Traffic Impacts Analysis for At-Grade Rail Crossings

Prepared for

King County Solid Waste Division

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Contents

Executive Summary 1

1. Introduction 2

2. Project Information 2

3. Rail Crossing Inventory 3
   - 3.1 At-Grade Crossing Categorization 4
   - 3.2 Tiered Crossing Summary 6

4. At-Grade Crossing Analysis 9
   - 4.1 Rail Blocking Events 9
     - 4.1.1 Configuration 1 – Transfer Waste via New Trains 9
     - 4.1.2 Configuration 2 – Add Rail Cars to Existing Trains 10
     - 4.1.3 Summary of Rail Transport Configurations 10
   - 4.2 Rail Crossing Types 11
   - 4.3 Potential Impacts 12
     - 4.3.1 Configuration 1 – Transfer Waste via New Trains 13
     - 4.3.2 Configuration 2 – Add Rail Cars to Existing Trains 14

5. Summary and Conclusions 15

Appendix A 16

Appendix B 18

FIGURES

Figure 1. Rail Routes and Landfill Locations 3

Figure 2. Representative Tier 3 Crossing 6

Figure 3. Representative Tier 2 Crossing 7

Figure 4. Representative Tier 1 Crossing 8

Figure 5. Representative Crossing Types 12

TABLES

Table 1. Roadway Functional Classification Attributes 5

Contents (continued)

Table 2. Summary of At-Grade Crossings by Tier 8
Table 3. Rail Blocking Event Data 10
Table 4. Waste Rail Cars Transported Per Week 11
Table 5. Configuration 1 Rail Event Impacts by Crossing Type 13
Table 6. Configuration 2 Rail Event Impacts by Crossing Type 14

Executive Summary

The Solid Waste Division (SWD) of the King County Department of Natural Resources and Parks is evaluating waste export by rail (WEBR) as a potential method for transporting municipal solid waste to regional landfills after the Cedar Hills Landfill reaches capacity. Under the scenario evaluated in this report, approximately 666,950 tons of waste per year could be transported out of King County by rail to landfills in south central Washington and north central Oregon. This additional waste could be accommodated either by operating new waste trains or adding railcars to existing trains. Each configuration would result in varying effects on roadway traffic at at-grade rail crossings.

Freight rail providers carrying waste from King County to the regional landfills travel on tracks that generally follow the I-5 freeway corridor to Portland, Oregon then travel east along either side of the Columbia River to the regional landfills. These waste rail trains intersect with roadways in urban areas, industrial lands, and rural communities at at-grade crossings. Between King County and the regional landfills, a total of 318 at-grade crossings were identified. Most of these at-grade crossings are located on private property or in rural areas with lower population density and lower traffic volumes. Roughly 13 percent of at-grade crossings are located in higher-density urban areas with higher roadway traffic volumes.

Two different WEBR transport configurations were evaluated – Operating new waste rail trains (Configuration 1) and adding rail cars to existing waste rail trains (Configuration 2) – for potential effects on roadway operations at representative at-grade crossings. These representative at-grade crossings reflect characteristics at intersections in urban, higher density areas where changes in train length or frequency may have more noticeable effects on vehicle wait times during a rail crossing.

Configuration 1 adds approximately 3 new waste trains per week to existing service. These new trains would transport about 12,800 tons of waste to the landfills weekly. Each train would be 5,434 feet (or 1.03 miles) long, which is comparable to trains currently traveling between King County and the regional landfills. Assuming these new trains travel at speeds similar to current trains, roadway traffic at at-grade crossings would be blocked for about 2 minutes, 18 seconds each instance the new waste train passes. New trains would travel through at-grade crossings about 6 times per week (3 trains with one outbound trip and one return trip each), with each event affecting up to about 96 vehicles total on the local roadway.

Configuration 2 adds double-stacked waste rail cars to existing train service about 6 times per week. These added cars would transport approximately 12,800 tons of waste weekly on trains already in service between King County and the regional landfills. The additional rail cars would lengthen the existing train by 2,717 feet (or 0.51 miles) and would extend the rail crossing time by about 54 seconds. This added blocking time would occur approximately 12 times per week (one outbound and one return trip for each of 6 lengthened trains) and could affect up to 36 additional vehicles per event beyond those already affected by the existing train crossing.

Both rail transport configurations would introduce delay at at-grade rail crossing intersections. With Configuration 1, new waste train service would add 6 new blocking events per week, each resulting in longer vehicle delays per blocking event compared to Configuration 2. With Configuration 2, adding waste rail cars to existing trains would incrementally increase the existing train blocking time (but would result in shorter new vehicle delays than Configuration 1). This incremental increase would occur more frequently during a typical week compared to Configuration 1.

1. Introduction

The Solid Waste Division (SWD) of the King County Department of Natural Resources and Parks is leading an update to the County's Comprehensive Solid Waste Management Plan. This management plan will describe potential future alternatives for handling municipal solid waste in the County once the Cedar Hills Landfill reaches capacity. The alternatives consider various waste export by rail (WEBR) hauling options, including a Full WEBR option where all waste is transported by rail for disposal, a Mass Burn option where the residual waste is transported by rail, and a Hybrid option that uses a combination of Mass Burn and WEBR methods for waste disposal to a regional landfill. The alternatives also consider high, medium, and low tonnage scenarios to account for variations in the amount of waste that could be processed in King County.

Each disposal option and tonnage scenario would result in additional trains or train cars traveling to and from King County. This rail crossing analysis evaluates only the Full WEBR option because it represents the highest waste-haul demand and is therefore expected to result in the most noticeable changes to rail operations compared to the Mass Burn and Hybrid options. The Mass Burn and Hybrid options were not evaluated because they would generate less waste requiring transport to regional landfills and would likely require fewer rail containers and/or less frequent rail trips for disposal. Potential impacts to at-grade crossings, such as rail blocking duration and vehicle delay on local roadways, would generally be less than those associated with the Full WEBR option.

This report includes an inventory of the at-grade rail crossings along the rail routes between King County and the regional landfills located in south central Washington and north central Oregon. It also provides a summary of the potential impacts of additional trains or train cars on traffic at representative at-grade rail crossing intersections as a result of the Full WEBR option with the 'medium tonnage' waste scenario.

2. Project Information

When the Cedar Hills Landfill reaches capacity, King County SWD anticipates potentially transporting solid waste from the County to one of three regional landfills via rail – Columbia Ridge Landfill near Arlington, Oregon, Finley Buttes Landfill near Boardman, Oregon, and Roosevelt Regional Landfill near Roosevelt, Washington.

Two major freight rail providers, Union Pacific (UP) and BNSF Railway (BNSF), serve the route between King County and the regional landfills. Between Seattle and Tukwila, the rail follows the I-5 freeway corridor through primarily industrial land areas, including the Duwamish manufacturing/industrial center. This segment is primarily owned by BNSF with UP operating on the corridor through trackage rights. From Tukwila, through Kent, Auburn, and Puyallup, the UP and BNSF own and operate on their own separate parallel tracks that generally follow the SR 167 corridor to the Port of Tacoma. Between Tacoma and the Vancouver–Portland area, the rail tracks (primarily owned by BNSF with UP trackage rights) generally follow the I-5 freeway corridor before diverging to opposite sides of the Columbia River to the landfills.

The BNSF rail corridor is on the Washington (north) side of the Columbia River while the UP corridor is on the Oregon (south) side of the river. Solid waste would be transferred at intermodal facilities from rail trains to trucks for delivery to the nearby landfills. Figure 1 illustrates the regional landfill locations and the study area extents of the rail corridors analyzed in this report.

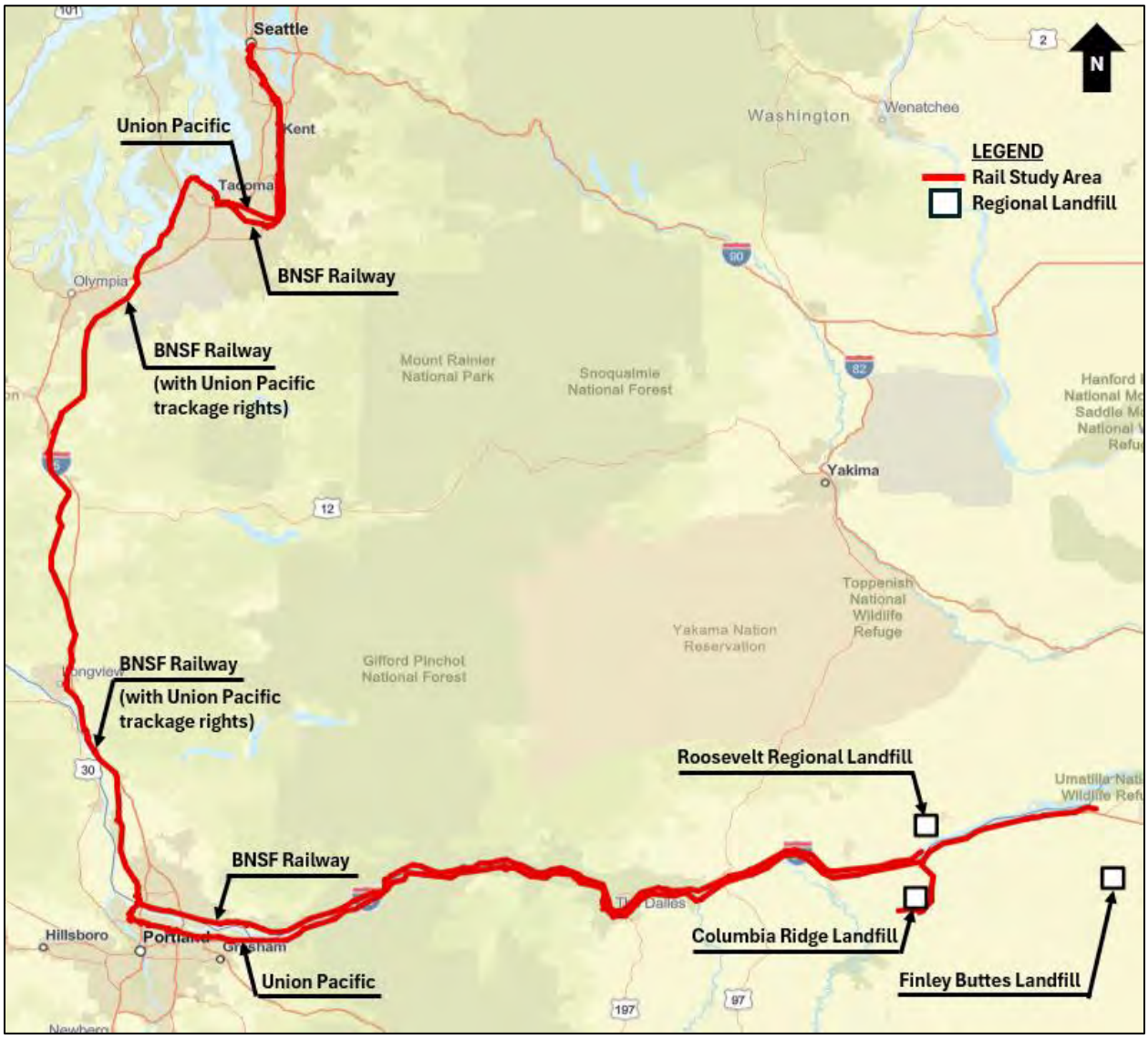


Figure 1. Rail Routes and Landfill Locations

Rail routes connecting King County with the regional landfills are also available across the Cascade Range and through central Washington. These routes were not evaluated because existing waste-haul operations use the I-5 and Columbia River corridors, which provide established access to the regional landfills.

3. Rail Crossing Inventory

Rail crossing information was compiled from data published by the Federal Railroad Administration (FRA) for Washington and Oregon. The FRA data included physical (coordinate location, number of tracks, type of traffic control devices) and operational (train speed, train crossing frequency) characteristics for both the roadway and rail at every public and private at-grade and grade-separated crossing on passenger and freight service lines.

Using the FRA database, an inventory of all crossings was compiled. The rail crossings were reviewed and supplemented where FRA information was incomplete and additional crossing attributes, such as roadway functional classification, number of roadway lanes crossing the rail line, and street names were incorporated into the spreadsheet inventory.

Location information from the crossing inventory was used to develop a GIS map that showed all crossings on the UP and BNSF rail corridors within the study area. This map was reviewed using aerial imagery to identify any missing crossings along the rail corridors between King County and the regional landfills. At-grade crossings that were not included in the FRA database, but identified through this review, were added to the inventory and the GIS map[1].

Within the study area, a total of 576 rail crossings were identified; 258 are grade-separated (45 percent) and 318 are at-grade (55 percent).

3.1 At-Grade Crossing Categorization

The at-grade crossings were categorized into three tiers based on an evaluation of their characteristics against specific criteria and threshold values. The criteria and thresholds were established to differentiate crossings by the potential level of impact that additional trains or train cars could have on surface street traffic operations.

The tiers are defined as follows:

- Tier 1 – Medium or high impacts to vehicles using the crossing due to additional trains, likely to have the most noticeable increase in traffic delay or safety concerns
- Tier 2 – Low impacts to vehicles using the crossing due to additional trains
- Tier 3 – Very low or minimal impacts to vehicles using the crossing due to additional trains, likely to occur at low traffic volume crossings in rural or less populated areas

The rail crossing evaluation criteria included:

- Access – Who has access to the roadway?
    - Public – the rail crosses a public roadway, all vehicles using the roadway would be affected by trains crossing at-grade
    - Private – the rail crosses a private roadway, is located on private property, or has restricted access, fewer vehicles would be affected by trains crossing at-grade because access/entry to private roadways is limited
- Roadway Type – What kind of road is it?
    - Major Arterial – this road typically serves more vehicles than a minor arterial or collector and is often an important connection between regional activity centers
    - Minor arterial – this road has fewer vehicles and provides more access to local commercial or retail than a major arterial
    - Collector – this road is typically low in vehicle volume and serves neighborhoods, schools, parks and residential driveway access
- Annual average daily traffic (AADT) – How many vehicles use the roadway?
    - This is the average number of cars, going both ways, that use this roadway in a day

[1] Rail Crossing Analysis - GIS Map

    - Higher AADT means more vehicles on the roadway would be affected by trains crossing an at-grade intersection.
    - Lower AADT could mean fewer vehicles would be affected by trains crossing at-grade
- Proximity to signalized intersections – How far is the at-grade crossing to a traffic signal?
    - An at-grade crossing located near a traffic signal has less space for vehicles to queue when a train passes. Vehicles waiting for the train to cross could back up into the traffic signal and affect other vehicles that are approaching the traffic signal.
    - An at-grade crossing located further away from a traffic signal usually has more space for vehicles to wait in queue during a rail crossing. More space means vehicles are less likely to back up into the traffic signal or affect other roadways at the signalized intersection.
- Track size – How many rail tracks does the roadway cross?
    - More tracks means more opportunities for trains to pass through the at-grade crossing, which could mean more delay for vehicles.

Thresholds for each of the criteria were selected based on the roadway functional classification attributes shown in Table 1. These attributes generally characterize a roadway's intended function based on the level of mobility or service they are intended to provide within a roadway network.

Table 1. Roadway Functional Classification Attributes

Roadway Type	Description	Minimum Daily Traffic Volume	Typical Configuration	Example Roadways in Study Area
Major Arterial	Provides high-mobility regional travel between major activity centers with limited access.	Serves more than 7,500 vehicles per day	Multi-lane divided roadway (4–6+ lanes), raised median, coordinated signals, limited driveways, high traffic volumes. Can exceed 25K AADT for high volume roadways.	King County: James Street, Willis Street Lewis County: Main Street
Minor Arterial / Collector	Minor Arterial: Connects communities and major destinations while balancing mobility and land access. Collector: Collects and distributes traffic from local streets to the arterial network while providing property access.	Serves between 500 and 7,500 vehicles per day	Minor Arterial: 2-3 lane urban street with center turn lane, sidewalks, bike lanes, signalized intersections every few blocks. Typical city commercial corridor. Collector: 2-lane neighborhood connector serving schools, parks, and residential areas. Frequent intersections and direct driveway access.	King County: W. Meeker Street, 37th Street Lewis County: Maple Street Multnomah County: NE 138th, NE 112th
Private Road	Privately owned roadway that primarily serves and provides access to specific properties or developments.	Serves less than 500 vehicles per day	Narrow roadway or access drive serving a subdivision, apartment complex, business park, or industrial site. Often privately maintained and signed as private.	Private business or landowner crossing

AADT: Annual average daily traffic

The physical and operational characteristics for each of the at-grade crossings were compared to the evaluation criteria and threshold values and then assigned to Tier 1, Tier 2, or Tier 3 as follows:

Tier 1 –Medium/High Impact Crossing

- AADT is greater than 7,500 vehicles *or*
- Rail crosses roadway classified as major (principal) arterial or higher (interstate, freeway, expressway) *or*
- Crossing is within 750 feet of a signalized intersection

Tier 2 – Low Impact

- AADT is between 500 and 7,500 vehicles *or*
- Rail crosses roadway classified as minor arterial or collector *or*
- Roadway crosses more than 3 rail tracks

Tier 3 – Minimal/Very Low Impact

- Private rail crossing *or*
- AADT is less than 500 vehicles

3.2 Tiered Crossing Summary

A total of 318 at-grade crossings were evaluated. About half of these crossings are located on private property or intersect with a private roadway. Roughly 15 percent of at-grade locations cross a public roadway with AADT of less than 500 vehicles. These crossings (approximately 66 percent of all at-grade locations) were assigned to Tier 3.

Figure 2 shows a representative Tier 3 public crossing, which is typically located in rural areas where the rail corridor crosses low-volume roadways.

Figure 2. Representative Tier 3 Crossing

About 21 percent of at-grade rail crossings were assigned to Tier 2 based on the criteria threshold evaluation. These rail crossings either intersect with minor arterials or collector roadways that carry between 500 and 7,500 vehicles per day or include three or more rail tracks.

Figure 3 depicts a typical Tier 2 crossing. These crossings are generally situated in less rural/more populated areas where potential changes in rail activity would be more noticeable to roadway traffic than with a Tier 3 crossing.

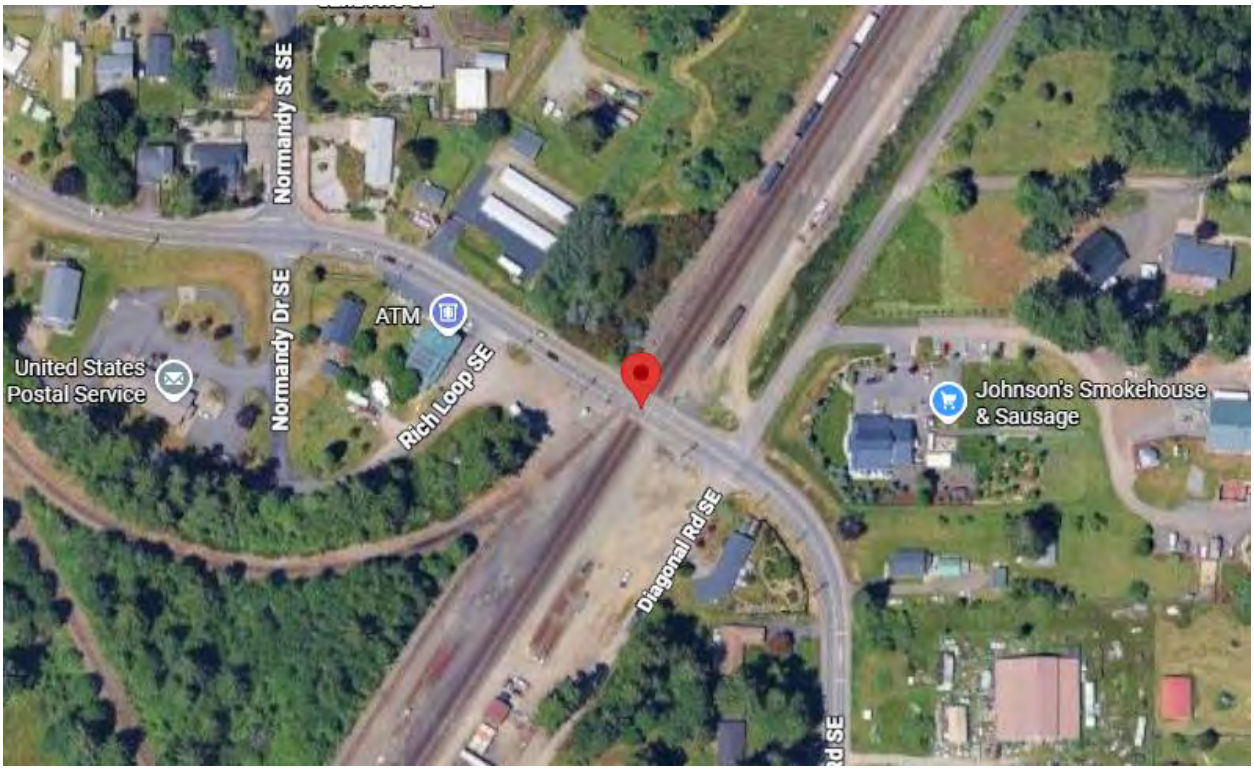


Figure 3. Representative Tier 2 Crossing

Approximately 13 percent of at-grade crossings were assigned to Tier 1. These crossing locations are either situated near a signalized intersection or intersect with higher classification roadways that carry more than 7,500 vehicles per day.

Figure 4 presents a sample Tier 1 at-grade crossing. They generally are located in urban or suburban areas near a signalized intersection and cross a locally or regionally significant roadway that supports general purpose traffic, possibly including freight and transit, as well as active transportation modes.

Figure 4. Representative Tier 1 Crossing

Table 2 summarizes the total at-grade crossings by tier and by county in Washington and Oregon. Crossings are categorized by tier and by state and city in Appendix A.

Clark, Pierce, and King counties have the most at-grade crossings within the study area. King County has the most Tier 1 crossings within the study area (14 crossings), followed by Pierce County with 12 Tier 1 crossings and Multnomah County with 10 Tier 1 crossings.

Table 2. Summary of At-Grade Crossings by Tier

State	County	Tier 3	Tier 2	Tier 1	Total By County
WA	King	11	13	14	38
WA	Pierce	20	13	12	45
WA	Thurston	8	6	0	14
WA	Lewis	11	13	3	27
WA	Cowlitz	14	5	0	19
WA	Clark	38	8	1	47
WA	Skamania	23	0	0	23
WA	Klickitat	22	2	0	24
OR	Multnomah	10	1	10	21
OR	Hood River	9	0	0	9
OR	Wasco	6	1	2	9

State	County	Tier 3	Tier 2	Tier 1	Total By County
OR	Sherman	6	0	0	6
OR	Gilliam	29	4	0	33
OR	Morrow	3	0	0	3
	Total Crossings by Tier	**210 (66%)**	**66 (21%)**	**42 (13%)**	**318 (100%)**

Source: Federal Rail Administration

4. At-Grade Crossing Analysis

An analysis of potential impacts at representative at-grade rail crossings was conducted to understand how increased waste volumes and associated future rail demand could affect vehicle delay and queuing on local roadways.

4.1 Rail Blocking Events

When the Cedar Hills Landfill reaches capacity, King County SWD anticipates diverting waste to other regional landfills. The King County Long-Term Disposal Options Final Report (March 2025) examined a projected 'medium tonnage' waste haul scenario that required approximately 666,950 tons of waste annually to be transported via rail to other regional landfills by the year 2040.[2] This 'medium tonnage' scenario would generate 23,820 containers of waste per year (assuming an average rail container payload of 28 tons) or approximately 76 containers per day (assuming 6 rail haul days per week). This diverted waste would be added to waste presently transported, and anticipated to remain in transport, from King County to the landfills.

Increased waste volumes and associated rail demand could increase vehicle delay and queuing on local roadways. When a train passes through an at-grade crossing, traffic on the intersecting roadway must stop until the crossing is cleared. The total roadway closure time, also referred to as the rail blocking event, includes the advance warning period (when lights may be activated and crossing gates descend), the time required for the train to fully cross the intersection, and the time for the crossing gates to rise before roadway traffic can proceed.

The time required for the train to pass through an at-grade intersection depends primarily on the train length and train operating speed. To estimate the blocking event durations, trains were assumed to travel at 35 miles per hour (mph) through an at-grade crossing. This assumed operating speed is comparable to FRA data discovered in the rail crossing inventory for typical train speed ranges in urban industrial areas.

Rail blocking event durations were estimated for 2 potential haul configurations under the WEBR alternative that either introduce new waste rail trains or add waste rail cars to trains already in service.

4.1.1 Configuration 1 – Transfer Waste via New Trains

Configuration 1 introduces new waste haul trains to transport the 666,950 annual tons of diverted waste from King County to the regional landfills. Under this configuration, the annual waste would be

[2] King County Long-Term Disposal Options Final Report, March 2025

transported on new train service operating approximately 3 times per week, with each trip including one outbound trip to the landfill and one inbound trip back to King County. The assumed new train frequency is based on the projected accumulation of waste per day and the resulting train length.

New trains operating 3 times per week would carry approximately 458 total containers a week or 152 containers per train (76 double-stacked rail cars per train). As a conservative estimate, rail cars measure approximately 71.5 feet each resulting in new train lengths of 5,434 feet (or 1.03 miles). This train length is comparable to trains currently traveling between King County and the regional landfills.

Operating new waste haul trains from King County to the regional landfills in Eastern Oregon and Washington would result in new rail blocking events at at-grade crossings. These new trains would operate separately from other waste haul trains and therefore would increase the frequency of train crossing events. With new waste trains estimated at 5,434 feet long and traveling at 35 mph through crossings, each blocking event would be roughly 2 minutes and 18 seconds in duration. Blocking events would occur with each of the 3 forecasted new rail roundtrips, for a total of 6 new blocking events per week.

4.1.2 Configuration 2 – Add Rail Cars to Existing Trains

Configuration 2 involves transporting the diverted 666,950 tons of annual waste from King County to the regional landfills by adding rail cars to trains that would already be operating on this route. The added rail cars would be attached to waste haul trains already in service. It is assumed that other waste trains would already be operating with at least one roundtrip train trip between waste generation and disposal locations each day. These existing waste trains will vary in length, and the number of rail cars each existing train would carry is unknown, therefore the existing train length cannot be quantified. The potential effects of adding waste under Configuration 2 are reported as the incremental difference from the additional waste cars only, not the effects of the entire train.

With this configuration, the assumed daily waste volume (76 containers) would be carried on 38 double-stacked rail cars, measuring roughly 71.5 feet each. The added waste rail cars would extend the length of a train by about 2,717 feet (or 0.51 miles). Assuming trains travel at 35 mph, the added rail cars would increase each rail blocking event by about 54 seconds. Rail blocking events would occur twice per day (on each outbound and inbound rail trip), 6 days per week.

More waste railcars could be added to existing trains to reduce the number of weekly haul events to 4 or 5 times per week. If more than 76 containers (38 rail cars) were added to individual trains due to a decrease in frequency, the longer train length could increase the duration of a rail blocking event by up to approximately 25 seconds per event.

4.1.3 Summary of Rail Transport Configurations

Table 3 represents the anticipated train lengths and rail blocking event times for the analyzed alternatives.

Table 3. Rail Blocking Event Data

Alternative	Number of Waste Containers/Cars[1]	Frequency	Additional Length of Train (feet)	Blocking Event Time per Rail Crossing[2]
Configuration 1 Operate New Train	152 containers 76 rail cars	3 roundtrips per week	5,434	2 minutes, 18 seconds

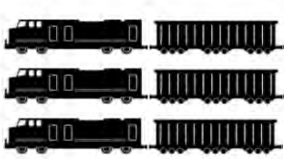
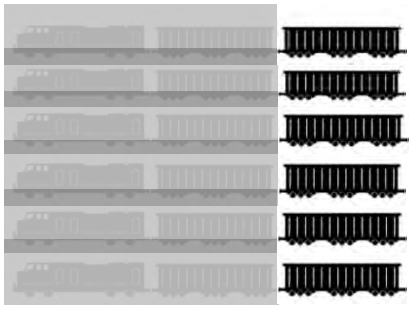
Alternative	Number of Waste Containers/Cars[1]	Frequency	Additional Length of Train (feet)	Blocking Event Time per Rail Crossing[2]
Configuration 2 Add Waste Rail Cars	76 containers 38 rail cars	6 roundtrips per week	2,717 (length of added cars only)	54 seconds (time for added cars only)

[1] Rail car lengths are 71.5 feet.

[2] Train speed through at-grade crossing is assumed to be 35 mph.

Operating a new waste train would introduce new instances of rail blocking events to at-grade crossings between King County and the regional landfills to 6 times per week (3 roundtrips). Adding rail cars to existing trains would likely result in less added blocking time per train than the new train configuration, but the additional delay would occur more frequently (up to 12 times per week, 6 roundtrips) during a typical week. Table 4 compares the rail cars expected to be transported per week under the 'medium tonnage' scenario with Configuration 1 and Configuration 2.

Table 4. Waste Rail Cars Transported Per Week

Alternative	Event Frequency (Trains per week)	Waste Cars from King County[1]	Total Waste Cars Transported per Week	Blocking Event Time per Rail Crossing[2]
Configuration 1 Operate New Train	3 new trains per week  6 blocking events per week (one outbound trip and one inbound trip per train)	76 double-stacked rail cars per new train 152 containers per each trip	3 new trains x 76 rail cars per train = 228 rail cars per week 456 containers per week	2 minutes, 18 seconds
Configuration 2 Add Waste Rail Cars	6 trains with added cars per week  12 blocking events per week (one outbound trip and one inbound trip per train)	38 double-stacked rail cars per new train 76 containers per each trip	6 trains x 38 added rail cars per train = 228 rail cars per week 456 containers per week	54 seconds (time for added cars only)

[1] Cars include waste generated by jurisdictions in and around King County.

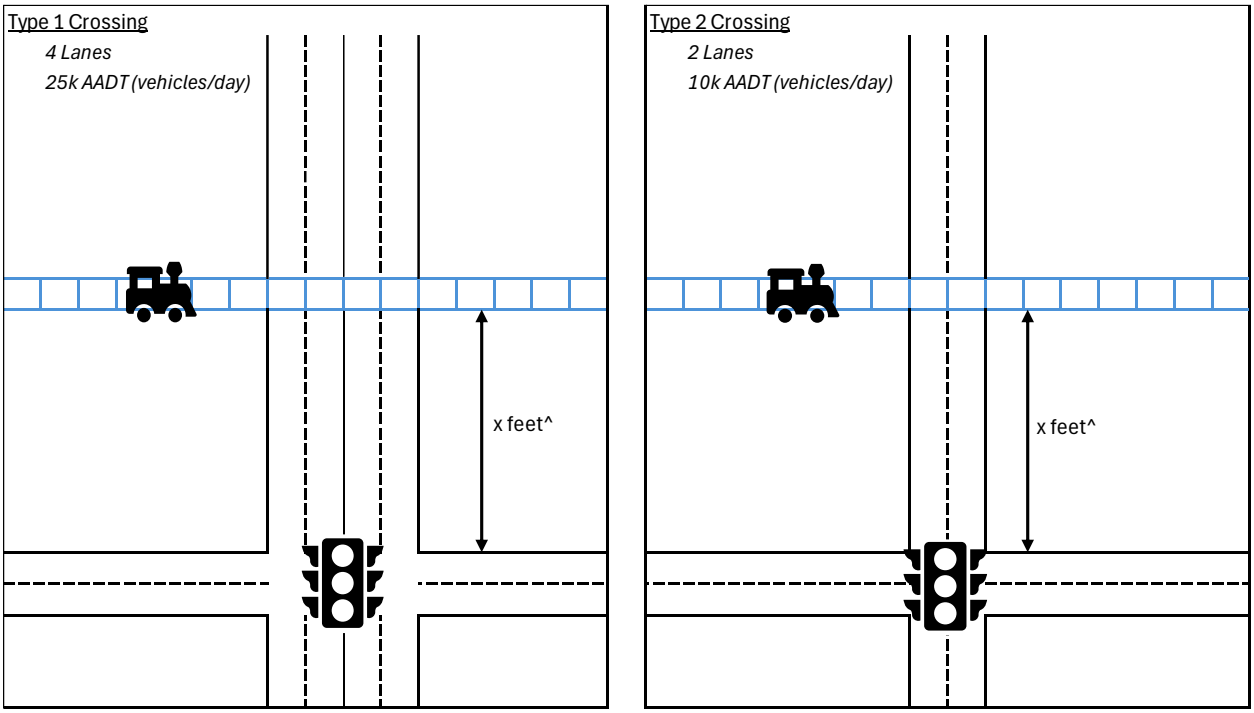
[2] Train speed through at-grade crossing is assumed to be 35 mph.

4.2 Rail Crossing Types

At-grade crossings along the haul routes between King County and the regional landfills vary in roadway configuration and traffic characteristics. Compared to Tier 2 and Tier 3 at-grade crossings, Tier 1 crossings are likely to experience more noticeable impacts when changes to train volumes or

train length occurs during rail blocking events. Tier 1 crossings are typically located on roads functionally classified as major arterials or higher in urban or developed areas that provide access between major activity centers. At Tier 1 crossings, rail can intersect multiple lanes of vehicle traffic on important regional connectors that carry higher vehicle volumes during peak periods.

Two representative at-grade crossing types were developed to reflect common Tier 1 crossing characteristics. The Type 1 crossing includes 4 roadway lanes (2 in each direction) and assumes an annual average daily traffic volume of 25,000 vehicles (combined in both directions). The Type 2 crossing includes 2 travel lanes (1 in each direction) and assumes a daily traffic volume of 10,000 vehicles. Both crossing types were assessed to understand the potential effects of increased train operations on roadway traffic. Figure 5 shows the two representative crossing types.



Notes:
AADT - Annual average daily traffic (combined, both directions of travel)
^ Distance between rail crossing and signalized intersection is based on individual locations. If the queue length exceeds the vehicle storage length to an upstream signalized intersection (measured by 'x'), additional impacts may incur.

Figure 5. Representative Crossing Types

Both representative crossing types are assumed to be located near a traffic signal. This configuration is common at Tier 1 at-grade crossings located in urban, densely populated areas. The distance between the rail crossing and the adjacent traffic signal is not defined because spacing varies considerably among all Tier 1 locations. The diagrams are intended to represent a range of configurations that could be affected by increased waste haul quantities and train lengths or frequencies.

4.3 Potential Impacts

The representative crossing types were evaluated for impacts under Configuration 1 (operate a new train) and Configuration 2 (add rail cars to train) at two different times of the day. Both haul configurations were analyzed during the weekday evening peak hour (5:00 p.m.), which is

considered to be the busiest time for local road traffic at the representative crossings, and during an off-peak hour after typical weekday local traffic volumes dissipate (after 8:00 p.m.). Under current rail operating procedures and contractor agreements, waste trains usually travel between King County and the regional landfills from 8:00 p.m. to 6:00 a.m., when daily traffic volumes on local roadways are typically lowest. The rail crossing impacts presented here are intended to represent a conservative range of potential effects on local roadway operations, including potential worst-case conditions.

4.3.1 Configuration 1 – Transfer Waste via New Trains

With Configuration 1, vehicles would be stopped at the at-grade rail crossing for approximately the duration of the new train's blocking event, or approximately 2 minutes and 18 seconds of delay for each vehicle. This vehicle delay is based on train characteristics and would occur regardless of the type of crossing, time of day, or local roadway traffic volume.

Vehicle queuing impacts at the at-grade crossings depend on roadway characteristics and the volume of vehicles arriving during a rail blocking event. Longer queues are generally expected during peak travel periods and at crossings with more travel lanes and higher traffic volumes, while shorter queues are anticipated at lower-volume crossings and during off-peak periods.

Peak hour traffic volumes were estimated based on daily traffic counts on roadways representing the higher-volume Tier 1 rail crossings. Peak hour traffic in the afternoon is typically 10% of daily traffic volumes while the off-peak volumes were roughly 4% of daily traffic[3]. About 2,500 vehicles (combined in both directions) are expected to arrive at a Type 1 crossing during the peak hour. During the blocking event, about 96 vehicles would arrive at the crossing and be affected by the train passing through. Assuming two blocking events per day (one outbound train trip and one inbound train trip), about 0.77% of the total daily traffic volume could be affected.

Type 2 crossings would likely experience shorter vehicle queues due to lower annual average daily traffic volumes. Assuming about 4% of daily traffic arrives at a Type 2 crossing during the off-peak hour, roughly 16 vehicles would be affected by a blocking event duration of 2 minutes, 18 seconds.

Table 5 presents the range of potential impacts to vehicle traffic at the Type 1 and Type 2 representative crossings. These impacts could occur 6 times per week, during both the outbound and inbound routes for each of 3 new waste train roundtrips. Detailed analysis results are included in Appendix B.

Table 5. Configuration 1 Rail Event Impacts by Crossing Type

Crossing Type, Time of Day	Roadway Volume (per hour)	Number of Roadway Lanes	Total Number of Vehicles Impacted^
Type 1 Peak Hour (5:00 p.m.)	2,500	4 Lanes (2 in each direction)	96
Type 1 Off-Peak (8:00 p.m.)	1,000	4 Lanes (2 in each direction)	38
Type 2 Peak Hour (5:00 p.m.)	1,000	2 Lanes (1 in each direction)	38

[3] Percentages for estimating peak hour traffic from AADT (when location-specific peak hour data is not available) are based on statewide aggregated counts and industry-standard benchmarks.

Crossing Type, Time of Day	Roadway Volume (per hour)	Number of Roadway Lanes	Total Number of Vehicles Impacted^
Type 2 Off-Peak (8:00 p.m.)	400	2 Lanes (1 in each direction)	16

Trains operate with 3 roundtrips (6 crossing events) per week. Train speed is 35 mph.

Peak hour analysis assumes 10% of daily traffic. Off-peak hour analysis assumes 4% of daily traffic.

^ Represents the total number of vehicles expected to be waiting in queue, in both directions, during a rail event. Values shown are rounded at various stages of calculation and displayed outputs may not precisely match manual calculations based on the blocking event time and vehicle inputs presented. Minor differences due to rounding do not materially affect the overall findings of the study.

4.3.2 Configuration 2 – Add Rail Cars to Existing Trains

Configuration 2 would add rail cars to waste trains that are already traveling between King County and the regional landfills. This configuration would lengthen an existing train by approximately 38 rail cars, resulting in about 54 seconds of additional delay during a rail blocking event. This additional delay represents the incremental impact of the added rail cars only.

Using the same hourly volume arrival assumptions as Configuration 1, Configuration 2 could result in approximately 36 additional vehicles impacted during a peak hour rail blocking event at a Type 1 crossing. Assuming two blocking events per day (one outbound train trip and one inbound train trip), about 0.29% of the total daily traffic volume at a Type 1 crossing could be affected. At a Type 2 crossing during the off-peak hour, roughly 6 additional vehicles on the local roadway could be impacted.

Table 6 shows the potential range of impacts to roadway traffic at the Type 1 and Type 2 representative crossings. These impacts would be expected to occur about 12 times per week (twice each during 6 existing waste haul roundtrips). Detailed analysis results are included in Appendix B.

Table 6. Configuration 2 Rail Event Impacts by Crossing Type

Crossing Type, Time of Day	Roadway Volume (per hour)	Number of Roadway Lanes	Total Number of Vehicles Impacted^[1]
Type 1 Peak Hour (5:00 p.m.)	2,500	4 Lanes (2 in each direction)	36
Type 1 Off-Peak (8:00 p.m.)	1,000	4 Lanes (2 in each direction)	16
Type 2 Peak Hour (5:00 p.m.)	1,000	2 Lanes (1 in each direction)	16
Type 2 Off-Peak (8:00 p.m.)	400	2 Lanes (1 in each direction)	6

[1] Impacts directly attributed to new rail cars carrying King County waste (in addition to vehicles impacted by existing trains).

Trains operate with 3 roundtrips (6 crossing events) per week. Train speed is 35 mph.

Peak hour analysis assumes 10% of daily traffic. Off-peak hour analysis assumes 4% of daily traffic.

^ Represents the additional number of vehicles expected to be waiting in queue, in both directions, that are impacted by the additional rail cars during a rail event. Values shown are rounded at various stages of calculation and displayed outputs may not precisely match manual calculations based on the blocking event time and vehicle inputs presented. Minor differences due to rounding do not materially affect the overall findings of the study.

5. Summary and Conclusions

King County SWD is exploring rail transport alternatives for delivering solid waste to regional landfills in southeast Washington and northeast Oregon. Rail transport could occur via two haul configurations – introducing new waste rail trains or adding waste rail cars to existing trains.

Configuration 1 (a new train) would introduce new rail blocking events of approximately 2 minutes, 18 seconds potentially affecting up to 96 vehicles during a typical peak hour on the local intersecting roadway. These additional blocking events could occur approximately six times per week, corresponding to the outbound and inbound movements of three new waste-train round trips.

Configuration 2 (adding to existing trains) would add approximately 38 railcars to existing trains, increasing the duration of an existing blocking event by approximately 54 seconds, rather than creating a separate event. The additional blocking time could affect up to 36 vehicles on the local roadway during the peak hour of traffic. These potential impacts could occur about 12 times per week.

Overall, Configuration 1 would result in fewer but longer new blocking events, while Configuration 2 would result in more frequent but shorter incremental impacts to existing blocking events. The findings in this report generally represent the worst-case or higher end of potential impacts to rail blocking durations and local traffic resulting from changes in waste-haul operations. This report conservatively analyzed waste trains passing through at-grade crossings during the peak hour and shoulder off-peak hour, when local roadway traffic volumes are relatively high. Because current waste trains typically operate between 8:00 p.m. and 6:00 a.m., when roadway volumes are substantially lower, the expected impacts on local vehicles would be less than those presented in this report.

Appendix A

Table A.1. Summary of At-Grade Crossings

State	County	City	Tier 3	Tier 2	Tier 1	Total
WA	KING	SEATTLE	5	2	2	9
WA	KING	RENTON	1	0	0	1
WA	KING	KENT	1	4	9	14
WA	KING	AUBURN	2	4	3	9
WA	KING	ALGONA	2	1	0	3
WA	KING	PACIFIC	0	2	0	2
WA	PIERCE	SUMNER	4	4	4	12
WA	PIERCE	PUYALLUP	8	3	7	18
WA	PIERCE	FIFE	1	3	0	4
WA	PIERCE	TACOMA	3	3	0	6
WA	PIERCE	RUSTON	1	0	0	1
WA	PIERCE	STEILACOOM	1	0	1	2
WA	PIERCE	FORT LEWIS	1	0	0	1
WA	PIERCE	DU PONT	1	0	0	1
WA	THURSTON	LACEY	1	1	0	2
WA	THURSTON	OLYMPIA	4	2	0	6
WA	THURSTON	TENINO	1	2	0	3
WA	THURSTON	BUCODA	2	1	0	3
WA	LEWIS	CENTRALIA	0	5	1	6
WA	LEWIS	CHEHALIS	1	3	1	5
WA	LEWIS	NAPAVINE	1	2	1	4
WA	LEWIS	WINLOCK	7	1	0	8
WA	LEWIS	VADER	2	2	0	4
WA	COWLITZ	CASTLE ROCK	7	0	0	7
WA	COWLITZ	KELSO	3	1	0	4
WA	COWLITZ	LONGVIEW	2	0	0	2
WA	COWLITZ	KALAMA	1	2	0	3
WA	COWLITZ	WOODLAND	1	2	0	3
WA	CLARK	RIDGEFIELD	3	1	0	4
WA	CLARK	VANCOUVER	7	2	0	9
WA	CLARK	CAMAS	25	0	0	25
WA	CLARK	WASHOUGAL	3	5	1	9

State	County	City	Tier 3	Tier 2	Tier 1	Total
WA	SKAMANIA	SKAMANIA	11	0	0	11
WA	SKAMANIA	STEVENSON	5	0	0	5
WA	SKAMANIA	CARSON	4	0	0	4
WA	SKAMANIA	COOK	3	0	0	3
WA	KLICKITAT	WHITE SALMON	2	0	0	2
WA	KLICKITAT	BINGEN	1	2	0	3
WA	KLICKITAT	LYLE	8	0	0	8
WA	KLICKITAT	WISHRAM	4	0	0	4
WA	KLICKITAT	ROOSEVELT	7	0	0	7
OR	MULTNOMAH	PORTLAND	5	1	10	16
OR	MULTNOMAH	TROUTDALE	1	0	0	1
OR	MULTNOMAH	DODSON	4	0	0	4
OR	HOOD RIVER	CASCADE LOCKS	6	0	0	6
OR	HOOD RIVER	HOOD RIVER	3	0	0	3
OR	WASCO	MOSIER	2	0	0	2
OR	WASCO	THE DALLES	4	1	2	7
OR	SHERMAN	RUFUS	6	0	0	6
OR	GILLIAM	ARLINGTON	29	4	0	33
OR	MORROW	BOARDMAN	3	0	0	3
		Total Crossings	**210**	**66**	**42**	**318**

Source: Federal Rail Administration

Appendix B

Table B.1. Summary of Rail Event Impacts by Crossing Type: Configuration 1 - Transfer Waste via New Train Service

Table B.2. Summary of Rail Event Impacts by Crossing Type: Configuration 2 - Add Rail Cars to Existing Trains

Table B.1. Summary of Rail Event Impacts by Crossing Type: Configuration 1 - Transfer Waste via New Train Service

Time of Day	Haul Alternative	Train Inputs					Crossing Type 1: 4 Lanes, 25k ADT vehicles/day			Crossing Type 2: 2 Lanes, 10k ADT vehicles/day		
		# of Rail Cars[1]	# of Containers	Train Length	Trains Per Week	Trains Per Day (Inbound + Outbound)	Hourly Volume[2]	Total Vehicles Impacted[3]	Crossing Delay Impact (mins, secs)[4]	Hourly Volume[2]	Total Vehicles Impacted[3]	Crossing Delay Impact (mins, secs)[4]
Evening, > 8pm	Alternative 1A: Evening >8pm, new 76 rail car trains, 3 trains/week	76	152	5434	3	2	1000	38	2 min, 18 sec	400	16	2 min, 18 sec
	Summary of Project Impact						-38 total vehicles are impacted per event for an average of 138 seconds (2 min 18 sec) per event -76 total vehicles (0.304% of ADT) impacted per day (38 vehicles per event x 2 events/day)			-16 total vehicles are impacted per event for an average of 138 seconds (2 min 18 sec) per event -32 total vehicles (0.320% of ADT) impacted per day (16 vehicles per event x 2 events/day)		
Peak Hour, 5pm	Alternative 1B: Peak Hour 5pm, new 76 rail car trains, 3 trains/week	76	152	5434	3	2	2500	96	2 min, 18 sec	1000	38	2 min, 18 sec
	Summary of Project Impact						-96 total vehicles are impacted per event for an average of 138 seconds (2 min 18 sec) per event -192 total vehicles (0.768% of ADT) impacted per day (96 vehicles per event x 2 events/day)			-38 total vehicles are impacted per event for an average of 138 seconds (2 min 18 sec) per event -76 total vehicles (0.760% of ADT) impacted per day (38 vehicles per event x 2 events/day)		

Notes:

-For all haul alternatives the following was assumed:

-Train/Rail speed of 35 mph

-Trains operate 3 times per week. Each train will have an inbound and outbound trip (2 total) per day

-The additional demand due to the project is expected to result in one new train with 76 rail cars per train, which equates to 12.8k tons/week and 667k tons annually (at 28 tons per container, 2 containers per rail car)

-Crossing types are representative of typical crossing layouts.

[1] -"# of Rail Cars" represents the total number of rail cars expected on a train.

[2] - The evening peak (>8 pm) assumed 4% of average daily trips (ADT) would occur during that hour. The Peak hour (5 pm) assumed 10% of ADT would occur during the peak hour. Vehicles are assumed to approach from both sides of the rail crossing.

[3] - The total number of vehicles impacted (in queue, waiting for train to pass) during a rail crossing event caused by additional King County rail cars. Values shown are rounded at various stages of calculation and displayed outputs may not precisely match manual calculations based on the blocking event time and vehicle inputs presented. Minor differences due to rounding do not materially affect the overall findings of the study.

[4] - Total rail crossing blocking time during the rail crossing event, measured in minutes and seconds. This represents the maximum increase in delay that a vehicle would experience at the crossing due to an event.

Table B.2. Summary of Rail Event Impacts by Crossing Type: Configuration 2 - Add Rail Cars to Existing Trains

Time of Day	Haul Alternative	Train Inputs					Crossing Type 1: 4 Lanes, 25k ADT vehicles/day			Crossing Type 2: 2 Lanes, 10k ADT vehicles/day		
		Increase in Rail Cars[1]	Increase in Containers	Increase in Train Length	Trains Per Week	Trains Per Day (Inbound + Outbound)	Hourly Volume[2]	Total Vehicles Impacted[3]	Crossing Delay Impact (seconds)[4]	Hourly Volume[2]	Total Vehicles Impacted[3]	Crossing Delay Impact (seconds)[4]
Evening, > 8pm	Alternative 2A: Evening >8pm, 38 Added Rail Cars, 6 trains/week	38	76	2717	6	2	1000	16	54	400	6	54
	Summary of Project Impact						-16 total vehicles are impacted per event for an average of 54 seconds per event -32 total vehicles (0.128% of ADT) impacted per day (16 vehicles per event x 2 events/day)			-6 total vehicles are impacted per event for an average of 54 seconds per event -12 total vehicles (0.120% of ADT) impacted per day (6 vehicles per event x 2 events/day)		
Peak Hour, 5pm	Alternative 2B: Peak Hour, 5pm, 38 Added Rail Cars, 6 trains/week	38	76	2717	6	2	2500	36	54	1000	16	54
	Summary of Project Impact						-36 total vehicles are impacted for an average of 54 seconds per event -72 total vehicles (0.288% of ADT) impacted per day (36 vehicles per event x 2 events/day)			-16 total vehicles are impacted for an average of 54 seconds per event -32 total vehicles (0.320% of ADT) impacted per day (16 vehicles per event x 2 events per day)		

Notes:

-For all haul alternatives the following was assumed:

-Train/Rail speed of 35 mph

-Trains operate 6 times per week. Each train will have an inbound and outbound trip (2 total) per day

-The additional demand due to the project is expected to be 38 additional cars per train, which equates to 12.8k tons/week and 667k tons annually (at 28 tons per container, 2 containers per rail car)

-Crossing types are representative of typical crossing layouts.

[1] -The number of additional King County rail cars added onto an existing train.

[2] - The evening peak (>8 pm) assumed 4% of average daily trips (ADT) would occur during that hour. The Peak hour (5 pm) assumed 10% of ADT would occur during the peak hour.

[3]- The additional number of vehicles impacted (in queue, waiting for train to pass) during a rail crossing event caused by additional King County rail cars. Values shown are rounded at various stages of calculation and displayed outputs may not precisely match manual calculations based on the blocking event time and vehicle inputs presented. Minor differences due to rounding do not materially affect the overall findings of the study.

[4] - Increase in rail crossing blocking time during the rail crossing event caused by additional King County rail cars, measured in seconds. This represents the maximum increase in delay that a vehicle would experience at the crossing due to an event.