APPENDIX C

PROGRAM STANDARDS

This memo establishes performance goals for future Stream service that can be used for planning, design and monitoring. It includes recommended standards for design and performance to support fast and reliable transit.

MEMORANDUM

To: **Darin Stavish**

From: **Stream System Expansion Study Project Team**

Date: **June 13, 2022**

Subject: **Stream Service Standards**

INTRODUCTION

Pierce Transit's Stream Bus Rapid Transit (BRT) Service Standards establish performance goals for future Stream BRT Service. These standards can be used for planning, design, and monitoring of system and route-level performance.

Goals of the Stream Service standards include:

- Establishing customer expectations for Stream service
- Ensuring service expansion meets a target performance level
- Establishes service expectations for Pierce Transit BRT Stream service
- Providing guidance and direction for route planners, engineers, and Pierce Transit Management

Data sources used for these standards include Pierce Transit Stream 1 planning efforts and established best practices from peer agencies providing similar BRT service. As the Stream system moves forward, these standards should be updated to meet future needs.

Agencies provide different types of service to meet the needs of various markets. Each service type has its own goals and standards to meet.

This document includes recommended standards for nine key design and performance topics relevant to fast, reliable transit. An appendix includes an overview of how these standards apply to Stream 1 and an analysis of how the four SSES candidate corridors perform on each standard.

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STANDARDS SUMMARY

The following table (Figure 1) summarizes the desired standard per topic.

Figure 1 Stream Program Standards Summary

	Desired Standard
Station Spacing	The desired station spacing is ½ mile. The minimum is ¼ mile. Land use and other context factors must be considered in determining final station spacing.
Station Location	Place Stream stations at the far-side of intersections in most cases.
Station Typology & Amenities	Create three station sizes (24', 18', and 13' canopy length), with amenities scaled to projected ridership. All Stream stations will have weather protection, ORCA card readers, ticket vending machines, bicycle parking, benches, and transit system information. Platform length will be 60', with a 12' minimum total width. Curb height will generally be ten inches. Design stations with a pedestrian bypass where possible.
In-Lane Stop Provisions	Design all stations as in-lane stops when buses operate in mixed traffic flow.
Service Span & Frequency	Span: ▪ Provide Stream service 20 hours per weekday (4:00 a.m.-Midnight). ▪ Provide Stream service 18 hours per weekend day (6:00 a.m.-Midnight). Frequency: ▪ Peak: 10 minutes. ▪ Morning and evening: 30 minutes. ▪ Off-peak: 15 minutes. ▪ Night: 60 minutes. ▪ Weekend: 20-30 minutes, with 60-minute frequency at night.
Target Travel Time Savings	20% reduction in end-to-end travel time and a ratio of 1.5 times the auto travel time during peak periods.
Peak Loading	The peak loading factor is 100% to 120%, or 80 to 95 passengers on Stream vehicles. No more than 15% of peak period Stream trips should exceed the peak loading factor for more than 20% of a trip's scheduled run time or not less than 5 minutes. For example, eight minutes for a longer trip that takes 40 minutes, but five minutes for a shorter trip that takes 20 minutes. No more than 50% of peak period trips and no more than 25% of all trips should exceed 80% of the peak load factor.
Reliability	**Headway**: When Stream should be running every 10 minutes or better, consider a bus late if it arrives 3 minutes longer than the intended headway (e.g., every 13 minutes during a time when Stream should be running every 10 minutes). **On-Time Performance**: When Stream should be running less frequently than every 10 minutes, consider a bus "on time" if it arrives no more than 5 minutes late and 1 minute early compared to the schedule. Strive for 90% on-time. **Delay:** 0.5 minutes of delay per trip per mile, with delay defined as the difference between the 20^{th} percentile and 80^{th} percentile running time.

STATION SPACING

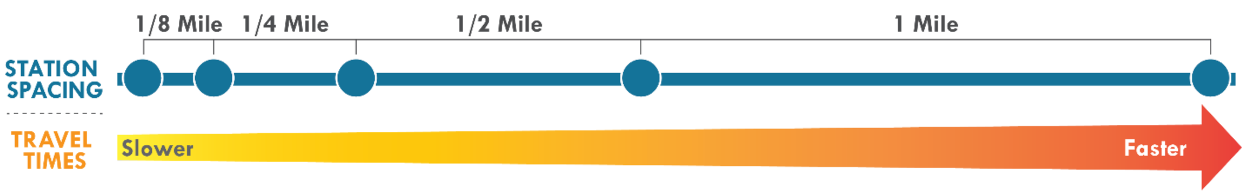
What is it?

Station spacing is the distance between stations along a transit route in the same direction.

Longer spacing between stations results in faster travel times since the bus is stopping less frequently (Figure 2). This makes transit travel times more competitive with driving, especially for longer trips. Fewer stations along a line can reduce the cost of station construction and ongoing maintenance.

Shorter spacing reduces walking distances from a station to a destination, which can be helpful for older adults or people with limited mobility. Shorter spacing results in longer travel times since the bus is slowing down, stopping, and speeding back up more frequently.

Figure 2 Station spacing has a direct impact on travel times



Source: Nelson\Nygaard

Desired Standard

Locate stations with average station spacing of ½ mile. The minimum is ¼ mile.

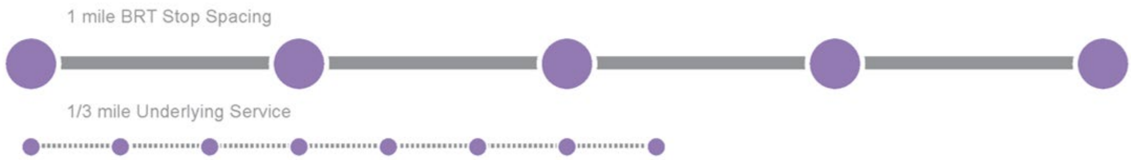
Land use and other context factors must be considered in determining final station spacing.

- Shorter spacing can be considered in these environments:[1]
  - Corridors with dense, consistently built-up development with high transit demand may require spacing approximately every ⅓ mile.
  - Areas with multiple high-demand destinations close to each other where the additional station is more likely to increase ridership rather than inconvenience on-board passengers may need shorter spacing. Spacing closer than ¼-mile should be rarely used and considered on a case-by-case basis.
- Longer spacing can be considered in these environments:

[1] Source: King County Metro RapidRide Standards

- Corridors with low densities or auto-oriented land uses may warrant station spacing of ½ mile up to 1 mile.
- Areas where station access is limited by topography or street connectivity.
- Corridors served by "underlay" or other local service (Figure 3).

Figure 3 Community Transit's Swift BRT has long station spacing, but maintains local underlay service



Implementation Guidance

Start by locating stations at current high ridership stops. Then fill in the gaps applying the spacing standard and other factors including:

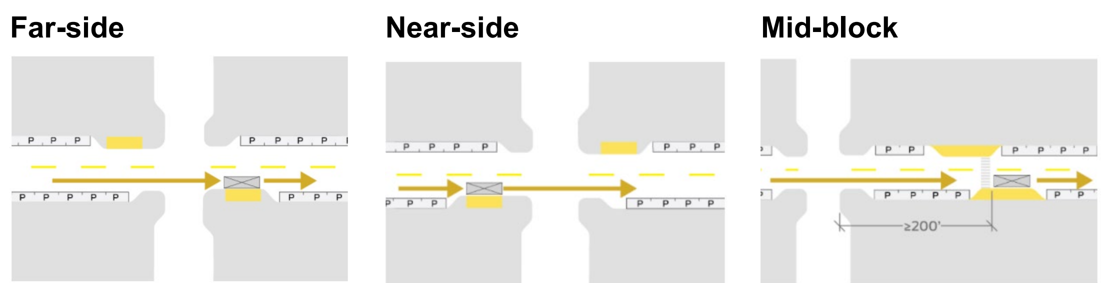
- Transfer opportunities.
- Safe crossing locations.
- Walking distance/route to major destinations.
- Space available for station amenities appropriate to expected ridership.

STATION LOCATION

What is it?

Station location refers to where along a block (or in relation to an intersection) the station is sited. Location options are near side (preceding the intersection), far side (after the intersection), or mid-block (between intersections) (Figure 4). Most transit agencies prefer far-side stops, which have the greatest benefit to travel times. Pierce Transit assumes that all future Stream corridors will operate curbside only.

Figure 4 Station Locations



Source: NACTO

Desired Standard

Place Stream stations at the far side of intersections.

Station location must consider station area context. Far-side is preferred, but location ultimately depends on site-specific needs.

Benefits of far-side stations include:

- Get buses through traffic signals before stopping, improving speed and reliability. Far-side stations are especially critical in locations with transit signal priority.
- Eliminate conflicts with drivers making right turns (drivers will try to pull around a stopped bus and turn right in front of the bus).
- Allow pedestrians to cross behind the bus instead of in front.

Near-side stations can be used when:

- Buses serving a far-side station would frequently block the intersection.
- Located at stop-controlled intersections, where a near-side station would help buses avoid stopping twice.
- Stream service is at a shared station, transit center, or major trip generator located at the near side of an intersection.

Minimize use of mid-block stations unless they are needed to serve major trip generators. All mid-block Stream station locations should have signalized pedestrian crossings.

Implementation Guidance

Pedestrian Crossings

Transit riders often must cross the street to their destination or to access the station. If no safe, marked crossings are available, people must either walk long distances to a crosswalk or cross anyway and be accused of “jaywalking.” Provide safe crossings at all stations. Design crossings with more protection as traffic speeds and volumes increase.

Stream 1 will add seven signalized crosswalks and 22 median refuge islands.

Crosswalk Clearance

Place the bus zone far enough from the intersection to accommodate the typical number and size of vehicles that will be stopped at the station. Maintain a 5’ clear distance between the back of the bus and the crosswalk striping.

STATION TYPOLOGY & AMENITIES

What is it?

Typology

Each station serves a unique market and location. Stations also represent a significant cost to rapid transit projects. A **station typology** is a classification of station types with associated amenity sizes and features so stations can be scaled to context and demand while also being cost-effective. Features that differ between station types typically include shelter quantity, shelter size, amount of seating, and amenities.

Amenities

Amenities refers to physical elements of stations that make them attractive, inviting, distinctive, and user-friendly, such as benches, lighting, bicycle parking, and information.

Desired Standard

Station Typology

Create three station sizes (24', 18', and 13' canopy length) based on expected ridership, land use context, and available space. Scale amenities to each type.

Stations are a significant cost for rapid transit projects. Match amenities to projected ridership to reduce capital and maintenance costs.

Amenities

All Stream stations will have weather protection, ORCA card readers, ticket vending machines, real-time information, bicycle parking, benches, and raised platforms.

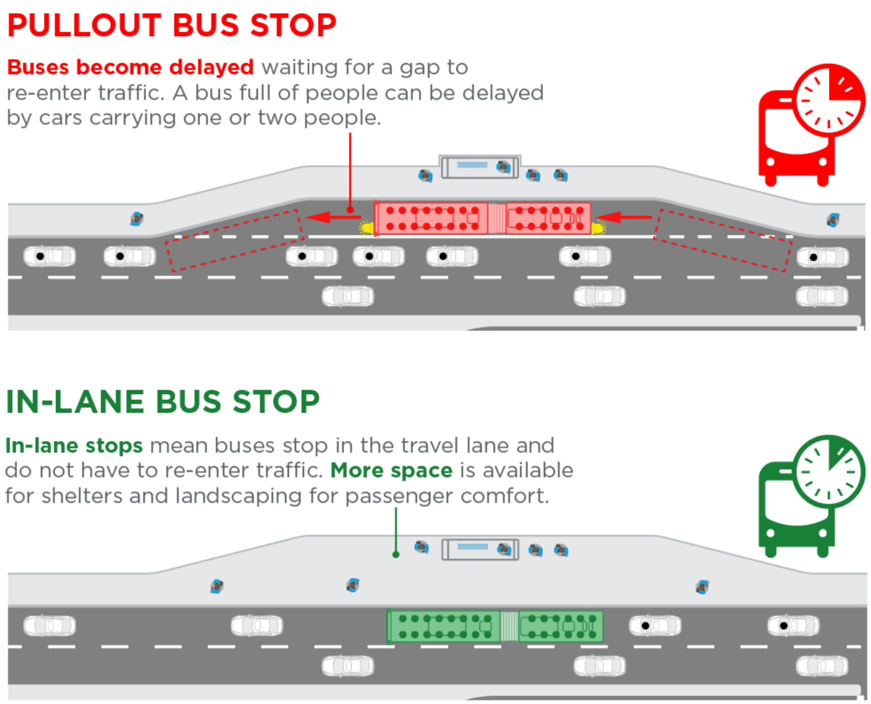
IN-LANE STOPS

What is it?

In-lane stops mean buses can stop in the travel lane to unload and load passengers (Figure 5). In-lane stops:

- Reduce delay by eliminating the time it takes a bus to pull over and then re-enter traffic.
- Improve ride comfort by reducing lateral movement needed to pull over to a stop.

Figure 5 Benefits of In-lane Stops Versus Pullouts



Source: Nelson\Nygaard

Desired Standard

> Design all stations as in-lane stops when buses operate in mixed traffic flow.

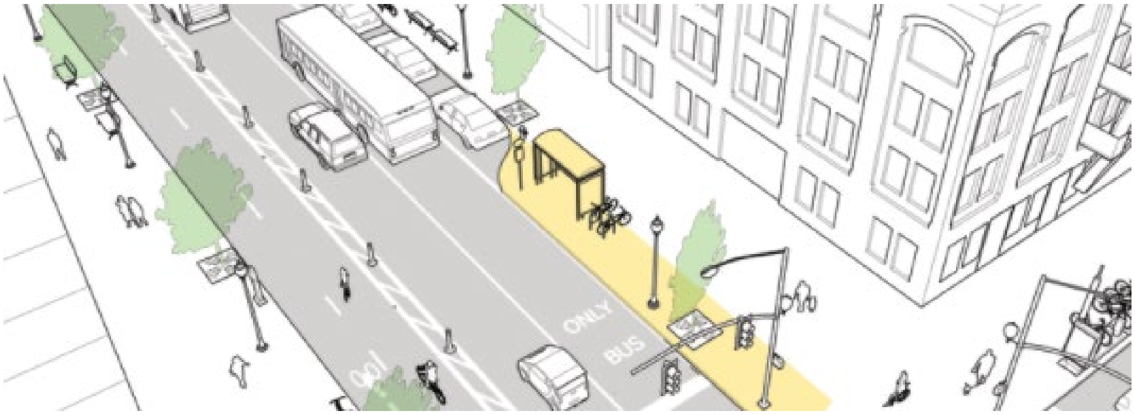
In-lane stops have a significant benefit to transit by reducing time spent re-entering traffic. The TCRP Transit Capacity and Quality of Service Manual found there is a 7% increase in bus speeds with in-lane stops.

Implementation Guidance

Buses running in the curb lane without pullouts will automatically stop in-lane.

If buses are running offset from the curb, in-lane stops can be achieved by extending the boarding area to the travel lane with bus bulbs (Figure 6).

Figure 6 Bus Bulb



Source: NACTO

SERVICE SPAN & FREQUENCY

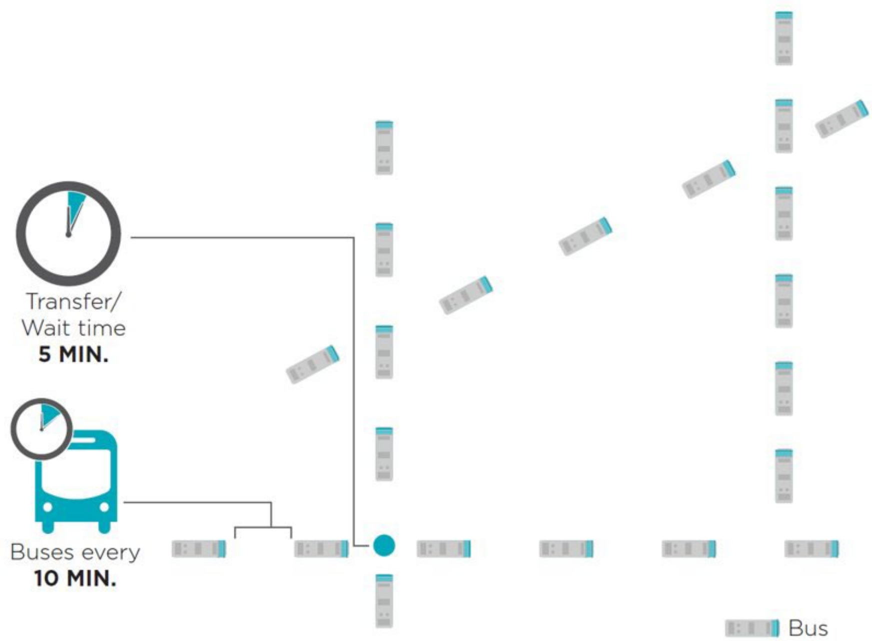
What is it?

Service span refers to the hours that transit service operates in a given day.

Transit agencies need to balance starting service early enough and running late enough to meet a variety of rider needs while being cost-effective.

Frequency means how often the bus arrives. High frequency adds convenience and minimizes wait times if passengers must transfer (Figure 7).

Figure 7 A network of intersecting frequent routes allows freedom to travel when and where you want



Source: Nelson\Nygaard

Desired Standard

Service Span

Provide Stream service **20** hours per weekday (4:00 a.m.-Midnight).

Provide Stream service **18** hours per weekend day (6:00 a.m.-Midnight).

Frequency

- **Peak:** 10-minute headways 6:30-9:30 a.m. and 2:30-5:30 p.m.
- **Off-Peak:** 15-minute headways between 5:00 a.m. and 7:00 p.m. (14 hours per weekday).
- **Early morning and evening:** 30-minute headways before 5:00 a.m. and between 7:00 and 11:00 p.m.
- **Night:** 60-minute headways 11:00 p.m. to 12:00 a.m.
- **Weekend:** 20- to 30-minute headways 6:00 a.m. to 10:00 p.m. Hourly headways 10:00 p.m. to 12:00 a.m.

Implementation Guidance

Adjust Service Frequency

Pierce Transit should monitor demand and ridership throughout the first year of operating Stream services. If ridership is high during midday periods, then the span of 10-minute frequency provision should shift to cover midday hours as well.

Performance Monitoring

Pierce Transit may consider managing service to ensure a consistent headway, e.g., every 10 minutes, rather than adherence to posted schedules (see Reliability – Headway Management section).

TARGET TRAVEL TIME SAVINGS

What is it?

Travel time is the total time it takes a passenger to travel from the stop where they board to the stop where they alight. How much time a transit trip takes is a major factor in the willingness to ride for people who have another option.

There are two ways to consider and measure travel time savings:

1. Travel Time Reduction: Look at end-to-end reductions based on current run times.
2. Transit to Auto Travel Time Ratio: Compare the time it takes to travel by bus versus car. Transit travel times competitive with driving will attract new riders.

Reducing running time can be achieved in many ways, including:

- Operational changes including modifications to routing, longer station spacing (see Station Spacing section), all-door boarding, or in-lane stops (see In-Lane Stops section).
- Street design changes including laneway treatments (bus lanes) or intersection treatments (queue jumps, transit signal priority, etc.).

Desired Standard

Travel Time Reduction: Reduce running time by 20% or more. Evaluate pre- and post-implementation.

Two agencies, King County Metro and TransLink, have targets related to their RapidRide and RapidBus programs, respectively. They target a 20% reduction in travel times – meaning a 6-minute reduction on a 30-minute trip today. This target is a reasonable starting point for Stream.

Transit to Auto Travel Time Ratio: Aim for a ratio of 1.5 for transit travel times compared to auto travel times during peak periods.

Transit is typically slower than driving due to stopping for passengers. But if taking the bus becomes too much longer than driving, it puts a time burden on existing riders trying to meet their daily needs and makes transit a less attractive option for non-riders. A transit to auto travel time ratio standard of 1.5 means, for example, that a 30-minute trip by car should strive to take no more than 45 minutes by transit.

Implementation Guidance

Travel Time Reduction

During project development, estimate travel time savings reductions using peer experience and/or traffic models. Normalize time savings per mile to understand the benefit at a distance-level. Translink uses its target to encourage local jurisdictions to support project elements that will help each line achieve the desired savings.

After project implementation, measure actual travel time savings and:

- Evaluate the performance of measures that were implemented and identify refinements.
- Consider implementing additional measures to reach the target savings.
- Apply lessons learned to future Stream projects.

Transit to Auto Travel Time Ratio

This ratio can be measured by comparing transit travel time between major destinations compared to driving time pulled from Google Maps.

PEAK LOADING

What is it?

Peak load refers to the greatest number of passengers on board an individual transit vehicle during the busiest portion(s) of a route. This number is used to identify when mitigations are needed (such as additional service or larger vehicles) to reduce overcrowding.

Overcrowding is a problem because:

- Buses may pass by passengers waiting at stations if there is no more room on board.
- Overcrowded buses run late when it takes longer for riders to board and alight.
- For riders taking a long trip, standing or overcrowding is uncomfortable.

Desired Standard

The peak loading factor is 100% to 120%, or 80 to 95 passengers on Stream vehicles.

No more than 15% of peak period Stream trips should exceed the peak loading factor for more than 20% of a trip’s scheduled run time or not less than 5 minutes. For example, eight minutes for a longer trip that takes 40 minutes, but five minutes for a shorter trip that takes 20 minutes.

No more than 50% of peak period trips and no more than 25% of all trips should exceed 80% of the peak load factor.

The standard encompasses two elements that directly measure the customer experience: how often do over-capacity conditions occur and how long do they persist.

Implementation Guidance

- A peak load factor is the ratio of the average number of passengers on-board at the busiest point of a trip to the capacity of a transit vehicle. Transit vehicle capacity is equal to the number of seats plus the number of standees possible assuming each standee occupies no less than four square feet of floor space. This value can be compared to a loading threshold which describes the desired load factor.
- Peak loads should be monitored at a trip level. The amount of time a trip is at or above the peak loading threshold must also be considered, not just whether or not a trip exceeds the threshold at any one point. Trips that are over capacity for longer periods result in greatly decreased comfort and convenience for riders. The average length of typical trips on a route is also a factor, i.e., so that passengers are not standing for a long time on longer trips.

RELIABILITY

What is It?

Reliability refers to the concept of consistency – the bus arrives at the same time or at predictable intervals day after day and the rider's trip arrives at their destination within a consistent range. This latter consideration is crucial as many transit riders are most concerned about reaching a destination at a specific time, such as arriving for work on time. Reliability builds confidence in the bus. Three methods to diagnose and track reliability issues are:

1. On-time performance.
2. Headway management.
3. Running time reliabilty.

Desired Standard

On-Time Performance

Consider a bus "on time" if it arrives no more than **5** minutes late and **1** minute early compared to the schedule. Strive for **90%** on-time.

Schedules already factor in congestion and thus do not represent the travel times possible if buses had service and streets designed for transit priority. Yet schedules remain a traditional part of service operations and since Stream frequencies will vary througout the day, a published schedule and adherence to it will remain important to track.

Headway Management

Consider a bus late if it arrives **3** minutes longer than the intended headway (e.g., every 13 minutes during a time when Stream should be running every 10 minutes).

As agencies move to higher frequencies where schedules are communicated on a headway basis (e.g., every 10 minutes) versus a time clock basis, what becomes more important is reducing bus bunching and maintaining spacing between buses.

King County Metro considers RapidRide service to be "late" if the service gap is greater than 3 minutes longer than the intended headway.[2] In San Francisco, Muni has shifted to managing a broad set of its routes based on headways.

[2] Source: King County Metro Service Guidelines (see p. 6)

- All Stream lines that fail to meet headway adherence standards should be actively monitored by dedicated staff during peak periods.

Running Time Reliability

The goal for operational reliability should be established at **0.5** minutes of delay per trip per mile, with delay defined as the difference between the 20th percentile and 80th percentile running time (e.g., the allowable variation in running time for a 10-mile trip is 5 minutes. 60% of the time, the complete bus trip will fall inside that amount of variation).

Implementation Guidance

Headway Management

- Publish clock-based schedules if headways are longer than 12 minutes. Publish headway-based schedules if headways are 12 minutes or less (example in Figure 8).

Figure 8 Example of a Clock and Headway-Based Schedule

❶	❷	❸	❹	❺
4:25 AM	4:31 AM	4:38 AM	4:41 AM	4:49 AM
5:00 AM	5:06 AM	5:13 AM	5:16 AM	5:24 AM
5:15 AM	5:21 AM	5:28 AM	5:31 AM	5:39 AM
5:30 AM	5:37 AM	5:45 AM	5:49 AM	5:58 AM
5:45 AM	5:52 AM	6:00 AM	6:04 AM	6:13 AM
6:00 AM	6:07 AM	6:15 AM	6:19 AM	6:28 AM
6:15 AM	6:22 AM	6:30 AM	6:34 AM	6:43 AM
6:27 AM	6:34 AM	6:42 AM	6:46 AM	6:56 AM
12 minute frequency until 6:27 PM				
6:27 PM	**6:34 PM**	**6:43 PM**	**6:46 PM**	**6:55 PM**
6:40 PM	**6:47 PM**	**6:56 PM**	**6:59 PM**	**7:08 PM**
6:55 PM	**7:02 PM**	**7:11 PM**	**7:14 PM**	**7:23 PM**
7:10 PM	**7:17 PM**	**7:26 PM**	**7:29 PM**	**7:38 PM**

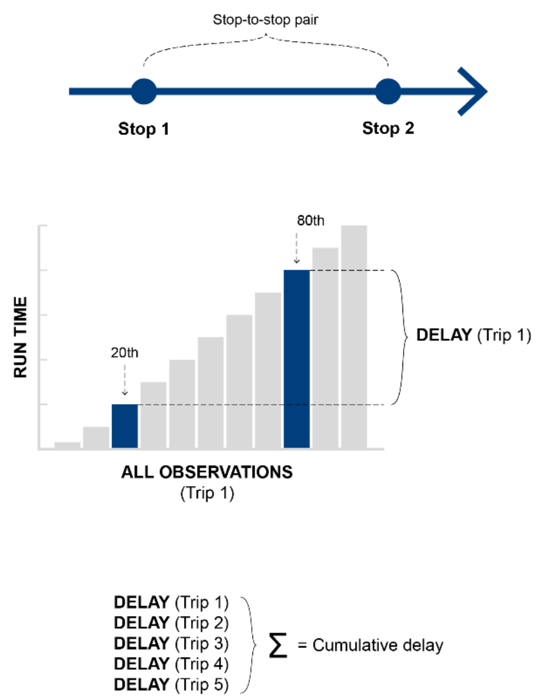
Source: C-TRAN

- To reduce bunching and gaps, operators should be held or advanced at the beginning or end of the line. Try to avoid headway management mid-route to minimize delay to riders.
- Headway status can be used to activate transit signal priority (TSP) or request a higher level of TSP.

Running Time Reliability

As part of transit priority projects, many agencies are diving deeper into actual run times to understand opportunities for transit priority. Automatic vehicle location (AVL) data for multiple observations of the same trip, arrayed from shortest to longest running time, reveals the variability in how long that specific trip takes on different days. The essential concept is to provide a trip for the rider where their on-board ride time is as consistent as possible. Many agencies compare run time percentiles and quantify the delta as transit delay (Figure 9). There is no generally accepted standard around what is an acceptable level of delay; this is a fairly new method being used to complement more traditional reliability metrics of on-time performance and headway management and are pointed toward better quantification and measurement of the rider experience.

Figure 9 Diagnosing Delay Methodology



Notes: Observations refer to the number of travel time records for the trip in Pierce Transit's automatic vehicle location (AVL) data. These running time (i.e., bus travel time excluding dwell time at stops) observations can be arrayed in percentiles, e.g., the 80th percentile is a relatively slow trip (80% of trips were as fast or faster) and the 20th percentile represents a relatively fast trip (only 20% of trips were faster). Delay is the difference between the 80th percentile travel time and the 20th percentile travel time over the course of a service change and is a way to understand and compare the variability in travel times across the transit system.

- Pierce Transit should monitor delay on an ongoing basis and identify corrective measures for areas that exceed the delay standard.

Transit Priority Treatments

- Install TSP where possible to improve reliability and help maintain consistent run times.
- When a lane is used exclusively by a Stream bus, standard red pavement paint should be applied to signify bus priority.

APPENDIX – STREAM CONTEXT

For each standard topic, Stream 1 design guidance and performance of SSES candidate corridors is described in further detail below.

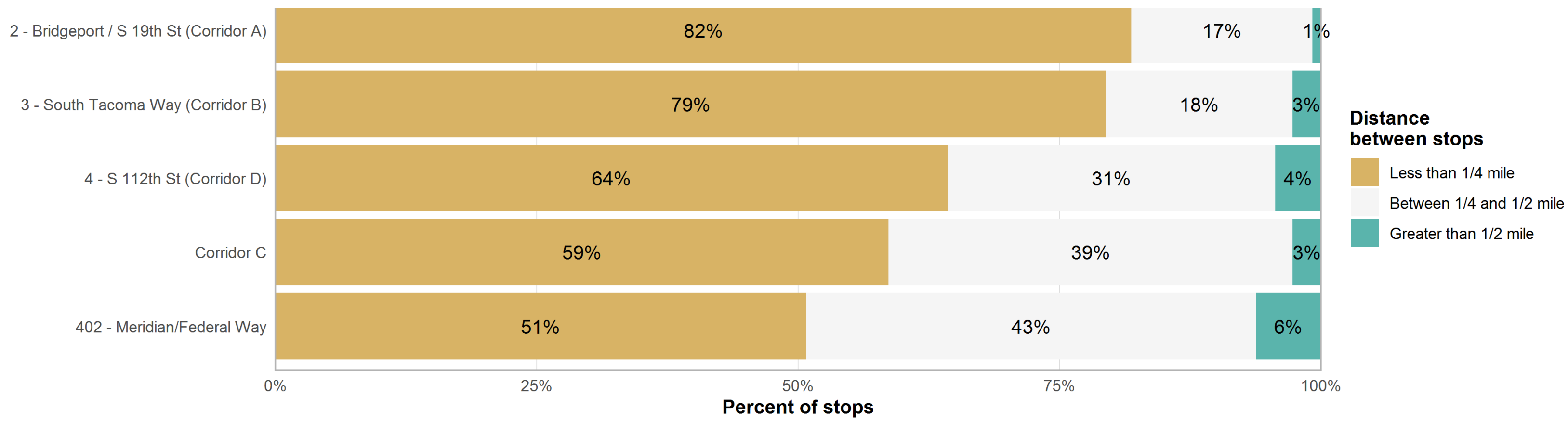
Station Spacing

The average station spacing along the planned Stream 1 corridor **is 0.49 miles**, including **30 pairs of stations**.

Average existing stop spacing on the candidate corridors is described below (see Figure 10 for more detail):

- Route 2 / Corridor A: 988 feet or 0.19 miles.
- Route 3 / Corridor B: 1,067 feet or 0.2 miles.
- Route 4 / Corridor D: 1,285 feet or 0.24 miles.
- Route 402 / Portion of Corridor C: 1,515 feet or 0.29 miles.

Figure 10 SSES Candidate Corridors – Distance Between Existing Bus Stops



Note: Corridor C runs between Puyallup Station and 176th St. The full Route 402 runs between 176th St to Federal Way.

Potential SSES Station Spacing Scenarios and Travel Time Savings

- The table below (Figure 11) shows the potential reduction in dwell time that passengers could experience on an average trip if stop spacing were reduced to every ¼ mile or every ½ mile.
- Corridors A and B would see a small reduction of more than one minute with ¼-mile spacing.
- All corridors would see a reduction of more than three minutes with ½-mile spacing.

This table displays the impact on the entire route length. Note the savings is four minutes per trip, or a little better, for all four corridors. These reductions do not include reduction of acceleration/deceleration time but also do not factor in the increase in dwell time that would be experienced at stops due to more passengers boarding in fewer locations.

Figure 11 Travel time savings from stop consolidation

Corridor	Route	Average stop spacing		Route distance (one-way; miles)	Stops per direction (A)	Average dwell time per stop (sec) (B)	Average percent of stops that are served by a trip (C)	Average dwell time per trip (minutes) (D = A x B x C)	Dwell reduction (minutes)	
		(feet)	(miles)						(1/4 mile)	(1/2 mile)
A	2	988	0.19	11.9	63	20.1	34.2%	7.20	1.71	4.46
B	3	1,067	0.20	11.3	56	18.6	39.0%	6.78	1.33	4.00
C	402	1,515	0.29	18.7	65	30.3	30.1%	9.88	-1.52	4.25
D	4	1,285	0.24	14.0	57	30.2	27.2%	7.80	0.14	3.97

Methodology Note: The reduction in dwell time was calculated by finding the difference in dwell time for different stop spacing (existing vs. ¼ mile vs. ½ mile). The ¼ and ½ mile dwell times were calculated by multiplying the average dwell time per stop in the PM peak with the number of stops along each route assuming the ¼ or ½ mile spacing, and then multiplying the result by the percent of stops that are served on a trip in the PM peak. The difference between these results and the existing dwell time are shown in the tables.

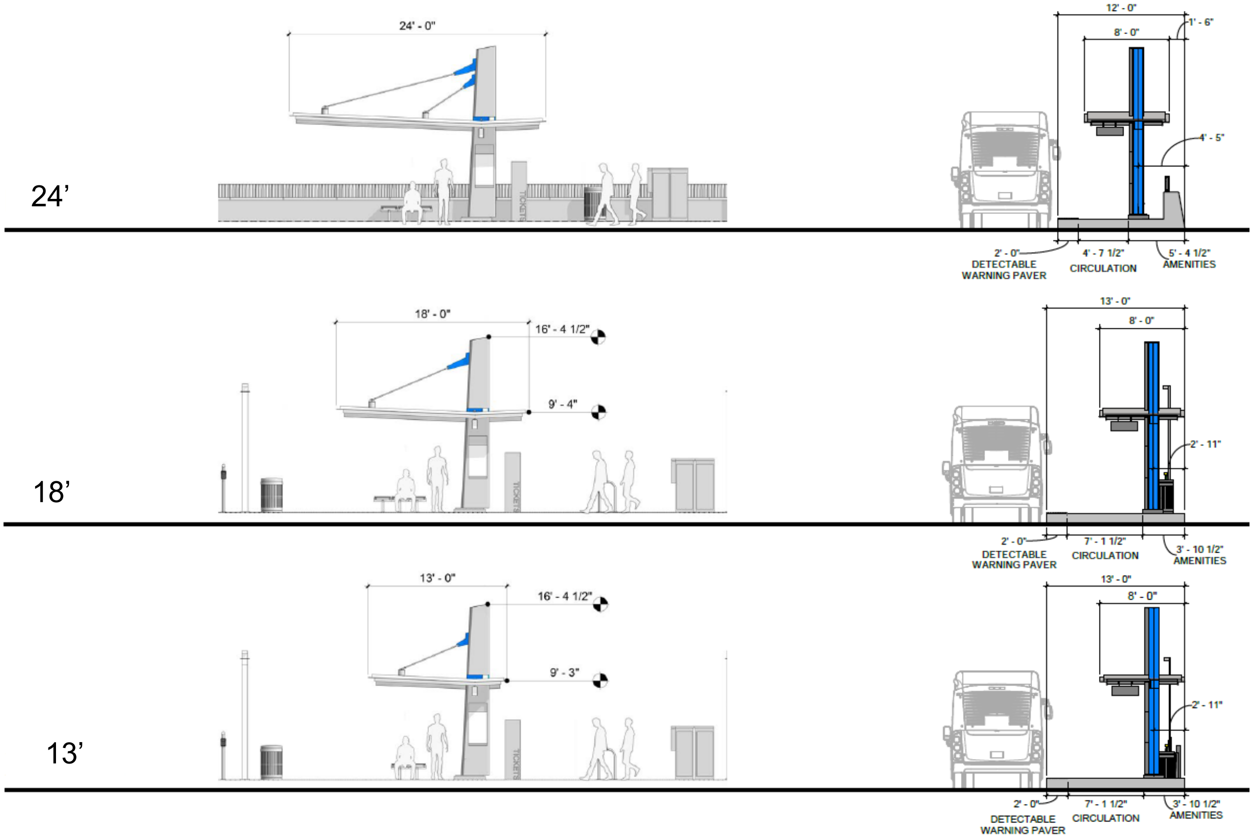
Station Location

Stream 1 will have 30 station pairs. At Tacoma Dome Station, the station pairs are within a transit center. Of the other stations, 67% will be far side, 26% will be near side, and 7% will be mid-block.

Station Typology & Amenities

Pierce Transit has developed branded stations, designed by Pivot, for Stream 1. There are three station sizes: 24’, 18’, and 13’ canopy lengths. (Figure 12). All will have 60’ platforms. The key difference is canopy size. Median station locations (those sited in the middle of the street) will all have 24’ stations.

Figure 12 Stream 1 Station Types



Source: Pierce Transit/Pivot Architecture

Estimated station installation costs range from $320,000 for Small stations to $370,000 for Large stations (Figure 13).

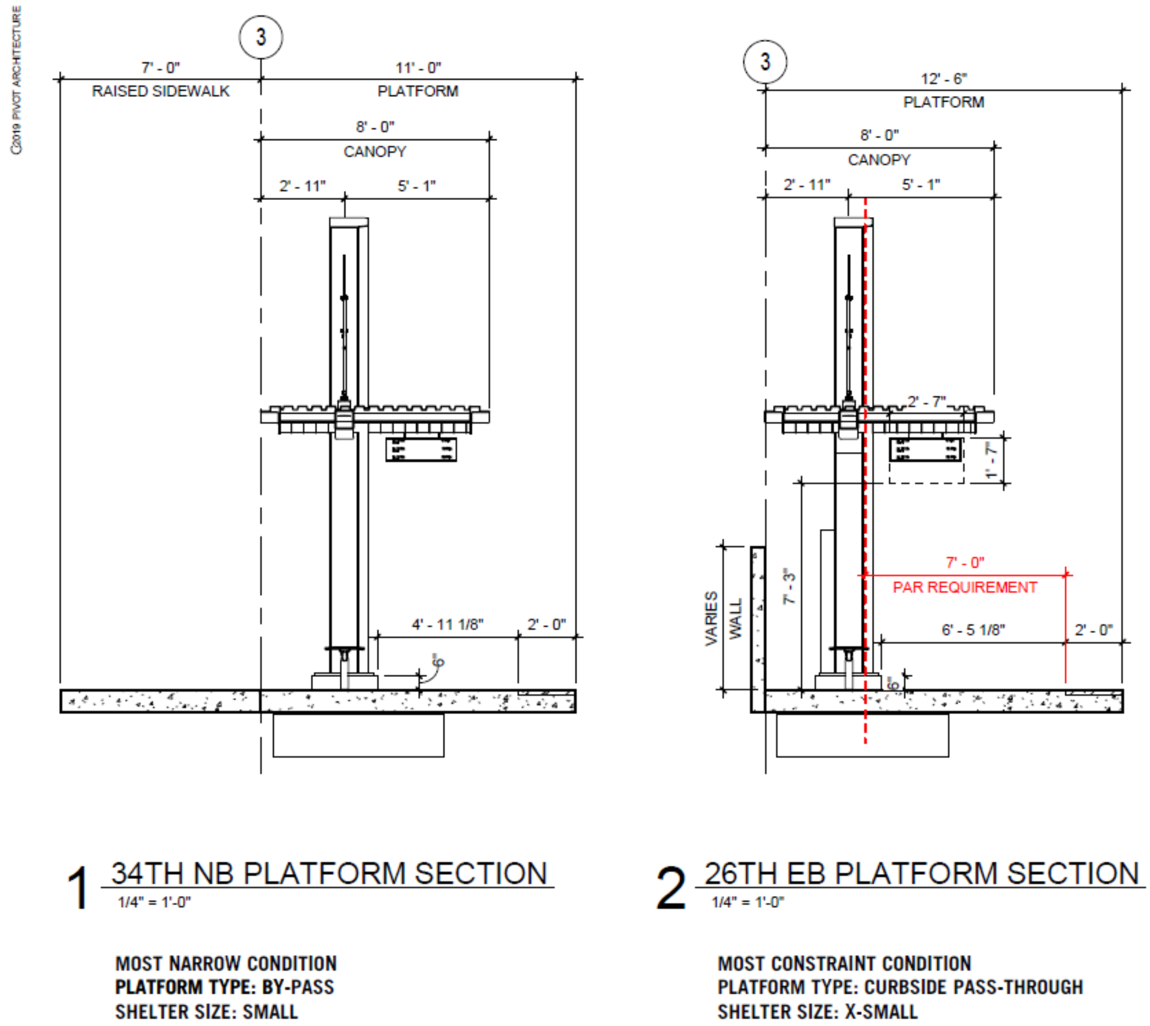
Figure 13 Stream Station Installation Costs, 2020 $

Station Size	Assumed All-Inclusive Cost
24' canopy	$370,000
18' canopy	$335,000
13' canopy	$320,000

Source: Pierce Transit

- Stations should generally be designed with a 10"-high curb, midway between typical 6" curb and 15" curb that would enable true level boarding.
- Curbside stations will use either a "curbside pass-through" or a "bypass" design (referring to the location of the public sidewalk), depending on available right-of-way. Where space allows, stations will use the bypass design to route the public sidewalk behind the station platform. In constrained station locations, the pass-through design will route the public sidewalk through the passenger circulation area. Sidewalks should provide a 7' minimum clear zone.

Figure 14 Curbside Pass-Through and Bypass Station Cross Sections



Source: Pierce Transit/Pivot Architecture

- Minimize property acquisition to the extent possible when planning station locations.
- Incorporate principles of Crime Prevention Through Environmental Design (CPTED) to contribute to a sense of safety at station areas. Elements of CPTED are natural surveillance and visibility; lighting; territorial reinforcement and space delineation; and natural access control.

Amenities

Stream 1 proposes 30 station pairs. Station design will use a “kit of parts” approach to establish amenities appropriate for each station location.

Proposed amenities for Stream 1 include the following. Items in **bold** are standard at all stations.

- **ORCA Card readers.**
- Real-time bus tracker – provided at approximately three-quarters of Stream 1 stations

- **Protection from weather.**
- **Ticket vending machines.**
- **Parking for bikes and e-scooters.**
- **Benches.**
- **Trash receptacles.**
- **Platforms spanning entire length of bus (60').**
- **Raised platforms for improved accessibility.**
- Railings – generally deployed at Large stations.
- **Cameras.**
- **System route map.**

In addition to the station amenities described above, Stream corridors should install comprehensive wayfinding in station areas to enable easy connections to and from Stream stations and major destinations or access routes. Apply wayfinding standards developed for Stream 1 to all future Stream corridors.

Stream Sponsorship

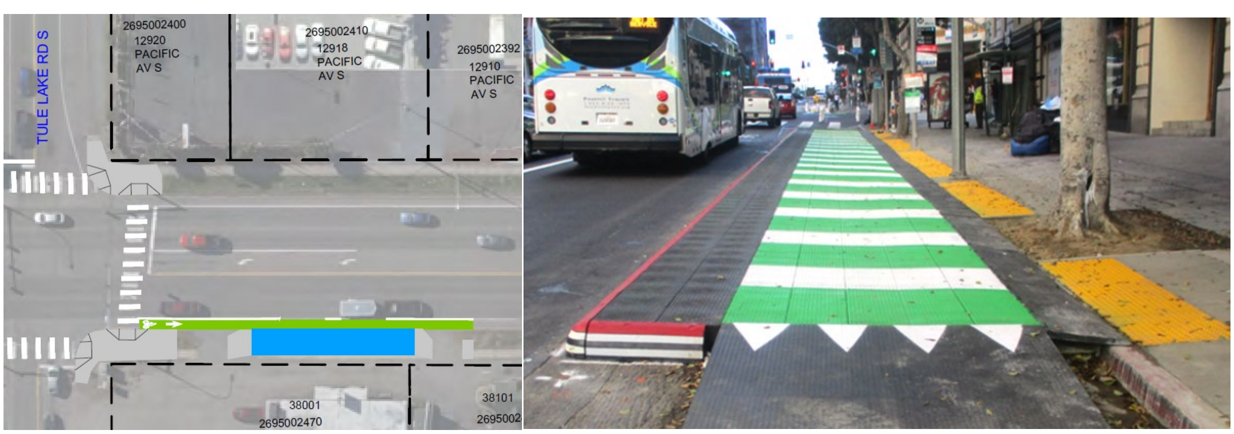
Sponsorship of Stream lines or specific stations can help offset the additional operating and capital costs associated with BRT systems beyond typical bus service and stop infrastructure. Explore partnerships to sponsor and/or name new Stream lines and/or stations, similar to the Multicare sponsorship agreement in place for Stream 1 (SR 7 / Pacific Avenue).

In-Lane Stops

Stream 1 concept designs show one pullout at SR 7 and 8th Ave (Walmart). This is an existing pullout near the end of the line and may be a layover location. All other stations are in-lane or are in the median.

A few stations (SR 7 and 168th Street, SR 7 and 184th Street, SR 7 and 159th Street, SR 7 & Tule Lake Road) are next to bike lanes. Bus bulbs or ZICLA platforms can be used so the bus does not have to stop in the bike lane while maintaining accessibility (Figure 15).

Figure 15 Tule Lake Road Station (left) and ZICLA Treatment (right)

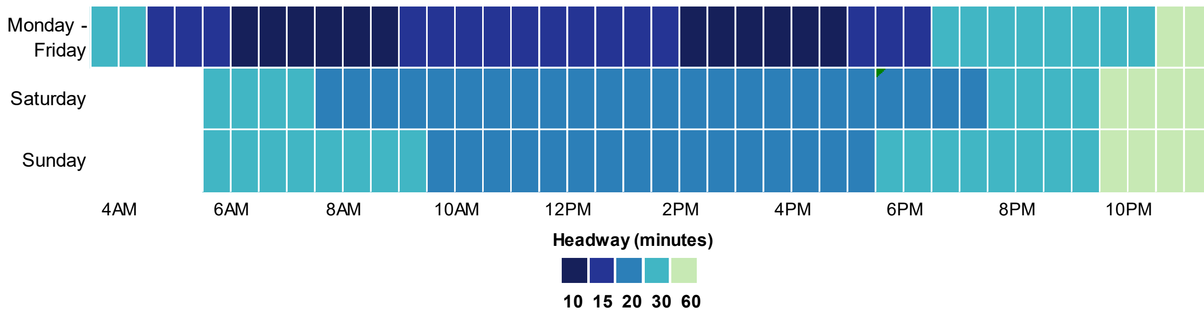


Source: Pierce Transit (left) and NACTO (right)

Service Span & Frequency

Stream will provide varying frequencies throughout the day (Figure 16). Ridership on current Route 1 peaks at 3:00 p.m., therefore the afternoon 10-minute headway period from 2:30-5:30 p.m. captures the traditional commute time as well as the earlier peaking on this specific route.

Figure 16 Stream Proposed Service Span and Frequency

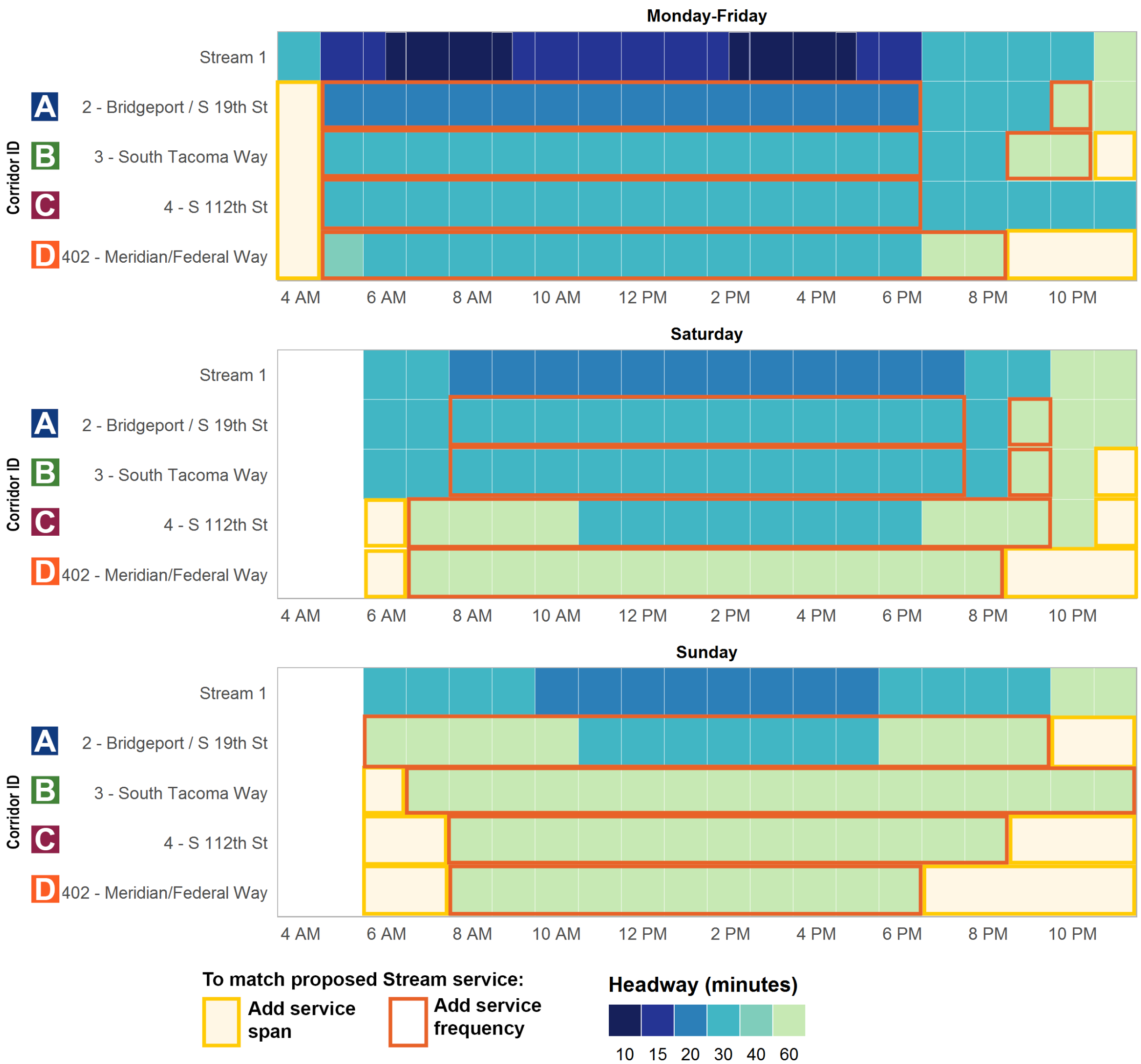


Source: September 2018 Pierce Transit Span & Headway Memo

Note that it is highly desirable for BRT to operate with no less than 30-minute headways, except for very late night service (e.g., after midnight or 1:00 a.m.) or very early morning service. The Stream standards could be modified to recognize that for cost-effectiveness reasons corridors in development may operate at lower frequency during these periods as the service grows. Over time, all Stream routes should operate until at least midnight at 30-minute frequencies. Of the existing routes operating on SSES candidate corridors, Route 2 operates with the highest existing weekday frequency and is closest to Stream 1 frequencies. Each route's span and frequency are shown in Figure 17, along with indications of how well existing service aligns with Stream 1. Orange boxes indicate where existing frequency is below proposed Stream standards, and gold boxes indicate where existing service span does not meet Stream standards.

- Routes 2, 3, and 4 provide weekday evening service roughly in alignment with proposed Stream standards.
- Stream proposes starting weekday morning service one hour before all existing routes.
- Route 4 matches proposed weekday Stream frequency for the longest span – five hours between 7:00 p.m. and midnight.
- Stream proposes higher weekday peak and midday frequencies than any of the existing routes.
- Route 402, with 30-minute maximum frequency, does not meet proposed Stream frequency at any time of day on any day of the week.
- Existing Sunday service on all routes is well below proposed Stream frequency. Route 2 is the only existing route with better than 60-minute frequency on Sundays.

Figure 17 Existing Candidate Corridor Route Span & Frequency and Differential from Stream Standards



Source: Pierce Transit & September 2018 Pierce Transit Span & Headway Memo

Target Travel Time Savings

Travel Time Reduction

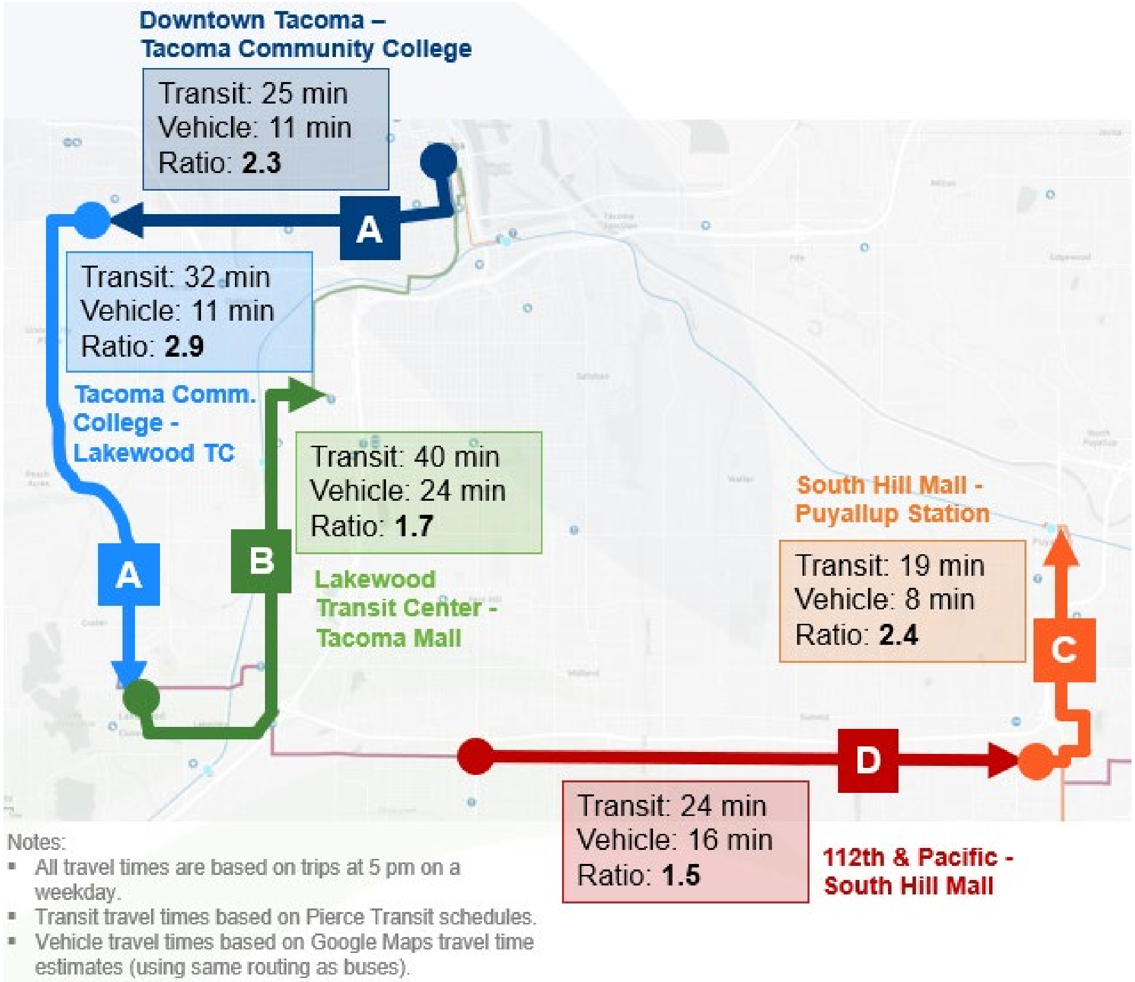
Stream 1 BRT is projected to be 20-22 minutes faster than current travel times between Spanaway to Tacoma Dome Station. This is a 32-35% travel time reduction.

Transit to Auto Travel Time Ratio

Travel times on SSES corridors between major destinations are approximately 1.5 to 3 times longer than driving (Figure 18). This analysis is based on travel times at 5:00 p.m.

Travel times between Downtown Tacoma and TCC, between TCC and Lakewood TC, and between South Hill Mall and Puyallup Station have the highest ratios.

Figure 18 Existing Transit Travel Times Compared to Auto Travel Times on the SSES Corridors



Peak Loading

Stream 1 will be operated with 60-foot articulated vehicles with 60 seats and space for 15 standees. Increasing the number of standees by assuming 3.75 square feet per passenger is recommended; although the vehicle floor area is not known, this is assumed to result in a total capacity of approximately 80 with standees. Figure 19 shows the range in passenger load possible using different load factor standards.

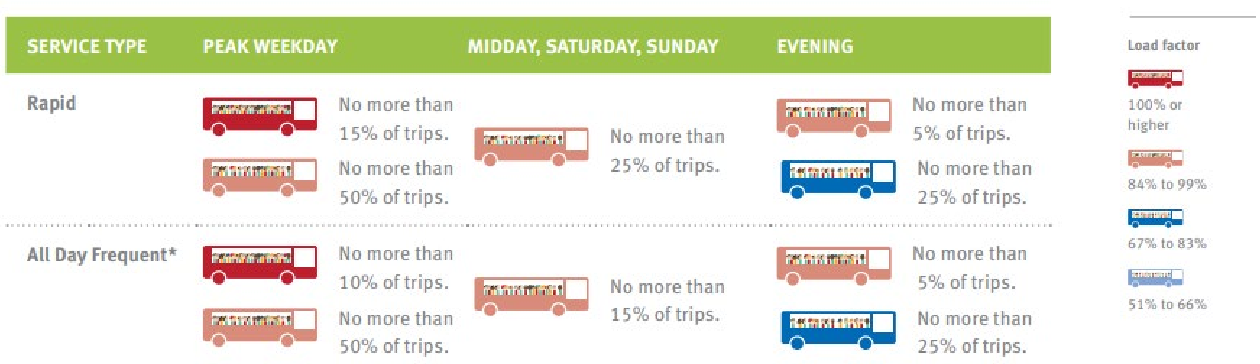
Figure 19 Passenger Loads at Load Factors between 60% and 120% of Capacity (with Standees)

Load Factor	Seated Capacity	Capacity with Standees	Passenger Load at Load Factor	Passenger Experience
60%	60	80	50	▪ Many seats are occupied and people need to sit next to each other if they want a seat. ▪ Some people are standing, but are doing so by choice.
80%	60	80	65	▪ Most seats are occupied and a small number of passengers are standing. ▪ Some passengers have to move around for others to alight the bus.
100%	60	80	80	▪ All seats are full, standing space is occupied, the vehicle is crowded, and passengers will need to shift position for others to alight.
120%	60	80	95	▪ All seats are full, standing space is fully occupied, the vehicle is overcrowded, and it is challenging for passengers to alight. ▪ Many people will have to alight and reboard to allow other riders to alight.

Source: Passenger experience adapted from TCRP Report 165 (Transit Capacity and Quality of Service Manual) and TransLink's Service Guidelines. Capacity with standees is based on approximately 3.75 square feet per passenger. Vehicle floor area for Stream 1 is not known, but the assumption of 80 is consistent with King County Metro (79) and TransLink. Resulting passenger load threshold at each load factor rounded to nearest 5.

TransLink's Service Guidelines set load factor standards for different time periods, as shown in Figure 20. For example, on Rapid service no more than 15% of peak weekday trips should exceed a load factor of 100% and no more than 50% of trips should exceed a load factor of 84%.

Figure 20 Passenger Load Factor Example



Source: TransLink Service Guidelines, p. 23

The SSES Transit Analysis documented relatively low average loads on existing services. Examination of current data shows that 90th percentile and maximum loads by trip and stop do not exceed the roughly 60-person seated capacity of the articulated vehicles planned for use on Stream 1 (see Figure 21), and Stream will operate at higher frequencies than existing service. (The highest maximum load in the observation period was 49, on Route 2 in the 2:00 p.m. hour at Henry Foss High School. A maximum load of 38 was sustained between TCC and just north of TCC.)

Figure 21 Maximum Weekday Passenger Load per Trip by Hour on Existing Routes, September-October 2019

Route	Corridor	Hour of Day																	
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	A	15	27	39	39	38	33	34	43	36	49	33	40	36	40	28	17	17	24
3	B	15	17	33	30	24	31	31	38	41	40	41	45	35	39	26	23	21	
4	D		19	32	28	28	23	33	31	33	39	32	27	24	24	22	18	18	13
402	C	8	21	20	31	25	20	30	21	27	22	28	25	24	26	31	19		

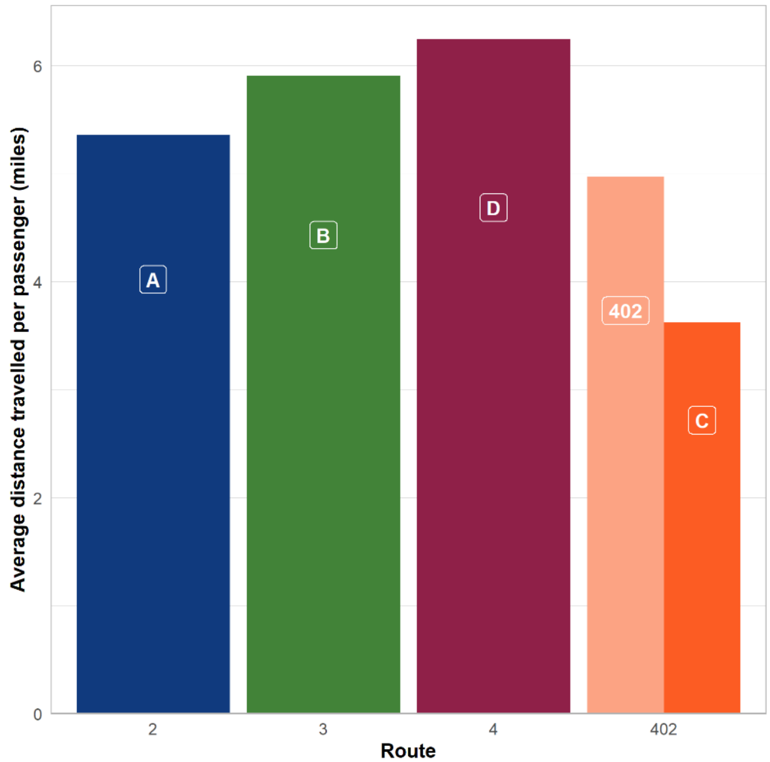
Note: Based on approximately 26-29 observations per trip/stop combinations.

Given the relatively low peak loads occurring on candidate corridor routes today, the significant additional service needed to match Stream 1 proposed frequency (see Service Span & Frequency, above), and the planned use of high-capacity 60’ articulated coaches on Stream 1, overcrowding may not be a significant issue on future Stream corridors for quite some time. This would also need to be validated based on future Stream ridership projections. It may be prudent to weigh the costs of purchasing, maintaining, and operating the planned articulated vehicles against the actual expected operational benefits of this additional passenger capacity. On some future corridors, 40’ coaches operating at Stream 1 frequency may comfortably serve the projected ridership on at least a portion of daily trips. However, it should also be noted that the maximum loads shown in Figure 21 are calculated from a relatively small available dataset; to understand current loading with statistical confidence, additional trip loading observations would need to be aggregated.

Peak loads on different routes may not always occur during the same time of day (i.e., not always at “peak” hour). Route 2 experiences peak loads during early afternoon hours, while Route 3 shows peak loads during the late afternoon.

On-board load should be actively monitored for any future Stream corridors, especially as it relates to average distance traveled per passenger. The current Route 4 (Corridor D) has the longest average trip per passenger, at more than 6 miles (Figure 22). On longer trips it is preferable for as many riders as possible to have a seat, so if average trip loads approach or exceed the seated capacity, service or vehicle adjustments should be considered. In addition, Figure 18 (above) shows travel times for a set of potential trips in each corridor, ranging from 20 to 40 minutes.

Figure 22 Average distance traveled per passenger by existing route



Stream Vehicles

Passenger capacity on Stream will be greater than on Pierce Transit local bus service due to the use of larger vehicles. Stream will use 60' articulated battery-electric buses with 60 seats and three doors. Bicycle storage will be inside the vehicle. Depending on corridor length, terrain, and other factors, these types of vehicles will generally need top-off chargers along Stream routes to supplement the base chargers at terminal locations.

Reliability

Current Stream candidate routes are operating with an average delay of 2.32 minutes per trip per mile. The minimum observed value is 0.42 and the maximum was 16.01 along various segments of the four candidate routes. If this standard were to be applied to all four routes, delay would drop from the current total value of 137.4 hours of daily delay to 61.9 hours of daily delay. The central concept is to get the system to operate at a higher degree of reliability with travel times falling into a tighter array of total time.

Corridor A (route 2) Observed Delay statistics:

- Minimum observed segment delay – 1.05 minutes per trip per mile.
- Average observed segment delay – 2.43 minutes per trip per mile.
- Maximum observed delay – 5.05 minutes per trip per mile.
- Average total daily delay per route mile 1.75 hours.
- Total round trip route miles 23.7 miles.

- Total route daily delay 41.5 hours.
- If operating according to suggested standard, maximum delay would be 17.8 hours of daily delay.