



SEATTLE CENTER MONORAIL STATIONS RECONFIGURATION EVALUATION REPORT

TABLE OF CONTENTS

1	EXECUTIVE SUMMARY	P. 3
2	EXISTING CONDITIONS ANALYSIS	P. 7
3	CONCEPT DESIGN	
	DRIVERS AND OBJECTIVES	P. 12
	OPERATIONAL GOAL	P. 14
	WESTLAKE STATION	P. 15
	SEATTLE CENTER STATION	P. 21
	BELLTOWN STATION	P. 26
4	APPENDICES	
	APPENDIX A: COST-BENEFIT ANALYSIS	P. 27
	APPENDIX B: COST OF IMPROVEMENTS	P. 28
	APPENDIX C: COMMUNITY OUTREACH	P. 29
	APPENDIX D: DISCARDED CONCEPTS	P. 37
	APPENDIX E: THROUGHPUT ANALYSIS	P. 40

EXECUTIVE SUMMARY

INTRODUCTION

In late 2017, VIA Architecture was selected by Seattle Monorail Services and Seattle Center to develop and evaluate potential improvements to the Seattle Monorail that will **increase capacity, improve accessibility, and better connect** it with the regional transit network, downtown transportation infrastructure, and other downtown resources. The results of that effort and are summarized in the following report and include concept designs for both Monorail stations, time lines, operating recommendations, and high-level cost estimates.

STUDY PRINCIPLES

The primary objectives of this feasibility study and concept design are to enhance patron experience at the existing Monorail stations and increase overall capacity of the 1-mile line to meet the demands of growth and development in Seattle Center and downtown. The larger goals of these objectives align with the goals put forward by the Seattle Comprehensive Plan 2035, adopted in 2017, and other community efforts as follows:

1. Maximize the operating potential of the existing Monorail line.
2. Make the best use of existing streets, parking facilities, and transit operations to move people to and from Seattle Center.
3. Encourage the use of public transit to Seattle Center by fully integrating the Monorail as part of the local and regional transit system.
4. Meet the transportation needs required by redevelopment of the Seattle Center Arena on its opening day.
5. Provide a phased approach to bring improvements on-line as quickly as possible, with subsequent improvements to be added as capacity needs increase with the completion of Sound Transit 2 connections to Bellevue and Redmond.
6. Provide universal access.
7. Contribute to a safer city*
8. Create an interconnected city where people have reliable, easy to use travel options*.
9. Develop a more vibrant city by creating streets and sidewalks that generate economic and social activity*.

*Goals take directly from the Seattle 2035 Comprehensive Plan

MONORAIL VITAL LINK TO WESTLAKE HUB

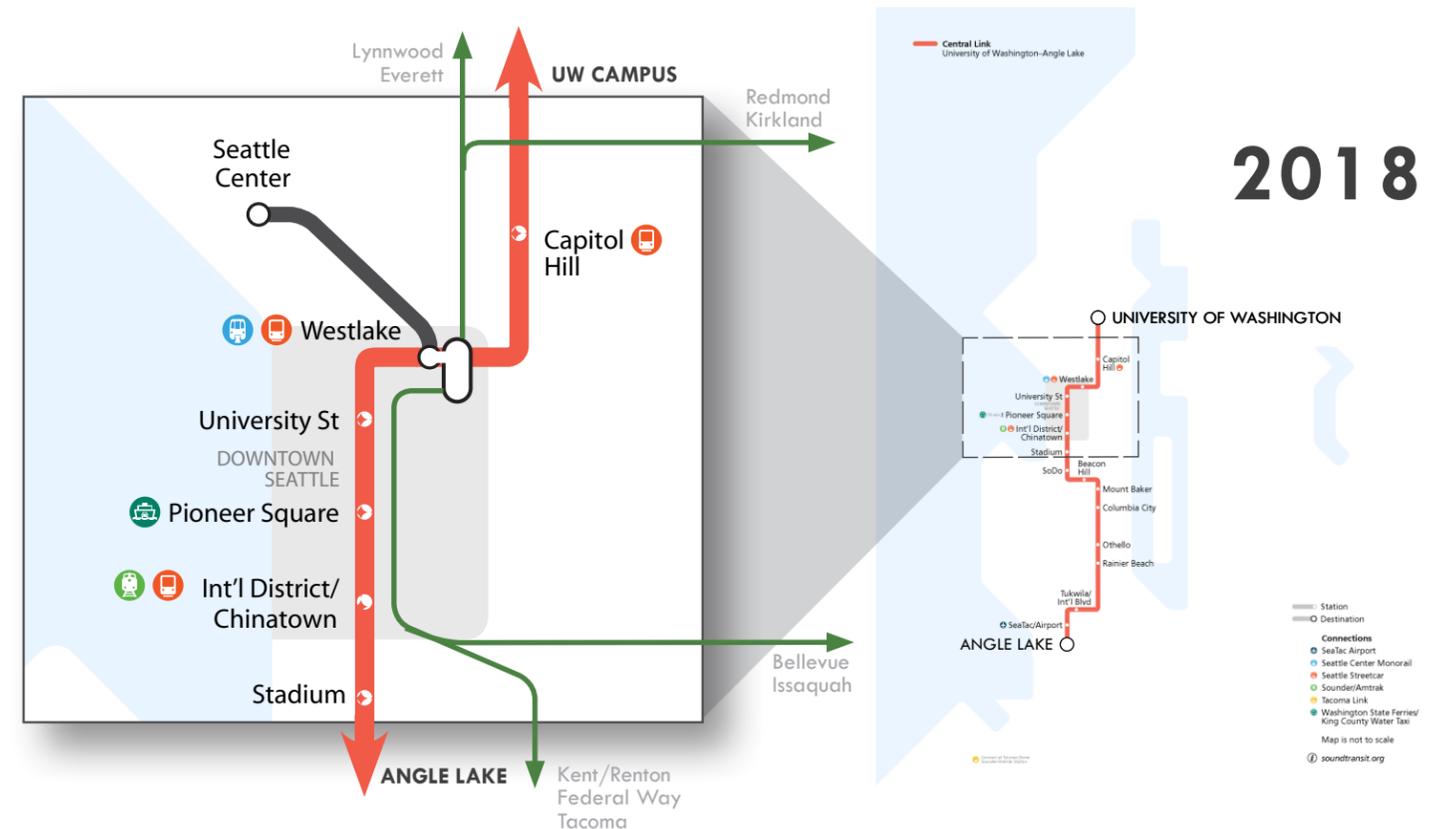


Figure 1a: This diagram shows existing connections from the Monorail to regional transit at Westlake Station. The red line represents Sound Transit Link Light Rail 1 (ST1). The green lines represent regional bus lines that will be supplemented or replaced by ST2 and 3 over time. The diagrams on the following pages show the growth of the Link Light Rail network and the regional stations that will be able to provide direct access to Seattle Center via public transit from 2018 - 2041, with the Monorail playing a key role in that connection until at least 2036.

ACHIEVABLE OUTCOMES

Doubling Monorail capacity to 6000 passengers per hour in each direction

- The major constraints on the system are at Westlake. The 1988 replacement of the original downtown station with one inside the Westlake Center shopping mall essentially cut system capacity in half.
- Capacity goals at Westlake can be achieved with automated ticketing, fare gates, additional vertical circulation capacity, improved visibility, enlarged and reconfigured platform and queuing spaces, and easy, intuitive connections to the transit tunnel below.
- To reach the capacity goals for the line, certain improvements (e.g., automated ticketing and fare gates) will also be needed at the Seattle Center station.
- Proposed improvements to the station platforms and circulation spaces can reduce headways (the average interval of time between trains departing a station) at peak times from the current 5 minutes to 2.5 minutes, effectively increasing ridership capacity to 6,000 per hour in each direction, or 12,000 riders per hour in total.

Accessible, easy connections to Westlake, downtown, and regional transit

- High speed, high capacity elevators at the plaza in front of Westlake Center will provide excellent visibility and ease of connection from the Monorail to the street, the regional bus system, and Link Light Rail.
- A stairway connecting to the Westlake Center mall balcony and Monorail platform will provide surge capacity and restore the balcony as civic space that contributes to the vibrancy of the city.
- Overall, improvements create better accessibility, visibility and intuitive connections for ease of access and transfer.

Utilize existing infrastructure to ease congestion

- Maximizing the operating capacity of the existing Monorail line to its greatest people-moving potential can mitigate congestion created by large events at Seattle Center.
- The fine grain, pedestrian oriented neighborhood of Uptown cannot provide the transportation capacity that exists in downtown without major investment and impact to the character of the neighborhood.
- Seattle Center patrons can easily and quickly avoid congestion after an event by accessing downtown's existing high capacity transportation infrastructure via the Monorail - Metro buses, Link train lines, protected bike facilities, parking garages and the street grid - all designed for higher capacity than available in the Uptown area.

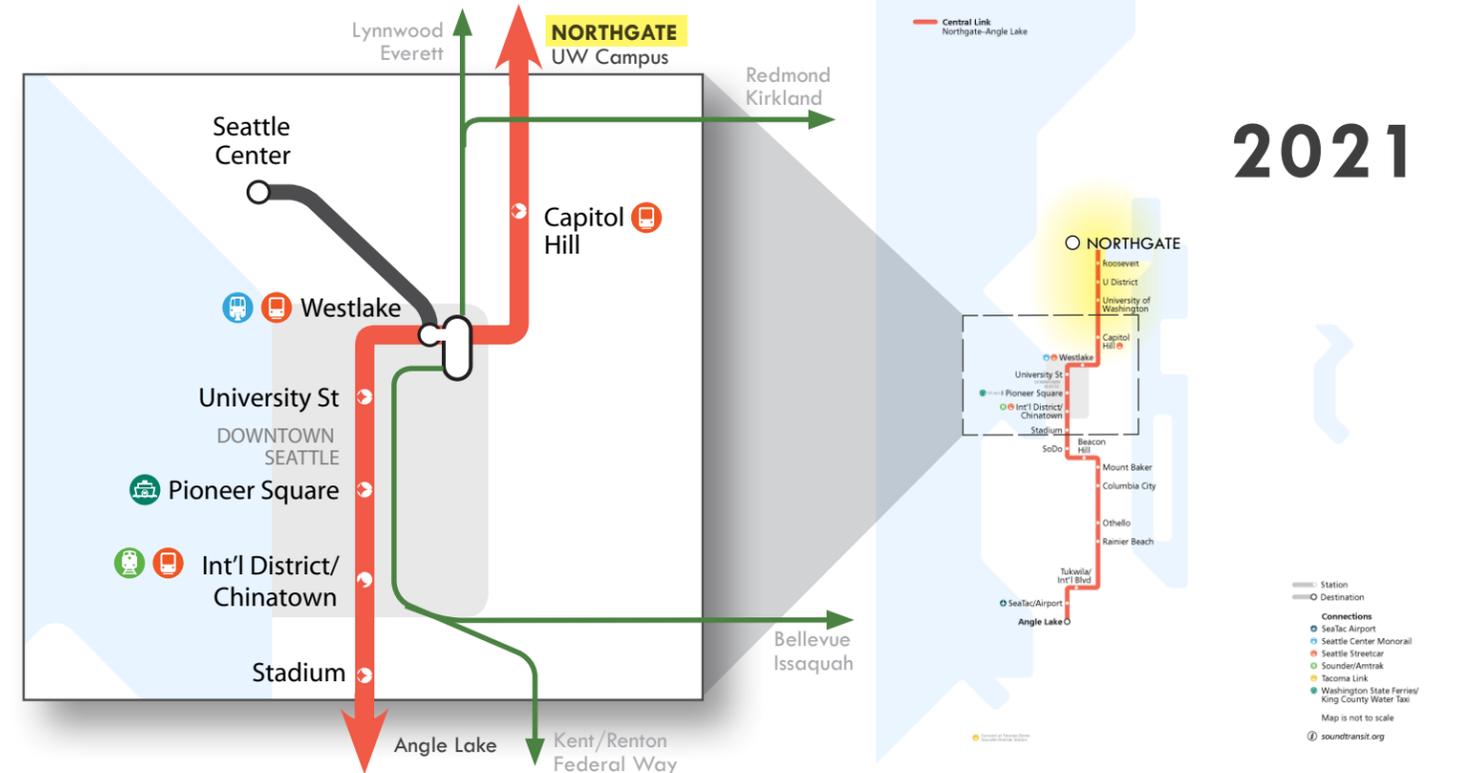


Figure 1b: Northgate Station projected connection in 2021.

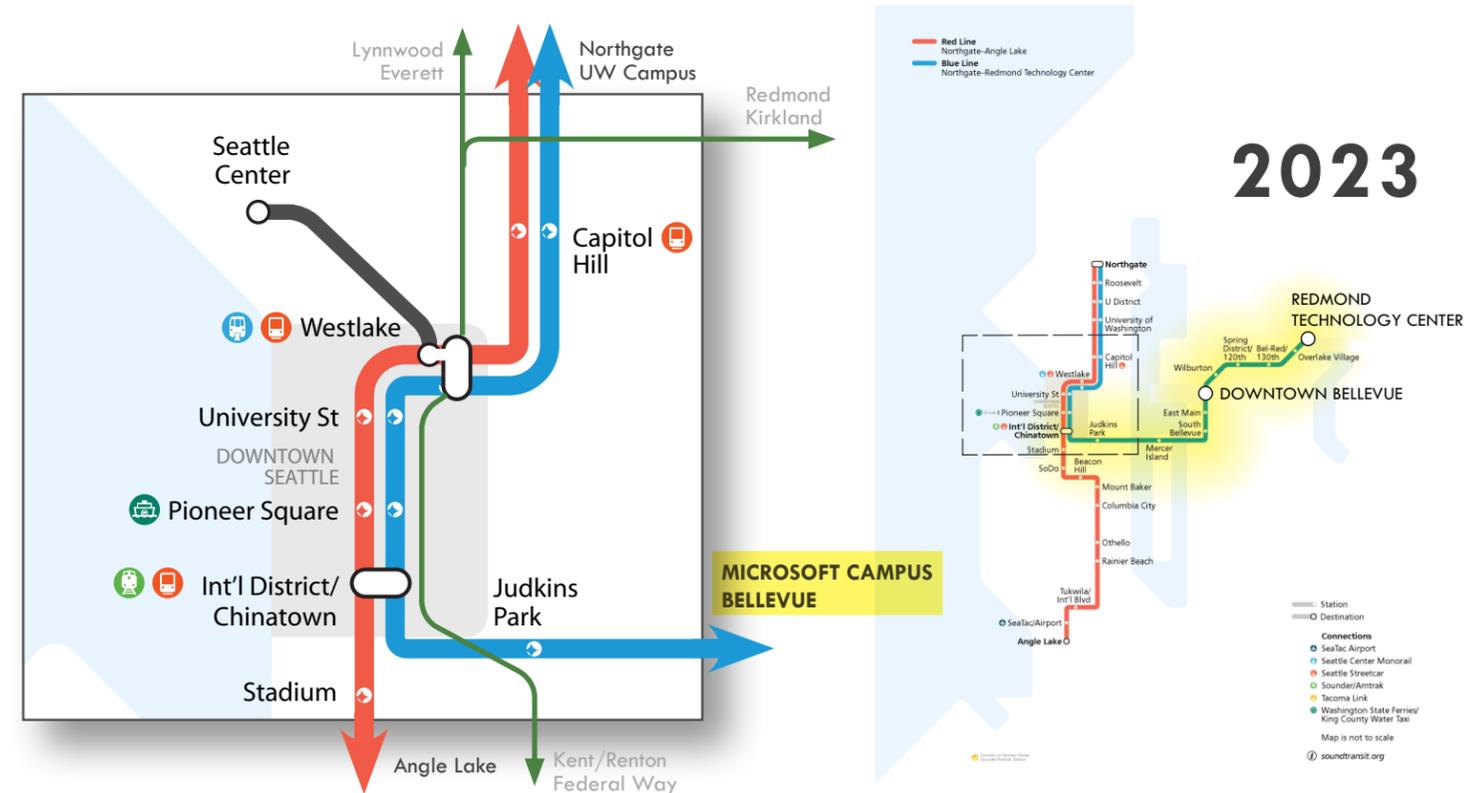


Figure 1c: Eastside projected connection in 2023; contingent on outcomes of Metro's 520 Connections project. The blue line represents ST2.

PHASING AND CAPITAL COSTS

The Seattle Center Monorail can provide a connection from Seattle Center to high capacity regional transit service more than twelve years before the proposed Sound Transit 3 line will connect there.

The results and recommendations of this study identify ridership goals for different levels of investment in the existing system. Improvements can be phased to have the Monorail operating at the highest capacity possible by opening day of the proposed Arena redevelopment.

To achieve this, the minimum level of improvements necessary are the Phase 1 improvements at Westlake proposed in this report, together with a commitment to staffing at both terminals to operate the Seattle Center Armory and its amenities late at night for post-event queuing and to keep Westlake Center mall open for escalator circulation to the street and transit tunnel. Estimated capital cost of Westlake Phase 1 is \$3.85 mil.

Phase 1 improvements at Seattle Center station, which replace 32 stationary platform edge guardrails with automatic platform edge gates matching those at Westlake, are the next priority. These gates are needed to achieve the 2.5-minute headway times and full 6,000 one-way and 12,000 two-way capacity of the system and to provide the same level of customer safety and experience at both stations. The capital cost for Phase 1 at Seattle Center is estimated at \$3.1 mil.

Phase 2 adds vertical connectivity directly from the Monorail platform to the transit tunnel, and creates additional street activation and tunnel access from the plaza in front of Westlake Center, visible from vibrant Westlake Park. Timely implementation of the second phase of capital improvements at Westlake station is important as rider demand will increase as Sound Transit 2 Link Light Rail expands connections to the north, south and east between 2021 and 2025, (figures 1b-1d). The capital cost for Phase 2 at Westlake Center station is estimated at \$9.2 mil.

Descriptions and images of the phases for Westlake station are shown on pages 15-21 and for Seattle Center station on pages 22-25. Appendix B includes a description the costs per phase for each station.

EXISTING MONORAIL LINE CONTEXT

The Seattle Monorail was built in 1962 for the World's Fair. It is one mile of double track connecting the major business and civic campuses of Westlake and Seattle Center at two terminal stations. Originally installed for the 6-month long Fair, the Monorail has achieved its 55th year of operation and the trains have logged over 2 million miles. The Seattle Monorail train cars have been designated as historic landmarks and serve as a cherished piece of living history. Today, the Monorail performs functions ranging from delighting tourists to ferrying event attendees and supporting daily commutes.

There are opportunities to enhance the Monorail experience for all user groups. At Westlake, the 1988 reconfiguration to rebuild the station inside Westlake Center shopping mall constricted the platform and guideway, limiting service. Although Link Light Rail has been in operation since 2009 at Westlake in the transit tunnel below the Westlake Monorail station, there is no easy, direct, or legible connection between the two. As Link Light Rail expands as a regional transportation network, the need to strengthen the Monorail's connection to both Link Light Rail and the wider urban fabric increases.

The simple, modernist, historic structure at Seattle Center Station has been hidden as the campus has developed over the past 50 years. With a major renovation of the Seattle Center Arena planned for 2020, strategies to increase wayfinding, visibility, and accessibility to the Seattle Center station are needed.

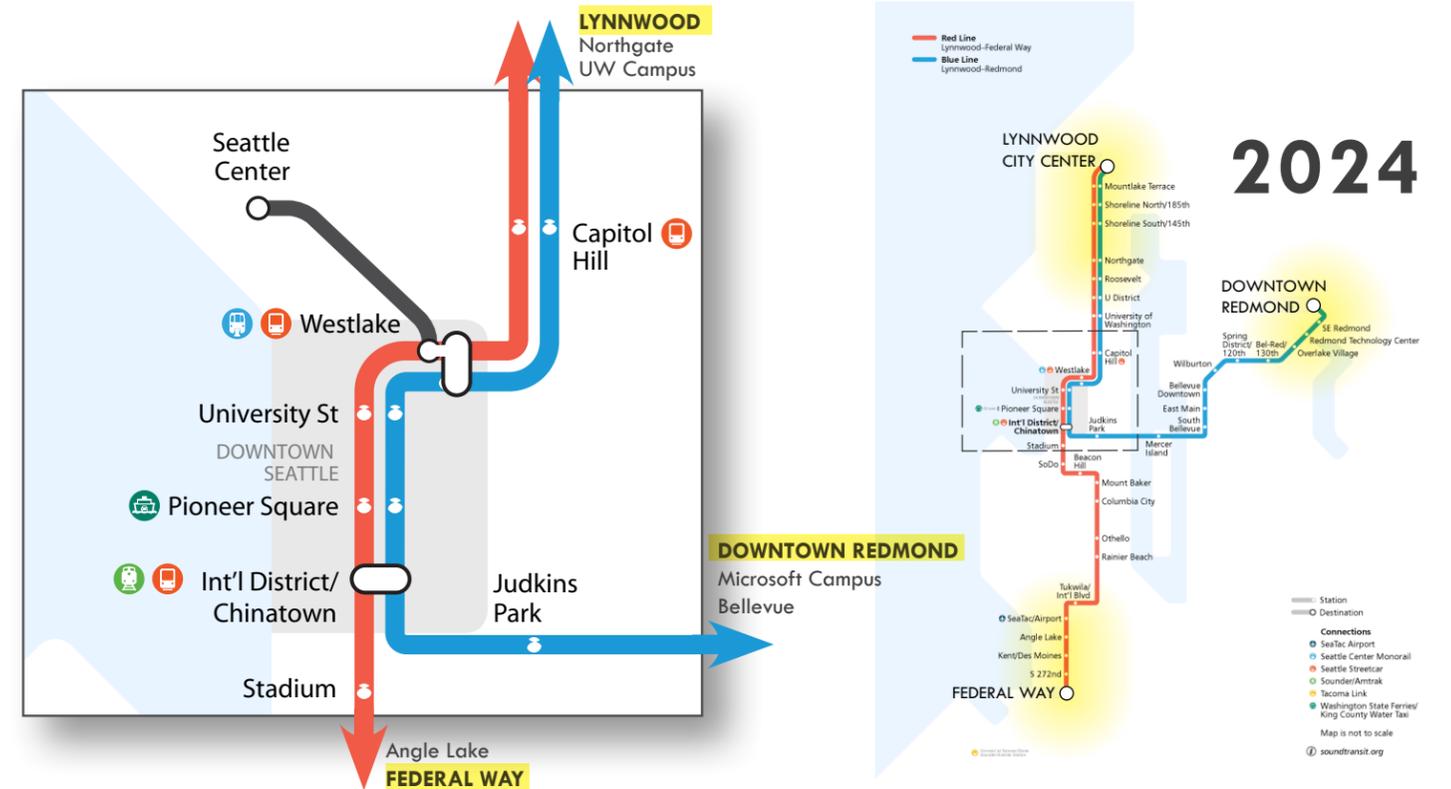


Figure 1d: Lynnwood projected connection in 2024.

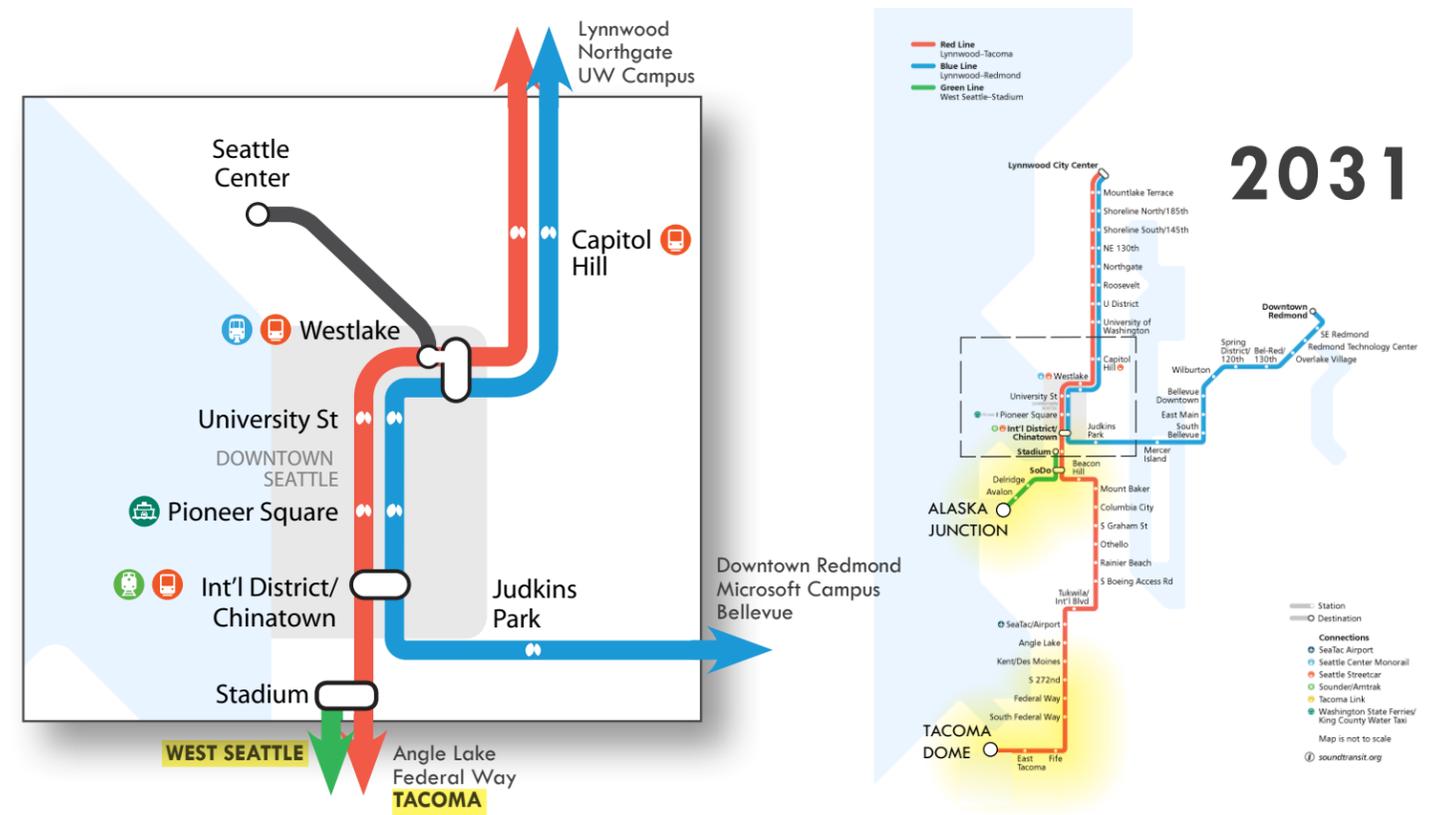


Figure 1e: West Seattle and Tacoma connections projected for 2031. The green line represents ST3.

STAKEHOLDER ENGAGEMENT

Stakeholder and community input was extensive and essential for the Monorail feasibility study process. The design team provide materials and support to Seattle Monorail Services who engaged with the following stakeholder groups:

- Uptown Alliance
- Belltown Community Council
- Queen Anne Community Council
- Magnolia Community Council
- Downtown Transportation Alliance (Commute Seattle)
- South Lake Union Community Council Transportation Committee
- Downtown Seattle Association
- Visit Seattle
- General Growth Properties – owner and manager of the Westlake Center shopping mall
- CBRE - property manager of the Westlake Center office building and garage
- Seattle Metropolitan Chamber of Commerce
- Nordstrom
- Westin Hotel
- The Vance Corporation
- Oak View Group

PUBLIC ENGAGEMENT

Community meetings were conducted in conjunction with the North Downtown Mobility Action Plan community process to seek input regarding the station options as part of the larger vision of connectivity within the North Downtown neighborhoods.

The team presented station concepts and collected feedback at two open houses sponsored respectively by the Uptown Alliance and Belltown Community Council. Public engagement consultant, enviroIssues, aided the team in collecting widespread survey response, both on site at the Monorail stations and through an online portal. Survey results and conclusions were presented with the station concepts at a public open house held at the Seattle Center Armory.

The team experienced almost uniform support and excitement for the proposed station upgrade strategies. Particular interest and support was given to improved connections to Link Light Rail and better integration with regional transit. An outline of the scope and results of the public outreach can be found in Appendix C.

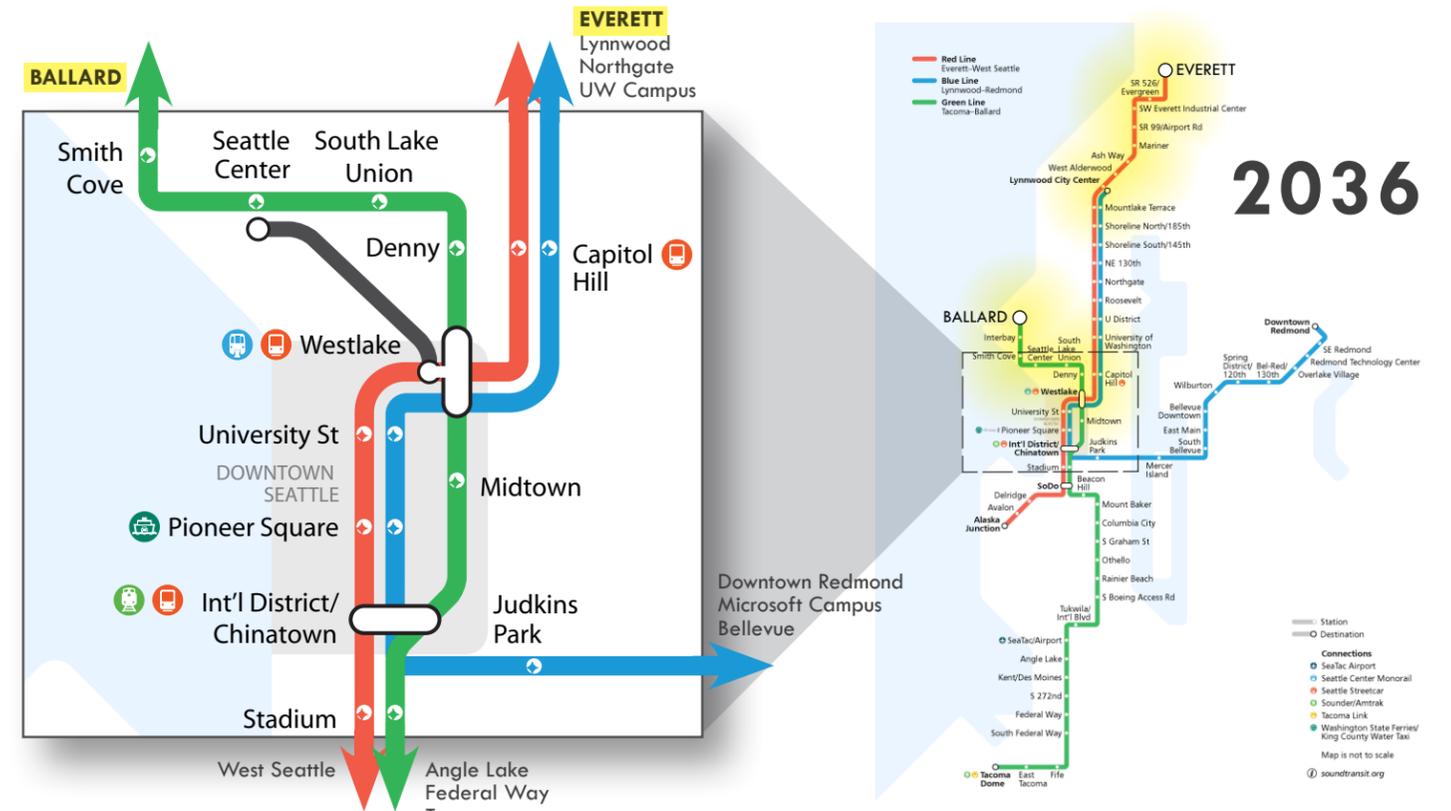


Figure 1f: Sound Transit 3 is projected to connect Seattle Center directly to Link Light Rail in 2036. The Monorail will then provide redundancy to the system, but will maintain competitive travel and wait times for service between Seattle Center and Downtown.

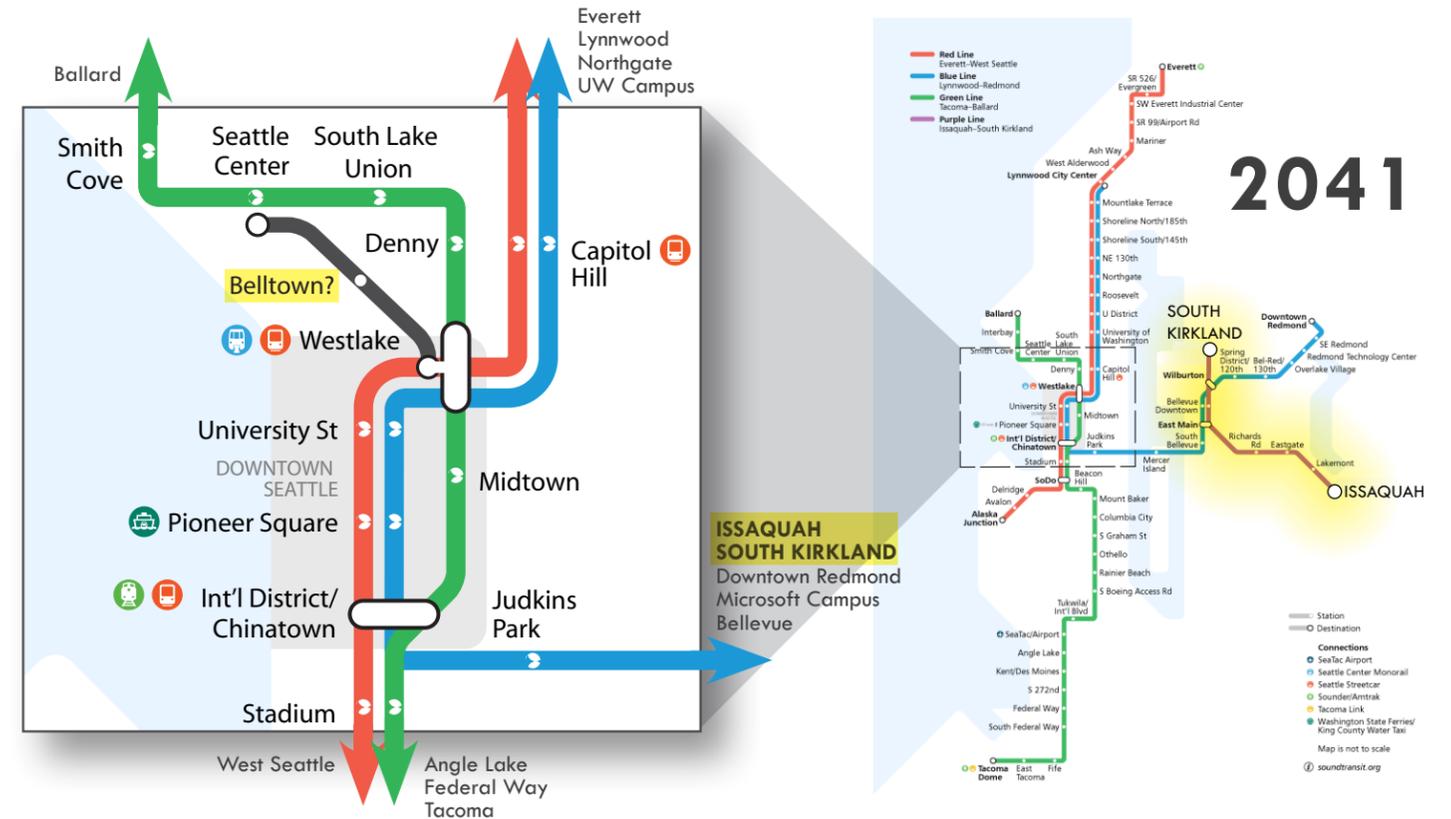


Figure 1g: Addition Eastside connections planned for 2041. Link Light Rail's direct connection to Seattle Center alleviates high event demand on the Monorail. Tight headways will not be as vital so this is the appropriate time to consider an added Belltown Station.

EXISTING CONDITIONS ANALYSIS

OPERATIONS

Improvements to the Monorail stations should be coordinated with operations to maintain and improve the flexibility and reliability of the system. This requires an understanding of current operational methods and challenges and how they interact with physical conditions at the stations.

The Monorail currently has great operational flexibility.

- Normal operation involves attendants at either station and two alternating trains, each with a driver.
- During times of light demand, the system can operate with a single train with only a driver and a ticket attendant inside the train itself.
- For heavier demand such as large festivals or events, additional personnel and equipment such as temporary barriers and queue markers are brought in for crowd control and greater ticketing capacity.

Operations must work within the physical constraints at the stations as well as the guideway itself.

- Two-train operation must be carefully coordinated to keep trains separated on either side of the 'gauntlet,' or track narrowing, south of Stewart Street.
- The mechanically retractable bridges that extend at Westlake over the near guideway to allow riders to reach the far train must be extremely reliable during two-train service.

Current operations must coordinate patron access and egress with the Seattle Center Armory and Westlake Center mall opening hours.

- Arena events typically end after the Westlake Center mall has closed. Crowds of event patrons returning to Westlake after an event do not have access to the mall escalators and must exit the platform only by the existing staircase and elevator.
- Congestion of patrons clearing the platform between train arrivals results in longer boarding/alighting times and can cause service delays.

CAPACITY

Monorail currently carries 2M riders/year (approx. 5500 per day on average), with a peak day in 2017 of over 21,000 passengers, but carried over 8M passengers during the 6 months of the 1962 World's Fair (44,000 per day).

The current capacity of the Monorail is 3,000 riders per hour in one direction. This is based on filling trains to their maximum operating capacity of 250 people per car, with a 4-car train leaving every 5 minutes. The existing headways during two train service of approximately 5-minutes consist of 90 seconds for the actual trip and 3.5 minutes for boarding and alighting of passengers and for the operator to make a security sweep while walking to the driver station on the opposite end of the train.

The need for more capacity is driven by:

- Growth of programming and development in and around Seattle Center, particularly the renovation of the Arena.
- The increased prominence of Westlake as a regional transit hub.

Currently, the Monorail can transport only about 13% of future NHL event attendees at the Arena to or from Westlake in 45 minutes. This is insufficient to fully leverage the Monorail line and its connection to the growing regional transit network (figures 1a-g), to alleviate congestion. Survey responses indicate that the proposed Monorail improvements may induce a tripling in rider demand (see Appendix C).

The key elements limiting capacity are at Westlake:

- Passengers must enter and exit both trains on a single platform.
- The size and configuration of the platform bottlenecks at ticketing, queuing, and exiting flows.
- Paths to the street and transit tunnel are sub-par.

The Seattle Center Station, by contrast, can more easily accommodate the future capacity demand by utilizing its three platforms and ample circulation space.

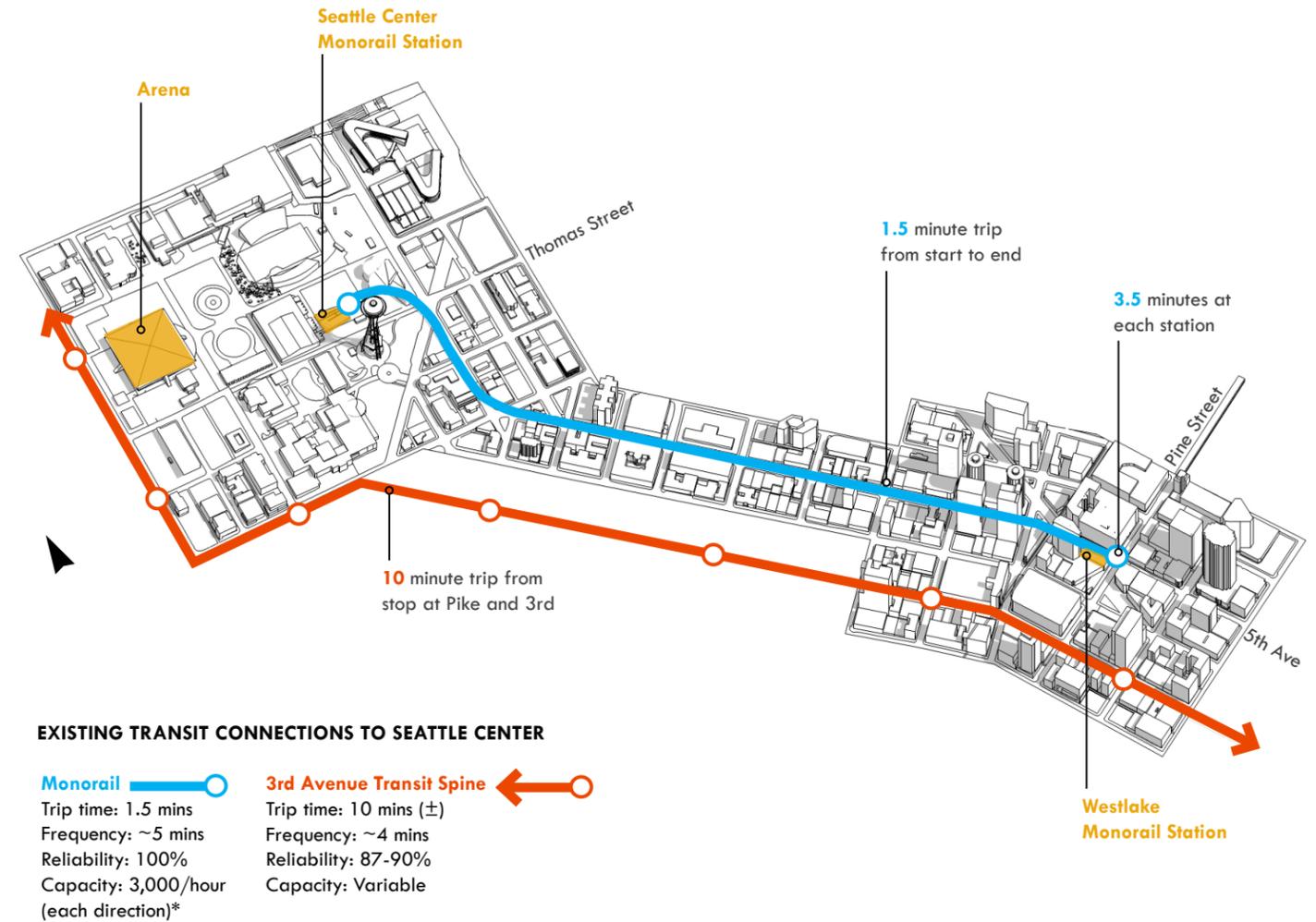


Figure 2: Comparison of the existing Monorail line with other transit options from Seattle Center to Westlake at peak hours.

ACCESSIBILITY

The ease of accessing and moving through a station is an important factor in people's decision to ride the Monorail. Consideration must be given to riders who experience sight, hearing, mobility, or cognitive challenges. The term accessibility includes full compliance with national accessibility standards as well as state and local accessible building and land use codes, but goes beyond these minimum requirements by considering the holistic experience for riders of all abilities. Improvements should eliminate barriers to access on existing ingress/egress paths and avoid segregated entrances.

Both Seattle Center and Westlake platforms are surrounded by high quality pedestrian environments. There is great opportunity to leverage this to provide accessibility improvements at entrances, ticketing centers, queuing areas, faregates and platforms at both stations.

Westlake accessibility issues are on the path from the street or transit tunnel to the platform and on the platform itself.

- When the mall is closed, patrons must either ascend three stories on stairway or wait on the Fifth Avenue sidewalk for the single, slow elevator.
- Riders in wheelchairs have no choice but to use the elevator; when it is not in service, there is no alternate accessible route.
- When the mall is open, there are escalators and additional elevator options, but the elevators are not located along a clear path to the platform.

- The elevator connection to the Monorail from the transit tunnel is tucked in an alcove in a location off the main pedestrian route and suffers from poor visibility and signage.
- The operable bridges leading to the train doors on the far guideway are not uniformly level, leading to slower boarding speed and difficult boarding for persons with mobility assistive devices, such as wheelchairs, scooters, etc., (figure 3).

Seattle Center Station is somewhat easier to access, however there are accessibility issues at the main entrance and on the platform.

- The path through the Armory building directly west of the station is accessible and the bridge connecting the station platform to the Armory east entrance provides a covered accessible route. This entrance, however, needs signage and wayfinding to clearly define it as an accessible path to the Monorail.
- The main entrance to the Monorail platform from Thomas Street on the south utilizes a ramp that does not meet current accessibility standards.
- The platform edge and the train door openings are not level and some require use of a portable ramp for wheelchair users boarding and alighting the trains.

At both Seattle Center and Westlake platforms wheelchair users must enter the train from one of only two doors, yet no signage or markings clearly indicate which doors are accessible.



Figure 3: View of existing operable bridges to the Red Train at Westlake

FLOW

A simple and smooth passenger flow through the stations is a key factor in achieving reliability and enhancing the passenger experience at both stations. The flow needs to be as simple and intuitive as possible, requiring minimal signage to navigate, and be configured to minimize conflict. The configuration needs to be flexible for multiple fare collection and operational scenarios.

Westlake platform has several flow issues that will require reconfiguration to add capacity and improve the customer experience:

- Passengers currently wait in a small, fenced fare-paid area.
- Passengers enter the trains by the four center doors and exit at four doors, two on either end of the train. This configuration is only optimal when there are an equal number of riders entering and exiting the train.
- The current train dwell time is at least twice as long as what it could be if the platform was configured to allow use of all train doors for boarding and alighting.
- The current two-gate ticketing kiosk configuration creates a bottleneck.
- The elevator has a low capacity and is slow.
- The stair, located adjacent to the elevator has low ceilings, poor lighting, and exposed pipes, discouraging use. It connects to the street and transit tunnel, but is often closed off below street level for safety reasons.
- The mall escalators that circulate through retail spaces before reaching the Monorail platform are another option for exiting the platform when the mall is open. They are distant from the stair and elevator, and the point of decision takes place just as passengers are exiting the train, leading to congestion as they hesitate while deciding which direction to take.

Seattle Center station is less space-constrained, but increased system capacity and post-event queuing at multiple entry points calls for better utilization of platforms, mitigating movement conflicts, and improved wayfinding and accessibility.

VISIBILITY AND WAYFINDING

Good visibility and wayfinding, including tactile wayfinding for vision impaired Monorail riders, are critical to ensure that investments in capacity and flow improvements are fully leveraged. Currently, both stations have visibility and wayfinding challenges.

The Westlake platform was moved from its original location above a visibly prominent intersection in 1988 to the east side of Westlake Mall on the third level above 5th Ave. The current location has the following challenges:

- Entrances to the platform from the transit tunnel, the mall, and the street are hard to find and poorly marked.
- Paths to the Monorail are not intuitive.
- The station is on a narrow street, limiting visibility in all directions and is not visible from the nearby large civic space, Westlake Park, (figure 4).
- Other than a few small street signs, there is little Monorail signage in the surrounding blocks, nor directions for access through the mall.

Seattle Center station also has visibility challenges. Despite being a freestanding building at street level, its visibility is obscured by adjacent buildings and landscape vegetation. The gift shop on the south side blocks the view of the station from the exit of the Space Needle, while the Next 50 Pavilion hides the station from the 'Artists at Play' plaza and MOPOP entrance to the north. Post-event crowds from Seattle Center will also benefit from improved wayfinding, improvements to the "front door" South Entrance and potential future north entrance.

- On platforms at both stations wayfinding signage should be provided to clarify the routes to platforms, indicate locations of exits, and note where exits lead.
- Ticketing, fare gates, platform waiting locations, and all other critical elements of the station must be clearly marked and intuitive enough for first time users to understand.



Figure 4: Blue and yellow silhouette shows the Monorail and guideway position behind Westlake Center

EXISTING CONDITIONS - WESTLAKE MONORAIL STATION

CONSTRAINTS & OPPORTUNITIES

As noted earlier, there are several constraints at the Westlake station that restrict flow and create a bottleneck. Figures 6a-b identify several of these constraints on the existing plan. Development and evaluation of opportunities to improve the platform flow included assessment of existing constraints, including:

- Current and planned use of the mall retail and public circulation spaces that limit opportunities for increasing platform and queuing space.
- Monorail's existing control room on the platform.
- The current platform layout with ticket kiosk and separate train boarding and exiting areas limits queuing capacity and requires longer dwell times.
- Limited vertical circulation access and egress capacity. The existing single platform elevator is slow, has limited capacity, and has no redundancy when elevator is down and the mall is closed.
- Existing building infrastructure, including mechanical shafts, ventilation shafts, and electrical rooms, constrains capacity improvements to stairs and elevators at the current street entrance.

Proposed updates to the platform and patron circulation spaces address these constraints. Optimizing the use of the available space includes introducing automated ticketing and fare gates and reconfiguring the platform waiting area to allow use of all eight train doors for boarding and alighting. Connecting to the regional transit system creates a seamless, intuitive connection to encourage ridership. Current constraints on effective connections are:

- The 5th Avenue entrance to the monorail elevator and public stair is hidden under the guideway and does not provide a prominent 'front door.'
- The elevator and stair are hidden from the primary view at the transit tunnel station below in an alcove off one of the secondary arms of the mezzanine.
- Signage and wayfinding to and from the Monorail is weak.

Opportunities to improve the street presence and the vertical circulation link to the transit tunnel are available. Proximity, visibility and speed of access can all be greatly improved.

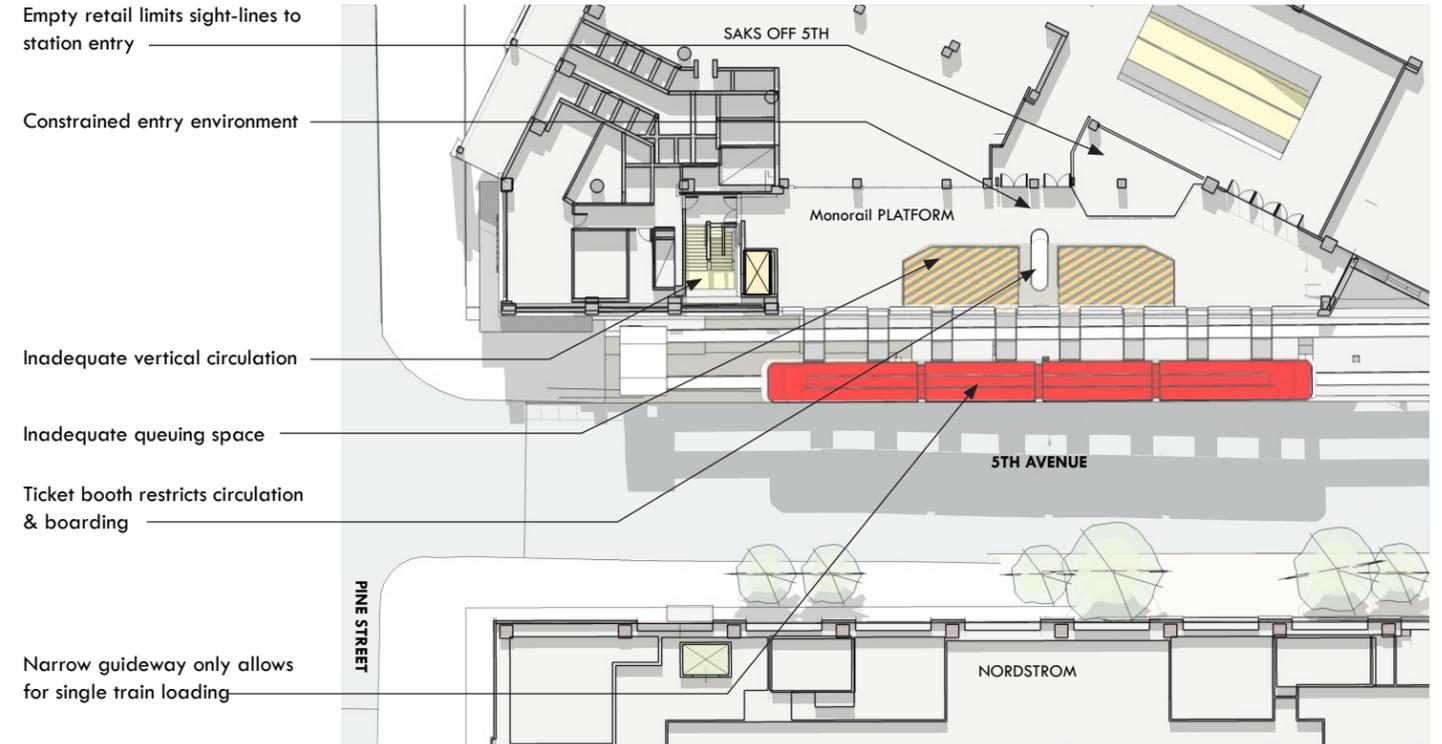


Figure 6a: Existing conditions at the Westlake Monorail platform

Monorail PLATFORM PLAN

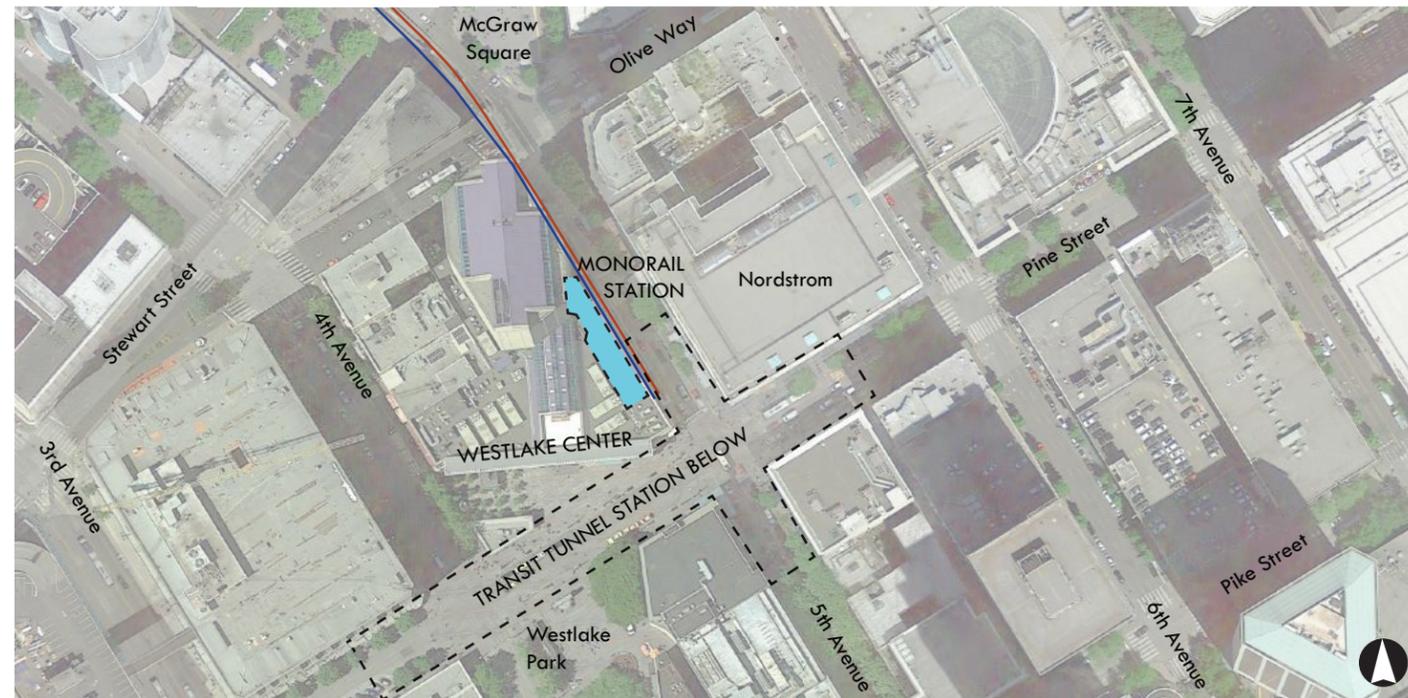


Figure 5: Site Aerial Context View

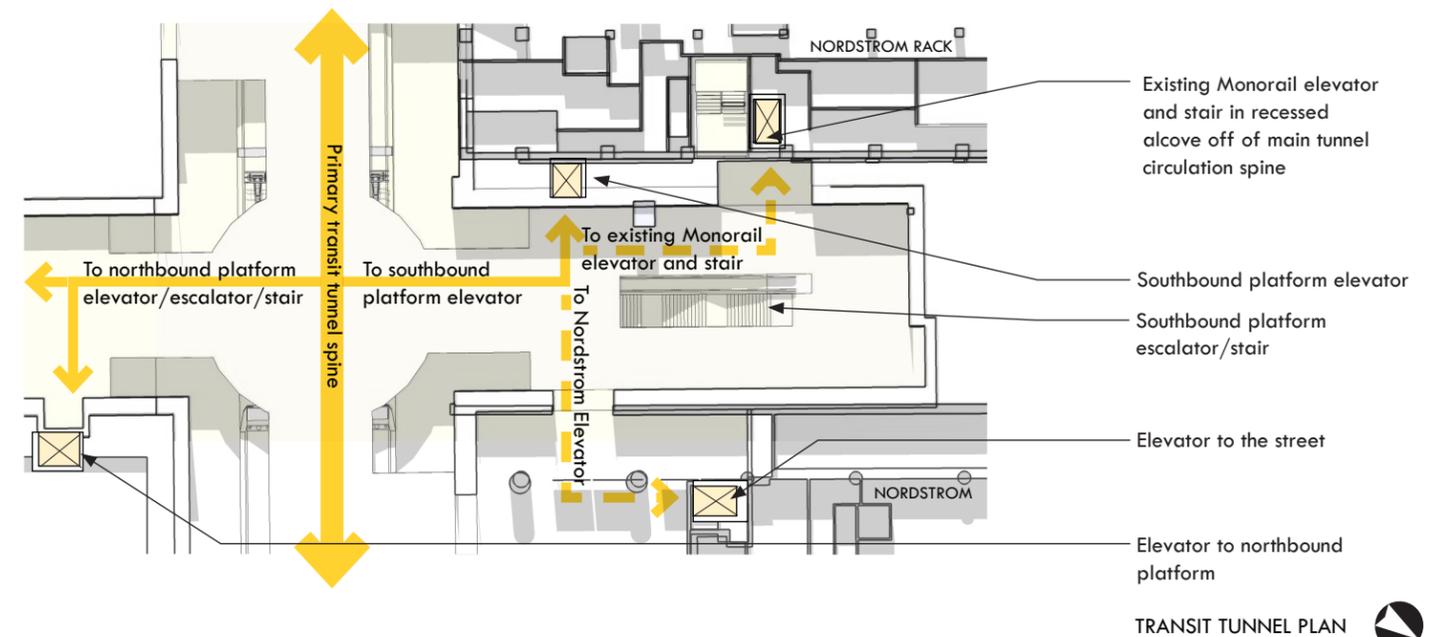


Figure 6b: Existing conditions at the Westlake Transit Tunnel Mezzanine

TRANSIT TUNNEL PLAN

EXISTING CONDITIONS - SEATTLE CENTER MONORAIL STATION

CONSTRAINTS & OPPORTUNITIES

In contrast to Westlake, Seattle Center station maintains its original 3-platform configuration and spacious setting, making improvements to capacity and flow less constrained. Evaluation of the current station condition and opportunities for improvement identified issues that are noted on the plan of the existing station in figure 8 and are as follows:

- The current platform layout with ticket kiosks and train boarding on the center platform limits the departure platform capacity for post-Arena events.
- The current platform gate configuration limits train boarding and alighting flow
- The platforms are not completely level with the train doors, requiring the train operator to assist passengers with disabilities boarding and alighting the trains by employing a portable ramp.

- Poor station visibility and identification from Thomas Street due to the existing gift shop and dense landscaping close to the south platform
- Access from Harrison Street to the platform is a circuitous route under the low bridge to the Armory and past the waste facility to the existing ramp
- The existing entrance ramp does not meet current accessibility requirements

Proposed upgrades to the platform layout address these constraints, optimize opportunities to reconfigure the platform space, and improve flow and queuing.

In addition to platform upgrades it is important to improve connections to Seattle Center institutions and venues such as the International Fountain, MOPOP, Memorial Stadium and the Artists at Play plaza.

Existing conditions that prevent a well-integrated station include:

- Poor station visibility from the north side - when approaching the station from the Artists at Play Plaza or the north side of the Armory at Harrison Street, the Next50 building blocks views to the station.
- There is no direct access to the station from the north side.

A phased approach is proposed for Seattle Center Station to address these issues with incremental investments that are aligned with the phasing of Westlake improvements.

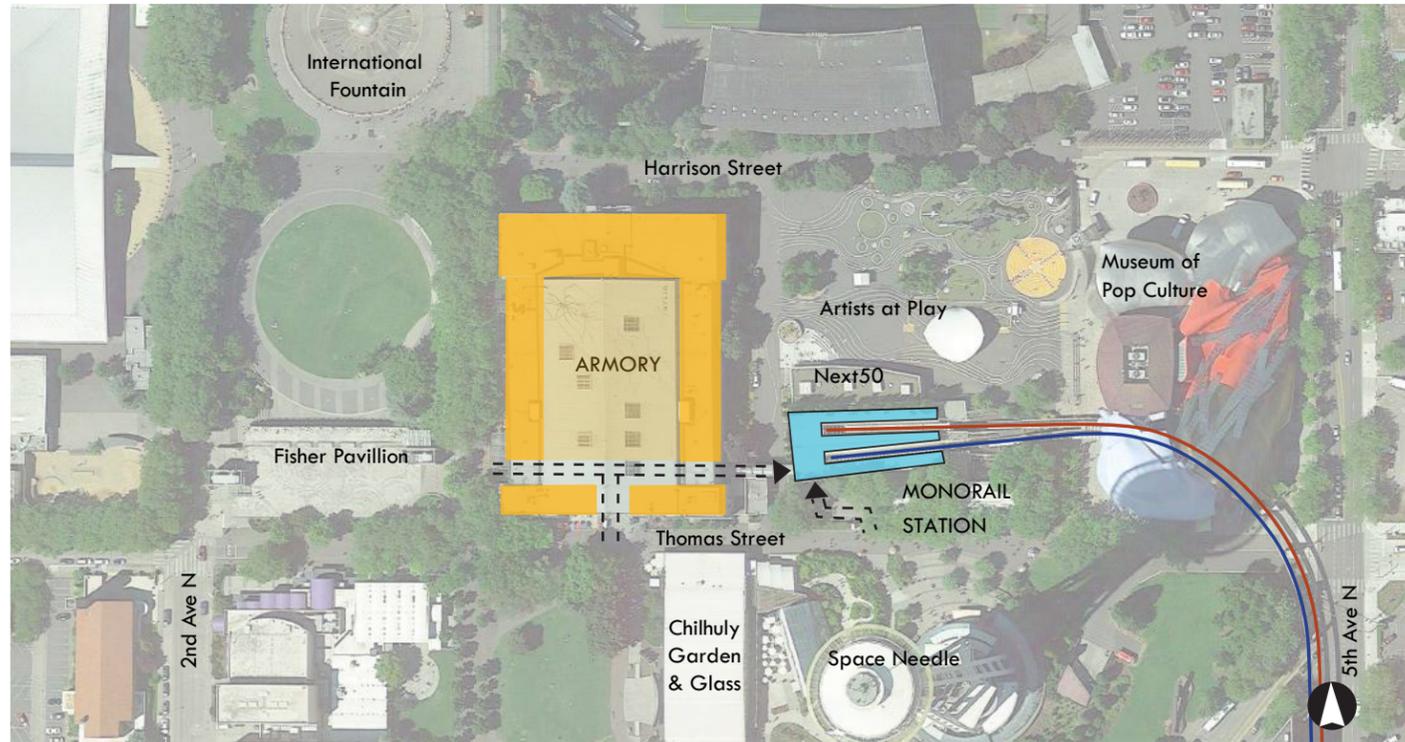


Figure 7: Site Aerial Context View

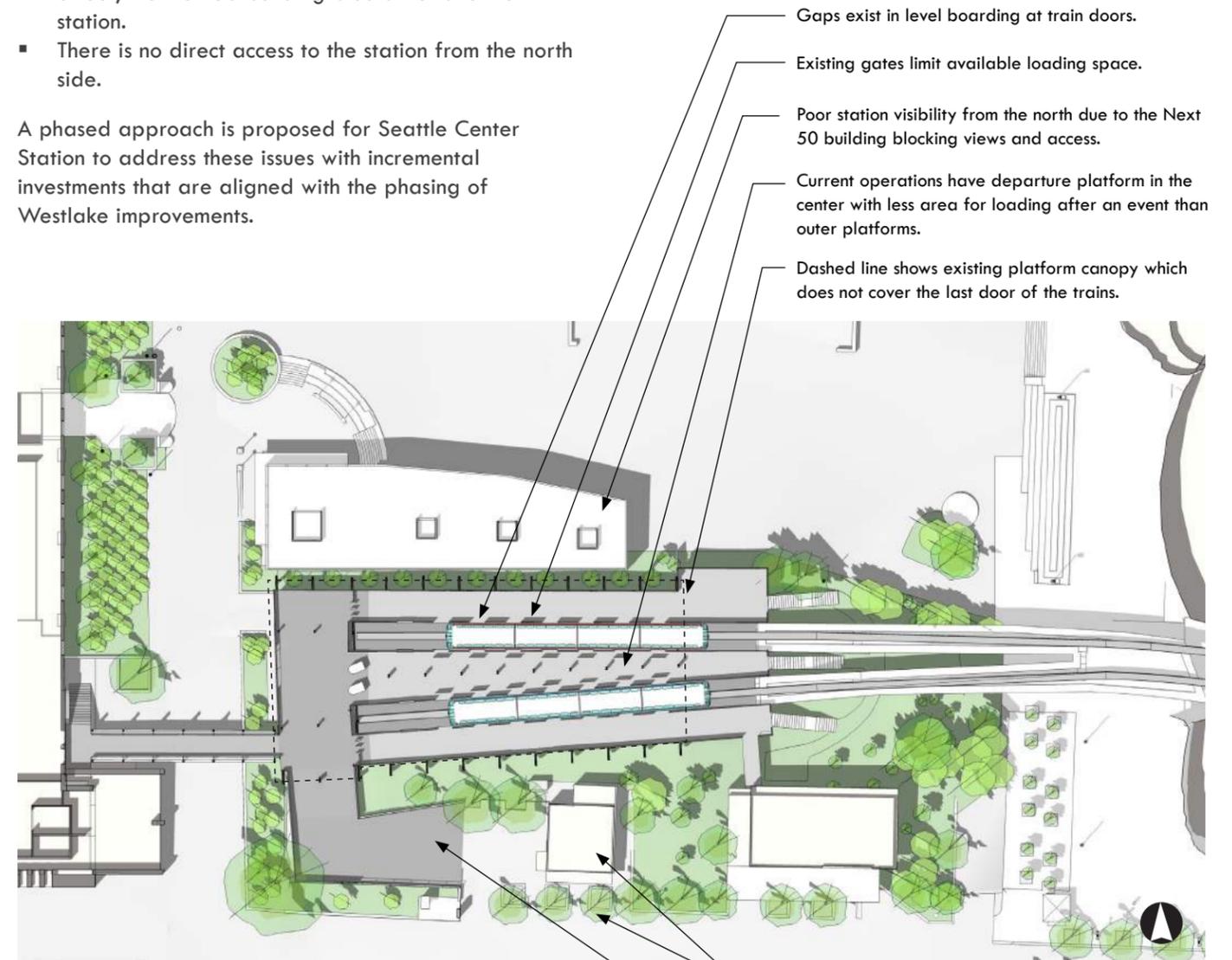


Figure 8: Existing Conditions at Seattle Center Station

CONCEPT DESIGN - DRIVERS AND OBJECTIVES

Increased utilization of the Monorail will reduce traffic congestion, make the regional transit system more efficient, and provide numerous additional benefits to local stakeholders, surrounding neighborhoods, and the environment:

- The renovated Seattle Center Arena will accommodate NBA and NHL games as well as larger concerts and events, with up to 19,125 patrons projected for a sold-out performance. This will increase the size of surge loads on the system, particularly during the post-event peak hour when everyone exits the venue at the same time.
- The current capacity of the Monorail can move only 13% of Arena patrons in 45 minutes. With improvements, this number would reach 26%.
- Westlake Center will be an increasingly vital regional transit hub over the next two decades (figure 8) as Sound Transit 2 (ST2) and Sound Transit 3 (ST3) are built out, (figures 1a-1g).
- Roads will become more congested as the region's population and employment increases, but event patrons will have the option to avoid the hassle of driving and parking and save time by taking the Link Light Rail to Westlake and transferring to the Monorail, (figure 10).
- Increasing the quality of the platform-to-platform connection from Link to the Monorail is a vital step to encourage patrons to utilize this regional transit asset. Our survey suggests that improving this connection alone will triple Monorail rider demand during events, (Appendix C).
- Redevelopment and increased density in the blocks surrounding Westlake, (figures 12-13), will drive increased foot traffic to the Monorail to reach events, bringing the need for improved wayfinding, visibility, and accessibility of the Westlake Monorail Station into focus.

- People who still wish to drive will find the area immediately around Seattle Center to be congested, which is likely to worsen given the increased frequency of and attendance at Arena events. Driving on Mercer street from I-5 to Seattle Center alone could take as long as 15 minutes, and parking may be scarce or difficult to find.
- Westlake Center has better freeway access and a surplus of available parking after 5pm and weekends when events generally take place. The Monorail will play a key role in utilizing this resource and mitigating increased congestion at Seattle Center.
- The Uptown neighborhood around Seattle Center will also continue to densify, generating more Monorail trips for commuting and leisure. Patrons will use the excellent pedestrian infrastructure within Seattle Center to access surrounding neighborhoods, (figure 11).

Appendix A contains a cost benefit analysis, weighing the benefits to arena patrons (reduced vehicle operating costs and reduced travel time) of Monorail utilization with its improved capacity and customer service, against the cost of station improvements. The cost-benefit analysis shows that the benefits greatly outweigh the costs. Appendix B provides a summary of the capital cost of the proposed station improvements. Finally, Appendix C contains the results of a public outreach survey indicating that increased ridership will be induced by improvements, completing the ridership-based case for investment.

Since these benefits are realized through utilization of the system, increased capacity will be a primary driver. Improvements to accessibility, visibility, wayfinding and regional transit connections will induce full utilization of this increased capacity.

Time Saved - Transit vs. Driving	2017	2020	2024	2035
Tacoma Dome Station	11	11	12	13
Federal Way	7	7	7	8
Everett Station	6	4	3	32
Lynnwood	17	16	47	49
Downtown Redmond	2	2	36	39
Downtown Bellevue	6	6	44	47
Sea-Tac Airport	11	11	11	13
Beacon Hill	32	32	32	33
Othello	23	23	23	24
U District	1	1	33	34
Northgate	-4	-4	33	34
Tukwila	26	26	26	27
Average	8	11	26	29

Figure 9: Travel Time Analysis Summary Table
 This the results table of a study that compared the origin -to-destination trip durations of driving vs. taking a bus or the Link Light Rail and transferring to the Monorail to arrive at Seattle Center. This assumes pre-event rush hour condition and Link Light Rail platform connection improvements at the Westlake Monorail station. Average time saved by taking transit is 18 minutes across all studied locations and time periods. Note that Northgate does not show a time savings on transit until the Sound Transit station is scheduled to open there in 2024. It is recommended that Phase 2 Monorail improvements be implemented by this time.

POSSIBLE BENEFITS OF DOUBLING MONORAIL CAPACITY



1250

Fewer cars circulating Uptown during events



249/yr

Tons of CO2 reduced



3000

Additional patrons at Westlake before and after events



\$5M/yr

Potential increased parking revenue near Westlake Station



\$3M/yr

Patron vehicle operating costs saved



12yr+

Emulates ST3 service to Seattle Center 12+ years earlier

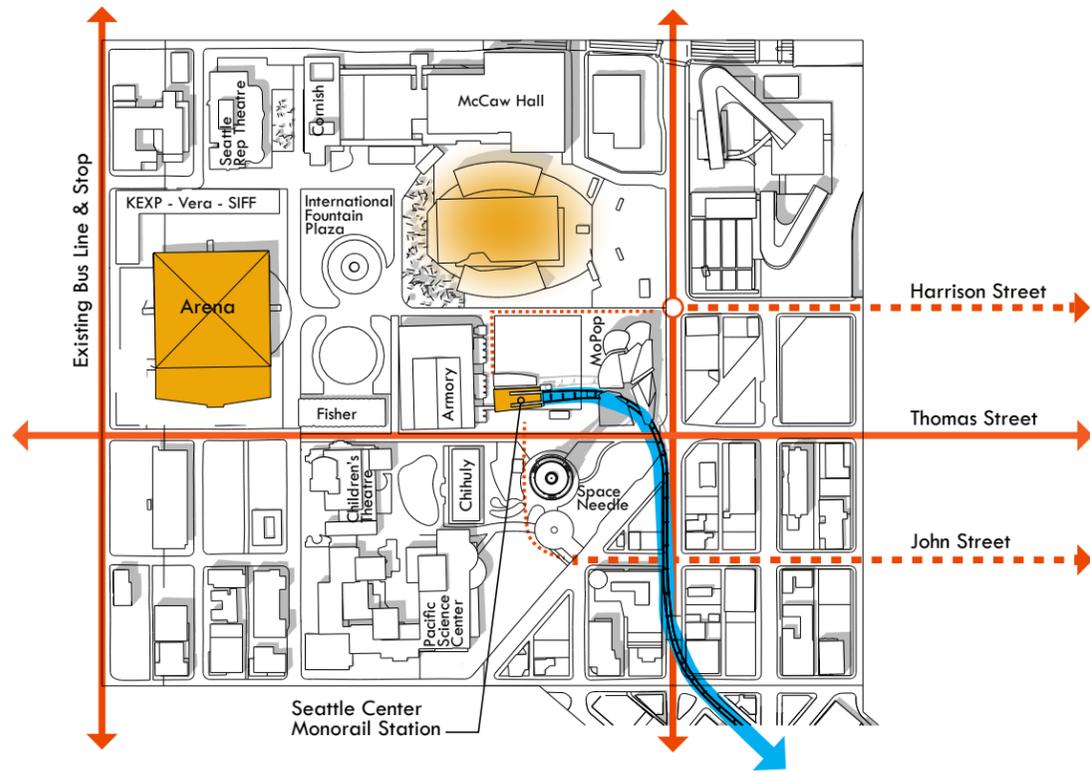


Figure 10: Seattle Center Connections and Development

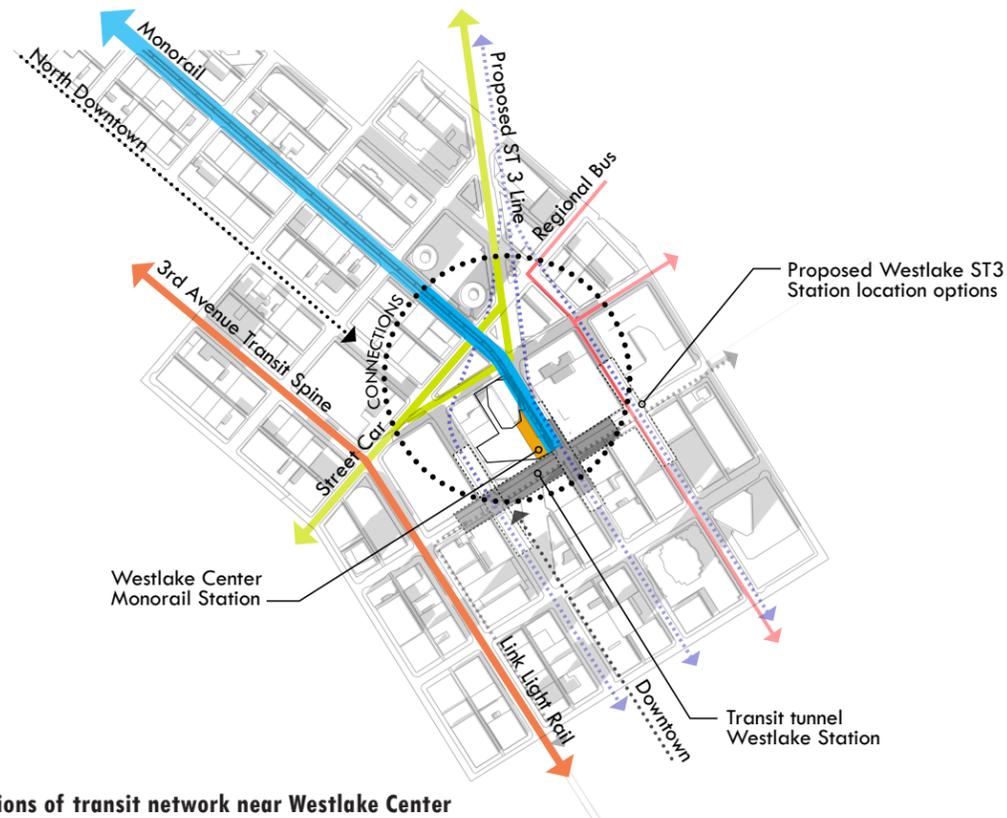


Figure 11: Future conditions of transit network near Westlake Center



Figure 12: Existing hotels, major retail, and parking locations near Westlake Center



Figure 13: Recent and pipeline development near Westlake Center

CONCEPT DESIGN - OPERATIONAL GOAL

The best value for investment will be achieved by maximizing capacity within the constraints of the current guideway alignment, train cars, and platform locations. Within these constraints, there is still room for a significant capacity increase.

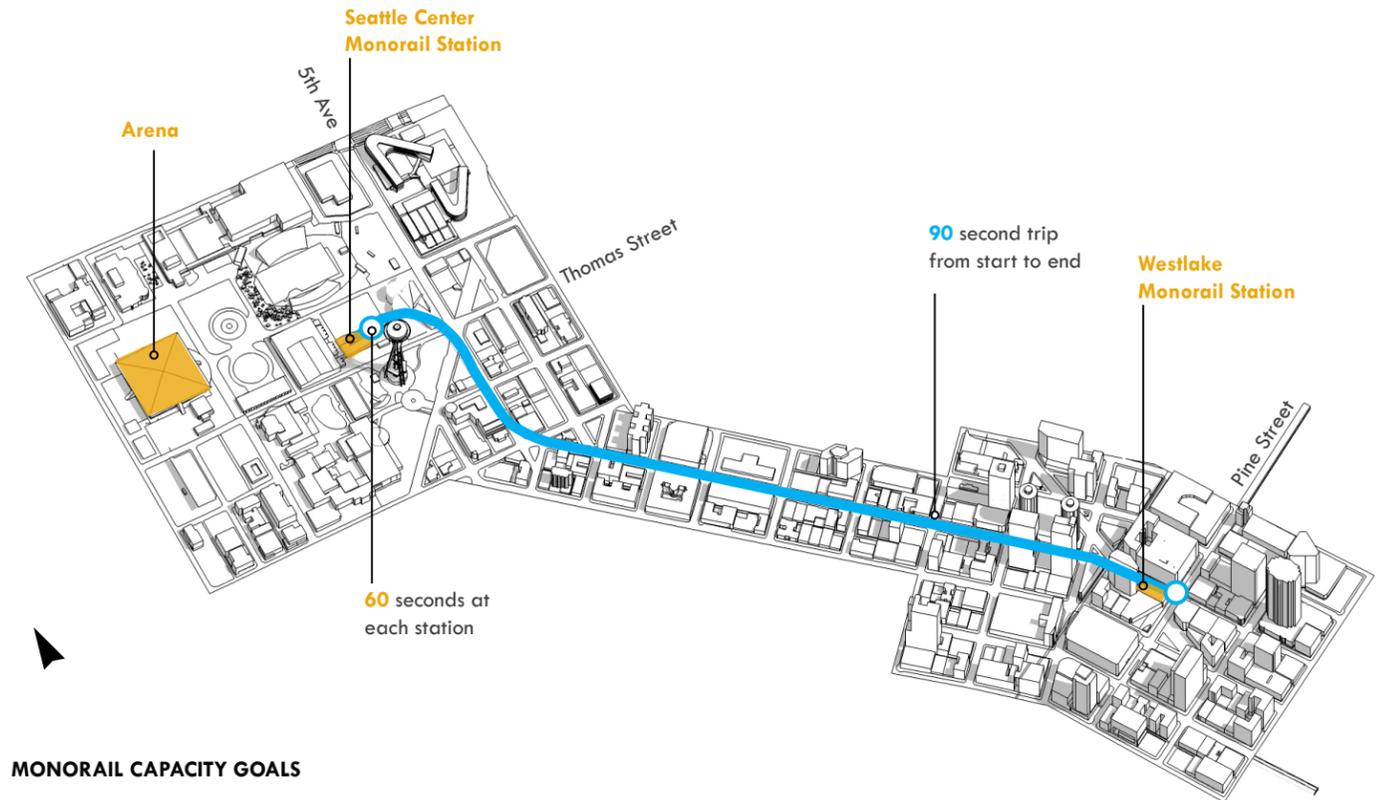
The proposed operational scenario moves 6,000 people per hour, per direction, a doubling of the current capacity. This is achieved by moving 250 people per train at 2.5-minute headways. Each train takes 90 seconds to travel between stations and spends 60 seconds at the platform.

This goal can be achieved by the following operational practices, supported by improvements to vertical circulation, platform capacity, and passenger flow at both stations:

- The time the train spends at the station platform is known as 'dwell time'. The dwell is set at 60 seconds which will allow all riders to get off the train and most passengers waiting on the platform to board. This time is rigidly set to maintain consistent headways. See Appendix E for calculations on how a one-minute dwell time maximizes system throughput.
- Although the functional maximum capacity of the trains is over 300, the operations goal is set at 250 passengers per train. This is because the boarding rate decreases as the train nears maximum capacity.
- A 250-passenger train load is achievable in 60 second dwell times and helps maintain operational efficiency, reliability, and passenger comfort.

- Short and consistent headways assure riders that the next train is not far away. The outreach survey results indicated that shorter wait times for trains was a very popular choice for improving the Monorail, (Appendix C).
- With operational procedures common to mass transit systems, such as synchronized train operations, the system can operate at maximum efficiency even within the constraints of the narrow guideway beam offset and single platform at Westlake.
- The security sweep by the train driver will happen simultaneously with the passenger alighting and boarding during the 60-second dwell time.
- Operations practices, rather than rebuilding the guideway and Westlake platform, is the more cost-effective solution to reach the capacity goals. Synchronized train operations can ensure that neither train is required to wait to enter Westlake platform.

The station upgrade strategies described in this report are based on achieving this operational goal. The Phase 2 improvements achieve maximum system capacity of 12,000 passengers per hour total for both directions in accordance with pedestrian simulation modeling and flow calculations included in Appendix E.



MONORAIL CAPACITY GOALS

EXISTING HEADWAY	→	HEADWAY GOAL
Trip time: 1.5 mins		Trip time: 1.5 mins
Frequency: ~5 mins		Frequency: 2.5 mins
Reliability: 100%		Reliability: 100%
Capacity: 3,000/hour (one direction)		Capacity: 6,000/hour (one direction)

-WHICH EQUALS-

33% of a post-event crowd per hour
1,200 fewer cars circulating in Uptown/event
3,000 more patrons at Westlake/event
249 tons of CO2 conserved/year

Figure 14: System Diagram

CONCEPT DESIGN - WESTLAKE STATION

PHASE 1: IMPROVE EXISTING PLATFORM

There are limited opportunities for improving flow and capacity within the many constraints of the existing station footprint and the Westlake Center mall building infrastructure. Although many options were explored (see Appendix D), the proposed options were selected as a cost-effective approach that supports phased investment.

Phase 1, shown in plan to the right, provides layout and equipment improvements that accommodate operational changes and more efficient platform queuing and flow. This phase avoids impacts to existing operational retail spaces and does not introduce any new vertical circulation elements. However, in order to clear the platform within the proposed headway with full train loads, this configuration requires use of the mall escalators to provide the required passenger exit flow. The key improvements provided in Phase 1 include the following:

- The existing ticketing booth and queuing area are removed and an existing empty retail space is incorporated into the reconfigured platform.

CAPACITY & FLOW PARAMETERS

Queuing

Required queuing area to comfortably fit 250 people:

LOS C (7 sf/person) = 1,750 sf of queue

Actual available queuing area = 1,006 sf

250 people (~4 sf per person)

Total Vertical Circulation Capacity

302 people/headway assuming use of escalators

122 people/headway w/o escalators

Achieves flow goal of 250 people per headway.

Requires mall escalators to achieve 250 people per headway flow goal.

- ✓ The Westlake Center mall escalators will be NEEDED in Phase 1 to accommodate the post event capacity and flow goal of 250 passengers arriving at the platform every 2.5 minutes. Many arena events will end after typical mall hours making this operating scenario undesirable as it requires additional security staffing in an otherwise empty mall. A permanent solution to ADD VERTICAL CIRCULATION capacity is preferred.

- A new platform boundary is proposed from the existing inside wall of the retail space to the elevator to separate queuing from the platform space. This accommodates an automated ticketing center and fare control through faregates.
- An attendant station is shown incorporated into the new platform envelope for staff providing information, surveillance, and additional aide to passengers.
- In order to maximize queuing areas and avoid boarding and alighting flow conflicts, markings will be incorporated into the floor paving, as shown in figure 15b. This will allow all 8 doors to be used for both ingress and egress as waiting patrons are directed to stand to the side while passengers leave.

Although Phase 1 increases capacity and can accommodate peak event flows, it does not address some of the existing conditions that limit capacity, operations efficiency and connectivity. Queuing on the platform is still constricted and the mall escalators must remain in operation after mall hours, requiring additional security staffing. Without new vertical circulation element additions, the connection to the transit tunnel remains unchanged. See Appendix E for calculations.

Walkways

Ideal Effective Width

LOS C = 9'-2"

LOS D = 7'-6"

+2'-0" refuge

Actual Walkway Width= 8'-0"

Achieves LOS D flow with space for reverse flow

Little space for refuge

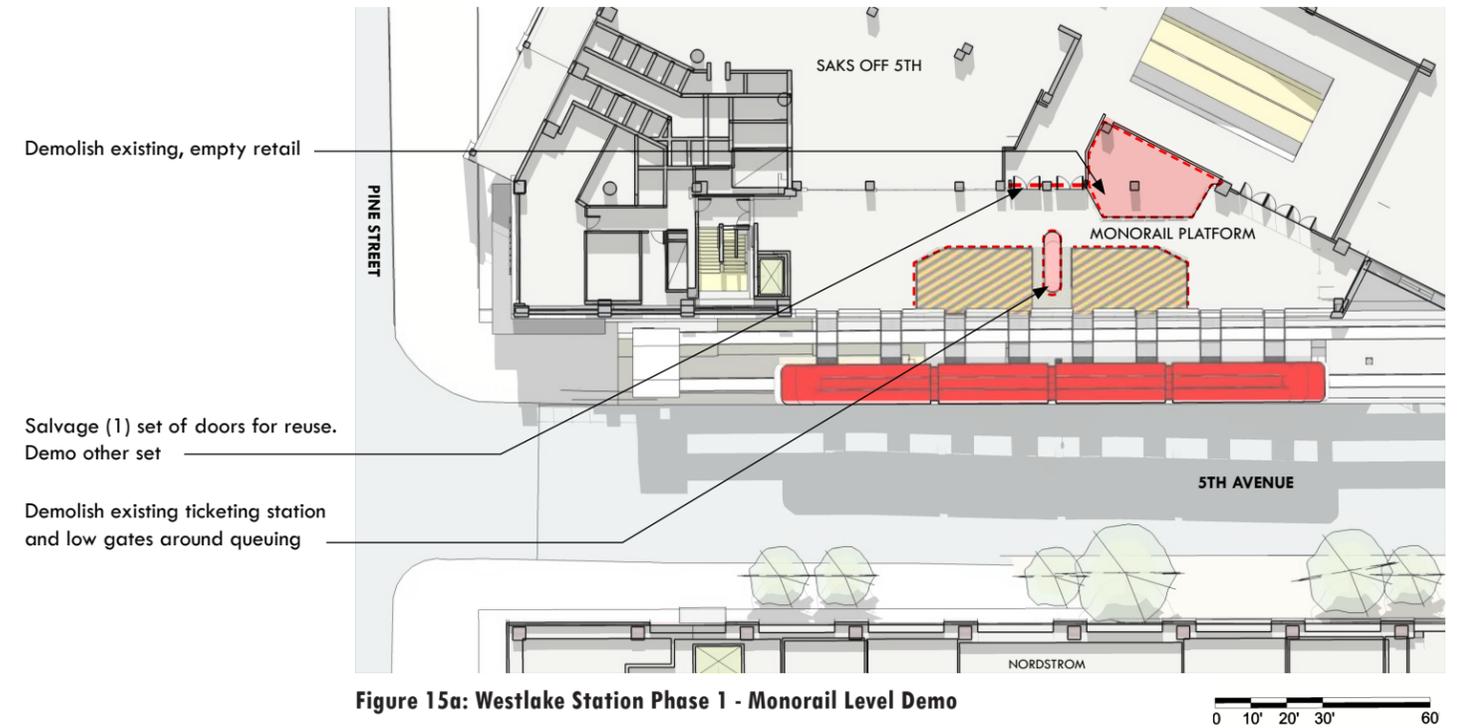


Figure 15a: Westlake Station Phase 1 - Monorail Level Demo

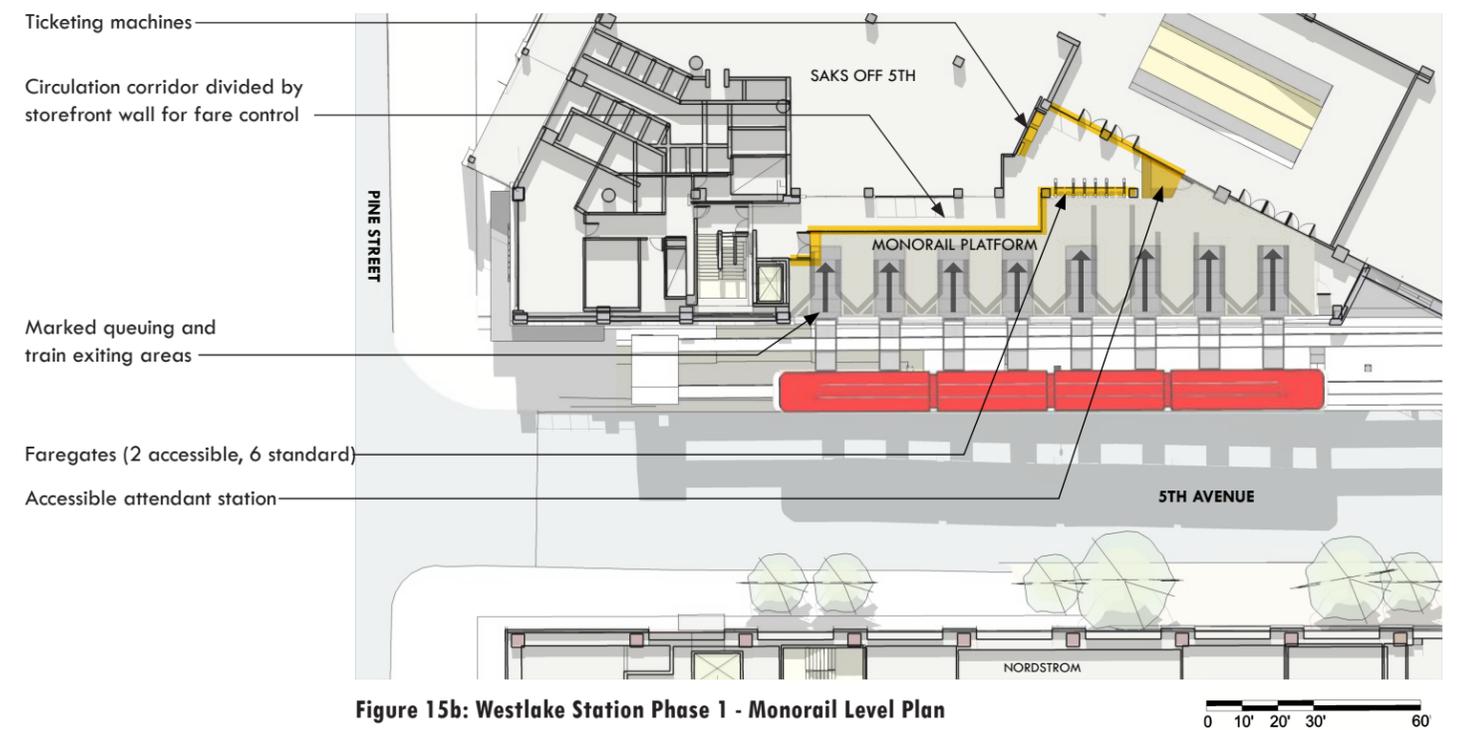


Figure 15b: Westlake Station Phase 1 - Monorail Level Plan

PHASE 2: REACHING CAPACITY AND FLOW GOALS

In order for the Monorail to provide optimal service as a high capacity transit shuttle from Westlake to Seattle Center that can reach event surge capacity goals, the overall footprint of the platform needs to increase and, more importantly, additional vertical circulation will be needed.

Plans for the proposed Phase 2 improvements shown in figures 16a & 16b include the following:

- The proposed platform boundary provides more queuing space and increased walkway widths.
- An interior public walkway connects via the existing Westlake Center mall balcony to a new exterior stair and elevator tower containing two high capacity elevators that provide a strong connection to the plaza and transit tunnel.
- The original intention of the balcony and the plaza below was one of civic space. This intent has been compromised by closure of the balcony to the public with the change of use on level 3 and the installation of an escalator at the other end of the building. The introduction of the stair and elevators will restore the public use and the civic intent of the balcony.
- The changeable message board on the face of the elevator tower will activate the plaza and serve as an invitation to the Monorail, the transit tunnel, and Seattle Center.

CAPACITY & FLOW PARAMETERS

WALKWAYS

Ideal Effective Width:

LOS C = 9'-2"

LOS D = 7'-6"

+2'-0" refuge

Actual Walkway Width= 10'-0" minimum

Accommodates reverse flow and refuge at LOS D or higher.

QUEUING

Ideal Queuing Area for 250 people/train :

LOS C (7 sf/person) = 1750 sf of queue

Actual available queuing area = 1290 sf

250 people (~5 sf per person)

Accommodates LOS D queuing.

TOTAL VERTICAL CIRCULATION CAPACITY

266 people/headway w/o escalators

Achieves flow goal of 250 people per headway.



According to advance pedestrian flow modeling, event surge goal of clearing **250 people per 2.5 minutes** from the platform is **ACHIEVED** with changes shown. In addition, the Monorail and the transit tunnel are given a **NEW FRONT DOOR**.

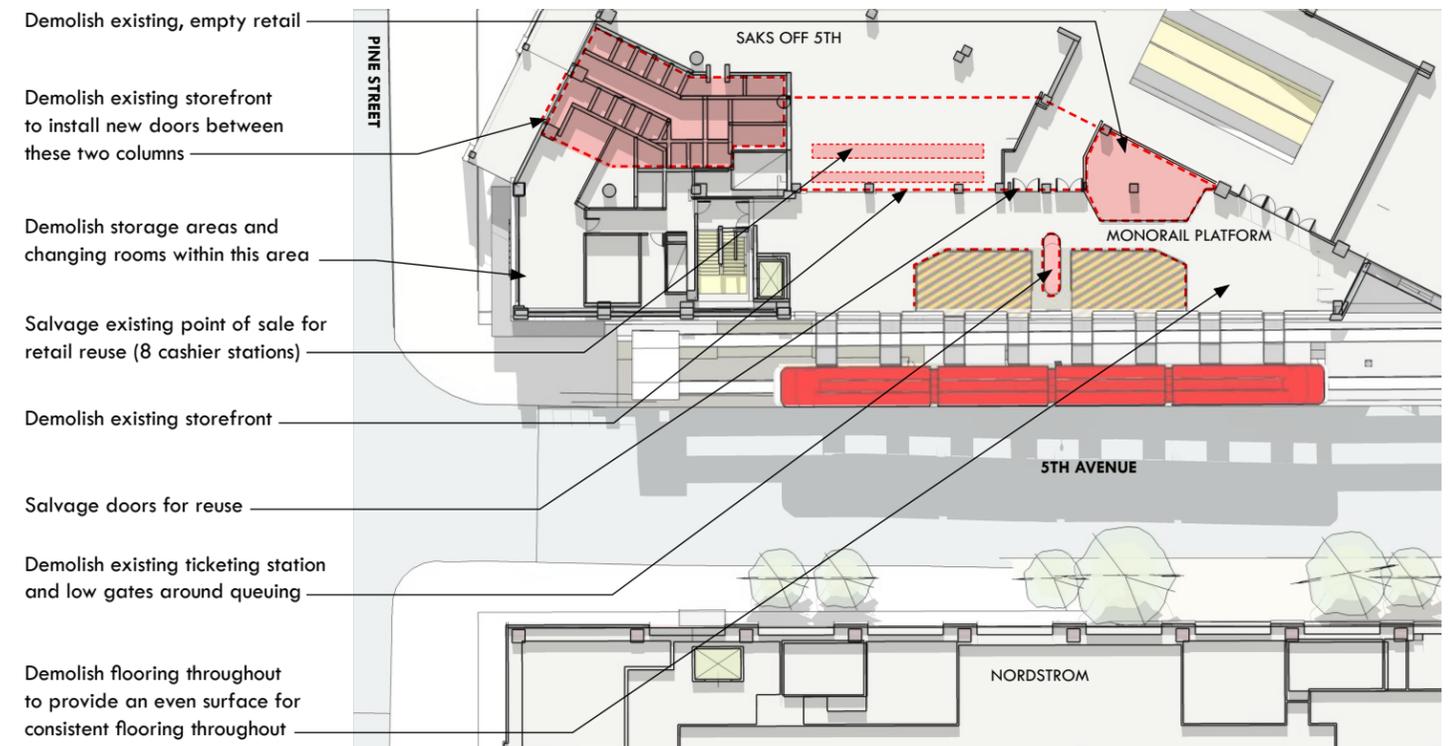


Figure 16a: Westlake Station Phase 2 - Monorail Level Demo

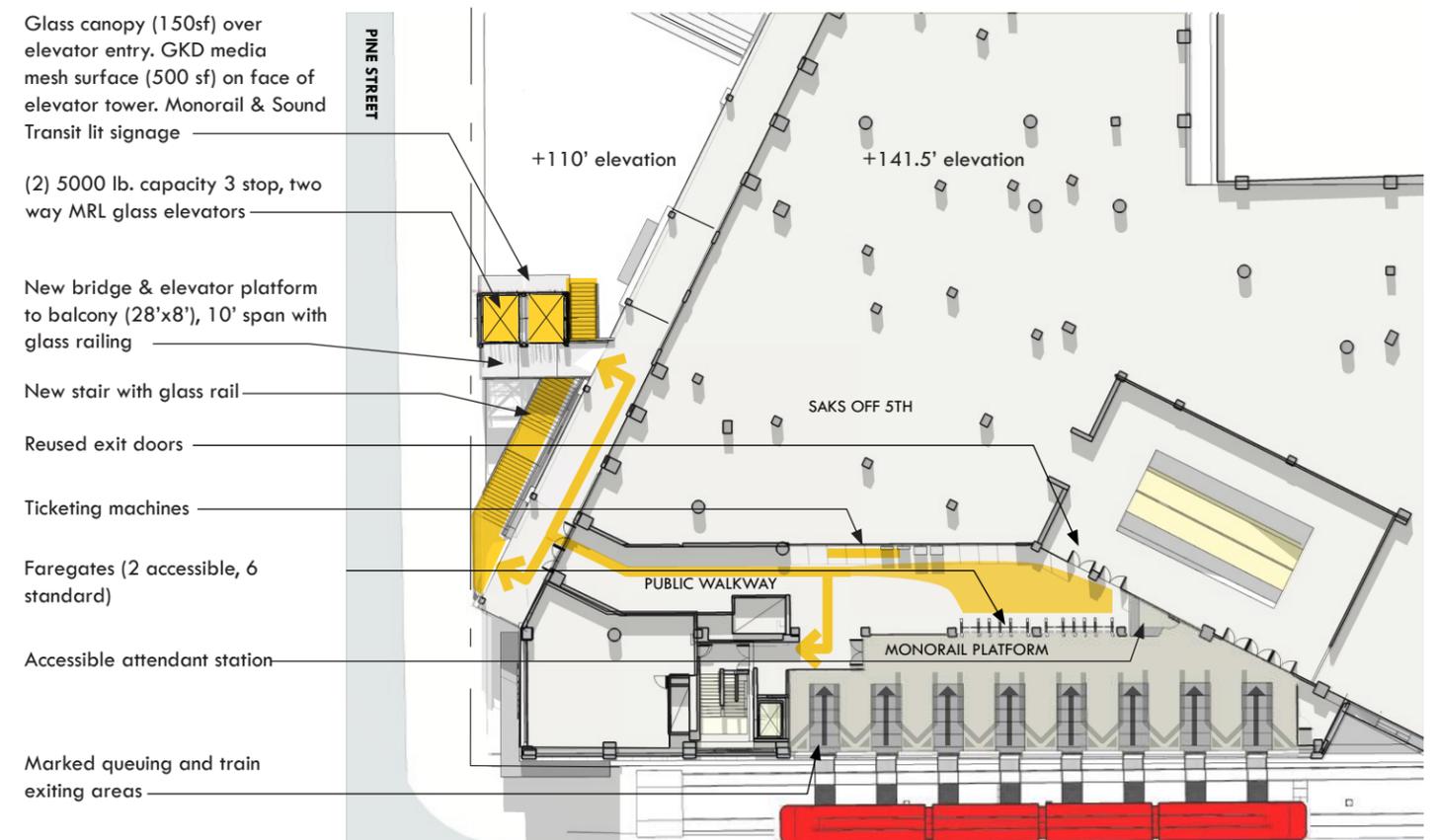


Figure 16b: Westlake Station Phase 2 - Monorail Level Plan

CONNECTION TO THE TRANSIT TUNNEL

A connection to the transit tunnel is not required to clear the Monorail platform, but reliable vertical circulation from Monorail to the street and the tunnel is critical for accessibility, wayfinding and transit connections. The proposed changes will improve access to the tunnel to make the connections between transit options better overall. The current vertical circulation does provide a connection, but it is slow and not identified as a primary passenger route. The strong, clear connection provided by the proposed modification creates a direct and intuitive link to the system of regional transit that travels through the tunnel to the Monorail platform.

Figures 18a & 18b show the following modifications at the transit tunnel mezzanine level that are necessary to achieve direct connection to Link Light Rail and other regional transit from the platform configuration shown on the previous page.

- Minor modifications to existing retail space on the lower level are required including removal of an empty retail space.
- The existing accessible lift from this level to the metro tunnel mezzanine level will be relocated. Some stair modifications are required.
- In order to provide a clear visual connection to the platform elevator and open circulation space, existing vestibule doors are relocated to the tunnel side of the southbound platform elevator.
- The proposed layout of the vestibule doors and the elevator doors will require a security grille to be installed at the bottom of the mall escalators for after-hours secure closure.
- To avoid impacts to the parking drive aisle below, the elevators land at the retail level. The elevator closest to the tunnel wall can continue down to the parking levels without impacting the drive aisle.



Figure 17: Westlake Station Phase 2 - digital signage detail

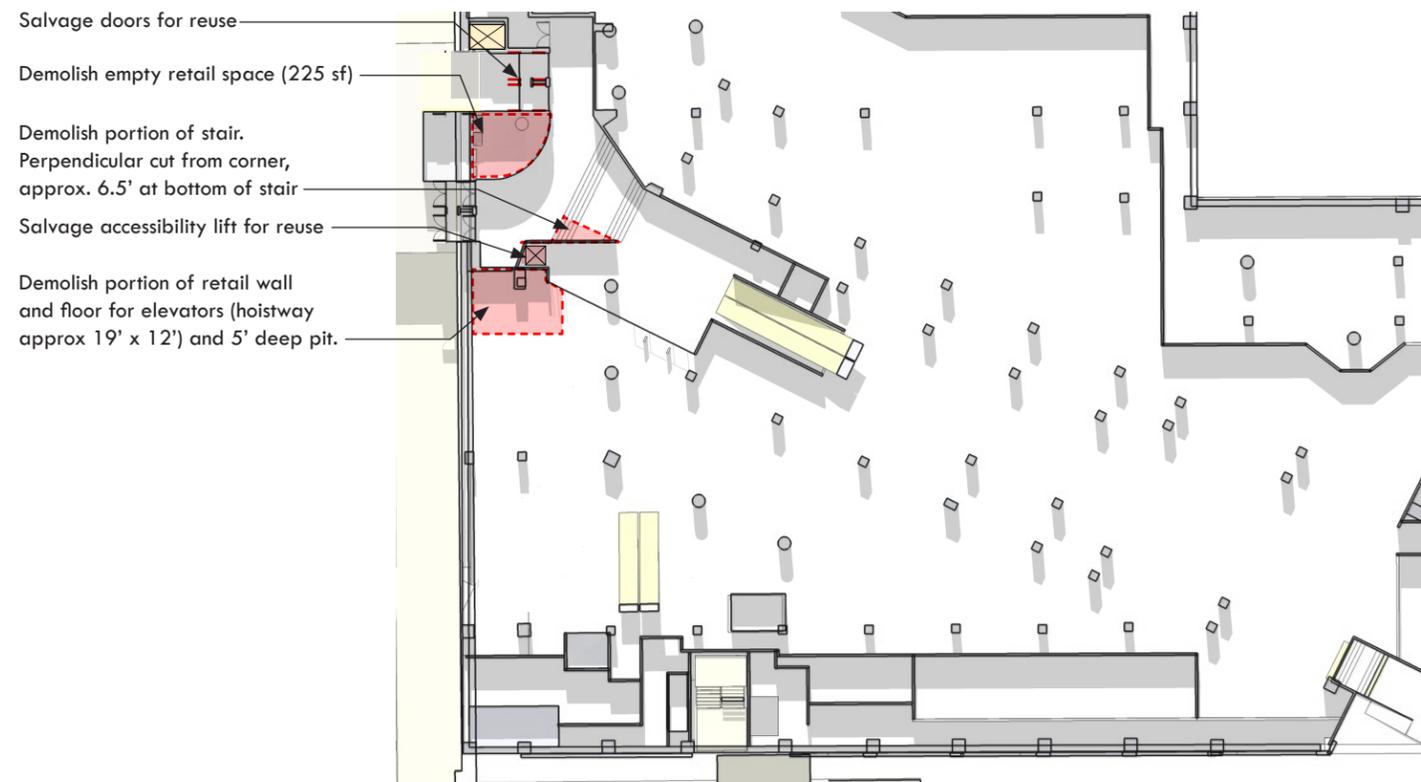


Figure 18a: Westlake Station Phase 2 - Metro Mezzanine Level Demo

0 10' 20' 30' 60'

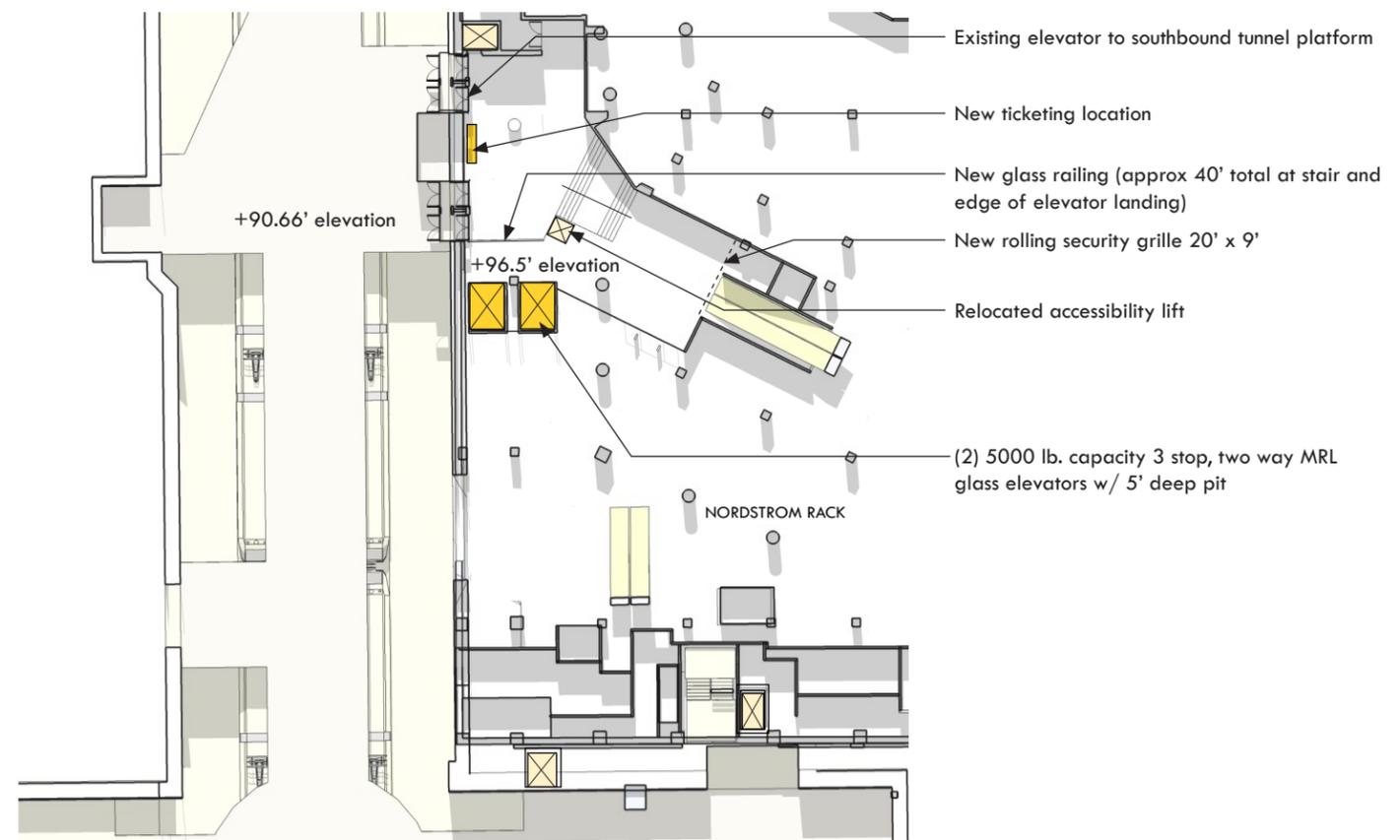


Figure 18b: Westlake Station Phase 2 - Metro Mezzanine Level Plan

0 10' 20' 30' 60'

CIVIC SPACE

Westlake Park is a vibrant center of civic activity in downtown Seattle. The Westlake Station for bus and light rail in the transit tunnel, one of the busiest transit centers in Seattle, is located just below the park, yet currently, there is no clear connection between the two. All existing entries to the tunnel are buried within buildings and shops. The proposed elevator tower creates a highly visible, memorable transit connection, making the use of the Monorail and the transit tunnel easy, pleasant, and convenient. Tying the multiple uses of the Monorail, the park plaza, and the transit tunnel together, the elevators create a strong anchor for these civic spaces and services.

The tower can serve as a hub for information, a natural place to distribute news, connect transit riders to local business, and encourage community interaction. The changeable message sign proposed for the face of the elevator tower adds the opportunity to incorporate community art, public notifications, and a place to find train or bus information. It also provides the ability to promote events and activities happening at Seattle Center, intrinsically connecting two major civic centers of the city.



Figure 19: Westlake Station Phase 2 view from Westlake Park



Figure 20: Westlake Station Phase 2 view from Pine & 5th



Figure 21a: Westlake Station Phase 2 view from Westlake Park (Night)

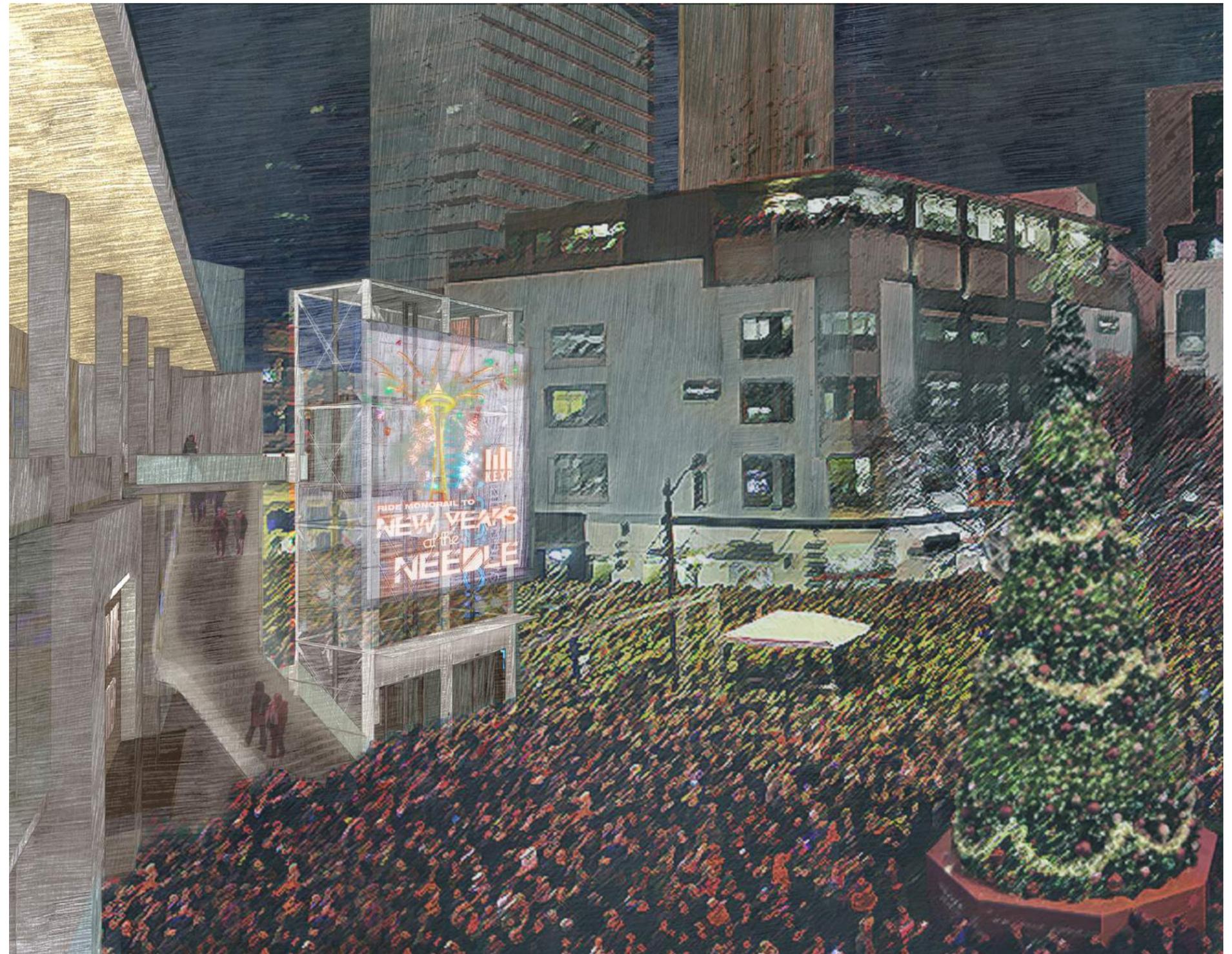


Figure 21b: Westlake Station Phase 2 view from Westlake Center mall balcony

CONCEPT DESIGN - SEATTLE CENTER STATION

SEATTLE CENTER STATION IMPROVEMENTS

The Seattle Center improvements are proposed to be implemented in 3 phases. Phase 1 and Phase 2 are aligned with the Westlake improvement phases. Phase 3 is proposed for inclusion as Seattle Center develops its master plan vision for the “Center of the Center.”

PHASE 1: PLATFORM LEVEL IMPROVEMENTS

The proposed platform improvements upgrade ticketing and boarding systems inside the station. The current ticketing booths will be removed and replaced by ticket vending machines. Faregates and automated platform edge gates are installed on the platform to facilitate safe and efficient boarding.

- Introduction of automated platform edge access gates on the platform.
- Replacement of the existing ticketing kiosks with ticket vending machines (TMVs), information panels and fare gates.
- Updates to platform paving to ensure level boarding at train doors.
- Reverse the platform operations to increase post event capacity by using the two outside platforms for train departures and the center platform for arrivals.
- Added signage and wayfinding to ensure accessible route is clear.

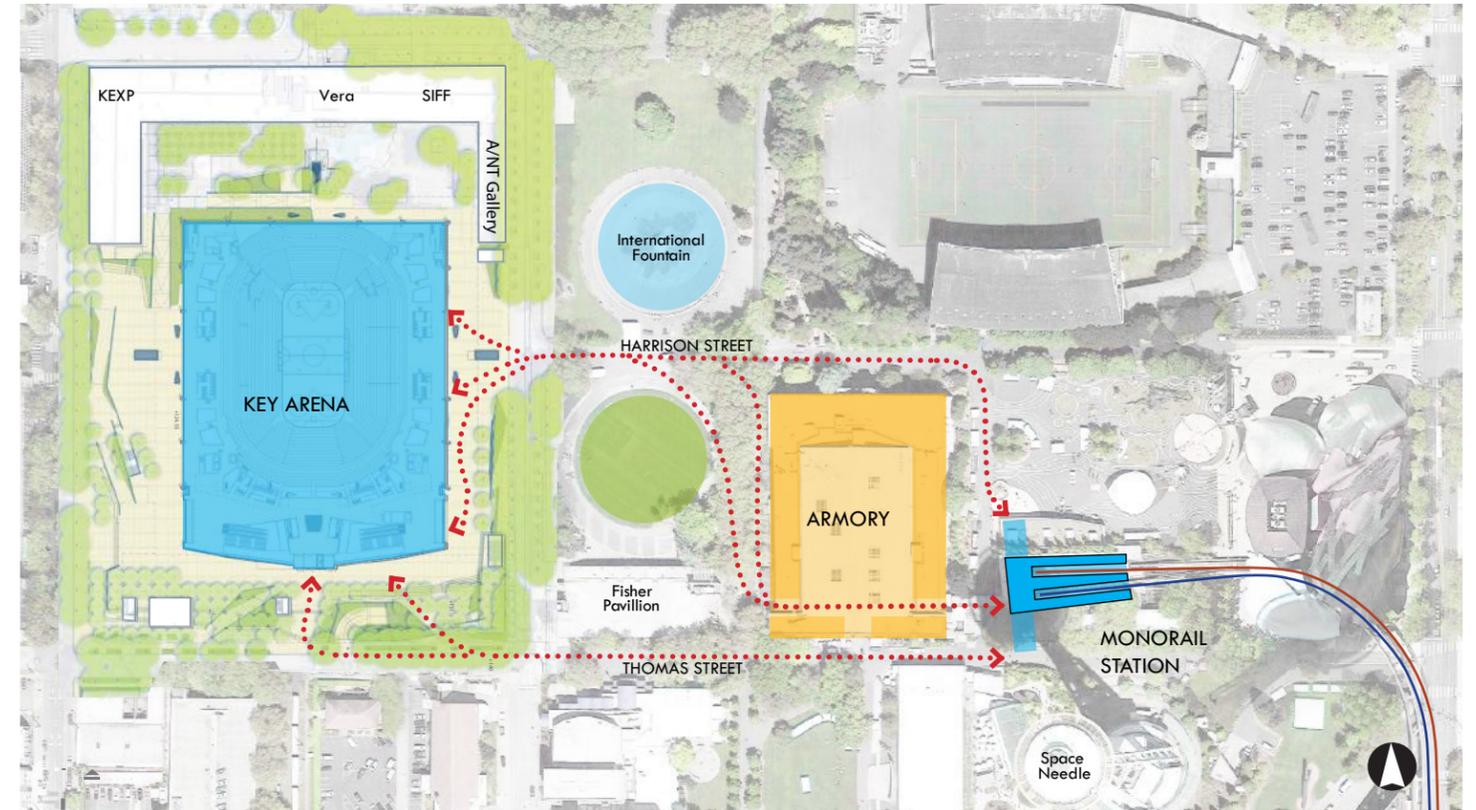


Figure 22a: Seattle Center context

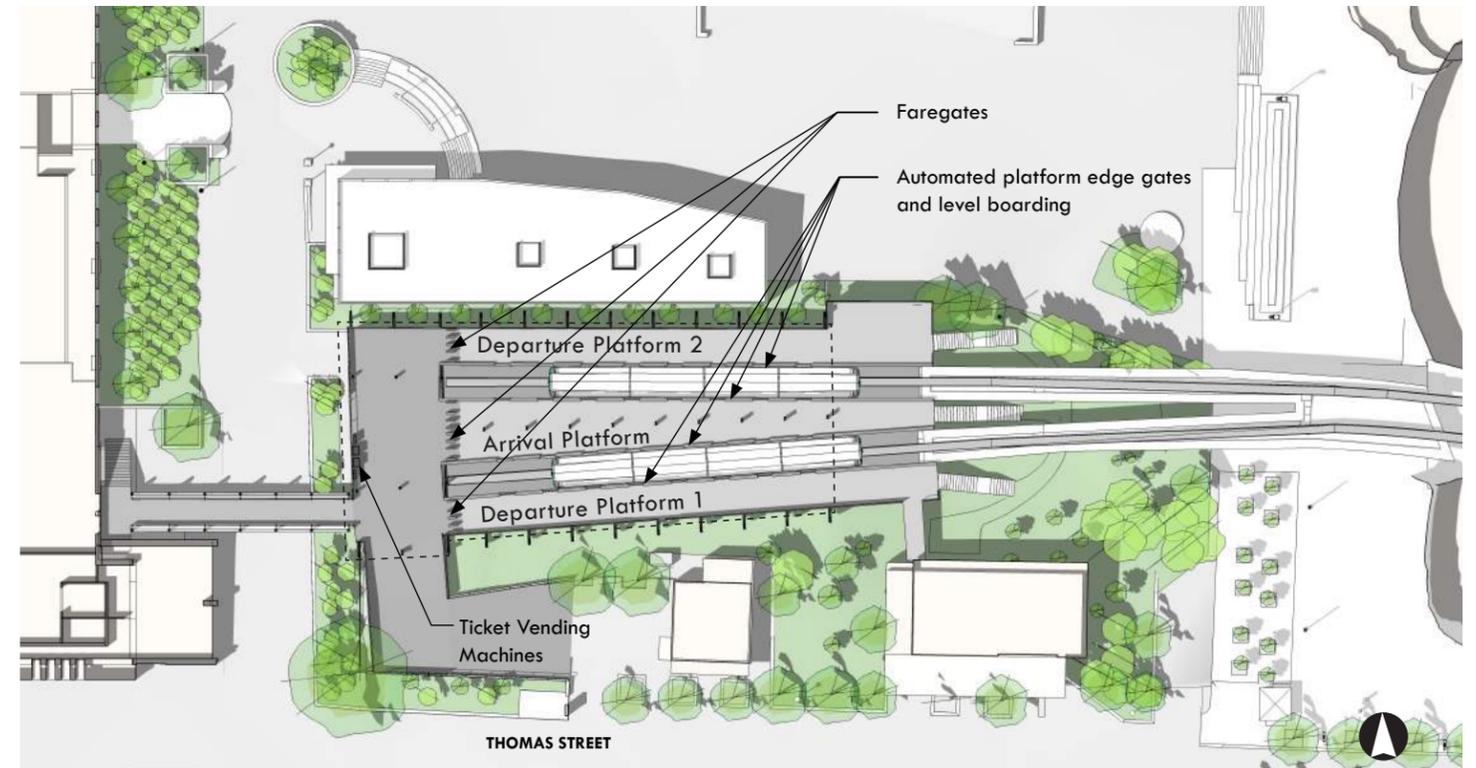


Figure 22b: Seattle Center Station - Phase 1

PHASE 2: ENTRY & ACCESSIBILITY IMPROVEMENTS

Phase 2 improves the customer experience with upgrades to the station visibility, clarity of path, and weather protection at the entrance and platforms. The current entrance of the station is relatively hard to find and does not meet current accessibility standards. The key elements of the station improvements shown in figures 23a-23c are the following:

- A passenger and freight elevator is added north of the bridge to the Armory.
- An attendant station for patron assistance located near the elevator replaces the ticketing booth.
- The entrance is reconfigured to have a more direct connection to Thomas Street using a staircase and an accessible ramp.
- The new ramp accommodates queuing for post-event ridership surges, (figure 23c).
- The new entrance is covered by a new canopy to provide weather protection, (figure 23b).
- An additional bay of structure and canopy, matching the historic station details and materials, is added on the platform for complete weather protection of the southernmost doorways where parked trains are currently exposed to weather, (figure 23b).
- Ticketing machines and trip information panels are enclosed by glass and a coiling grille for additional weather protection and after-hours security.
- The waste removal facility, attached to the Armory next to the pedestrian bridge, is relocated to create a better view and access corridor between the Monorail station and the Armory.
- The gift shop is relocated and selected plantings are removed to make the station more visible from Thomas Street and allow for a clearer presence.

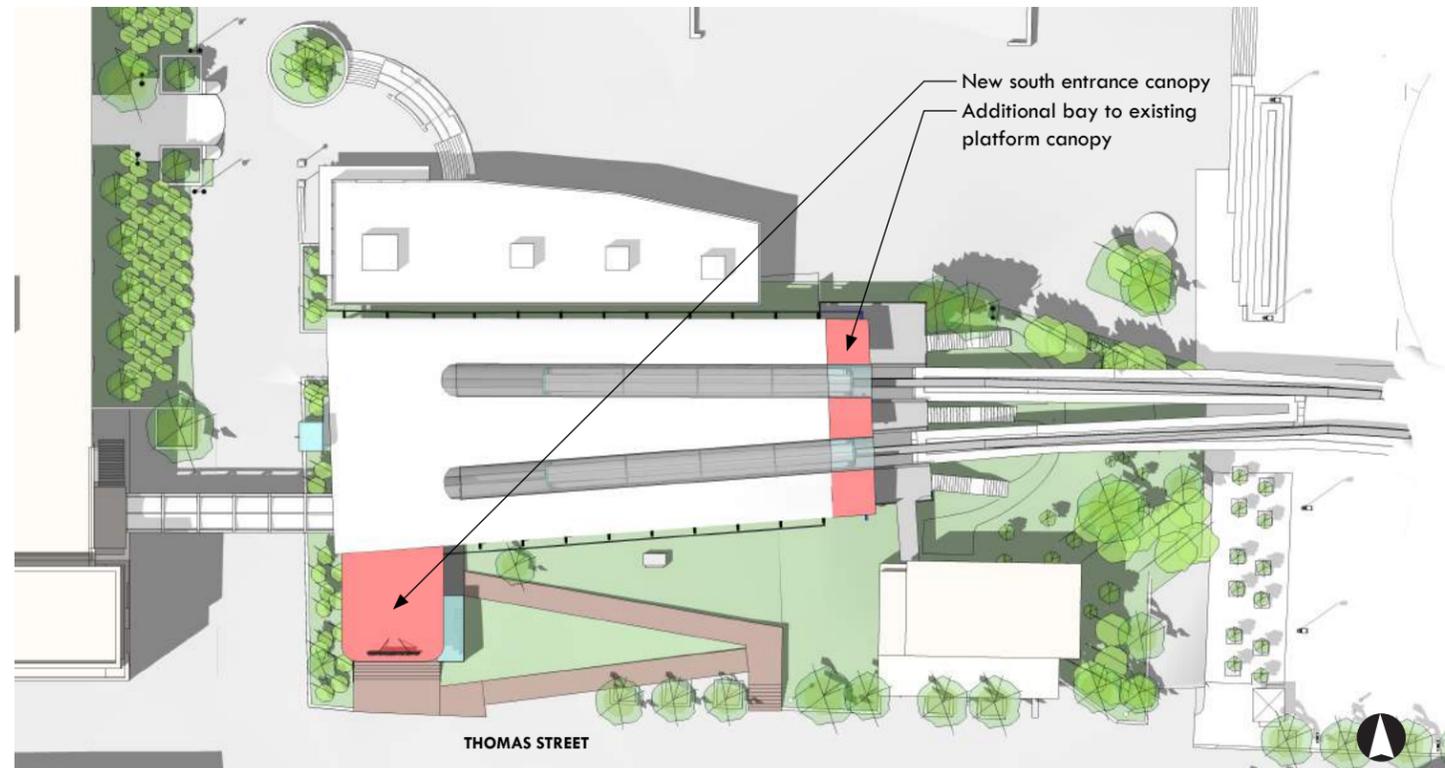


Figure 23b: Seattle Center Station - Phase 2 Roof View

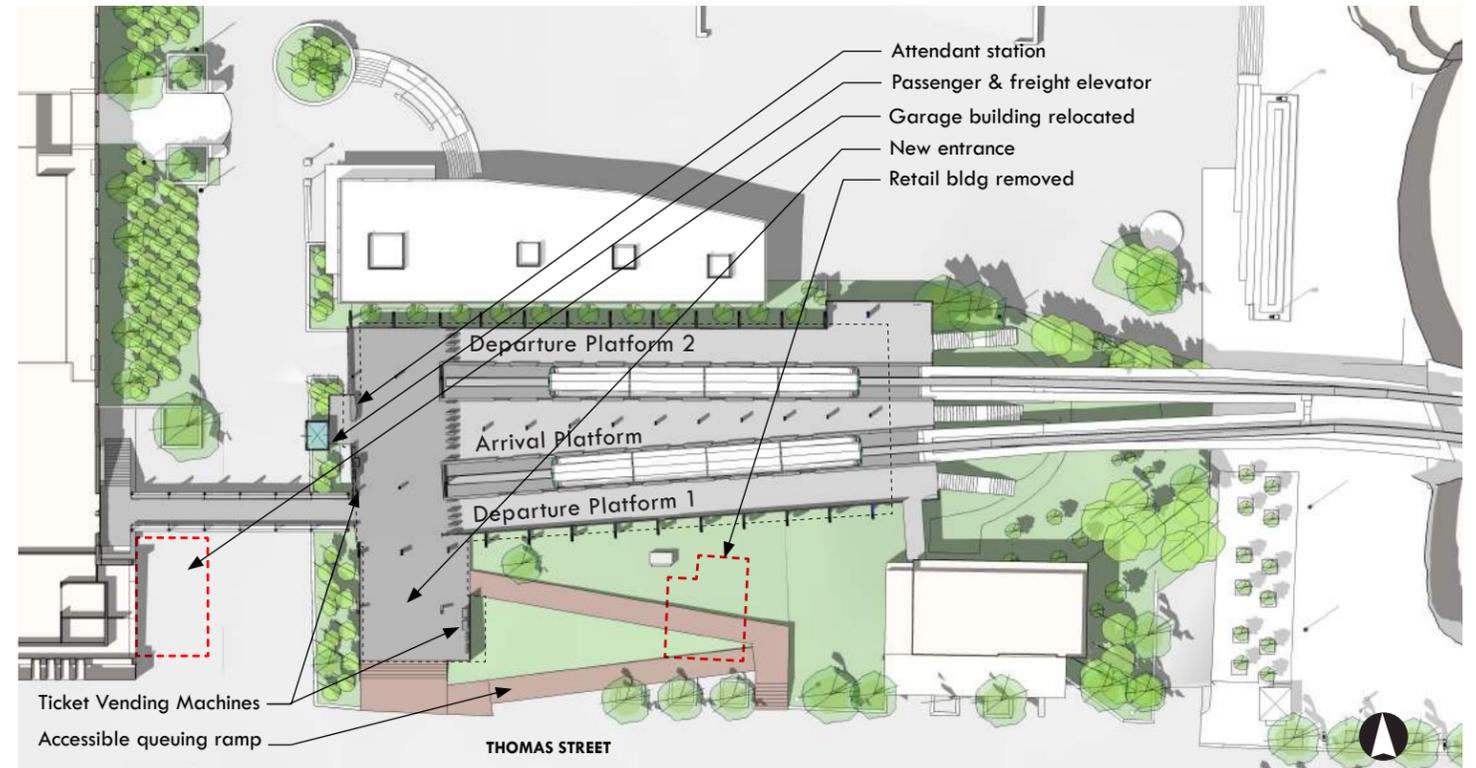


Figure 23a: Seattle Center Station - Phase 2

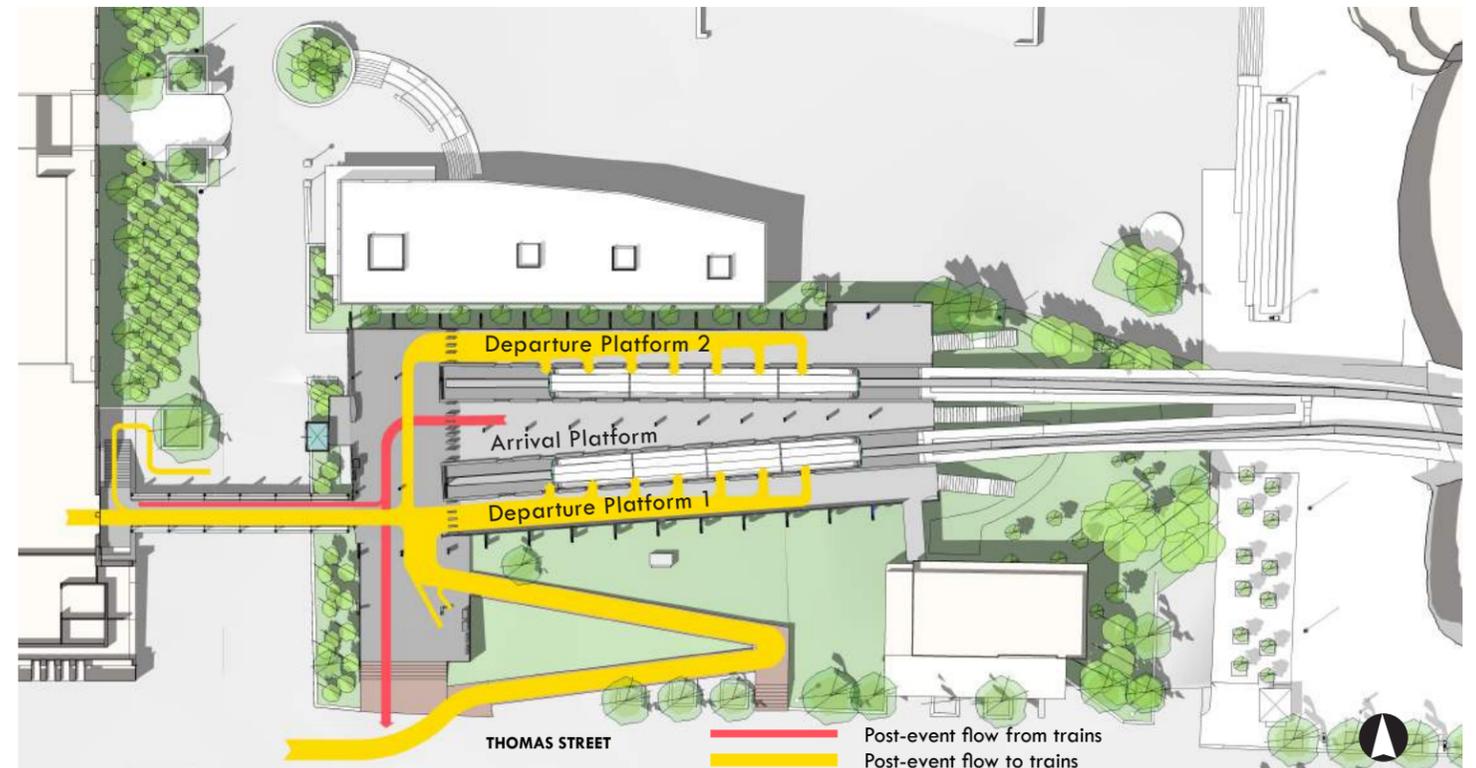


Figure 23c: Seattle Center Station - Phase 2 Post-Event Surge

PHASE 3 - ADDITION OF A NORTH ENTRANCE

As Seattle Center develops its master plan vision for the “Center of the Center,” Phase 3 responds to intensifying activation of the center of the campus with a north entrance facing the Artists at Play plaza that further integrates the station into its context. The north entrance mirrors the south entrance by providing an accessible ramp that is woven into a natural landscape bank. When approaching the station from the north via Harrison Street, the entrance compliments the vibrancy of the Artists at Play plaza and playground. The additional entrance doubles the capacity for queuing that serves post event surges and reduces flow conflicts as each entrance feeds a dedicated platform.

The following will be part of Phase 3 improvements:

- Removal of the Next 50 building to allow a north entrance for improved station visibility and access.
- Addition of a North entrance stair, covered landing and ticket center.
- Addition of an accessible queuing ramp that mirrors the south entrance design.
- Landscape and seating integrated with the ramp and stair.

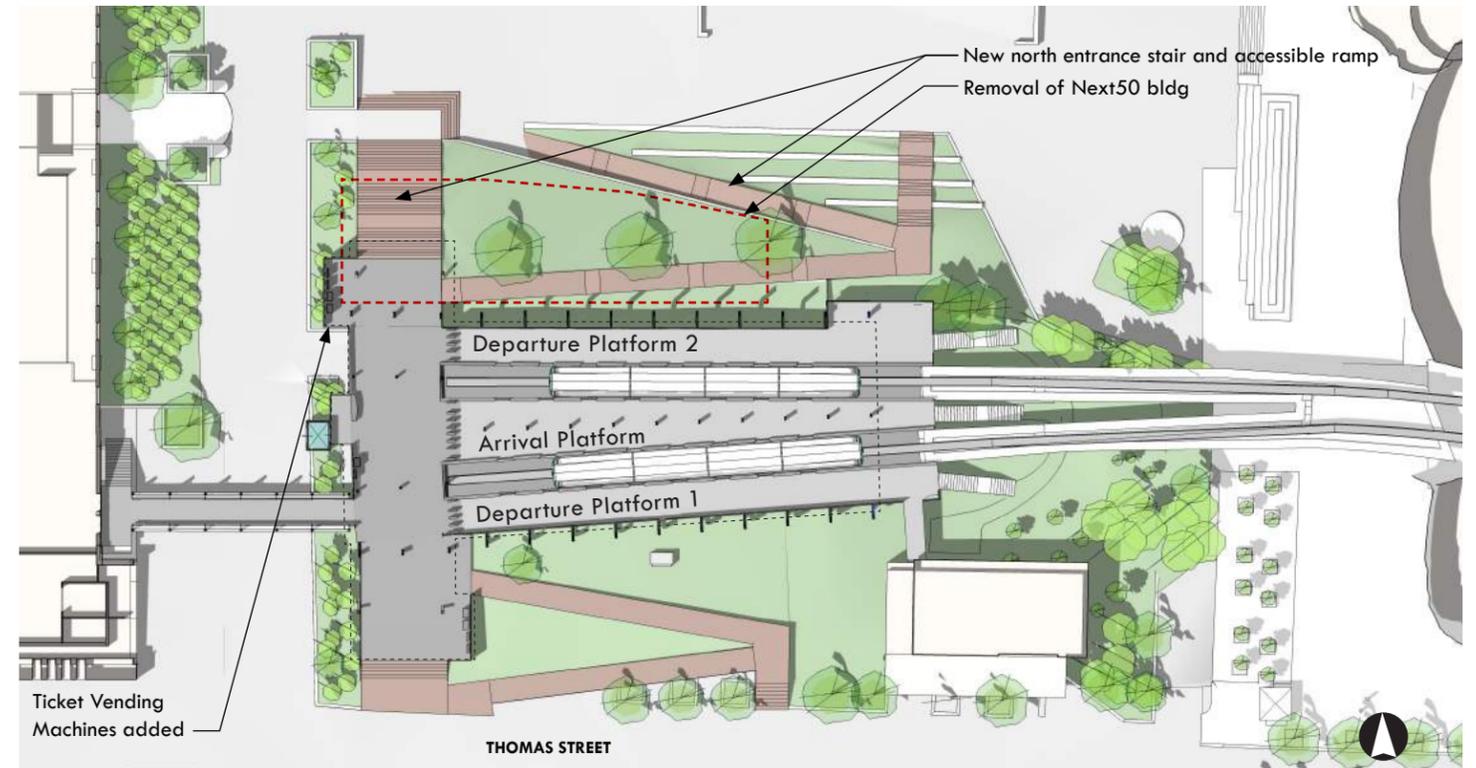


Figure 24a: Seattle Center Station - Phase 3

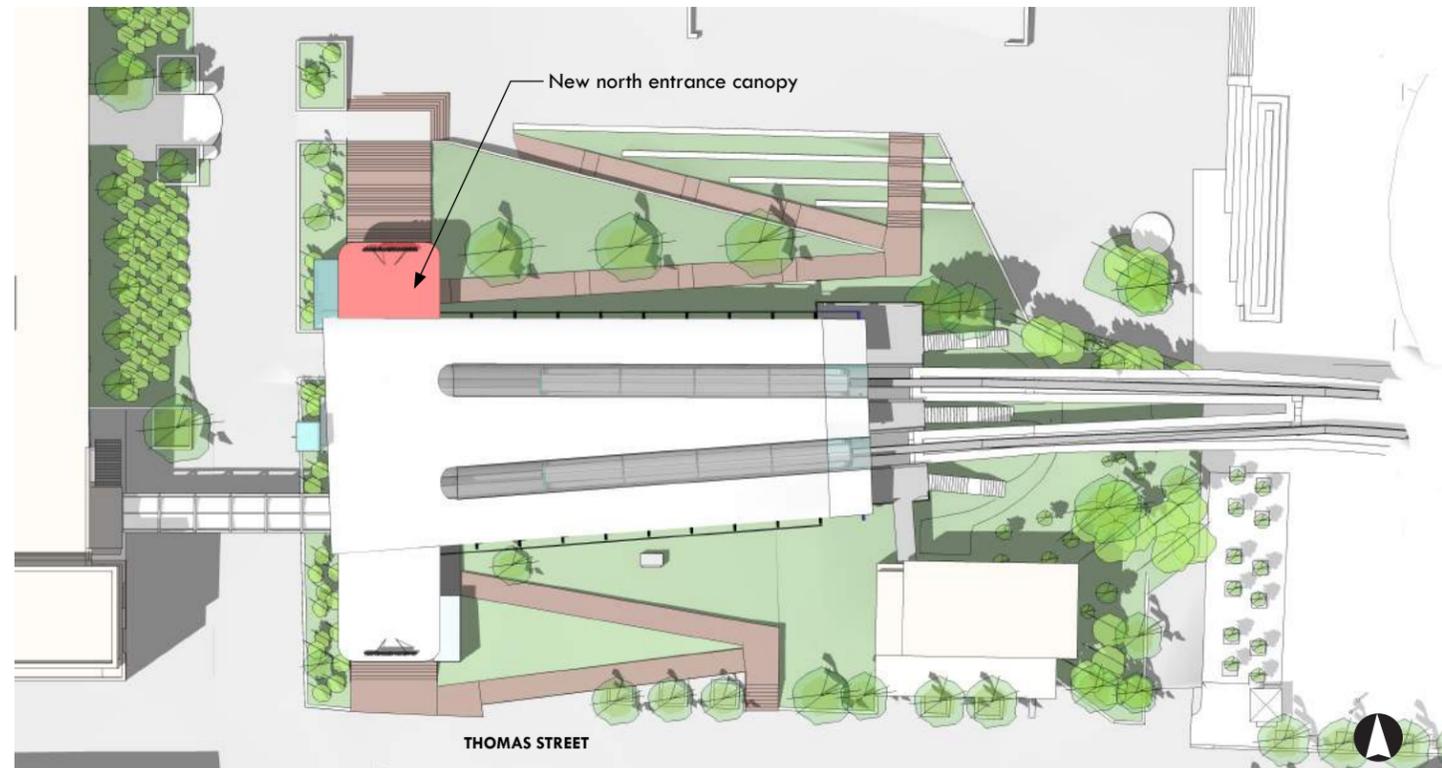


Figure 24b: Seattle Center Station - Phase 3 Roof View

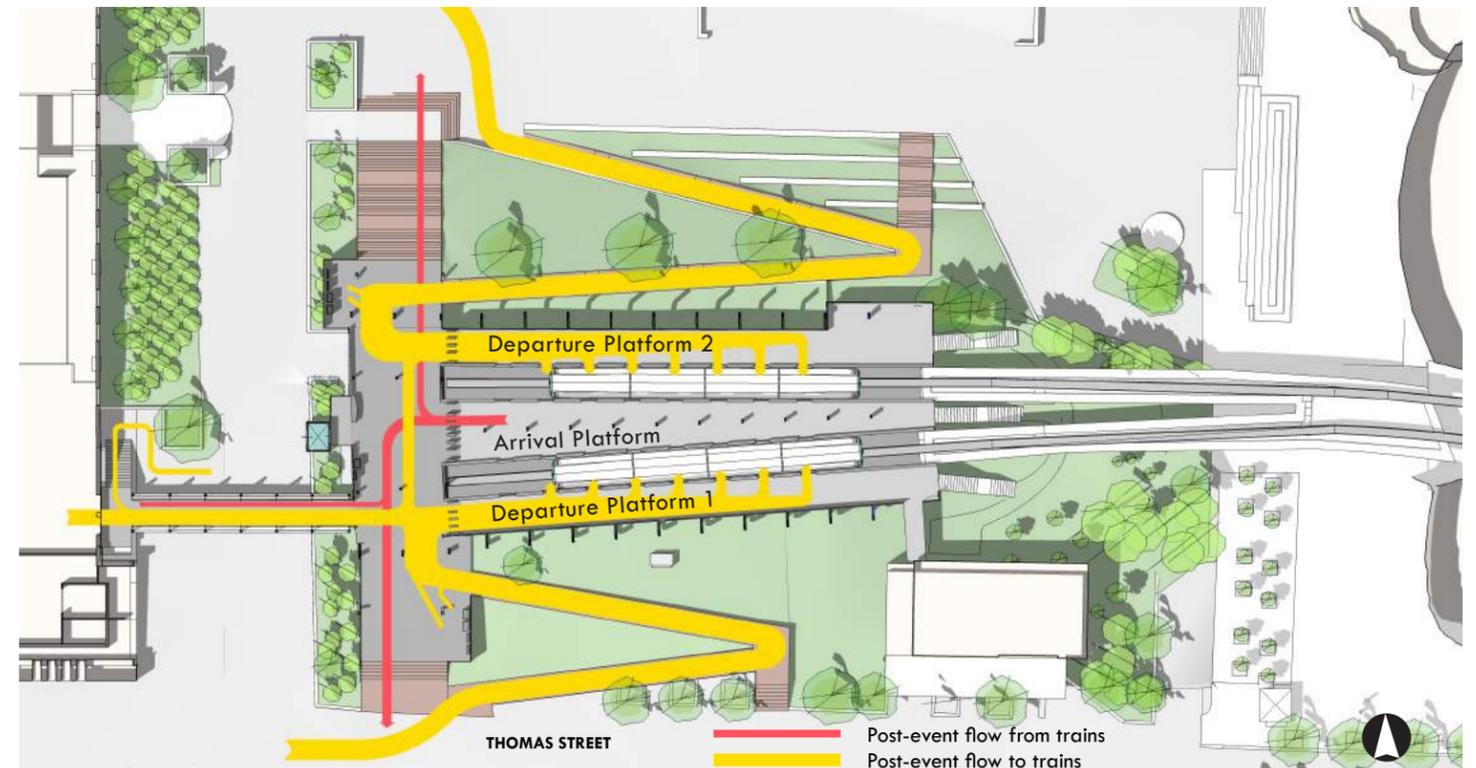


Figure 24c: Seattle Center Station - Phase 3 Post-Event Surge



Figure 25: New north entrance looking south-east

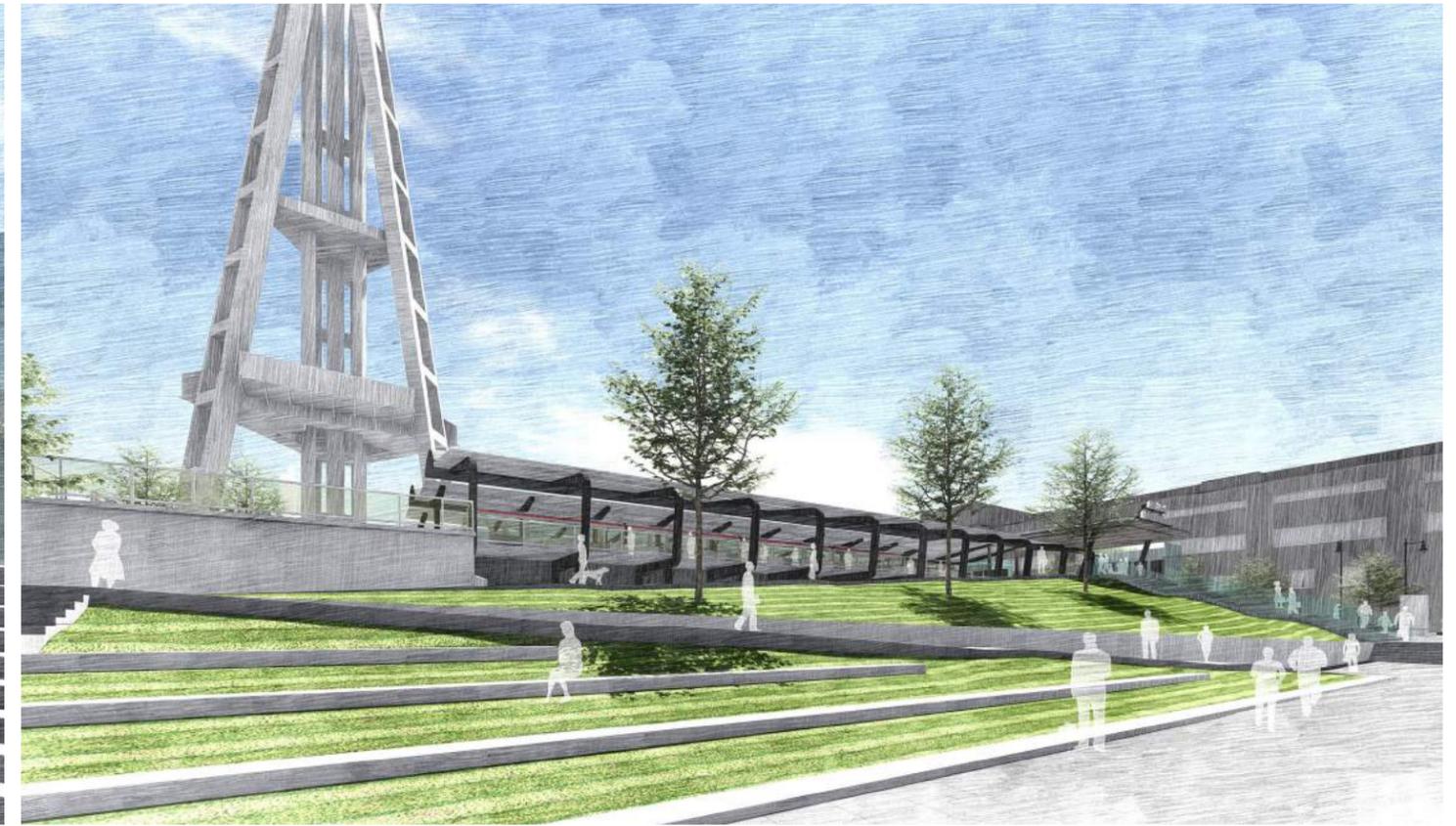


Figure 26: New north entrance looking south-west



Figure 27: Seattle Center Station south entrance (across from Space Needle) - night time view



Figure 28: New south entrance looking north - day time view



Figure 29: New north entrance from Artists at Play plaza

BELLTOWN MONORAIL STATION

This study also includes a feasibility analysis of the cost, constructibility, and operational impact of adding a station in Belltown along 5th Avenue near Bell Street. Despite the tightly constrained environment, a station was found to be technically feasible with minimal impact to 5th Avenue and surrounding properties and to Monorail operations during construction.

The station concept locates new structural supports far enough from the existing ones so as not to interfere with their foundation area. These columns end in T-spans which support one platform on either side of the guideway. Each platform is 30 feet above the ground, requiring elevators for accessibility, and escalators and stairs for passenger flow on both sides of the street. A limitation of this design is that passengers can only cross over to the other platform at the street crossings. This can be partially mitigated through a robust wayfinding strategy that indicates departure times and heading directions to passengers before they choose which platform to board.

Construction would occur at night so as to minimize impact to Monorail operations. 5th Avenue traffic would be impacted during construction, and a lane of parking would need to be permanently converted to a bulb-out. The station would likely cost about \$40 million or more to construct, not including design and property costs.

The station would add 4-6 minutes to round trip time, reducing the system's post-event capacity to move passengers out of Seattle Center Station by half. Considering this, the station should be implemented in 2035 when the Link Light Rail ST3 line with a stop near Seattle Center can make up for the lost capacity.



Figure 30: Belltown station location on the Monorail line

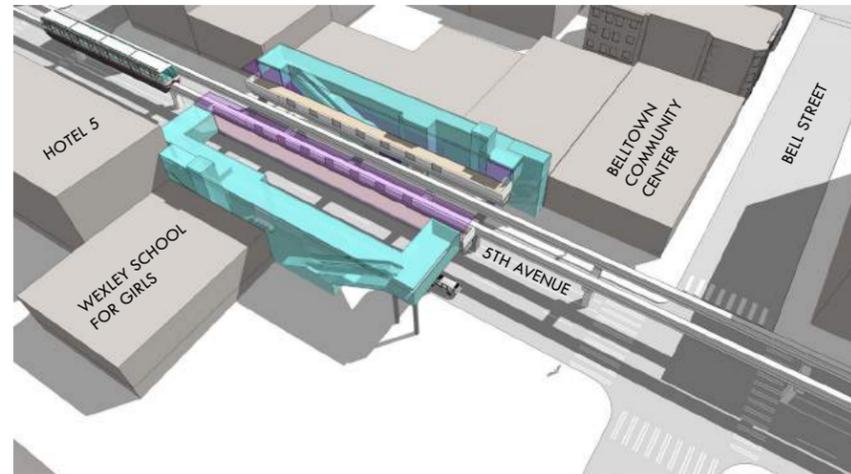


Figure 31: Aerial View



Figure 32: Street Level View

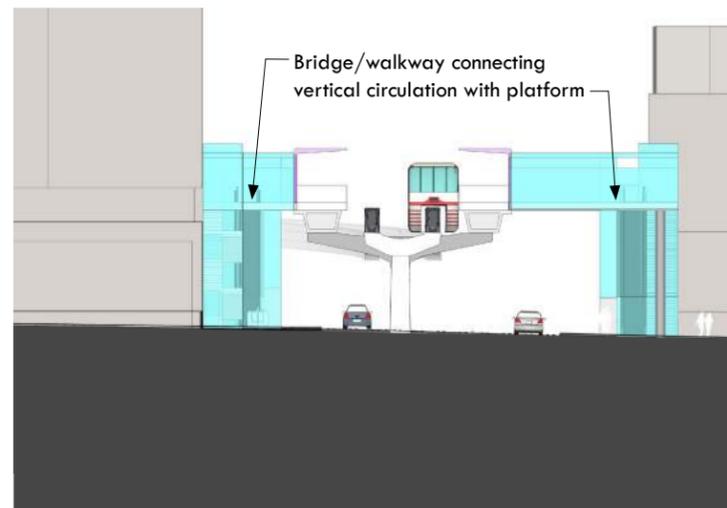


Figure 33: Cross Section

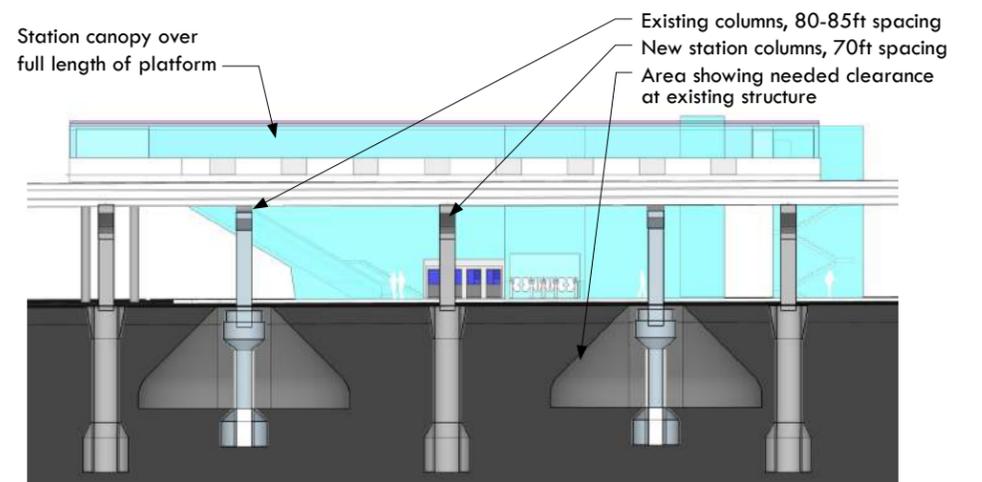


Figure 34: Longitudinal Section

- COLOR KEY
- Entry
 - Circulation
 - Vertical Circulation
 - Existing Buildings

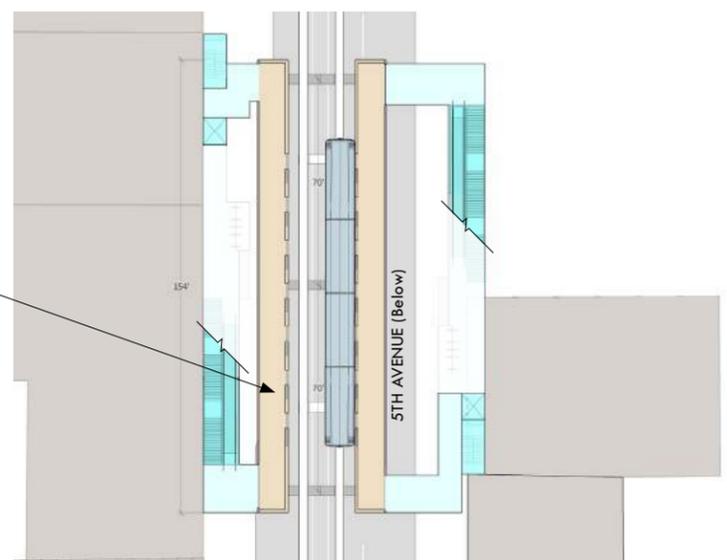


Figure 35: Platform Plan

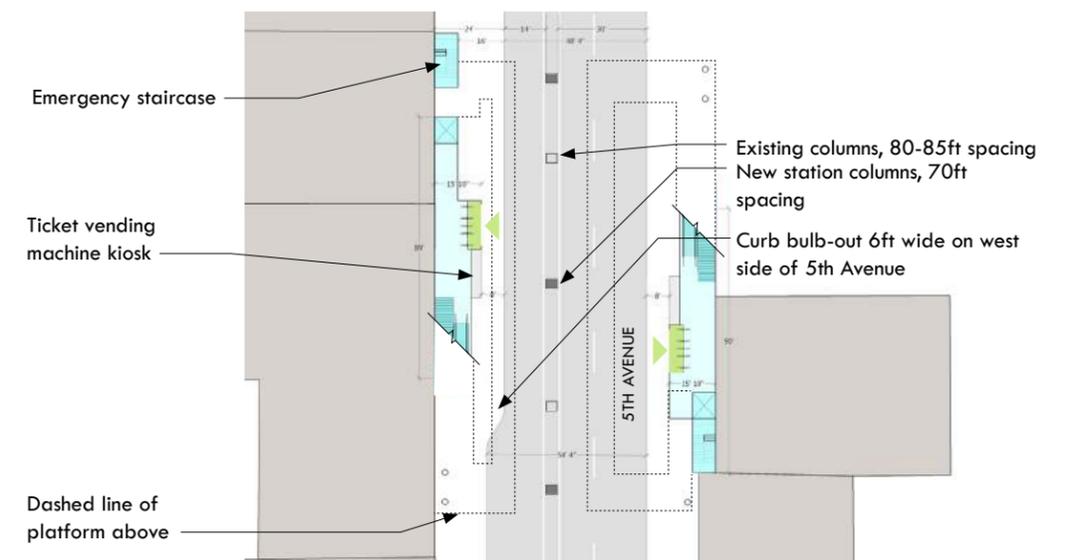


Figure 36: Ground Floor Plan

APPENDIX A: COST-BENEFIT ANALYSIS

To quantitatively demonstrate the value of investing in doubling the Monorail's capacity and improving the user experience at the stations, a study was undertaken to compare the magnitude of this investment with benefits to event patrons.

For this study, it was assumed that the average travel distance to the arena would be 10 miles, which is conservatively lower than the Arena Renovation Draft EIS assumption. The forecasted benefits are cumulative over an estimated 249 events per year over a 15-year time frame. The 15-year time frame reflects the time the renovated arena opens until the time that the ST3 Link Extension to Ballard opens (figure A1).

This analysis concludes that the benefits realized to patrons in terms of travel time saved and vehicle operating costs reduced as a result of Monorail improvements deliver a return on investment of roughly 7.7x - creating a surplus value of \$92 million (figure A2). This analysis is based on completion of the proposed Phase II improvements at Westlake platform and Phase III improvements at Seattle Center Station. These options represent the best grades in wayfinding, visibility, accessibility, and passenger flow to encourage the level of utilization that will provide this benefit.

This study does not take into account additional benefits that would be experienced by non-event patrons as a result of reduced traffic congestion near the Arena and on major congested arterials leading to it, such as Mercer and Denny.

	Cost (\$M)	VOC ²	Travel Time ³	Total	Surplus (\$M)
Total Benefit ¹ (\$M)		46	60	106	
Phase I	7.0	6.60	8.56	15.16	99
Phase II	20.0	2.31	2.99	5.30	86
Phase III	23.0	2.01	2.60	4.61	83

Figure A2: Cost Benefit Analysis Summary Table

- 1) Total benefits assume filling the capacity target of 6000 passengers per hour in one direction. Benefits are calculated over a 15 year span (see Figure A1) and only consider Seattle Center Arena events
- 2) Vehicle ownership costs are 89 cents per mile per APTA + .10 cents per mile due to congestion per USDOT
- 3) Value of time saved based on WSDOT congestion impact assessment methodology. Quantity of time saved based on travel time analysis
- 4) Surplus is total social benefit minus capital cost
- 5) Return on Investment is expressed as a ratio. e.g. For every dollar spent on phase I improvements, \$6.60 is saved on VOCs

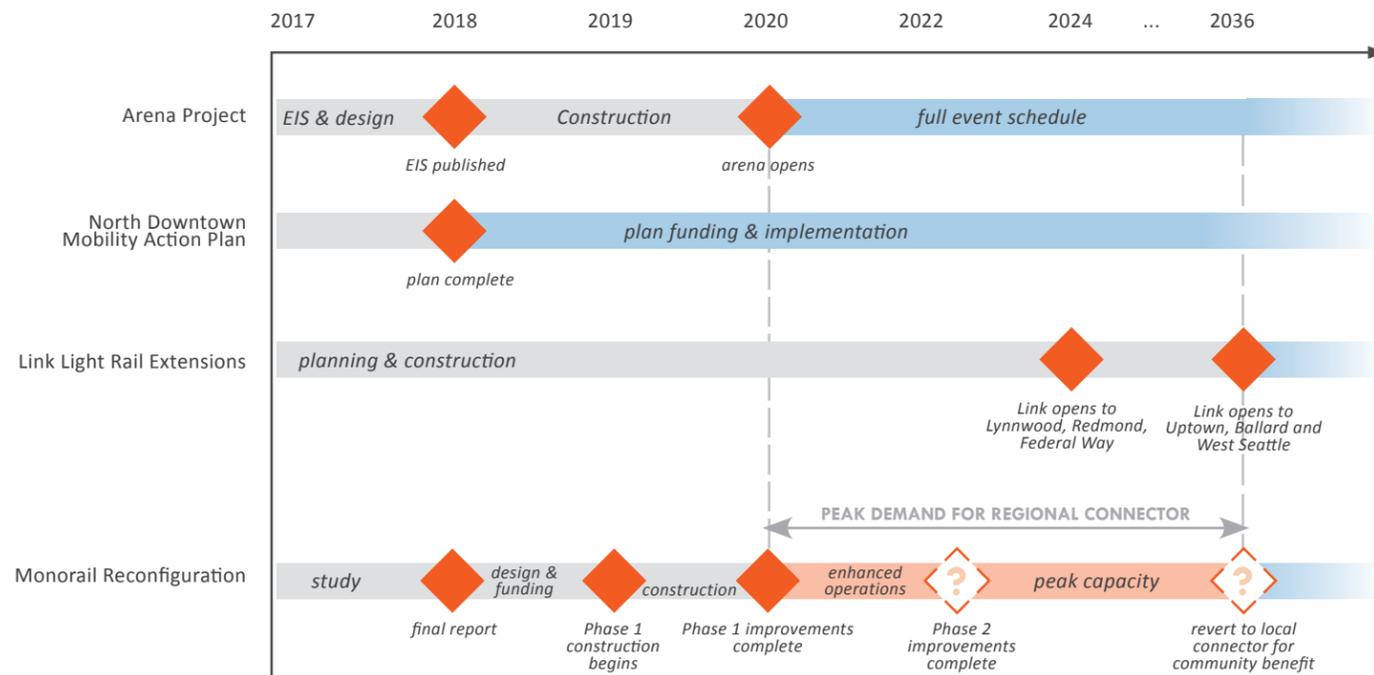


Figure A1: The benefit of increasing Monorail capacity will primarily be realized from the time that improvements are completed until the Link Light rail creates a redundant transit spine.

		Visibility	Wayfinding	Accessibility	Flow	Transit Connection
Westlake Station	Phase I	○	◐	◐	◐	◐
	Phase II	●	●	●	◐	●
Seattle Center Station	Phase I	◐	◐	◐	◐	
	Phase II	◐	◐	◐	◐	
	Phase III	●	●	●	●	

Figure A3: Alternatives Evaluation

- = Excellent performance
- ◐ = Good performance
- ◑ = Fair performance
- ◒ = Poor performance
- = Very Poor performance

APPENDIX B: COST OF IMPROVEMENTS

PHASING AND CAPITAL COSTS

The results and recommendations of this study identify ridership goals for different levels of investment in the existing system. Improvements can be phased to have the Monorail operating at the highest capacity possible by opening day of the proposed Arena redevelopment.

To achieve this, the Phase 1 Improvements at Westlake Center and a commitment to staffing at both ends, making the Armory and its amenities available for exiting patrons to queue, and Westlake Center open for vertical circulation, are the minimum level of improvements needed. The capital costs for Phase 1 at Westlake are estimated at \$3.85 M.

Phase 1 at Seattle Center, which replaces 32 stationary access gates with the same automatic gates at the Westlake platform, would be the next priority, and is needed to achieve the 2.5- minute headway times and full 6,000 one-way and 12,000 two-way capacity. The capital costs for Phase 1 at Seattle Center is estimated at \$3.1 M.

Additional improvements can come online as Sound Transit 2 Link Light Rail connections north, south and east are completed by 2025. Phase 2 at Westlake Center adds vertical circulation directly from the Monorail Platform to the Link Light Rail Station and creates additional opportunities at Westlake Plaza. The capital costs for Phase 2 at Westlake are estimated at \$9.2 M. The Seattle Center Monorail can replicate and bring the connection between existing Link Light Rail lines to Seattle Center 15 years sooner than the proposed Sound Transit 3 Link Light Rail station arrives near Seattle Center. Multiple funding sources and opportunities should be explored to realize this unique opportunity.

The table in figure B1 summarizes the cost of the phased improvements.

MONORAIL FEASIBILITY STUDY PROJECT COSTS (IN 2018 \$'S) *

WESTLAKE STATION		SEATTLE CENTER STATION		
PHASE 1	PHASE 2	PHASE 1	PHASE 2	PHASE 3
\$3.85 million	\$9.2 million	\$3.1 million	\$3.85 million	\$3 million

* Project Costs are based on the conceptual drawings included in this report and include soft costs and sales tax. Estimates are based on the March 2018 construction market. Escalation is not included.

Figure B1: Summary of high level cost estimates for phased improvements at both Monorail stations.

APPENDIX C: COMMUNITY OUTREACH



Figure C1: Public outreach event #2 presentation

A robust outreach process was critical in identifying stakeholder priorities and desires. In addition to numerous meetings and events with formal stakeholders, public outreach for this study consisted of the following events and surveys:

- **Event #1 @ KEXP - 13 March 2018**

About 100 people attended this event in Uptown hosted by the Uptown Alliance. The event consisted of a brief introduction followed by a poster session where design team members explained the analysis and preliminary design alternatives in a conversational setting. There was a station set up to collect feedback and survey responses. This event was held in conjunction with the City of Seattle's North Downtown Mobility Action Plan outreach effort.

- **Event #2 @ Belltown Community Center - 14 March 2018**

Around 50 people attended this event held by the Belltown Community Council. The analysis and preliminary design alternatives were presented, followed by conversation with individual community members in an open poster session. This event was also held in conjunction with NODOMAP outreach.

- **Online Survey - March-April 2018**

Over 2000 people participated in the online Monorail survey prepared by enviroissues. It was promoted by the project team during outreach events as well as local and regional media. The results of the survey are summarized in this appendix.

- **Event #3 @ Seattle Center - 25 April 2018**

Around 50 people attended the third outreach event, held at the Seattle Center Armory. At this public open house, the Monorail team presented revised concepts as well as the results of previous outreach efforts, namely the online survey. This event was held in collaboration with City of Seattle Department of Transportation and Office of Planning and Community Development staff who presented updates on other current projects in north downtown neighborhoods.

Summaries of results from the three public outreach events and survey can be found on the following pages. The key takeaways are as follows:

- **Current and proposed Monorail improvements could triple Monorail ridership during events**

A comparison of the answers of the survey reveals that the transportation mode preference for traveling to events would be significantly modified by improvements to the Monorail.

- **Improving the platform-to-platform connection between the Monorail and Link Light Rail is the most critical improvement to increasing ridership**

Over 70% of survey respondents indicated this as one of their top three desired improvements, with 'more frequent headways' and 'improved street connections' following at around 45% each.

- **After improvements, most riders will get to the Westlake Monorail station via the Link Light Rail**

The survey answers reinforces the priority of improving the connection to the link.

- **Those who predict they will attend more events at Seattle Center are the most likely to consider taking the Monorail from a Link Light Rail transfer**

This indicates that the Monorail will be an increasingly popular option to get to and from Seattle Center events relative to other modes of travel.

- **ORCA acceptance will increase ridership**

80% of respondents indicated that ORCA as a way of paying Monorail fares, in planning coincident to the development of this report, will affect their decision to use the Monorail.

- **Improving the Monorail is a popular idea**

95% of riders believe improving the Monorail is worthwhile.

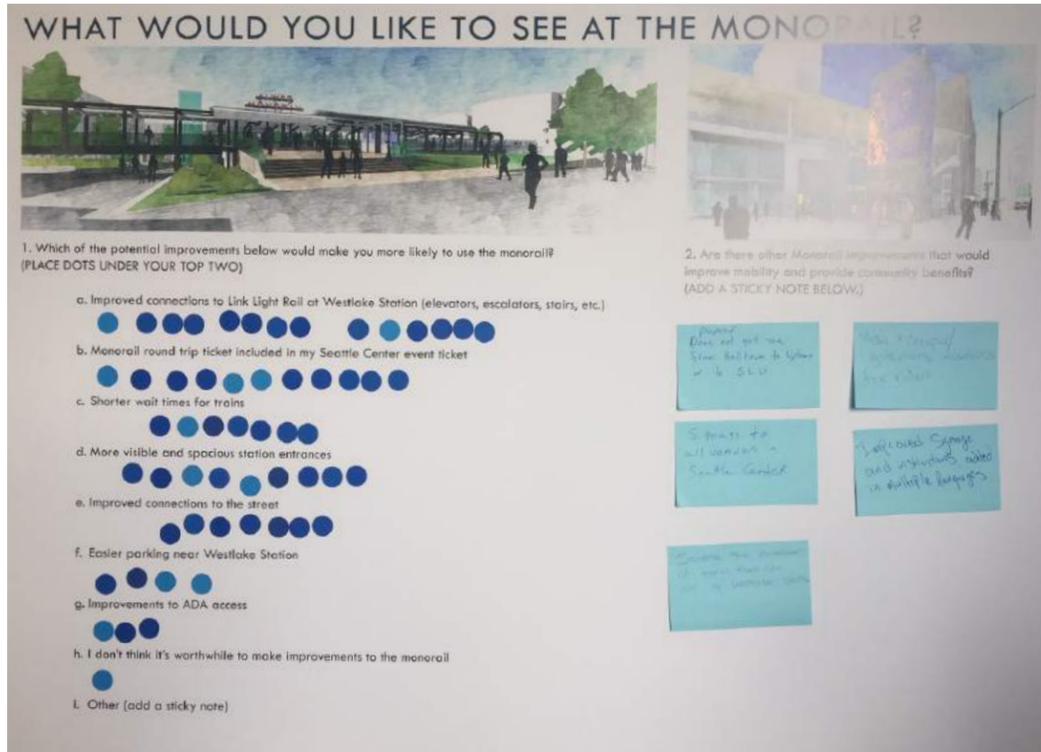


Figure C2: Feedback board after public outreach event #1

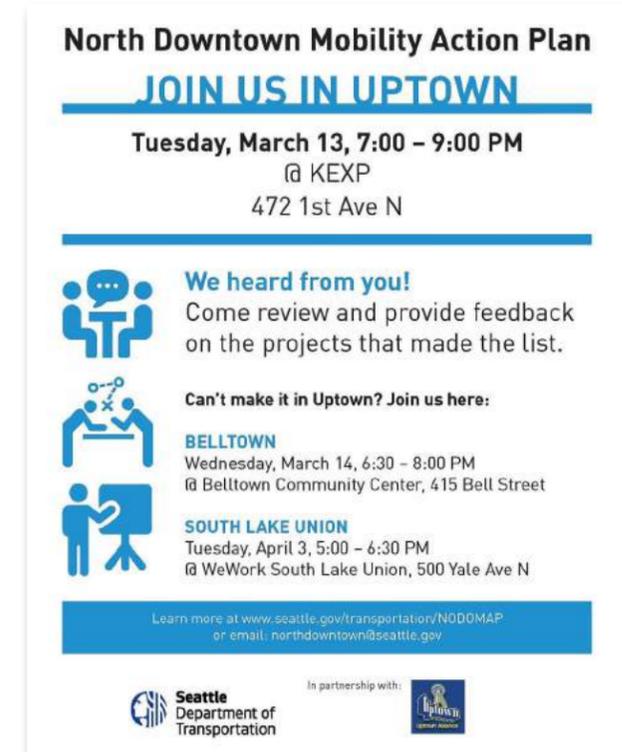


Figure C4: Outreach event promotion poster

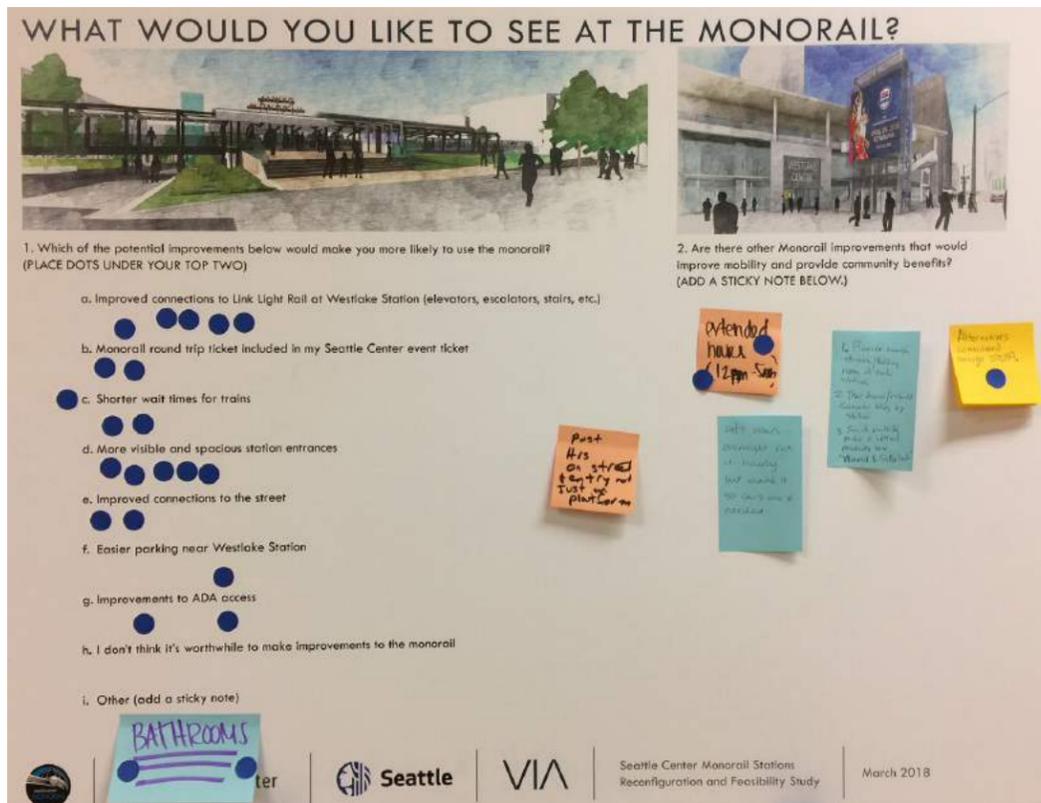


Figure C3: Feedback board after public outreach event #2

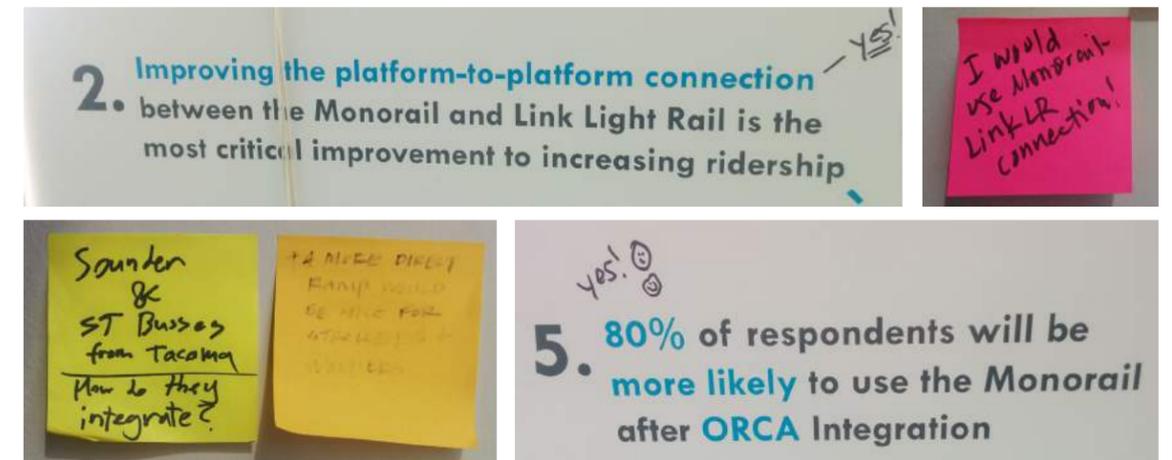


Figure C5: Feedback collected on boards during public outreach event #3



Research objectives

This survey project was designed to measure public interest in supporting improvements to the Seattle Monorail. The survey questions were designed to understand the following:

- How respondents travel to Seattle Center now
- Which potential improvements to the Monorail would increase ridership
- Whether any differences in opinion or behavior are related to ZIP code, age or present travel behavior

Approach

The brief survey contained nine substantive questions, plus six demographic questions. Survey takers were also asked if they would like to sign up for project updates. Surveys were distributed in two ways: online, advertised through social media, community networks and blogs, and local news channels, and paper copies were collected at open houses held in Uptown and Belltown neighborhoods in mid-March and at the Westlake Monorail Station.

The online version was launched on March 13, 2018 and responses were accepted until April 12, 2018. The paper copies were merged with the online responses to complete the dataset. In all, N=1,972 surveys were counted as completes, which means the participant began the survey and answered the final question. No questions were required, which means participants could skip questions if they chose.

Who we heard from

ZIP code

Just under 1,900 survey participants provided their ZIP code when asked. Of the ZIP codes collected, 80 percent were ZIP codes within the City of Seattle.

Age

The survey asked about the age of the survey respondent. In comparing the responses between the survey and the American Community Survey projections for Seattle in 2016, the table shows the survey captured a slightly higher response rate from participants between 35 to 49 years old.

	Adults over 18 years of age, American Community Survey (2016) Estimate, Seattle	Survey Results
Under 25 years	10 percent	6 percent
25 to 34 years	27 percent	31 percent
35 to 49 years	27 percent	34 percent
50 to 64 years	21 percent	19 percent
65+ years	15 percent	15 percent



Household Type

Twenty-six percent of respondents indicated they live alone, 63 percent indicated they live in a two-adult household and about 13 percent live in a household with three or more adults. Seventy-four percent of those respondents do not have children living at home with them, 13 percent have one child and 10 percent have two.

Getting around

Less than one in five participants (16 percent) said they do not own a car. Forty-four percent own one car, 30 percent own two cars and 10 percent own three cars or more. Regardless of high car ownership, 86 percent of all respondents indicated they use an ORCA pass for regular transit trips.

Executive summary

- Current and proposed Monorail improvements could triple Monorail ridership during events at the Seattle Center. After improvements are made, upwards of 70 percent of survey participants say they will ride the Monorail to get to Seattle Center.
- Improving the platform-to-platform connection between the Monorail and Link Light Rail is the most critical improvement to increasing ridership.
- After improvements, most riders will get to the Westlake Monorail station via the Link Light Rail.
- Those who predict they will attend more events at the Seattle Center are the most likely to consider taking the Monorail from a Link Light Rail transfer.

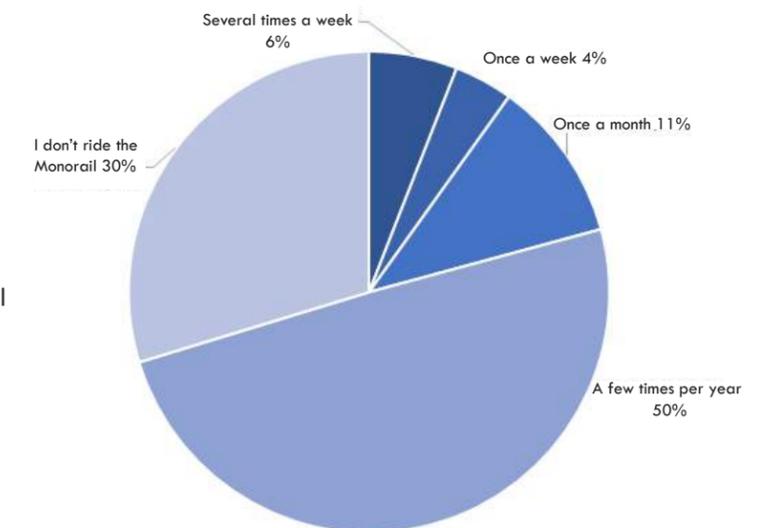
Key findings

Highlights from several key questions are summarized in the following pages using charts and tables to display data from subgroups.

Frequency of Monorail use

Question: How often do you ride the Monorail?

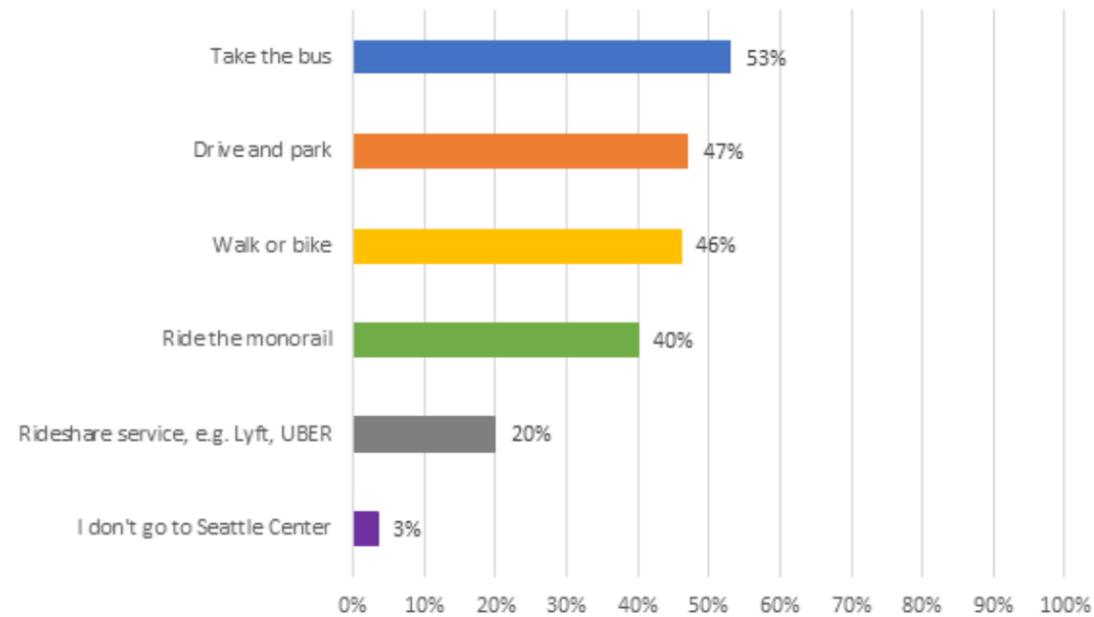
- Thirty percent of survey takers do not ride the Monorail at all, and another 50 percent ride only a few times a year.
- Those who ride the Monorail at least once a month or more often (approximately 30 percent) are likely to live downtown (ZIP 98101) or near Queen Anne (ZIP 98109).





Getting to Seattle Center now

Question: Which options do you currently use to get to Seattle Center? (select all that apply)*



*Percentages will sum to greater than 100 percent because multiple answers were permitted.

- Four in ten participants say they use the Monorail when visiting Seattle Center. Using the Monorail is less common than the bus (53 percent), driving (47 percent) or biking/walking (46 percent).
- Respondents without cars were no more likely to take the Monorail. Instead, they are more likely to bike, walk or take the bus over the Monorail.
- Downtown residents in ZIP code 98101 are the heaviest users of the Monorail (67 percent). Belltown residents favor the bus (83 percent) as their first choice in traveling to Seattle Center and Queen Anne residents are most likely to bike or walk to Seattle Center from home.
- Approximately 40 percent of participants from all age groups say they are driving to Seattle Center.
- Almost half of those who think they will attend more events at Seattle Center when the new Arena opens are currently driving to Seattle Center for events today. This is an important target audience for education about potential improvements to the Monorail stations.

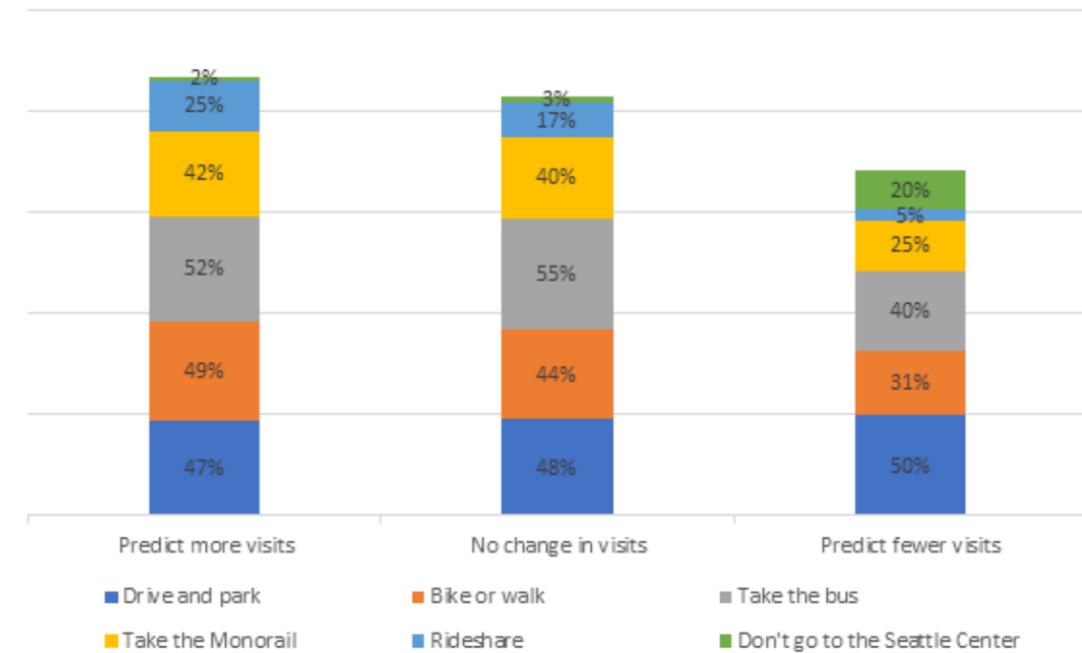
	98122 (Belltown)	98109 (Queen Anne)	98119 (Queen Anne/Interbay)	98101 (Downtown)
Drive and park	31 percent	24 percent	30 percent	18 percent
Bike or walk	51 percent	84 percent	81 percent	64 percent



	98122 (Belltown)	98109 (Queen Anne)	98119 (Queen Anne/Interbay)	98101 (Downtown)
Take the bus	83 percent	35 percent	45 percent	47 percent
Take the Monorail	29 percent	31 percent	23 percent	67 percent
Rideshare	38 percent	19 percent	14 percent	26 percent
Don't go to Seattle Center	0 percent	1 percent	1 percent	3 percent

	Under 25	25 to 34	35 to 65	65+
Drive and park	39 percent	41 percent	53 percent	39 percent
Bike or walk	43 percent	56 percent	41 percent	44 percent
Take the bus	60 percent	63 percent	49 percent	38 percent
Take the Monorail	33 percent	35 percent	46 percent	30 percent
Rideshare	29 percent	31 percent	16 percent	4 percent
Don't go to Seattle Center	5 percent	3 percent	3 percent	4 percent

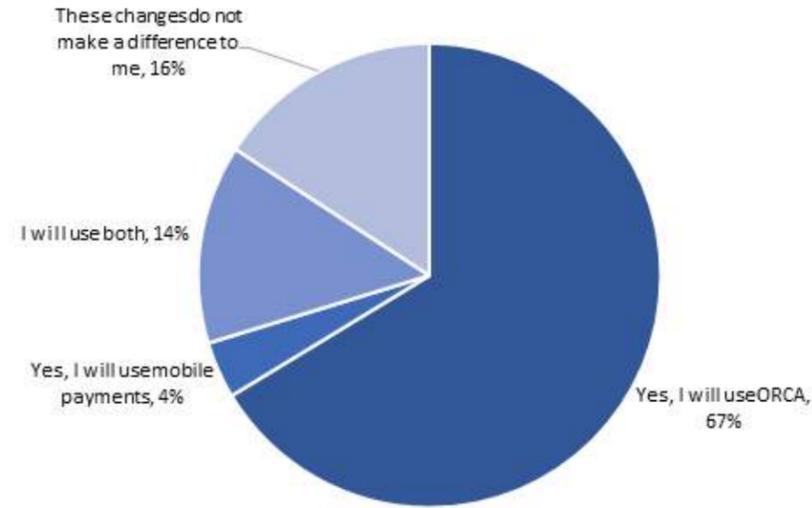
Current travel behavior based on projected visits to Seattle Center





Impact of new payment options

Question: By spring of 2019, you will be able to pay for your Monorail ticket using a credit card, mobile phone, and your ORCA card. Will this affect your decision to use the Monorail?

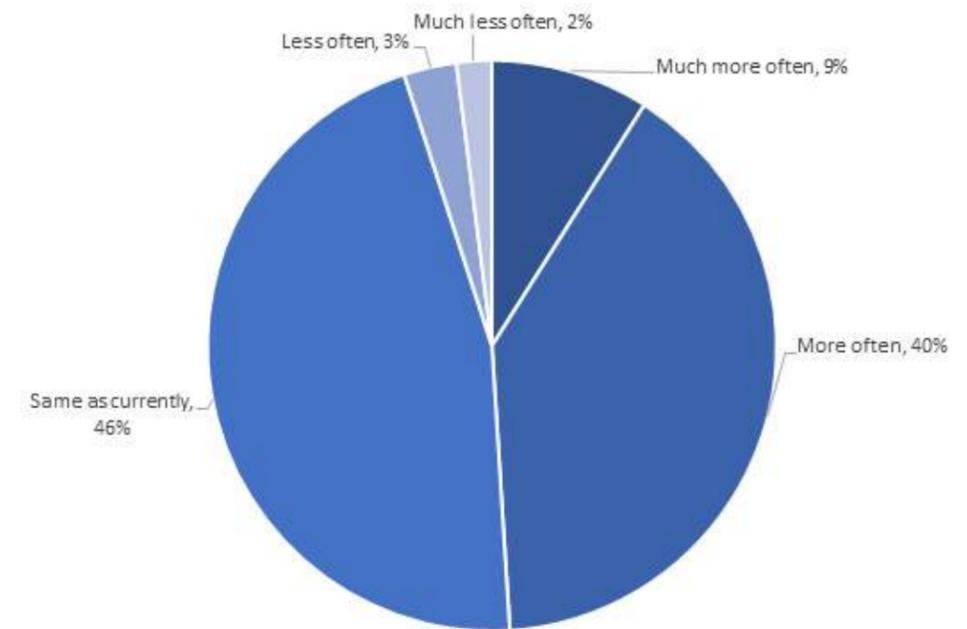


- Two-thirds of all survey participants say they plan to use ORCA once this payment option becomes available. Another 14 percent say they will use both ORCA and mobile payment options.
- Among current ORCA pass holders (86 percent of all survey takers), the likelihood of using ORCA as a payment option grows to 76 percent among this large group.
- Among those who don't have an ORCA pass or don't use one regularly (14 percent), almost half (49 percent) aren't persuaded additional payment option for the Monorail. 10 percent say they would get a pass to access the new benefit.
- Adding ORCA payment options appears to provide greater options for riders under 35 as they are more likely to have ORCA cards (91 percent) compared to participants over 35 (84 percent).
- Four percent of participants said they will take advantage of mobile/credit card payments and 14 percent said they would alternate between ORCA and mobile/credit card options.
- Sixteen percent of all participants were not persuaded by the addition of new payment options and said they would not affect their use of the Monorail. Among participants over 50, a full quarter (26 percent) said the additional payment choices did not impact them.



Estimation of frequency of attending events at Seattle Center

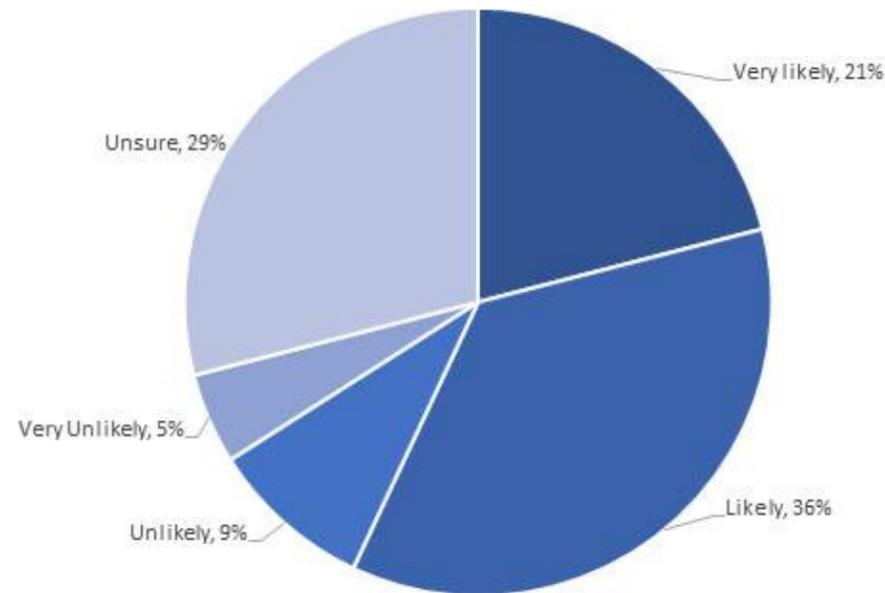
Question: Compared to today, how often do you see yourself attending events at Seattle Center once the new Arena opens?



- Just under half (49 percent) of survey participants say the new Arena will cause them to visit Seattle Center more often than they do now. A similar percentage (46 percent) indicate their frequency of visits to Seattle Center will not change with the new Arena. About five percent think they will visit less often.
- Survey participants under 35 reported the highest likelihood of increased visits to Seattle Center once the new Arena opens.
- Households with children think they will be more likely to attend more events compared to households without children.

Interest in attending events at the new Arena

Question: How likely are you to attend events at the new Arena?



- 57 percent of all participants say they are likely to attend events at the new Arena.
- There is greater interest among participants between the ages of 25 and 64.
- The small group of participants who say they aren't interested in more flexible payment options for the Monorail also say they are less likely to attend events at the new Arena (30 percent unlikely compared to 14 percent of the general population).
- Among those who don't visit Seattle Center today, 29 percent think they would be likely to attend an event when the new Arena opens.

	Overall	Under 25	25-34	35-64	65+
Very likely	21 percent	17 percent	23 percent	22 percent	10 percent
Likely	36 percent	38 percent	39 percent	37 percent	25 percent
Unlikely	9 percent	10 percent	8 percent	7 percent	18 percent
Very unlikely	5 percent	4 percent	3 percent	5 percent	8 percent
Unsure	29 percent	32 percent	27 percent	28 percent	40 percent

	Plan to use ORCA or credit/mobile to pay	Changes to payment options make no difference	Don't visit Seattle Center now
Very likely	22 percent	14 percent	13 percent
Likely	38 percent	24 percent	16 percent
Unlikely	8 percent	13 percent	17 percent
Very unlikely	3 percent	17 percent	28 percent

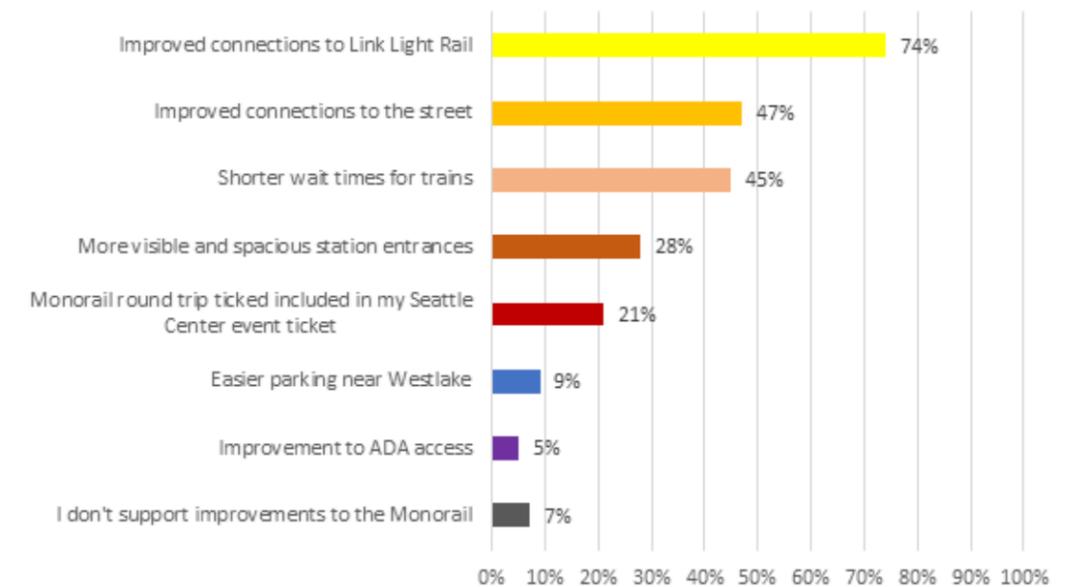


Unsure	29 percent	33 percent	27 percent
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Most requested improvements to the Monorail

Question: Which of the potential improvements below would make you more likely to use the Monorail? (select your top three)*

- The possible improvements and participant reactions are shown in the chart below. About seven percent of participants did not select any improvements and indicated they did not think it was worthwhile to make improvements to the Monorail. Almost half of all participants said they would be more likely to ride the Monorail with improved connections to Link Light Rail, improved connections to the street and shorter wait times.



*Percentages will sum to more than 100 percent because multiple answers were permitted.

- The top improvements requested are similar when controlling for the travel mode used now by visitors to Seattle Center.
- Those who predict they will visit Seattle Center less frequently once the new Arena is built are interested in shorter wait times, as well as improved connections to Link Light Rail. These two needs were also mentioned by the subgroup who currently does not go to the Seattle Center at all. These are also the same top benefits that attract current Monorail riders. It seems the wait times could be a real issue for regular riders, as well as a perceived barrier for nonriders.



	Overall	Drive and park	Take the Monorail	Walk, bike or take transit
Improved connections to Link Light Rail	74 percent	75 percent	79 percent	77 percent
Improved connections to the street	47 percent	46 percent	49 percent	51 percent
Shorter wait times for trains	45 percent	44 percent	47 percent	48 percent
More visible and spacious station entrances	28 percent	27 percent	30 percent	30 percent
Monorail round trip ticket included in my Seattle Center event ticket	21 percent	25 percent	25 percent	20 percent

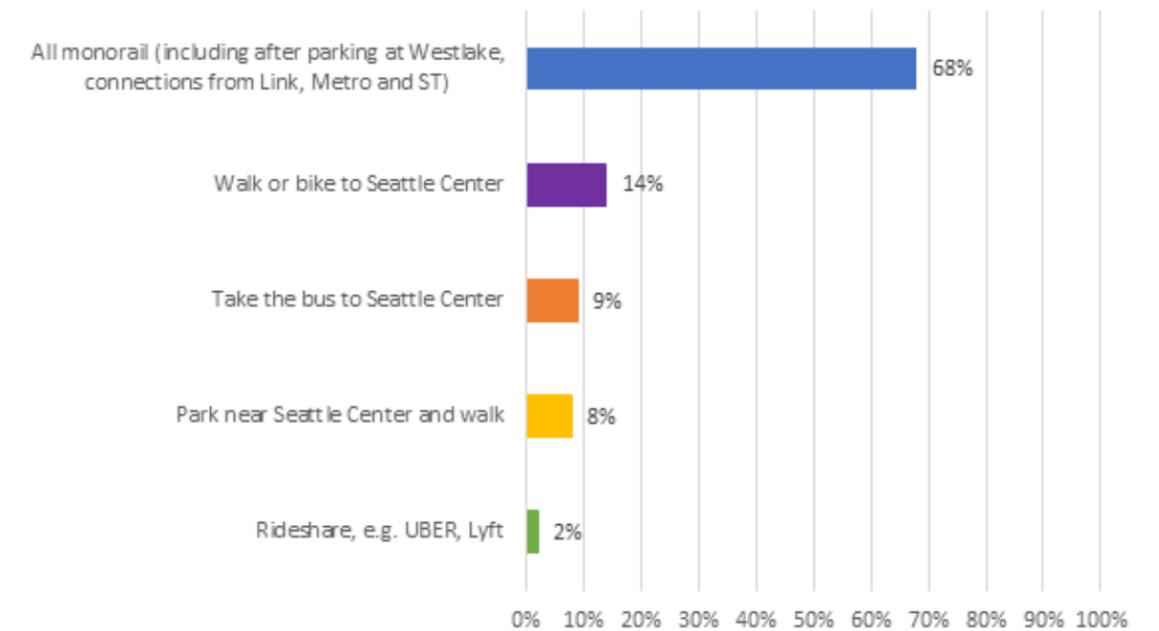
	Overall	More often	No change	Less often
Improved connections to Link Light Rail	74 percent	79 percent	72 percent	54 percent
Improved connections to the street	47 percent	51 percent	46 percent	26 percent
Shorter wait times for trains	45 percent	50 percent	42 percent	35 percent
More visible and spacious station entrances	28 percent	31 percent	25 percent	17 percent
Monorail round trip ticket included in my Seattle Center event ticket	21 percent	21 percent	21 percent	22 percent

	Overall	Do not ride the Monorail or only ride a few times a year	Ride at least once a month
Improved connections to Link Light Rail	74 percent	74 percent	74 percent
Improved connections to the street	47 percent	48 percent	43 percent
Shorter wait times for trains	45 percent	45 percent	48 percent
More visible and spacious station entrances	28 percent	29 percent	23 percent
Monorail round trip ticket included in my Seattle Center event ticket	21 percent	21 percent	21 percent



If proposed changes were made, what behavior changes can be expected?

Question: If some of the changes described in the previous question were made, which of these options would be your first choice for getting to an event at Seattle Center?



- 43 percent of all participants say their preference would be to transfer to the Monorail from Light Rail; five percent would park at Westlake Station and take the Monorail from there; and another 20 percent would take the Monorail after a bus trip on Metro, Sound Transit, Community Transit or Pierce Transit (total = 68 percent).
- Those who predict they will attend more events at Seattle Center are the most likely to consider taking the Monorail from a bus or Light Rail transfer (+ eight-point difference). Among those who don't think their attendance at Seattle Center events will change with the new Arena, about half are interested in a Monorail transfer (46 percent), 26 percent will consider walking, biking or direct buses and 17 percent will drive at least part or all the way.
- Residents living south of downtown and I-90 (i.e. South ZIPs) are more likely to indicate a willingness to transfer to the Monorail from Link Light Rail. Not surprisingly, living farther from Seattle Center makes walking, biking or a bus less appealing than it is for residents living in the central core.

	Overall	Drive and park	More often	No change
Transfer to the Monorail from Link Light Rail	43 percent	42 percent	51 percent	35 percent



	Overall	Drive and park	More often	No change
Transfer to the Monorail from a King County Metro bus	13 percent	12 percent	11 percent	14 percent
Transfer to the Monorail from Sound Transit Express, Community Transit or Pierce Transit bus	7 percent	8 percent	7 percent	7 percent
Park near Westlake Station and take the Monorail	5 percent	7 percent	6 percent	4 percent
TOTAL MONORAIL	68 percent	69 percent	75 percent	60 percent
Walk or bike to Seattle Center	14 percent	4 percent	13 percent	16 percent
Take the bus to Seattle Center	9 percent	8 percent	6 percent	11 percent
TOTAL OTHER TRANSIT/WALK/BIKE	23 percent	12 percent	19 percent	27 percent
Park near Seattle Center and walk	8 percent	16 percent	4 percent	11 percent
Rideshare service/Uber/Lyft/Taxi	2 percent	3 percent	1 percent	2 percent
TOTAL CAR	10 percent	19 percent	5 percent	13 percent

	Overall	North ZIPs	Central ZIPs	South ZIPs
Transfer to the Monorail from Link Light Rail	43 percent	41 percent	38 percent	58 percent
Transfer to the Monorail from a King County Metro bus	13 percent	18 percent	9 percent	20 percent
Transfer to the Monorail from Sound Transit Express, Community Transit or Pierce Transit bus	7 percent	3 percent	1 percent	2 percent
Park near Westlake Station and take the Monorail	5 percent	2 percent	3 percent	5 percent
TOTAL MONORAIL	68 percent	64 percent	51 percent	85 percent
Walk or bike to Seattle Center	14 percent	5 percent	30 percent	3 percent
Take the bus to Seattle Center	9 percent	18 percent	11 percent	6 percent
TOTAL OTHER TRANSIT/WALK/BIKE	23 percent	23 percent	41 percent	9 percent
Park near Seattle Center and walk	8 percent	11 percent	6 percent	5 percent
Rideshare service/Uber/Lyft/Taxi	2 percent	3 percent	3 percent	2 percent
TOTAL CAR	10 percent	14 percent	9 percent	7 percent

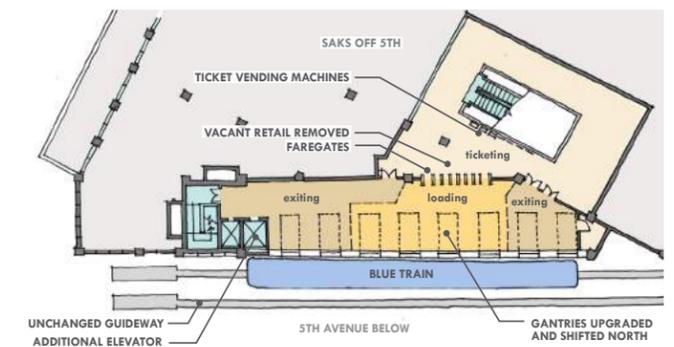
APPENDIX D: DISCARDED CONCEPTS

Throughout the existing conditions analysis and feasibility study process, several concepts were developed and discarded. This is a record of concepts that were not fully developed because they were flawed or inferior to another concept that was pursued further.

CONCEPT D1: MOVE GANTRIES

Minimal investment option that focused on reconfiguring the platform to accommodate an elevator without expanding its envelope. The major problems with the concept were:

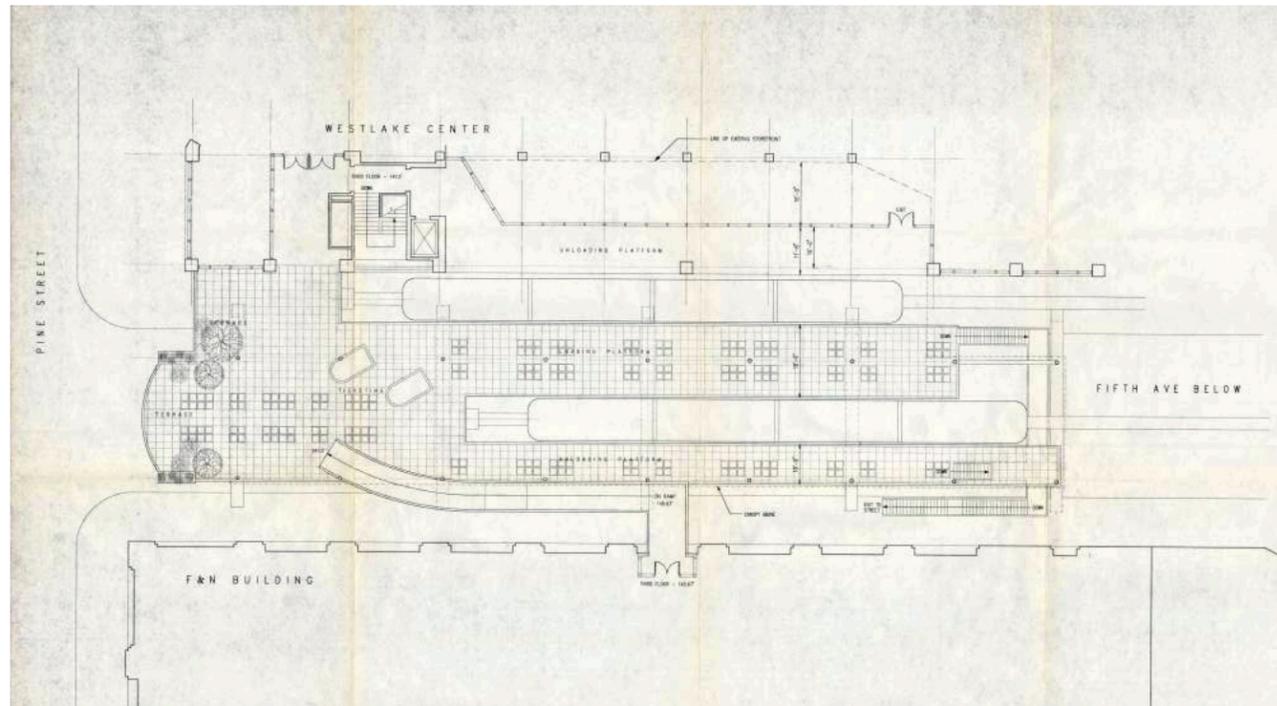
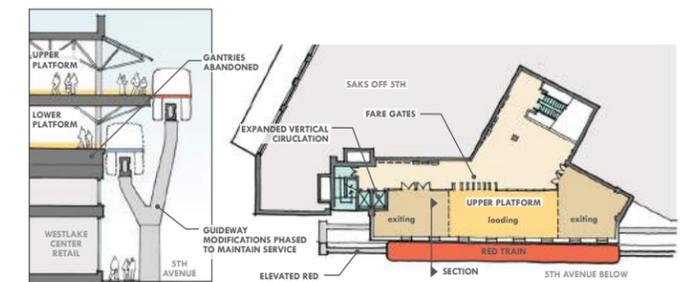
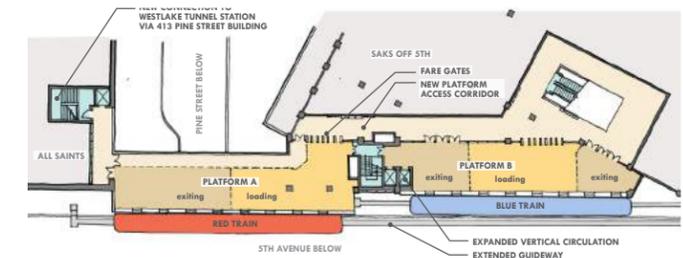
- High cost of relocating gantries
- One additional elevator still insufficient to provide reliable, fast vertical circulation
- Passengers coming from elevator and stair enter directly into fare-paid zone
- Combined queuing and exiting area still too small



CONCEPT D2: ADDITIONAL PLATFORM

These concepts focused on ways to modify the guideway in order to enable an additional platform at Westlake Station. They were not advanced because:

- Simultaneous docking at Westlake not operationally vital to increase capacity or operational flexibility
- Multiple platforms with trains going to same destination causes confusion
- High construction cost and structurally intrusive at Westlake Mall or All Saints

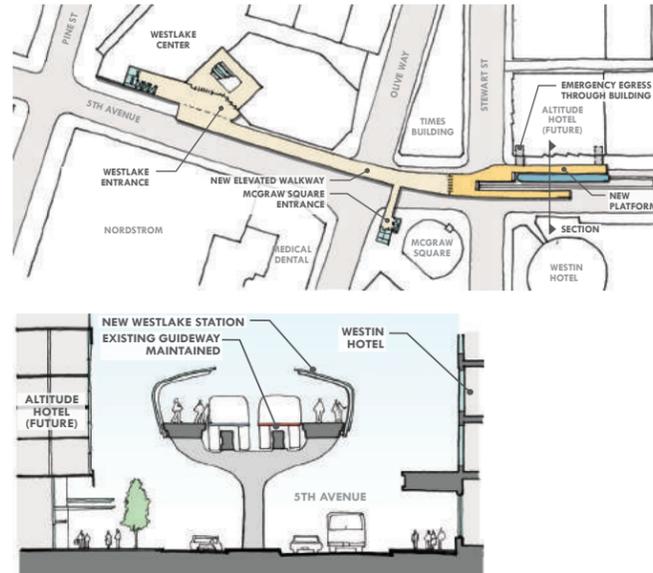


1995 concept to redesign Westlake Station in a similar way to Seattle Center Station

CONCEPT D3: MCGRAW SQUARE PLATFORM

These concepts involved eliminating the narrow guideway and single platform issues at Westlake by creating a new station a block away at McGraw Square, connecting to either the Times Building, the Westin, or the upcoming Altitude hotel. This concept was not preferred for almost the same reasons as concept D2:

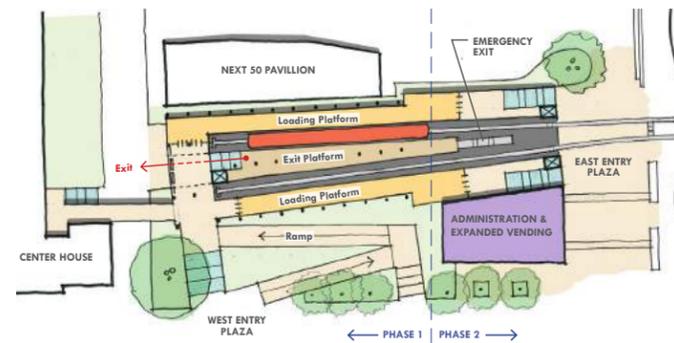
- Simultaneous docking at Westlake not operationally vital to increase capacity or operational flexibility
- Multiple platforms with trains going to same destination causes confusion
- High construction cost
- Less direct connection to Link Light Rail Platform



CONCEPT D4: EAST PLAZA ENTRANCE

This early concept for Seattle Center proposes reversing the entry and exit platforms and creating a new general entry at the East Plaza. It was not preferred for several reasons:

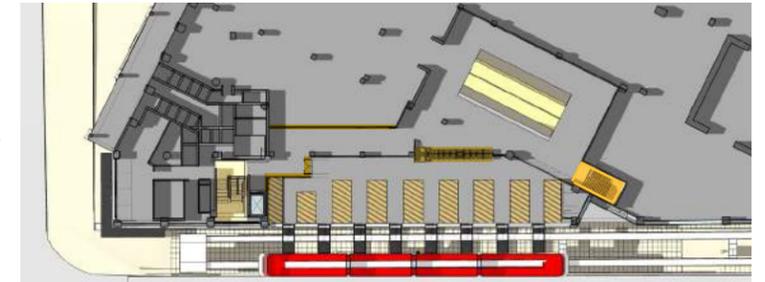
- Post-event crowds from the Arena will be approaching from the northwest - Both south and east entrances remain hidden
- Multiple platforms with trains going to same destination causes confusion
- Exit platform circulation conflicts with maintenance area underneath platform
- Inefficient vertical circulation - concept requires 3 separate elevators
- Can no longer exit directly into Armory, Space Needle plaza, or North Plaza - exit is on onto "side street" area



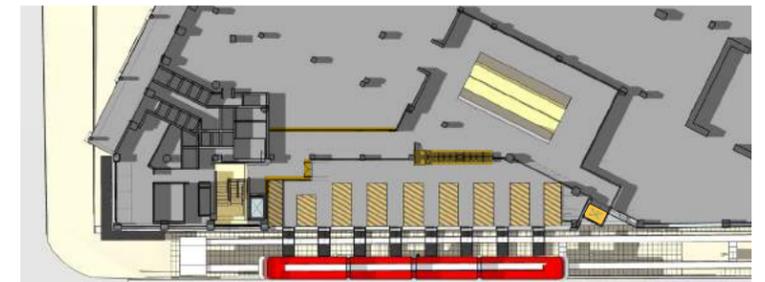
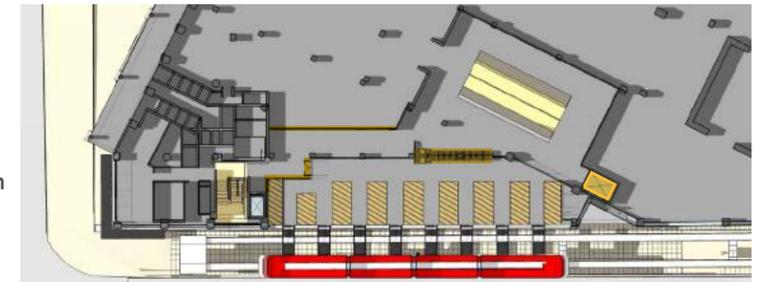
CONCEPT D5: ALTERNATIVE VERTICAL CIRCULATION

These concepts looked at opportunities to improve vertical circulation at the north end of the platform. This concept was not preferred several reasons:

- The location of the new vertical circulation would not increase visibility of the Monorail greatly.
- No direct connection to transit tunnel platform could be made here.
- Security gates would need to be installed to close off the new circulation around the escalators when the mall was closed.
- Queuing control might be difficult with so many points of entry.
- The space where a high capacity elevator or stair could fit was highly impactful to the new food court below and would eliminate a mall entry point.
- The space available at the north end of the platform was too tight to allow for the amount of added circulation needed to fully eliminate the use of the escalators for event surge flow.



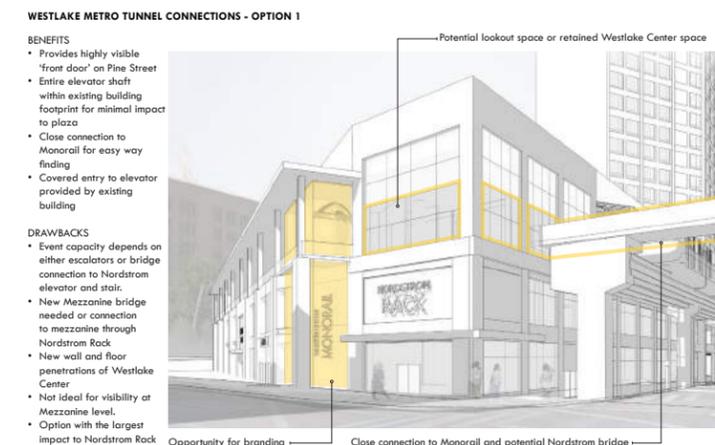
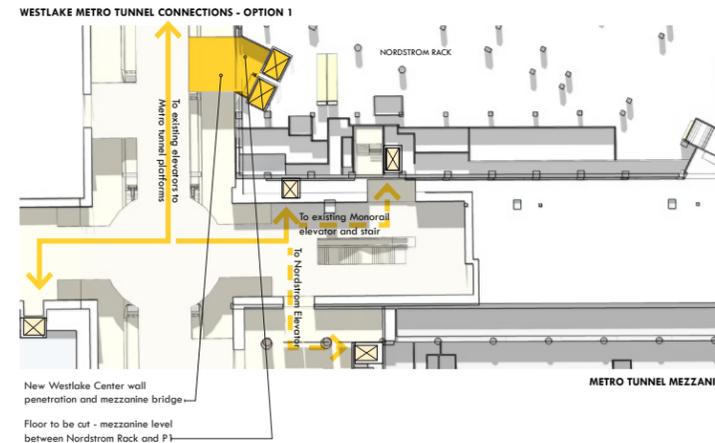
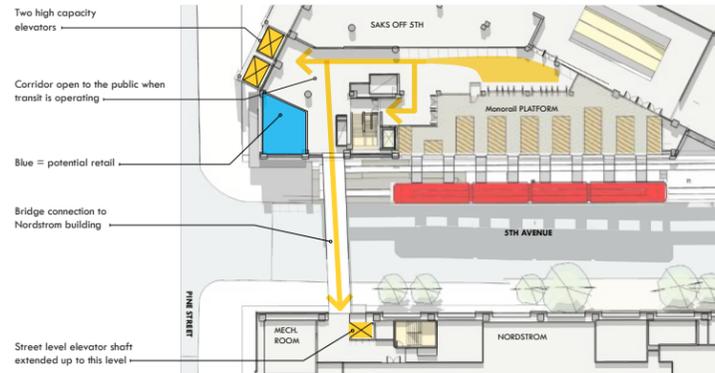
TOTAL VERTICAL CIRCULATION CAPACITY
Could potentially move 250 people per headway if existing elevator has increased speed and capacity of existing. Detailed analysis needed.



CONCEPT D6A: BALCONY TRANSIT CONNECTION

This concept looked at an alternative to connect the Monorail to the transit tunnel that had the least impact to the plaza space. This configuration was eliminated due to the following difficulties:

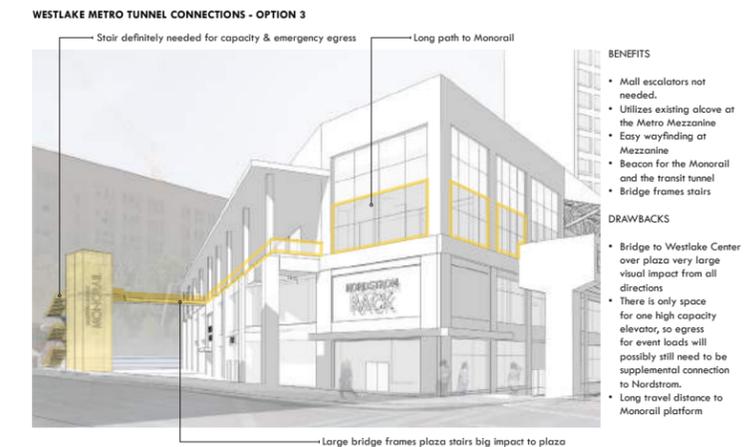
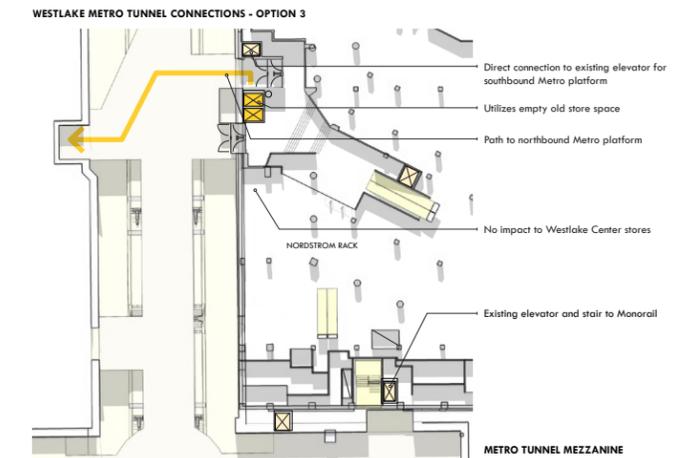
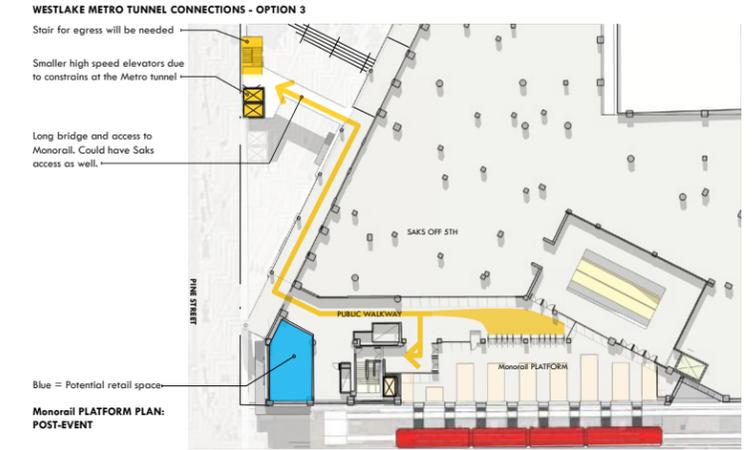
- The impacts below grade were large and expensive. The floor and wall of Westlake Mall would need to be cut to create a new connection to the tunnel mezzanine as the level is approximately 6' lower.
- A new bridge over the platform would need to be added to provide connection to the elevators without shutting down the tunnel for construction.
- The elevators alone would not reach vertical circulation goals, so either the platform boundary would need to expand to create access for a new stair or a bridge connecting to Nordstrom vertical circulation across 5th Avenue vertical circulation would be needed.
- NOTE: Although the bridge across 5th Avenue would be expensive and the existing elevator shaft would need to be brought up to this level from the street, it did seem like an appealing way to provide more connection to the Monorail. Interest in the bridge was expressed by Nordstrom and Seattle Monorail Services and could potentially be a future add to the Phase 2 configuration.



CONCEPT D6B: STARBUCKS TRANSIT CONNECTION

This concept looked at an alternative to connect the Monorail to the transit tunnel that had the least impact to the mall at the tunnel mezzanine level by utilizing existing empty retail space. This configuration was eliminated for the following reasons:

- This option created a very long bridge across the plaza.
- Visibility of the Westlake Center Mall was reduced from the plaza to the south.
- The pathway to the Monorail platform was longer and more circuitous.
- Space available below grade was constricted, requiring smaller elevators to be used, reducing overall capacity.



APPENDIX E: THROUGHPUT ANALYSIS

EXISTING FLOW ASSUMPTIONS AT WESTLAKE STATION*

Existing Headway

Travel Time	90 sec
Dwell Time	195 sec
Total Headway	4.8 min

Headway Goal

Travel Time				90 sec
Dwell Time	15 sec +	45 sec Load/Unload	=	60 sec
		Total Headway		2.5 min
Assuming events mostly uni-directional load/unload				270 people/45 sec

Ticketing

Ticket Booth	6 people/min	x 2	Gates	= 12 people/min	58 people per 2.5min headway
Fare Gates Goal	25 people/min	x 4	Gates	= 100 people/min	250 people per 2.5min headway

Queuing

Existing Station	800 sf	/ 250	people/train	= 3.2 sf/person	LOS D-
Queuing Goal	7.0 sf/person	x 250	people/train	= 1750 sf	LOS C

Platform Circulation

Existing station	Typical 10' width	w/4' pinch point from north end of train to elevator & stair
Circulation goal	250 people per 2.5min headway	= 100 people/min / 10 people/ft/min = 12'-0" Effective width

EXISTING VERTICAL CIRCULATION

Escalators

40" tread width =	72 people/min	(90 ft/min)	180 people per 2.5min headway
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Stairs

Width of stairs = 56"

LOS C	Allow 30" reverse flow	3.00 ft	x 10 p/ft/min	30 people/min	2.5 min/headway	75 people per 2.5min headway
LOS D	Allow 30" reverse flow	3.00 ft	x 13 p/ft/min	39 people/min	2.5 min/headway	98 people per 2.5min headway

Elevator

Load and Unload	3000 lb. capacity	= 12 people	40.0 sec/stop	Assumes 12 people on and 12 people off each stop
Doors open & close			3.0 sec/stop	
Platform to Street	30.00 ft	/ 150 fpm	12.0 sec/trip	
Street to Metro	25.00 ft	/ 150 fpm	10.0 sec/trip	
Worst case - 12 people on and 12 people off each stop			2.49 min/trip =	4.98 min/round trip
Best case - 12 people off at street only			1.23 min/trip =	2.47 min/round trip
			Maximum 12 people/2.5 headway	
Total Capacity	w/escalators	267 people per 2.5min headway	to	290 people per 2.5min headway
	w/o escalators	87 people per 2.5min headway	to	110 people per 2.5min headway

* Take offs of Seattle Center widths and areas determined that Westlake would govern flow of the overall system and that specific flow calculations for Seattle Center were not needed.

FLOW ASSUMPTIONS FOR PHASE 1 AT WESTLAKE STATION*

PHASE 1 IMPROVEMENTS

Ticketing

Existing Ticket Booth	6 people/min	x 2	Gates	= 12 people/min	58 people per 2.5min headway
Proposed Fare Gates	25 people/min	x 5	Gates	= 125 people/min	313 people per 2.5min headway

Queuing

Existing Station	800 sf	/ 250	people/train	= 3.2 sf/person	LOS D-
Proposed Queuing	970 sf	/ 250	people/train	= 3.9 sf/person	LOS D+

Platform Circulation

Proposed circulation	Typical 7' width within platform and 8' width outside platform				
LOS D	100 people/min	/ 15 people/ft/min	=	6'-8" effective width	

Assumes use of existing escalators, stairs, and elevator only.

40" tread width =	72 people/min	(90 ft/min)		180 people per 2.5min headway
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Stairs

Width of stairs = 56"

LOS C	Allow 30" reverse flow	3.00 ft	x 10 p/ft/min	30 people/min	2.5 min/headway	75 people per 2.5min headway
LOS D	Allow 30" reverse flow	3.00 ft	x 13 p/ft/min	39 people/min	2.5 min/headway	98 people per 2.5min headway

Elevator

Load and Unload	3000 lb. capacity	= 12 people	40.0 sec/stop	Assumes 12 people on and 12 people off each stop	
Doors open & close			3.0 sec/stop		
Platform to Street	30.00 ft	/ 150 fpm	12.0 sec/trip		
Street to Metro	25.00 ft	/ 150 fpm	10.0 sec/trip		
Worst case - 12 people on and 12 people off each stop			2.49 min/trip =	4.98 min/round trip	
Best case - 12 people off at street only			1.23 min/trip =	2.47 min/round trip	
				Maximum 12 people/2.5 headway	
Total Capacity	w/escalators	267 people per 2.5min headway	to	290 people per 2.5min headway	
	w/o escalators	87 people per 2.5min headway	to	110 people per 2.5min headway	

* Take offs of Seattle Center widths and areas determined that Westlake would govern flow of the overall system and that specific flow calculations for Seattle Center were not needed.

FLOW ASSUMPTIONS FOR PHASE 2 AT WESTLAKE STATION*

PHASE 2 IMPROVEMENTS

Ticketing

Ticket Booth	6 people/min	x 2	Gates	= 12 people/min	58 people per 2.5min headway
Proposed Fare Gates	25 people/min	x 9	Gates	= 225 people/min	563 people per 2.5min headway

Queuing

Proposed Queuing	1060 sf	/ 250	people/train	= 4.2 sf/person	LOS D+
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Platform Circulation

Proposed circulation	Typical 10' width within platform and 12' width outside platform typical w/ 10' pinch point				
Circulation goal	250 people per 2.5min headway	= 100 people/min	/ 10 people/ft/min	=10'-0" Effective width	

VERTICAL CIRCULATION

Existing Escalators

40" tread width =	72 people/min	(90 ft/min)		180 people per 2.5min headway
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Existing Stairs

Width of stairs = 56"

LOS C	Allow 30" reverse flow	3.00 ft	x 10 p/ft/min	30 people/min	2.5 min/headway	75 people per 2.5min headway
LOS D	Allow 30" reverse flow	3.00 ft	x 13 p/ft/min	39 people/min	2.5 min/headway	98 people per 2.5min headway

New Stair Exterior

Width of new stair = 96 in

LOS C	Allow 30" reverse flow	5.50 ft	x 10 p/ft/min	55 people/min	2.5 min/headway	138 people per 2.5min headway
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Existing Elevator

Maximum 12 people/2.5 headway

New Elevators

56 people/min
*per elevator consultant

Total Capacity w/o escalators 281 people per 2.5min headway to 303 people per 2.5min headway No escalators needed

* Take offs of Seattle Center widths and areas determined that Westlake would govern flow of the overall system and that specific flow calculations for Seattle Center were not needed.

PEDESTRIAN MODELING

The Westlake concept designs were based on the throughput calculations on the previous pages. The existing conditions and Phase 1 and 2 concept designs were then tested by sub-consultant, Jensen Hughes, using dynamic passenger modeling to confirm flow and capacity assumptions. Figure E1 summarizes the results of the dynamic passenger models.

Modeling assumptions:

- Pedestrian flow to the escalator assumes the maximum capacity of the escalators, and the remaining passenger flow is divided between the other vertical circulation elements (VCE).
- Approximately 4% of the population (ie: 10 passengers out of a 250 passenger headway) are assumed to use the elevators.
- Elevators have a capacity of 17 passengers, and a round trip time of 4 minutes (with stops at all 3 levels).

Key findings from the model results:

- The existing Westlake configuration is unable to accommodate the 2.5 minute headways during the Post-Game scenarios due to the segregated boarding and alighting train doors. The model results indicate that there is insufficient time for the passengers to alight the train within the 1 minute dwell time.
- The additional capacity of the new stairs and elevators provided by Phase 2 improvements is required for the Post-Game scenario where the Westlake Center mall escalators are closed.
- The model results indicate that a 1-minute dwell time is sufficient for flows from Arena events where most riders are going in the same direction, but insufficient for the boarding and alighting flows during the “Festival” scenario where large volumes of passengers are traveling in both directions. A 2-minute dwell time (with a 3.5 minute headway), or longer, would provide sufficient time to accommodate the forecasted “Festival” scenario.

Observations and Recommendations

- The new stairs in Option 2 reduce in width as they curve around the new elevators. The model results indicate that this reduced width creates a pinch point, and may cause congestion during events with large counterflow. It is recommended to provide equal stair width along the length of the stairs if possible.
- Ticket vending machines (TVM) typically have a capacity of 1 passenger/minute, or 60 s per transaction. Therefore, an array of 4 TVM would process approximately 7% of the “Bite of Seattle” passenger flow (ie: 190 passengers/headway @ 3.6 minute headway). TVM usage is typically 10 to 20% of total population, though it may be a higher percentage for the monorail since it is not integrated with the Seattle Metro ticketing system. It is recommended to review the anticipated TVM usage with the Monorail operator.
- Fare gates typically have a capacity of 25 passengers/minute. Therefore, a flow of 250 passenger/headway with 50 passenger/headway counterflow could be accommodated with 6 fare gates. The four pairs of existing egress doors provide additional capacity out of the platform; therefore, 5 faregates would provide sufficient capacity and redundancy for the events considered in this analysis.

Option	Scenario	ID	Assumption	Headway	Boarding/Headway	Alighting/Headway	Platform Clearance	Sufficient Existing VCE Capacity			Sufficient New VCE Capacity			
								Escalators	Stairs	Elevator	Stairs	Elevator	Faregate	TVM
Baseline	Post-Game	BL-03	All Stairs and Escalators	2.5	25	250	X	-	-	-	-	-	-	-
		BL-04	Only Stairs	2.5	25	250	X	-	-	-	-	-	-	-
	Festival	BL-05	All Stairs and Escalators	2.5	190	190	✓	✓	✓	✓	-	-	-	-
		BL-06	All Stairs and Escalators	3.5	190	190	✓	✓	✓	✓	-	-	-	-
Phase 1	Post-Game	S1-03	All Stairs and Escalators	2.5	25	250	✓	✓	✓	✓	-	-	✓	✓
		S1-04	Only Stairs	2.5	25	250	✓	-	X	X	-	-	-	-
	Festival	S1-05	All Stairs and Escalators	2.5	190	190	X	-	-	-	-	-	-	-
		S1-06	All Stairs and Escalators	3.5	190	190	✓	✓	✓	✓	-	-	✓	✓
Phase 2	Post-Game	S2-03	All Stairs and Escalators	2.5	25	250	✓	✓	✓	✓	✓	✓	✓	✓
		S2-04	Only Stairs	2.5	25	250	✓	-	✓	✓	✓	✓	✓	✓
	Festival	S2-05	All Stairs and Escalators	2.5	25	250	X	-	-	-	-	-	-	-
		S2-06	All Stairs and Escalators	3.5	190	190	✓	✓	✓	✓	✓	✓	✓	✓

Figure E1: Summary of dynamic passenger modeling

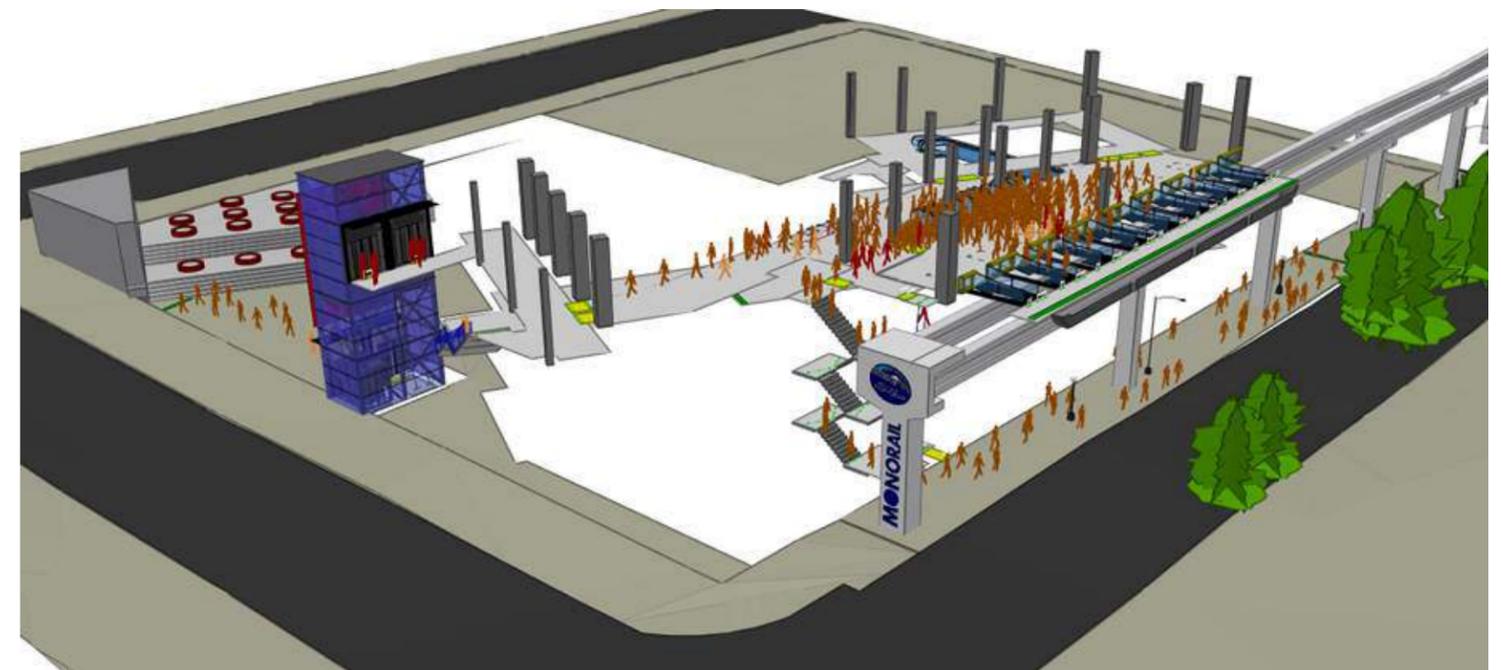


Figure E2: Image from the dynamic passenger modeling at Westlake