Seattle Department of Transportation

WEST SEATTLE BRIDGE CORRIDOR CONGESTION MANAGEMENT STUDY

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PREPARED BY

CASSEDAY CONSULTING

In collaboration with

Smart City Traffic, LLC

Transportation Consulting Services

WSP PARSONS BRINCKERHOFF

ABBREVIATIONS

ADT	Annual Daily Traffic
ATM	Active Traffic Management
BNSF	Burlington Northern Sante Fe Railroad
CCTV	Closed Circuit Television
DMS	Dynamic Message Sign
ITS	Intelligent Transportation System
MMA	Methyl Methacrylate lane markings
SODO	South Downtown area of Seattle
TIM	Traffic Incident Management
TOC	Transportation Operations Center
WSBC	West Seattle Bridge Corridor
WSDOT	Washington State Department of Transportation

CASSEDAY CONSULTING
9726 NE 138th Pl
Kirkland, WA 98034
(206) 450-8758
katherine@cassedaytraffic.com

WEST SEATTLE BRIDGE CORRIDOR CONGESTION MANAGEMENT STUDY

EXECUTIVE SUMMARY

The Seattle City Council and the Seattle Department of Transportation (SDOT) have been developing solutions for incident and congestion management in the West Seattle Bridge Corridor (WSBC). A White Paper and Priority Investment List[1] was prepared in September 2015 and a Progress Report[2] was prepared and submitted to the Council in May of 2016 in which substantial progress was reported.

In response to the progress report, the Seattle City Council requested that SDOT further study and prepare recommendations on four topics:

1. Lower Spokane Street Congestion Management: What approaches can address the multi-modal chokepoints on lower level Spokane Street?
2. Truck Queuing and Train Blockages: What approaches can address truck and train blockages on lower level Spokane Street?
3. Median Barrier Gate for Incident Response: What is the feasibility and value of implementing a median gate to allow for emergency vehicle U-turns on the upper level facilities?
4. Emergency Lane Striping Feasibility: What is the utility of striping a lane on the upper level facilities as a "fire lane" with respect to reducing emergency vehicle response time?

The West Seattle Bridge Corridor consists of:

The Upper Roadway – the Spokane Street Viaduct and West Seattle Bridge extending from 35th Avenue SW to Interstate 5 (I-5). Incidents on the upper roadway create long delays as there are limited alternative routes to absorb traffic diversions.

The Lower Roadway – S/SW Spokane Street from Harbor Avenue to Airport Way S with access to I-5. The lower roadway is subject to frequent disruptions from the lower Spokane Street swing bridge openings, from rail crossings, and truck queues due to Port of Seattle facility operations.

FOUR STUDY TOPICS -- FINDINGS

The recommended actions and treatments for WSBC Congestion Management are focused on traffic management enhancements that aim to address the complex sources of congestion. To respond to the Council request to investigate four topics for the corridor, findings from the four studies requested are summarized below.

1. LOWER SPOKANE STREET CONGESTION MANAGEMENT

The primary sources of congestion on the lower roadway are daily swing bridge openings and daily railroad activities across SW Spokane Street. These sources of congestion require modern traffic detection and signal systems to implement traffic congestion recovery plans.

Existing and expected queuing from port container terminal operations could impact SW Spokane Street, and the impacts of port-based truck traffic backing up on to SW Spokane Street can be severe. As a result, monitoring of queues through in-pavement detection and CCTV cameras is essential so that the SDOT Transportation Operations Center (TOC) has real-time information to manage traffic.

Commuters from West Seattle that choose the lower roadway are likely attracted by the direct route and lower volumes. However, they will continue to travel at the risk of a swing bridge opening. Advanced driver information that relies on real-time traffic information will reduce driver uncertainty and reduce driver frustration. Actions to reduce incidents on the WSBC upper roadway, to restore travel lanes on the upper roadway and to provide alternative routes to both the upper and lower WSBC roadways will improve the overall reliability of the WSBC corridor.

Recommended actions to address Lower Spokane Street Congestion Management include a combination of treatments for the lower roadway and actions for the upper roadway:

- Smart Traffic Signals and ITS for Spokane Street (L1)
- Swing bridge Delay Information System (L2)
- Rail Crossing Delay Information System (L3)
- Establish Duwamish Waterway User Group (L4)
- Terminal 5 Gate Queue Management Plan and Port/City MOA (L5)
- Active Traffic Management system on the upper roadway (U1)
- Construct Refuge Pullouts (U3)

2. TRUCK QUEUING AND TRAIN BLOCKAGES

Two primary and irregular sources of truck queuing along SW Spokane Street exist: swing bridge openings and temporary closures of SW Spokane Street at grade crossings during train movements. Bridge openings typically interrupt traffic on SW Spokane Street for an average of 12 minutes (7 to 30 minutes range). The queue that builds up behind the swing bridge gates is expected to increase significantly with added truck traffic from future Terminal 5 operations. Train blockages occur on a daily basis across S Spokane Street where two mainline tracks and tail tracks cross S Spokane Street. Train volume and train lengths are expected to increase in the future resulting in more frequent and longer gate closures.

The *Terminal 5 Improvement Project, Transportation Technical Report for Final EIS* concluded that, (with recommended improvements and a Gate Management Plan), truck traffic would reach SW Spokane Street but would not back up on to SW Spokane Street. The EIS analysis is based on a set of assumptions and parameters, which, while appropriate for planning purposes, may not reflect the actual conditions for port operations or truck arrival patterns in the future.

The SW Spokane Street swing bridge gate across the west end of the bridge is only 450 feet from the signalized intersection of SW Spokane Street at the T5 access ramp. The consequences of a back-up onto SW Spokane Street

when the swing bridge must open are severe. In the case of truck queues blocking the swing bridge, the bridge operator must call in the police to force trucks off of the bridge. This process proves challenging as truck drivers are resistant to losing their place in line approaching the terminal gate. The options to turn around are limited and difficult, and travel over the high bridge is undesirable due to steep grades. In addition, the bridge operator must visually confirm that no vehicles, bicyclists, or pedestrians remain on the bridge before opening. This safety protocol is further burdened with the chaos of trucks queued over the bridge as a ship approaches.

A Gate Queue Management Plan for Terminal 5 should be solidified in an interagency agreement between the Port of Seattle, Northwest Seaport Alliance and the City of Seattle, as a condition of approval for the T5 Expansion. The Northwest Seaport Alliance manages both Port of Seattle and Port of Tacoma container terminal facilities. The Port of Seattle maintains ownership of terminals within Seattle. In this document, we refer to the terminals as port facilities. As part of a Gate Queue Management Plan for T5, the following requirements should be added to the agreement:

1. The agreement would explicitly prohibit truck queues on SW Spokane Street.
2. The Northwest Seaport Alliance will install in-pavement queue detection and CCTV cameras on the Terminal 5 access ramp.
3. If queues reach beyond the 95th percentile of queue storage, the Northwest Seaport Alliance will modify on-dock operations to add truck queue storage adequate to eliminate queues that reach SW Spokane Street.
4. When the first incident of a truck queue reaching 95% of the Terminal 5 access ramp storage length, the Northwest Seaport Alliance will operate the security gates with two operators. When the first incident occurs, there is a strong indication that additional incidents will occur.
5. Electronic information to truck drivers during incidents and ITS monitoring and communication to the SDOT Transportation Operations Center (TOC).
6. TOC, SPD and Port/Seaport police protocols will be developed by the Port of Seattle/Northwest Seaport Alliance and in coordination with SDOT and SPD.

As truck volumes into Terminal 5 increase, westbound queues on SW Spokane Street during a swing bridge opening will more frequently reach Terminal 18 and block access to the roadway leading to Terminal 18 Gates 3 and 4. Such a blockage means that trucks in queue on SW Spokane Street from Terminal 18 at Gate 1 may not be able to leave the queue to enter through Gates 3 and 4 as they currently do now. This condition will then result in queues from Terminal 18 backing up to the SR 99 ramps, Spokane Street Viaduct and to East Marginal Way. Additional queue storage for Terminal 18 access to Gate 1 is recommended to not only remove queued trucks from SW Spokane Street but to improve reliability of truck access to Terminal 18 for the commercial drivers.

Recommended actions for the Lower Spokane Street roadway to address truck queuing and train blockages include a combination of treatments:

- Smart Traffic Signals and ITS for Spokane Street (L1)
- Swing Bridge Delay Information System (L2)
- Rail Crossing Delay Information System (L3)
- Establish Duwamish Waterway User Group (L4)
- Terminal 5 Gate Queue Management Plan with queue detection, Terminal 18 entrance modifications and Port/City MOA (L5)

3. MEDIAN GATES FOR INCIDENT RESPONSE

Median gates are available to be installed that open longitudinally for an opening up to 42' wide and would operate with a remote control of the gates. For the West Seattle Bridge and Spokane Street Viaduct upper roadway, two median gate installations would be needed for U turn access along the upper roadway.

The potential benefits of median gates on the upper level roadway were discussed in a meeting with Seattle Fire Department (SFD) and Seattle Police Department (SPD) representatives, as part of a Traffic Incident Management (TIM) monthly meeting. The emergency responders did not believe that the gates would improve response because it would be difficult to maneuver a large fire truck in a U-turn through the opening, and in order to use the U turn opening in the median for fire apparatus access to an incident, the road would need to be cleared of any traffic queued behind the incident and the opposite direction would require traffic control to provide sufficient maneuvering space. The operation would require traffic control, added traffic control personnel and the time to perform this maneuver would negate any response time savings. Using the median gates could put another direction of travel at risk of delay, further congestion and collisions. SFD did not expect there would be any reduction in the response time for an incident on the WSBC upper roadway.

The SFD and SPD did suggest that, for an incident that was projected to extend beyond 90 minutes, the gates could be useful in clearing traffic from the back-up behind such a major incident. Incidents of this duration are very rare and dispersion can be handled with other operations.

Median gates are not recommended for the upper roadway since they are not expected to improve response time in the event of emergency on the bridge and using median gates would impact traffic and may impact safety in the opposite direction. Other actions that can have a positive impact on collisions and incidents on the upper roadway include:

- Active Traffic Management system on the upper roadway (U1)
- Construct Refuge Pullouts (U3)

4. EMERGENCY LANE STRIPING FEASIBILITY

The feasibility and/or effectiveness of striping or painting one travel lane as a "Fire Lane" on the WSBC upper roadway considered relevant factors and experience from New York City. The New York Fire Department (NYFD) was consulted to learn more about operation of city arterials with fire lane striping, where the practice has been in place for more than three decades. Indeed, no other jurisdiction has been found that uses this type of striping. NYFD indicates that the lanes are ineffective in supporting emergency vehicle response because:

1. The streets are so congested, that there is nowhere for drivers to move to.
2. The compliance with clearing for approaching emergency vehicles is limited.
3. There is a lack of public understanding of the markings, and lack of knowledge of what to do when emergency vehicles approach.

The NYFD does support public education and information campaigns to educate drivers on how to respond when emergency vehicles are approaching.

Conditions on the West Seattle upper roadway could be similar to those experienced in New York City during a blocking event, with high degree of congestion and fully used travel lanes. Since this Fire Lane strategy does not

work effectively in New York City, it is unlikely to work well on the WSBC upper roadway as an effective way to provide a clear lane for incident response.

Based on the experience in New York City for arterial "Fire Lane" striping of a travel lane, it appears that in order to provide a lane dedicated to Fire access on the WSBC upper roadway, it is necessary to dedicate a lane. In the eastbound direction, the Bus Lane can provide this purpose where SFD would operate in the bus lane, extending from the on-ramp from Delridge Way SW. In the westbound direction, providing a dedicated SFD access lane would require taking a lane from general traffic, which is not viable given the heavy traffic volumes (especially during peak commute periods). What is viable for the corridor is a flexible lane use, based on emergency need or incident condition, which can be implemented as part of an Active Traffic Management (ATM) system for the upper roadway.

Emergency Lane or "Fire Lane" striping is not recommended for WSBC. It is suggested that this strategy be removed from further evaluation.

A recommended treatment for the WSBC that can provide flexible lane use to assist with emergency response is the Active Traffic Management system on the upper roadway (U1).

FULL REPORT

The full report thoroughly explores and describes the complexities of congestion on the upper roadway and lower roadways. The report provides the detailed study findings in support of the recommendations, benefits, and estimated costs in a summary table.

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Casseday Consulting was hired to independently review, investigate, and recommend congestion management measures using the technical reports already prepared by SDOT, interviews with City staff and in consideration of the Terminal 5 Expansion Environmental Impact Statement documents relating to future traffic operations.

The study team approach was to evaluate these four elements in the overall context of the entire corridor, both upper and lower roadways. In addition to the four elements targeted for the study, and because the SDOT Traffic Operations Division has enabled new approaches to traffic signal operations since 2016, additional concepts for traffic and incident management were developed for the WSBC.

To answer the questions and address these four topics, this report includes four sections to provide the background for study findings and recommendations:

- A review of the corridor context and issues
- Identification and assessment of potential actions and projects to help manage the corridor traffic
- Four Study Topic Findings and
- Recommendations to implement for corridor management.

WEST SEATTLE BRIDGE CORRIDOR CONGESTION MANAGEMENT STUDY

CASSEDAY CONSULTING

WEST SEATTLE BRIDGE CORRIDOR CONTEXT

The West Seattle Bridge Corridor (WSBC) is a major east-west arterial corridor that connects West Seattle to Seattle, Interstate 5 (I-5) and the region. The WSBC is heavily used and relied upon by commuter and commercial travelers.

The WSBC is the City's highest volume arterial corridor and is the lifeline connecting West Seattle to Downtown, I-5 and the region. The upper roadway is a key commuter facility with dominant eastbound flows in the morning and westbound flows in the afternoon – over 110,000 vehicles per day and over 20,000 bus riders per day travel the upper level, reflecting a high reliance on the facility. The lower roadway, S/SW Spokane Street is the commercial route to and from the Northwest Seaport Alliance Terminals 5 and 18, business and industry serving Terminals 5 and 18, the Duwamish Manufacturing Industrial Center and the Duwamish Waterway. The lower roadway carries 12,000 vehicles per day.

The West Seattle Bridge Corridor consists of:

The Upper Roadway – Including the Spokane Street Viaduct and West Seattle Bridge extending from 35th Avenue SW to Interstate 5 (I-5). As with all of the bridges in the City, incidents on the upper roadway create long delays as there are limited alternative routes to absorb traffic diversions.

The Lower Roadway – S/SW Spokane Street from Harbor Avenue to Airport Way S with access to I-5. The lower roadway is subject to frequent disruptions from the lower Spokane Street Swing Bridge openings, from rail crossings, and truck queues due to Port of Seattle facility operations.

This study report provides an overview of the corridor context and issues, identifies potential treatments and actions to help manage the corridor traffic and identifies recommend actions to enhance traffic and congestion management for the WSBC.

CONGESTION MANAGEMENT GOALS FOR THE CORRIDOR

The recommendations were developed based on an analysis and understanding of the upper and lower roadways context, operations and issues, identifying and assessing a broad set of potential actions for the corridor.

UPPER ROADWAY FOCUS FOR CONGESTION MANAGEMENT:

The upper roadway is the primary West Seattle commuter corridor for cars and transit with higher eastbound AM peak volumes, and westbound PM peak volumes. Truck volumes in either direction are typical compared to other principal arterials in the city, at 1 to 5 percent of the total.

Although the crash rate on the upper roadway is lower than average rates for similar roadways, the impact of delays and overall transportation system disruption due to incidents can be more impactful than on other principal arterials.

UPPER ROADWAY GOALS:

- Minimize crash occurrence
- Identify and respond rapidly to incidents that do occur
- Improve operations capability on alternative routes

LOWER ROADWAY FOCUS FOR CONGESTION MANAGEMENT:

The lower Spokane Street roadway supports major freight operations, providing access to the Port of Seattle and the Duwamish/SODO industrial area. Lower Spokane Street serves as an alternate route when upper level operations are interrupted due to incidents, although its capacity is limited by the fact that there is only one lane in each direction. Daily traffic on the lower roadway is currently 9,800 to 12,000 vehicles per day on weekdays and about 20-25% of that is truck traffic.

LOWER ROADWAY GOALS:

- Manage a roadway that experiences frequent and unpredictable disruptions as the "normal" operating condition.
- Manage truck queues to minimize impacts on Spokane Street.

SW Spokane Street swing bridge openings to serve marine traffic create interruptions to the roadway network, resulting in backups along SW Spokane Street and connecting streets. With 67 daily train crossings on the mainline BNSF tracks between 1st Avenue S and 4th Avenue S, east-west travel long S/SW Spokane Street is often interrupted by trains. Rail and waterway operations are expected to increase in volume and frequency. Truck queue management efforts must rely on Port of Seattle, terminal operator and truck operator actions.

In addition to the demands on the east-west travel network for freight and port-related activites, I-5 congestion and incidents can affect the operation of the lower roadway. When an incident occurs on I-5, north-south arterial volumes increase in SODO which in turn can translate into gridlock for east-west travel on S Spokane Street.

RECENT SDOT AND CITY ACTIONS IN WSBC

A White Paper and Priority Investment List[1] for WSBC was prepared in September 2015 and a Progress Report[2] was prepared and submitted to the Council in May of 2016 in which substantial progress was reported.

Mobility improvements already implemented for the WSBC include:

- Changes in Traffic Incident Management (TIM) protocols that focus on quick clearance of incidents. This includes providing additional SDOT Maintenance and e-laborer support of clearance and monitoring of incidents. SDOT is completing procurement of 3 new incident response vehicles and equipment, and funding 7 additional e-laborer positions to enhance the incident response service.
- Expansion in the hours staffed at the SDOT Transportation Operations Center (TOC). In 2014, the hours of TOC operation spanned 6 AM to 7 PM on weekdays only. In 2015 the hours of TOC operation extended to seven days a week from 6 AM to 10 PM, and staff is now available on-call after hours.
- Installing Zone markers on the upper roadway to help travelers involved in incidents and disabled vehicles to pinpoint their location when communicating with 911 dispatch reducing response time.
- Painted eastbound red bus lane.
- Revised mechanical opening sequence of the SW Spokane Street swing bridge to reduce the time it takes to open and close it.
- Added enhanced markings of at-grade crossing of Alki Trail at five-way intersection at Delridge Way.
- City funded the separation and extension of the RapidRide C and D Lines to improve reliability and connectivity in March 2016. Frequency changes for these lines were also made.
- King County Metro revised West Seattle service in the 2015 and 2016 service changes, particularly and with capital improvements on Westlake Avenue (for C Line operations), all funded by the Seattle Transportation Benefit District's Proposition One (STBD) funds passed in November 2015.

- SDOT began design for the South Lander Street Railroad Grade Separation project across the Burlington Northern Santa Fe (BNSF) mainline tracks. This grade crossing will speed emergency response to the WSBC, and reduce delay for all travelers in the area.
- New traffic signal operations capabilities are now available, as SDOT has implemented two core central traffic signal operations platforms: SCOOT, which provides for adaptive traffic signal control which could improve traffic flow in unpredictable conditions such as those encountered on S Spokane St between E Marginal Way and I-5; and CONCERT which provides conditional/responsive traffic signal control for a variety of conditions (e.g. if a bridge is open, the signals can be automatically retimed to manage traffic during and after that condition).
- SDOT is in the final design phase for the Michigan and 1st Avenue ITS projects, which will improve traffic operations south of S Spokane Street, and the subarea as a whole. These specific ITS improvements will enhance SDOT's ability to manage the roadways in SODO and south of S Spokane Street as an integrated network. With the improvements in place, 1st Ave S will operate as a seamless whole from S Michigan Street to S Royal Brougham Way.

CORRIDOR CONDITIONS AND ISSUES

A combination of field observations, review of previous studies, and a review of studies of future proposals including the Terminal 5 Improvement Project EIS[3] and Coal Train Study[4] were synthesized to develop the project context and problem statement. This first step was the basis for consideration of potential actions and development of recommendations for a WSBC Congestion Management Plan.

The upper and lower roadways were assessed individually to better understand their unique operational issues and then how the two facilities could operate as a complete corridor system.

CORRIDOR CONTEXT: OPERATIONS ON THE UPPER ROADWAY

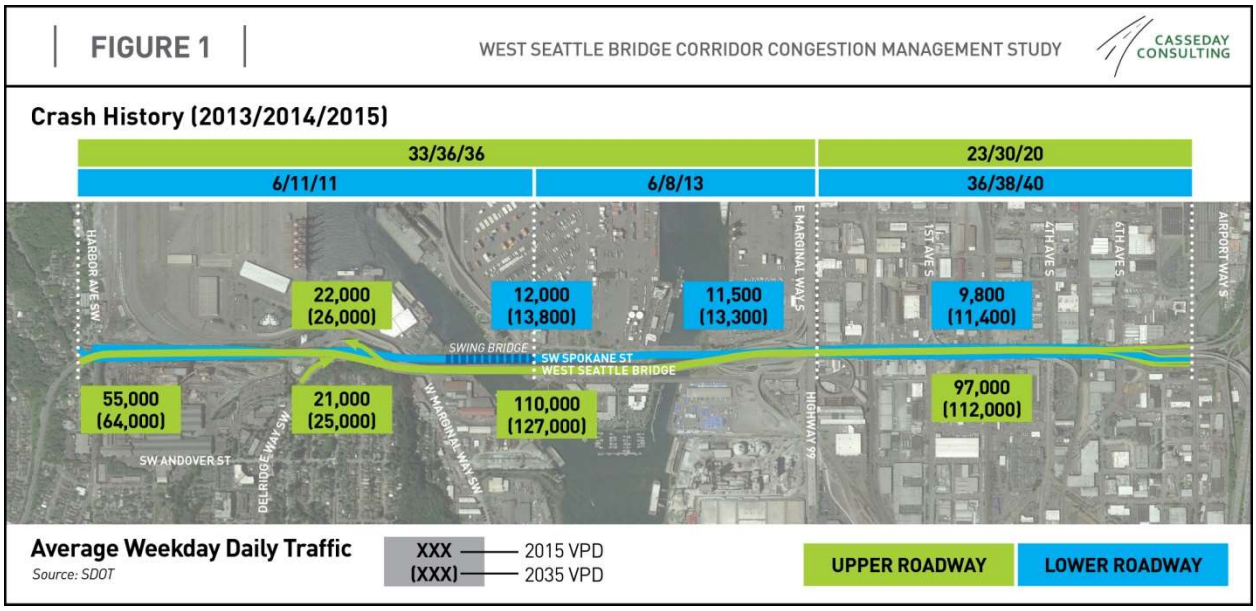
The following describe the Upper Roadway operations context in the corridor for traffic demand, safety, incidents and clearance.

WEST SEATTLE BRIDGE/SPOKANE STREET VIADUCT TRAFFIC DEMAND:

The West Seattle Bridge and Spokane Street Viaduct, together, operate at or near capacity during peak hours with over 110,000 vehicle trips per day and an additional 15,000-20,000 daily trips expected on the corridor by 2035 (source: SDOT). The truck volume is 1% to 5% of annual daily traffic (ADT). Figure 1 shows the daily traffic and collision data from years 2013-2015 for the corridor.

The WSBC serves a large base of commuters, predominantly eastbound in the morning and westbound in the afternoon.

King County Metro's RapidRide C Line uses the West Seattle Bridge as will the future RapidRide H Line (conversion of the Route 120). Over 20,000 daily transit patrons travel across the West Seattle Bridge which is expected to grow to 25,000 patrons by 2030.



WEST SEATTLE BRIDGE/SPOKANE STREET VIADUCT SAFETY AND INCIDENT CONDITIONS:

As with all of the bridges in the City, incidents on the upper roadway create long delays as there are limited alternative routes to absorb traffic diversions. The lower roadway is subject to frequent disruptions from the SW Spokane Street Swing Bridge openings, from rail crossings in SODO, and also can be subject to truck queues from Port of Seattle terminals.

Crash records indicate that about 50 crashes per year occur over the three mile upper roadway corridor. In addition, the SDOT Transportation Operations Center (TOC) has recorded approximately 10 disabled vehicles or incidences of debris in the roadway annually . Most crashes are rear-end and side-swipe, the majority of which occur during turbulent conditions outside of the peak congestion periods. Secondary crashes are rear-end crashes. The crash rate is lower than typical for similar roads, but incidents and blockages can be more impactful on this key arterial.

Wayfinding can be challenging under current corridor conditions. For example, eastbound travel toward I-5 can be confusing. Signage could be improved to help clarify lane use leading to I-5 northbound and southbound. This can help motorists negotiate this complex interface between WSBC and I-5. In addition, lane striping is currently worn out (not highly visible) in many locations indicating a high wear rate, and introducing a challenge to drivers.

SPD, SFD and SDOT are reducing clearance times for all incidents and with a focus on quickly restoring traffic flow. Roadway clearance time depends on injury severity, potential of criminal action, and if large trucks are involved. SDOT e-laborers routinely support incident clearance.

During incidents on the upper roadway, there is limited capacity available on the lower roadway to accommodate diverted traffic. The lower roadway capacity is approximately one-fifth that of the upper roadway.

There are several dynamic message signs (DMS) in place on approaches to the upper level bridge. Drivers could benefit from additional DMS placement to relay incident messaging, including westbound on the Spokane Street

Viaduct, on lower S Spokane Street, on Delridge Way SW, and southbound on 4th Avenue S at a location where freight traffic originating in the SODO could benefit from WSBC information.

IN SUMMARY, THE UPPER ROADWAY:

- Serves as the primary route for general purpose, transit and commuter travel, with truck volumes that are typical for a major arterial.
- Will continue to experience crashes as typical for similar roadways, but could benefit from further crash risk reduction measures, especially to address rear-end and sideswipe crashes.
- Would benefit from further measures reducing incident clearance time and restoring traffic.

CORRIDOR CONTEXT: OPERATIONS ON THE LOWER ROADWAY

S/SW Spokane Street is a series of complex roadway geometry and operating conditions. The following describes the major conflicts and congestion challenges for the lower roadway network. Existing truck and rail challenges on the lower roadway are shown in Figure 2. Future truck and rail challenges on the lower roadway are shown in Figure 3.

MAJOR SOURCES OF CONGESTION ON THE LOWER ROADWAY:

- Lower Spokane Street swing bridge openings
- Rail operations (between E Marginal Way and 6th Avenue S)
- SW Spokane Street/West Marginal Way/Chelan Avenue operates at LOS D in the AM peak hour and LOS F in the PM peak hour (2013)[3], and is interrupted by train operations crossing the north leg of the intersection. Since Terminal 5 has been out of operation, the impact of these crossings is minimal.

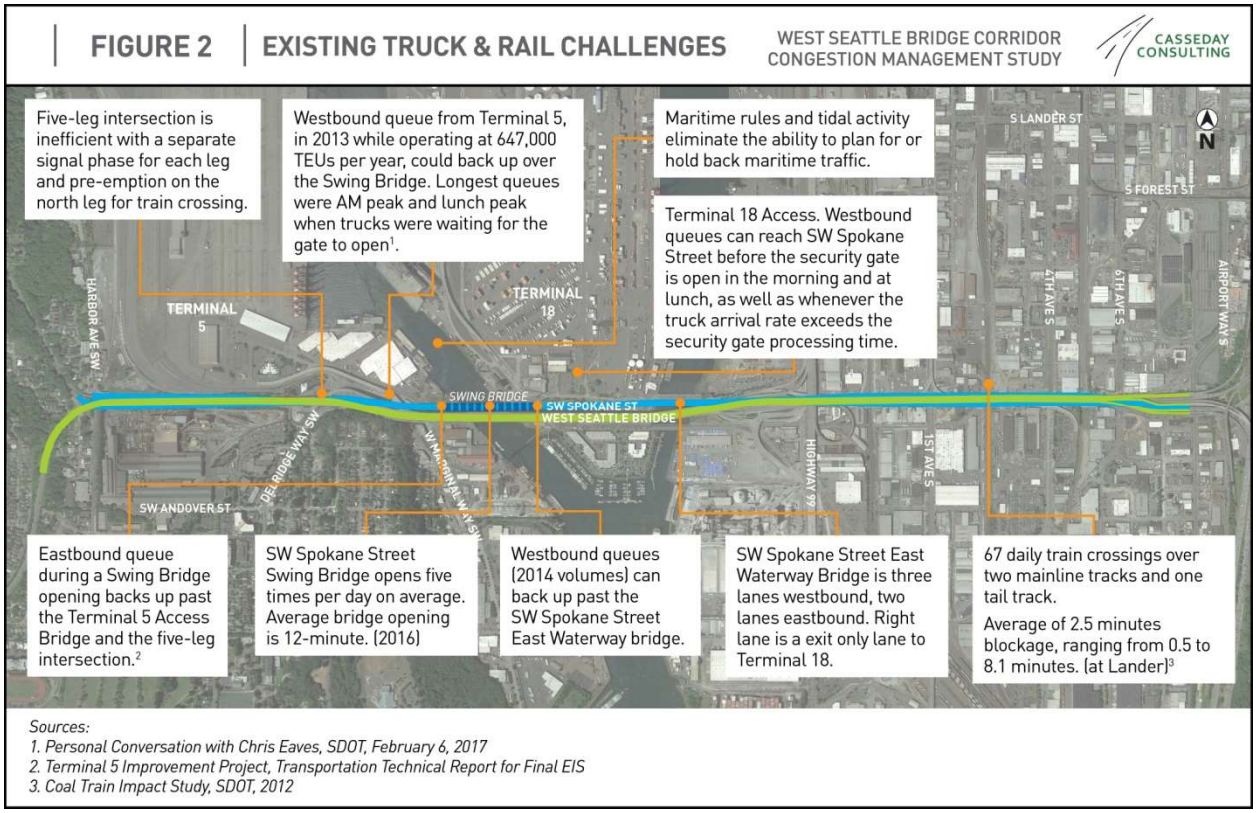
LOWER ROADWAY TRAFFIC DEMAND

S/SW Spokane Street carries a range of 9,800 to 12,000 vehicles per day on a weekday with future demand estimated at nearly 14,000 vehicles per day by 2035 (source: SDOT). The AM peak for commuter traffic is in the eastbound direction and the AM peak for truck access to terminals is in the westbound direction. AM truck traffic arrives at Terminal 18 before the gates open and highest volumes occur during the morning and through lunch.

Operations at the intersection of SW Spokane Street/West Marginal Way/Chelan Avenue are affected by the geometry resulting in the need for each of the five approach streets to be served by an individual traffic signal phase. Pre-emption by a train crossing of Chelan Avenue north of the intersection exacerbates the challenges with the intersection operations.

The lower roadway experiences general purpose traffic demand from drivers attracted to a relatively low volume roadway, with the risk of a Swing Bridge opening disruption. Truck volumes make up 20-25% of total volume on the lower roadway on weekdays. The lower roadway experiences significant truck volumes and truck queuing from port container terminal and industrial/commercial operations including Terminal 18 and Terminal 5 operations (now and with proposed improvements).

The Alki Trail connects to the West Seattle Bridge Trail over the Duwamish Waterway, providing pedestrian and bicycle connections between West Seattle and SODO. Based on the bicycle counter located at the SW Spokane Street swing bridge, on average there are over 700 bicycles crossing the bridge on an average weekday, with a peak of 1,200 bicycles on the highest day[1]. This is an important connection for pedestrians and bicyclists.



INTERMODAL CONFLICTS AND FLOW INTERRUPTION

There are four main sources of intermodal conflicts and flow interruptions on the lower roadway:

- SW Spokane Street swing bridge openings
- Port Terminal 18 operations
- Port Terminal 5 operations (future)
- S Spokane Street railroad crossings (SODO)

SW SPOKANE SWING BRIDGE OPENINGS

There is a federal mandate to maintain marine commerce, so the swing bridge opens when ships request the opening and are approaching the bridge. Tides are a major factor in the timing and number of openings. Most ships are commercial vessels, although some pleasure craft (sailboats) also require bridge openings. Given the

importance of marine traffic and business along the Duwamish River and a ship's dependence on the tides for efficient travel, restricted opening hours are not recommended for the SW Spokane Street swing bridge.

In 2016, there was an average of 5 bridge openings per day, ranging from 0 to 14 openings per day. The average bridge opening is 12 minutes with a range of from 7 to 30 minutes.[5] Two thirds of the openings occur between 7 AM and 7 PM. Again, tides are a major factor as there are openings in the early morning hours. There is no regular distribution pattern of openings during the day; openings are spread out randomly across the 12-hour window noted above.

An automated signal is sent to the TOC when the bridge operator presses the button to activate the bridge opening sequence. Electronic flashing warning signs on approaches to the corridor highlight that the swing bridge is open and advise motorists to use the upper roadway. These advisory signs are activated when the bridge operator activates the bridge opening sequence. Some advisory signs are located with little advanced warning time for approaching drivers and thus may have limited value to divert drivers to alternate routes.

Westbound queues approaching the swing bridge (based on 2014 volumes) can back up past the SW Spokane Street bridge across the East Waterway and beyond. The distance between swing bridge gates and the fixed bridge over the East Waterway is relatively short at 1,185 feet. Eastbound queues approaching the swing bridge (based on 2014 volumes) back up to and beyond the five-leg intersection at Chelan Avenue SW, but not to Harbor Avenue.

In the past, westbound trucks approaching Terminal 5 have queued onto the swing bridge as they waited to enter the Terminal 5 (T5) gate. SPD, Port of Seattle police and SDOT were regularly called to manage these queues so that bridge operations would not be interrupted.

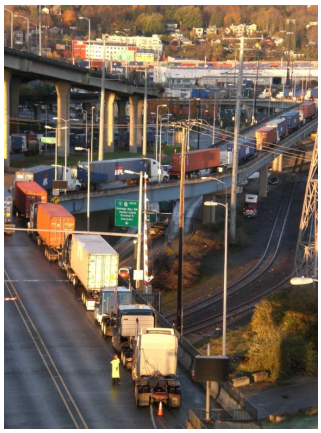
There is limited closed circuit television (CCTV) coverage of the lower corridor to monitor operations from the TOC. There is a mix of wireless, copper and fiber optic communications in place for ITS and traffic signals. The wireless and copper communications have limited and often unreliable bandwidth, which limits ITS capabilities. Current traffic signals are not capable of responding to closures or providing for queue recovery either due to lack of detection, need for an updated traffic signal controller, or communications needs.

PORT CONTAINER TERMINAL 18 OPERATIONS:

Trucks queue from Terminal 18 (T18) at Gate 1 onto SW Spokane St whenever truck arrival rates exceed security gate processing time. In addition, trucks queue in the morning before the gate opens and during lunch while the gate is closed. Truck queue storage between T18 Security Gate 1 and SW Spokane Street is short, with capacity for four trucks. Trucks divert to Gate 4 as directed by the terminal operator when queues are not dissipating on SW Spokane Street and when queues impact roadway operations.

PORT CONTAINER TERMINAL 5 OPERATIONS:

Prior to 2013 when Terminal 5 was operating, truck queues on the Terminal 5 Access Bridge backed up on to the swing bridge. (See photo.)[6]



With Terminal 5 Expansion and planned improvements, trucks were not forecast to back up along the T5 access ramp on to SW Spokane Street.[3] With Terminal 5 Expansion, T5 operations would result in an additional 93 trucks arriving during the AM peak hour. A single truck in queue consumes 80 feet of a lane. When the bridge is opened, the additional T5 truck volume would add approximately 1,860 feet to the westbound swing bridge queue during a 15-minute bridge opening in the morning peak. Westbound queues during a swing bridge opening could block Terminal 18 access to Gates 3 & 4 and will more frequently reach past East Marginal Way and beyond when a mainline train blocks the crossing.

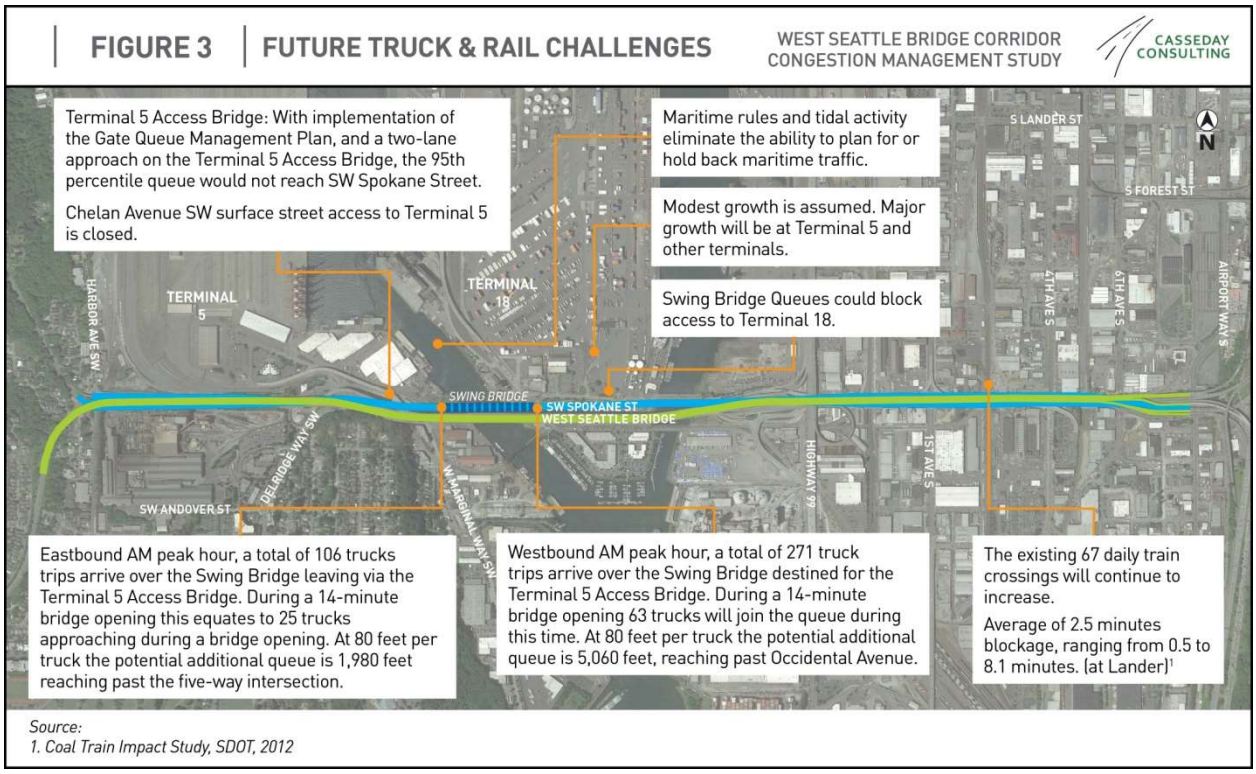
Future Terminal 5 Gate Management Plan[3], as proposed by the Port of Seattle, is based on:

- Main Gate with at least 8 inbound lanes
- Two security gates with one operator, processing one truck every 22.7 seconds. Rolling tractor-trailer trucks consume on average 80 feet of space.
- Two inbound lanes on Terminal 5 Access Bridge, one for truck queue and one for Terminal 7, local businesses, and employee access
- Additional gate management protocols for high volume conditions
    - Opening the pre-check gate up to 30 minutes before the main gates so that trucks queue at the main gate
    - Opening the pre-check gate up to 1 hour before the main gates on high volume days
    - Extensions of main gate hours
- Electronic information to truck drivers during incidents, ITS monitoring, police enforcement
- Closure of the north leg of Chelan Avenue SW/SW Spokane Street intersection which eliminates traffic issues when a train blocks Chelan Avenue SW, eliminates a major conflict with bikes and pedestrians on the Alki Trail, and reduces the intersection from five legs to four legs. Signal operations can be made more efficient as a four-leg intersection.

RAIL CROSSING OPERATIONS (S SPOKANE STREET BETWEEN EAST MARGINAL WAY AND I-5)

There are 67 daily train crossings[4] on the mainline BNSF tracks (between 1st Avenue S and 4th Avenue S). The average roadway closure at the east-west crossings is an average of 2.5 minutes, ranging from 0.5 to 8.1 minutes[4] (as recorded at Lander Street). With many trains throughout the day, it can be very difficult to navigate S Spokane Street between East Marginal Way and I-5. One regular outlier is the assembly of garbage trains which can block Lander Street and other east-west streets for 20 minutes during the mid-day.

The traffic signal systems on SW Spokane Street are not capable of responding to closures or providing for train blockage or queue recovery.



Source:
1. Coal Train Impact Study, SDOT, 2012

IN SUMMARY, THE LOWER ROADWAY:

- Is a major freight route on an interruptible roadway.
- Experiences truck queues from port terminal operations.
- Supports general access to West Seattle for all travelers.
- Experiences unpredictable delays due to rail crossing and swing bridge openings that are largely unpredictable and not subject to City management (City cannot limit these operations).
- Is the only pedestrian and bicycle trail connection between West Seattle and SODO, with trail connections to Downtown.

WEST SEATTLE BRIDGE CORRIDOR POTENTIAL TREATMENTS FOR TRAFFIC MANAGEMENT

Based on the context described above, the study team articulates the following goals for corridor operations and management:

Upper Roadway Congestion Management Goals

- Minimize crash occurrence
- Identify and respond rapidly to incidents that do occur
- Improve operations capability on alternative routes

Lower Roadway Congestion Management Goals

- Manage a roadway that experiences frequent and unpredictable disruptions as the "normal" operating condition.
- Manage truck queues to minimize impacts on Spokane Street.

TREATMENTS FOR THE WSBC UPPER ROADWAY

Congestion management on the upper roadway would implement a set of traditional traffic improvements, crash reduction measures, ITS safety improvements, and incident management measures. In addition to improved signing and striping, an Active Traffic Management System, consisting of overhead electronic signs that are able to display advisory speeds, lane closures symbols, move right or left symbols, and other information is recommended.

Potential treatments considered for the Upper Roadway include:

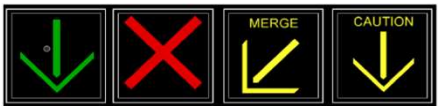
- U1 Active Traffic Management (ATM) System
- U2 Positive Striping and Lane Markings
- U3 Refuge Pullouts
- U4 Median Gates

U1 UPPER ROADWAY ACTIVE TRAFFIC MANAGEMENT SYSTEM

An Active Traffic Management (ATM) system is proposed for the upper roadway network of West Seattle Bridge (upper roadway) and the Spokane Street Viaduct extending from Fauntleroy Way SW to Interstate 5 to support crash reduction. This system would be similar to that on I-5 in Seattle, and would include overhead displays capable of posting advisory speeds, variable speed limits, lane use symbol, and advance warnings of queues or blockages ahead. The ATM system has been proven to reduce rear-end crashes and to manage traffic flows. Additionally, ATM systems are used to support traffic management during incidents, which could improve emergency vehicle response time. The system would include the required congestion detection, cameras, communication connections to both the TOC and equipment in the corridor and central software. In their study of their ATMS[1], WSDOT cited that, internationally, active traffic management systems have shown a reduction in

[1] http://www.wsdot.wa.gov/NR/rdonlyres/73AC9A17-6178-4271-B3A9-91911BD1C8C6/0/FinalATMConceptofOperations.pdf

collisions to fall anywhere between 15 and 40 percent. Although it is premature to provide a scientifically supportable report on the crash reduction benefits of the ATMS deployed by WSDOT in the Seattle area, the experience has indicated that crashes have been reduced since the systems were deployed An ATM system will also support incident response, as the signs can display red "x" symbols signifying a lane is closed, as well as "Merge LEFT/RIGHT" with a yellow arrow to support traffic management and emergency responder access to an incident scene. Figure 4 shows the potential locations for ATM sign bridges.



Estimated cost: $5,400,000 Can expect daily benefits from ATM, including advance warning for queues and backups, implementation of variable speed limit, plus benefits to incident response with flexible lane use for emergency responders, plus expected reduction in collisions.

U2 Positive Striping/Lane Markings

Existing striping and markings in the corridor are painted twice yearly, yet they wear out quickly due to the high volumes of traffic and moves between lanes in the corridor. Raised traffic lane striping, lane markings plus edge lines can help increase safety and smooth traffic flow for the upper level roadways. They would reinforce the lane use restrictions and provide positive guidance to the motorists, especially through the merge and transition areas such as the eastbound on-ramp from Delridge Way SW to the West Seattle Bridge, merging through and crossing the bus lane. Raised markers provide increased driver visibility, as well as some tactile queues to drivers, and can last longer than traditional paint stripes, at up to four years, as compared to the six month life of paint. Regular maintenance for striping and a review of corridor signing is an important element of monitoring the operations of the WSBC.

Estimated cost $250,000 for raised pavement markings, applying MMA for all striping in the corridor. Can expect daily benefit from the positive striping and markings.

U3 REFUGE PULLOUTS

Disabled vehicles can be pushed out of the lane and off the upper roadway using available off-ramps. However, breakdowns can occur anywhere along the corridor and may not be close to an off-ramp opportunity. Refuge pullouts are recommended for the upper roadway. A pullout can provide several benefits including enabling quick clearance of disabled vehicles, (including vehicles involved in minor incidents), from traveled lanes to await a tow and also providing a space for enforcement activities.

On the Spokane Street viaduct westbound, a refuge lane could be provided using only striping in the area near the 1st Avenue S on-ramp. A refuge area is not proposed for the viaduct in the eastbound direction, as the 4th Avenue S off-ramp provides space to push vehicles from the viaduct itself in that direction.

In addition to the existing opportunities along the corridor for pullout, such as westbound between the off and on ramps to 1st Avenue S, it is envisioned that two locations could be added – one in each direction on the approaches to the West Seattle Bridge. The work would involve widening the approach spans for a short distance to add the refuge areas on the right-hand side.

SPD would also like to have enforcement areas[7] – there is a constant call for additional enforcement (of the bus lane, for speeding, etc.) and there is little space for either the officer to stage for enforcement or for pulling someone over. SPD would also like breakdown areas to get disabled vehicles out of the travel lane. Police reinforces the "Steer and Clear" actions to get the disabled vehicles out of the lanes after a collision. Implementation of ATM in the corridor may offer the possibility of automated speed enforcement in the corridor, in the future.

Estimated cost: $2,500,000 for one pullout to $5,000,000 for two pullouts. Both SFD and SPD support providing pullouts on the upper roadway to help to clear disabled vehicles and incidents.

U4 MEDIAN GATES

Median gates are available that open longitudinally and allow for remote control of the gates. A median opening could be installed to provide up to a 42-foot opening with movable barrier along a center trackway. In a meeting with SFD and SPD[7], the potential benefits of median gates were discussed. The emergency responders did not believe that the gates would improve response capabilities because it would be difficult to maneuver a large fire truck in a U-turn through the opening, and the road would need to be cleared of any traffic queued behind the incident to allow the truck to perform the maneuver. The operation would require traffic control, added traffic control personnel and the time to perform this maneuver would negate any response time savings. Using the median gates could put another direction of travel at risk of delay, further congestion and collisions. SFD did not expect there would be any reduction in the response time for an incident on the WSBC upper roadway.

The SFD and SPD did suggest that, for an incident that was projected to extend beyond 90 minutes, the gates could be useful in clearing traffic from the back-up behind such a major incident. Incidents of this duration are very rare and dispersion can be handled with other operations.

Median gates would be rarely used and are not recommended for the WSBC.

WSBC LOWER ROADWAY TREATMENTS

Congestion management for the lower level of the WSBC would rely on state-of-the art ITS technology to manage traffic and provide driver information to simultaneously address the recurring congestion, queuing and recovery from multiple complex sources of traffic congestion. ITS recommendations are designed to:

1. Implement queue and traffic detection with fiber communications to enable traffic signals to adjust based on real-time conditions
2. Automatically adjust to conditions such as swing bridge openings or railway blockages, for example
3. Operate in "recovery" signal timing mode when the bridge opening and rail closures have ended
4. Provide real-time responsive traffic signal control to manage the unpredictable flows
5. Increase CCTV camera coverage to support detection and clearance of crashes/disabled vehicles, or other incidents
6. Implement improved systems including dynamic messaging signs (DMS) and web-based information to inform emergency responders (SFD) and to advise motorists of:
    - Estimated delay due to swing bridge opening operations (with count-down timer of remaining delay)
    - Estimated delay due to rail crossing operations on the mainline track (the track between 1st Avenue S and 4th Avenue S)

Potential treatments for WSBC lower roadway congestion management include:

- L1 Smart Traffic Signals and ITS along S/SW Spokane Street
- L2 Swing Bridge Delay Information System
- L3 Rail Crossing Information System
- L4 Duwamish Waterway Users Group
- L5 Terminal 5 Gate Management Plan

In addition, it is recommended that the City and Port of Seattle/Northwest Seaport Alliance continue to collaborate on queue management strategies and consider codifying this effort in a memorandum of agreement.

Descriptions of these components for the lower roadway are shown in Figure 5 and described below.

L1 PROVIDE "SMART" TRAFFIC SIGNALS/ITS (SPOKANE STREET FROM HARBOR AVENUE TO I-5)

A Smart Traffic Signal system would upgrade existing traffic signals with dynamic signal control and detection to support the needed responsive traffic signal operation capabilities. The system would include traffic and queue detection, travel time detection, fiber optic communications for reliable operations, and additional CCTV cameras for traffic and operations monitoring. The system would provide for unique traffic signal operations during bridge openings and rail crossings, as well as implementing recovery timing to clear resulting backups. The traffic data collected would additionally be used to provide real-time traveler information including key destination travel times via on-street DMS, and via the Travelers website and Twitter feeds.

Estimated cost: $6,000,000 Implementing smart signals along the Spokane Street corridor would provide benefits on a daily basis.

L2 Swing Bridge Delay Information System

The Swing Bridge Delay Information System would upgrade the seven existing flashing warning signs with dynamic message signs (DMS), each which would provide a countdown timer posting the estimated time to opening. This system would improve the locations of the information signs and provide enhanced information to improve the drivers' decision-making ability, and help reduce driver frustration. The system will require new software, new fiber optic cable connections to the DMS and to the Lower Spokane Street swing bridge control tower - all connected to the SDOT Transportation Operations Center.

Operating the swing bridge involves multiple steps carefully implemented by the bridge operator. The Swing Bridge Delay Information System would provide an automated electronic connection between the control systems at the swing bridge to the TOC and a set of new dynamic message signs to automatically provide information to

traveling public about the status of the swing bridge (open for ships; to re-open for vehicles) and also provide a countdown to the expected re-opening of the roadway. Providing the information on expected delays from the swing bridge operation can assist the traveling public in making en-route travel choices, and help reduce driver frustration. The system would include new fiber connections to signals, cameras, dynamic message signs (DMS) and to the Lower Spokane Street swing bridge control tower. Five new cameras would be added to increase the areas viewed by the TOC in the corridor, specifically near the 5-way intersection, at SW Spokane Street and Terminal 5 access ramp, at eastbound facing Terminal 18, and at 1st Avenue South. Up to seven locations have been identified for Lower Spokane Street countdown signs to provide timely traveler information.

Estimated cost: $950,000 Swing Bridge Delay Information system would leverage the rail delay information system for the Spokane Street lower roadway, using common communication system. This system would provide benefits on a daily basis.

L3 RAIL CROSSING INFORMATION SYSTEM

The Rail Crossing Information System (RCIS) was conceived based on long-standing concerns over long rail crossing delays that occur on the BNSF mainline in the SODO and at the Broad Street crossing at the north end of the Seattle waterfront. Trains can block cross streets for up to 20 minutes, with shorter delay times for the commuter rail trains, and longer for mainline freight trains and train-building and railcar filling activities, such as the Rabanco waste management trains. Emergency service dispatchers have indicated that the RCIS could improve their response times. If dispatchers knew that a train was crossing an intersection, and the estimated time the road would be blocked, they could advise the drivers of routes that could reduce response time or dispatch a unit from an alternate location. Of course, general purpose traffic is also impacted by rail crossing delays. A system that informs drivers of delays could reduce driver frustration, and be used by those familiar with the area to decide to divert around blocked rail crossings.

To help motorists know whether to drive around (search for the nearest grade separation), the RCIS would consist of:

- Train detection along the tracks to help identify approaching train direction and speed with communications to the SDOT TOC
- Software/processing system to estimate the duration of the crossing delay
- DMS at key locations to provide the countdown information to motorists, an estimate of the remaining closure period, RCIS Field Display with Flasher or Countdown Timer
- A connection to police and fire dispatch for improved emergency response
- The system would also be integrated with SDOT's Traveler's Information Map that currently provides real-time traffic conditions.

Estimated cost: $600,000 This would expand the proposed Rail Crossing Delay Information System to Spokane Street. This would provide benefits on a daily basis.

RCIS Field Display: Flasher

RCIS Field Display: Countdown Timer

L4 ESTABLISH DUWAMISH WATERWAY USER GROUP

US maritime law requires that the swing bridge be opened upon demand/request from a ship captain approaching the bridge. Ship movements along the Duwamish Waterway are dependent on the tides, with large vessel operations not being feasible during very low tides. There are efficiencies to be gained by running with the tides. While no regulation can be implemented to formally restrict bridge openings, there may be value in holding discussions with the businesses that rely on the Duwamish Waterway. Goals of such a group could include: assessing the potential to voluntarily limit times when vessels operate, such as during the morning or afternoon peak roadway traffic periods during major incidents on the upper roadway. It could be highly beneficial to incident management if there could be a marine travel delay by one or two hours (thus delay a bridge opening to beyond the peak period); to assist incident management and recovery within the WSBC.

Estimated cost: None. SDOT staff would initiate the user group for collaboration. Potential benefits would likely be very limited and unreliable, since it would be completely voluntary.

L5 TERMINAL 5 GATE MANAGEMENT

Expansion of Terminal 5 is predicted to increase the total number of trucks accessing the terminal both daily and during the peak periods. The Port of Seattle/Northwest Seaport Alliance and the City of Seattle are working together to confirm details of a T5 Gate Management plan as part of the conditions for City approval. The Gate Queue Management Plan would be one condition of the T5 Expansion approval by the City. A Gate Queue Management plan should include queue detection on the T5 access ramp to monitor any truck queues and prevent trucks from impacting SW Spokane Street and the swing bridge operations. The Gate Queue Management plan would also include cameras, signal interconnect to assist in detecting and monitoring the truck activity near T5. The plan would include provisions for operation of two fully staffed security gates and conversion of the T5 access ramp to a three lane configuration to increase truck queuing space without impacting roadway operations.

Estimated cost: None. This would be implemented via Terminal 5 Gate Queue Management Plan through agreement between Port of Seattle/NW Seaport Alliance and City of Seattle. Expected benefits could occur any day, at all times in the corridor.

CORRIDOR WIDE TRAFFIC MANAGEMENT RECOMMENDATIONS

In addition to the treatments identified for congestion management on both the upper and lower roadways of the WSBC, it is important to also identify recommendations for overall traffic management that could include additional staffing for the transportation operations center, identifying alternative travel routes for West Seattle travelers, smart phone alerts and messaging apps, and identifying an on-going monitoring program to track progress in the WSBC traffic management.

C1 STAFF TRANSPORTATION OPERATIONS CENTER 24/7

Seattle DOT currently operates the Transportation Operations Center (TOC) for 16 hours a day, seven days per week (6 AM – 10 PM). Two operators staff the TOC between 8 AM and 6 PM weekdays and between 12 PM and 4 PM weekends. Weekdays, a supervisor and a senior operator staff the center between 7 AM and 5 PM with

overlap from 9 AM to 5 PM for a total of four staff. The TOC has an on-call operator available for off hours and for New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas Day. Incidents in the corridor can occur at any time, day or night. Traffic on the West Seattle Bridge Corridor is tied to the commuting traffic plus port container terminal operations and marine traffic which can peak on any day of the week, based on shipping demands and schedules. The WSBC itself does not currently demand that the TOC staffed hours be expanded, but expanded hours of staffing at the TOC would benefit the WSBC as well as the entire city. Incident management could be increased by adding staffing at the TOC to 24/7, all year long. As the City grows and complexities grow, City and SDOT should review the merits of expanding hours of TOC operation.

Estimated cost: $875,000/year. Provides for Citywide service, not only for WSBC. Expected benefits would occur when collisions, backups or incidents block the corridors.

C2 Enhance Alternative Routes via ITS

The West Seattle Bridge Corridor consists of two routes, upper and lower levels, that provide the main connection between West Seattle and Downtown Seattle, I-5 and the region, but these are not the only connections: they are just the most used and most direct connections. During incidents, traffic could be actively rerouted to alternative routes to the south. ITS systems are proposed to enable and maximize the alternative route options. The improvements would include upgrades to traffic signals and traffic and travel time detection at an estimated twelve intersections to enable implementing special traffic signal timing for the diversion route, install cameras to monitor traffic, install DMS to support the alternative route, and provide fiber-optic communications to support real-time operations and monitoring. See Figure 6 for the potential alternative routes.

Estimated cost: $6,600,000, for ITS and signal enhancements along alternative route corridors. Expected use and benefits would occur when collisions or incidents block upper roadway.

FOUR STUDY TOPICS FINDINGS

The recommended actions and treatments for WSBC Congestion Management are focused on traffic management enhancements that aim to address the complex sources of congestion. To respond to the Council request to investigate four topics for the corridor, findings from the four studies requested are summarized below.

1. LOWER SPOKANE STREET CONGESTION MANAGEMENT

The primary sources of congestion on the lower roadway are daily swing bridge openings and daily railroad activities across SW Spokane Street. These sources of congestion require modern traffic detection and signal systems to implement traffic congestion recovery plans.

Existing and expected queuing from Port operations could impact SW Spokane Street, and the impacts of port-oriented truck traffic backing up on to SW Spokane Street can be severe. As a result, monitoring of queues through in-pavement detection and CCTV cameras is essential so that the SDOT Transportation Operations Center (TOC) has real-time information to manage traffic.

Commuters from West Seattle that choose the lower roadway are likely attracted by the direct route and lower volumes. However, they will continue to travel at the risk of a swing bridge opening. Advanced driver information that relies on real-time traffic information will reduce driver uncertainty and reduce driver frustration. Actions to reduce incidents on the WSBC upper roadway, restore travel lanes on the upper roadway and to provide alternative routes to both the upper and lower WSBC roadways will improve the overall reliability of the WSBC.

Recommended actions to address Lower Spokane Street Congestion Management include a combination of treatments for the lower roadway and actions for the upper roadway:

- Smart Traffic Signals and ITS for Spokane Street (L1)
- Swing Bridge Delay Information System (L2)
- Rail Crossing Delay Information System (L3)
- Establish Duwamish Waterway User Group (L4)
- Terminal 5 Gate Queue Management Plan and Port/City MOA (L5)
- Active Traffic Management system on the upper roadway (U1)
- Construct Refuge Pullouts (U3)

2. TRUCK QUEUING AND TRAIN BLOCKAGES

Two primary and irregular sources of truck queuing along SW Spokane Street exist: swing bridge openings and temporary closures of SW Spokane Street at grade crossings during train movements. Bridge openings typically interrupt traffic on SW Spokane Street for an average of 12 minutes (7 to 30 minutes range). The queue that builds up behind the swing bridge gates is expected to increase significantly with added truck traffic from future Terminal 5 operations. Train blockages occur on a daily basis across S Spokane Street where two mainline tracks and tail tracks cross S Spokane Street. Train volume and train lengths are expected to increase in the future resulting in more frequent and longer gate closures.

The *Terminal 5 Improvement Project, Transportation Technical Report for Final EIS* concluded that, (with recommended improvements and a Gate Management Plan), truck traffic would reach SW Spokane Street but would not back up on to SW Spokane Street. The EIS analysis is based on a set of assumptions and parameters,

which, while appropriate for planning purposes, may not reflect the actual conditions for port operations or truck arrival patterns in the future.

The SW Spokane Street swing bridge gate across the west end of movable bridge is only 450 feet from the signalized intersection of SW Spokane Street and the Terminal 5 access ramp. The consequences of a back-up onto SW Spokane Street when the swing bridge must open are severe. In the case of truck queues blocking the swing bridge, the bridge operator must call in the police to force trucks off of the bridge. This process proves challenging as truck drivers are resistant to losing their place in line approaching the terminal gate. The options to turn around are limited and difficult, and travel over the high bridge is undesirable due to steep grades. In addition, the bridge operator must visually confirm that no vehicles, bicyclists, or pedestrians remain on the bridge before opening. This safety protocol is further burdened with the chaos of trucks queued over the bridge as a ship approaches.

A Gate Queue Management Plan for Terminal 5 should be solidified in an interagency agreement between the Port of Seattle/Northwest Seaport Alliance and the City of Seattle, as a condition of approval for the T5 Expansion. The Northwest Seaport Alliance manages both Port of Seattle and Port of Tacoma container terminal facilities. The Port of Seattle maintains ownership of terminals within Seattle. As part of a Gate Queue Management Plan for Terminal 5, the following requirements should be added to the agreement:

1. The agreement would explicitly prohibit truck queues on SW Spokane Street.
2. The Port of Seattle/Northwest Seaport Alliance will install in-pavement queue detection and CCTV cameras on the Terminal 5 Access Bridge.
3. If queues reach beyond the 95th percentile of queue storage, the Northwest Seaport Alliance will modify on-dock operations to add truck queue storage adequate to eliminate queues that reach SW Spokane Street.
4. When the first incident of a truck queue reaching 95% of the Terminal 5 Access ramp storage length, the Northwest Seaport Alliance will operate the security gates with two operators. When the first incident occurs, there is a strong indication that additional incidents will occur.
5. Electronic information to truck drivers during incidents and ITS monitoring and communication to the SDOT Transportation Operations Center (TOC).
6. TOC, SPD and Port of Seattle/Northwest Seaport Alliance police protocols will be developed by the Port of Seattle/Northwest Seaport Alliance and in coordination with SDOT and SPD.

As truck volumes into Terminal 5 increase, westbound queues on SW Spokane Street during a swing bridge opening will more frequently reach Terminal 18 and block access to the Terminal 18 Gates 3 and 4 roadway. Such a blockage means that truck queues on SW Spokane Street from Terminal 18 at Gate 1 may not be able to leave the queue to enter through Gates 3 and 4 as they currently do now. This condition could then result in queues from Terminal 18 backing up to the SR 99 ramps, Spokane Street Viaduct and to East Marginal Way. Additional queue storage for Terminal 18 access to Gate 1 is recommended to not only remove queued trucks from SW Spokane Street but to improve reliability of truck access to Terminal 18 for the commercial drivers.

Recommended actions for the Lower Spokane Street roadway to address truck queuing and train blockages include a combination of treatments:

- Smart Traffic Signals and ITS for Spokane Street (L1)
- Swing Bridge Delay Information System (L2)
- Rail Crossing Delay Information System (L3)
- Establish Duwamish Waterway User Group (L4)
- Terminal 5 Gate Queue Management Plan with queue detection, Terminal 18 entrance modifications and Port/City MOA (L5)

3. MEDIAN GATES FOR INCIDENT RESPONSE

Median gates are available to be installed that open longitudinally for an opening up to 42' wide and would operate with a remote control of the gates. For the West Seattle Bridge and Spokane Street Viaduct upper roadway, two median gate installations would be needed for U turn access along the upper roadway.

The potential benefits of median gates on the upper level roadway were discussed in a meeting with Seattle Fire Department (SFD) and Seattle Police Department (SPD) representatives, as part of a Traffic Incident Management (TIM) monthly meeting. The emergency responders did not believe that the gates would improve response because it would be difficult to maneuver a large fire truck in a U-turn through the opening, and in order to use the U turn opening in the median for fire apparatus access to an incident, the road would need to be cleared of any traffic queued behind the incident and the opposite direction would require traffic control to provide sufficient maneuvering space. The operation would require traffic control, added traffic control personnel and the time to perform this maneuver would negate any response time savings. Using the median gates could put another direction of travel at risk of delay, further congestion and collisions. SFD did not expect there would be any reduction in the response time for an incident on the WSBC upper roadway.

The SFD and SPD did suggest that, for an incident that was projected to extend beyond 90 minutes, the gates could be useful in clearing traffic from the back-up behind such a major incident. Incidents of this duration are very rare and dispersion can be handled with other operations.

Median gates are not recommended for the upper roadway since they are not expected to improve response time in the event of emergency on the bridge and using median gates would impact traffic and may impact safety in the opposite direction.

Other treatments for WSBC that can have a positive impact on collisions and incidents on the upper roadway include:

- Active Traffic Management system on the upper roadway (U1)
- Construct Refuge Pullouts (U3)

4. EMERGENCY LANE STRIPING FEASIBILITY

The feasibility and/or effectiveness of striping or painting one travel lane as a "Fire Lane" on the WSBC upper roadway considered relevant factors (congestion) and experience from New York City. The New York Fire Department was consulted to learn more about operation of city arterials with fire lane striping, where the practice has been in place for more than three decades. Indeed, no other jurisdiction has been found that uses this type of striping. The study team consulted with New York City Fire Department (NYFD)[8]. NYFD finds that the lanes are ineffective in supporting emergency vehicle response because:

1. The streets are so congested, that there is nowhere for drivers to move to.
2. The compliance with clearing for approaching emergency vehicles is limited.
3. There is a lack of public understanding of the markings, and lack of knowledge of what to do when emergency vehicles approach.

NYFD does support the concept of public education and information campaigns to educate drivers on how to respond when emergency vehicles are approaching.

Conditions on the West Seattle upper roadway could be similar to those experienced in New York City during a blocking event, with high degree of congestion and fully used travel lanes. Since this Fire Lane strategy does not work effectively in New York City, it is unlikely to work well on the WSBC upper roadway as an effective way to provide a clear lane for incident response.

Based on the experience in New York City for arterial "Fire Lane" striping of a travel lane, it appears that in order to provide a lane dedicated to Fire access on the WSBC upper roadway, it would be necessary to dedicate a lane. In the eastbound direction, the Bus Lane can provide this function where SFD would operate in the bus lane, extending from the on-ramp from Delridge Way SW. In the westbound direction, providing a dedicated Fire access lane would mean taking a lane from general traffic, which is not viable given the heavy traffic volumes (especially during peak commute periods).

What is viable for the corridor is a flexible lane designation for varying use, based on emergency need or incident condition, which can be implemented as part of an Active Traffic Management (ATM) system for the upper roadway.

Emergency Lane or "Fire Lane" striping is not recommended for WSBC. It is suggested that this strategy be removed from further evaluation.

A recommended treatment for the WSBC that can provide flexible lane use to assist with emergency response is the Active Traffic Management system on the upper roadway (U1).

STUDY RECOMMENDATIONS FOR WEST SEATTLE BRIDGE CORRIDOR CONGESTION MANAGEMENT

The study process focused on all sources of congestion and revealed how the WSBC lower roadway operates with daily unpredictable interruptions in traffic flow and that effective travel in the corridor relies on a highly reliable upper roadway. When incidents occur on the upper roadway, reliability is compromised – and to improve the overall reliability of the corridor as a whole, there are three areas where treatments/actions can make a difference:

1. Manage the daily unpredictable disruptions on the WSBC lower roadway.
2. Reduce crashes on the WSBC upper roadway.
3. Reduce incident clearance times to restore normal traffic on both roadways.

The recommendations for West Seattle Bridge Corridor Congestion Management developed in this study are intended to provide benefits in support of the context and key issues in the corridor. Recommended actions/projects are shown in Table 1 and were developed to provide the following benefits:

1. **Manage Daily Unpredictable Disruptions.** The concept for "normal" operations on the lower roadway must respond to the daily unpredictable disruptions. Strategies rely on; implementing ITS to revise signal timing during disruptions, provide rapid clearance and recovery after disruptions and legibly inform travelers and emergency responders of a swing bridge opening, train blockages, and expected clearance times. Recommended projects include L1 through L5 (listed in Table 1).
2. **Reduce Crash Occurrence.** Minimizing crash occurrence through a combination of "low tech" (e.g. striping and signing improvements) and ITS systems that are proven to reduce rear-end accidents – the most frequent type of accident on the upper roadway – is proposed. An Active Traffic Management System is recommended that would include: overhead signs capable of posting advisory speeds, variable speed limits and warning messages approaching backups or queues at targeted locations (for example in the eastbound direction). This would be similar to the system installed on I-5. Recommended projects include U1 and U2 (listed in Table 1).
3. **Reduce Incident Clearance Times.** SDOT incident response procedures (with enhancements to the procedures and equipment already funded) promise reduced clearance times at a reasonable cost. Providing refuge or pullout areas for the Service Patrol to push disabled vehicles or vehicles involved in collisions can help to restore traffic in the corridor. Recommended projects include C1, C2 and U3 (listed in Table 1).

Table 1: Summary of Recommendations

ID	Improvement/Initiative	UPPER (U)/ LOWER (L)	Benefits (Manage Disruptions; Reduce Crashes; Reduce Clearance Time)	Frequency of Use: At All Times (24/365)	Frequency of Use: 5-10 Times Per Month (Incidents)	Frequency of Use: Rarely (Major Incidents) (X)	Estimated Cost	Notes
RECOMMENDED								
U1	Install Upper Roadway Active Traffic Management System (ATM)	U	Reduce Crashes; Reduce Clearance Time	■	■	■	$5,400,000	Reduce rear-end crashes, provide advance warning of queues and blockages, variable speed limit, flexible lane use.
U2	Install Positive Striping/Lane Markings	U	Reduce Crashes	■			$250,000	For entire corridor.
U3	Construct Refuge Pullouts	U	Reduce Clearance Time		■	■	$2,500,000 (1 pullout) to $5,000,000 (2 pullouts)	SPD and SFD support this option.
L1	"Smart" Traffic Signals/ITS (Spokane Street from Harbor Avenue to I-5)	L	Manage Disruptions	■	■	■	$6,000,000	Includes fiber, CCTV, detection.
L2	Swing Bridge Delay Information System	L	Manage Disruptions	■			$950,000	Leverages rail delay information system.
L3	Rail Crossing Delay Information System	L	Manage Disruptions	■			$600,000	
L4	Establish Duwamish Waterway User Group	L	Manage Disruptions	■		■	$0	SDOT staff initiative.
L5	Terminal 5 Gate Management and Port of Seattle/City of Seattle MOA	L	Manage Disruptions	■			$0	Via Terminal 5 mitigation MOA.
C1	Staff TOC 24 X 7	U/ L	Manage Disruptions		■	■	$875,000/yr	Provides Citywide service, not justified solely for WSBC.
C2	Enhance Alternative Routes via ITS	U/ L	Manage Disruptions		■	■	$6,600,000	ITS and signal enhancements along alternative route corridors.

Attachment A: End Notes

1. *West Seattle Bridge/Duwamish Waterway Corridor, Whitepaper and Priority Investment List,* SDOT, September 9, 2015
2. *West Seattle Bridge Corridor Improvements, Progress Report on Whitepaper and Investment List*, May 27, 2016
3. *Terminal 5 Improvement Project, Transportation Technical Report for Final EIS*, Port of Seattle, October 6, 2016
4. *Coal Train Impact Study*, SDOT, 2012
5. SW Spokane Street Swing Bridge Opening data, 2016, provided by John Buswell, SDOT
6. Christopher Eaves, SDOT
7. Meeting with Casseday Consulting, SDOT, SFD, SPD, March 10, 2017
8. Personal conversation with Captain Simon Ressner, Fire Department-City of New York, Bureau of Operations- Office of City Planning, March 3, 2017