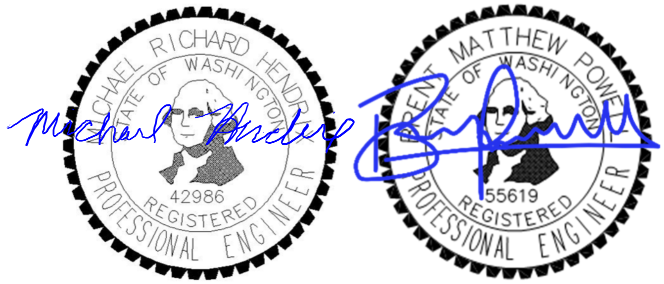


PERTEET

505 FIFTH AVENUE S, SUITE 300
SEATTLE, WA 98104
206.436.0515

TRAFFIC ANALYSIS REPORT (REVISED)

Port of Kingston
Lindvog Remote Ferry Holding Lot

Submitted to
Port of Kingston and Project Partner Agencies

May 1, 2020

perteet.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

The Kingston-Edmonds ferry route handles the second-highest annual volume of vehicle and drivers (over 2 million) and the third-highest volume of additional passengers (1.9 million) in the Washington State Ferries (WSF) system. During peak and near-peak periods, the on-dock ferry terminal holding areas fills to maximum capacity, forcing ferry traffic to queue within the travel lane on State Route (SR) 104 from the ferry terminal (SR 104 milepost 24.44) to Lindvog Road NE (SR 104 milepost 23.89) and on a variable-width shoulder from Lindvog Road NE to Balmoral Place NE (SR 104 milepost 22.49). The ferry traffic queue creates congestion on SR 104 in Kingston, blocking intersections or commercial driveways, and prohibiting local traffic from access to downtown Kingston. The traffic conditions can result in near or full gridlock in Kingston.

The Kingston-Edmonds Ferry, while operated by WSF, is part of a larger, regional transit and community system that also includes Washington State Department of Transportation (WSDOT), Kitsap Transit, Kitsap County, Port of Kingston, and the Kingston community and businesses.

The Port of Kingston, leading the effort for the Project Partners (WSF, WSDOT, Kitsap Transit, and Kitsap County), is revisiting the feasibility of a remote ferry holding lot. The remote holding lot—planned at the southwest quadrant of the SR 104 and Lindvog Road NE intersection—will be a temporary parking area for ferry vehicle traffic. In addition to providing extra storage space for queued vehicles, the lot will meter egress traffic. The primary goal for this facility is to remove the ferry-traffic congestion in downtown Kingston that restricts local traffic access and mobility.

Port of Kingston hired Perteet Inc. to analyze the feasibility of the remote holding lot at the proposed site. As part of this effort, Perteet modeled and evaluated traffic operations through Kingston with and without the remote holding lot. Our traffic operations review included two main components. First, we studied active traffic management (ATM) strategies for the remote holding lot, focusing on how the lot should operate to best achieve the primary goal for the project of managing queuing through Kingston. Second, we simulated traffic demands for the local roadway network and ferries to test the proposed ATM systems. We modeled traffic operations with the remote holding lot in 2040—consistent with the WSF Long-Range Planning horizon. Our observations and analysis from the traffic simulations helped us refine our ATM recommendations.

Our key findings from this traffic analysis effort include the following:

- The site should be designed to accommodate at least 380 vehicles to satisfy peak ferry-traffic demands through 2040, though infrequent extreme peak periods will require temporary shoulder queuing on SR 104;
- The remote holding lot can achieve its primary goal of managing queueing through downtown Kingston, which will improve access and mobility for local traffic;
- The remote holding lot can be controlled by WSF staff or full automation without significant impacts on effectiveness;
- Operating the remote holding lot at all times on all days will result in a more familiar user experience and ensure that queues are always managed through Kingston;
- Using a variable-operations system at the remote holding lot will generally achieve the primary goal of the project, but certain peak arrival periods for ferry traffic will introduce temporary access and mobility restrictions for local traffic through downtown Kingston.

1 INTRODUCTION

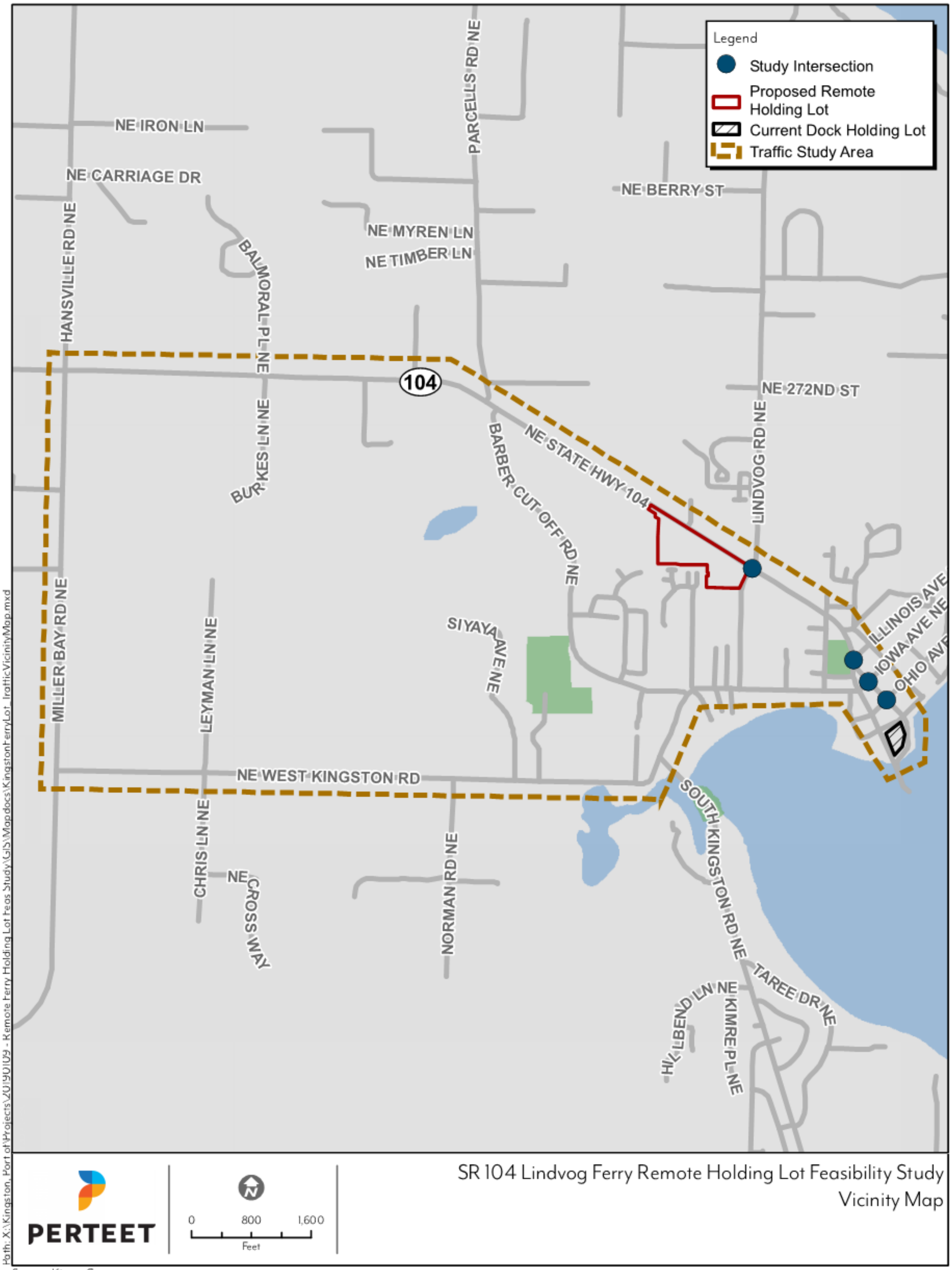
1.1 Project Background

The Kingston-Edmonds ferry route handles the second-highest annual volume of vehicle and drivers (over 2 million) and the third-highest volume of additional passengers (1.9 million) in the Washington State Ferries (WSF) system. During peak and near-peak periods, the on-dock ferry terminal holding areas fills to maximum capacity, forcing ferry traffic to queue within the travel lane on State Route (SR) 104 from the ferry terminal (SR 104 milepost 24.44) to Lindvog Road NE (SR 104 milepost 23.89) and on a variable-width shoulder from Lindvog Road NE to Balmoral Place NE (SR 104 milepost 22.49).

The Kingston-Edmonds Ferry, while operated by WSF, is part of a larger, regional transit and community system that also includes Washington State Department of Transportation (WSDOT), Kitsap Transit, Kitsap County, Port of Kingston, and the Kingston community and businesses. The Port of Kingston (Port), leading the effort for the Project Partners (WSF, WSDOT, Kitsap Transit, and Kitsap County), is revisiting the feasibility of a remote ferry holding lot. The remote holding lot—planned at the southwest quadrant of the SR 104 and Lindvog Road NE intersection—will be a temporary parking area for ferry vehicle traffic.

Port of Kingston hired Perteet Inc. to analyze the feasibility of the remote holding lot at the proposed site. As part of this effort, Perteet modeled and evaluated traffic operations through Kingston with and without the remote holding lot. We also developed a plan for using active traffic management (ATM) at the remote holding lot.

Figure 1-1 presents a vicinity map for our study area, including the existing dock lot location and proposed remote holding lot location.



Source: Kitsap County

Figure 1-1. Vicinity Map.

1.2 Project Need

The ferry traffic queue creates congestion on SR 104 in Kingston, blocking intersections or commercial driveways, and prohibiting local traffic from access to downtown Kingston. The traffic conditions can result in near or full gridlock in Kingston. The current ferry lot at the dock of Port of Kingston does not provide adequate capacity to store all the demand for the ferry system during peak periods. Project Partners have reported that queues on SR 104 for the ferry have extended as far back as Miller Bay Road NE.

Primary Goal

The primary goal for this facility is to remove the ferry-traffic congestion in downtown Kingston that restricts local traffic access and mobility.

1.3 Partner Agency Projects

The Port of Kingston Comprehensive Plan for Harbor Improvements lists over 30 capital improvement plans from 2018 through 2023. These projects involve port improvements that do not directly impact the capacity of the existing or the proposed remote holding lot. Therefore, we did not consider or model these Port improvements.

1.3.1 SR 104 Changes

WSDOT has one project that will directly impact the implementation of the remote ferry holding lot, SR 104 – Kingston Ferry Terminal Traffic Improvement. This project will alter the traffic flow within downtown Kingston to change the existing one-way couplet along Main Street (eastbound SR 104) and NE 1st Street (westbound SR 104) to make both routes two-way. After this change, SR 104 will be on NE 1st Street only. The intersection control along the proposed SR 104 route on NE 1st Street will be as follows:

- Traffic signal at Washington Boulevard NE
- Two-way stop-control at Ohio Avenue NE (stop-controlled approaches on Ohio Avenue NE)
- Multilane roundabout at Iowa Avenue NE with two westbound SR 104 lanes and one lane elsewhere
- Unsignalized "Y-intersection" at the SR 104 and Main Street merge/diverge point

Though construction funding has not yet been identified, the Project Partners agreed that this element should be incorporated into the traffic modeling for the proposed remote holding lot. Accordingly, Perteet assumed that this project will be completed and operational prior to the installation of a remote ferry holding lot, so our modeling of 2040 scenarios reflect the WSDOT SR 104 improvements.

1.3.2 Washington State Ferries Long Range Plan

The current ferry vessels sail on variable schedules with headways ranging between 35 and 60 minutes during most of the day. Current boat capacities per WSF are 188 and 202 vehicles. Perteet used the current WSF ferry schedule for modeling in the existing condition model.

The WSF Long Range Plan (LRP) states that, by 2040, the system will be operating with 30-minute headways using three 144-vehicle capacity vessels. These improvements are scheduled for implementation beginning in 2030. Again, based on Project Partner guidance to incorporate this planned project, Perteet modeled these updates in the ferry schedule and capacities in the various 2040 scenarios and as we developed the size of the remote holding lot.

1.4 Methodology

1.4.1 Remote Holding Lot Capacity

We began our analysis by developing the required capacity of the remote holding lot. We sized the lot to accommodate traffic through 2040. During our analysis, we determined that the peak demand for the lot would occur prior to 2040, likely around 2033, before the full implementation of the WSF LRP improvements.

In discussions with the Project Partners, we agreed to size the remote holding lot to accommodate an 85th percentile queue through 2040. Additional queueing beyond the 85th percentile level will be stored in the shoulder lanes along SR 104. This target achieved a balance of site design and effectiveness.

See Chapter 2 for details on the remote holding lot capacity calculation.

1.4.2 WSDOT Access Review

Since the site fronts SR 104, a managed access state route, we completed an access review consistent with the WSDOT Design Manual Chapter 540. This is documented in Chapter 3.

1.4.3 Active Traffic Management

Just as the dock lots in the WSF system have planned operations, the remote holding lot requires a concept of operations. The ATM elements that we developed, and describe in detail in Chapter 3, further the project goal of limiting queuing through downtown Kingston.

We developed an operations plan that can be carried out using automated or manual methods. At this point, the question of how much staff will be involved at the remote holding lot has not been fully answered. Additionally, the Project Partners are still assessing if the remote holding lot should be under continuous or as-needed operation. We describe the pros, cons, and elements of each strategy in Chapter 4.

Perteet worked with Fehr & Peers to generate the recommended ATM measures. Some of the elements—the allowable egress rate at the remote holding lot, for example—required us to test different configurations with our traffic model to finalize the operations plan. In this sense, the work between the ATM development and traffic modeling efforts were collaborative and iterative.

1.4.4 Traffic Modeling

We developed a traffic simulation model to test the ATM strategies and to visualize and quantify the effects of the remote holding lot in Kingston. We used a traffic modeling program called PTV Vissim (Vissim; version 11), which allowed us to model the complex interactions of ferry traffic, local traffic, WSF operations at the existing dock lot, and anticipated operations at the remote holding lot.

We began by evaluating existing conditions under three typical high-demand periods. Then, we modeled conditions the highest demand condition—summer mid-day traffic on a Saturday—in our horizon year of 2040, which we selected to be consistent with the WSF LRP, under three scenarios: No-Build, Continuous-Use, and Variable-Use. The Continuous-Use and Variable-Use scenarios incorporate the construction of the remote holding lot with different operational schemes.

WSDOT provided data at several intersections within our traffic model. However, we did not have access to data at all of the intersections within our traffic modeling study area, which extended from downtown Kingston to Miller Bay Road NE. We used the WSDOT intersection data as well as state route permanent traffic recorder data to estimate all of the travel volumes for our existing conditions model. For future volumes, we turned to the Kitsap County TransCAD travel demand forecast, provided by Fehr & Peers.

Our analysis focused on four key metrics:

1. **Average queue length** along SR 104 through downtown Kingston approaching the dock lot,
2. **Maximum queue length** along SR 104 through downtown Kingston approaching the dock lot,
3. **Average control delay** for local traffic at four study intersections (see below), and
4. Corresponding **level of service** for local traffic at four study intersections.

The four study intersections that we evaluated are:

- SR 104 at Ohio Avenue NE
- SR 104 at Iowa Avenue NE
- SR 104 at Illinois Avenue NE
- SR 104 at Lindvog Road NE

In addition to data analysis, we leveraged the visualizations of the simulations in Vissim to observe and record videos of the traffic models. This process allowed us to refine the model elements, including the ATM strategies, to ensure that the project goals were being met. It also allowed us to observe areas where the remote holding introduced complications or clear improvements.

Chapter 5 includes full details on the traffic analysis process and the results.

2 REMOTE HOLDING LOT CAPACITY REQUIREMENTS

As reported by Project Partners, the peak hour queue can extend all the way from the ferry terminal to Miller Bay Road NE, with typical peak queues extending to Barber Cut Off Road NE. To alleviate this excessive queuing, the project partners are exploring the use of a remote holding lot. The proposed remote holding lot is located at the southwest corner of the intersection of SR 104 and Lindvog Road NE in the Community of Kingston. Perteet analyzed this space to fit the capacity necessary to capture traffic queuing on SR 104 during peak hours. Our goal was to design the remote holding lot to accommodate a typical peak hour queue length through 2040.

2.1 Existing Conditions Queueing

Perteet collaborated with the Project Partners to establish a capacity target in terms of percentile queueing, specifically the 85th percentile. A percentile is a statistical term for the frequency under which an observation group falls. For example, a 30th percentile score indicates that 30% of the scores within a sample are at or below that value, while the remaining 70% of scores exceed that value.

The Project Partners provided data on wait times in terms of number of hours. Using this data set, we calculated that the 85th percentile queue corresponded to a 2-hour wait time. Using standard vehicle lengths established by WSF, we calculated that that 2-hour wait time translated to a demand of 524 vehicles in the existing condition. That demand included vehicles occupying a full dock lot plus the SR 104 shoulder and storage lanes. That distance for total vehicles translated to approximately Barber Cut Off Road NE, consistent with the Project Partners' observations of that being the typical peak queue length.

2.2 Future Conditions Queueing

Between now and 2040, we anticipate a 19% increase in ferry volumes based on the vehicle estimates in the WSF LRP. This represents a demand increase. However, ferry vessel capacity and sailing schedules will change in the upcoming years with the WSF Long Range Plan. Washington State Ferries will enact improvements starting in 2030 for sailings at higher frequencies such that there will be an increase in the capacity of the ferry system by approximately 23%. Therefore, we expect the peak hour volumes to reach their maximum quantities by around 2033, when the WSF improvements are close to full implementation. After that point, we expect that the capacity benefits will outweigh the increased system demand, and the overall queues formed for the ferry system will be lower than they are today. The Project Partners confirmed that we should design the remote holding lot to accommodate the peak demand to capacity scenario, which is the 2033 horizon, which will have a ferry system 85th percentile demand of 508 vehicles.

Furthermore, the Project Partners directed us to assume that the WSDOT SR 104 project has been completed for our future demand calculations. This project will alter the existing dock lot configuration, and current estimates from WSDOT and WSF indicate that the proposed dock lot design will have 43 fewer stalls for ferry vehicles to use.

The Project Partners directed us to account for one additional variable in this calculation: the shoulder space on SR 104. We agreed that this shoulder space should be retained, so that, in the event that traffic volumes grow over the 85th percentile demand volumes, extra traffic that would not fit in the proposed remote holding lot could safely queue in the shoulder of SR 104.

2.3 Capacity Calculation

Considering the above parameters—85th percentile queueing, designing to the 2033 anticipated maximum demand to capacity ratio, including the WSF LRP and WSDOT projects, and storing the full 85th percentile queue within the lots and not within the shoulder—we developed a minimum capacity requirement of 380 vehicles in the remote holding lot. Note that this value includes a 10% capacity contingency in the analysis to account for the uncertainty of volume modeling and other unforeseen factors.

During conceptual site design, Perteet optimized the site with a conceptual layout of 11 lanes parallel with SR 104, each storing 35 vehicles. Therefore, the remote holding lot is being designed to adequately hold 385 vehicles and will serve as a holding space for vehicles.

3 ROW ACCESS ANALYSIS

The proposed remote holding lot site layout requires two access points to achieve the operational schemes discussed in Chapter 4 of this report. Since SR 104 is a WSDOT managed access highway, these access connections are documented within this Section.

Perteet referenced WSDOT's Design Manual M22-01.16 Chapter 540 to determine the ROW Access requirements. SR 104 adjacent to the proposed site has managed access control (Class 3) per the WSDOT Access Control Tracking System Limited Access and Managed Access Master Plan. Accordingly, we evaluated three sections of the WSDOT Design Manual:

- 540.03(3), which governs private access requirements on Managed Access Class 3 facilities,
- 540.04, which governs corner clearance criteria, and
- 540.05, which governs access connection categories.

Our analysis of each of these are described below.

3.1 540.03(3) Private Access Requirements

Under section 540.03(3)(b) of WSDOT's Design Manual, the legal requirements for Class 3 facilities state that "no more than one access connection may be provided to a [site]. This applies unless it can be shown that additional access connections will not adversely affect the desire function of the state highway in accordance with the assigned managed access Class 3 and will not adversely affect the safety or operation of the state highway". The proposed remote holding lot improves safety and operations along the state highway. The existing conditions of SR 104 has local traffic pass queued ferry traffic lined up on the shoulder, presenting safety and inefficiency issues. The proposed function of the lot will capture these queued vehicles so that local traffic is not impeded by the ferry route. The ferry traffic will have a separate lane as it merges on to SR 104, once released from the lot, such that local and ferry traffic will not interact until passing Lindvog Road NE. Many active traffic management elements are proposed in the holding lot to increase safety and functional operations of the lot (discussed in Chapter 4).

We also considered practical design with design considerations, based off section 540.02, to prohibit the requirements of 540.03(3)(b). Practical Design, per chapter 1100 of the WSDOT Design Manual, discusses identifying baseline need, identifying land use and transportation context, and selecting design control compatible with context. The baseline need of this facility is to alleviate ferry traffic queueing in Kingston, which requires space to safely and efficiently hold vehicles until they can be released to the ferry dock. In order to have a holding lot to do so, a single access point to the facility (including both ingress and egress) would reduce efficiency and capacity. The lot has several conceptual requirements with design vehicle turning movements, site facilities, and drive lanes, that the transportation context requires additional access points. Also, the spacing of ingress and egress of the holding lot meets the minimum requirements for private access spacing for Class 3 of 330 ft. Therefore, the ROW access and proposed remote holding lot ultimately maintain safety and efficiency features.

3.2 540.04 Corner Clearance Criteria

The two proposed access points are nearer to the Lindvog Road NE intersection than any other cross street. The west access point is right-in and is an extension of the SR 104 shoulder that stores excess ferry queues. The east access point is right-out and connects to SR 104 with a new eastbound travel lane that ends at the Lindvog Road

NE intersection. The access points are located 1330 feet and 180 feet from Lindvog Road NE, respectively. Per 540.04, corner clearance spacing must meet or exceed the access point spacing listed in Exhibit 540-1, which is 330 feet for Class 3 facilities. The ingress access point for this site satisfies this requirement. The egress access point for this site does not meet that requirement. Access points that do not satisfy Exhibit 540-1 must satisfy Exhibit 540-2 to meet the corner clearance criteria. The minimum distance from the access connection to a public road is 100 feet for right-turn out only without a restrictive median, which is the situation for the egress access point at this site. We were able to uphold this minimum corner clearance with our exiting access point.

3.3 540.05 Access Connection Category

Permanent access connection categories are dictated by daily vehicle volume for the access point. As discussed in Chapters 4 and 5 of this report, the volumes using the site will vary daily depending on day of week, season, and operational scheme at the remote holding lot. Assuming the remote holding lot is fully operational at all times—the maximum site usage scheme—all ferry traffic using the Kingston ferry will use both access points of the site. Per the WSF LRP, vehicle volumes on the Kingston-Edmonds ferry route in 2040 are estimated at 2,514,400 annually. Assuming vehicles will make one trip per direction on the Kingston-Edmonds ferry route, the annual trips via the Kingston ferry are projected at 1,257,200 annually. In the most balanced scenario of those trips being evenly distributed across 365 calendar days, the daily volume through the site would be over 3,400 vehicles. Therefore, the access connection category for the ingress and egress points of this site are both Category III.

4 ACTIVE TRAFFIC MANAGEMENT

The remote holding lot will require active traffic management (ATM) features. This chapter of the report expands on possible ATM elements that can be implemented in the holding lot and throughout the surrounding roadway network for efficient travel. ATM elements are for arrival to and departure from the remote holding lot and through Kingston to the main ferry dock. We collaborated with Fehr & Peers to develop these strategies.

Existing WSF holding lots use WSF personnel to take payment on arrival to the ferry queue area. WSF personnel will then direct drivers to the appropriate holding lane. WSF loading procedures have WSF personnel directing lanes and communicating with personnel on the ferry to allow vehicles to load. This system allows visual inspection of size of vehicle for loading and allows loading speed to vary based on driver comfort with loading the ferry.

There are existing intelligent transportation system (ITS) elements currently in place on SR 104 to assist drivers traveling to the ferry and to assist both WSDOT, Kitsap County, and WSF to help manage traffic. These devices include warning signs of congestion ahead located just west of Fir Hollow Drive NE and a blank-out sign system including loop detection, controller cabinet and wireless radio just east of Barber Cut-Off Road. When vehicle back-ups on the shoulder are detected via loop detectors in the shoulder, the blank-out sign system is activated and the warning sign assembly begins flashing to alert drivers of the conditions. Figures 4-1 and 4-2 show images of the warning sign and blank-out sign systems, respectively.

Figure 4-1. Congestion Warning Sign

Figure 4-2. Lane Use Control Sign at Barber Cut-Off Road

4.1 Active Traffic Management Concepts at the Remote Holding Lot

Active traffic management (ATM) are strategies to manage traffic such that operations are working efficiently, and traffic is flowing smoothly up to the facilities capacity. The ATM methods that we will discuss are options for the current and future conditions of the study area.

Traffic into the remote holding lot will enter via eastbound SR 104. As discussed later in this section, the remote holding lot may operate with continuous-use or variable-use operations, however, for several reasons discussed later, continuous-use operations is recommended and this recommendation has been concurred by the Working Group. In either case, there will be ATM elements such as variable message signs, traffic signal indications, lane use signals/signs, and/or WSF staff controlling vehicles within the remote holding lot. The concept of operations for the remote lot is described below. Note that a reservation system was not analyzed as part of the ATM concept. A reservation system may be employed at some time in the future but was not considered for the operation of the holding lot.

4.1.1 Entry to the Remote Holding Lot

At the entry point of the remote holding lot, a license plate reader (LPR) camera is installed to record the order of vehicles that enter the remote holding lot. For system reliability, two LPR cameras are proposed to be installed. Each camera would be located on illumination poles. One LPR camera would collect the rear license plate while the second camera would capture the front license plate. The purpose of this LPR camera will do the following:

- Track the time and date for entry into the lot. The intent is to ensure that vehicles leave the lot in a determined order to prevent line cutting.
- Remove the license plate from the database of vehicles passing signs when indicating that the lot is operational as described in section 4.3.3.

The vehicle then activates an in-ground detection system at a ticket dispenser and gate unit. The detector will activate or turn on the ticket dispenser. The use of the detector is meant to prevent vandalism or other behavior that would allow someone to continue pressing the ticket button to get additional queue tickets.

Multiple entry treatments were considered at the remote lot in addition to the ticket dispenser. These included the following:

- No control. Order of entry vehicles would be via LPR cameras
- Traffic signal control similar to a ramp meter. Order of entry vehicles would be via LPR cameras

These alternatives were not chosen for the following reasons:

- Reliability of technology. The LPR can detect a number of vehicles entering, however, it is possible that one or more vehicles may enter the lot and not be tracked. This could create a situation at the dock where the vehicle had entered in the correct order but was not caught in the system. Due to this, it would be unclear if they were in the correct order by the ticket booth attendant. The use a ticket and an LPR system would create a backup system to minimize this event.
- Requirement to control entry rates. As the holding lot lanes fill, the number of vehicles able to fill one lane will decrease. As this occurs, the system needs to be able to accommodate the time needed to change the lane use control signs as described in section 4.1.2. A system with no control does not allow this to occur.

Early in the development of the entry concepts, fare collection was proposed to be relocated to the remote holding lot. This was dismissed for several reasons. These include safety of the fare collection being away from the main point of activity. Further, depending on if the lot is operated in a part-time configuration, the fares will need to be removed and transported to a safe location requiring additional staff and security. Second, one of the requirements of WSF staff is to review the vehicle for safety and security concerns when boarding a ferry. Doing this check before entering the secure area of the dock could lead to potential safety concerns. An additional check at the dock would require the addition of WSF staff.

The ticket dispensing machine will issue a ticket with the following information:

- Lane Assignment. This will be a large number and the most prominent of the text on the ticket.
- Bar code or QR code. This code is intended to be read by equipment at the ferry dock to ensure that vehicles are in the proper order at arrival at the dock.
- Sequence number. This would be the number of tickets issued in sequence.
- Time and date of issuance. This information, along with the sequence number, is a catch all in case the scanning equipment at the ferry toll booth is broken or inoperable.

In addition to providing the ticket, the machine will provide a voice message similar to the following: *"Proceed to Lane X"* where X is the number of the lane available.

Combined, the ticket provides a tactile indication for a driver, the voice message provides an audible indication, and the lane use signals (described in Section 4.1.2) provides a visual indication. These three systems work in series to provide the driver with a clear indication of which lane to proceed to.

4.1.2 Queuing in the Remote Holding Lot

Lane use controls are a critical element of the ATM for the remote lot. The lane use controls will provide the following:

- Direction for drivers entering the lot
- Warning on when the lane is about to depart to the ferry dock
- Information such as wait time. Further information like "Turn off Engine" can also be used
- Alerting to a potential incident either in the lot or on the route to the ferry

To provide this information, two options were reviewed. One option utilizes conventional signal heads (red, yellow, and green ball indications) and lane use arrows (red X and green down arrow). A second option utilized small message boards similar to the lane controls found in the Puget Sound freeway system including I-5, I-90, and SR 520.

In general, the following items were standard in each option:

1. Lane Number Pavement Marking
2. Traffic signal mast arm standards approximately every 175-feet. This was meant to allow maximum flexibility due to incidents within the lot. Further, these structures will also serve as lighting standards, locations for CCTV cameras, and in-ground detection support. Other options such as sign bridges were considered. Due the span length required, the cost for each of these bridges was estimated to be over $500,000. Comparatively, the use of a standard signal mast arm was both lower cost and able to be maintained/replaced if needed without special engineering.

As shown in Figure 4-1, the indications are utilizing conventional signal heads and lane use controls. This lower cost option directs a driver to the correct lane using the lane control signal heads. A static lane number sign is above each lane control and signal indication for clarity. Once the driver enters the lane, they proceed in a line. In the entering lane, only a red signal indication is shown at the front of the line. For a line preparing the leave for the dock, a flashing yellow light begins. The intent is that this light begins flashing simultaneously with the green light of the lane that is departing before it. Finally, for the lanes which are departing to the dock, a green indication is shown. This is demonstrated in Figure 4-3.

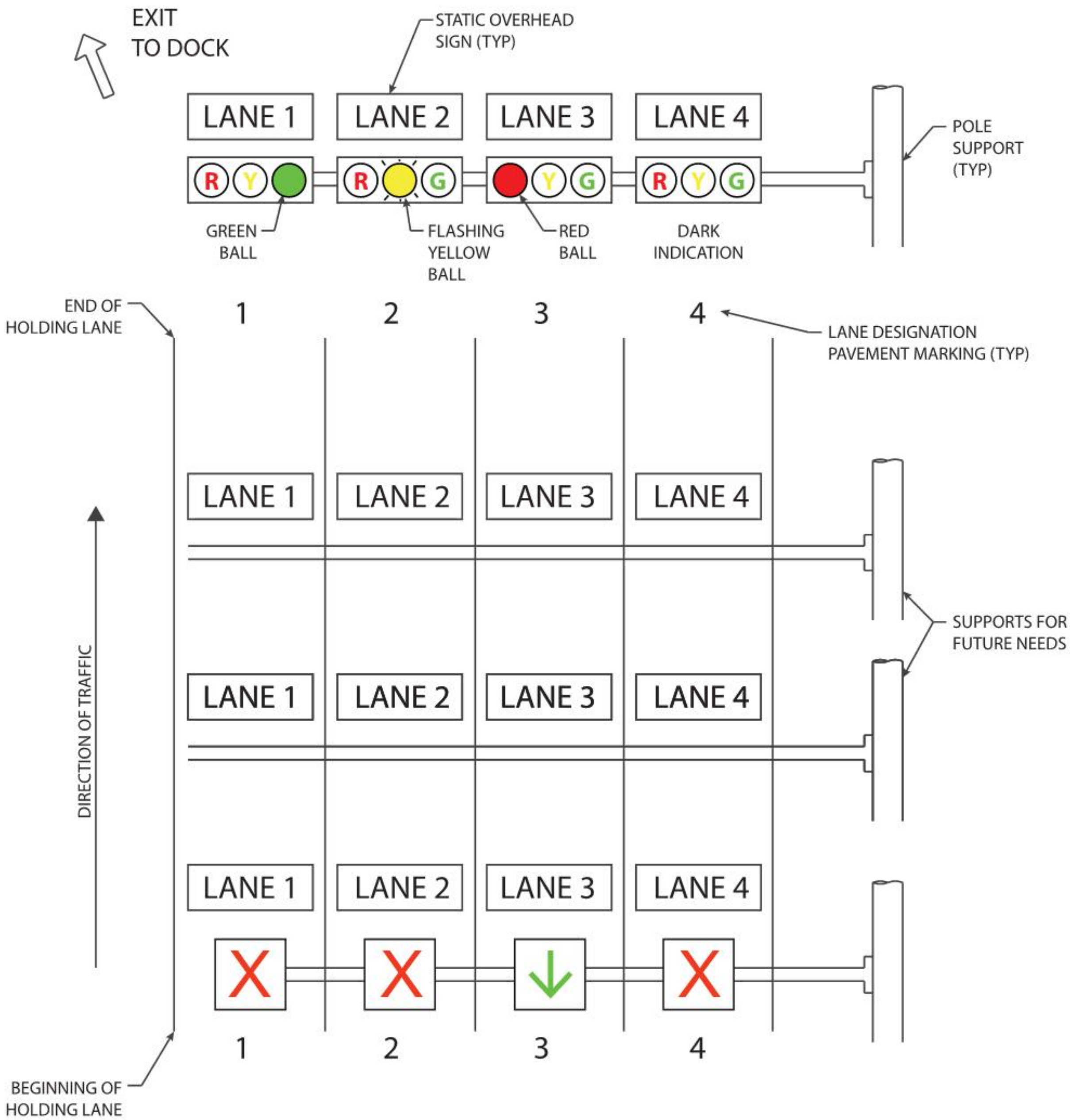


Figure 4-3. Holding Lot Indications – Standard Signal Heads

There are many challenges with this option. These include that the flashing yellow indication is not used to indicate a prepare to start action in our roadway system. As such, signing or other educational methods would be needed. Further, the use of just signal indications prevents an ability to alert drivers of conditions to be prepared for, up to and including, incidents within the lot, such as a stalled vehicle. However, use of these signals along with WSF staff, could mitigate any potential challenges.

Option 2 uses variable message signs above each lane. These boards convey messages to the drivers in each lane group and can be changed as needed. This configuration is shown in Figure 4-4.

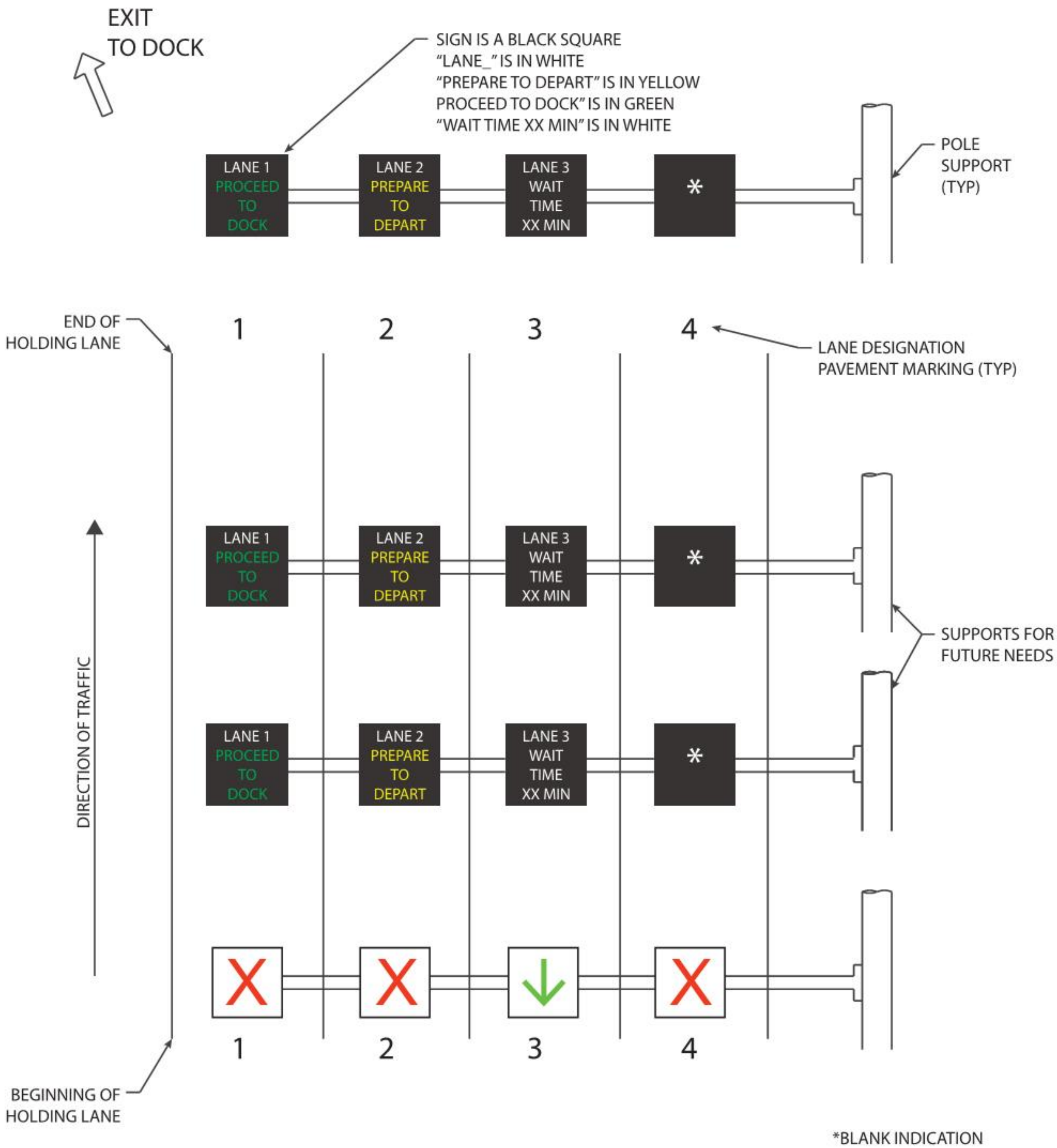


Figure 4-4. Holding Lot Indications – Variable Message Signs

Instead of using red/yellow/green signal heads to indicate the dismissal of lane groups, the message sign is used to indicate what the driver should do. The standard messages and expected actions are listed below. Note that for all signs, the lane number would be indicated above each message.

- PROCEED TO DOCK. Message would be in green letters. The message would be shown to the lane that should proceed to the dock
- PREPARE TO DEPART. Message would be in yellow. The message would be shown to the lane that is to depart after the lane that was just shown PROCEED TO DOCK
- WAIT TIME XX MIN. This message is expected to be in white. This is an informational message shown to the lanes waiting to depart. This message may also switch between the wait time and a DO NOT IDLE message

The size of the signs are estimated to be 6-ft by 6-ft with 8-inch letter heights. This will provide visibility of up to 240-feet from the sign for drivers. Due to the length of the holding lot, the use of multiple signs in one lane is expected. An additional benefit to using variable message signs is that they can serve for incident response management, which is discussed in Section 4.1.4.

For mounting options, two options were considered for the variable message sign option: signal mast arms and monotube sign bridges. A qualitative review of sign bridges indicated that the sign bridge for a large span would be in the vicinity of $500,000. Four of these signs would cost almost $2 million. Use of signal mast arms would be a lower cost, however, the poles would need to be sized to accommodate the additional loads. Using pre-approved signal mast arm poles, it was determined that a pole capable of accommodating a 60-ft mast arm would be required even though only a 40-ft mast arm would be required for the proper placement of the variable message signs. For comparison, each mast arm pole, including foundation, is estimated to cost $40,000. There are 12 poles and mast arms on the site. This results in a cost of $480,000 which is almost the cost of one sign bridge. One additional advantage of the mast arm pole option is the ability to have illumination integrated into the pole and not requiring additional poles and foundations as a sign bridge would require.

Detection and Monitoring

A critical ATM element in the remote holding lot is detection for vehicle location and the resultant lane capacity. We reviewed the following technologies:

- Video detection
- Conventional Loop Detection
- In-ground micro-radar "pucks"
- Radar detection

Video detection was disregarded due to the necessity for consistent detection with minimal chance for failure. Missing a lane detection would be a critical failure in the operation of the lot. Loop detectors were disregarded due to the need for multiple loops and the potential for pavement failure. Pole mounted radar detection was also reviewed. This type of detection is being used successfully in WSDOT's Olympic Region and could be used for this application. The detection can cover multiple lanes and when mounted to the signal mast arm poles, could adequately cover the holding lot area. The use of the microradar "pucks" was chosen due to the reliability and low impact in the pavement. Due to the overall low cost, these pucks are placed at 50-foot intervals in each lane to maximize the detection. The use of any of the four detection types are not precluded from being used. For both video and radar detection, the number of poles and mast arms located throughout the holding lot would also provide locations for the devices to adequately cover the lot and provide detection.

Detection of some vehicles such as motorcycles and large tractor-trailer vehicles could be missed by the LPR camera due to occlusion or the small size of the license plate. In a continuous operation model and when the lot is not being fully used, this should not be a problem as most vehicles will still be able to use the next ferry. However, even in high use times, the obtaining of a ticket with a sequential number would serve as a backup to an LPR camera not being able to identify the vehicle. Further, during times when the volumes are expected to be high, such as Sundays during the summer, some WSF staff are expected to be in place at the holding lot to serve as a backup to the system. These staff members can be used to identify vehicles that are provided priority boarding, such as vanpools and government agency vehicles, and direct them to the Bypass Lane on the southern part of the lot. Although the detection system is intended to detect times when the lane is becoming full, there is the potential that vehicles may over run the holding lane length. In those circumstances, the use of on-site staff will prevent these situations.

Surveillance of the lot from a remote site is critical. To perform this operation, closed circuit television (CCTV) cameras can monitor both the capacity of the lot and determine if there is an incident. Further, the use of CCTV's would allow WSF staff to determine if the lot was ready to be activated under the variable-use option. CCTV cameras along with wireless sensors can be mounted to the signal mast arm poles throughout the site and provide adequate coverage.

4.1.3 Exiting the Remote Holding Lot

Once the lot at the dock has boarded a ferry and has capacity for additional vehicles from the remote holding lot, one lane is released with one of the ATM indicators described above (standard red/yellow/green signal or variable message sign). As vehicles leave the lot, a LPR camera will monitor the order of vehicles leaving to prevent line cutting. To enter SR 104, vehicles from the remote lot will have a separate lane to the right of the through/right turn lane on the eastbound approach of SR 104 at Lindvog Road NE. Ferry traffic will not directly interact with local SR 104 traffic, since the local traffic will have a separate lane, as well, closest to the centerline. This lane for local traffic will be able to go straight on SR 104 and turn right onto Lindvog Road NE. A special phasing sequence will be initiated to allow for continuous operation between the remote lot and the ferry dock. Further, a NO TURN ON RED blank-out sign would be installed on the existing signal mast arm for eastbound traffic in addition to two additional traffic signal heads.

As noted in Section 5.3.2, we used our traffic simulation models to test and confirm that releasing one lane from the remote holding lot at 7-minute intervals minimized queueing in downtown Kingston per the project goals.

4.1.4 Incident Management

Perteet has considered possible incidents that could occur throughout the time drivers spend in the remote holding lot. The proposed remote holding lot is conceptually designed to fit emergency vehicles that may need to reach a driver or incident within the lane groups. The gate entry and perimeter of the facility are equipped to function for the maximum turning movements of a WB-62. Therefore, any emergency response vehicles up to that size can access any of the holding lanes during an incident.

The variable message signs (if chosen instead of standard signals) above each lane group, spaced throughout the holding lot, will also serve as a major tool for communicating to all drivers during an incident. If a car stalls or blocks a lane, arrows above the lane group will notify drivers of the situation and point in the direction of what lane to transfer to. At this time, we assume that WSF staff would be able to activate or deactivate any of these messages, and that the puck detection system could notify staff of irregularities with a lane that has been given clearance to proceed but is not doing so.

Additionally, a public announcement (PA) system for the remote holding lot, which can be heard throughout the entire lot will be employed. This audio system can be used for announcements, alerts, and instructions in the case of emergency situations to help all drivers in conjunction with the visual signing. The remote holding lot will be able to portray incidents visually and audibly to drivers with the use of information displays and a PA system. For design purposes, the PA system should be designed and installed in a manner to minimize sound into the adjacent residential neighborhood. Locations of multiple directional speakers on the mast arm poles facing away from the neighborhood would help address that concern.

4.2 Remote Holding Lot Activation and Operational Strategies

The operations for the remote holding lot can either be continuous-use or variable-use. If continuous-use operations are in effect, ferry travelers will not be subject to any confusion during lot activation and deactivation because those transition periods would not occur. Additionally, guide and regulatory signing to the holding lot would be standard static signing. However, at some off-peak times the remote lot is not necessary to prevent queues from forming on SR 104.

Regardless, if the remote lot is used on a variable or continuous basis, the same ATM elements as described in section 4.1 would still be required for the remote lot. Additional ATM features would be required for variable-use operations outside of the lot, including dynamic signing (either conventional signing with flashing lights or variable message sign boards) to notify drivers when and when not to use the remote holding lot and vehicle tracking items such as additional LPR cameras and CCTV cameras.

Table 4-1 summaries some of the differences of the remote holding lot with continuous-use and variable-use operations.

Table 4-1. Continuous-Use vs Variable-Use Operations

Factor	Continuous-Use	Variable-Use
Consistent ferry route	x	
Activation / deactivation of ATM systems for lot status		x
Dynamic signage throughout Port of Kingston		x
Continual monitoring of RHL	x	

Perteet will continue to work with the Project Partners to decide the best operation timing for the remote holding lot. The following section details strategies for activation/deactivation of the lot for the variable-use scheme. And Chapter 5 details the differences in traffic analysis metrics between the two options.

4.3 Active Traffic Management Concepts outside the Remote Holding Lot

If continuous-use operations are chosen for the remote holding lot, additional ATM will consist of new signage throughout downtown Kingston, which will be discussed further in this section. Once a lane group is released from the remote lot and vehicles approach the tollbooth at the dock, there will be more license plate readers to guarantee the order and validity of vehicles in the queue. The tollbooth operations will remain the same as existing conditions, and the main lot will have a dock controller if the variable-use operation is chosen. Otherwise, no additional ATM features will be implemented at the main holding lot.

4.3.1 Variable-Use Activation

If variable-use operations are chosen, more ATM elements will be implemented between the dock and the remote holding lot. The activation is shown in Figure 4-5.

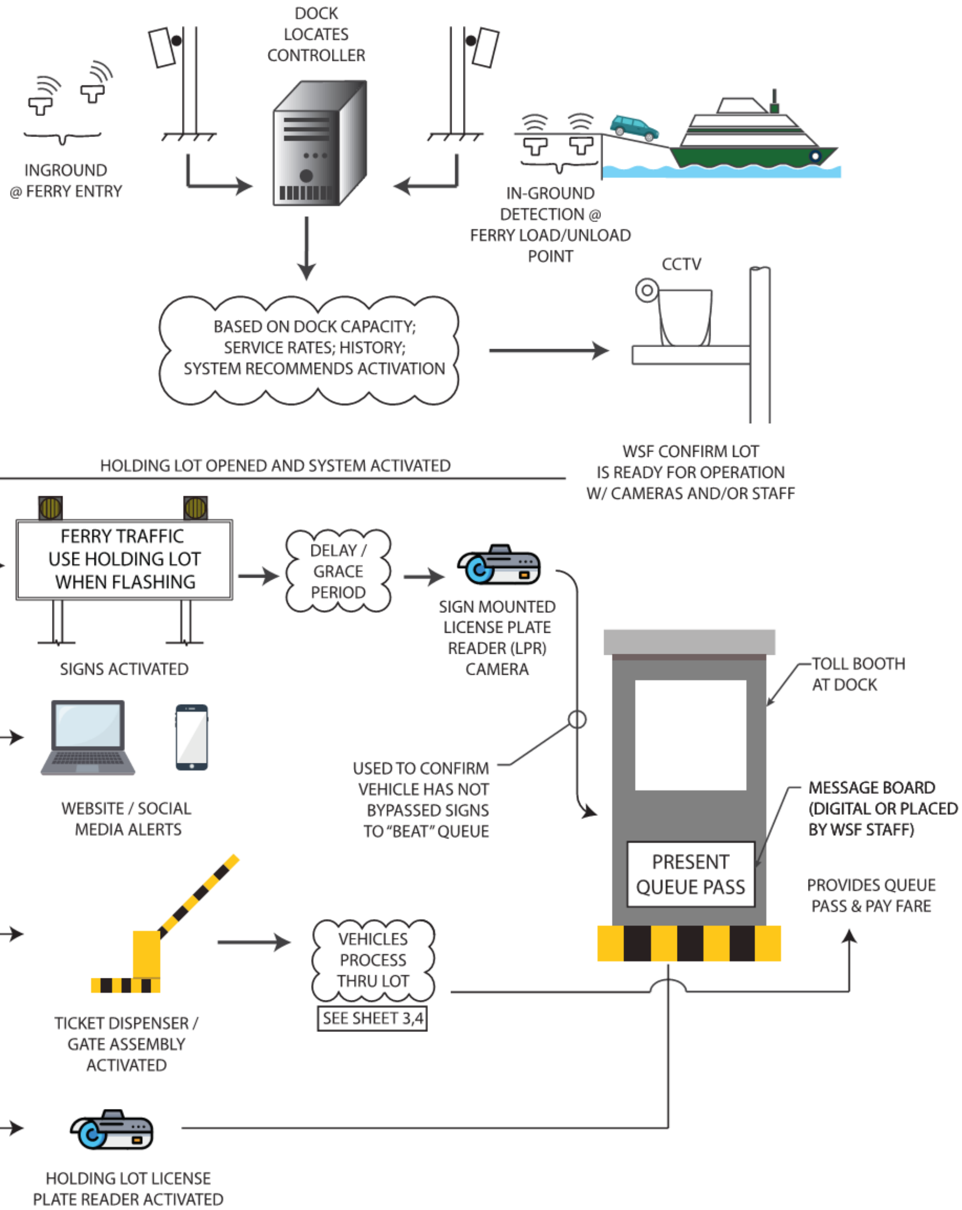


Figure 4-5. Activation of Remote Holding Lot with As-Needed Operations.

The activation process begins at the ferry dock.

A master controller will review the following:

- Available dock capacity. A threshold of dock capacity would automatically be triggered. This value would likely be in the 75% to 85% range and is meant to alert when there is a lower capacity on the dock. Further, this value will change depending on ferry scheduling.

- **Entering service rates.** The service rate will track how many additional vehicles are entering the dock
- **Historical information, such as sailing capacities based on similar time periods in prior years.** Based on prior data, the capacity of the dock may be adequate for a specific sailing, but the dock capacity thresholds and service rate thresholds may be met. To prevent activation of the lot for a brief time period, this information can be used to prevent a recommended activation.

Once these thresholds are met or exceeded, the controller would recommend activation of the remote holding lot. The WSF supervisor may override the system if they see that the system is observing a temporary issue which may be resolved in a timely manner. The supervisor may also activate the system if none of the thresholds are met due to other information, such as a large volume of traffic incoming. One example would be the opening of the Hood Canal Bridge after an extended closure.

When the remote holding lot is opened and the system is activated, signage throughout downtown Kingston will display text that the lot is in use and license plate readers will began tracking car behavior and order in the queue.

4.3.2 Variable-Use Deactivation

Conversely, the deactivation process is shown in the chart in Figure 4-6.

If the rate of entry into the remote holding lot is less than the rate of exit, the ferry dock is under one boatload of queued vehicles, and queue loops do not indicate backups on SR 104, the system will recommend deactivation of the remote holding lot.

To achieve the processes shown in Figures 4-3 and 4-4, the variable-use operations will require more ATM components between the dock and the holding lot, including: in-ground detection at the ferry entry, dock controller, dynamic signage, message boards at the tollbooth, and queue loops on SR 104.

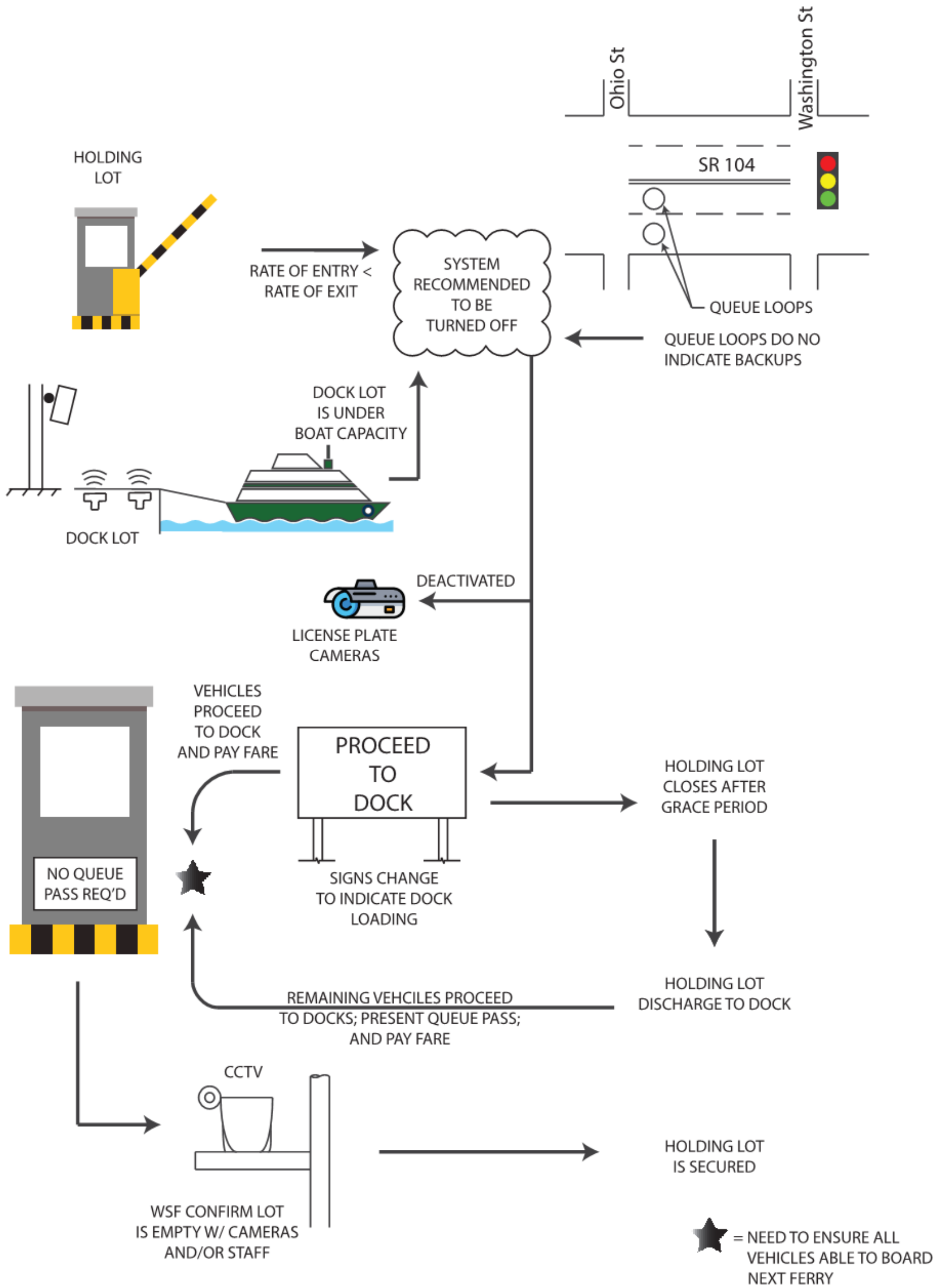


Figure 4-6. Deactivation of Remote Holding Lot with As-Needed Operations.

The activation and deactivation are shown in Figure 4-7 as a flow chart based on the various inputs.

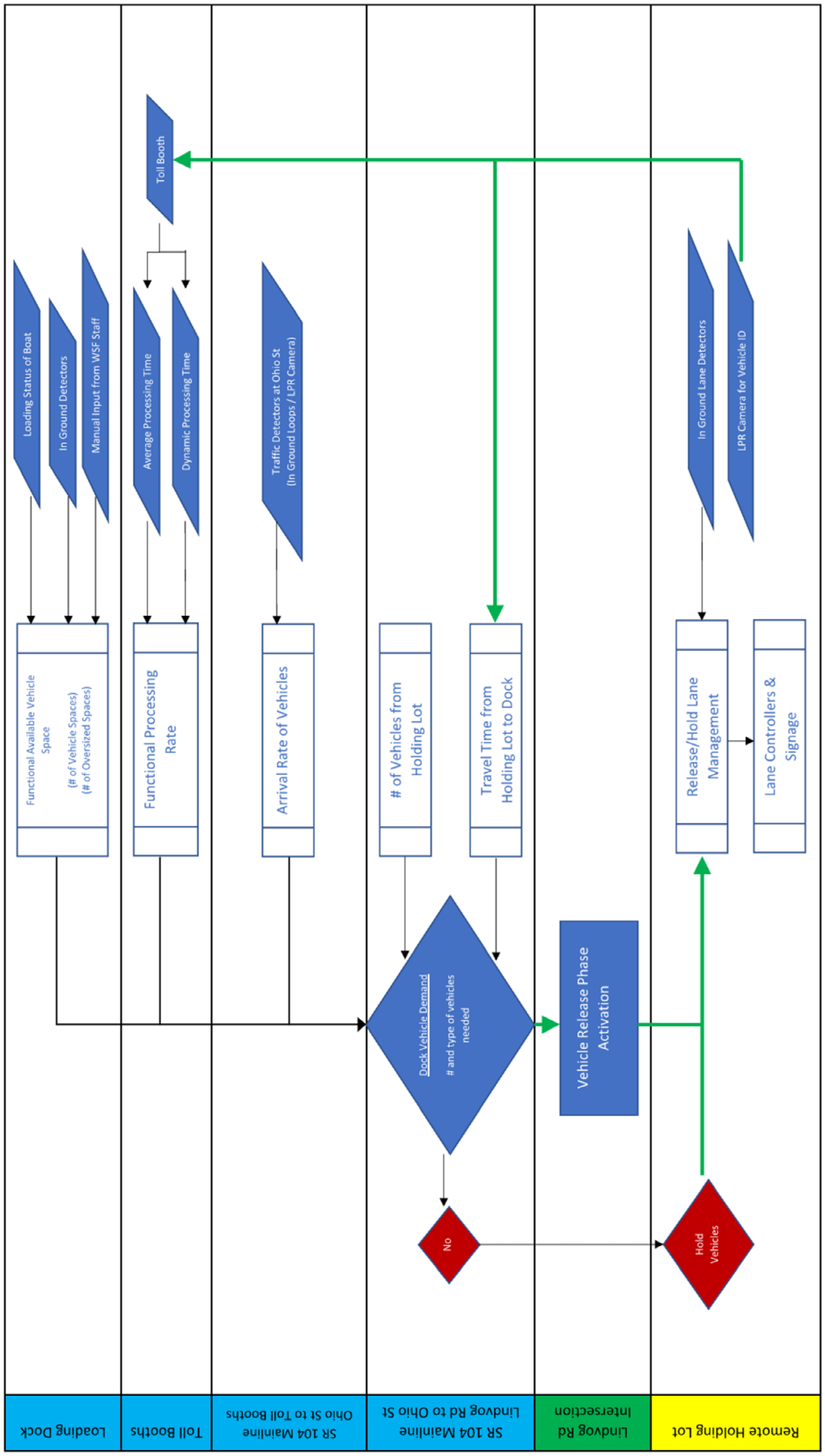


Figure 4-7. Flow Chart of Deactivation of Remote Holding Lot with As-Needed Operations.

4.3.3 Remote Holding Lot Signage

As mentioned at the beginning of this section, new signage will need to be added throughout the Kingston roadway network to show how to access the holding lot, regardless of whether continuous or variable operations are chosen. These signs will be located on major routes in downtown Kingston, such as SR 104 and NE Kingston Road, as well as on local streets, as shown below.

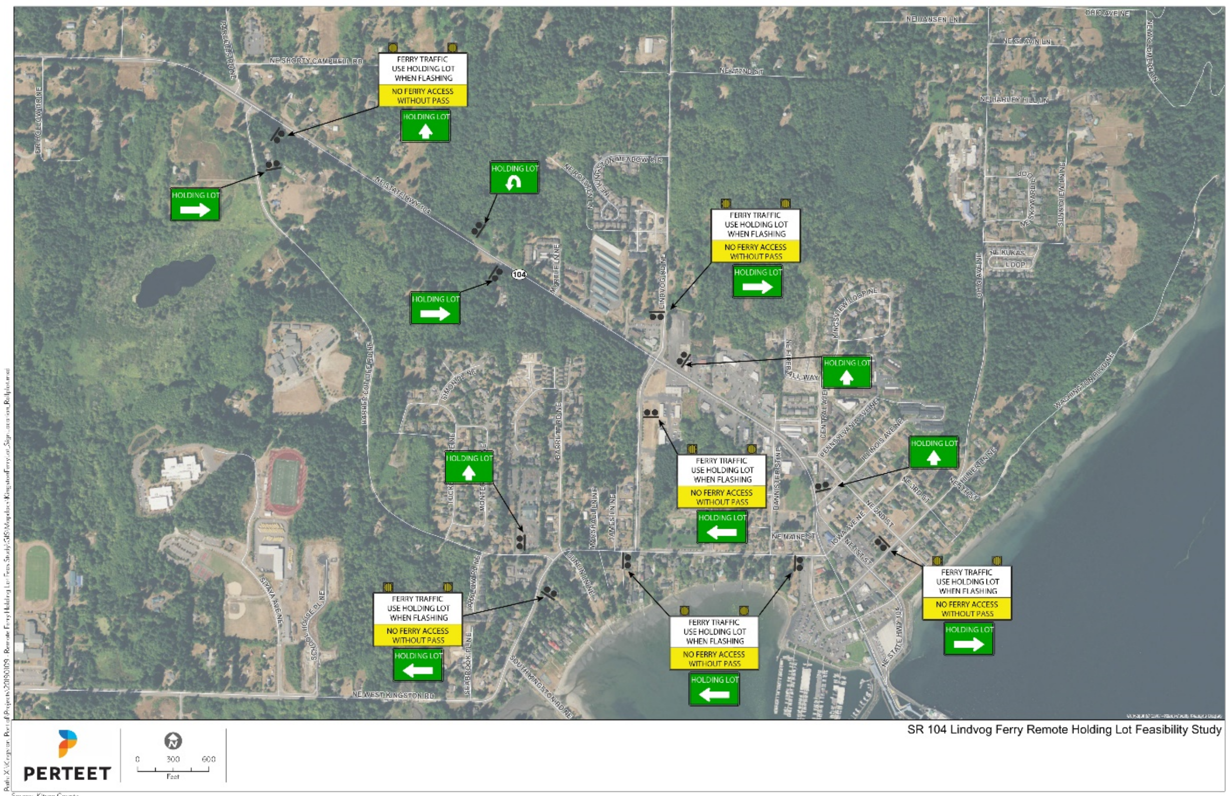


Figure 4-8. Remote Holding Lot Signage Locations

The purpose of these regulatory/guide signs is to direct traffic to the correct location in order to queue for the ferry. This may result in directing traffic to the remote holding lot or to the ferry dock.

As shown in Figure 4-8, these signs will emphasize no ferry access without going through the remote lot first and will point in the direction of the lot. This figure exemplifies static signing with flashing warning lights that could be used if the remote holding lot is used on a variable-use basis. Use of variable message signs (VMS) is also a possibility, however, the use of VMS would result in a higher capital cost.

In addition to providing direction on when to use the remote holding lot, these signs would also serve as a location for LPR cameras. Due to the disparate nature of traffic accessing the ferry, it is possible for a driver to disregard the flashing lights and instead proceed directly to the ferry dock. In those cases, it is difficult for the toll booth operator to know when the vehicle passed by the flashing light. To prevent this judgment, the LPR camera system can notify the tollbooth operator of such events.

In additional conversations with the Working Group, the use of LPR cameras located on County roads would likely result in community complaints as the system would gather license plate data from all vehicles passing these points. The monitoring system would be programmed to "drop" the license plate data after a specific time frame (e.g. 30 minutes) to prevent the use of the system for tracking in addition to reducing the computational storage. However, the presence of the camera would still be a community concern. Due to this reasoning, LPR cameras are not recommended for use on the directional/regulatory signing. Since this element is key to assisting the WSF staff in determining the appropriate order of vehicles arriving at the dock, a variable-use operation of the lot would be difficult to enforce.

If the remote lot is under continuous-use operations, flashing lights to notify drivers of remote lot activation would not be required.

4.3.4 Dock-Lot Operational Considerations

Similar to other ferry lines, the remote holding lot will uphold standard protocol for ferry traffic queueing. If a driver leaves the queue at any time, the driver forfeits their place in line and will need to rejoin the back of the queue. No new ATM elements will be added to stop this from happening. To prevent drivers from skipping the remote holding lot, tollbooth attendants at the main lot will not allow drivers to proceed without license plate number verification. Tollbooth attendants can check the CCTV or license plate reader to verify the validity of the vehicle in the queue. A set of LPR cameras located after the Ohio Street intersection will provide an alert to the ferry operators of this condition.

4.3.5 Offsite ITS and ATM Elements

Between the remote holding lot to the dock, other ITS and ATM elements are required to maintain an operational system and to guide ferry traffic to the dock. The following items are required and should be coordinating with outside agencies that have projects within the Kingston area. Supporting ATM elements and the purpose of those elements along with the coordinating agency are shown in Table 4-2.

Table 4-2. Offsite ITS and ATM Elements.

ATM Element	Coordinating Agency	Purpose of Element	Notes
On-dock wireless sensors and wireless access points	WSF	Track dock lot filled capacity	For the basis of design, wireless sensors were used, however, other detection methods may be utilized depending on final design.
Signal controller upgrade at SR 104 and Lindvog Rd	WSDOT/ Kitsap County	An upgraded controller will accommodate the addition of the remote holding lot signal phase and connection to the remote holding lot controllers.	
Back of Queue detection at SR 104 and Ohio St	WSDOT/ Kitsap County	Addition of queue detection (loop detectors) at SR 104 and Ohio Street will provide information to the remote holding lot for modifications to the rate of release. This is intended to prevent queue backups in downtown Kingston.	This element, combined with information from the toll booths on service rates, will provide additional information to modify the release rate at the holding lot as necessary.
CCTV cameras from Lindvog Rd to Ferry Toll Booths	WSDOT/ Kitsap County	To assist in monitoring traffic conditions along the route. These would be key when arrival rates at the toll booths decline below expected and assume an incident has occurred on the route.	This item is not required for operation of the holding lot, however, this would provide additional information when incidents occur.
Modify the Existing Lane Control sign at Barber Cut-off Road with a new Variable Message Sign	WSDOT/WSF	This would provide ferry wait time to incoming motorists allowing for a choice to proceed to the lot or to change travel plans.	The existing lane use signs would be removed and replaced with the VMS. It is assumed that the existing mast arm and communication equipment can be reused.
Provide communications to Olympic Region TMC	WSDOT	The communication to the TMC would include CCTV camera feeds from the holding lot in addition to calculated wait times based on the sensors.	Wait time information is expected to be distributed to region wide VMS signs such as near Hood Canal Bridge and at decision points where drivers could elect to use other routes and/or ferry routes.

Guide and regulatory signing, including activated signing for variable-use operations, is included in the cost of the remote holding lot. Additionally, LPR cameras located at SR 104 and Ohio Street for determining the arrival rate are also considered to be part of the remote holding lot project cost.

5 TRAFFIC MODELING

Perteet used Vissim to model traffic operations within the study area in each scenario. Vissim is a microsimulation traffic modeling software used by agencies to analyze traffic through multiple coordinated or uncoordinated intersections.

5.1 Model Development

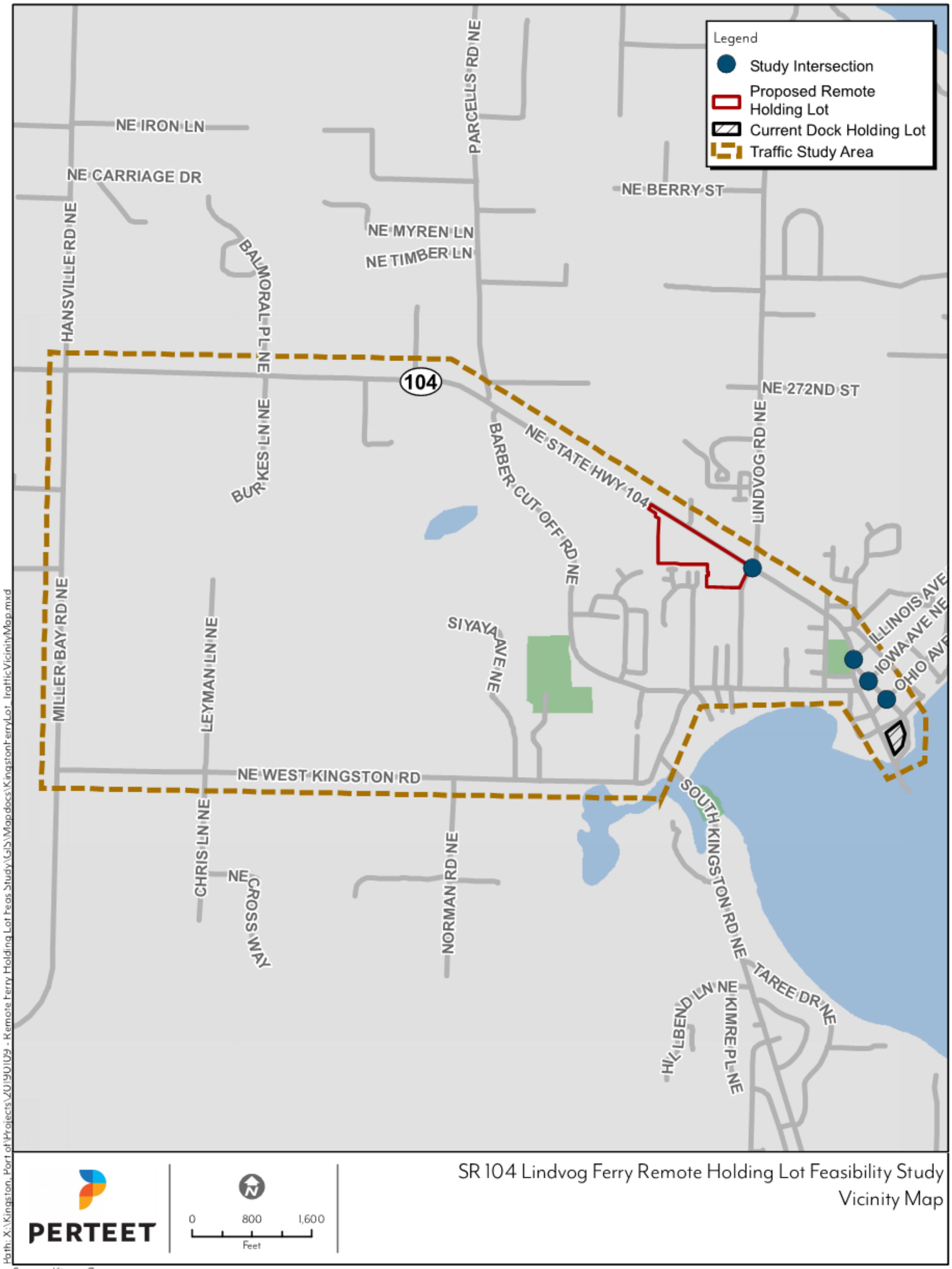
5.1.1 Study Area

Figure 5-1 shows the roadway network used to access the Port of Kingston ferry terminal. The traffic study area is bounded by Miller Bay Road NE to the west, SR 104 to the north, and NE West Kingston Road to the south.

The proposed remote ferry lot location is at the southwest corner of the intersection of SR 104 and Lindvog Road NE in the Community of Kingston. Because the intent of implementing a remote ferry holding lot is to address the queuing, the study area for this project will extend from the Port of Kingston dock along SR 104 to Miller Bay Road NE. Figure 5-2 provides a zoomed-in view of the proposed remote ferry holding lot, existing dock lot, and the roadway network in between.

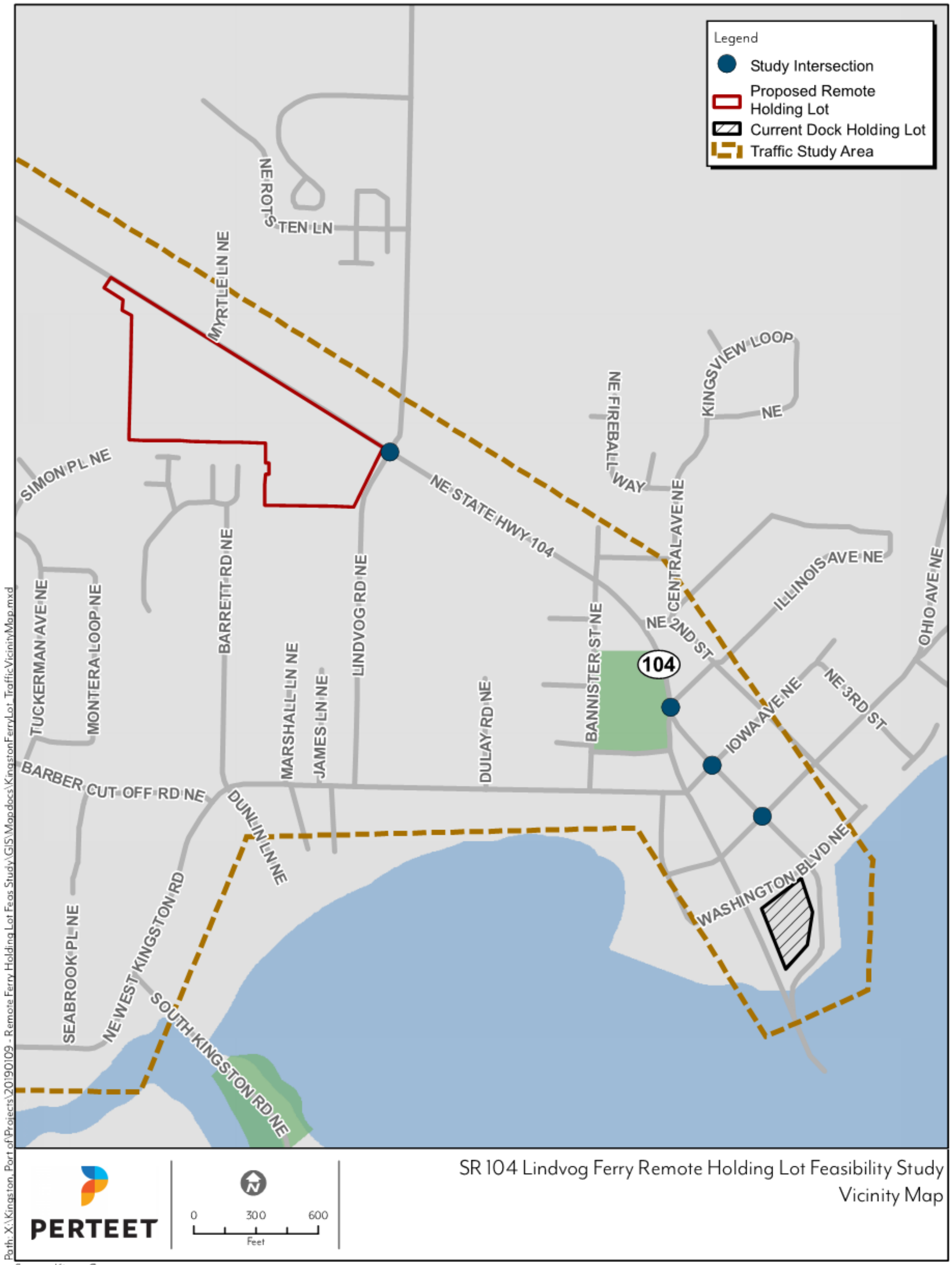
This feasibility study analyzes ferry and local traffic that will be impacted by a remote holding lot. The feasibility study is not focused on improving the existing intersection operations at peak-hours in downtown Kingston. The roadway network includes traffic volumes entering and leaving through the following intersections:

1. SR 104 at Ohio Avenue NE
2. SR 104 at Iowa Avenue NE
3. SR 104 at Illinois Avenue NE
4. SR 104 at Lindvog Road NE



Source: Kitsap County

Figure 5-1. Vicinity Map, Study Area, and Study Intersections.



Source: Kitsap County

Figure 5-2. Zoomed-in Study Area.

5.1.2 Scenarios

We evaluated six total scenarios, using different combinations of peak hours, analysis years, and build conditions.

Peak Hours

We evaluated three project peak hours. The morning and afternoon peak hours reflect maximum weekday travel demands. The midday peak hour reflects maximum weekend travel demands.

We established the weekday peak hours shown in Table 5-1 based on site PTR 095 outside of the study area. This data provided weekday and weekend volumes entering and exiting downtown Kingston. After processing the volumes from PTR 095.

Table 5-1. Peak Hours.

Parameters	Values	Justifications
Weekday AM	9am – 10am	WSDOT Site PTR 095 data from July 2018
Weekday PM	5pm – 6pm	WSDOT Site PTR 095 data from July 2018
Weekend MD	2pm – 3pm	WSDOT Site PTR 095 data from July 2018

Analysis Years

Perteet evaluated 2019 traffic for the existing conditions analysis. The process of estimating and adjusting the existing traffic volumes is explained in Section 5.1.3.

The horizon year for this study is 2040 to match WSF's planning horizon. Kitsap County currently uses a 2036 planning horizon. We established the 2040 horizon year to accommodate both Kitsap County (with some extra growth to scale to 2040) and Washington State Ferries.

Build Conditions

We worked with the Project Partners to establish two build alternatives for us to test. These two alternatives reflect the same operations at the remote holding lot when the lot is in use. However, the alternatives differ in when the remote holding lot is active. The **Continuous-Use** alternative reflects the remote holding lot being active for the full duration of the simulation, and all ferry traffic uses routes to first reach the remote holding lot before the dock lot. The **Variable-Use** alternative begins with ferry traffic proceeding directly to the dock lot and then the remote holding lot is activated during the simulation, at which point ferry traffic begins to adjust routing behaviors to reach the remote holding lot.

Scenarios

These six scenarios we tested are the following:

1. Existing Conditions, AM Peak Hour
2. Existing Conditions, MD Peak Hour
3. Existing Conditions, PM Peak Hour
4. 2040, No-Build, MD Peak Hour
5. 2040, Continuous-Use, MD Peak Hour
6. 2040, Variable-Use, MD Peak Hour

5.1.3 Traffic Volumes

Data Sources

Perteet received several data documents from WSDOT. WSDOT provided us data for morning (AM), midday (MD), and afternoon (PM) peak hours for SR 104 at Lindvog Road NE and SR 104 at Bannister Street NE. These turning movement counts were from various days in September 2019.

Remaining data included AM and PM turning movement counts between February and March 2019. Intersections with turning movement counts included:

- SR 104 Couplet (NE 1st Street) and Washington Boulevard NE,
- SR 104 Couplet and Washington Boulevard NE,
- SR 104 Couplet and Ohio Avenue NE,
- SR 104 Couplet (NE 1st Street) and Iowa Avenue NE,
- SR 104 Couplet and NE West Kingston Road,
- SR 104 and Illinois Avenue NE,
- SR 104 and Bannister Street NE, and
- SR 104 and Lindvog Avenue NE.

This data was used to establish the basis of turn movements and estimate approximate traffic at specific study areas. Since the data was from different months, days, and times observed, we modified the volumes to reflect July volumes during their respective peak hour. This process is further discussed below.

Fehr & Peers pulled volumes from the Kitsap County TransCAD travel demand model, which forecasts to 2036 for the Kingston area. This dataset included segment volumes on major streets in and around Kingston during the PM peak hour. Perteet used this data to isolate traffic volumes to ferry and local quantities and estimate volumes for intersections without any count data. The baseline volumes provided in this data set were from 2016, so we adjusted the volumes to current 2019 data, and then applied growth rates in the same manner that Fehr & Peers projected for 2036 volumes.

Methodology

Perteet separated local and ferry volumes to accurately model the flow of traffic throughout the Kingston region. To consider peak travel times of ferry users, we adjusted all data to reflect July volumes during the weekday AM and PM and weekend MD peak hours. WSDOT permanent count site PTR 095 supported July as the busiest ferry travel month of the year with the most traffic volumes recorded. Our adjustments to WSDOT data reflected how volumes varied during peak hours in comparison to other hours throughout the day in July 2018. Where WSDOT data was not from the peak hour and day of the week we wanted to analyze, we multiplied the data by a conversion factor to estimate data of a specific peak hour.

Perteet acknowledges that Site PTR 095 is the closest permanent count site to use for consistent volumes entering and leaving downtown Kingston, however it cannot be taken as a perfect representation of the traffic in the study area. We used this site data for seasonal adjustments to apply to the select intersections that WSDOT provided turn movement counts for within the study area, using as much downtown data as provided to us.

Existing Local-Traffic Volumes

Traffic movement counts provided from WSDOT throughout several months of 2019 were converted to July volumes. Site PTR 095 provided data for all hours of the day and all days of the week, so our volumes could be adjusted to volumes of the Tuesday 9- 10 AM, Friday 5-6 PM, and Saturday 2-3 MD peak hours.

We identified local volumes from intersection descriptions on the WSDOT turning movement data. At intersections close to the ferry terminal, such as Washington Boulevard NE and NE 1st Street, the turning movements included descriptions of "Ferry Unload" and "Kingston Ferry (Boarding)". Therefore, we could identify the movement of vehicles as local traffic not going towards or away from the ferry. For intersections further away from the ferry terminal without such labels, we assumed local traffic percentages for the different turning movements. For instance, from our PTR data we concluded that most ferry volumes head east during the morning, so we estimated that 40% of the traffic eastbound thru at SR 104 and Bannister Street NE would be local traffic. We applied the 40% local traffic estimate to SR 104 with Bannister Street NE and 10% local traffic to SR 104 with Illinois Avenue NE and NE West Kingston Road with the SR 104 Couplet for traffic flow towards the ferry terminal.

For intersections in the study area with no turning movement count data, we estimated percentages of traffic that would turn at that intersection. We based these percentages off intersections with similar characteristics, such as the southbound movements of NE 1st Street and Ohio Avenue NE total volume being comparable to the southbound movements of NE 1st Street and Iowa Avenue NE. This way known volumes would be distributed appropriately throughout the Kingston network.

2040 Local-Traffic Volumes

Perteet established growth rates for the 2040 Horizon Year with the 2036 Fehr & Peers Kitsap County Outputs. We identified ferry volumes entering the Kingston-Edmonds ferry terminal and followed the traffic flow through NE 1st Street as traffic exits the terminal. We applied the same growth rate Fehr & Peers applied to the 2016 data to attain 2036 volumes and found the 2040 local traffic volumes growth factor of 2.12%.

Existing Ferry-Traffic Volumes

The Fehr & Peers travel demand model provided 2016 July volumes traveling north/south and east/west for Kingston. Boundaries applicable to our study area include the Kingston-Edmonds ferry terminal, NE West Kingston Road, Illinois Avenue NE, SR 104, Balmoral Place NE, and Miller Bay Road NE. Perteet estimated the remaining intersections in our study area through volume balancing from the data-provided segments.

With volumes at all the intersections in the study area, Perteet created an origin-destination (O-D) matrix to identify where ferry traffic begins and ends. Notably, this matrix did not include routes to destinations other than the ferry terminal. We then adjusted the data to be 2019 ferry volumes by applying a growth rate to the 2016 data.

The data provided by the travel demand model only displayed PM traffic, so we adjusted the direction of the origin and destinations to reflect AM traffic since PM traffic is mainly in the westbound direction and AM traffic is headed eastbound. We kept the same origins and destinations for the MD traffic as the PM traffic, since both peak demands are in the westbound direction. We again used Site PTR 095 to compare Friday 5 PM traffic volumes to Tuesday 9 AM and Saturday 2 MD peak hours. With only PM volumes provided from the travel demand model, we could convert the volumes to the specific peak hours we were analyzing for ferry traffic.

2040 Ferry-Traffic Volumes

Perteet then projected the 2019 ferry volumes in the O-D matrix to 2040 volumes. Our growth factor for this calculation was based off Fehr & Peer's 2016 to 2036 growth model.

5.1.4 Additional Inputs

We used aerial imagery to develop the roadway network, including channelization and intersection locations and configurations, to build the existing conditions models in Vissim. We based dock lot operations off of observations and Project Partner feedback.

To build out WSDOT's SR 104 project, we traced the road and intersection configurations shown in multiple proposed-design exhibits provided by WSDOT.

Additionally, WSDOT provided signal timing plans to us that we incorporated into our traffic models.

5.1.5 Calibration

To achieve the maximum queue lengths for ferry traffic for all three existing-condition analysis hours consistent with the 85th percentile target established when sizing the remote holding lot, we began the model with ferry traffic completely filling the dock lot and forming a queue on SR 104 in the downtown Kingston area. This resulted in queues during the model that met the expected target based on observations from the Partners. Specifically, the expected target queue length for the weekend MD peak hour scenario was a back-up to the SR 104 and Barber Cut Off Rd NE intersection. The other two scenarios had expected targets between Barber Cut Off Road NE and the SR 104 and Lindvog Road NE intersection.

5.1.6 Remote Holing Lot Operations

We built the remote holding lot in the Vissim model by tracing the proposed improvement. The model matches the number and length of lanes as shown in the proposed concept layout and in Figure 5-3.

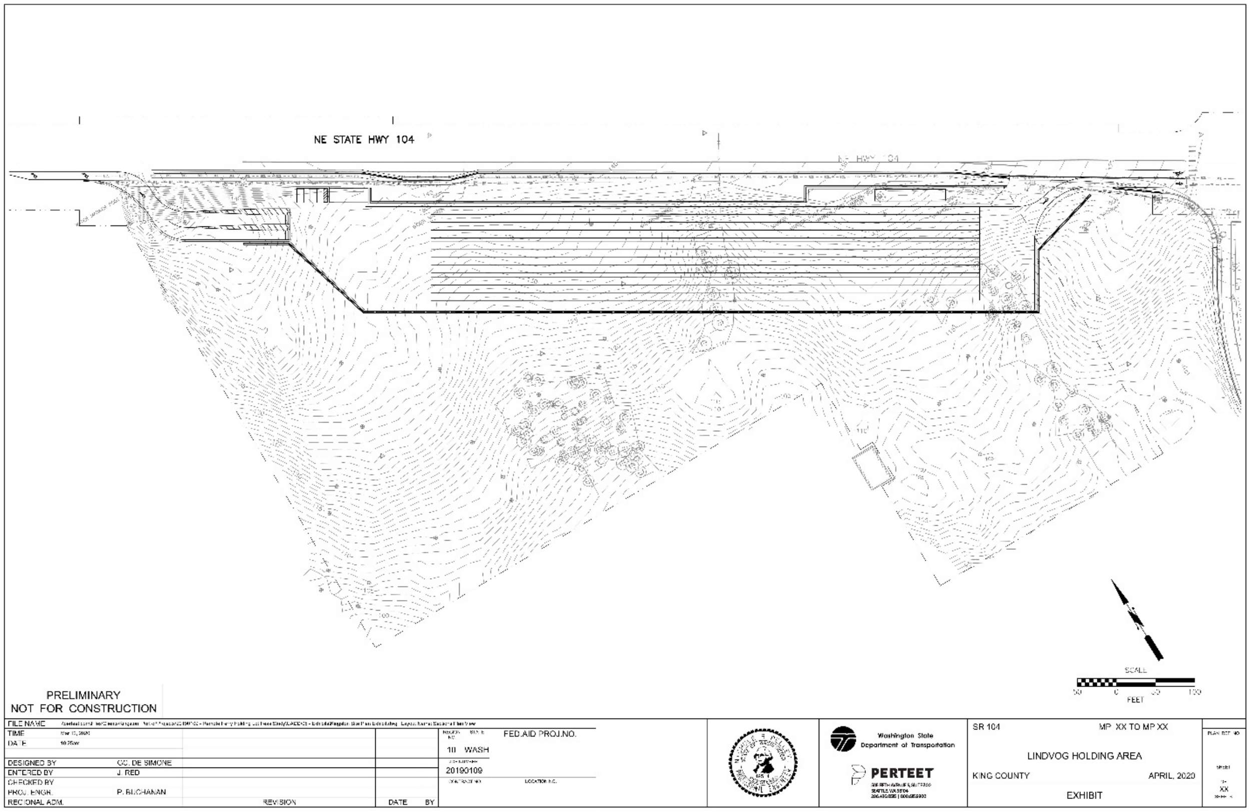


Figure 5-3. Proposed Remote Holding Lot Concept Layout.

We modeled the active traffic management within the remote holding lot, consistent with the strategies outlined in Chapter 4.

5.2 Data Analysis Metrics

Our Vissim evaluation included two components: visual observation and data analysis. This section summarizes the latter effort for each scenario.

We focused on the evaluation of local traffic, as opposed to ferry traffic, since the ferry traffic delays and travel times are dependent on the sailings of the Kingston ferry; the remote holding lot does not increase ferry-traffic travel times. However, the remote holding lot reduces queuing and congestion through downtown Kingston, which should improve delay times for local traffic near SR 104.

Our analysis focused on four key metrics:

1. **Average queue length** along SR 104 through downtown Kingston approaching the dock lot,
2. **Maximum queue length** along SR 104 through downtown Kingston approaching the dock lot,
3. **Average control delay** for local traffic at four study intersections, and
4. Corresponding **level of service** for local traffic at four study intersections.

5.2.1 Queue Length

We collected queue data at the intersection of SR 104 at Washington Boulevard NE. We evaluated the queue lengths that developed on SR 104 approaching the ferry dock lot. We report these queues in two different versions for each scenario: average and maximum; both measured in feet. The former metric provides insight on the typical queue length that will occur at the SR 104 and Washington Boulevard NE intersection, whereas the latter documents the longest queue the model produced within the analysis hour.

Consistent with the primary goal of the project to manage queueing through Kingston, we aimed to achieve a maximum queue length that would not congest the local access points through 2040. We established our target for this maximum queue length as not reaching the intersection of SR 104 at Iowa Avenue NE, which will receive a roundabout treatment under the proposed WSDOT project. Ideally, our queue length would not exceed Ohio Avenue NE. The available queue storage distance between Washington Boulevard NE and Iowa Avenue NE is 650 feet. The distance between Washington Boulevard NE and Ohio Avenue NE is 330 feet.

5.2.2 Control Delay and Level of Service

We evaluated control delays for local traffic at each of the study intersections listed in Section 5.1.1. Our analysis spanned one hour of the simulation (starting after a 30-minute model "warm-up" period to avoid capturing data while the network was initially empty). Control delays are published in terms of seconds of delay per vehicle, on average. These control delays correlate to level of service (LOS) based on the following thresholds, taken from the *Highway Capacity Manual*.

Table 5-2. Level of Service Criteria.

Level of Service	Average Control Delay (seconds per vehicle)		
	Signal (All vehicles)	Roundabout (All vehicles)	TWSC (Worst movement)
A	≤ 10	≤ 10	≤ 10
B	10-20	10-15	10-15
C	20-35	15-25	15-25
D	35-55	25-35	25-35
E	55-80	35-50	35-50
F	80 +	50 +	50 +

Although we were not aiming to reach a particular LOS grade at the study or other location, we used the control delay results to quantify the benefits for local traffic mobility and accessibility with the installation of the remote holding lot.

5.3 Scenarios

The following sections summarize the results of our scenario models.

5.3.1 Existing Conditions

We modeled three times of day for our existing conditions analysis: AM (weekday), PM (weekday), MD (weekend). Of these three, the weekend MD scenario had the highest traffic volumes, as described in Section 5.1.3. As these scenarios reflect existing conditions without any remote holding lot, the queuing for the dock lot is uncontrolled and backs up and beyond downtown Kingston.

Table 5-3 presents the average and maximum queue lengths resulting from the dock lot and the local-traffic control delays and level of service results at the four study intersections.

Table 5-3. Dock-lot Queueing and Local-traffic Level of Service, Existing Conditions Analysis.

Dock-lot Queue Length (feet)			
Metric	Weekday AM Peak Hour	Weekday PM Peak Hour	Weekend MD Peak Hour
Average	2,479	3,733	3,379
Maximum	4,484	4,479	6,669

Local-traffic Intersection Control Delays (seconds per vehicle) and Levels of Service			
Study Intersection	Weekday AM Peak Hour	Weekday PM Peak Hour	Weekend MD Peak Hour
NE 1st Street and Ohio Avenue NE	11 (LOS B)	7 (LOS A)	12 (LOS B)
NE 1st Street and Iowa Avenue NE	8 (LOS A)	45 (LOS E)	32 (LOS D)
Main Street/NE 1st Street and Illinois Avenue NE	117 (LOS F)	56 (LOS F)	42 (LOS E)
Lindvog Road NE and SR 104	12 (LOS B)	15 (LOS B)	19 (LOS B)

5.3.2 Future Conditions

Our future-conditions analysis used only the weekend MD peak hour model, to which we added the 2040 traffic volumes, anticipated local projects (SR 104 couplet removal and WSF LRP), and the remote holding lot (if applicable). Results for the three scenarios are listed in a comparison table at the end of this section.

2040 No-Build Scenario

The no-build scenario reflects what 2040 traffic will look like in the study area if a remote holding lot is never constructed. As we anticipated, with higher traffic volumes by 2040—both local and ferry traffic—the resulting queues and congestion in the study area increase.

In order to generate comparable results between the 2040 no-build scenario and the existing conditions weekend MD peak hour model, the no-build scenario began with ferry traffic filling the dock lot and forming a queue on NE 1st Street with the same volume of vehicles used in the previous model. Therefore, the difference in the final queue length on the shoulder of SR 104 is a result of the expected increase in traffic volumes.

2040 Continuous-Use Scenario

The results of the continuous-use scenario could reflect either permanently continuous operations (year-round) or continuous operations of the remote holding lot on any single day. Unlike the variable-use scenario, the continuous-use scenario does not have any queueing or demand requirements to activate the remote holding lot.

To remain consistent and produce comparable results, the model began with the same volume of ferry traffic as the no-build scenario. However, we shifted any traffic queued on SR 104 at the beginning of the model to the remote holding lot, to reflect how the lot would operate when active.

Having the remote holding lot in use for the full duration of the traffic model under the continuous-use scenario resulted in consistent queue management along NE 1st Street (SR 104) under certain conditions. We tested multiple release time intervals from the remote holding lot, allowing a full lane of vehicles (35 vehicles) to exit the lot at once. Our goal was to find a release interval during the peak-demand period that limited queueing on NE 1st Street to be between Washington Boulevard NE and Ohio Avenue NE, with only occasional spillover to the segment between Ohio Avenue NE and Iowa Avenue NE. We found that the optimum departure interval at the remote holding lot is 7 minutes or 420 seconds. This queue never approached the roundabout at Iowa Avenue NE.

Releasing 35 vehicles every 7 minutes would be equivalent to releasing 5 vehicles every minute. However, the remote lot needs to release traffic in larger batches to have infrequent signal impacts at the Lindvog Road NE and SR 104 intersection. Releasing a full lane of remote-lot traffic has operational benefits within the site, as it eliminates partial-lane releases under fully-occupied conditions.

With all three toll booths at the dock in operation, each with a processing rate of approximately 24 seconds per vehicle (see the *Terminal Design Manual*), an average of 7.5 vehicles per minute will be admitted to the dock lot per minute. This rate should equal or exceed the release rate at the remote lot, or else the queue through Kingston will likely grow with each successive release from the remote lot.

The release rate at the remote holding lot could potentially be reduced below the 7 minutes timeframe we modeled. The system should be designed to be responsive to travel conditions between the sites to confirm that queues are continually managed through downtown Kingston with the release timeframe(s) that are ultimately implemented.

If, for example, a release rate of 35 vehicles every 7 minutes is used at the remote lot, that would translate to 300 vehicles per hour. Under the proposed WSF Long-Range Plan, vessels will have 30-minute headways and 144-vehicle capacities, producing a capacity of 288 vehicles per hour. The proposed release rate at the remote lot would satisfy that capacity requirement. Until the Long-Range Plan is implemented, vessels will have a higher capacity (195 vehicles on average) but longer headway (approximately 40 minutes), equating to an average hourly capacity of 292 vehicles per hour. The maximum vessel size that is currently in use is 202 vehicles, so multiple vessels of that size in succession would have a total capacity slightly above the throughput that the remote holding lot can provide with a 7-minute release interval. As noted, this release interval could be adjusted based on vessel sizes if necessary to fill each boat.

This 7-minute release interval achieved the goal of limiting queueing through the NE 1st Street corridor to improve local traffic flow. This is reflected in the data shown under the no-build and continuous-use scenarios in Table 5-4. The Illinois Avenue NE intersection, for example, operates at LOS F for local traffic in the no-build scenario and at LOS A in the continuous-use scenario. Other intersections operate with similar levels of service across both models.

The continuous-use scenario will require alternate release strategies to progress vehicles through the remote holding lot to the dock lot. During off-peak hours, demands may not reach one full lane of storage in the remote holding lot, leading to situations where vehicles should be released in groups of less than 35 vehicles at a time. The system should be configured to recognize when these situations occur and modify the release patterns to facilitate timely access to the dock lot and vessels.

2040 Variable-Use Operations

We configured this Vissim model to reflect a setup where queueing or ferry demand would trigger the use of the remote holding lot based on certain conditions being met. Those conditions are:

1. The dock lot reaches 85% capacity, indicating that it will shortly fill up completely, or
2. The queue on NE 1st Street reaches 35 vehicles or approximately 500 feet, nearing the operations at the Iowa Avenue NE roundabout.

The former condition is necessary because the Vissim model demonstrated that the toll booths at the dock lot are the limiting factor in driver progression into the dock lot. If the dock lot reaches capacity, then the toll booths cannot permit additional vehicles to pass, and the queue grows to the point of reaching Iowa Avenue NE under most arrival patterns.

The latter condition is necessary to specifically control queuing before it reaches the roundabout. However, this requirement poses some difficulties. If the dock lot has sufficient open space, this queue on NE 1st Street will be processed over time. If the processing rate is greater than the arrival rate for new vehicles in the queue, then this queue will decrease in length, potentially to the point where the triggered remote holding lot is no longer required. However, the remote holding lot requires a transition time into and out of sending all traffic to the remote holding lot, so it isn't feasible to make quick activation/deactivation changes.

Over the course of an hour, this scenario returns the same LOS grades at each study intersection as the continuous-use scenario. However, the Vissim simulation, which triggers based on condition #2, shows that there will be some queuing at or near the roundabout because of the transition period required to activate the remote holding lot but not reroute traffic that are immediately near the dock lot queue at the time of activation. This queue near the roundabout is limited and doesn't grow with any significance during the transition period. The toll booths, which have the capability of processing vehicles and do so under condition #2, will reduce the queue over time as vehicles are admitted to the dock lot. Our observation of the Vissim model is that the queue through the roundabout will be a very brief duration (less than 5 minutes) and that the Iowa Avenue NE roundabout will continue to operate well at all other points during the analysis hour.

If the lot is going to be activated and deactivated during the day, we would anticipate the queue to reach the Iowa Avenue NE roundabout multiple times per day.

Comparison

Table 5-4 presents a comparison summary of the four metrics for the three 2040 scenarios.

Table 5-4. Dock-lot Queueing and Local-traffic Level of Service, Future Conditions Analysis.

Dock-lot Queue Length (feet)			
Metric	No-Build	Continuous-Use	Variable-Use
Average	3,022	70	139
Maximum	7,181	411	876

Local-traffic Intersection Control Delays (seconds per vehicle) and Levels of Service			
Study Intersection	No-Build	Continuous-Use	Variable-Use
NE 1st Street and Ohio Avenue NE	15 (LOS B)	21 (LOS C)	22 (LOS C)
NE 1st Street and Iowa Avenue NE	2 (LOS A)	3 (LOS A)	3 (LOS A)
Main Street/NE 1st Street and Illinois Avenue NE	78 (LOS F)	4 (LOS A)	7 (LOS A)
Lindvog Road NE and SR 104	17 (LOS B)	30 (LOS C)	29 (LOS C)

The continuous-use scenario generated the lowest queue lengths of the three scenarios. The queues in the continuous-use scenario meet the goals of the project in that they never reach the Iowa Avenue NE intersection. As described above, the variable-use scenario has a queue length that passes into the Iowa Avenue NE intersection. The no-build scenario maximum queue length is the longest of the three, which demonstrates the benefit of the remote holding lot.

There are two level of service changes between the three scenarios. Under the no-build scenario, the intersection at Illinois Avenue NE operates at LOS F for local traffic. This grade improves to LOS A for local traffic if the remote holding lot is constructed because the remote holding lot will meter traffic through this intersection to alleviate congestion. The other level of service change is at Lindvog Road NE, which sees increased local-traffic control delays with the remote holding lot constructed because of the additional signal phase required for the remote holing lot egress traffic.

6 CONCLUSIONS

Implementing a remote holding ferry lot will alleviate ferry traffic queueing in Kingston by providing additional storage space for ferry traffic and metering traffic flow through downtown Kingston to the dock lot. Vissim modeling with continuous-use operations showed significantly reduced local traffic delays at the Illinois Avenue NE intersection, demonstrating the benefits to local traffic mobility and access. With variable-use operations, our modeling also shows similar decreases in traffic queueing. However, variable-use operations still generate brief queueing at the Iowa Avenue NE roundabout because of the transition period required to activate the remote holding lot. Overall, the remote holding lot will noticeably improve the traffic conditions along SR 104 with either of the operation options we evaluated.

Perteet developed several ATM options that can be utilized within the remote holding lot and within the downtown Kingston region. This includes license plate readers in several locations, ticket machines, overhead message boards or standard signal heads, puck detection in the lane groups, and CCTVs for monitoring. It will be crucial for signals to have specific phasing for ferry traffic to reach the dock with a platooning effect, so coordination among signal agencies is highly recommended.

Further consideration must be taken for the operational times of the remote holding lot. We have documented the benefits and drawbacks of the continuous-use and variable-use operational schemes with the goal of providing the Project Partners with enough information to come to a final decision. Major differences include the amount of ATM required to properly lead people through the ferry queuing process given the chosen operation and the brief queuing that develops at the roundabout when activating the system under variable-use operations.

7 REFERENCES

Comprehensive Plan of Harbor Improvements 2018- 2023. Port of Kingston, Kingston, WA, 2018.

Design Manual M 22-01.18. Washington State Department of Transportation. Olympia, WA, 2019.

Local Agency Guidelines (LAG) Manual. Washington State Department of Transportation. Olympia, WA, 2019.

"SR 104 – Kingston Ferry Terminal Traffic Improvement." Washington State Department of Transportation, 27 Jan. 2020, https://www.wsdot.wa.gov/projects/sr104/kingston-ferry-terminal/home.

Washington State Ferries 2040 Long Range Plan. Washington State Ferries, Olympia, WA, 2019.