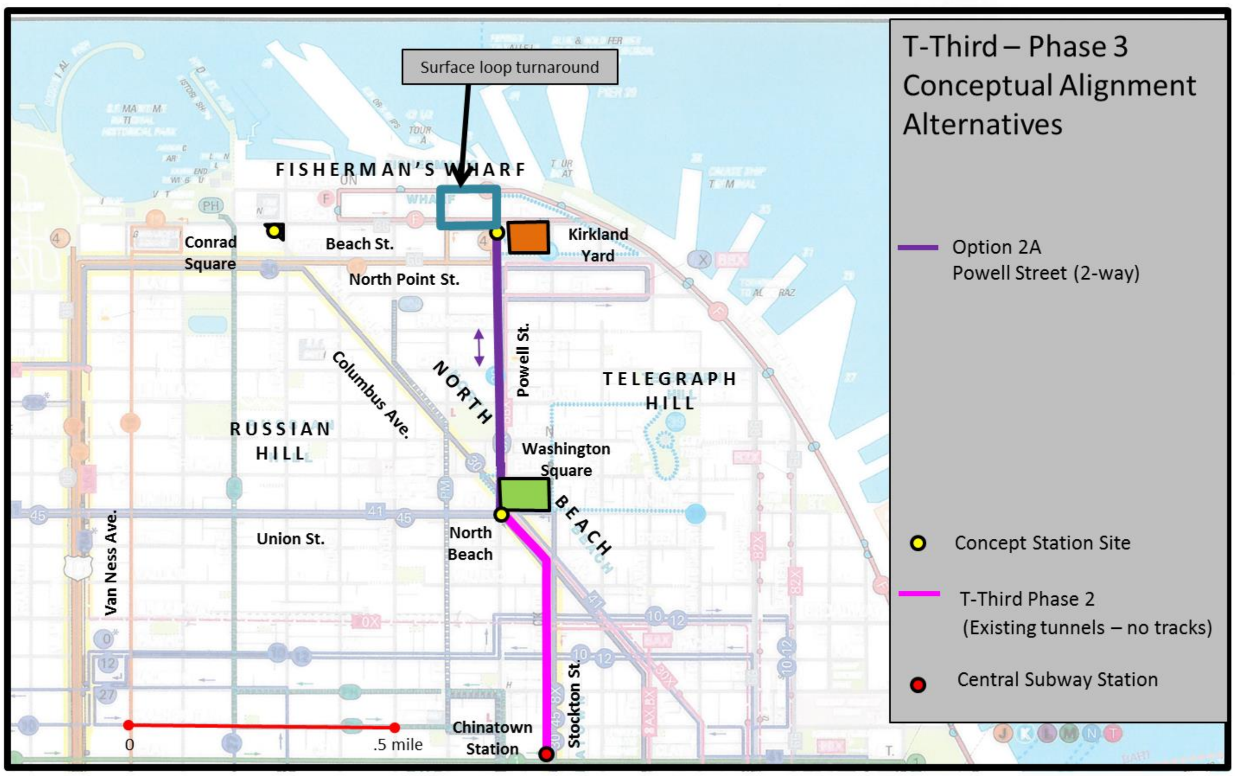

Table 5-2 Powell Street (Option 2A –to Kirkland) Concept Alignment Cost Estimates

Description	Guideway Length in Feet	# of Stations	Low Estimate (-30% from Point) ($000)	Point Estimate ($000	High Estimate (+50% from Point) ($000)
2A-1: Surface C&C	3,602	2	282,340	367,043	550,564
2A-1: Surface SEM	3,602	2	339,808	441,750	662,625
2A-2: Subway C&C	3,611	2	643,511	836,564	1,254,846
2A-2: Subway SEM	3,611	2	700,978	911,272	1,366,907

The second group of Option 2A alignments and costs below are for an alignment that achieves a turnaround by utilizing a short surface loop via Powell, Jefferson, Mason and Beach Streets back to the Kirkland Yard. These alignments range in cost (point cost) from a low of $405 million for a surface line with cut and cover construction of a station in North Beach, to a high of $950 million for a subway with SEM construction of a station in North Beach.

Figure 5-3 Powell Street (Option 2A-to Kirkland w/ Short Loop) Concept Alignments Map

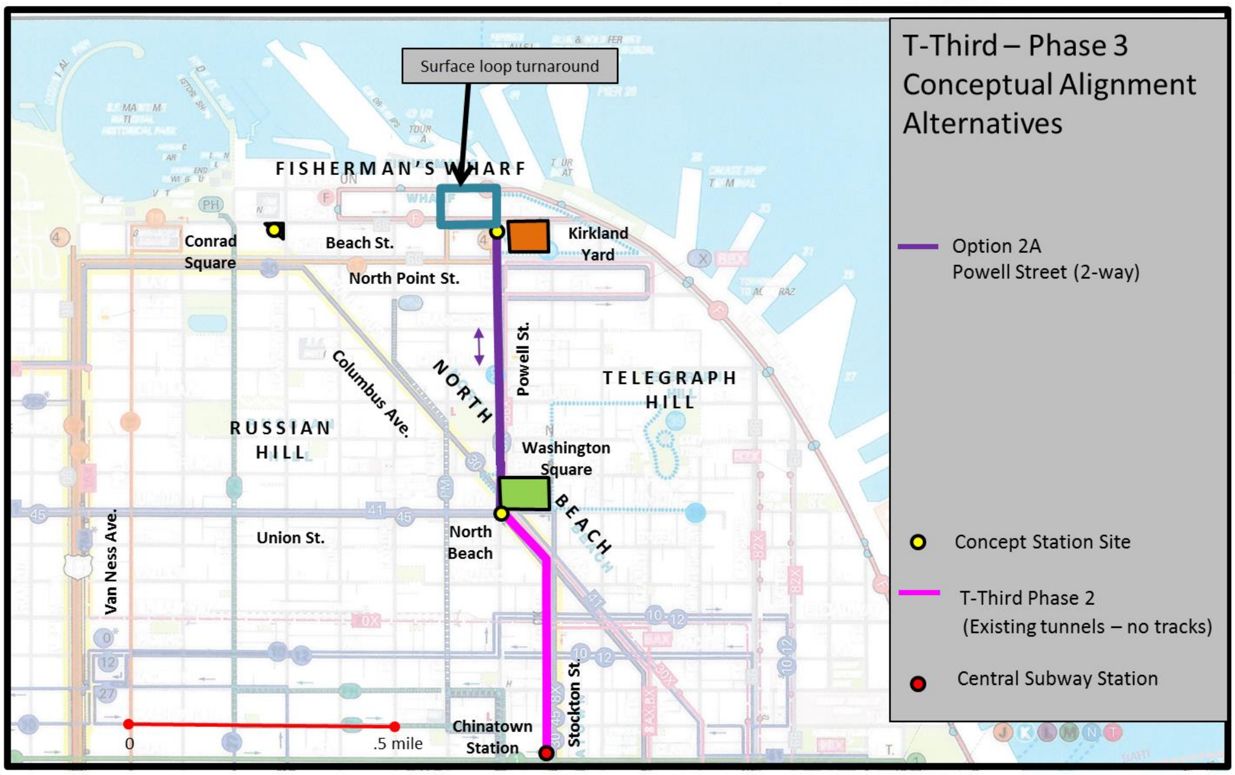

Table 5-3 Powell Street (Option 2A-to Kirkland w/Short Loop) Concept Alignment Cost Estimates

Description	Guideway Length in Feet	# of Stations	Low Estimate (-30% from Point) ($000)	Point Estimate ($000	High Estimate (+50% from Point) ($000)
2A-3: Surface C&C	5,382	2	311,600	405,080	607,620
2A-3: Surface SEM	5,382	2	360,067	479,787	719,681
2A-4: Subway C&C	5,270	2	672,770	874,601	1,311,902
2A-4: Subway SEM	5,270	2	730,238	949,309	1,423,963

The third group of Option 2A alignments and costs below are an alignment that achieves a turnaround by using the F-Line streetcar loop via new track on Powell, and then via the loop of Jefferson, Jones and Beach Streets back to the Kirkland Yard. These alignments range in cost from a low of $455 million for a surface line with cut and cover construction of a station in North Beach, to a high of $999 million for a subway with SEM construction of a station in North Beach.

Figure 5-4 Powell Street (Option 2A-to Kirkland w/F-Line Loop) Concept Alignments Map

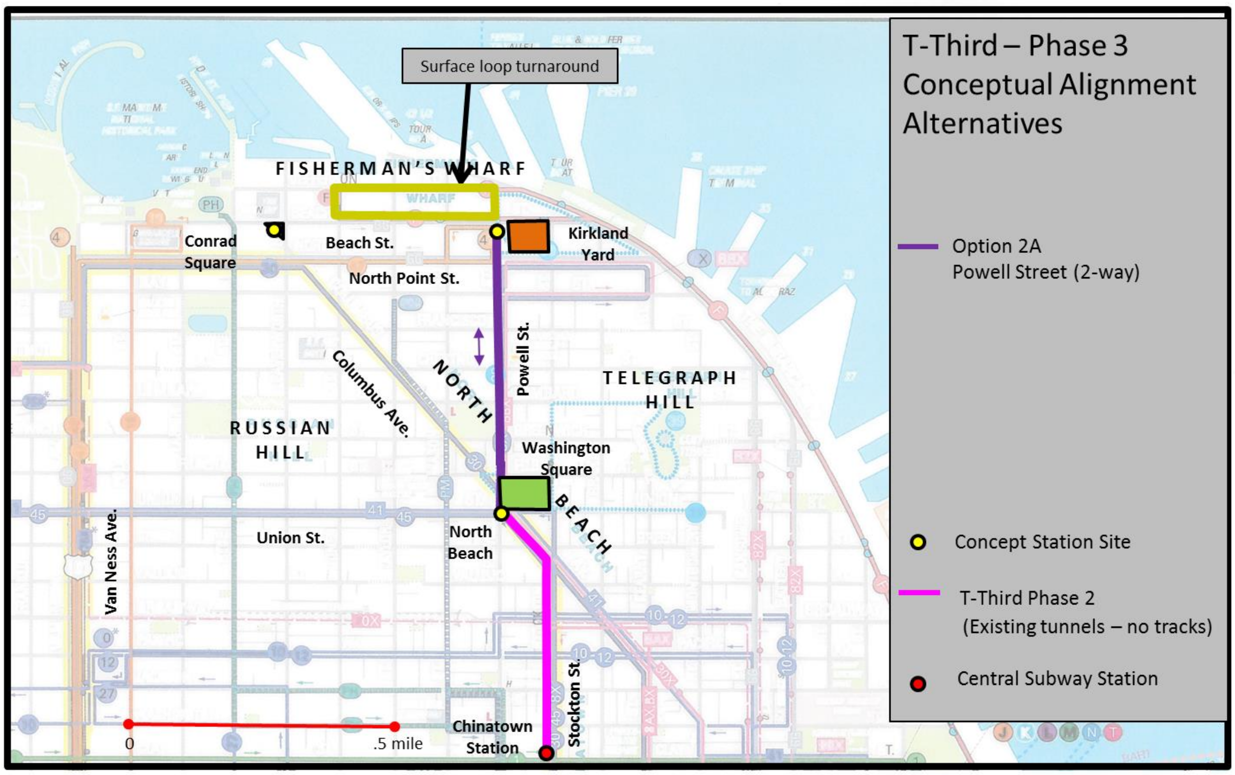

Table 5-4 Powell Street (Option 2A-to Kirkland w/F-Line Loop) Concept Alignment Cost Estimates

Description	Guideway Length in Feet	# of Stations	Low Estimate (-30% from Point) ($000)	Point Estimate ($000	High Estimate (+50% from Point) ($000)
2A-5: Surface C&C	7,420	2	349,314	454,109	681,163
2A-5: Surface SEM	7,420	2	406,782	528,816	793,224
2A-6: Subway C&C	7,429	2	710,485	923,630	1,385,445
2A-6: Subway SEM	7,429	2	767,952	998,338	1,497,507

5-2-3 Powell Street / Beach Streets Alignments to Kirkland Yard and Conrad Square

The costs estimates for the four Option 2B Powell Street / Beach Street alignments are shown below. These alignments assume a subway station at North Beach and either a surface or a subway station at or near the Kirkland Yard, and either a surface or a subway station at Conrad Square. Only two of the four concept alignments were analyzed for a cost estimate. Initial analysis found the other two concept alignments: surface Powell Street to subway Beach Street, and subway Powell Street to surface Beach Street infeasible due to excessive grade requirements necessitated by presence of the North Beach Outfall sewer lines. The group of Option 2B Powell Street / Beach Street concept alignments that did receive a cost estimate had a range in cost from a low of $443 million for a surface line with cut and cover construction of a station in North Beach, to a high of $1.4 billion for a subway with SEM construction of a station in North Beach.

Figure 5-5 Powell Street (Option 2A-to Kirkland) + Beach Street (Option 2B-to Conrad Square) Concept Alignments Map

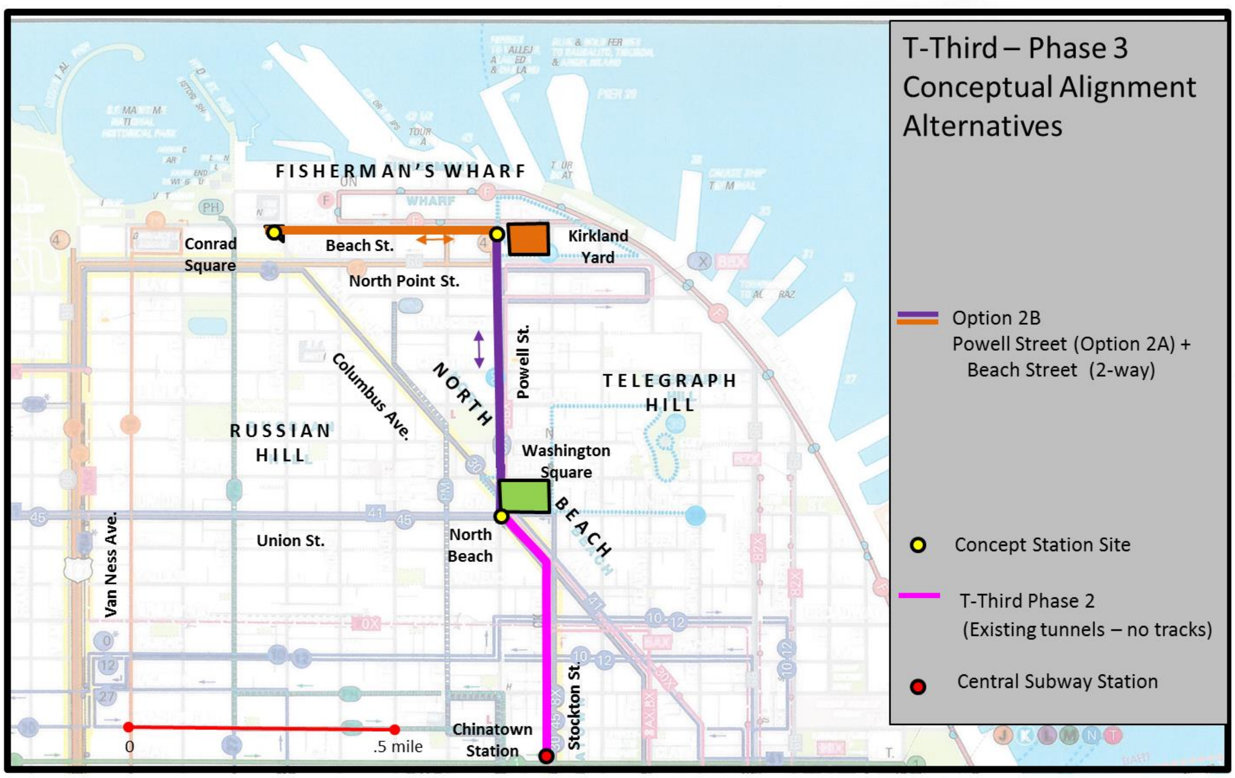

Table 5-5 Powell Street (Option 2A-to Kirkland) + Beach Street (Option 2B-to Conrad Square) Concept Alignment Cost Estimates

Description	Guideway Length in Feet	# of Stations	Low Estimate (-30% from Point) ($000)	Point Estimate ($000	High Estimate (+50% from Point) ($000)
2B-1: Surface C&C	6,909	3	340,351	442,456	663,684
2B-1: Surface SEM	6,909	3	397,818	517,163	775,745
2B-2: Subway C&C	5,382	3	1,025,137	1,332,678	1,999,017
2B-2: Subway SEM	5,382	3	1,082.518	1,407,274	2,119,911
2B-3: Surface to Subway	N/A	Initial analysis is this concept does not appear feasible due to required elevation changes and conflicts with major utilities			
2B-4: Subway to Surface	N/A	Initial analysis is this concept does not appear feasible due to required elevation changes and conflicts with major utilities			

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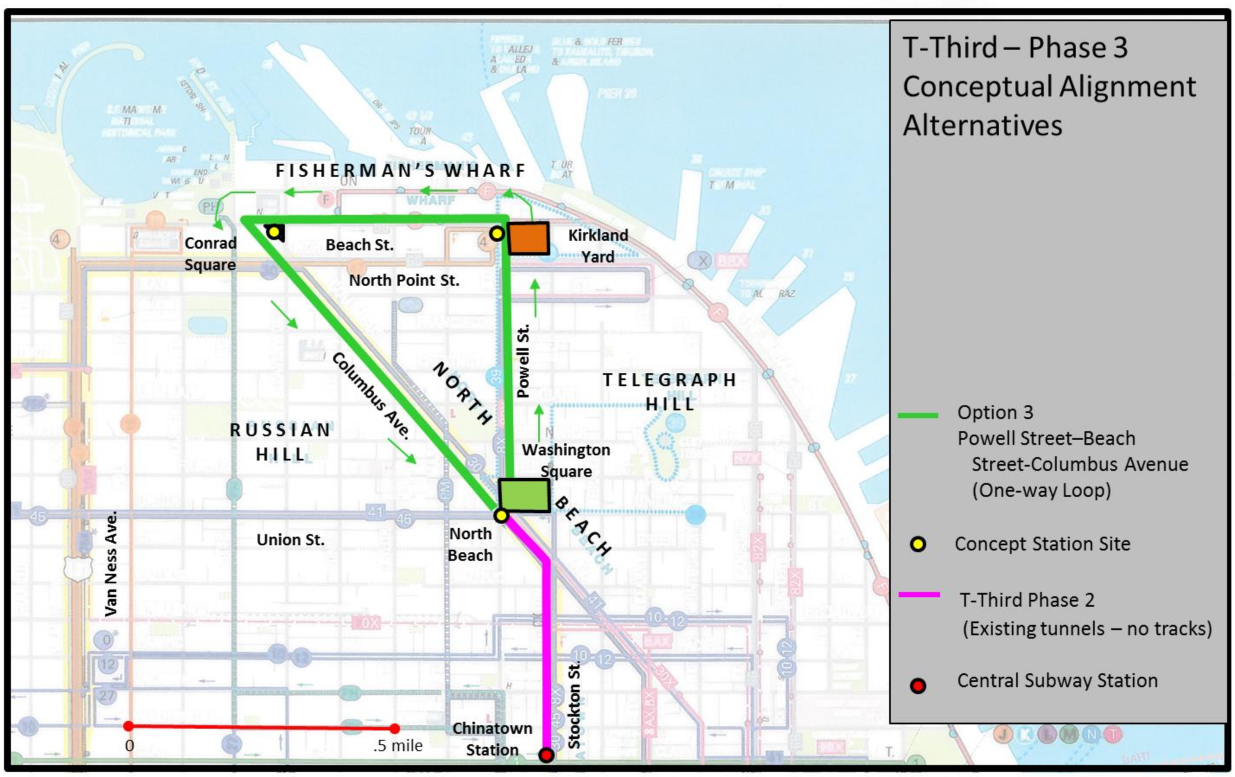
5-2-4 One-Way Loop: Powell-Beach-Columbus Alignments

The costs estimates for the two Option 3 One-Way Loop alignments are shown below. These alignments assume a subway station at North Beach and either a surface or a subway station at or near the Kirkland Yard, and either a surface or a subway station at Conrad Square. Unlike the other concept alignments that are bi-directional concepts, this concept is a single tunnel loop.

As part of the analysis, two sub-concepts were analyzed for the subway option at Conrad Square. The firs sub-concept located the station alignment on Columbus Avenue in the same manner as all other concept alignments. The second sub-concept located the station on Beach Street at Columbus. The different locations result in different possible tunnel alignments that: 1) are more favorable or less favorable to west expansion, and B) result in different properties and buildings being affected due to their location above the tunnel alignment.

Figure 5-6 One-Way Loop (Option 3-to Kirkland and to Conrad Square) Concept Alignments Map



The Option 3 group of One-Way Loop concept alignments had a range in cost from a low of $496 million for a surface line for a surface line with cut and cover construction of a station in North Beach, to a high of $1.139 billion for a subway with SEM construction of a station in North Beach.

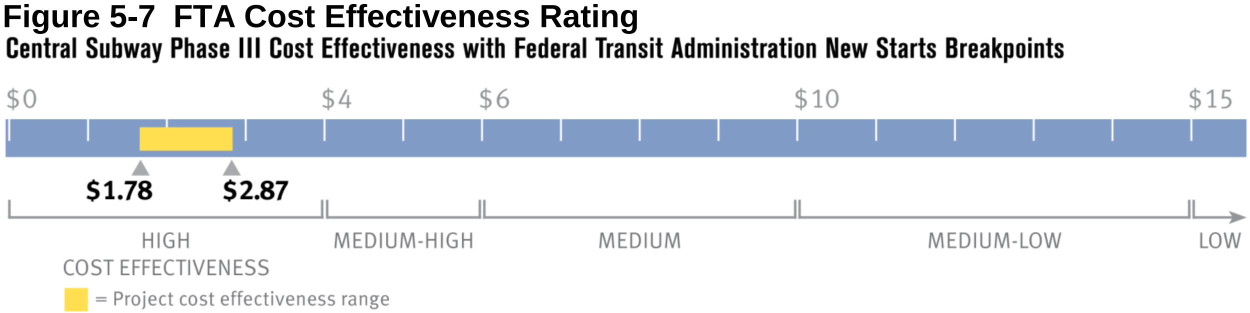
Table 5-6 One-Way Loop (Option 3-to Kirkland and Conrad Square) Concept Alignment Cost Estimates

Description	Guideway Length in Feet	# of Stations	Low Estimate (-30% from Point) ($000)	Point Estimate ($000	High Estimate (+50% from Point) ($000)
3-1: Surface C&C	8,472	3	381,325	495,722	743,583
3-1: Surface SEM	8,472	3	438,792	570,430	855,644
3-2A: Subway C&C	8,530	3	835,965	1,086,754	1,630,161
3-2A: Subway SEM	8,530	3	876,132	1,138,971	1,708,457
3-2B: Subway C&C	8,427	3	832,653	1,082,448	1,623,673
3-2B: Subway SEM	8,427	3	872,819	1,134,665	1,701,998

5-3 COST BENEFIT ANALYSIS

The Transportation Authority completed a “cost effectiveness” calculation of a T-Third Phase 3 extension to Fisherman’s Wharf following FTA “New Starts” guidelines. Concept alignment option 1-2: Columbus Avenue subway with new stations at North Beach and Conrad Square was the alignment selected for the calculation. Based on the outcomes of inputs that are explained in greater detail below, the projected extension would receive a “high” rating using the current FTA guidelines. Using the point cost estimate resulted in a cost per new trip of $1.78, which is well below the cost threshold of $4.00 per new trip required to obtain a “high” FTA rating.

Figure 5-7 FTA Cost Effectiveness Rating



Due to time and budget constraints, cost effectiveness was only calculated for the horizon year of 2040, and not for the current year. However, since FTA guidance directs that current year cost effectiveness should be weighted equally with the horizon forecast year (each at 50%), and alternate calculation was completed as follows. Transportation Authority staff assumed an estimate of base year ridership equal to half of the horizon year ridership forecast, and the outcome was a cost estimate of $2.87 per new trip. The outcome would still receive a “high” rating.

Ridership forecasts were calculated using Champ 4.3 Fury, the Transportation Authority travel demand model. In order to estimate new passengers on the T-Third line as a result of the extension, a comparison was made between a baseline run that included T-Third Phase 2 (Central Subway) service as far north as Chinatown, and a build model run that included the T-Third Phase 2 extension, plus new stations at North Beach and near Fisherman’s Wharf. The projected ridership increase was estimated to be 40,000 passengers per day. Multiplication of the daily figure by a factor of 320 resulted in an annual total of 12.9 million passengers per year.

Costs for an extension from Chinatown to Fisherman’s Wharf were estimated by a consultant at $933 million for a subway with SEM station construction at the North Beach station, plus another $20 million for LRT vehicles (three 2-car train sets).

Operating costs were estimated using planned peak service levels (2.5 minute service), and modeled scheduled run times. The additional service provided by a T-Third Phase 3 Fisherman’s Wharf extension was projected to add $7.1 million in annual operations costs.

5-4 FUNDING CONCEPTS AND SOURCES

A number of potential funding sources could be utilized to provide capital funding to construct a future T-Third-Phase 3 extension to the Fisherman’s Wharf area. As explained above, the “order of magnitude” cost estimates for the different concept alignments range from a low point of $367 million (Alt. 2A-1) to $1.49 billion (Alt. 2B -2). It is a wide range, but over 75% of cost estimates for all concept alignments fall into a range between $500 million and $1.00 billion dollars. As mentioned earlier, the inclusion of a cost estimate that shows a price point, a price point minus 30% estimate, and a price point plus 50% estimate is done solely for comparison purposes. San Francisco costs on recent projects have consistently been between the price point and the price point, plus 50% estimates.

5-4-1 Federal Transit Administration (FTA) New Starts / Small Starts

The FTA New Starts Program provides grants for large projects that cannot traditionally be funded from a transit agency’s annual formula funding. This program has facilitated the creation of dozens of new or extended public transportation systems across the country. These grants are generally eligible for a maximum 80 percent federal share of the net project cost. Under this program, FTA awards grants on a competitive basis for new fixed guideway systems such as heavy rail (subway), light rail, or streetcars. In addition, eligible projects include extensions to existing fixed guideway systems, bus rapid transit (BRT), and projects that expand the capacity of an existing corridor by 10 percent or more.

Applicants seeking New Starts funding must complete two phases, project development and engineering, prior to receiving a grant. In order to enter into Project Development, an applicant must make a written request to the Secretary of Transportation and initiate the environmental review process. Upon completion of the applicable environmental reviews and the activities of the project development phase, a project may advance to the engineering phase. The Secretary may award funding by signing a Full Funding Grant Agreement (FFGA) once the project has been selected as the locally preferred alternative and it has achieved a sufficient overall rating by FTA. This rating is based on project justification factors that include economic development, mobility improvements, cost effectiveness, environmental benefits, land use, and congestion relief, as well as the degree of local financial commitment.

MAP-21 streamlined the project approval process for New Starts by setting time limits on environmental reviews and consolidating the steps to apply for funding. Project sponsors must complete the required activities of the project development phase within two years. MAP-21 also eliminated the duplicative alternatives analysis phase and instead allows for the review of alternatives to be performed during the metropolitan planning and environmental review processes. In addition, it allows for an expedited technical review process for applicants who have recently completed a New Starts project successfully.

FTA Small Starts projects are defined as those applying for less than $75 million in federal funding or those with a total project cost of $250 million or less. Applicants seeking Small Starts funding must complete only one phase, project development, prior to receiving a grant. In order to enter into project development, a project sponsor must make a written request to the Secretary and initiate the environmental review process. The Secretary may award funding by signing a Small Starts Grant Agreement (SSGA) once the project has been adopted as the locally preferred alternative and the environmental reviews have been completed, and based on FTA's ratings of the project benefits and the local financial commitment.

MAP-21 eliminated the dedicated funding set-aside for Small Starts projects. These projects must now compete alongside the larger-scale New Starts projects for the available funding.

5-4-2 Proposition K (Local Sales Tax)

In November 2003, San Francisco voters approved Proposition K, (Prop. K) a new 30-year Expenditure Plan tied to an extension of the local (San Francisco) half-cent sales tax for transportation projects and programs. Revenues are estimated under three scenarios over the 30-year period of the new Expenditure Plan. The conservative projection developed as part of the 2003 Prop. K Expenditure Plan puts total revenue at $2.4 billion (2003 dollars) over the thirty year lifespan of the program. Actual revenues provide for almost $2 billion in Prop. K funds that will be available to projects. Of this total, $493 million is available for named capital projects included in the Expenditure Plan, such as Central Subway, Doyle Drive and Caltrain Electrification, including $223 million for T-Third Phase 1 and Phase 2 projects. Nearly all of these funds have been spent to date. No funds have been identified for a T-Third Phase 3 project. The remainder of Prop. K revenues is identified for a range of projects, including transit vehicle procurement, bicycle and pedestrian projects, transportation demand management, and other transit enhancement projects. The Transportation Authority Board of Commissioners may adopt a new Prop. K Expenditure Plan starting in 2023/24, at which time funding could be identified for the T-Third Phase 3 project.

5-4-3 FTA Formula Funds (Section 5307 – Urban Transit Formula Funds)

SFMTA is an eligible recipient of federal transit formula funds that can be used on a variety of transit capital projects, including a T-Third Phase 3 LRT extension. Section 5307 is the largest transit formula program, and eligible projects include capital investments in the construction of maintenance and passenger facilities, capital investments in new and existing fixed guideway systems, including rolling stock, overhaul and rebuilding of vehicles, track, signals, communications, and computer hardware and software.

5-4-4 Land Based Funding Sources

The following sub-sections describe sources that were analyzed in greater detail in Section 3. (See also Appendix E).

5-4-4-1 Infrastructure Finance District (IFD) and Enhanced IFD

Cities and counties can create Infrastructure Financing Districts (IFDs) to pay for regional scale public works. IFDs can divert property tax increment revenues for 30 years to finance highways, transit, water systems, sewer projects, flood control, child care facilities, libraries, parks, and solid waste facilities. IFDs can't pay for maintenance, repairs, operating costs, and services. Establishment of an IFD requires the city or county to develop an infrastructure plan. Copies of the plan must be sent to every landowner, and the establishing agency must consult with other local governments, and hold a public hearing. Every local agency that will contribute its property tax increment revenue to the IFD must approve the plan. Schools cannot shift property tax increment revenues to an IFD. Once other local officials approve the proposal, the proposal must be voted on. Voters in the city or county seeking the IFD creation must approve the proposal with a 2/3 majority, or IFD creation fails. If the IFD is approved, voters via a majority, will set an appropriations limit. The issuance of bonds must also be approved by voters with a 2/3 majority.

Per Senate Bill 628 (Beall), as of January 1, 2015, cities and counties will have the option of pursuing an Enhanced IFD which would enjoy many of the same qualities of a standard IFD, except the voter threshold for approval would be 55% of property owners within the proposed district instead of 67%, and it could be extended for 45 years. The T-Third Phase 3 project would be eligible to receive Enhanced IFD funds if it is included in the San Francisco Bay Area region's Sustainable Communities Strategy.

5-4-4-2 Community Facilities District (Mello-Roos) (CFD)

The Community Facilities Act (more commonly known as Mello-Roos) was approved in California in 1982. The Act enabled "Community Facilities Districts" (CFDs) to be established by local government agencies as a means of obtaining community funding. Counties, cities, special districts, joint powers authority and schools districts use these financing districts to pay for public works and some public services. A CFD is an area where a special property tax on real estate, in addition to the normal property tax, is imposed on real property owners within a Community Facilities District. The CFD must be approved by voters within the district by a 2/3 majority or the CFD is not established. These districts seek public financing through the sale of bonds for the purpose of financing public improvements and services. These services may include streets, water, sewage, electricity, infrastructure, schools, parks and police protection to newly developing areas. The tax paid is used to make the payments of principal and interest on the bonds.

5-4-4-3 Special Assessment District

An Assessment District is a financing mechanism under The California Streets and Highways Code, Division 10 and 12 which enables cities, counties and special districts to designate specific areas as Assessment Districts. Approval of a majority of the landowners is required. The District is allowed to collect special assessments to finance improvements constructed or acquired by the District. Assessment Districts help each property owner pay a fair share of the costs of such improvements over a period of years at reasonable interest rates, and insures that the cost will be spread to all properties that receive direct and special benefit by the improvements constructed. Improvements that provide a direct and special benefit: streets, sidewalks, curbs and gutter, water, sewer, gas, electric lighting, flood control, are allowed. Improvements that provide a general public benefit: parks, schools, libraries, jails, etc. are generally not allowed to be financed by an Assessment District.

5-4-4-4 Development Impact Fee

An impact fee is a fee imposed by a local government on a new or proposed development project to pay for all or a portion of the costs of providing a public service to a new development. Impact fees are considered to be a charge on new development to help fund and pay for the construction or needed expansion of offsite capital improvements. Impact fees became more widespread in the United States following the decline of available Federal and State grants for local governments. The use of impact fees have expanded to non-utility uses, including roads, parks, schools, and other public services.

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Section 6 - Evaluation of Concept Alignments

6-1 OVERVIEW

This section was drafted to give a preliminary evaluation of the feasibility of various concepts to help guide the direction of a possible future study. The multi-agency team analyzed a total of fourteen concept alignments. The concept alignments all are located along three corridors: Columbus Avenue, Powell Street and Beach Street. Within this group, one concept alignment was first raised in the T-Third Phase 2 study and environmental review process, and two of the three alignments were raised during the San Francisco Planning and Urban Research (SPUR) Charrette in 2013. The concept alignments are listed below.

The Columbus Avenue (two-way) alignment (Option 1) includes two concepts:

- 1-1: Subway / surface alignment with a surface station and off-street turnaround at Conrad Square
- 1-2: All subway alignment, station and an underground turnaround below Conrad Square

The Powell Street one-segment / one station alignment (Option 2A) includes six concepts:

- 2A-1: Subway / surface alignment with a surface station and off-street turnaround at Kirkland Yard
- 2A-2: All subway alignment with a station and underground turnaround below Kirkland Yard
- 2A-3: Subway / surface alignment with a surface station at Kirkland Yard and a short loop turnaround on Powell, Jefferson, Mason and Beach Streets
- 2A-4: All subway alignment with a station at Kirkland Yard and a short surface loop turnaround on Powell, Jefferson, Mason and Beach Streets
- 2A-5: Subway / surface alignment with a surface station at Kirkland Yard and a loop turnaround via Powell Street to existing F-Line tracks for several blocks on Jefferson, Jones and Beach Streets
- 2A-6: All subway alignment with a station at Kirkland Yard and a surface loop turnaround via Powell Street to existing F-Line tracks for several blocks on Jefferson, Jones and Beach Streets

The Powell Street - Beach Street two segment / two station alignment (Option 2B) incorporates the Powell Street single segment – one station concept at Kirkland, but the line extends further via Beach Street to Conrad Square, where a second station and a turnaround would be located. This group includes four concepts:

- 2B-1: Subway / surface alignment with a surface station at Kirkland Yard; a Beach, Jones, North Point, and Columbus surface alignment with a surface station and an off-street turnaround at Conrad Square
- 2B-2: Subway alignment and subway station at Kirkland Yard, and a Beach Street subway alignment with a subway station and underground turnaround below Conrad Square
- 2B-3: Subway / surface alignment with a surface station at Kirkland Yard; a Beach Street subway alignment with a subway station and underground turnaround below Conrad Square
- 2B-4: Subway alignment and subway station at Kirkland Yard, and a Beach, Jones, North Point, Columbus surface alignment with a surface station and off-street turnaround at Conrad Square

The Powell Street / Beach Street / Columbus Avenue one-way loop two station alignment (Option 3) would only have a single tunnel bore and track. For initial planning purposes, a train storage and terminal appears more likely to be at or near a Kirkland Yard station than at a Conrad Square station. The terminal station must have a center platform that can accommodate two 2-car trains on each side, as well as a pocket track to move non-service trains out of the way from regular service trains. The one-way loop alignment includes two concepts:

- 3-1: Subway / surface loop alignment via Powell Street with a surface station at Kirkland Yard; a surface alignment via Beach Street, with a surface station at Conrad Square; and a surface alignment via Columbus Avenue to north of Taylor Street, with a subway back to Washington Square
- 3-2: All subway loop alignment via Powell Street with a subway station at Kirkland Yard, a subway alignment via Beach Street, with an underground station under Conrad Square, and a subway alignment back to Washington Square

6-2 EVALUATION OF CONCEPT ALIGNMENTS

This section discusses areas the concept study considered while analyzing the alignments, and how the alignments differ in terms of these considerations. Two concepts—2B-3 and 2B-4, those with two segments that used different configurations on each segment—were determined not feasible as part of the constructability analysis (see Chapter 4). Aside from these two concepts, the study did not definitively screen out any other alignments, nor is it intended to limit alignments to the samples analyzed here. The goal of the concept study is to show preliminary technical strengths and weaknesses of the concept alignments, for consideration by stakeholders, governing bodies, and the public during any future planning efforts.

This study's alignments are similar in some respects: all are rail extensions with one or more stations in each of two neighborhoods. Many typical measures of transit project performance are modeled at a scale that cannot be differentiated between the similar concept alignments. For example, overall ridership would not differ significantly between the concept alignments. Therefore, this section focuses on the differences between the particular concepts that are important to defining an alignment.

The considerations below were selected to perform a preliminary evaluation of the feasible concept alignments. Each will be addressed in a short section following the initial matrix.

- Passenger Experience
- Operational Efficiency
- System Performance
- Local Operations Considerations
- Infrastructure Resiliency
- Construction Disturbance
- Construction Cost and Risks

For each area of evaluation considered, the concepts were scored on a "plus, zero , minus" scale (+, 0, -), with a plus (+) being a positive score, a zero (0) being a neutral score, and a minus (-) being a negative score.

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Table 6-1 Concept Alignment Evaluation Matrix

	1-1	1-2	2A-1	2A-2	2A-3	2A-4	2A-5	2A-6	2B-1	2B-2	2B-3	2B-4	3-1	3-2
Evaluation Elements	Evaluation of Concept Alternatives													
	Columbus Ave. Subway- / Surface	Columbus Ave. Subway	Powell St. Subway / Surface	Powell St. Subway	Powell St. Subway / Surface w/ short loop	Powell St. Subway w/ short loop	Powell St. Subway / Surface w/F-Line loop	Powell St. Subway w/ F-Line loop	Powell St + Beach St. Subway / Surface	Powell St.+ Beach St. Subway	Powell St. + Beach St. Subway / Surface + Subway	Powell St. + Beach St. Subway + Surface	One-Way Loop Subway / Surface (Powell-Beach-Columbus) Surface	One-Way Loop (Subway Powell-Beach-Columbus) Subway
Passenger Experience	0	+	0	+	-	-	-	-	-	+	NF	NF	0	+
Operational Efficiency	-	+	-	+	-	0	-	-	-	+	NF	NF	+	+
System Performance	0	+	0	+	0	+	-	-	0	+	NF	NF	+	+
Local Operations Considerations	-	+	-	+	-	0	-	-	-	+	NF	NF	-	+
Infrastructure Resiliency	+	+	0	+	0	-	0	-	0	+	NF	NF	0	0
Construction Disturbance	-	0	-	0	-	-	-	-	-	-	NF	NF	-	-
Capital Construction Cost and Risk	+	0	+	0	+	0	+	0	+	-	NF	NF	+	0
Total	-1	5	-2	5	-3	-2	-4	-6	-3	3	NF	NF	1	3
Capital Cost ($ millions in 2014 Dollars)	407-482	848-933	367-442	837-912	406-480	875-950	454-529	924-999	443-518	1,333-1,408	NF	NF	496-571	1,087-1,139
Constructability Rating	4	5	3/4	4	3/4	2	3/4	2	3/4	4	1	2	3	3/4

NF = Not Feasible

Based on the criteria evaluation concept alignments 1-2 (Columbus Avenue subway to a Conrad Square station), 2A-2 (Powell Street subway to a Kirkland Yard station), and 3-2 (One-Way Loop subway with stations at Kirkland Yard and Conrad Square) scored more pluses and fewer minuses. All three concept alignments are subway concepts, which supply greater transit benefits and infrastructure resiliency, but which also have capital costs approximately twice the amount of surface alignments of the same route.

The following sub-sections explain issues or show data used to choose the plus, zero and minus ratings listed in the matrix. Greater detail on information used to create these summary sub-sections is present in Sections 1-5 of this concept study.

6-2-1 Passenger Experience

The passenger experience of using transit can be separated into three parts: the experience accessing transit, the waiting experience, and the on vehicle (riding) experience.

6-2-2-1 ACCESSING STATIONS

Access considerations for station locations include the proximity to origins and destinations of value to a passenger, the walkability of the surrounding areas, and the legibility of the transit station within the neighborhood—that is, the visibility and logical placement of the station. These aspects are important because of the significant tourist population expected to use these stations, who may not be as familiar with the immediate area.

In all the concepts, the North Beach station is sited near Columbus Avenue close to Washington Square Park, a major hub in an already pedestrian-friendly area offering an easily accessible, visible, and logical station location.

Of the two potential Fisherman's Wharf stations, Conrad Square offers more legibility than Kirkland Yard. The square is located at the terminus of Columbus Avenue, one of the City's most physically and visually prominent corridors. Columbus Avenue is a relatively flat route that closely ties together Fisherman's Wharf, North Beach, Chinatown, Jackson Square, and the Financial District. The square itself is surrounded by commercial uses and is a half-block from Aquatic Park and the popular Hyde Street cable car turnaround. The Cannery Shopping Center is across the street and Ghiradelli Square is a short walk to the west. A Conrad Square station would also be more easily accessible to those traveling to or from Fort Mason, northern Russian Hill, and areas to the west currently not served by LRT trains.

A Kirkland Yard station would provide more direct access to the northeastern Embarcadero waterfront and Pier 30. However, these areas are already linked to Downtown via the F-Line streetcar. Utilitarian uses in the immediate vicinity, such as the Pier 39 parking garage, SFPUC North Point facility, and the bus yard itself (assuming it remains an active transit division) would result in a less walkable station area with fewer obvious destinations.

However, both Fisherman's Wharf station sites are relatively flat walks from major sites, both are immediately nearby several hotels, and both have existing high pedestrian volumes. The two sites are less than a half mile apart, so including both stations would improve accessibility, but is unlikely to significantly increase ridership due to the close spacing. The center of Fisherman's Wharf itself is about equidistant between the two sites, at Taylor Street.

Implementation of new transit systems on existing streets or transit corridors is generally preferred over implementation of new transit on streets or transit corridors that are currently without transit, for reasons of public familiarity and acceptance of the presence of transit service on a specific street. All proposed concept alternatives follow existing transit corridor streets of Columbus Avenue, Powell Street and Beach Street. Some concept alternatives would operate briefly on other streets with existing transit service, and a few would operate for a few blocks on streets without current transit service. Conrad Square is a location of note, because it is proposed as a key transit hub, but currently does not host transit service.

Both surface and subway can be sufficiently marked to make service visible to the general public. Surface lines are more visible between stations, and offer the possibility of additional stops (at a cost of reduced travel speeds). Loop options (series 3 concepts) may require space for train layovers between the two station sites, which would reduce the accessibility as one stop would primarily become for off-loading and one for on-loading. However, although not considered here, loop options would make it possible to site a station somewhere in between the two locations in this study. Such a combined station could provide train storage in the station, similar to non-loop concepts.

6-2-1-2 WAITING AT STATIONS

The public's preference for waiting for subway service versus waiting for surface service is mixed. Subway platforms offer more complete weather protection, but can be less interesting places to wait because of their isolation. Surface platforms are more exposed to the elements of wind, rain, heat, and cold, but if located in an attractive neighborhood, the waiting experience can be an asset to the service. Subway stations generally can provide larger platforms space with more seating than surface platforms, due to space constraints on surface streets where transit must share space with mixed traffic roadways and sidewalks.

The waiting experience can also be affected by crowding. Any of the concept alternatives are expected to help reduce crowding significantly on nearby bus, streetcar, and cable car lines. Peaks of high ridership should therefore be more dispersed. However, the location of the Fisherman's Wharf station will affect which route substitutions are most likely. Conrad Square is closer to the 30-Stockton bus route and Powell- Hyde Street Cable Car, while Kirkland Yard is closer to the F-Embarcadero and 8X – Bayshore Express bus routes.

6-2-1-3 ON VEHICLE EXPERIENCE AND RELIABILITY

Along with the crowding issue discussed above, the on-vehicle experience, travel time and transit service reliability are key elements of the passenger experience. Subway service is speedier due to less delay from traffic congestion and intersection crossings. Rail transit service is generally quicker than bus transit service, and vehicles generally can carry higher volumes of passengers.

Reliability is the ability of the transit service to maintain its schedule despite disruptions. LRT service that operates in mixed traffic without signal priority at signalized intersections has the lowest level of reliability, because it has the greatest opportunity to be delayed by outside influences (e.g. traffic congestion, unfavorable signal timing, etc.). LRT service that has conflicts with other rail transit service (e.g. two LRT lines sharing the same track as in the Market Street Subway) must endure similar challenges as service that has conflicts with mixed traffic, and therefore is likely to have lower reliability than if it was the sole transit service on a segment of track. At the high end of the spectrum for this criterion, with the highest reliability, is single line subway service with no interaction with mixed traffic.

6-2-2 Operational Efficiency

This section discusses the infrastructure components of the concepts and how they relate to the cost and reliability of service. Travel time and reliability considerations are also closely related to transit operational efficiency. To avoid unreliable service for passengers, infrastructure that makes transit vulnerable to frequent schedule disruptions must be addressed with more resources, increasing the cost of service. Conversely, infrastructure that improves transit speed and operational flexibility will also tend to improve reliability.

6-2-2-1 LRT TURNAROUND AND TERMINAL STORAGE CAPACITY

The ability of transit vehicles to turn around to allow a return trip in service to their point of origin, and allow for operator breaks (layover) is a key issue in transit system design. Inadequate space, or poor design for turnaround actions, or transit vehicle layover hamper transit performance by causing problems and slowing service down.

Turnaround track designs that use a loop are the preferred design, as they do not require the operators to change cabs or require the trains to use track switches. These are frequently used for surface track turnarounds, but require enough space to provide such a loop. The surface loop concepts would need terminal storage capacity and layover space, likely at the Kirkland Yard area. However, the surface turnaround loops presented in concept alignments 2A-3 through 2A-6 would likely be slower than a surface “X” crossover style turnaround due to the loop length. Additionally, the two loops analyzed as part of concept alignments 2A-3 through 2A-6 are not in exclusive right-of-way, so they would be adversely affected by traffic congestion in an area where traffic congestion is a frequent occurrence. Finally, concept alignments 2A-5 and 2A-6 would also share track with F-Line streetcars, which would also slow the turnaround due to transit vehicle congestion and the added surface stops that would be required.

When underground or in other restrictive spaces, “X” crossover tracks may be used in order to reduce the amount and cost of construction. Turnaround performance is improved by redundancy of “X” crossover locations before and after a terminal, and adequate storage track to allow LRT vehicles and operators to layover. These facilities can also be costly to construct underground, as they require excavation beyond the tunnel widths provided by TBMs. The cost estimates in Chapter 5 assume a single X crossover where this terminal is used.

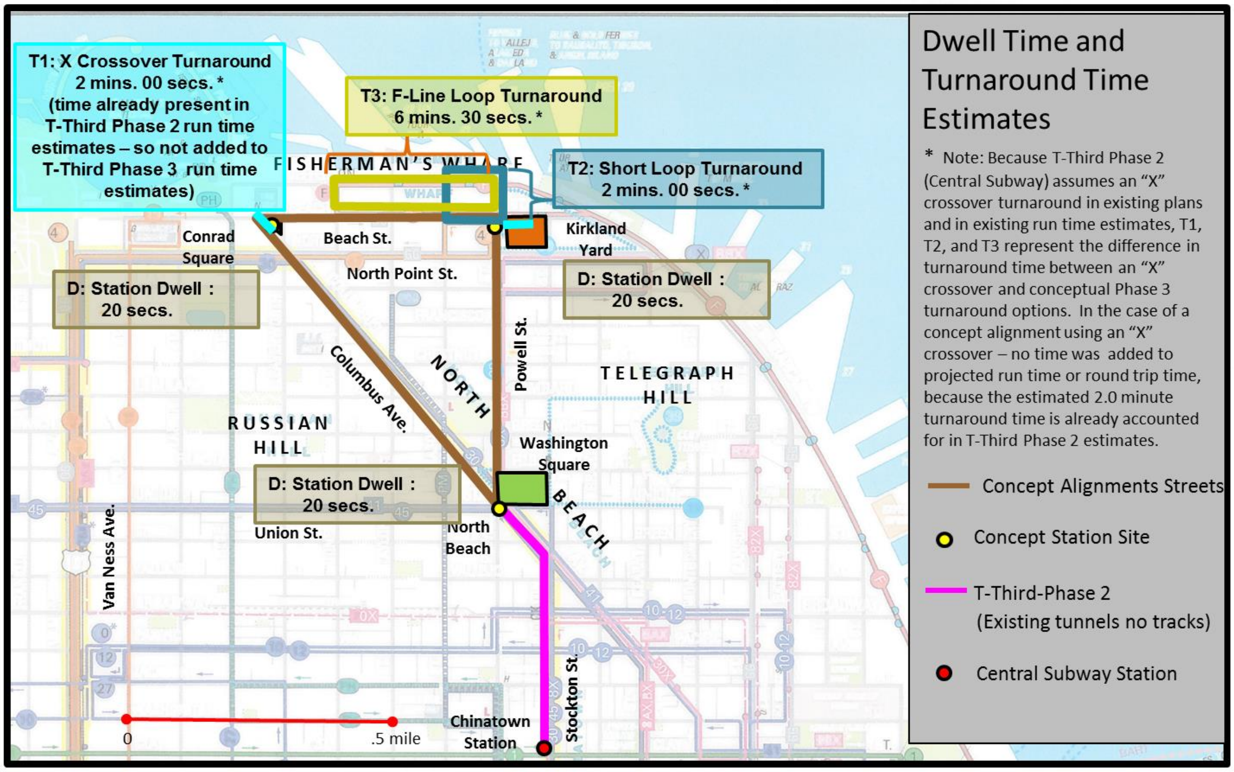
One benefit of the One-Way loop concepts is that they do not require a turnaround, even if built underground. However, these options still need terminal train storage capacity and layover space. Table 6-2 summarizes the turnaround designs for each alternative.

Table 6-2 Concept Alignments Turnaround Design

Concept Alignment	1-1	1-2	2A-1	2A-2	2A-3	2A-4	2A-5	2A-6	2B-1	2B-2	2B-3	2B-4	3-1	3-2
X crossover	✓								✓		N/A	N/A		
Surface Loop					✓	✓	✓	✓			N/A	N/A	✓	
To Be Determined		✓	✓	✓						✓	N/A	N/A		✓
Number	1	TBD	TBD	TBD	1	1	1	1	1	TBD	N/A	N/A	1	TBD

Based on the designs, typical dwell time and turnaround time can be estimated for each concept alignment. The turnaround times are shown in Figure 6-1.

Figure 6-1 Dwell time and Turnaround Time Estimates



6-2-2-2 TRAVEL TIME

Rail transit service is generally quicker than bus transit service, and vehicles generally can carry higher volumes of passengers. Travel time ranks as a top desire of transit passengers. Faster travel time also saves transit vehicle capital funds and operations / maintenance dollars, because fewer vehicles operating at a higher average speed can provide the same service as a larger fleet.

Run time assumptions for different concept alternatives are based on the following sources: surface / subway scheduled run times of existing (2014) SFMTA LRT service, modeled run times for the T-Third-Phase 2 (Central Subway) project (Systra Operations Analysis Report (2013), and surface scheduled run times of existing (2014) F-Line streetcar service for the concept alternatives with a surface loop turnaround.

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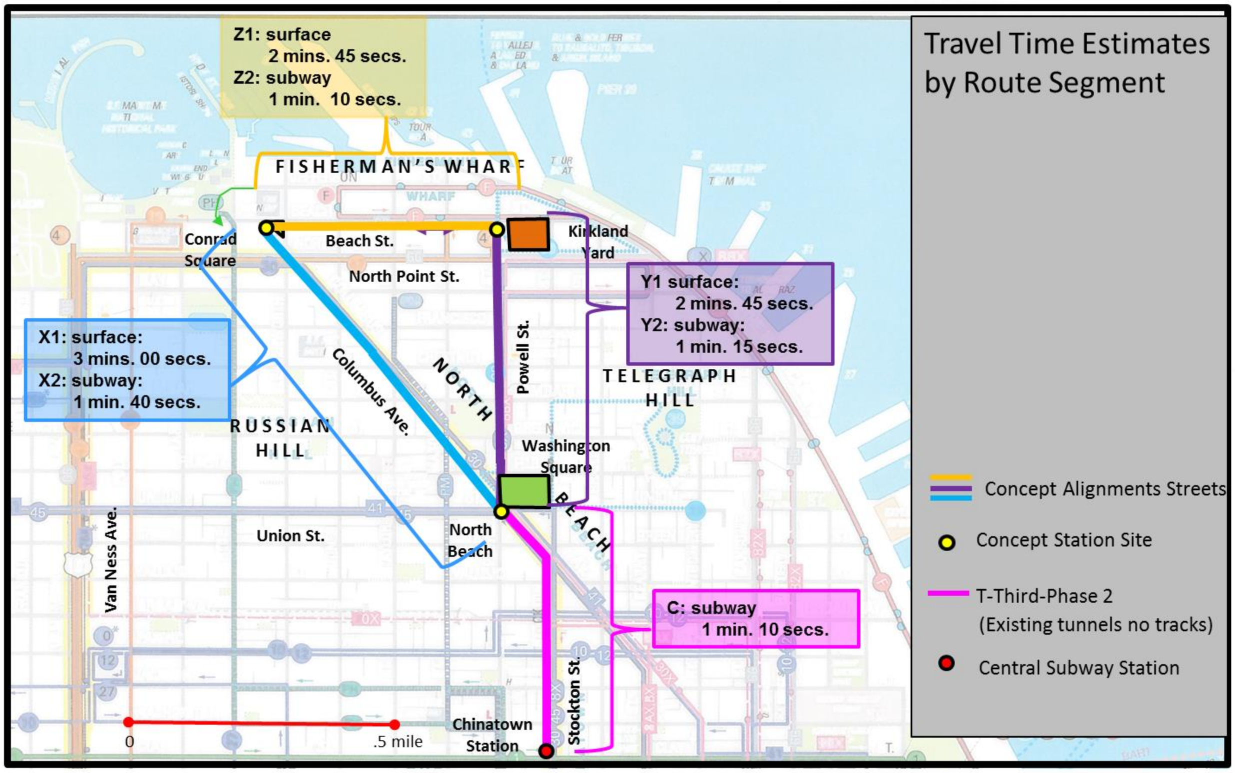
Figure 6-2 Travel Time Estimates Concept Alignment Segments



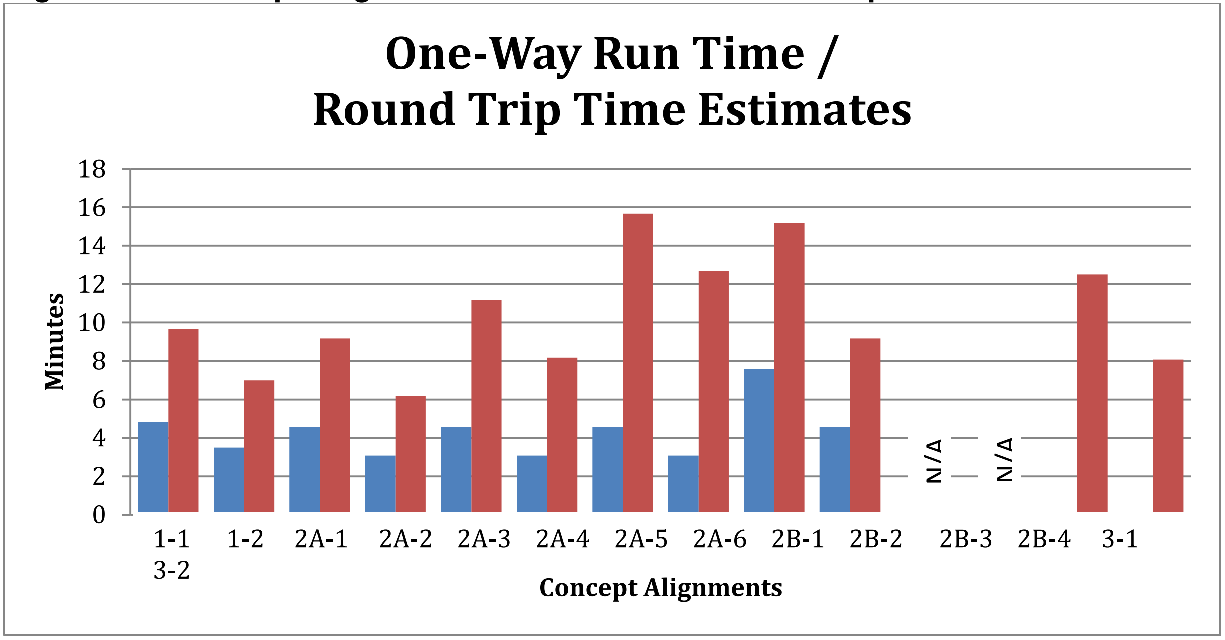
As explained in Section 2; based on these information sources, the average speed of surface LRT is about 9.0 mph, the average speed in the Market Street Subway is 18.0 mph, and the average projected speed in the T-Third Phase 2 (Central Subway) service is 20.0 mph. The data shows the average SFMTA subway LRT speed is twice as fast as the average surface LRT speed. The average surface F-Line streetcar speed in the Fisherman's Wharf area is 5.2 mph. Note that these times do not reflect any additional surface stops beside the three stations at the conceptual station locations.[3]

The estimated run times and turnaround times were used to build round trip travel time estimates for each concept alignment. The blue bars show one-way run time estimates,

[3] Travel time estimates used in the CHAMP travel demand model correspond to the estimates for Chinatown Station to North Beach Station subway (C) and North Beach Station to Station 2 (Conrad Square) subway (X2), and vary slightly from those listed here. Both were prepared using estimated travel times from Systra Operations Analysis Report (4/24/13). The Transportation Authority derived an average travel speed of 19 mph based on the average Systra simulated travel speed of T-Third Phase 2 (Central Subway) Union Square to Chinatown segment in each direction in the AM and PM peak periods. This estimate made no additional effort to estimate dwell time at stations because the CHAMP model simulates dwell time as a function of passenger boards and exits. The estimated travel times in this section are more conservative. The difference between the estimates is too small to substantially affect ridership in CHAMP.

while the red bars show a round trip time estimate that is comprised of two one-way run time estimates, plus a turnaround time estimate. See Figure 6-3.

Figure 6-3 Concept Alignments Run Time and Round Trip Time Estimates



6-2-2-3 LRT VEHICLE REQUIREMENTS

For a given frequency of service, the number of trains required will vary based on the cycle time of each concept. Cycle time is the sum of round trip travel time plus layover/recovery time. Reducing the number of trains reduces capital costs, maintenance requirements, and storage facility requirements. Service assumptions are based on the 2030 service frequency listed in the T-Third-Phase 2 (Central Subway) SEIS/R, which calls for 2.5 minute peak frequency for trains.

As can be inferred from Figure 6-4, surface level LRT service is slower than subway service and requires a higher number of LRT vehicles to provide the same level of service. Options with more than one station, or surface options that include additional stops, would further slow the cycle time and increase the need for vehicles.

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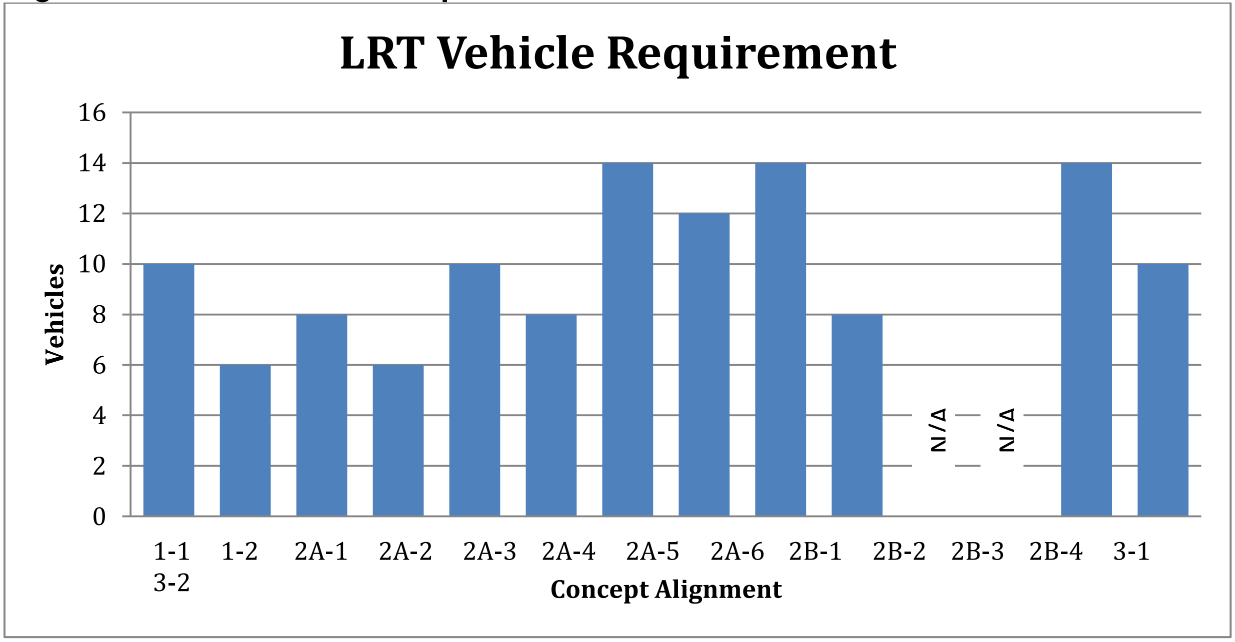
Figure 6-4 LRT Vehicle Requirements – T-Third-Phase 3 – Peak Period



The projected cost of each LRT vehicle is $3.66M, or $7.32M per 2-car train. The number of LRT vehicles required for implementation of a T-Third-Phase 3 service extension during the peak period is estimated at 12-20 vehicles. Using the LRT vehicle capital cost shown above, the added equipment for a T-Third-Phase 3 extension would range from $44 million to $66 million in 2014 dollars.

6-2-2-4 OPERATIONS COSTS

All concepts for extension will increase operational costs, as any extension is a pure increase in service when no other service cuts are assumed. Costs are proportional to vehicle miles, vehicle hours, and number of peak vehicles. Increases in operational cost may be justified by increased ridership and fare collection, as well as improvement of system performance by improving connections and lessening crowding.

Cost estimates for service, or operations costs were estimated using Transportation Authority modeling that included using planned 2040 service levels (2.5 minute peak service frequency), modeled and scheduled run time, and standard operating costs (2014 dollars). Due to time and budget constraints, only concept alignment 1-2 (Subway to North Beach and along Columbus Avenue to Conrad Square) was projected. The projection included application of increased operating costs per added vehicle service hour, added vehicle mile, and added vehicles required per day. The estimate for an added day of service on the T-Third Phase 3 extension is $22,051. A multiplier of 320 was applied to the daily total to achieve an annual total of approximately $7.1 million dollars.

Given the vehicle requirement estimates in Figure 6-4, the highest vehicle need was for concept alignments 2A-5, 2B-1 and 3-1 which would require four more trainsets (eight LRVs) than concept alignment 1-2, so operations costs plus LRV acquisition costs should be less than $9.7 million dollars annually. This is an area that requires additional analysis if a decision is made to proceed further with a T-Third Phase 3 project.

6-2-3 System Performance

Extension of a single transit route should improve the existing transit system network's accessibility and capacity. Increased service can result in passengers changing transit routes, new passengers beginning to use the system, existing passengers choosing to use transit more, and other impacts to the larger system.

6-2-3-1 IMPACTS ON EXISTING T-THIRD LINE

The T-Third Phase 2 provides critical connections to intra-city and regional transportation networks through the Market Street Muni and BART subways and the 4th and King Caltrain station. An extension would bring the benefits of these connections to North Beach and Fisherman's Wharf. In the example extension modeled in Section 2, the improved travel times and the faster access to the northern neighborhoods from other parts of San Francisco, would attract over 40,000 additional trips per day to the T-Third line. The new ridership would bring total T-Third daily trips to nearly 115,000.

Ridership would be significant in all alternatives included in this report, due to the similarities of concept alternatives with respect to major drivers of ridership. These include the population and jobs within easy access of most stations, and the connections available from this line to regional networks and other dense or growing neighborhoods like Mission Bay. (In the example, nearly all of the ridership growth is on the portion of the line north of the Mission Bay neighborhood.) Although resources do not allow full modeling of all scenarios analyzed in this report, it is expected that concept alternatives with longer travel times will show some reduction in ridership below the example modeled. For this reason, concepts with some surface segments would have reduced ridership. Meanwhile, concepts with stations at both Conrad Square and Kirkland may have additional ridership, but this effect would be muted by the proximity of those stations to each other.

A different system performance issue concerns the potential for passenger crowding with the introduction of LRT service to the North Beach and Fisherman's Wharf areas. As stated in Section 2, with service assumptions of 2-car trains every 2.5 minutes in the peak period, the maximum passenger load reaches 74% of planning capacity. However crowding is sensitive to the frequency of service. If the service were to be reduced to a 2-car train every 3 minutes, the passenger load would reach 88% of planning capacity –

above the 85% service standards SFMTA uses to reduce sensitivity to surges in demand.

6-2-3-2 IMPACTS ON EXISTING TRANSIT SERVICE

A T-Third Phase 3 extension would offer quicker service and a higher passenger capacity than existing bus and streetcar service to these northern neighborhoods, increasing the attractiveness of Muni service overall. A significant proportion of the trips are new trips on the Muni system, increasing daily Muni ridership by 9,500.

Table 6-3 Daily and Peak Period Ridership (Daily Trips)

	Daily	AM	PM
2040 Baseline	1,020,314	223,262	285,799
2040 Extension	1,029,823	225,682	289,378
Difference	9,509	2,420	3,579
% Difference	0.9%	1.1%	1.3%

The remaining trips would arise from changes in travel patterns that shift more passengers onto this route from slower or overcrowded corridors. In this sense, the extension would augment surface bus, rail, and streetcars that are subject to capacity constraints. The 30-Stockton, 45-Union/Stockton, and F-Market & Wharves are crowded today and are projected to be over capacity in 2040. With a T-Third Phase 3 extension, the LRT service is projected to draw passengers from these lines, alleviating crowding on surface transit. In the PM peak, 5,800 boardings will be shifted from the E and F rail lines and the Powell-Mason Cable Car, and 400 boardings will be shifted from the 30-Stockton, 45-Union/Stockton, and 8X/8AX/8BX-Bayshore Express routes. This lessens crowding significantly, reducing the person-miles traveled (PMT) in crowded or over-capacity conditions by 18,000 miles (-80%) in the PM peak period. See Table 6-4.

Table 6-4 Forecast Peak Period Passenger Crowding Person-Miles Traveled in Crowded Conditions)

	Uncrowded	Crowded	Overcapacity	Crowded + Overcapacity
2040 Baseline	19,000	7,000	15,000	22,000
2040 Extension	23,000	3,000	1,000	4,000
Difference	3,000	-4,000	-13,000	-18,000
% Difference	17.1%	-59.3%	-90.5%	-80.4%

Different concept alignments may slightly affect which nearby routes riders are drawn from, but the capacity and speed of the route should draw passengers regardless of specific station locations. Additional modeling could be done to confirm balances.

6-2-3-3 FUTURE WESTERN EXPANSION OF LRT SERVICE

As stated in Section 2, if the T-Third Line is extended to serve part or all of the North Beach/Fisherman's Wharf Corridor, the possibilities for further extension should be considered and understood. The most likely extension would be to neighborhoods west of North Beach and Fisherman's Wharf, including Russian Hill, Union Street / Lower Pacific Heights, the Marina, and the Presidio. Although an extension to this area would be many years in the future, initial assessments of issues, opportunities and challenges to such an extension could impact the analysis of alignment concepts of a T-Third Phase 3 extension.

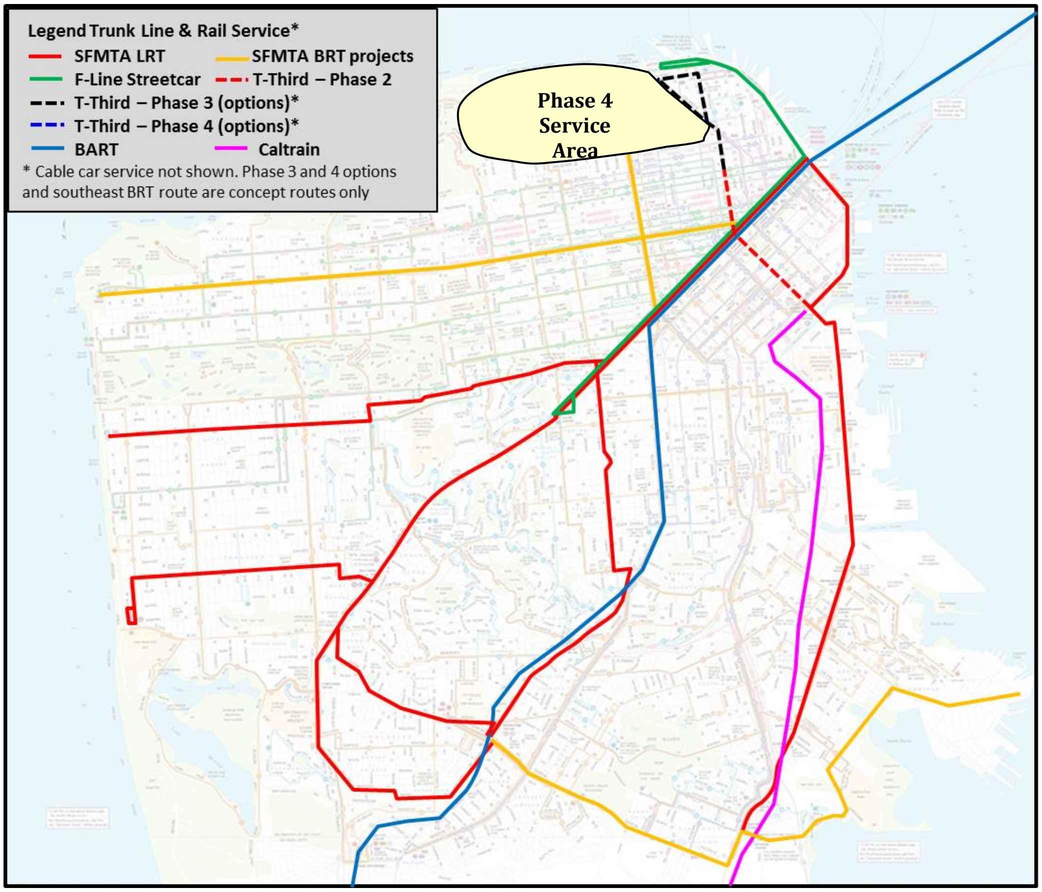
The three route options (Waterfront, Lombard Street and Union Street) were reviewed for this potential. Subway based service would offer faster travel times and higher reliability than surface service. An LRT route operated via Conrad Square and Kirkland would have two more stations and a longer path of travel than a westward expansion route that joined the T-Line at the North Beach station, while a direct Conrad Square route would shorten the path of travel in this direction. One-way loop concepts may suggest an obstacle or a redundancy if further western expansion is pursued, but such facilities could be useful under certain circumstances. For example, a west branch that that split south of a loop wold allow two lines of service – one western, and one northern – that could merge into a combined service in the Central Subway tunnel.

All of the westward expansion route options would result in an increase of several thousand passengers per day on the T-Line LRT service. Initial capacity analysis based on Transportation Authority modeling data has projected the increase in passenger levels could result in "downstream" overloading of the T-Line during the AM and PM peak periods unless the T-Line capacity is increased. It is also possible that platform and station capacity along the existing T-Third corridor would be expanded to support a substantial increase in passengers that would accompany further extension to western neighborhoods.

A separate western route with independent tunnels may also be possible, with either a passenger transfer or a rail connection near North Beach station. If such a scenario is envisioned, significant work should be included in the construction and configuration of the tunnels near that station to reduce construction and plan for most efficiency of operations in that area.

The technical and practical feasibility of future western expansion should be given serious consideration, and will require additional study and analysis beyond the scope of this report.

Figure 6-5 Existing and Conceptual Rail + Planned and Proposed BRT Service in San Francisco



6-2-4 Local Operations Considerations

This category groups together the potential effects of transit operations within a corridor, including changes in noise, aesthetics, and physical changes that affect neighborhood resources, like changes to sidewalk widths or parking configurations.

6-2-4-1 NOISE

As documented in previous recent SFMTA studies (T-Line-Phase 2 Central Subway SEIS/R, F-Line Extension to Fort Mason Center EIS), streets that host transit service provided by buses or electric streetcars (LRT or historic streetcar) are noisier than streets without transit service. Older historic streetcars (non-PCC cars) are much noisier than LRT vehicles. Subway LRT service is quieter than surface LRT service, and quieter than mixed traffic, except on curves, especially tight curves where train steel wheels on steel track can be very noisy. Electric trolley buses are an exception to the general rule on transit noise as they are likely equal to or quieter than mixed traffic due to their nearly silent electric motors and rubber tires. However, even surface operated electric trolley buses are noisier than LRT vehicles in service in a subway.

An important factor in noise evaluation is the impact of background noise. Arterial streets with more than two traffic lanes and streets in industrial or commercial areas have higher levels of background noise than residential streets with two lanes of traffic. The higher background noise level allows for sounds from individual noise sources to more easily fade into the background

This concept study did not conduct noise evaluations of concept alignments, so assessment of noise is based on the above general statements. Noise data collection would be a priority in any future study that follows this concept study.

6-2-4-2 STREET AND NEIGHBORHOOD AESTHETICS

Aesthetics are an important factor of the attractiveness of a street or a neighborhood, especially in older neighborhoods with narrow streets and a well-developed “feel” or “appearance”. However defining the characteristics of individual elements that comprise positive aesthetics, or what is considered attractive by a hypothetical “average” person, is a difficult and challenging issue to quantify. Generally, streets that are quieter with less traffic and without transit are found to have better aesthetics than those that support higher levels of traffic and / or transit service.

Although a preferred set of aesthetics is challenging to determine, another useful concept in this area that can be easily measured is level or significance of visible change. In comparison to a street with bus transit service or no transit surface, a surface LRT line represents a high level of change due to the installation of fixed rails, station platforms, and overhead electrical wires and support poles and infrastructure.

A subway is mostly hidden beneath the surface, but its visible elements can take significant space near stations. Space is needed for headhouses to access the stations, and for ancillary uses like ventilation shafts and potential emergency exits. To the extent these facilities are located in public right of way or other public space, they may impact local aesthetics. If off-street locations can be utilized, chances are greater that good design can minimize negative impacts and enhance the aesthetics of an area.

Lastly, alignments with combinations of surface and subway require portals. The portals assumed in combination concepts here are located within the right of way, and would require both street space in the horizontal plane and walls surrounding the portal. The space for the portal structure would be in addition to space already required for a surface line.

6-2-4-3 NEIGHBORHOOD RESOURCES

Neighborhood resources include facilities like sidewalks and on-street parking, as well as cultural resources such as buildings or sites with historical, architectural, archeological, cultural, or scientific importance.

Surface routes and loops can take up parking spaces and constrain sidewalk widths. With underground construction, this effect may be largely avoided along the alignment, but may be concentrated at subway station locations. To avoid these impacts and allow sufficient space for elevators, escalators, and stairs to stations, locating subway stations off-street is preferred.

Cultural resources are often documented with a survey to identify possible resources and evaluate their significance. A survey is beyond the scope of this concept study, but would be an early action if further action is initiated on a T-Third Phase 3 project. The concept alignment corridors are located on streets (Columbus, Powell and Beach) that likely have cultural resource sites present due to the age of the neighborhoods, and their importance in San Francisco history. Any project alternative would monitor for impacts to existing buildings or sites of significance due to construction. For concept alignments with significant underground excavation, construction must plan and monitor for the possibility of encountering buried historic resources.

6-2-5 Infrastructure Resiliency

Infrastructure resiliency refers to the durability of infrastructure. FTA considers underground tunnels and stations to have useful lifespans of 125 years; surface stations to have useful lifespans of 70 years, and surface transit rights-of-way to have useful lifespans of 20 to 30 years. Designs must take into account the natural occurrences that are likely to occur during these lifespans. But, when evaluating life cycle costs or annualizing capital costs (as FTA does), longer-lasting infrastructure may be more cost effective.

Two specific considerations for long lifespan infrastructure in the San Francisco Bay Area include resistance to earthquake damage, and vulnerability to flooding, groundwater, and sea level changes.

All of the concept alignments are in the seismically active Bay Area region and would need to be designed to accommodate a high level of seismic ground motion. None of the alignments are near faults where offsetting or spreading movements are expected. However, all the alignments are in a zone with potential for ground liquefaction. Design would need to account for this potential and utilize ground improvement methods to reduce this risk where warranted. This may be required for surface alignments as well as for underground concepts.

In the parts of the alignment closest to the Bay, groundwater is likely to be high—this study assumes levels are 10 to 15 feet below surface—and flooding due to sea level rise is a likely risk over the lifespan of the infrastructure. All underground construction would be designed to limit water infiltration and use pumps to prevent water build up at low points. For subway infrastructure, a Kirkland Yard-area station was found to be the most vulnerable to flooding, but with appropriate design measures to protect the portals, the potential impacts can be mitigated. The largest concern was that concepts with surface infrastructure nearest the Wharf could experience significant flooding under some sea level rise projections.

6-2-6 Construction Disturbance

Construction disturbance includes the temporary disruptions to residents, businesses, pedestrians, and traffic during construction. Construction noise and dust, traffic congestion, reduced accessibility, and wayfinding challenges are included in this grouping. The primary differences between the concepts relate to the amount of underground versus surface construction, and the methods of underground construction.

Subway construction of LRT service is likely to have a longer duration than a surface construction, although the direct impacts of surface construction are likely to be more extensive. If a combination of tunnel boring machines and mining are used instead of cut-and-cover methods, underground construction impacts may be concentrated at station locations. Off-street station locations would reduce the need for road closures or restrictions.

Construction staging areas would be needed for all concepts to set up and store equipment and materials. Identification of off-street locations for staging would reduce the need for road closures or restrictions. For underground concepts, large excavation volumes would result in truck traffic to remove the soil materials from the site.

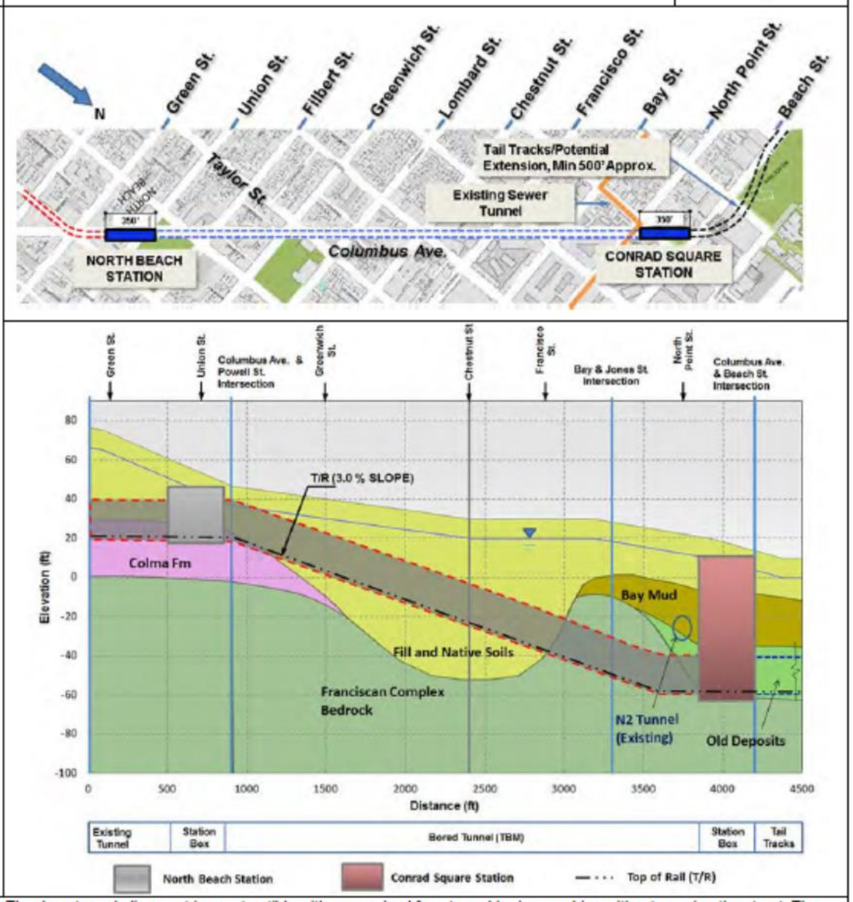
6-2-7 Capital Construction Costs and Risks

Chapter 4 and Appendix D evaluate the constructability of the concept alternatives in detail, but this section reviews some key findings.

6-2-7-1 UTILITY ISSUES

All concepts, including surface alignments, would require utility relocations outside the track right of way. Both the utility agencies and the SFMTA consider this standard practice to facilitate maintenance and emergency work without disrupting each others' services.

Figure 6-6 Plan View / Cross Section of Concept Alignment 1-2 Columbus Ave.

Alt. No.	PLAN AND PROFILE	SCORE
		5
1-2		

Summary: The deep tunnel alignment is constructible with pressurized face tunnel boring machine without opening the street. The tunnels would need to avoid impacting existing sewer tunnel beneath North Point Street. At least one cross-passage will be required beneath Columbus Avenue to meet NFPA 130 requirements. Due to relatively high groundwater level observed at Pagoda site it is possible that ground improvement will be performed from the street to control the water within the excavated SEM cross-passage opening with some traffic/street disruption. The construction would likely proceed from North Beach station shaft using Pagoda site. Detailed instrumentation/monitoring program would need to be implemented for streets/buildings/utility settlement/vibration/air monitoring. There is a possibility the buried wooden piles supporting utilities could be encountered along the tunnel alignment or within the station box construction. The station construction should provide for watertight support of excavation; excavation would likely proceed top-down under traffic deck with bottom-up build-out. Utilities within the station box construction/entrances/ventilation shafts would need to be relocated or supported in place. ROW would need to be identified for housing station entrances, emergency exits and ventilation shafts. Conrad Square station would need to include invert grouting for stability. Tunnels could be extended beyond Conrad Square station and later capped for future use. No impact for 100-year flood event is anticipated. See Risks Matrix Table 4.1.1.for other subsurface risks. It should be noted that for a future westward tunnel extension, a double stub tunnels should be constructed west from the North Beach Station. Subsurface obstructions in the tail track area were not evaluated and shall be part of a further study.

The largest utility constraint is the large sewer running along North Point Street. Along with geotechnical considerations of tunneling, this constraint requires any underground tunneling to stay at the substantial depth of 50 to 60 feet below grade in order to avoid the sewer. Careful geotechnical monitoring and a response plan would also be required to tunnel below this and other utilities.

Even with the excellent maps shown in Section 4, a detailed analysis of this issue is required before decisions regarding concept alignments can be made. Using existing information, The Columbus Avenue alignments appear to have lesser conflicts and impacts with utilities than the Powell Street alignments. The Powell Street + Beach Street alignments and the One-Way Loop (longest concept alignment) both appear to have the most conflicts and impacts with utilities.

6-2-7-2 Capital Costs

Capital costs are analyzed in Chapter 5 and Appendix D. The costs are estimated in 2014 dollars, since it would be premature to make assumptions that would allow escalation to Year-of-Expenditure (YOE). As Chapter 5 notes, costs may also vary substantially, since planning phase estimates of this type cannot accurately predict all possible scope that will be included. To account for this uncertainty, Chapter 5 includes substantial cost ranges in keeping with transit project historical patterns. Follow-up study and design work would refine the base estimates and contingencies included here, but the estimates are sufficient for understanding cost order of magnitudes, and for purposes of comparing alignments.

The concepts are mainly differentiated by the amount of surface versus subsurface construction. Both the length of each alignment and the number of stations are also drivers of cost. All concepts include some underground construction to tie in to the existing Phase 2 tunnels, and all include an underground North Beach station. Concepts that include largely surface construction and that only include only one station at the northern end of the alignment produce the lowest costs. Utility relocation costs and ground improvement costs may still be substantial with these alternatives.

As shown in Chapter 5, base estimates for full subway alignments are about 50% more costly than surface alignments. The two segment subway concept, 2B-2, and the one-way loop subway concept, 3-2, have the highest cost estimates due to inclusion of three underground stations (North Beach, Kirkland, and Conrad Square). The high cost of 2B-2 is also driven by its length of double-bore tunnel compared to the other alignments.

As noted in Section 2, FTA takes infrastructure lifespan into account when evaluating the cost effectiveness of a transit project, by annualizing capital costs over the expected useful lifespan of each project component. In that analysis, the greater expense of underground components is offset—in whole or in part—by the longer lifespan of those components. In part for this reason, as well as the high ridership that would be expected on a T-Third extension, all of the feasible concept alignments are expected to score in the “High” range of FTA’s cost effectiveness.

Within each concept alignment here, variations in scope are possible that would have cost effects; for example, number and location of stations at Fisherman’s Wharf, and configuration of terminal track and platform facilities. Future project development should still monitor costs when making decisions about scope or alignment, in order to keep the cost effectiveness competitive.

6-2-8 Appendix Information

A separate section of reference reports and data (e.g. traffic count data, transit route data, etc.) is in the Appendix. The data sources are listed below with their Appendix designation. These are available for review by contacting staff in Sustainable Streets.

A: 2014 SFMTA TRANSIT SERVICE INFORMATION

B: SFMTA TRAFFIC COUNT DATA

C: DETAILED DESCRIPTIONS OF CONCEPT ALIGNMENTS

D: CONSTRUCTABILITY ANALYSIS AND COST ESTIMATES
(HNTB CONSULTANTS)

E: LAND USE AND VALUE CAPTURE ANALYSIS
(STRATEGIC ECONOMICS)

F: TRANSPORTATION AUTHORITY MEMORANDUM – OUTPUT
SUMMARY CENTRAL SUBWAY EXTENSION TO FISHERMAN’S WHARF – 2040

G: THIRD STREET LIGTH RAIL PHASES 1 + 2 – 2018-2030
SERVICE INTEGRATION PLAN – REVISION 1

H: SFMTA BOARD RESOLUTION TO LEASE PAGODA PALACE SITE

I: TRANSPORTATION AUTHORITY MEMORANDUM – COST EFFECTIVENESS
CALCULATION

J: T-THIRD PHASE 3 CONCEPT STUDY – AUTHORIZATION ACTION
TRANSPORTATION AUTHORITY BOARD OF DIRECTORS