Pines Road/BNSF Grade Separation Project

US Department of Transportation
Office of the Secretary of Transportation

Better Utilizing Investments to Leverage Development (BUILD)

FY 2020 Grant Application

Location: Spokane Valley, Washington

Primary Project Type: Road

Secondary Project Type: Road/Rail Crossing

BUILD Funding Request: $17,886,500

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1 Project Description

In 2019, the Pines Road (SR 27) crossing of the BNSF Railway Company (BNSF) railroad tracks resulted in over 28,000 vehicle hours of delay[1] and the adjacent Pines Road (SR 27) / Trent Avenue (SR 290) intersection experienced 9 recorded collisions.[2] In 2018, the at-grade crossing was rated Washington State's top Tier 1 road-rail conflict.[3] The City of Spokane Valley seeks a BUILD Discretionary Grant of $17,886,500 to complete funding for the Pines Road/BNSF Grade Separation Project to create a safer, more efficient, and reliable transportation network for its users.

1.1 Project Overview

The Pines Road (SR 27) at-grade crossing of the BNSF Railway Company tracks is located 275 feet south of Trent Avenue (SR 290) in the City of Spokane Valley, WA. Pines Road (SR 27) and Trent Avenue (SR 290) are significant rural corridors for local and regional travel and freight movement. Pines Road is a state highway, State Route 27, and is one of Spokane Valley's primary north-south arterial roadways connecting rural eastern Washington with the urbanized greater Spokane region. Pines Road (SR 27) also directly connects Trent Avenue, also a state highway, State Route 290, with Interstate 90 (I-90) to the south, and is a preferred freight route to I-90 between rural north Idaho, Montana and Canada. The BNSF corridor carries freight between western ports and Midwest intermodal facilities as shown in Figure 1.

Figure 1: BNSF Freight Movement in the Pacific Northwest

The BNSF corridor also hosts Amtrak, with two passenger trains per day.

The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks, provides a roundabout at the intersection of Pines Road (SR 27) and Trent Avenue (SR 290), and adds a shared-use path along the project's southeast

[1] 62 trains/day (60 freight and 2 passenger) with an average crossing time of 3.55 minutes/train, creating 3.7 hours of roadway blockage due to freight and passenger trains/day (15.3% of the day); with 17,002 vehicles/day (2019 1-day City ADT projected into 2020), 15.3% of vehicles will be affected for an average of 1.78 minutes (including lead/lag time for gate operations), resulting in 77 vehicle hours/day of delay, or 28,061 vehicle hours/year
[2] Analysis of Washington Department of Transportation (WSDOT) Vehicle Crash Data, 2015-2019
[3] Freight Mobility Strategic Investment Board's *Study of Road-Rail Conflicts – Phase 2 – Development of Project Priorities*, August, 2018

limits. These improvements will reduce the risk of collisions between the existing 17,000 vehicles/day[4] and 62 trains/day[5] at the crossing and help prevent unintended releases of hazardous materials. The existing crossing is shown in Figure 2.

Figure 2: View of Existing Pines Road/BNSF Crossing

Train horns through Spokane Valley will be reduced as the bisection of the city created by the railroad tracks is eliminated.

Replacement of the existing signalized intersection with a roundabout at the Pines/Trent intersection is predicted to reduce all collisions by at least 21%.[6]

Afternoon peak hour intersection delays are anticipated to drop 40 seconds at the time of project completion, improving the intersection level of service from D to A.[7] Pedestrians and cyclists will be able to cross Trent Avenue more safely and comfortably. The improvements support freight movement and regional mobility goals as articulated in various plans including the Horizon 2040, the Metropolitan Planning Organization's (MPO) regional transportation plan and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region.

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[4] 2019 1-day traffic volume count performed by the City, grown at a 10-yr historical 1.46% rate into 2020
[5] Average daily train count provided by email from BNSF's Stephen Semenick to Spokane Valley's Adam Jackson on April 15, 2020 at 10:39 PM.
[6] Crash Modification Factors Clearinghouse: *Convert signalized intersection to modern roundabout*: http://www.cmfclearinghouse.org/detail.cfm?facid=4184
[7] Appendix D - Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis, October 24, 2018 – Table 8

Figure 3: Selected Project Configuration

Figure 3 illustrates the project configuration, which is the result of a two-year alternative process that evaluated the benefits of various project alignments and compared a signalized intersection to a roundabout. The analysis was a coordinated effort with the Washington State Department of Transportation (WSDOT) and BNSF that considered a variety of project elements specific to the rail corridor and highway design requirements. Final design elements will accommodate BNSF's current mainline track expansion project and their long-term expansion to 4 mainline tracks. All highway alignments are subject to WSDOT approval. To date, the City has secured full funding for the preliminary engineering and right of way phases.

1.1.1 Project Benefits Specific to Rural Areas

Rural areas will directly benefit from this project by its improved mobility and safety along the project's two state highways, which are main thoroughfares for the Inland Northwest's rural population. USDOT's Rural Opportunities to Use Transportation for Economic Success (ROUTES) seeks to improve the condition of the roadway infrastructure serving national and regional agricultural and industrial economic activity. The project connects rural traffic to interstate rail, freeway routes, and urban economic activity centers in the greater Spokane region and greater Pacific Northwest. Consistent with ROUTES, the project improves travel times for passenger and freight users while serving as an economic generator, helping unlock the potential for undeveloped industrial and commercial properties that will help create jobs for both rural and urban populations alike. Due to its location near the City's northern boundary, the project serves as a gateway for freight, goods, and travelers coming to and from rural Washington, Idaho, Montana, and Canada. Project outreach included extensive coordination with freight industry representatives who provided input during the project's alternative evaluation. Consistent support for the selected alternative was found amongst freight representatives.

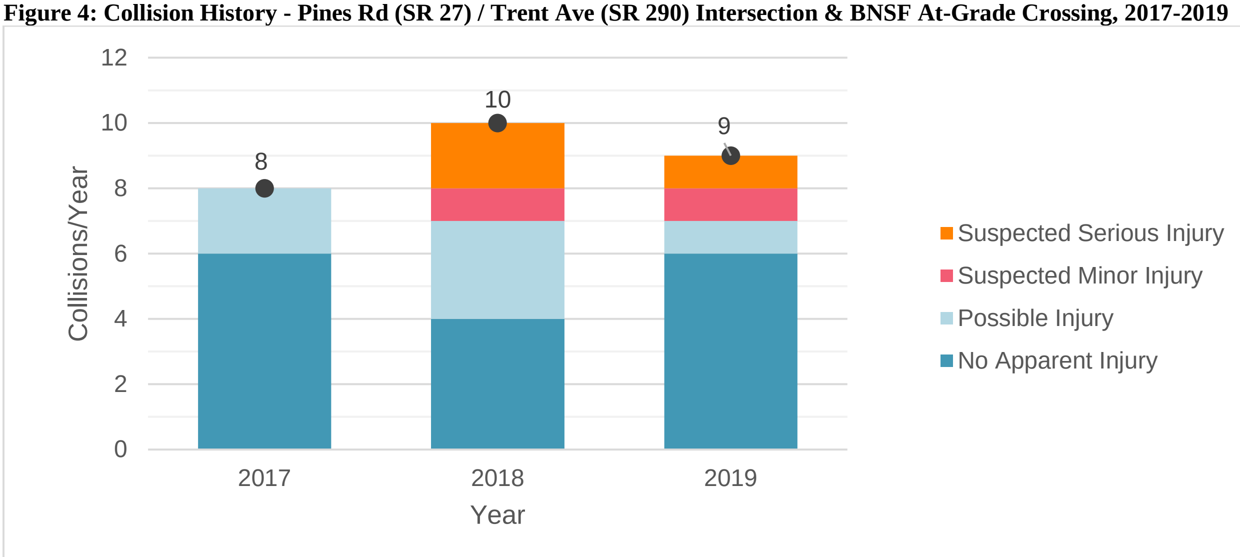
1.2 Transportation Challenges the Project Aims to Address

1.2.1 Safety Risks at and Near the Crossings

At-grade railroad crossings have the potential for fatalities, serious injuries, and hazardous material spills (e.g. Bakken oil), particularly when there are high volumes of rail traffic and roadway traffic. Similarly, incidents at road intersections and at-grade rail crossings could result in fatalities or serious injuries, particularly when there are high volumes of vehicle or rail traffic. The conflicts and risks associated with this project's existing at-grade crossing will continue to grow over time, as both train and vehicle volumes grow. It is projected the number of freight trains on this corridor will increase from 60 trains per day to a potential 106 trains per day by 2040.[8]

Collision history at the Pines Road / Trent Avenue intersection for 2017 to 2019 is summarized in Figure 4. Replacement of the existing signalized intersection with a roundabout will reduce collisions. Since all traffic moves through the roundabout in the same direction, the highest severity collisions associated with left turn and opposing movements will be virtually eliminated.

Figure 4: Collision History - Pines Rd (SR 27) / Trent Ave (SR 290) Intersection & BNSF At-Grade Crossing, 2017-2019



1.2.2 Inefficient Emergency Services Access

Key emergency services (fire, police, medical) are located south of the railroad tracks near I-90. On average, fire and police emergency personnel travelled through the project intersection three times each day when responding to an emergency.[9] Emergency vehicle access through the intersection is likely higher than three per day when accounting for privately-operated ambulance responses that do not access the state-operated intersection signal controls. Of particular importance is the Valley Hospital located 1.5 miles south of the project location near the intersection of Pines Road and Mission Avenue. Valley Hospital is one of the five major hospitals in the Spokane Region. The project has coordinated with healthcare providers and emergency responders to ensure safety and reliability. The long and frequent delays at the rail crossing disrupts emergency services which can compromise public welfare. The grade-

[8] DRAFT Washington Department of Transportation (WSDOT) Washington State Rail Plan, December 2019: https://www.wsdot.wa.gov/sites/default/files/2019/12/31/draft-state-rail-plan-2019.pdf, Exhibit 5-6 illustrating 104 BNSF trains and two Amtrak trains passing through Spokane-Sandpoint corridor.

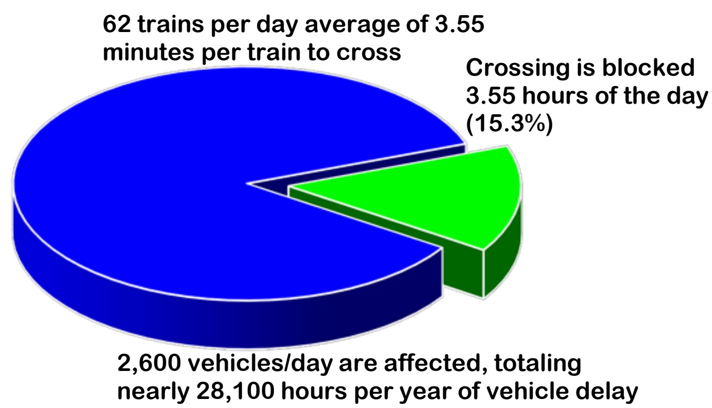
[9] WSDOT's Opticom Emergency Response Log: 888 traffic preemption occurrences by police and fire personnel between August 26, 2019 and April 15, 2020 (233 days), 2.7 occurrences per day. Record excludes ambulance emergencies because they are operated by private businesses and not permitted to pre-empt traffic signal operations.

separated crossing removes this barrier to emergency vehicles, creating more reliable access to street network, while the roundabout provides for a safe and efficient intersection.

1.2.3 Long Delays at the Crossings and Adjacent Intersections

The current daily freight and passenger train volume is estimated to be 62 trains/day, which means that on average, people and freight are delayed 62 times per day at each roadway-railway crossing. A City survey recorded an average of 3.55 minutes of delay for each train crossing. This average time over 62 crossings per day results in 77 vehicle hours of crossing delays to traffic on Pines Road daily. Delays are further compounded by the time required for the vehicle queues created by the train crossing to dissipate. In addition, queued vehicles may block adjacent intersections, most importantly the Pines/Trent intersection causing delays to through traffic on Trent Avenue. Figure 5 illustrates the delays due to train crossings.

Figure 5: Delays Due to Frequent Train Crossings



The existing Pines / Trent intersection operates at level of service (LOS) D in the afternoon peak hour. Trent Avenue as a corridor operates at LOS E with average delays per vehicle of approximately 60 seconds. By 2040, the PM peak hour delays will further increase to over two minutes per vehicle degrading this intersection to a LOS F if no improvements are implemented. Conversion of this intersection to a roundabout results in significant reduction in delay. With 2040 volumes and a roundabout at the intersection, the average delay per vehicle is forecast to be 8 seconds in the PM peak, as the intersection will operate at LOS A.[10]

1.2.4 Constrained Access to Future Developable Land

Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS E conditions at the Pines Road/Trent Avenue intersection. Specifically, the Pinecroft Business Park, located immediately southeast of the project, has capacity to double its employee population from 2,000 to over 4,000, and nearly double its 500,000 square feet of existing buildings space to upwards of 900,000 square feet.[11] These parcels, along with several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area. This project will provide needed transportation improvements, allowing for cost-effective development of the area.

[10] Appendix D - Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis, October 24, 2018
[11] Letter to City of Spokane Valley Council, J. Traeger, JMA Commercial Real Estate, LLC for Pinecroft, LLC (http://www.spokanevalley.org/filestorage/6862/6927/8180/11735/Pinecroft_Business_Park.pdf)

1.2.5 Lack of Community Connectivity

The rail corridor bisects the northern parts of Spokane Valley from the majority of the city south of the railway. On Pines Road, the rail corridor provides a barrier between neighborhoods, recreation areas, commercial retail sites, and schools located on both sides of the railway. The new grade-separated crossing and roundabout will provide sidewalks along both sides of Pines Road, making the route more appealing to pedestrians and more reliable for all users and modes. In addition to a grade separated crossing of the railroad tracks, the roundabout will create a safer and more comfortable crossing of Trent Avenue, see 214.5. Quality of Life for more information.

1.2.6 Noise Pollution from Train Horns

Spokane Valley residents have long complained about the noise pollution of the train horns. Federal law requires locomotives to sound their horns at 96 to 110 decibels as they approach at-grade crossings and continue blowing the horn until the lead locomotive fully occupies the crossing. The required pattern is two long, one short and one long horn, repeated as necessary until the train clears the crossing. With 60 trains crossing Pines Road, horns are a source of significant public concern in Spokane Valley.[12]

1.3 Project History and Relationship to Other Plans

The following summarizes some of the other plans that provide context to the Pines Road/BNSF grade-separation project.

1.3.1 Washington State Joint Transportation Committee

The Joint Transportation Committee (JTC) was created in 2005 and its purpose is to review and research transportation programs and issues to better inform state and local government policymakers, including legislators. From 2017-2018, the JTC conducted an evaluation of prominent road/rail conflicts and developed a prioritization process to address the impacts on a statewide level based on mobility, safety and community criteria. Using this process, Pines Road/BNSF Grade Separation Project was ranked as the top unfunded project in the state out of over 300 crossings reviewed and out of nearly 4,200 total crossings statewide. [13]

1.3.2 Horizon 2040 https://www.srtc.org/horizon-2040/

Horizon 2040 is the Spokane Regional Transportation Council's (SRTC) long-range transportation plan for the Spokane region through 2040. Horizon 2040 identifies the following projects along the BNSF railroad as regionally significant:

- Pines Road (SR 27)/Trent Avenue (SR 290) underpass (planned construction 2020-2030);
- Barker Road/Trent Avenue (SR 290) overpass; and
- Sullivan Road Bridge improvements/Trent Avenue (SR 290) overpass

[12] "Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016
[13] Freight Mobility Strategic Investment Board's *Study of Road-Rail Conflicts – Phase 2 – Development of Project Priorities*, August, 2018, prepared for the Washington State Joint Transportation Committee

1.3.3 Great Northern Corridor Coalition http://greatnortherncorridor.org/coalition

The Great Northern Corridor Coalition (GNCC) is a multi-state cooperative of eight northern tier states, several MPOs and ports, BNSF Railway and other interested parties. The Coalition's mission is to promote a premier multi-state corridor by collectively promoting public policy, research and multi-modal infrastructure development that expands commerce and enhances safety on the corridor (see Figure 6). The GNCC has identified this project in its strategic planning documents and continually promotes grade crossing safety improvement projects.

Figure 6: Great Northern Corridor Route (Chicago to West Coast Ports)

1.3.4 Inland Pacific Hub https://www.srtc.org/inland-pacific-hub/

The Inland Pacific Hub (IPH) is a partnership of public and private sector representatives from northern Idaho and eastern Washington working together to create a multi-modal global gateway to foster increased domestic and international commerce. Phase 2 of the IHP initiative identified priority projects to support the IPH vision, including the Horizon 2040 and Bridging the Valley programs.[14]

1.3.5 Bridging the Valley https://www.srtc.org/bridging-the-valley/#

Bridging the Valley (BTV) was completed in 2006 and presented a plan to separate vehicle traffic from train traffic in the 42-mile corridor between Spokane, Washington, and Athol, Idaho. This stretch included 75 at-grade rail crossings, 11 of which were recommended to be grade separated. The Pines Road/BNSF project is one of these 11 projects. BTV included project objectives to:

[14] Inland Pacific Hub Transportation Investment and Project Priority Blueprint, 2012

- Improve public safety by reducing rail/vehicle collisions
- Improve emergency services access to residents and businesses along the corridor
- Eliminate waiting times and improve traffic flow for all travel modes at rail crossings
- Reduce noise levels, particularly related to train whistles at crossings
- Enhance economic opportunities for a rail corridor served by a key regional railroad

BTV included grade-separation of Pines Road under the BNSF railway and realignment of the project intersection. The original concept addressed the road/rail grade-separation objective, but had significant property access issues. It required the full acquisition and relocation of several existing businesses while resulting in significant traffic impacts to both Trent Avenue and Pines Road during construction. The original concept also included a signalized intersection that would lead to long delays at the intersection. The City conducted an engineering evaluation of two different alignments and intersection controls. The proposed layout is a result of a coordinated review of the project with the Washington State Department of Transportation (WSDOT) that focused on providing the public with the most benefit, minimizing the impacts to property owners and the traveling public, satisfying WSDOT requirements for state highway design and meeting the objectives of Horizon 2040.

1.4 Project Parties

The City of Spokane Valley is the applicant for this project and will manage any grant funding awarded and all design and construction activities associated with the project. The City will work closely with the WSDOT and BNSF Railway Company to deliver the project. See 4.7.1 for support from WSDOT, BNSF (via GNCC) and other stakeholders.

The **City of Spokane Valley** is located near the eastern border of Washington and is the ninth largest city in Washington with a population of nearly 100,000.[15]

WSDOT is responsible for building, maintaining, and operating the state highway system and state ferry system. They are responsible for 26 miles of highway within Spokane Valley, including Pines Road (SR 27) and Trent Avenue (SR 290). If project timing is consistent with WSDOT's staffing demands in its construction management office, there is a high likelihood that the project's construction administration services would be contracted to WSDOT staff, promoting a streamlined delivery process with federal documentation guidelines, saving the project time and money.

BNSF Railway Company operates the east-west Class I railway at the heart of this project. This railway connects Seattle and Portland in the west to Chicago and Minneapolis-St. Paul in the east with many service points in between. This railway also connects customers with the global marketplace. The Spokane region is a convergence of several rail lines on the northern tier of

[15] United States Census Bureau https://www.census.gov/quickfacts/spokanevalleycitywashington, July 1, 2019

BNSF's network. BNSF Railway intends to begin construction of its double track expansion project at the project location as early as 2021. The Pines Road/BNSF Grade Separation project will accommodate up to four tracks to satisfy current BNSF needs and provide for long term growth of BNSF. It will also help alleviate the bottleneck that exists along the rail corridor illustrated previously in Figure 6.

The project partners will coordinate closely and support project delivery as follows:

Project Activity:	Spokane Valley	WSDOT	BNSF Railway
Manage Funding Allocations	✓		
Procurement	✓		
Project Reviews/Approvals	✓	✓	✓
Public Involvement	✓	✓	
Construction Management	✓	✓	

1.5 Summary of Project Benefits

Construction of this project has both national and regional significance. At the national level, the project supports the USDOT's ROUTES Initiative by improving rural mobility and reliability while reducing risk for freight trains, passenger trains, and freight trucks by eliminating road/rail conflicts. The elimination of the project's at-grade crossing reduces train/vehicle incident risks at the crossing. The BNSF rail corridor carries freight and passenger trains between western ports and Midwest intermodal facilities; serving as a critical link, connecting rural mid-west America with ports and metropolises on the west coast.

At a regional level, the elimination of delays at the rail crossing will enhance the mobility of freight trucks traveling to/from Interstate 90 just south of the project.

Additional regional benefits include:

- Improved mobility and safety for all users, promoting increased access to and from rural areas with the greater Spokane urbanized area
- Significantly improving the traffic operation of the intersection
- Unlocking the economic potential to develop prime vacant land zoned for industrial, mixed-use, and commercial uses
- Re-connecting communities and recreation areas
- Improving the quality of life through noise and emissions reductions
- Improving access for police, fire and medical providers
- Doubling of the distance between the project intersection and Trent Elementary

The overall project supports regional commerce within the Inland Pacific Hub and achieves regional planning goals that have been in place for more than a decade.

Expected system users that will benefit from this project include:

- Travelers and local residents (automobile drivers/passengers, pedestrians, bicyclists)
- Trucking companies and the companies that use their services for freight transport
- BNSF Railway and companies that use the railway for freight transport
- Amtrak and their passengers
- Property owners near the project (businesses, vacant land owners)
- Emergency services providers
- East Valley School District

Table 1 provides a summary of the conditions at the Pines Road/BNSF railroad crossing with and without the project.

Table 1: Before and After Conditions at Pines Road BNSF Railway Crossings

Conditions	No Project	With Project
At-grade crossings	1	0
Longest segment with no at-grade crossings* (miles)	1.0	2.1
Daily Train Horns at Pines/BNSF Crossing	62	0
Predicted annual collisions** – Pines/Trent intersection	25	20***
Predicted annual incidents (Fatal and Injury) - Pines/Trent intersection	4	3
Predicted annual incidents** - Pines Road/BNSF crossing	2	0
Annual vehicle hours of peak hour intersection delay** - Pines/Trent intersection	13,432	3,454
Annual vehicle hours of railroad crossing delay** - Pines Road/BNSF crossing	38,797	0

** Between Evergreen Road and Vista Road*
*** Based on 2026 (project opening year) volumes and a roundabout at Pines & Trent; number of predicted collisions and delays will increase as volumes increase*
**** The total number of collisions at the Pines/Trent intersection is predicted to drop 3 collisions/year. Due to the project's safety improvements, accidents of all severities are expected to decrease by 21%*

This project will generate key long-term benefits that leverage federal investment by enhancing the mobility and safety of people and freight in the region, while also providing economic opportunities and enhancing the environment and surrounding rural communities. The project outcomes are summarized in Table 2.

Table 2: Expected Project Outcomes

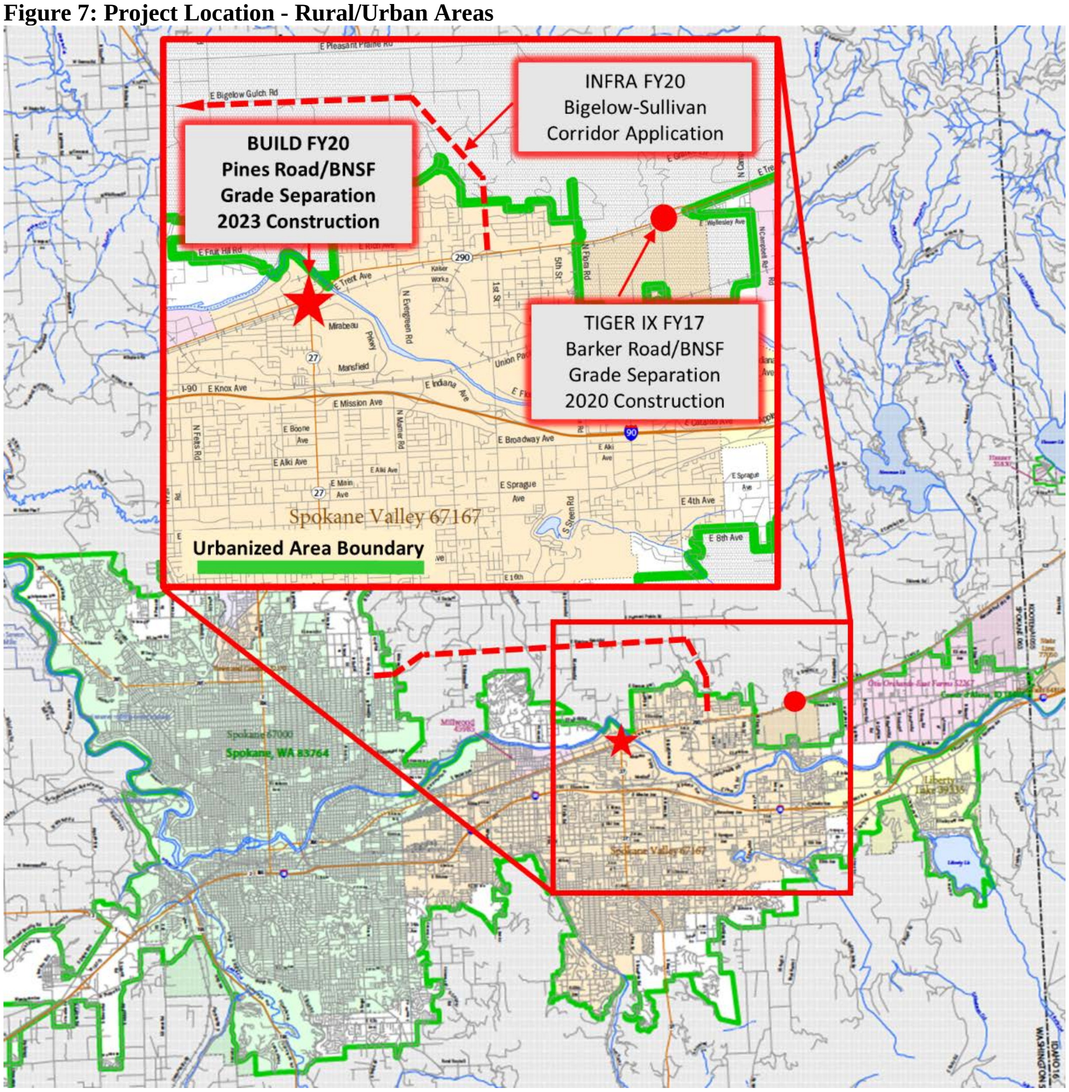
Safety Outcomes	• Eliminates the risk of conflict between roadway users and trains by separating uses • Eliminates potential queuing of vehicles stopped for train crossings • Reduces the potential for high severity collisions at the intersection • Adds ADA-accessible active transportation features to increase safety • Improves emergency access for police, fire and medical providers
State of Good Repair	• Improves infrastructure resilience through new construction of the underpass, intersection improvement via roundabout or improved signalization, and approaches to current standards • The City of Spokane Valley's various street-related funds have sufficient funding to cover operations and maintenance; there is a Capital Reserve available as a contingency • The City has successfully implemented similar projects, including most recently the Sullivan Road West Bridge replacement at the Spokane River and is currently underway with a very similar grade separation project at the intersection of Barker Road and Trent Avenue.
Economic Competitiveness	• Decrease transportation costs and improve long-term efficiency, reliability, and costs in the movement of workers and goods • When combined with other Horizon 2040 regionally significant projects, creates an 3.6-mile section with only one remaining at-grade BNSF crossing • Contributes to reliable movement of regional freight by road and rail • Enhance the access and reliability to close to 170 acres of prime, buildable industrial-zoned land and 56 acres of residential-zoned land
Environmental Sustainability	• Reduces fuel consumption and tailpipe emissions for idling vehicles • Eliminates the need for train horns for a 2.1-mile section
Quality of Life	• Improves community connectedness between neighborhoods, industrial jobs, and nearby recreational areas • Eliminates train horn noise at Pines Road and improves the health and well-being of surrounding residents and businesses[16] • Reduces delay for all modes of travel and improve traffic circulation • Greatly enhance accessibility for active modes by eliminating infrastructure gaps and reducing delay • Moves the intersection away from the school and provides pedestrian facilities for all users, including school children
Partnership and Innovation	• Helps fulfill the vision of the MPO's Horizon 2040 Metropolitan Transportation Plan • Addresses one of Washington State's highest priority road-rail conflicts. • Supports the Great Northern Corridor Coalition's vision for safe, efficient, and environmentally sound transportation services

[16] "Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016

2 Project Location

The project is located in the City of Spokane Valley, WA, in the northeast corner of the state, approximately 9 miles from the Idaho border and 90 miles south of the Canadian border. It is one-quarter mile within the urbanized area (UA) of Spokane Valley (67167) and is located on SR 290, which straddles the north limits of the greater Spokane urban area boundary, as shown in Figure 7. The geographic location is 47°41’21” N, 117°14’22” W.

Figure 7: Project Location - Rural/Urban Areas



The Pines Road/BNSF grade separation project is four miles west of the City’s Barker Road/BNSF grade separation project and two miles west of the Sullivan Road/SR 290 interchange reconstruction project included in the INFRA FY20 Bigelow-Sullivan Freight Mobility & Safety Project (Figure 8). The Barker Road/BNSF project was awarded over $9 million from the TIGER IX program and goes to bid in June 2020. The Pines Road/BNSF grade separation project is a continuation of the regional *Bridging the Valley* goal discussed in Section 1.3.5 and promotes near-identical benefits for rural areas as the TIGER IX awarded project.

Figure 8: Project Locations and Connections to Existing Transportation Infrastructure

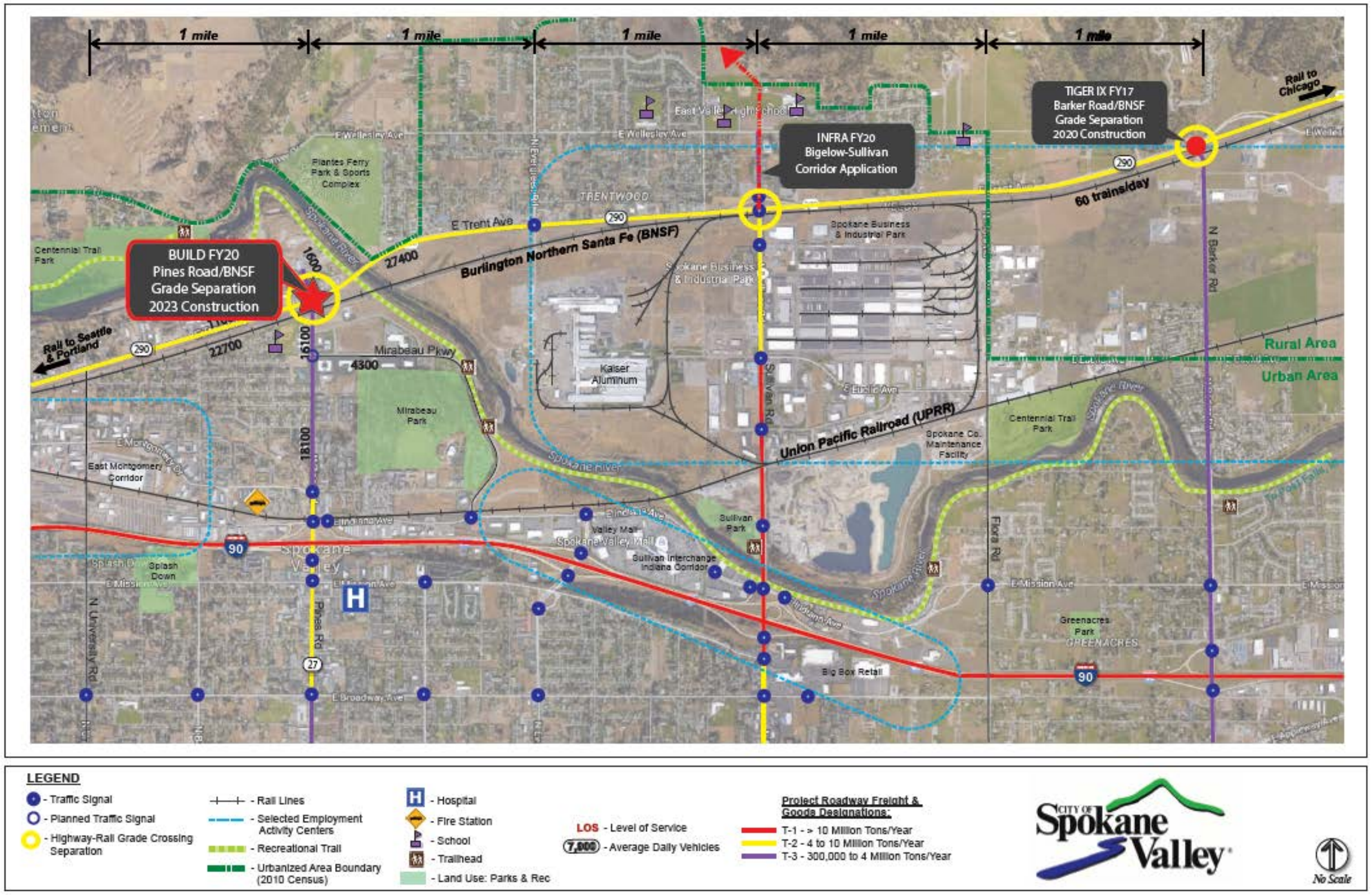


Figure 8 includes the proposed project location and surrounding area. Key features shown include:

- *Pines Road/BNSF Grade Separation Project: highway-rail crossing improvements on the BNSF rail line: Grade separation at Pines Road (SR 27)*
- *TIGER IX-Funded Barker Road/BNSF grade separation project and closure of Flora Road/BNSF at-grade crossing (2020 Construction)*
- *INFRA FY20 Project Application: Bigelow-Sullivan Freight Mobility & Safety Project*
- *Freight Rail Routes: BNSF and UPRR lines*
- *Land Use: key industrial areas, parks and recreation areas, schools, and vacant land*
- *Traffic Data: BNSF train volumes (Freight 60 per day, Amtrak 2 per day) and average daily traffic on project roadways (up to 35,000 vehicles/day[17]).*

[17] Based on a 60/40 split of the most recent City ADT volumes at the intersection of Pines Road and Trent Avenue

3 Grant Funds, Sources and Uses of Project Funds

The City of Spokane Valley is requesting **$17,886,500** in BUILD grant funds, which is **62%** of the **$28,660,000** total future project cost (estimated in year of expenditure). This section discusses the cost, committed and expected funding, federal funding overview, project budget, BUILD funding allocation, and the City's financial condition and grant management capabilities.

3.1 Project Costs

Not included in the project's estimate, previously incurred project costs include:

- $395,000 for planning (done in 2004), preliminary engineering (done in 2004), which included 30% design plans and cost estimates for the previous concept, and environmental documentation (initial NEPA approval in 2006).
- Through March 2020, approximately $513,000 for preliminary engineering design (2017-2020). In close coordination with WSDOT and BNSF, the City selected a project alignment and a roundabout configuration for the intersection.
- The City expended $494,000 for early property acquisition completed in 2017. Early acquisition was critical to prevent future increased relocation/acquisition costs of the property.

The future costs will be incurred for the following activities:

- Pre-construction activities:
  - Final engineering design
  - Additional acquisition of real property
- Construction, including construction engineering and management

The total estimated future cost in 2018 dollars is $23,909,000. This cost has been escalated at 3.5% annually to reflect the year costs are to be incurred as summarized in Table 3.

Table 3: Annual Inflated Project Costs

Phase	2018 Cost	Year of Expenditure	Inflated Cost (3.5% annually)
Design Engineering (2020-2022)	2,908,000	2021	3,225,000
Right-of-Way (2020-2022)	4,670,000	2022	5,359,000
Construction (2023-2025)	13,489,000	2024	16,582,000
Construction Engineering (2023-2025)	2,842,000	2024	3,494,000
Total Project Cost	**$ 23,909,000**		**$ 28,660,000**

3.2 Committed and Expected Funding

As of April 2020, the City **secured $8,741,500,** or **30.5%,** of the total future project cost of **$28,660,000.** Secured funds (see Appendix E) include valuable contributions at the federal level and elevate the importance of the project to the regional and national scale:

- **$1,246,500** from Federal Railroad Administration's Consolidated Railroad Infrastructure and Safety Improvements (CRISI) Discretionary grant program for Preliminary Engineering (PE) and National Environmental Policy Act (NEPA) phase. CRISI funds are obligated and require a local match of $1,246,500.
- **$3,795,000** from Federal Highway Administration's Surface Transportation Block Grant (STBG) program for the project's Right-of-Way (ROW) phase.
- **$3,700,000** from committed local funds from the City of Spokane Valley to fully fund the PE and ROW phases.

In 2000, the Washington state Freight Mobility and Strategic Investment Board (FMSIB) **awarded the project $3,360,000**. However, due to inactivity, in 2007 FMSIB placed its committed funds into "deferred" status. As a "deferred" award, the project is eligible for FMSIB funding but must wait until FMSIB's next call for projects.

There is opportunity to receive additional non-Federal matching funds through various programs such as Washington State Transportation Improvement Board (TIB), Washington State Legislative Direct Appropriation (LDA), or City contributions. Table 4 provides a detailed breakdown of the committed and expected funding for both federal and non-federal sources.

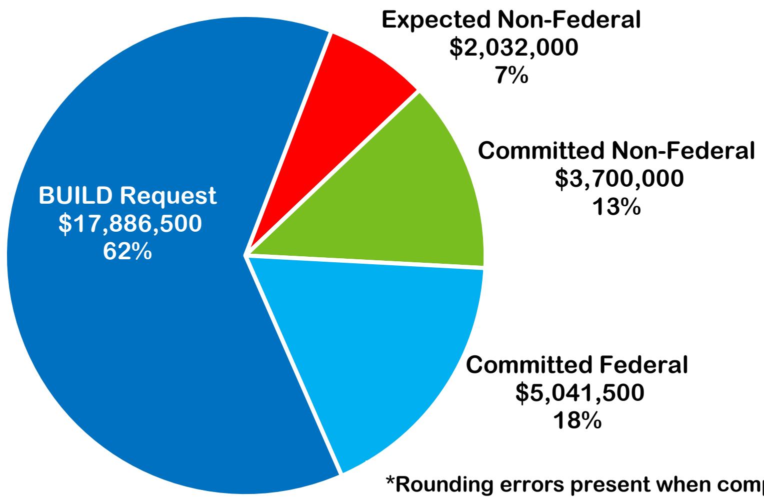
Table 4: Funding Sources

Status	Source	Total ($)	Total (%)
Federal Funding			
Requested	BUILD	17,886,500	62%
Committed	CRISI Program	1,246,500	4%
Committed	STBG Program	3,795,000	13%
	Subtotal	**$ 22,928,000**	**80%**
Non-Federal Funding			
Committed	City of Spokane Valley	3,700,000	13%
Expected	BNSF*	300,000	1%
	Other (City, TIB, FMSIB, State Alloc.)	1,732,000	6%
	Subtotal	**5,732,000**	**20%**
	Total	**$ 28,660,000**	**100%**

* *Per 23CFR 646.210, BNSF will determine funding commitment as the 60% design and cost estimates are brought to current standards.*

The share of the anticipated funding sources is summarized in Figure 9. Expected funding from BNSF will be determined once the design has reached 60%. Conservatively, the project has assumed a BNSF contribution of $300,000.

Figure 9: Funding Sources*



*Rounding errors present when compared to Table 4.

3.3 Project Budget

The City's committed funds are from the Capital Reserve and Grade Separation Project funds. See Appendix A for the City's endorsement and commitment of funding for this project. The engineering phase will be funded by CRISI and City funds while the ROW phase will be funded by STBG and City funds. The construction phase will be funded primarily with BUILD funds, along with expected non-federal funds. Table 5 summarizes the project budget and allocation of costs.

Table 5: Allocation of Project Funding

Project Phase	BUILD	Other Federal	Non-Federal	Total
Engineering	$ -	$ 1,246,500	$ 1,978,500	$ 3,225,000
(% by Phase)	*0%*	*39%*	*61%*	*100%*
Right-of-Way Acquisition	$ -	$ 3,795,000	$ 1,564,000	$ 5,359,000
(% by Phase)	*0%*	*71%*	*29%*	*100%*
Construction	$ 17,886,500	$ -	$ 2,189,500	$ 20,076,000
(% by Phase)	*89%*	*0%*	*11%*	*100%*
TOTAL	**$ 17,886,500**	**$ 5,041,500**	**$ 5,732,000**	**$ 28,660,000**

3.4 BUILD Funding Allocation

Awarded BUILD funding will be expended on the project's construction phase for the railway-highway grade separation and associated intersection improvements.

4 Selection Criteria

This section provides a summary of how the project meets the merit selection criteria for outcomes related to safety, state of good repair, economic competitiveness, environmental protection, quality of life, innovation, partnership, and non-Federal revenue for transportation infrastructure investment.

4.1 Safety

The BNSF mainline and Trent Avenue are high volume train and vehicle corridors respectively. As such, there is potential for significant safety hazards for vehicle, pedestrian, and bicyclist cross-traffic. There is currently an average of 60 freight trains and two Amtrak trains per day using the BNSF line at the Pines Road crossing and the corridor has high growth projections for train volumes to increase to 106 daily trains in the future, or four to five trains every hour on average. This is of particular concern to the community because the BNSF rail corridor is the route for commodity travel from the North American interior through Spokane Valley on its way to west coast terminals. As discussed in Section 1.3.1, the Pines Road/BNSF grade separation project is ranked the state's number one unfunded, road-rail conflict priority. To illustrate the magnitude of shipments, the Washington State Department of Ecology estimates that over 2.8 billion gallons of Bakken oil travels through Spokane Valley annually.[18] This project eliminates the risk of fatalities, serious injuries, and commodity spills that can happen at road/rail at-grade crossings.

In addition to the positive outcomes of the roadway-railway grade separation, the project offers additional safety benefits by replacing the existing at-grade intersection of Pines Road at Trent Avenue with a roundabout. As discussed in Section 1.1, it is expected that a roundabout will result in a 21% reduction in collisions. Table 6 summarizes the expected collision reduction for the railroad crossing and Pines/Trent intersection in 2040 horizon year (the 2040 horizon year matches the MPO regional travel demand model future forecast horizon).

Table 6: Annual Collision Reduction, 2040 Horizon Year

Location	All Collisions	Fatal and Injury Collisions
Pines / BNSF RR Crossing	1.1	0.3
Pines / Trent Intersection	6.8	1.7
Total	7.9	2.0

The grade separation project also improves emergency access and provides enhanced detour/evacuation routes to residents, businesses, and schools by eliminating the delay impact resulting from crossing trains or incidents on the tracks. Additionally, improved access to Trent Avenue enhances the highway's role as a good alternate route to I-90 and Highway 95 in Idaho.

[18] As of March 31, 2020, 42 gallons per barrel x 680 barrels per car x 24,596 cars per quarter x 4 quarters = 2.81 billion gallons: https://fortress.wa.gov/ecy/publications/documents/2008006.pdf

Students at Trent Elementary are not allowed to walk to school through the project intersection because of its associated hazards. This project will improve pedestrian accessibility and move the physical intersection location almost one-quarter mile from the school, twice its current distance. The safety of active modes will be enhanced with the addition of ADA-accessible sidewalks on the Pines Road underpass, including a shared-use path along the southeast project limits. Further, all ADA-related project improvements will be completed to satisfy current standards.

4.2 State of Good Repair

The project will address current roadway condition issues as the project will require full reconstruction of the affected portions of those roadways. All design will be to current design standards to provide a robust finished product that will have long term resilience greater than the current infrastructure. WSDOT has responsibility for maintenance of Pines Road and Trent Avenue, including the intersection being completed as part of this project. WSDOT has the resources to implement and properly maintain the asset for the design life of all elements.

The financial condition of the City of Spokane Valley is reported in their comprehensive annual budget and monthly financial reports.[19] The City employs staff with experience in grant management, project management and asset management.

The City successfully manages approximately five to eight million dollars in grants (federal and non-federal) on an annual basis and documents these figures in the annual budget. The primary source of the City capital funding for transportation projects comes from the City's Real Estate Excise Tax (REET) Revenue. Transportation operations funding comes from state gas tax revenue and a utility tax on telephones. The City's Street Fund has sufficient funding to cover operations and maintenance of the project. The City has a Capital Reserve Fund as a contingency for capital projects, and the General Fund may be used as a contingency for operating costs. Independent Audit Opinions are performed annually for the City of Spokane Valley under the U.S. Office of Management and Budget (OMB) Circular A-133. The two most recent, for fiscal years 2017 and 2018, reported no Significant Deficiencies or Material Weaknesses.

The project creates opportunities to provide access to currently undeveloped land by creating excess capacity within the Pines/Trent intersection. Further economic activity in the area creates opportunities for direct developer contribution to future upgrading, and adds to the City's tax base, both of which can further support long-term management of the infrastructure.

The City continues to demonstrate its ability to implement comparable projects. The City's most recent completed project is the $15 million Sullivan Road West Bridge Replacement Project. This project combined four funding sources: one federal, two state, and a local city match.

Also underway is the City's Barker Road/BNSF Grade Separation Project, recipient of a $9 million TIGER IX award offered by the USDOT. The project is federally funded at 64% and

[19] Spokane Valley Budget & Financial Reports: http://www.spokanevalley.org/content/6836/6902/7156/default.aspx

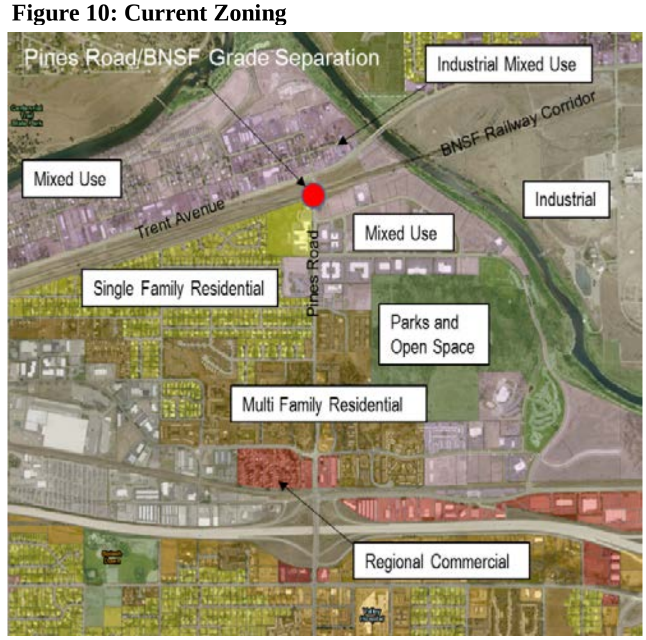
non-federally funded at 36%. It includes three federal funding sources, two state funding sources, one private contribution and a local city match. The project is nearing completion of the PE and ROW phases and will advertise in June 2020.

4.3 Economic Competitiveness

The smooth flow of trade, vital to U.S. economic competitiveness, is facilitated by addressing key deficiencies across the system. The Pines Road grade separation of the BNSF mainline provides an opportunity to target a local deficiency that effectively ripples benefit through the rest of the transportation system. The BNSF mainline that travels through the City of Spokane Valley is part of a broad rail network that moves freight between international marine ports and terminals on the west coast, and points across the western half of the U.S. All three of Washington's east-west freight lines are owned by BNSF and they all funnel through the Spokane rail corridor.[20] The BNSF railway also serves interstate passenger rail service via Amtrak's Empire Builder route between Seattle and Chicago. Currently, the BNSF line carries an average of 60 freight and two passenger trains daily, and usage is projected to reach up to 104 freight trains and two passenger trains daily.[21] Upon completion, there will be 2.1 miles of rail corridor that will be unencumbered by at-grade crossings. When combined with the other Horizon 2040 regionally significant projects (Barker Road/BNSF Grade Separation and Sullivan Road Bridge Reconstruction), the only remaining at-grade crossings between Harvard Road and Vista Road would be at Evergreen and University Roads.

The Pines Road grade separation also has a significant benefit to trade facilitated by trucking. Pines Road serves as a primary arterial roadway directly connecting a State Highway at the project site with Interstate 90 to the south. The project promotes improved interstate freight movement to/from Canada and Idaho through Spokane County/Kootenai County by reducing vehicle-train conflicts as envisioned in the 2006 Bridging the Valley Plan.

Figure 10: Current Zoning

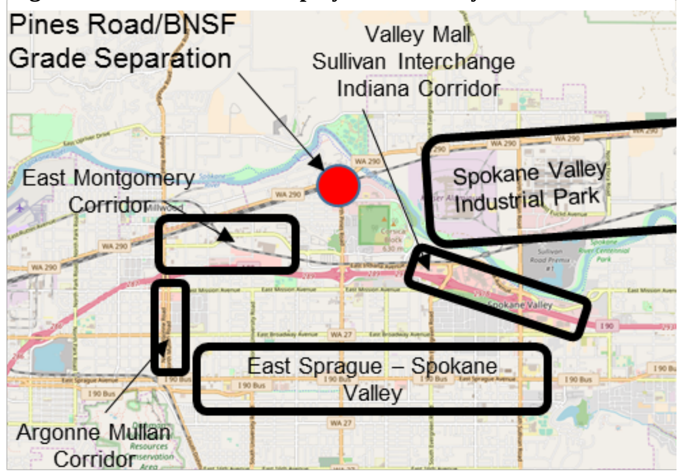


The project improves regional economic vitality by significantly improving reliability and accessibility to close to 170

[20] DRAFT Washington Department of Transportation (WSDOT) Washington State Rail Plan, December 2019: https://www.wsdot.wa.gov/sites/default/files/2019/12/31/draft-state-rail-plan-2019.pdf, Section 6.1, Line 2085.
[21] Ibid. Exhibit 5-6 illustrating 104 BNSF trains and two Amtrak trains passing through Spokane-Sandpoint corridor.

acres of mixed-use or commercially-zoned and 56 acres of prime industrially-zoned parcels shown in Figure 10. The City is expected to accommodate an additional 20,000 residents[22], the Pines/Trent/I-90 area will remain a centralized corridor for growth (See Figure 11: Selected 2040 Employment Activity Centers). This project contributes significantly to supporting and managing this economic growth by building transportation infrastructure necessary to attract, retain, and expand businesses.

Figure 11: Selected 2040 Employment Activity Centers



The investment to expand the capacity of the transportation network will allow the land to support economic development at a much higher intensity. The economic and tax impacts of that higher level of development stemming from the construction and occupation of industrial developments are estimated as follows[23]:

- $1.3 billion in total economic output in Spokane County ($686 million in direct spending)
- 8,719 new jobs supported in the county (4,312 direct jobs)
- $8.2 million in new general fund taxes to the city (25 year present value at 4%)
- $101.9 million in new general fund taxes to the state (25 year present value at 4%)

4.4 Environmental Sustainability

Grade separation of the BNSF rail line generates environmental benefits in reduced noise and air pollution. For Spokane Valley residents this represents a seemingly continuous sounding of horns along the railway corridor from Barker to Pines Road. The required sounding of train horns is significantly reduced with the grade separation of Pines Road.

The project supports air quality improvements and fuel efficiency. No longer will vehicle traffic be idling waiting for the crossings to be cleared by freight and passenger trains blocking Pines Road. Crossings are occupied for an average of approximately three and a half minutes for each train to pass plus the time to dissipate queues. Further reductions in idling will result from reductions in peak hour intersection delays at the Pines/Trent intersection. By 2040, the afternoon peak hour intersection delays are anticipated to drop nearly 40 seconds per vehicle with a roundabout.[24]

[22] Exhibit 2: Residential Land Capacity, *Existing Conditions-Housing and Economic Trends* (http://www.spokanevalley.org/filestorage/6862/6927/7094/7096/7112/Final_Existing_Conditions_2015_0930.pdf) prepared for the *Spokane Valley Comprehensive Plan:* http://www.spokanevalley.org/cp

[23] Fiscal and Economic Benefits of the Pines Road Underpass Project, ECONorthwest 2016; http://www.spokanevalley.org/PinesBNSF

[24] Appendix D - Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis, October 24, 2018 – Tables 8 & 9 Comparison between PM Peak Hour Delay for "No Build" and Alternative 2a (47-8 = 39 seconds)

These savings equate to nearly 40 hours of daily time savings.[25] Idling vehicles consume fuel and emit harmful air pollutants. Spokane Valley and the rest of the region are identified by the U.S. Environmental Protection Agency (EPA) as maintenance areas for Particulate Matter (PM10) and Carbon Monoxide (CO), providing a significant annual reduction in CO, particulate matter, and greenhouse gas as compared with the current configuration.

4.5 Quality of Life

The Pines Road/BNSF Grade Separation project will substantially contribute to the improved livability for residents in the region by enhancing community connectivity while reducing the negative effects of train horn noise and decreasing transportation delays.

The BNSF rail corridor bisects the community. The area north of Trent Avenue is largely residential. Plantes Ferry Park and Sports Complex are also located to the north, while Trent Elementary School is located immediately south of the Pines Road/BNSF crossing. The majority of the City's commercial, employment, and residential uses lie south of the BNSF corridor and Trent Avenue. This project will help knit together the northern and southern sectors of the community by eliminating barriers that impede mobility.

The project will complete key gaps in the City's pedestrian and bicycle networks that provide transportation and recreational options. Sidewalks are proposed for the project and a shared-use path will run along the southeast project limits. Given the project's proximity to schools, commercial centers, employment areas, parks, and the Spokane River, safe and comfortable pedestrian connections are very important and will provide a great benefit for the community.

This project significantly improves connections to many community amenities. The 37.5-mile paved, mixed-use Centennial Trail runs along the Spokane River between Spokane, Washington and Coeur d'Alene, Idaho. It connects several local amenities and includes crossings of the Spokane River. Pines Road is a gateway to the Trail and the City is coordinating the adjacent property, Avista Utilities, for improvements to this trail connection as part of the project. South of Trent Avenue, Mirabeau Parkway provides access to Mirabeau Point Park from Pines Road, with river and Centennial Trail access. Plantes Ferry Park and Sports Complex is a 95-acre regional sports complex, located north of Trent Avenue, with sporting fields, trails, picnic areas, and playgrounds. Pines Road and Trent Avenue are important routes to this facility.

The positive outcome for freight and passenger rail travel achieved by removing one at-grade crossings of the BNSF line supports the continued implementation of Horizon 2040 and the previous Bridging the Valley Plan. The project will also accommodate the planned additional mainline tracks for the rail corridor.

[25] PM Peak Hour assumes 10% of intersection ADT of 35,000 vehicles (based on most recent City volume counts)
Roundabout: 40 seconds/vehicle x 10% x 35,000 vehicles / 3600 seconds/hour = 38.9 hours

The ability to safely walk or bike across Trent Avenue between the residential communities, schools, commercial centers, and employment areas is hampered by gaps in the active transportation networks on Pines Road and the nature of traffic on Trent Avenue. The project enhances mobility for active modes by constructing Americans with Disabilities Act (ADA)-compliant sidewalks that connect the land uses to the north and south of the project area, and improve the comfort and safety of crossing Trent Avenue with a roundabout.

4.6 Innovation

The City of Spokane Valley will evaluate innovative bridge construction techniques to reduce the impact on the community and the existing traffic. This may include constructing the structures off-site before staging for construction. The project will also take advantage of the Spokane Regional Transportation Management Center (SRTMC) Intelligent Transportation Systems (ITS) infrastructure to communicate traveler information about construction activities and expected delays throughout the project using SRTMC's website and 511 telephone system. Other ITS technologies, such as work zone queue management and speed management systems, will be evaluated for applicability during project engineering.

4.7 Partnership

This project demonstrates support from numerous public and private partners across the region. Two states, several regional public entities, multiple cities, and local business organization, as well as two Class I railroads actively participated in the Horizon 2040 planning document, and in the previous Bridging the Valley plan and other workshops, stakeholder outreach, and funding initiatives to further this effort. Table 7 summarizes the key partners associated with the Pines Road/BNSF grade separation project and other related projects.

Table 7: Partners in the Project Development

State and Local Agencies	
• Washington State Dept. of Transportation • WA Freight Mobility Strategic Investment Board • State and Federal Legislators	• Idaho Transportation Department • Washington Utility and Transportation Commission
Regional Agencies	
• Spokane Regional Transportation Council • Spokane Regional Traffic Management Center • Spokane Transit Authority	• Kootenai Metropolitan Planning Organization • Avista Utilities
Railroads	
• BNSF Railway Company	• Union Pacific Railroad
Local Agencies and Districts	
• Counties: Spokane, Kootenai • Cities & Towns: Athol, Rathdrum, Spokane, Spokane Valley, Millwood	• Police/Fires/Emergency Responders • Area School Districts • Freight/Industry Representatives
Chambers of Commerce	
• Spokane Valley	• Greater Spokane Incorporated

The City of Spokane Valley has an excellent working relationship with WSDOT, and collaborate on roughly 10 to 20 projects per year. WSDOT maintains and operates 26 miles of state roadways within Spokane Valley. The City and WSDOT are both members of the SRTMC and work together to provide active regional transportation systems management and operations (e.g. incident management, traveler information). WSDOT and the City have delivered several ITS projects together, and WSDOT operates and maintains City traffic signals and ITS infrastructure on the state highways within the City through a long-standing Interlocal Agreement. The City and WSDOT collaboratively review traffic impact studies and permits for properties on Trent Avenue and Pines Road.

The City coordinates with BNSF regarding all roadway crossings in the city. The two entities have worked together to complete several crossing diagnostic reviews in the past few years and coordinate all regularly scheduled and unplanned maintenance activities. In recent years, the City and BNSF have worked together to implement structural improvements at an overpass, enhance safety at at-grade crossings, and minor road upgrades at other crossings. Soon the City will execute a Construction and Maintenance agreement with BNSF on the Barker Road/BNSF project. Lastly, the two have worked together on the evaluation of this application's design alternative. As required by CFR 646.210, BNSF will evaluate its funding contribution when the project reaches 60% design.

4.7.1 Letters of Support

The City has conducted extensive public outreach to the general public, elected officials, school districts, emergency responders, and freight & industry representatives to gain input on the most practical and effective improvements that would best serve the community. Further, the City has requested support through its website and at local gatherings like public meetings or presentations to groups like Washington State Congressmen or the Spokane Valley Chamber of Commerce. Letters of support are posted to the City's website: http://www.spokanevalley.org/PinesBNSF

5 Project Readiness

With the help of BUILD funding, the Pines Road/BNSF Grade Separation Project is expected to begin construction by 2023. This project readiness section provides a summary of the technical feasibility, project schedule, required approvals needed, and mitigations for anticipated scope, schedule, and budget risks. In 2020, both federal (CRISI & STBG) and city funds will be used to begin the engineering and right-of-way acquisition phases of the project.

5.1 Technical Feasibility

The technical feasibility of the proposed improvements has been thoroughly established through previous planning and preliminary engineering efforts.

5.1.1 Statement of Work

The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout at the intersection of Pines Road and Trent Avenue. The proposed typical section for Pines Road consists of four travel lanes with a shared center turn lane. A 6 foot wide sidewalk will be located on the west side of the road along with a 12 foot wide shared path on the east. The sidewalk and shared use path will be separated from the roadway by a swale when necessary for drainage. The Trent alignment and typical section remains the same. Table 8 provides the detailed project scope of work pertaining to how the design and construction will be achieved for the project.

5.1.2 Design Criteria and Basis of Design

The project will be led by the City of Spokane Valley. Design criteria was identified in the Bridging the Valley preliminary engineering effort and includes national, City, AASHTO, WSDOT, and BNSF standards. The process will follow WSDOT's project development and delivery procedures and standards supplemented with City procedures and standards as needed. In June 2019, WSDOT granted interim approval for the project's Basis of Design and engineering design is currently ongoing. Procedures and design criteria from the *Union Pacific Railroad and BNSF Railway Guidelines for Railroad Grade Separation Projects* and the AREMA *Manual for Railway Engineering* will also be used.

Table 8: Project Scope of Work

Engineering	Bid Letting & Construction
Procurement of Engineering Services Task 1: Surveying & Mapping Task 2: Utility Coordination Task 3: 30% Plans and Estimate Update* Task 4: 60% PS&E Task 5: 90% PS&E Task 6: Final PS&E Task 7: Local Agency Permits Task 8: Public Involvement Task 9: Project Management Task 10: Quality Management Task 11: Project Team Meetings Tasks 1 through 6 will be completed in the order shown, while Tasks 7 through 11 will be ongoing throughout the course of the engineering.	Final PS&E Review by FHWA, WSDOT, Spokane Valley, and BNSF Advertisement and Bid Letting Procurement of Contractor Notice to Proceed Shop Drawings and Submittal Reviews Fabrication of Structural Supports Mobilization and Erosion Control Temporary Traffic Control Utility Demarcation Bridge Structure Construction Roadway and Rail Construction Site Visits and Inspection Record ("As Constructed") Drawings Meetings

*Although 30% plans and costs were developed in 2004, they will need to be updated to current standards (including all required railroad clearances) and to account for current conditions and unit prices. This update will also include geotechnical updates.

5.1.3 Basis of Cost Estimate and Contingency Levels

A detailed project cost estimate is included in Appendix B. Costs were developed in 2018 dollars and inflated at 3.5% annually to the start of each respective phase. Various contingencies are identified in the cost estimate. As an average, the overall contingency amount is 24%.

5.2 Project Schedule

The project has been the subject of several reviews with WSDOT and BNSF, all of which have led the City to its selected road and intersection configuration. Committed CRISI and STBG funds for preliminary engineering and right of way, partnered with local contributions over the next 2 years, result in full funding for the project's PE and ROW phases. This timing aligns with BUILD FY20's award, contract negotiations, and funding authorization schedule and ultimately allows for the project to begin construction in spring 2023.

The project schedule shown in Table 9 includes the major project milestones for right-of-way acquisition, engineering, and construction and demonstrates that the project can meet the funding obligation and construction deadlines required by the BUILD grant program. The schedule considers procurement and review timelines. The timelines for right-of-way acquisition and construction are dependent on funding; however, given the project's development through 2020 and its committed funding status, it is a strong candidate for funding support at all levels, particularly with support from the BUILD program.

Table 9: Project Schedule

Phase	Begin	End
Design Engineering	09/2017	12/2022
Environmental Documents (NEPA)	06/2020	06/2021
Right-of-Way	01/2020	12/2022
CN Ad/Bid/Award	01/2023	09/2023
Construction*	09/2023	10/2025

*Substantial Completion Date. Construction contract finalization by 06/2026.

5.2.1 Minimizing Impacts to the Travelling Public

The project's selected alignment and intersection configuration promotes an efficient construction schedule. The BNSF underpass and much of the associated roadway elements can be constructed without impacting existing travel on either of the project's two state highways. This improves work zone safety during construction and supports a faster construction sequence, leading to a more efficient project delivery.

5.3 Required Approvals

This section provides a summary of all required approvals related to environmental permits and reviews, state and local approvals, and state and local planning.

5.3.1 Environmental Permits and Reviews

The project has completed the environmental process as follows:

Environmental Process & Completed Efforts
National Environmental Policy Act (NEPA) and State EPA (SEPA) Status As part of FRA's CRISI-funded PE contract, FRA has determined that the project qualifies for NEPA Categorical Exclusion (CE). Currently, the City is working with FRA to complete the draft CE documentation. Draft CE documents are anticipated to be submitted to FRA by December 31, 2020. The Bridging the Valley project received NEPA Class II Categorical Exclusion and SEPA Categorical Exemption per WAC 197-11- 800 on August 22, 2006. The approval documentation is posted on the City's website.
Reviews, Approvals, and Permits by other Agencies The NEPA approval documentation provides a full list of all required permits and reviews. The Bridging the Valley stakeholders listed in Section 1.4 participated in reviews. This included reviews by the City of Spokane Valley, WSDOT, and BNSF.
Environmental Studies and other Documents Full environmental documentation in hard copy is on file at the Spokane Regional Transportation Council (SRTC). Copies are available upon request. The project was found to have no effect for most environmental components. Where there are small environmental impacts, mitigation measures have been identified and include procedures for hazmat disposal, erosion control, and stormwater treatment facilities.
WDOT Discussions on NEPA Compliance The City coordinates all documentation with FRA and WSDOT Local Programs staff to ensure compliance with all agencies.
Public Engagement Extensive public engagement has been an on-going effort as part of the Horizon 2040 and the previous Bridging the Valley planning and engineering efforts. Efforts included public open houses, alternatives workshops, site visits with neighborhoods at each crossing in Washington and Idaho, mailings, and outreach. Public support has been overwhelmingly positive. Since 2017, the City conducted 10 public meetings discussing the project alternatives and its selected configuration. In addition, the City met individually with State Legislators and local stakeholders from police & fire departments, school districts, freight industry representatives and BNSF project managers. Public engagement will continue through preliminary engineering and right-of-way, phases of this project.

5.3.2 State and Local Approvals

The Pines Road/ BNSF Grade Separation project is included in the Statewide Transportation Improvement Program (STIP ID WA-10615 and WA-12522), Horizon 2040 Metropolitan Transportation Plan, and the Spokane Valley TIP. Additional right-of-way, engineering, and construction approvals will be obtained from the City, WSDOT, and BNSF at key milestones throughout the project.

5.3.3 Federal transportation Requirements Affecting State and Local Planning

Significant planning and preliminary engineering for this project have been completed. These efforts show that the proposed project is not only feasible but has the support of all project partners, the community, the region, and beyond:

Planning or Design Effort with Supporting Project Elements
Detailed Project Work Plan – FRA CRISI Documentation/Coordination (Spring 2020) • A detailed description of the steps necessary to complete project, including project management approach, quality assurance/control, project schedule, a detailed project budget, and an environmental class of action recommendation memorandum.
Bridging the Valley Planning Study • Grade Separation Analysis: development, evaluation, refinement, and documentation of grade separation alternatives to support transportation needs and BNSF operations • Traffic Analysis: evaluation of impacts with alternatives for years 2001 and 2020 • Economic Analysis: benefit-cost analysis of all alternatives
Bridging the Valley 30% Preliminary Engineering • Right-of-Way needs were determined for this project • Design reports, 30% plans, estimates, and environmental documentation for projects
Inland Pacific Hub Transportation Investment and Project Priority Blueprint • Lists the Bridging the Valley grade separation projects as priority rail improvement projects with significant project synergy economic benefits • Support from local partners and identifies a midterm construction period of 2016-2021
Washington State Freight Mobility Plan 2014 • Identifies project for future implementation
Horizon 2040 Metropolitan Transportation Plan • Identifies this project and other Bridging the Valley grade separation projects
Spokane Valley Comprehensive Plan (2014) • Goal to support and encourage the continued viability of passenger and freight rail system in the region; Policy to support Bridging the Valley grade separation projects
City of Spokane Valley TIP & WA State TIP • Includes project funding for early pre-construction activities
Fiscal and Economic Analysis of Project • Analysis of incremental development, tax revenue benefits, economic output, jobs, and wages showing the significant benefit of implementing this project[26]
Joint Transportation Committee Prioritization of Rail-Rail Conflicts in WA *(*Aug. 2018) • Rated the overall top priority grade separation project requiring funding support
City of Spokane Valley – Project Design Alternative Analysis • 2017-2019: Coordinating with WSDOT, BNSF, and public input, the City selected a project alignment and a roundabout for the intersection design.

[26] Fiscal and Economic Benefits of the Pines Road Underpass Project, ECONorthwest 2016; http://www.spokanevalley.org/PinesBNSF

5.4 Assessment of Project Risks and Mitigation Strategies

The City has identified the following potential project risks and the mitigation measures:

Potential Risks	Mitigation Measures
Design Coordination	The approved configuration accommodates WSDOT and BNSF requirements and WSDOT granted interim approval for the Basis of Design. Project must also satisfy FHWA and FRA funding requirements.
Project Funding	The City has multiple options for meeting the project's remaining financing needs. The City plans to pursue other funding opportunities including TIB, FMSIB, state legislative direct appropriations, or annual City contributions.
Environmental Approvals	Bridging the Valley has already received NEPA approval for a categorical exclusion. As part of FRA's CRISI-funded PE contract, FRA has determined that the project qualifies for NEPA Categorical Exclusion (CE). Currently, the City is working with FRA to complete the draft CE documentation. Draft CE documents are anticipated to be submitted to FRA by December 31, 2020. The selected project configuration minimizes exposure by reducing its excavation limits and reduces its impact to neighboring properties. With the selected alignment, the project more closely matches the existing ground levels surrounding the project limits. Other design alternatives required the lowering of Trent Avenue by 12', creating extensive walls and large earthwork impacts, increasing exposure to utility conflicts or disturbing culturally significant properties. With this in mind, the BNSF undercrossing still requires the project to excavate nearly 20' below the existing track elevation. The City has no records of previous work to this depth and unexpected discoveries may occur. Section 106 documentation will be completed in the PE phase and will identify any application action.
Right-of-Way Acquisition	The selected alternative (Figure 3) minimizes the property acquisition impacts. In 2017, the City purchased the project's first property (Pinecroft) before it could be developed for industrial use. Now in 2020, the City has begun using its secured FHWA/STBG funding to initiate early acquisition of other needed properties and to minimize project delivery risks.
Utility Conflicts	The project requires coordination with 12 separate utilities, each of which have a franchise agreement and/or easement that identifies prior rights and proposed work responsibilities. As the City progresses with preliminary engineering, utility relocation plans will be developed. Phillips 66 Pipeline owns a 10" high pressure petroleum line located at the south edge of BNSF's right of way. Relocation of the pipeline is anticipated to take up to one year to complete. The PE phase will identify necessary relocation plans and continued coordination is required.
Water Table at Pines Road	The project is near the Spokane River. Sometimes the water table is low near rivers. The nearby Argonne Road/BNSF Grade Separation project constructed an underpass of the rail line and did not run into any water table issues. Similar construction techniques will be used for excavation and if necessary, permanent drainage infrastructure can be provided.

6 Benefit Cost Analysis

6.1.1 Benefit-Cost Assessment Summary

Table 10 summarizes the BCA findings identified in Appendix C. Annual costs and benefits are computed over the lifecycle of the project (estimated at 39 years). As stated earlier, construction is expected to be completed by the end of 2025 with 2026 being the project opening year. Benefits accrue during the full operation of the project.

Table 10: Overall Results of the Benefit Cost Analysis, 2018 Dollars

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$40,145,349	$87,967,852
Total Discounted Costs	$18,571,840	$21,873,922
Net Present Value	$21,573,509	$66,093,930
Benefit / Cost Ratio	2.16	4.02
Internal Rate of Return (%)	13.14%	
Payback Period (years)	5.68	

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 13.1%. With a 7% real discount rate, the $18.6 million investment would result in $40.1 million in total benefits for a Net Present Value of $21.6 million and a Benefit/Cost ratio of 2.16.

The grade separation component of the project generates the majority of the project benefits. Table 11 below provides a summary of the benefits and costs associated with grade separation (GSP). At a 7% discount rate, GSP would result in a Net Present Value of $26.9 million and a Benefit/Cost ratio of 3.73.

Table 11: Results of the Grade Separation Component, 2018 Dollars

Benefit	Undiscounted Net Benefits	Discounted Total Benefits at 3%	Discounted Total Benefits at 7%
Reduced Travel Time Costs	$79,770,770	$39,752,760	$17,722,607
Improved Safety & Avoided Accident Costs	$67,981,955	$36,114,062	$17,511,412
Avoided Emissions Costs	$104,841	$51,334	$22,147
Reduced Vehicle Operating Costs	$3,081,698	$1,512,503	$660,522
Residual Value of Infrastructure Asset	$9,974,925	$3,341,430	$816,037
Operations & Maintenance Cost Savings	$330,000	$175,306	$85,005
Total GSP Benefits	**$161,244,188**	**$80,947,394**	**$36,817,730**
GSP Capital Expenditures	**($13,263,588)**	**($11,626,207)**	**($9,862,485)**
Net Present Value (NPV)	**$147,980,601**	**$69,321,187**	**$26,955,245**
Benefit Cost Ratio (BCR)	**12.16**	**6.96**	**3.73**

Lastly, the roundabout is expected to result in $13.5 million in undiscounted benefits. With a 7% discount rate, the Benefit/Cost ratio is 0.38. Significant benefits from improved traffic fluidity are expected to occur as a result of the roundabout improvement. This benefit was not quantified in absence of detailed traffic modeling.

Table 12: Results of the Roundabout Component, 2018 Dollars

Benefit	Undiscounted Net Benefits	Discounted Total Benefits at 3%	Discounted Total Benefits at 7%
Improved Safety and Avoided Accident Costs	$13,470,909	$7,020,458	$3,327,619
Improved Traffic Fluidity*	-	-	-
Total RAB Benefits	**$13,470,909**	**$7,020,458**	**$3,327,619**
RAB Capital Expenditures	**($11,673,724)**	**($10,247,715)**	**($8,709,356)**
Net Present Value (NPV)	**$1,797,184**	**($3,227,257)**	**($5,381,736)**
Benefit Cost Ratio (BCR)	**1.15**	**0.69**	**0.38**

**Discussed qualitatively in the absence of detailed traffic modelling*

6.1.2 Cost Share

A community the size of Spokane Valley is greatly challenged to fund a project of this magnitude on its own. With many competing needs for city funds, the financial wherewithal to locally shoulder the entire burden of this project is not possible. With such geographically dispersed benefits generated by this project, federal assistance is not only a necessity but also a wise investment for the broader multi-modal transportation system.

Private funding in the project by BNSF will reduce the reliance on Federal funding. BNSF is expected to contribute funding to the project in partnership with the City of Spokane Valley. The City of Spokane Valley has already spent approximately $1,000,000 on right of way acquisition and preliminary design analysis. Further, the City has committed an additional $3,700,000 of its own funds toward the project and will continue to pursue additional non-Federal funding sources such as TIB, FMSIB, and LDA. City funds will be allocated to the project annually.

The City of Spokane Valley is sufficiently positioned to financially deliver this project with the assistance of the BUILD funding. The City is able to undertake all necessary long-term maintenance and rehabilitation through funds available from several street funds.

Appendix A

Local Agency Endorsement Form

10210 E Sprague Avenue ♦ Spokane Valley WA 99206
Phone: (509) 720-5000 ♦ Fax: (509) 720-5075 ♦ www.spokanevalley.org

U.S. Department of Transportation

Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grants Program

Call for Projects

Local Agency Project Endorsement

Project: Pines Road/BNSF Grade Separation Project

The attached project application reflects established local funding priorities consistent with the adopted local plans and programs.

The project described is financially feasible; local match revenue identified in the project application is available and committed to the project. If awarded Federal funds, the City is committed to securing all remaining unsecured non-Federal funds in order to satisfy BUILD program requirements. Costs identified in the application represent accurate planning level estimates needed to accomplish the work described herein.

This project has the full endorsement of the governing body/leadership of this agency or organization. This document must be signed by a person in a position or a representative of a governing body that has the authority to make decisions for the entire organization.

Mark Calhoun, City Manager
Name and Title of Designated Representative

Mark Calhoun
Signature of Designated Representative

5/12/2020
Date

Appendix B

Detailed Cost Estimate

City of Spokane Valley, WA
Pines Road/BNSF Grade Separation Project
Opinion of Probable Construction Cost
Alternative 2 with Roundabout

ITEM NO.	Contingency Code (%) or Unit	ITEM	UNIT	TRENT QUANTITY	PINES QUANTITY	TOTAL QUANTITY	UNIT PRICE	ITEM COST
		SECTION 1: PREPARATION						
	%	CLEARING AND GRUBBING	LS			1	$50,000.00	$50,000.00
	%	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS			1	$10,000.00	$10,000.00
	U	REMOVING ASPHALT CONC. PAVEMENT	SY		4500	4500	$4.00	$18,000.00
	%	CONSTRUCTION SURVEYING	LS			1	$15,000.00	$15,000.00
	%	SPCC PLAN	LS			1	$4,000.00	$4,000.00
	%	TRAFFIC CONTROL	LS			1	$152,000.00	$152,000.00
	%	SURVEYING	LS			1	$150,000.00	$150,000.00
	%	RECORD DRAWING (MIN BID $10,000 LS)	LS			1	$10,000.00	$10,000.00
	%	MINOR CHANGE, UNEXPECTED SITE CONDITIONS	LS			1	$50,000.00	$50,000.00
	%	CONTRACTING AGENCY FIELD OFFICE	LS			1	$10,000.00	$10,000.00
	%	PROPERTY RESTORATION	LS			1	$10,000.00	$10,000.00
	%	UTILITY POTHOLING	LS			1	$10,000.00	$10,000.00
		SECTION 2: GRADING						
	U	ROADWAY EXCAVATION INLC. HAUL	CY		117420	117420	$10.00	$1,174,200.00
	U	COMMON BORROW INLC. HAUL	CY			0	$10.00	$0.00
		SECTION 3: STOCKPILING						
						0		
		SECTION 4: DRAINAGE						
						0		
		SECTION 5: STORM SEWER						
	U	CATCH BASIN	EACH			0	$2,500.00	$0.00
	U	STORM SEWER PIPE18 IN. DIAM.	LF			0	$60.00	$0.00
	U	SEWER MANHOLE	EACH			0	$3,000.00	$0.00
		SECTION 6: SANITARY SEWER						
	U	SEWER MANHOLE	EACH			0	$3,000.00	$0.00
	U	SEWER PIPE X IN. DIAM.	LF			0	$60.00	$0.00
		SECTION 7: WATER LINES						
		SECTION 8: STRUCTURES						
	U	WORK ACCESS	LS		1	1	$25,000.00	$25,000.00
	U	TEMPORARY SHORING	LS		1	1	$50,000.00	$50,000.00
	U	STRUCTURE EXCAVATION CLASS A INCL. HAUL	CY		1267	1267	$25.00	$31,675.00
	U	FURNISHING AND DRIVING STEEL TEST PILE	EACH		4	4	$17,000.00	$68,000.00
	U	FURNISHING ST. PILING	LF		6400	6400	$100.00	$640,000.00
	U	DRIVING ST. PILE	EACH		64	64	$4,500.00	$288,000.00
	U	FURNISHING STEEL PILE TIP OR SHOE	EACH		68	68	$500.00	$34,000.00
	U	PILE SPLICES	EACH		68	68	$500.00	$34,000.00
	U	CONTROLLED DENSITY FILL	CY		66	66	$150.00	$9,900.00
	U	CONC. CLASS 4000 FOR BRIDGE (ENCASEMENT)	CY		326	326	$650.00	$211,900.00
	U	ST. REINF. BAR FOR BRIDGE (ENCASEMENT)	LB		32400	32400	$1.25	$40,500.00
	U	PRECAST REINFORCED CONCRETE	LS		1	1	$190,000.00	$190,000.00
	U	ELASTOMERIC PAD - SUPERSTR.	EACH		32	32	$1,500.00	$48,000.00
	U	ERECTION OF SUPERSTRUCTURE	LS		1	1	$200,000.00	$200,000.00
	U	RR BRIDGE SAFETY WALKWAY & RAILING	LF		752	752	$200.00	$150,400.00
	U	STRUCTURAL CARBON STEEL	LS		1	1	$12,480.00	$12,480.00
	U	STRUCTURAL LOW ALLOW STEEL (FURNISH FOB)	LS		1	1	$1,509,408.00	$1,509,408.00
	U	BRIDGE DECK WATERPROOFING	SY		720	720	$160.00	$115,200.00
	U	T-WALL RETAINING WALL	SF		8700	8700	$50.00	$435,000.00
		SECTION 9: SURFACING						
	U	CRUSHED SURFACING BASE COURSE (CSBC)	CY		488	488	$20.00	$9,760.00
	U	CRUSHED SURFACING TOP COURSE (CSTC)	CY		2476	2476	$60.00	$148,560.00
		SECTION 10: LIQUID ASPHALT						
		SECTION 11: BITUMINIOUS SURFACE TREATMENT						
		SECTION 13: CEMENT CONCRETE PAVEMENT						
	U	CEMENT CONC. PAVEMENT (PCC)	CY		5295	5295	$300.00	$1,588,500.00
		SECTION 14: HOT MIX ASPHALT						
	U	HMA Plantmix Pavement	TON		1395	1395	$110.00	$153,450.00
		SECTION 15: SEAL COAT						
						0		
		SECTION 16: IRRIGATION AND WATER DISTRIBUTION						
	%	IRRIGATION SYSTEM	LS			1	$20,000.00	$20,000.00
		SECTION 17: EROSION CONTROL AND ROADSIDE PLANTING						
	%	EROSION/WATER POLLUTION CONTROL	LS			1	$150,000.00	$150,000.00
	U	SEEDING, FERTILIZING, AND MULCHING	ACRE		2	2	$5,000.00	$10,000.00
	%	LANDSCAPING	LS			1	$100,000.00	$100,000.00
		SECTION 18: TRAFFIC						
	U	CEMENT CONC. TRAFFIC CURB	LF		7620	7620	$33.00	$251,460.00
	U	PRECAST CONCRETE BARRIER	LF		200	200	$50.00	$10,000.00
	U	PERMANENT IMPACT ATTENUATOR	EACH			0	$25,000.00	$0.00
	U	PAINT LINE	LF		13600	13600	$0.25	$3,400.00
	%	MISC PLASTIC STRIPING	LS			1	$5,000.00	$5,000.00
	%	PERMANENT SIGNING	LS			1	$20,000.00	$20,000.00
	%	ILLUMINATION SYSTEM COMPLETE	LS			1	$100,000.00	$100,000.00
	%	TRAFFIC SIGNAL SYSTEM	LS			0	$300,000.00	$0.00
	%	ITS SYSTEM COMPLETE	LS			1	$50,000.00	$50,000.00
		SECTION 19: OTHER ITEMS						
	U	UTILITIES - GAS MAIN RELOCATION	LF			0	$200.00	$0.00
	U	UTILITIES - WATER LINE RELOCATION	LF		300	300	$100.00	$30,000.00
	U	UTILITIES - FIBER OPTIC RELOCATION Centrury Link	LF			0	$200.00	$0.00
	U	UTILITIES - TELECOMMUNICATION RELOCATION	LF		300	300	$150.00	$45,000.00
	U	CEMENT CONCRETE SIDEWLAK	SY		4020	4020	$50.00	$201,000.00
		UTILITIES - YELLOWSTONE PIPELINE RELOCATION						
	%	Shoofly	LS			1	$860,000.00	$860,000.00
	U	Railroad Flagging	Day			400	$1,000.00	$400,000.00

1	Construction Subtotal			$9,912,793
2	Mobilization		10%	$991,279
3	**Subtotal**			**$10,904,072**
4	Unit Price Contingencies	$8,136,793	25%	$2,034,198
5	Percentage Item Contingencies	$1,776,000	31%	$550,560
4	**Contingencies**		**24%**	**$2,584,758**
5	**Subtotal**			**$13,488,831**
6	Sales Tax (N/A included in unit costs)			$0
7	**Subtotal**			**$13,488,831**
8	Total Construction Subtotal			$13,488,831
9	Design Engineering		22%	$2,908,000
10	RIGHT-OF-WAY			$4,670,000
11	Construction Engineer and Inspection		21%	$2,842,097
12				
13	**TOTAL PROJECT COST (DESIGN, CONSTRUCTION, CONSTRUCTION ENGINEERING)**			**$23,908,927**
	YEAR 2018 CONCEPTUAL ESTIMATE TOTAL			**$23,908,927**

Phase	2018 Cost	Year of Expenditure	Inflated Cost (@3.5%)
Construction (2023-2025)	**$13,488,831**	**2024**	**$16,582,000**
Design Engineering (2020-2022)	**$2,908,000**	**2021**	**$3,225,000**
Right of Way (2020-2022)	**$4,670,000**	**2022**	**$5,359,000**
Construction Engineering (2023-2025)	**$2,842,097**	**2024**	**$3,494,000**
Total	**$23,908,927**		**$28,660,000**

Appendix C

Benefit Cost Analysis

Pines Road/BNSF Grade Separation

Benefit Cost Analysis Supplementary Documentation

BUILD Grants Program

City of Spokane Valley

May 7, 2020

Contents

Tables

Figures

1 Executive Summary

With increasing growth in freight train traffic, the Pines Road grade crossing is becoming increasingly difficult for motorists, pedestrians, and other users. In 2018, the at-grade crossing was rated Washington State's top Tier 1 road-rail conflict.[1] Extended delays at the project location result in inefficient emergency services access, noise pollution from train whistles, inefficient freight truck movements along a preferred long-haul freight route, and a worsening Level of Service (LOS) projected to reach 'F' in future years due to high traffic volumes. The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout at the intersection of Pines Road and Trent Avenue. This will allow pedestrians and cyclists to be able to cross Trent Avenue more safely and comfortably. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the MPO's regional transportation plan, and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region.

The City of Spokane Valley seeks a BUILD Discretionary Grant of $17,886,500 to complete funding for the Pines Road/BNSF Grade Separation Project to create a safer, more efficient, and reliable transportation network for its users.

The proposed concept is illustrated in Figure 1.

Figure 1: Pines Road/BNSF Grade Separation Project

[1] Freight Mobility Strategic Investment Board's *Study of Road-Rail Conflicts – Phase 2 – Development of Project Priorities.* August, 2018

Table ES-1 summarizes the impacts and associated monetary benefits expected from the project. Section 8 summarizes the results for the entire project as well as for its individual components, including both the grade separation and roundabout.

Table ES-1: Summary of Infrastructure Improvements and Associated Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results ($2018, Discounted at 7%)
With increasing growth in freight train traffic, the Pines Road grade crossing is becoming increasingly difficult for motorists, pedestrians, and other users. Extended delays at the project location result in inefficient emergency services access, noise pollution from train whistles, inefficient freight truck movements along a preferred long-haul freight route, and a lack of industrial development potential due to a current Level of Service (LOS) 'E' operating condition, with an LOS 'F' condition expected due to worsening conditions.	The project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout at the intersection of Pines Road and Trent Avenue. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the MPO's regional transportation plan, and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region. The elimination of delays at the rail crossings will improve the mobility of freight trucks traveling from Canada to Interstate 90, unlock the economic potential to develop prime vacant commercial and industrial land, support active pedestrian and bicycle lifestyles, and improving the quality of life through noise and emissions reductions.	Reduced Travel Time Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Motorists, shippers, local businesses and residents	Reduced Travel Time Costs	**$17,722,607**
		Improved Safety and Avoided Accident Costs from Eliminated Pines Road Grade Crossing	Motorists, shippers, local businesses and residents	Improved Safety and Avoided Accident Costs	**$20,839,031**
		Avoided Emission Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Local residents and residents across the country	Avoided Emissions Costs	**$22,147**
		Reduced Vehicle Operating Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Motorists, shippers, local businesses and residents	Reduced Vehicle Operating Costs	**$660,522**
		Residual Value of Infrastructure Asset	Local, state, and federal governments	Residual Value of Infrastructure Asset	**$816,037**
		Reduced Ongoing Infrastructure Maintenance Cost	Motorists, shippers, local businesses and residents	Operations & Maintenance Cost Savings	**$85,005**
		Fewer rail crossing blockages will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area. This also allows both short and long-haul trucks to experience improved delivery timeliness.	Motorists, shippers, local businesses and residents	Improved Travel Time Reliability	**n/a**

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results ($2018, Discounted at 7%)
		Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.	Motorists, shippers, local businesses and residents, local/state/federal governments	Unlock Future Development Potential	**n/a**
		Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities.	Pedestrians, cyclists, local businesses and residents.	Improved Connectivity	**n/a**
		Grade separation will reduce noise pollution from train whistles.	Pedestrians, cyclists, local businesses and residents.	Reduced Noise Pollution	**n/a**
		Fewer rail crossing blockages will improve travel time and reliability for emergency responders that may otherwise not be able to pass or be forced to take a longer route.	Motorists, shippers, local businesses and residents	Improved Emergency Vehicle Access	**n/a**

The period of analysis used in the estimation of benefits and costs is 39 years, including 9 years of construction and planning and 30 years of operation. The total project costs include $23.9 million dollars (2018$) in future capital costs as shown in Table ES-2. These costs capture only future capital costs and do not include previously incurred costs ($1,028,385[2]). Values shown below include both rounded and non-rounded values to allow for comparison with the application narrative. The benefit cost analysis used non-rounded and constant project costs for accuracy and do not overstate project costs through rounding.

Table ES-2: Summary of Future Project Costs, Constant and Year of Expenditure Dollars*

Component	Non-Rounded Values		Rounded Values	
	2018$	YOE$	2018$	YOE$
Construction	$13,488,831	$16,582,000	$13,488,900	$16,582,000
Right of Way	$4,670,000	$5,359,000	$4,670,000	$5,359,000
Construction Engineering	$2,842,097	$3,494,000	$2,842,100	$3,494,000
Preliminary Engineering	$2,326,400	$2,580,000	$2,326,400	$2,580,000
Final Engineering	$581,600	$645,000	$581,600	$645,000
Total Project Costs	**$23,908,927**	**$28,660,000**	**$23,909,000**	**$28,660,000**

**This table does not include previously incurred costs of $1,028,385*

Tables ES-5, ES-6 and ES-7 provide various summaries of the relevant data and calculations used to derive the benefits and costs of the project. Based on the analysis presented in the rest of this document, the project is expected to generate $40.1 million in discounted benefits and $18.6 in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Net Present Value of $21.6 million and a Benefit/Cost Ratio of 2.16.

When assessing both project components, the grade separation and roundabout result in significant societal benefits. The table below provides a summary of the grade separation component which accounts for the majority of the overall project benefits. It's important to note that each of these components are crucial to the entire project. While the results are disaggregated to aid in understanding of project conditions, the overall project results are best viewed as a whole.

Table ES-3: Summary of the Grade Separation Component Benefits

Benefit	Undiscounted Net Benefits (2018$)	Discounted Total Benefits at 3% ($2018)	Discounted Total Benefits at 7% ($2018)
Reduced Travel Time Costs	$79,770,770	$39,752,760	$17,722,607
Improved Safety and Avoided Accident Costs	$67,981,955	$36,114,062	$17,511,412
Avoided Emissions Costs	$104,841	$51,334	$22,147
Reduced Vehicle Operating Costs	$3,081,698	$1,512,503	$660,522
Residual Value of Infrastructure Asset	$9,974,925	$3,341,430	$816,037
Operations and Maintenance Cost Savings	$330,000	$175,306	$85,005
Total Grade Separation Benefits	**$161,244,188**	**$80,947,394**	**$36,817,730**
Grade Separation Capital Expenditures	**($13,263,588)**	**($11,626,207)**	**($9,862,485)**
Net Present Value (NPV)	**$147,980,601**	**$69,321,187**	**$26,955,245**
Benefit Cost Ratio (BCR)	**12.16**	**6.96**	**3.73**

The grade separation results in undiscounted benefits of $161.2 million and a benefit cost ratio of 12.2. At a 7% discount rate, the component results in a net present value of $26.9 million and a benefit cost ratio of 3.73.

Lastly, as an individual component, the roundabout has a discounted benefit cost ratio of 0.38. This result is conservative since improved traffic fluidity and reduced congestion at the intersection is not estimated in

[2] Includes $510,000 for ROW/property acquisition, $394,385 for planning and preliminary design, and $124,000 in preliminary engineering alternative analysis

the absence of detailed traffic modelling. Given that safety benefits account for $3.3 million in discounted benefits, it's expected that improved speeds and fluidity at the intersection would result in significant additional societal benefits.

Table ES-4: Summary of the Roundabout Component Benefits

Benefit	Undiscounted Net Benefits (2018$)	Discounted Total Benefits at 3% ($2018)	Discounted Total Benefits at 7% ($2018)
Improved Safety and Avoided Accident Costs	$13,470,909	$7,020,458	$3,327,619
Improved Traffic Fluidity*	-	-	-
Total RAB Benefits	**$13,470,909**	**$7,020,458**	**$3,327,619**
RAB Capital Expenditures	**($11,673,724)**	**($10,247,715)**	**($8,709,356)**
Net Present Value (NPV)	**$1,797,184**	**($3,227,257)**	**($5,381,736)**
Benefit Cost Ratio (BCR)	**1.15**	**0.69**	**0.38**

**Discussed qualitatively in absence of detailed traffic modelling*

The following tables provide various summaries of the relevant data and calculations used to derive the benefits and costs of the whole project.

Table ES-5: Summary of Total Project Benefits and Costs

Calendar Year	Project Year	Direct Beneficiaries	Total Benefits ($2018)	Total Costs ($2018)	Undiscounted Net Benefits ($2018)	Discounted Total Benefits at 7% ($2018)	Discounted Total Costs at 7% ($2018)	Discounted Net Benefits at 7% ($2018)
2017	1	Workers otherwise unemployed (shadow wage benefit); not quantified	$0	-$1,420,052	-$1,420,052	$0	-$1,420,052	-$1,420,052
2018	2		$0	-$515,667	-$515,667	$0	-$515,667	-$515,667
2019	3		$0	-$515,667	-$515,667	$0	-$481,931	-$481,931
2020	4		$0	-$2,072,333	-$2,072,333	$0	-$1,810,056	-$1,810,056
2021	5		$0	-$2,041,333	-$2,041,333	$0	-$1,666,336	-$1,666,336
2022	6		$0	-$2,041,333	-$2,041,333	$0	-$1,557,323	-$1,557,323
2023	7		$0	-$8,165,464	-$8,165,464	$0	-$5,821,863	-$5,821,863
2024	8		$0	-$4,899,278	-$4,899,278	$0	-$3,264,596	-$3,264,596
2025	9		$0	-$3,266,185	-$3,266,185	$0	-$2,034,016	-$2,034,016
2026	10	Federal and State governments, pedestrians, cyclists, motorists, local residents and businesses, trucking companies, AMTRAK and their passengers, property owners along the project corridor, and other residents across the country.	$4,193,345	$0	$4,193,345	$2,440,565	$0	$2,440,565
2027	11		$4,271,792	$0	$4,271,792	$2,323,572	$0	$2,323,572
2028	12		$4,354,455	$0	$4,354,455	$2,213,584	$0	$2,213,584
2029	13		$4,440,884	$0	$4,440,884	$2,109,832	$0	$2,109,832
2030	14		$4,532,110	$0	$4,532,110	$2,012,311	$0	$2,012,311
2031	15		$4,627,435	$0	$4,627,435	$1,920,221	$0	$1,920,221
2032	16		$4,727,157	$0	$4,727,157	$1,833,273	$0	$1,833,273
2033	17		$4,832,248	$0	$4,832,248	$1,751,429	$0	$1,751,429
2034	18		$4,941,954	$0	$4,941,954	$1,674,011	$0	$1,674,011
2035	19		$5,056,973	$0	$5,056,973	$1,600,908	$0	$1,600,908
2036	20		$5,177,281	$0	$5,177,281	$1,531,771	$0	$1,531,771
2037	21		$5,303,106	$0	$5,303,106	$1,466,353	$0	$1,466,353
2038	22		$5,435,191	$0	$5,435,191	$1,404,557	$0	$1,404,557
2039	23		$5,573,744	$0	$5,573,744	$1,346,132	$0	$1,346,132
2040	24		$5,694,502	$0	$5,694,502	$1,285,324	$0	$1,285,324
2041	25		$5,742,384	$0	$5,742,384	$1,211,338	$0	$1,211,338
2042	26		$5,791,758	$0	$5,791,758	$1,141,825	$0	$1,141,825
2043	27		$5,841,048	$0	$5,841,048	$1,076,208	$0	$1,076,208
2044	28		$5,891,149	$0	$5,891,149	$1,014,429	$0	$1,014,429
2045	29		$5,942,609	$0	$5,942,609	$956,346	$0	$956,346
2046	30		$5,993,460	$0	$5,993,460	$901,430	$0	$901,430
2047	31		$6,046,101	$0	$6,046,101	$849,857	$0	$849,857
2048	32		$6,099,336	$0	$6,099,336	$801,252	$0	$801,252
2049	33		$6,153,054	$0	$6,153,054	$755,429	$0	$755,429
2050	34		$6,207,459	$0	$6,207,459	$712,251	$0	$712,251
2051	35		$6,261,913	$0	$6,261,913	$671,494	$0	$671,494
2052	36		$6,317,135	$0	$6,317,135	$633,099	$0	$633,099

Calendar Year	Project Year	Direct Beneficiaries	Total Benefits ($2018)	Total Costs ($2018)	Undiscounted Net Benefits ($2018)	Discounted Total Benefits at 7% ($2018)	Discounted Total Costs at 7% ($2018)	Discounted Net Benefits at 7% ($2018)
2053	37		$6,373,137	$0	$6,373,137	$596,927	$0	$596,927
2054	38		$6,429,929	$0	$6,429,929	$562,847	$0	$562,847
2055	39		$16,462,449	$0	$16,462,449	$1,346,774	$0	$1,346,774
Total			**$174,715,097**	**-$24,937,312**	**$149,777,785**	**$40,145,349**	**-$18,571,840**	**$21,573,509**

**Total costs used within the benefit cost analysis considered previously incurred costs of $1,028,385*

Table ES-6: Summary of Project Benefits by Benefit Type

Calendar Year	Project Year	Reduced Travel Time Costs	Improved Safety and Avoided Accident Costs	Avoided Emissions Costs	Reduced Vehicle Operating Costs	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings
2017	1	$0	$0	$0	$0	$0	$0
2018	2	$0	$0	$0	$0	$0	$0
2019	3	$0	$0	$0	$0	$0	$0
2020	4	$0	$0	$0	$0	$0	$0
2021	5	$0	$0	$0	$0	$0	$0
2022	6	$0	$0	$0	$0	$0	$0
2023	7	$0	$0	$0	$0	$0	$0
2024	8	$0	$0	$0	$0	$0	$0
2025	9	$0	$0	$0	$0	$0	$0
2026	10	$1,471,515	$2,660,577	$1,287	$48,966	$0	$11,000
2027	11	$1,543,811	$2,664,040	$1,336	$51,605	$0	$11,000
2028	12	$1,619,672	$2,667,533	$1,387	$54,864	$0	$11,000
2029	13	$1,699,272	$2,671,056	$1,439	$58,117	$0	$11,000
2030	14	$1,782,798	$2,674,610	$1,494	$62,208	$0	$11,000
2031	15	$1,870,441	$2,678,196	$1,852	$65,945	$0	$11,000
2032	16	$1,962,407	$2,681,812	$2,234	$69,704	$0	$11,000
2033	17	$2,058,907	$2,685,461	$2,638	$74,242	$0	$11,000
2034	18	$2,160,166	$2,689,141	$3,068	$78,579	$0	$11,000
2035	19	$2,266,419	$2,692,853	$3,524	$83,176	$0	$11,000
2036	20	$2,377,912	$2,696,598	$3,644	$88,127	$0	$11,000
2037	21	$2,494,904	$2,700,368	$3,768	$93,065	$0	$11,000
2038	22	$2,617,666	$2,704,172	$3,896	$98,457	$0	$11,000
2039	23	$2,746,483	$2,708,008	$4,029	$104,223	$0	$11,000
2040	24	$2,858,883	$2,711,878	$4,135	$108,606	$0	$11,000
2041	25	$2,900,546	$2,715,782	$4,154	$110,901	$0	$11,000
2042	26	$2,942,817	$2,719,721	$4,173	$114,048	$0	$11,000
2043	27	$2,985,703	$2,723,693	$4,193	$116,459	$0	$11,000
2044	28	$3,029,214	$2,727,701	$4,213	$119,021	$0	$11,000

Calendar Year	Project Year	Reduced Travel Time Costs	Improved Safety and Avoided Accident Costs	Avoided Emissions Costs	Reduced Vehicle Operating Costs	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings
2045	29	$3,073,359	$2,731,743	$4,233	$122,273	$0	$11,000
2046	30	$3,118,148	$2,735,821	$4,254	$124,237	$0	$11,000
2047	31	$3,163,589	$2,739,940	$4,274	$127,298	$0	$11,000
2048	32	$3,209,693	$2,744,094	$4,296	$130,253	$0	$11,000
2049	33	$3,256,469	$2,748,284	$4,317	$132,984	$0	$11,000
2050	34	$3,303,926	$2,752,511	$4,339	$135,683	$0	$11,000
2051	35	$3,352,075	$2,756,775	$4,402	$137,660	$0	$11,000
2052	36	$3,400,925	$2,761,077	$4,467	$139,666	$0	$11,000
2053	37	$3,450,487	$2,765,416	$4,532	$141,702	$0	$11,000
2054	38	$3,500,772	$2,769,793	$4,598	$143,767	$0	$11,000
2055	39	$3,551,789	$2,774,208	$4,665	$145,862	$9,974,925	$11,000
Total		**$79,770,770**	**$81,452,863**	**$104,841**	**$3,081,698**	**$9,974,925**	**$330,000**

Table ES-7: Summary of Pertinent Quantifiable Data

Calendar Year	Project Year	Avoided Person Hours of Delay at Crossing	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)	Avoided Fatalities	Avoided Injuries	Avoided PDO Accidents
2017	1	0	0	0	0	0.00	0.00	0.00
2018	2	0	0	0	0	0.00	0.00	0.00
2019	3	0	0	0	0	0.00	0.00	0.00
2020	4	0	0	0	0	0.00	0.00	0.00
2021	5	0	0	0	0	0.00	0.00	0.00
2022	6	0	0	0	0	0.00	0.00	0.00
2023	7	0	0	0	0	0.00	0.00	0.00
2024	8	0	0	0	0	0.00	0.00	0.00
2025	9	0	0	0	0	0.00	0.00	0.00
2026	10	84,691	12,067	2,041	1,339	0.24	1.75	11.63
2027	11	88,852	12,660	2,141	1,404	0.24	1.76	11.71
2028	12	93,218	13,282	2,246	1,473	0.24	1.77	11.79
2029	13	97,799	13,935	2,357	1,546	0.24	1.77	11.86
2030	14	102,606	14,620	2,472	1,622	0.24	1.78	11.94
2031	15	107,651	15,338	2,594	1,701	0.24	1.79	12.02
2032	16	112,944	16,092	2,722	1,785	0.24	1.80	12.10
2033	17	118,497	16,884	2,855	1,873	0.24	1.81	12.18
2034	18	124,325	17,714	2,996	1,965	0.24	1.82	12.26
2035	19	130,441	18,585	3,143	2,062	0.24	1.82	12.35
2036	20	136,857	19,500	3,298	2,163	0.24	1.83	12.43
2037	21	143,591	20,459	3,460	2,269	0.24	1.84	12.51
2038	22	150,656	21,466	3,630	2,381	0.24	1.85	12.60
2039	23	158,070	22,522	3,809	2,498	0.24	1.86	12.68
2040	24	164,539	23,444	3,965	2,600	0.24	1.87	12.77
2041	25	166,937	23,786	4,023	2,638	0.24	1.88	12.85
2042	26	169,370	24,132	4,081	2,677	0.24	1.89	12.94
2043	27	171,838	24,484	4,141	2,716	0.24	1.89	13.03
2044	28	174,342	24,841	4,201	2,755	0.24	1.90	13.11
2045	29	176,883	25,203	4,262	2,796	0.24	1.91	13.20
2046	30	179,461	25,570	4,324	2,836	0.24	1.92	13.29
2047	31	182,076	25,943	4,387	2,878	0.24	1.93	13.39
2048	32	184,729	26,321	4,451	2,920	0.24	1.94	13.48
2049	33	187,421	26,704	4,516	2,962	0.24	1.95	13.57
2050	34	190,153	27,093	4,582	3,005	0.24	1.96	13.66
2051	35	192,924	27,488	4,649	3,049	0.24	1.97	13.76
2052	36	195,735	27,889	4,717	3,094	0.24	1.98	13.85
2053	37	198,588	28,295	4,785	3,139	0.24	1.99	13.95
2054	38	201,482	28,708	4,855	3,184	0.24	2.00	14.04

Calendar Year	Project Year	Avoided Person Hours of Delay at Crossing	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)	Avoided Fatalities	Avoided Injuries	Avoided PDO Accidents
2055	39	204,418	29,126	4,926	3,231	0.24	2.01	14.14
Total		**4,591,093**	**654,150**	**110,629**	**72,561**	**7.24**	**56.25**	**385.09**

In addition to the monetized benefits presented in Tables ES-5 to ES-7, the project would generate benefits that are difficult to monetize. A brief description of those benefits is provided below.

Economic Competitiveness

- ***Improved Travel Time Reliability***

  On average, motorists are delayed 60 times per day at each roadway-railway crossing. With some trains nearly one and a half miles in length, crossings are closed for approximately three to five minutes for each train to pass. Delays are further compounded by the time required for the vehicle queues created by the train crossing to dissipate. Furthermore, the current Pines Road and Trent Avenue intersection operates at a LOS of 'E' which is projected to reach LOS 'F' due to worsening conditions. The project would transform the intersection to a LOS 'A', which will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area.

- ***Improved Access to Future Development Potential***

  Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.

Quality of Life

- ***Improved Connectivity***

  Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities. The BNSF Railway bisects the northern parts of Spokane Valley from the main city south of the railway. The project will connect a diverse neighborhoods surrounding the Study area including residential, commercial, mixed-use and industrial areas. The new grade-separated crossing and roundabout will provide sidewalks, making the route more appealing to pedestrians and bicyclists. In addition to an improved crossing of the railroad tracks, the roundabout will create a safer and more comfortable crossing of Trent Avenue.

- ***Improved Emergency Vehicle Access***

  Key emergency services (fire, police, and EMS) are located south of the railway crossing. The long and frequent delays at the rail crossings causes delays for providing emergency services to the north. Eliminating the Pines Road grade crossing will improve travel time and reliability for emergency responders that may otherwise not be able to pass or be forced to take a longer route.

- ***Reduced Noise Pollution***

  Spokane Valley residents have long complained about the noise pollution of the train whistles. Federal law requires locomotives to sound their horns at 96 to 100 decibels as they approach at-grade crossings and continue blowing the horn until the train clears the crossing. Not only do the horns disturb the peacefulness of the surrounding area, medical studies have linked loud noises, such as train whistles, to stress-related health problems.[3] As part of the broader Bridging the Valley plan, all existing at-grade crossings will be eliminated, which will allow noise from train horns and whistles to be severely reduced. The Pines Road project alone will significantly reduce the amount

[3] *"Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016.*

of train horn and whistle noise and serves as an incremental improvement toward the overall goal of removing all at-grade crossings.

2 Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Grant Application for the Pines Road/BNSF Grade Separation project.

- Section 1 – Executive Summary
- Section 2 – Introduction: Outlines the BCA document layout and structure to assist USDOT reviewers.
- Section 3 - Methodological Framework: Introduces the conceptual framework used in the Benefit-Cost Analysis (BCA).
- Section 4 - Project Overview: Provides an overview of the project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the Pines Road/BNSF Grade Separation is expected to generate.
- Section 5 - General Assumptions: Discusses the general assumptions used in the estimation of project costs and benefits.
- Section 6 – Demand Projections: Estimates of travel demand and traffic volumes.
- Section 7 – Benefits Measurement, Data and Assumptions: Details the specific data elements and assumptions used to address the goals of the project and to comply with program requirements.
- Section 8 – Summary of Findings and Benefit-Cost Outcomes: Estimates the project's Net Present Value (NPV), its Benefit/Cost Ratio (BCR), and other project evaluation metrics.
- Section 9 – Benefit Cost Sensitivity Analysis: Provides the outcomes of the sensitivity analysis that evaluates the different assumptions made by the City and the impact that the variability of those assumptions may have on the overall project.
- Section 10 - Supplementary Data Tables: Includes a breakdown of all benefits associated with the merit criteria outcomes for the project, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.

3 Methodological Framework

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Applications (June 2018). In particular, the methodology involves:

- Establishing existing and future conditions under the Build and No Build scenarios;
- Assessing benefits with respect to each of the eight merit criteria identified in the notice of funding opportunity (NOFO);
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using USDOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects

- Discounting future benefits and costs with the real discount rates recommended by USDOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4 Project Overview

With increasing growth in freight train traffic, the Pines Road grade crossing is becoming increasingly difficult for motorists, pedestrians, and other users. Extended delays at the project location result in inefficient emergency services access, noise pollution from train whistles, inefficient freight truck movements along a preferred long-haul freight route, and a worsening Level of Service (LOS) projected to reach 'F' in future years due to high traffic volumes. The Pines Road/BNSF Grade Separation Project replaces an existing at-grade crossing with an underpass of BNSF's railroad tracks and provides a roundabout at the intersection of Pines Road and Trent Avenue. This will allow pedestrians and cyclists to be able to cross Trent Avenue more safely and comfortably. The improvements support freight movement and regional mobility goals as articulated in various plans such as Horizon 2040, the MPO's regional transportation plan, and the Inland Pacific Hub Transportation Study, a partnership of public and private agencies dedicated to creating a freight gateway in the region. In 2018, the at-grade crossing was rated Washington State's top Tier 1 road-rail conflict.[4]

The project will improve the current conditions in the area and in nearby neighborhoods by:

- ***Creating*** an underpass which will foster increased connectivity for all road users, pedestrians, and cyclists by installing new sidewalks and shared-use lanes
- ***Converting*** an existing intersection into an improved roundabout allowing a greater flow of traffic
- ***Improving*** public safety by eliminating rail/vehicle encounters at the Pines Road/BNSF crossing
- ***Improving*** travel time reliability through the elimination of rail crossing blockages, allowing for greater predictability in travel times
- ***Improving*** emergency services access along the Project corridor
- ***Eliminating*** wait times and prolonged queuing both at the crossing and along the Project corridor
- ***Eliminating*** vehicle queuing along Trent Avenue as a result of train crossings
- ***Reducing*** noise pollution arising from train whistles at the Pines Road/BNSF crossing
- ***Unlocking*** the economic development potential of prime industrial, commercial, and mixed-use land near the Project location
- ***Linking*** a large residential neighborhood to the north with the City's commercial and employment hub to the south
- ***Unlocking*** the economic development potential of approximately 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection.

[4] Freight Mobility Strategic Investment Board's *Study of Road-Rail Conflicts – Phase 2 – Development of Project Priorities,* August, 2018

4.1 Base Case and Alternative Case

4.1.1 Base Case

The Base Case for the Pines Road Grade Separation project is defined as the No Build scenario. In the Base Case, the lack of grade separation and continued freight train growth continues to delay road users and maintains the LOS 'E' designation. Vehicle queuing along Trent Avenue continues to pose severe safety concerns.

The key assumptions used to define the Base Case (No Build Scenario) are as follows:

- Average Annual Daily Traffic (AADT) on Trent Avenue (East of Pines Road) of **27,374** (2018), growing at a rate of **1.8% per year** which is the historical 10-year annual average growth rate (AAGR) based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate to be most suitable.
- AADT on Trent Avenue (West of Pines Road) of **22,693** (2018), growing at a rate of **0.7% per year** which is the historical 10-year annual average growth rate based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate to be most suitable.
- AADT at the Pines Road crossing of **16,758** (2019), growing at a rate of **1.5% per year** derived using the historical 10-year annual average growth rate. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate to be most suitable. AADT is broken down by the following modes:
  - **87%** passenger vehicles
  - **12%** trucks, and
  - **1%** transit
- **60** daily freight trains (2018) growing at a rate of **3.8% per year** until 2040, based on the 2019 WSDOT State Rail System Plan.
- Average freight train speed of **25 miles per hour**
- Average freight train length of **6,500 feet**
- **2** daily passenger trains (2018) assumed constant throughout the analysis period based on the 2019 WSDOT State Rail System Plan
- Average passenger train speed of **35 miles per hour**
- Average passenger train length of **1,000 feet**
- Average lead and lag time for gate closure of **0.6 minutes**

Freight and passenger train forecasts were obtained from the Washington State Rail System Plan which includes mainline track forecasts under 3 unique forecast scenarios as summarized by Table 8.

Table 8: WSDOT Freight Rail Demand Forecast Scenarios

Low Growth Scenario	Moderate Growth Scenario	High Growth Scenario
- Driven by a significant decline in export volumes and the resulting cumulative effects	-Driven by growth in industries requiring longhaul movement of heavy commodities	- Driven by robust growth in export volumes
- Assumes that tariffs imposed by the U.S. and other nations have a substantial, lasting effect on international trade and suppress export activity	- Assumes no long-term effects from tariff and trade tensions	- Assumes that tariffs imposed by the U.S. and other nations have little to no effect on international trade volumes and/or are removed with minimal or no lingering effects
- Assumes high potential negative effects on agricultural imports/exports and international containerized trade, and declined energy exports	- Based on FHWA's FAF 41 growth rates and long-term macroeconomic forecasts derived from REMI model	- Assumes high potential growth in energy exports caused by proposed bulk shipment facilities for coal and oil, and robust potential growth in international containerized trade and agricultural imports and exports

Source: 2019 Washington State Rail System Plan

It's noted that the revised 2019 State rail plan significantly revises downwards freight train volumes from those included in 2013 forecasts. Assuming the 2019 plan's moderate growth scenario, current train volumes (60 trains per day) are not reached until 2022 while the high growth scenario reflects current volumes and follows the trend of the 2013 forecasts. As a result, the high growth scenario is chosen as the base forecast in the analysis. Sensitivity analysis (see Section 9) includes assessment of the low and moderate scenarios.

4.1.2 Alternative Case

The Alternative Case is defined as the Build scenario. In the Alternative Case, grade separation will eliminate train/vehicle encounters and eliminate wait times at the Pines Road crossing. The existing signalized intersection is converted to a roundabout allowing for greater flow of traffic and reduced collision severity. Traffic congestion and related safety concerns along Trent Avenue [due to train crossings] are eliminated. Specifically, the new infrastructure and improved process described in the project overview section above will result in the following changes to some key inputs and assumptions:

- Average Annual Daily Traffic (AADT) on Trent Avenue (East of Pines Road) of **27,374** (2018), growing at a rate of **1.8% per year** which is the historical 10-year annual average growth rate (AAGR) based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate to be most suitable.
- AADT on Trent Avenue (West of Pines Road) of **22,693** (2018), growing at a rate of **0.7% per year** which is the historical 10-year annual average growth rate based upon City of Spokane Valley traffic counts. Forecasted peak volume AADT is in line with historical trends. Through analysis, it was determined that the 10-year growth rate to be most suitable.
- AADT at the Pines Road crossing of **16,758** (2019), growing at a rate of **1.5% per year** derived using the historical 10-year annual average growth rate. Forecasted peak volume AADT is in line

with historical trends. Through analysis, it was determined that the 10-year growth rate to be most suitable. AADT is broken down by the following modes:

  - **87%** passenger vehicles
  - **12%** trucks, and
  - **1%** transit

- **60** daily freight trains (2018) growing at a rate of **3.8% per year** until 2040, based on the 2019 WSDOT State Rail System Plan
- Average freight train speed of **25 miles per hour**
- Average freight train length of **6,500 feet**
- **2** daily passenger trains (2018) assumed constant throughout the analysis period based on the 2019 WSDOT State Rail System Plan
- Average passenger train speed of **35 miles per hour**
- Average passenger train length of **1,000 feet**
- Average lead and lag time for gate closure of **0.6 minutes**

As mentioned during the Base Case overview above, freight and passenger train forecasts were obtained from the Washington State Rail System Plan. The high growth scenario was selected due to its alignment with current freight train volumes, however a sensitivity analysis was performed in Section 9 which provides an assessment of the low and moderate growth scenarios.

4.2 Project Cost and Schedule

Table 9 summarizes the project's capital cost components with design engineering and right-of-way acquisition beginning in 2021 and substantial completion expected at the end of 2025. Costs shown in Table 10 and Table 13 are provided both rounded and non-rounded to allow for comparison with the application narrative.

Table 9: Future Capital Cost Summary Table

Year	2018 Dollars	YOE$
2021	$2,041,333	$2,223,610
2022	$2,041,333	$2,301,436
2023	$8,165,464	$9,528,099
2024	$4,899,278	$5,916,949
2025	$3,266,185	$4,082,695
Total	**$20,413,594**	**$24,052,790**

Costs are shown both rounded and non-rounded in the tables below to allow for comparison with the costs presented within the project narrative.

Table 10: Capital Cost Components

Component	Non-Rounded Values		Rounded Values	
	2018$	YOE$	2018$	YOE$
Construction	$13,488,831	$16,582,000	$13,488,900	$16,582,000
Right of Way	$4,670,000	$5,359,000	$4,670,000	$5,359,000
Construction Engineering	$2,842,097	$3,494,000	$2,842,100	$3,494,000
Preliminary Engineering	$2,326,400	$2,580,000	$2,326,400	$2,580,000
Final Engineering	$581,600	$645,000	$581,600	$645,000
Total Project Costs	**$23,908,927**	**$28,660,000**	**$23,909,000**	**$28,660,000**

Table 11 summarizes the anticipated funding sources for the project with Table 12 below shows the allocation of project funding. Table 13 summarizes project costs including previously incurred costs ($1,028,385) to ensure transparency.

Table 11: Summary of Anticipated Funding Sources

Funding Source	Capital YOE$, Rounded	Percent of Total Capital Cost Financed
Federal Sources		
CRISI Program	$1,246,500	4%
STBG Program	$3,795,000	13%
BUILD Request	$17,886,500	62%
Total Federal Sources	**$22,928,000**	**80%**
Non-Federal Sources		
City of Spokane Valley Allocation	$3,700,000	13%
Other (City, Transportation Improvement Board, State Allocation)	$1,732,000	6%
BNSF Estimated Contribution	$300,000	1%
Total Non-Federal Sources	**$5,732,000**	**20%**
Total Project Costs	**$28,660,000**	**100%**

Table 12: Allocation of Project Funding

Project Phase	BUILD	Other Federal	Non-Federal	Total Cost (YOE$)
Engineering	$0	$1,246,500	$1,978,500	$3,225,000
Right-of-Way Acquisition	$0	$3,795,000	$1,564,000	$5,359,000
Construction	$17,886,500	$0	$2,189,500	$20,076,000
Total	**$17,886,500**	**$5,041,500**	**$5,732,000**	**$28,660,000**

Table 13: Capital Cost Components Including Previously Incurred Costs

Component	Non-Rounded Values		Rounded Values	
	2018$	YOE$	2018$	YOE$
Previously Incurred Costs	$1,028,385	$1,028,385	$1,029,000	$1,029,000
Construction	$13,488,831	$16,582,000	$13,489,000	$16,582,000
Right of Way	$4,670,000	$5,359,000	$4,670,000	$5,359,000
Construction Engineering	$2,842,097	$3,494,000	$2,843,000	$3,494,000
Preliminary Engineering	$2,326,400	$2,580,000	$2,327,000	$2,580,000
Final Engineering	$581,600	$645,000	$582,000	$645,000
Total Project Cost	**$24,937,312**	**$29,688,385**	**$24,940,000**	**$29,689,000**

Lastly, Table 14 summarizes the anticipated project schedule including preliminary engineering and necessary right-of-way acquisitions.

Table 14: Project Schedule

Phase	Begin	End
Design Engineering	Sep-17	Dec-22
Environmental Documents (NEPA)	Jun-20	Jun-21
Right-of-Way	Jan-20	Dec-22
CN Ad/Bid/Award	Jan-23	Sep-23
Construction*	Sep-23	Oct-25
Construction*	Sep-23	Dec-25

**Substantial Completion Date. Construction contract finalization by 06/2026.*

4.3 Effects on Selection

The main benefit categories associated with the project are mapped into the eight merit criteria set forth by USDOT in the table below.

Table 15: Expected Effects on Merit Criteria Outcomes and Benefit Categories

Merit Criteria	Impact Categories	Description	Monetized	Qualitative
Safety	Improved Safety and Avoided Accident Costs	Improved Safety and Avoided Accident Costs from Eliminated Pines Road Grade Crossing	Yes	-
State of Good Repair	Residual Value of Infrastructure Asset	Residual Value of Infrastructure Asset	Yes	-
	Operations & Maintenance Cost Savings	Reduction in maintenance costs for the existing at-grade crossing	Yes	-
Economic Competitiveness	Reduced Travel Time Costs	Reduced Travel Time Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Yes	-
	Reduced Vehicle Operating Costs	Reduced Vehicle Operating Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Yes	-
	Improved Travel Time Reliability	Fewer rail crossing blockages will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area. This also allows both short and long-haul trucks to experience increase in delivery timeliness	-	Yes
	Improved Access to Economic Development Potential	Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS 'E' operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.	-	Yes
Environmental Sustainability	Avoided Emissions Costs	Avoided Emission Costs from Vehicle Idling and Delay Time at Pines Road Crossing	Yes	-
Quality of Life	Improved Connectivity	Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities	-	Yes
	Improved Emergency Vehicle Access	Fewer rail crossing blockages will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area.	-	Yes
	Reduced Noise Pollution	Grade separation will reduce noise pollution from train whistles.	-	Yes
Innovation	Innovative Bridge Construction	The City of Spokane Valley will evaluate innovative bridge construction techniques to reduce the impact on the community and the existing traffic. This may include constructing the structures off-site before staging for construction.	-	Yes

Merit Criteria	Impact Categories	Description	Monetized	Qualitative
	Intelligent Transportation Systems	The project will take advantage of the Spokane Regional Transportation Management Center (SRTMC) Intelligent Transportation Systems (ITS) infrastructure to communicate traveler information about construction activities and expected delays throughout the project using SRTMC's website and 511 telephone system.	-	Yes
Partnership	Support from Public and Private Partners	This project demonstrates support from numerous public and private partners across the region. Two states, several regional public entities, multiple cities, and local business organization, as well as two Class I railroads actively participated in the Horizon 2040, and in the previous Bridging the Valley plan and other workshops, stakeholder outreach, and funding initiatives to further this effort.	-	Yes

5 General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of project development and including 30 years of operations.

The monetized benefits and costs are estimated in 2018 dollars with future dollars discounted in compliance with BUILD requirements using a 7 percent real rate, and sensitivity testing at 3 percent.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2018 Dollars;
- The period of analysis begins in 2017 and ends in 2055. It includes project development and construction years (9) and full years of operations (30).
- A constant 7 percent real discount rate is assumed throughout the period of analysis. A 3 percent real discount rate is used for sensitivity analysis.

6 Demand Projections

Accurate demand projections are important to ensure the reasonable BCA output results. The magnitudes of the long-term benefits accruing over the Pines Road Grade Separation project study period are a function of vehicle traffic at the Pines Road Crossing and Pines Road / Trent Avenue intersection, and freight and passenger train growth.

6.1 Methodology

Recent and historical traffic counts supplied by the City of Spokane Valley were used to inform and provide historical 10-year annual average growth rates. Moreover, although motorists may choose to take longer detours to avoid the congested and unreliable crossings which could be avoided in the Alternative Case, the additional benefits of avoided detours were not estimated due to a lack of reliable data.

6.2 Assumptions

All assumptions used in the estimation of demand inputs for the Pines Road Grade Separation project are provided in Table 16.

Table 16: Assumptions used in the Estimation of Demand

Variable Name	Unit	Value	Source
Pines Road Crossing			
AADT (2019)	vehicles/day	16,758	2017 actual traffic count data grown by validated historical 10-year average annual growth rate. Validated through comparison with SRTC Travel Demand Model outputs. Share of vehicle counts based upon engineering estimates.
Passenger Vehicles	%	87.0%	
Trucks	%	12.0%	
Buses	%	1.0%	
AADT Growth Rate	%	1.46%	Historical 10-year average annual growth rate at crossing validated through comparison with Spokane Regional Transportation Council (SRTC) Travel Demand Model (TDM) outputs
Freight Trains at Crossing (2018)	trains/day	60.0	BNSF
Maximum Trains at Crossing	trains/day	125	City of Spokane Valley AADT data
Freight Train Traffic Growth (2016-2040)	%	3.76%	WSDOT 2019 State Rail System Plan https://www.wsdot.wa.gov/sites/default/files/2019/12/31/draft-state-rail-plan-2019.pdf
Passenger Trains at Crossing (2018)	trains/day	2.00	WSDOT 2019 State Rail System Plan https://www.wsdot.wa.gov/sites/default/files/2019/12/31/draft-state-rail-plan-2019.pdf
Passenger Train Traffic Growth	%	0.00%	WSDOT 2019 State Rail System Plan https://www.wsdot.wa.gov/sites/default/files/2019/12/31/draft-state-rail-plan-2019.pdf
Avg. Freight Train Speed	miles/hour	25.0	City of Spokane Valley
Avg. Passenger Train Speed	miles/hour	30.0	HDR assumption
Avg. Freight Train Length	feet	6,500	BNSF
Avg. Passenger Train Length	feet	1,000	HDR assumption
Lead and Lag Time	minutes	0.60	HDR based upon industry standard
Trent Avenue Intersection			
AADT, East of Pines Road (2019)	vehicles/day	27,859	City of Spokane Valley AADT data
AADT, West of Pines Road (2019)	vehicles/day	22,851	
AADT Growth Rate East of Pines Road	%	1.77%	2018 actual traffic count data grown by validated historical 10-year average annual growth rate. Validated through comparison with SRTC Travel Demand Model outputs
AADT Growth Rate West of Pines Road	%	0.70%	

6.3 Demand Projections

The resulting projections for average traffic volumes at the Pines Road crossing and Trent Avenue intersection, as well as train volumes and expected hours of vehicle delay (Base Case) are presented in the table below.

Table 17: Demand Projections

Category	2026	2035	2045	2055
Total Annual Traffic at Pines Road Crossing	6,705,387	7,637,906	8,826,899	10,200,983
Total Annual Traffic at Trent Ave. Intersection	11,498,164	13,466,370	16,050,820	19,131,276
Annual Freight Trains at Pines Road Crossing	28,682	38,854	45,625	45,625
Annual Passenger Trains at Pines Road Crossing	730	730	730	730
Total Vehicle Hours of Delay - Passenger Vehicles	12,320,131	18,975,395	25,731,430	29,737,043
Total Vehicle Hours of Delay - Trucks	1,699,328	2,617,296	3,549,163	4,101,661
Total Vehicle Hours of Delay - Bus Driver and Passenger	141,611	218,108	295,764	341,805

7 Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table ES-1 and provides an overview of the associated methodology, assumptions, and estimates.

7.1 Safety Outcomes

The proposed project would contribute to promoting merit outcomes through accident reductions due to eliminated train/vehicle encounters at the Pines Road grade crossing.

7.1.1 Methodology

Accident costs, and impacts on life, limb and property, are a significant component of road user costs. Road safety is a key economic factor in the planning of roads, as well as an important indicator of transportation efficiency, while outside of the economic context, highway safety is often the object of public concern and a leading social issue. Estimating safety benefits requires data on the frequency and severity of accidents for the type of road and area under consideration; in addition, the costs of injuries and fatalities must be monetized. Base Case collisions at the Pines Road crossing were derived using the FRA's collision prediction formulae. Collisions at the Pines Road and Trent Avenue intersection were calculated using crash data actuals provided by the City of Spokane Valley and crash modification factors (CMF) obtained from the US DOT Crash Modification Factor Clearinghouse. The Project team carefully assessed collisions within the Project limits, particularly at the Pines Road and Trent Avenue intersection, to ensure that appropriate incidents are captured in the benefit cost analysis. While PDO (property damage only) accidents occur, only benefits realized from mitigated injury accidents and fatalities were monetized.

7.1.2 Assumptions

The assumptions used in the estimation of safety benefits are summarized in the table below.

Table 18: Assumptions used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Value of a Statistical Life	2018$/fatality	$9,600,000	Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2016) https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-on-valuation-of-a-statistical-life-in-economic-analysis
Cost of Serious Injury	2018$/injury	$1,008,000	
Cost of a Minor Injury	2018$/injury	$28,800	
Cost of an Unknown Injury	2018$/injury	$174,000	
Cost of PDO	2018$/injury	$4,400	
Number of Fatalities per Fatal Collision	fatalities/fatal crash	1.00	

Variable Name	Unit	Value	Source
Number of Injuries per Fatal Collision	injuries/injury crash	0.30	
Number of Injuries per Possible Injury Collision	injuries/injury crash	1.28	
Number of Injuries per Suspected Minor Injury Collision	injuries/injury crash	1.32	
Number of Injuries per Suspected Serious Injury Collision	injuries/injury crash	1.76	
Number of Injuries per Unknown Injury Collision	injuries/injury crash	1.00	
Number of Vehicles per Crash	vehicles/crash	1.91	
2018 Expected Accident Rate, Crossing	accidents/year	2.3997	HDR Calculations Using FRA Collision Prediction Formulae
2026 Expected Accident Rate, Crossing	accidents/year	2.3998	
2036 Expected Accident Rate, Crossing	accidents/year	2.3999	
2046 Expected Accident Rate, Crossing	accidents/year	2.3999	
2055 Expected Accident Rate, Crossing	accidents/year	2.3999	
Fatalities as Share of Total Accidents	%	9.09%	HDR calculation using FRA GX Tool
Injuries as Share of Total Accidents	%	27.3%	
PDO as Share of Total Accidents	%	63.6%	
Crash Modification Factor	factor	0.79	US DOT Crash Modification Factor Clearinghouse. "Convert Intersection With Minor-Road Stop Control to Modern Roundabout
Growth in Intersection Accidents	%/year	0.88%	Historical 10-year Average Annual Growth Rate at Crossing

7.1.3 Benefit Estimates

The table below shows the benefit estimates of eliminated train/vehicle encounters. With a 7 percent discount rate applied to the benefits, the estimated present value is $20.8 million. See Section 10.3 and 10.4 for additional information.

Table 19: Estimates of Safety Benefits, 2018 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Improved Safety and Avoided Accident Costs	$2,660,577	$81,452,863	$20,839,031
Total	**$2,660,577**	**$81,452,863**	**$20,839,031**

7.2 State of Good Repair Outcomes

7.2.1 Methodology

The proposed project would contribute to the state of good repair by converting an existing intersection into an improved roundabout. Due to the time period considered for the analysis, the remaining (or residual) value of the new infrastructure asset is not fully captured. As a result, the residual value of the new grade separation underpass is monetized. The estimated underpass lifespan was deducted from the benefit cost analysis benefit period to obtain the service life outside the study period. The remaining life as a factor of the estimated asset service life was multiplied by the project capital costs to derive the estimate.

7.2.2 Assumptions

The assumptions used in the estimation of State of Good Repair benefits are summarized in the table below.

Table 20: Assumptions used in the Estimation of State of Good Repair Benefits

Variable Name	Unit	Date	Value	Source
Estimated Asset Service Life	years	2017-2055	50	Transportation for America, Bridges Overview. "Expected Lifespan of 50 years."
BCA Benefit Period	years	2017-2055	30	HDR Calculations with City of Spokane Valley Consultation
Service Life Remaining	years	2017-2055	20	
Project Capital Costs	2018$	2017-2055	$24,937,312	
Annual Maintenance Cost Savings	2018$	2017-2055	$11,000	Estimate based upon long term maintenance of at-grade crossing infrastructure

7.2.3 Benefit Estimates

The table below shows the estimated residual value of the new infrastructure asset. With a 7 percent discount rate, the estimated present value is $0.90 million. See Section 10.5 for more information.

Table 21: Estimates of State of Good Repair Benefits, 2018 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Residual Value of Infrastructure Asset	$0	$9,974,925	$816,037
Operations and Maintenance Cost Savings	$11,000	$330,000	$85,005
Total	**$11,000**	**$10,304,925**	**$901,042**

7.3 Economic Competitiveness

To quantify the benefits associated with economic outcomes, multiple impacts were considered primarily in relevance to motorists. Specifically, these impacts included travel time costs, vehicle operating costs, and pavement maintenance costs – all of which were monetized.

7.3.1 Methodology

Travel time savings will be generated for motorists (automobiles, trucks, and transit buses) at the Pines Road crossing. Reduced crossing blockage times will lead to decreased vehicle travel time costs which are monetized using DOT guidance for value of time of automobile drivers and passengers, bus passengers, as well as heavy vehicle truck drivers and bus drivers. Out-of-pocket vehicle operating cost savings will accrue from decreased vehicle wait times and idling as a result of the new underpass across Trent Avenue. The out-of-pocket cost savings were monetized based on the change in delay time and associated fuel and oil used while idling.

Travel time savings in hours between the Base and the Alternative Cases were estimated based on AADT forecasts derived on the City of Spokane's historical traffic counts and the Federal Rail Administration (FRA) database regarding daily train counts, speeds, and lengths. The expected crossing time delay was then derived by applying the probability of delay which is a function of train frequency, speed, length, and lead and lag time.

Value of time for vehicle type, as well as occupancy assumptions for both automobiles and trucks are available in the Benefit-Cost Analysis Guidance for Discretionary Grant Applications published by US DOT. The average transit bus occupancy was derived from consultation with the City of Spokane Valley. The estimate for travel time savings is simply the product of hours of delay, vehicle occupancy, and respective value of time.

The reduction in vehicle idling time at Pines Road crossing will translate into lower vehicle operating costs from reduced fuel and motor oil consumption in the Alternative. The change in vehicle delay time (by vehicle type and by year) is multiplied by the associated vehicle fuel consumption rate to obtain annual estimates of fuel consumption from idling. This multiplied by the cost per unit of fuel provides an estimate of the change in fuel costs. The same methodology is applied to track the change in motor oil consumption and costs. The sum of the two costs produces an estimate for the overall vehicle operating cost impacts due to vehicle delay time at the crossing.

7.3.2 Assumptions

The assumptions used in the estimation of economic outcomes and benefits are summarized in the table below.

Table 22: Assumptions used in the Estimation of Economic Outcomes

Variable Name	Unit	Date	Value	Source
Average Passenger Vehicle Occupancy	persons	2017-2055	1.67	2017 National Household Travel Survey
Average Truck Occupancy	persons	2017-2055	1.00	
Average Transit Bus Occupancy	persons	2017-2055	60.0	City of Spokane Valley
Value of Time for Automobile Driver and Passenger	2018$/hour	2017-2055	$16.6	Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-valuation-
Value of Time for Truck Driver	2018$/hour	2017-2055	$29.5	
Value of Time for Bus Driver	2018$/hour	2017-2055	$31.0	
Value of Time for Bus Passenger	2018$/hour	2017-2055	$16.6	
Vehicle Fuel Burned at Idle - Automobile	gal/hr	2017-2055	0.36	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Average of gasoline passenger vehicles
Vehicle Diesel Burned at Idle - Truck	gal/hr	2017-2055	0.49	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Combination Trucks

Variable Name	Unit	Date	Value	Source
Vehicle Diesel Burned at Idle - Transit Bus	gal/hr	2017-2055	0.97	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Transit Bus
Average Consumption of Motor Oil per Hour	quarts/hr	2017-2055	0.03	Based on US DOT: HERS-ST Highway Economic Requirements System (2002) oil consumption of 1.38qt/1000miles and assuming that "One hour of idle time is equal to approximately 25 miles of driving" (Ford Motor Company, 2011)
Cost of Motor Oil - Automobile	2018$/hour	2017-2055	$10.58	Average oil price sourced from HERS model and inflated to 2018$ by Motor Oil CPI (BLS CUUR0000SS47021)
Cost of Motor Oil - Truck	2018$/hour	2017-2055	$4.23	
Cost of Motor Oil - Bus	2018$/hour	2017-2055	$4.23	
Cost of Diesel	2018$/gallon	2019	$2.40	Energy Information Administration, Annual Energy Outlook 2020. Net of State and Federal taxes.
		2020	$2.31	
		2021	$2.32	
		2022	$2.37	
		2023	$2.40	
		2024	$2.45	
		2025	$2.48	
		2026	$2.54	
		2027	$2.55	
		2028	$2.60	
		2029	$2.63	
		2030	$2.70	
		2031	$2.74	
		2032	$2.77	
		2033	$2.83	
		2034	$2.86	
		2035	$2.89	
		2036	$2.93	
		2037	$2.96	
		2038	$2.99	
		2039	$3.02	
		2040	$3.03	
		2041	$3.05	
		2042	$3.11	
		2043	$3.13	
		2044	$3.16	
		2045	$3.22	
		2046	$3.22	
		2047	$3.26	
		2048	$3.30	
		2049	$3.32	
		2050	$3.35	
		2051	$3.35	
		2052	$3.35	
		2053	$3.35	
		2054	$3.35	
		2055	$3.35	
Cost of Diesel	2018$/gallon	2019	$2.08	Energy Information Administration, Annual Energy Outlook 2020. Net of State and Federal taxes.
		2020	$2.06	
		2021	$2.07	
		2022	$2.08	
		2023	$2.07	
		2024	$2.04	
		2025	$2.07	

Variable Name	Unit	Date	Value	Source
		2026	$2.10	
		2027	$2.13	
		2028	$2.15	
		2029	$2.19	
		2030	$2.27	
		2031	$2.30	
		2032	$2.32	
		2033	$2.38	
		2034	$2.42	
		2035	$2.46	
		2036	$2.49	
		2037	$2.51	
		2038	$2.54	
		2039	$2.58	
		2040	$2.60	
		2041	$2.62	
		2042	$2.67	
		2043	$2.70	
		2044	$2.72	
		2045	$2.77	
		2046	$2.78	
		2047	$2.83	
		2048	$2.87	
		2049	$2.90	
		2050	$2.93	
		2051	$2.93	
		2052	$2.93	
		2053	$2.93	
		2054	$2.93	
		2055	$2.93	

7.3.3 Benefit Estimates

The complete set of economic outcomes is shown in the table below. With a 7 percent discount rate, the estimated present value of benefits over the project life cycle is over $18.4 million. These benefits accrue to many users including motorists, local residents and businesses, and shippers. See Section 10.6 and 10.7 for additional information.

Table 23: Estimates of Economic Benefits, 2018 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Reduced Travel Time Costs	$1,471,515	$79,770,770	$17,722,607
Reduced Vehicle Operating Costs	$48,966	$3,081,698	$660,522
Total	**$1,520,481**	**$82,852,468**	**$18,383,129**

Improved Travel Time Reliability

On average, motorists are delayed 60 times per day at each roadway-railway crossing. With some trains nearly one and a half miles in length, crossings are closed for approximately three to five minutes for each train to pass. Delays are further compounded by the time required for the vehicle queues created by the train crossing to dissipate. Furthermore, the current Pines Road and Trent Avenue intersection operates at a LOS of ‘E’ which is projected to reach LOS ‘F’ due to worsening conditions. The project would transform the intersection to a LOS ‘A’, which will improve travel time reliability as there will be a significantly lower chance for drivers to be delayed thus reducing the unpredictability of trips in the area.

Improved Access to Future Development Potential

Close to 170 acres of mixed-use or commercially-zoned parcels and 56 acres of prime industrially-zoned parcels are undeveloped because property owners and developers cannot afford to mitigate the LOS ‘E’ operating conditions at the Pines Road /Trent Avenue intersection. These parcels, and several hundred more acres beyond the city limits, are some of the last undeveloped parcels available for industrial use in the area.

7.4 Environmental Sustainability Outcomes

The proposed project would contribute to environmental sustainability benefits through a net reduction in emissions due to reduced vehicle delay time at the Pines Road Crossing. Environmental costs are increasingly considered as an important component in the evaluation of transportation projects and the main environmental impacts of vehicle use and exhaust emissions can impose wide-ranging social costs on people, material, and vegetation. The negative effects of pollution depend not only on the quantity of pollution produced, but also on the types of pollutants emitted and the conditions into which the pollution is released.

7.4.1 Methodology

The change in vehicle delay time at the Pines Road crossing is used to estimate the total fuel consumption while idling by vehicle type. The total estimated vehicle delay times are multiplied by the appropriate emission factors for tons of for CO_2, NO_x VOC, PM, and SO_2 per hour of vehicle idling. Each pollutant is then multiplied by its monetary value to get the total emission cost impact due to vehicle delay time.

7.4.2 Assumptions

The assumptions used in the estimation of environmental sustainability benefits are summarized in the tables below.

Table 24: Assumptions used in the Estimation Environmental Sustainability Benefits – Idling Emissions (Auto)

Emissions per Hour of Vehicle Idling - Passenger Cars and Trucks (grams/veh-hour)						
Year	C02	NOx	PM2.5	SO2	VOC	Source
2017	5,417	5.713	4.944	0.146	0.036	Based on MOVES average annual emission factors for passenger cars and trucks in Spokane County. Moves model run in May 2020.
2020	5,216	4.270	3.206	0.112	0.035	
2025	4,819	1.668	0.945	0.081	0.032	
2030	4,452	0.652	0.278	0.058	0.030	
2035	3,965	0.248	0.113	0.049	0.026	
2040	3,532	0.095	0.046	0.041	0.024	
2045	3,254	0.049	0.035	0.034	0.022	
2050	2,998	0.025	0.027	0.027	0.020	
2055	2,998	0.025	0.027	0.027	0.020	

Table 25: Assumptions used in the Estimation Environmental Sustainability Benefits – Idling Emissions (Truck)

Emissions per Hour of Vehicle Idling - Freight Trucks (grams/veh-hour)						
Year	C02	NOx	PM2.5	SO2	VOC	Source
2017	19,825	198.240	18.514	6.940	0.173	Based on MOVES average annual emission factors for freight
2020	19,672	156.537	15.906	5.754	0.171	

Emissions per Hour of Vehicle Idling - Freight Trucks (grams/veh-hour)						
Year	C02	NOx	PM2.5	SO2	VOC	Source
2025	19,400	98.261	10.551	3.399	0.167	trucks in Spokane County, assuming the average of single and combination unit trucks both long and short haul. Moves model run in May 2020.
2030	19,132	61.680	6.999	2.009	0.162	
2035	18,853	35.435	3.043	0.693	0.159	
2040	18,579	20.358	1.323	0.239	0.155	
2045	18,422	19.961	1.320	0.237	0.154	
2050	18,266	19.571	1.316	0.236	0.152	
2055	18,266	19.571	1.316	0.236	0.152	

Table 26: Assumptions used in the Estimation Environmental Sustainability Benefits – Idling Emissions (Bus)

Emissions per Hour of Vehicle Idling - Transit Bus (grams/veh-hour)						
Year	C02	NOx	PM2.5	SO2	VOC	Source
2017	19,243	268.353	20.783	4.033	0.168	Based on MOVES average annual emission factors for transit busses in Spokane County. Moves model run in May 2020.
2020	19,133	208.214	17.760	2.902	0.166	
2025	18,933	124.713	11.634	1.867	0.163	
2030	18,735	74.699	7.621	1.201	0.159	
2035	18,530	43.151	3.117	0.561	0.156	
2040	18,326	24.927	1.275	0.262	0.153	
2045	18,216	24.762	1.271	0.260	0.152	
2050	18,106	24.599	1.267	0.258	0.151	
2055	18,106	24.599	1.267	0.258	0.151	

Table 27: Assumptions used in the Estimation of Environmental Sustainability - Idling Emissions (Emission Values)

Pollutant	Unit	Year	Value	Source
CO_2 cost per short ton	2018$/short ton	2017	$0.91	US DOT, BCA Guidance January 2020; The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks (July 2018)
		2020	$0.91	
		2025	$0.91	
		2030	$0.91	
		2035	$1.81	
		2040	$1.81	
		2045	$1.81	
		2050	$1.81	
		2055	$1.81	
NOx cost per short ton	2018$/short ton	2017-2055	$8,600	US DOT, BCA Guidance January 2020; The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars and Light Trucks Preliminary Regulatory Impact Analysis (October 2018).
VOC cost per short ton	2018$/short ton	2017-2055	$2,100	
PM cost per short ton	2018$/short ton	2017-2055	$387,300	
SO_2 cost per short ton	2018$/short ton	2017-2055	$50,100	

7.4.3 Benefit Estimates

The table below shows the benefit estimates of reducing vehicle delay times. With a 7 percent discount rate, the estimated present value of benefits over the project life cycle is $0.02 million dollars. See Section 10.8, 10.9, and 10.10 for additional information.

Table 28: Estimates of Environmental Sustainability Benefits, 2018 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Avoided Emissions Costs	$1,287	$104,841	$22,147
Total	**$1,287**	**$104,841**	**$22,147**

7.5 Quality of Life Outcomes

Improved Connectivity

Grade separation will provide pedestrian and cycling facilities allowing for greater connectivity and promotion of active lifestyles, in addition to improved access to nearby businesses and other public facilities. The BNSF Railway bisects the northern parts of Spokane Valley from the main city south of the railway. The project will connect a diverse neighborhoods surrounding the Study area including residential, commercial, mixed-use and industrial areas. The new grade-separated crossing and roundabout will provide sidewalks, making the route more appealing to pedestrians and bicyclists. In addition to an improved crossing of the railroad tracks, the roundabout will create a safer and more comfortable crossing of Trent Avenue.

Improved Emergency Vehicle Access

Key emergency services (fire, police, and EMS) are located south of the railway crossing. The long and frequent delays at the rail crossings causes delays for providing emergency services to the north. Eliminating the Pines Road grade crossing blockage will improve travel time and reliability for emergency responders that may otherwise not be able to pass or be forced to take a longer route.

Reduced Noise Pollution

Spokane Valley residents have long complained about the noise pollution of the train whistles. Federal law requires locomotives to sound their horns at 96 to 100 decibels as they approach at-grade crossings and continue blowing the horn until the train clears the crossing. Not only do the horns disturb the peacefulness of the surrounding area, medical studies have linked loud noises, such as train whistles, to stress-related health problems.[5] As part of the broader Bridging the Valley plan, all existing at-grade crossings will be eliminated, which will allow noise from train horns and whistles to be severely reduced. The Pines Road project alone will significantly reduce the amount of train horn and whistle noise and serves as an incremental improvement toward the overall goal of removing all at-grade crossings.

7.6 Innovation

The City of Spokane Valley will evaluate innovative bridge construction techniques to reduce the impact on the community and the existing traffic. This may include constructing the structures off-site before staging for construction. The project will also take advantage of the Spokane Regional Transportation Management Center (SRTMC) Intelligent Transportation Systems (ITS) infrastructure to communicate traveler information about construction activities and expected delays throughout the project using SRTMC's website and 511 telephone system. Other ITS technologies, such as work zone queue management and speed management systems, will be evaluated for applicability during project engineering.

7.7 Partnership

This project demonstrates support from numerous public and private partners across the region. Two states, several regional public entities, multiple cities, and local business organization, as well as two Class I railroads actively participated in the Horizon 2040, and in the previous Bridging the Valley plan and other workshops, stakeholder outreach, and funding initiatives to further this effort. Table 29 summarizes the key partners associated with the Pines Road/BNSF grade-separation project and other related projects.

[5] *Spokane Valley, Cheney residents want to silence train whistles." The Spokesman-Review, March 6, 2016.*

Table 29: Partners in Project Development

State and Local Agencies	
• Idaho Transportation Department • Washington State Department of Transportation • Washington Freight Mobility Strategic Investment Board • Washington Utility and Transportation Commission • State and Federal Legislators	
Regional Agencies	
• Spokane Regional Transportation Council • Spokane Transit Authority • Kootenai Metropolitan Planning Organization	
Railroads	
• BNSF Railway Company	• Union Pacific Railroad
Local Agencies and Districts	
• Kootenai County • Spokane County • City of Athol • Town of Millwood • City of Rathdrum	• City of Spokane • City of Spokane Valley • Area Fire Districts/Emergency Response Systems • Area School Districts
Chambers of Commerce	
• Spokane Valley	• Greater Spokane Incorporated

8 Summary of Findings and Benefit-Cost Outcomes

The tables below summarizes the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (39 years). As stated earlier, construction is expected to be completed by 2025 with 2026 being the project opening year. Benefits accrue during the full operation of the project.

Table 30: Overall Results of the Benefit Cost Analysis, 2018 Dollars

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$40,145,349	$87,967,852
Total Discounted Costs	$18,571,840	$21,873,922
Net Present Value	$21,573,509	$66,093,930
Benefit / Cost Ratio	2.16	4.02
Internal Rate of Return (%)	13.1%	
Payback Period (years)	5.68	

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 13.1 percent. With a 7 percent real discount rate, the $18.6 million investment would result in $40.1 million in total benefits for a Net Present Value of $21.6 million and a Benefit/Cost ratio of approximately 2.16.

With a 3 percent real discount rate, the Net Present Value of the project would increase to $66.1 million, for a Benefit/Cost ratio of 4.02.

Table 31: Benefit Estimates by Merit Criteria Outcome for the Full Build Alternative, 2018 Dollars

Merit Criteria	Impact Categories	7% Discount Rate	3% Discount Rate
Safety	Improved Safety and Avoided Accident Costs	$20,839,031	$43,134,520
State of Good Repair	Residual Value of Infrastructure Asset	$816,037	$3,341,430

Merit Criteria	Impact Categories	7% Discount Rate	3% Discount Rate
	Operations & Maintenance Cost Savings	$85,005	$175,306
Economic Competitiveness	Reduced Travel Time Costs	$17,722,607	$39,752,760
	Reduced Vehicle Operating Costs	$660,522	$1,512,503
	Improved Travel Time Reliability	n/a	n/a
	Unlock Future Development Potential	n/a	n/a
Environmental Sustainability	Avoided Emissions Costs	$22,147	$51,334
Quality of Life	Improved Connectivity	n/a	n/a
	Improved Emergency Vehicle Access	n/a	n/a
	Reduced Noise Pollution	n/a	n/a
Innovation	Innovative Bridge Construction	n/a	n/a
	Intelligent Transportation Systems	n/a	n/a
Partnership	Support from Public and Private Partners	n/a	n/a
Total Benefit Estimates		**$40,145,349**	**$87,967,852**

As summarized, the project as a whole yields substantial societal benefits. It's important to recognize that its individual components, while both necessary for the entire project, result in positive societal outcomes as well. The grade separation is estimated to result in a discounted net present value of $26.9 million and a benefit cost ratio of 3.73, while the roundabout is expected to result in a benefit cost ratio of 0.38. Results for both components are summarized in the following tables. While the net present value of the roundabout is negative, improved traffic fluidity and reduced congestion at the intersection was not estimated in absence of detailed traffic modelling. It's expected that significant societal benefits would be captured by the roundabout as a result of improved traffic fluidity.

Table 32: Grade Separation Benefits

Benefit	Undiscounted Net Benefits (2018$)	Discounted Total Benefits at 3% ($2018)	Discounted Total Benefits at 7% ($2018)
Reduced Travel Time Costs	$79,770,770	$39,752,760	$17,722,607
Improved Safety and Avoided Accident Costs	$67,981,955	$36,114,062	$17,511,412
Avoided Emissions Costs	$104,841	$51,334	$22,147
Reduced Vehicle Operating Costs	$3,081,698	$1,512,503	$660,522
Residual Value of Infrastructure Asset	$9,974,925	$3,341,430	$816,037
Operations and Maintenance Cost Savings	$330,000	$175,306	$85,005
Total Grade Separation Benefits	**$161,244,188**	**$80,947,394**	**$36,817,730**
Grade Separation Benefits Capital Expenditures	**($13,263,588)**	**($11,626,207)**	**($9,862,485)**
Net Present Value (NPV)	**$147,980,601**	**$69,321,187**	**$26,955,245**
Benefit Cost Ratio (BCR)	**12.16**	**6.96**	**3.73**

Table 33: Roundabout Benefits

Benefit	Undiscounted Net Benefits (2018$)	Discounted Total Benefits at 3% ($2018)	Discounted Total Benefits at 7% ($2018)
Improved Safety and Avoided Accident Costs	$13,470,909	$7,020,458	$3,327,619
Improved Traffic Fluidity*	-	-	-
Total RAB Benefits	**$13,470,909**	**$7,020,458**	**$3,327,619**
RAB Capital Expenditures	**($11,673,724)**	**($10,247,715)**	**($8,709,356)**
Net Present Value (NPV)	**$1,797,184**	**($3,227,257)**	**($5,381,736)**
Benefit Cost Ratio (BCR)	**1.15**	**0.69**	**0.38**

**Discussed qualitatively in the absence of detailed traffic modelling*

9 Benefit Cost Sensitivity Analysis

9.1 Variation in Key Inputs and Assumptions

The BCA outcomes presented in the previous sections rely on a large number of assumptions and long-term projections; both of which are subject to considerable uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the “critical variables.”

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the “preferred” or most likely value for the variable; and
- Assess the robustness of the BCA and evaluate, in particular, whether the conclusions reached under the “preferred” set of input values are significantly altered by reasonable departures from those values.

The outcomes of the quantitative analysis for the Pines Road Grade Separation project using a 7 percent discount rate are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters, as indicated in the column headers.

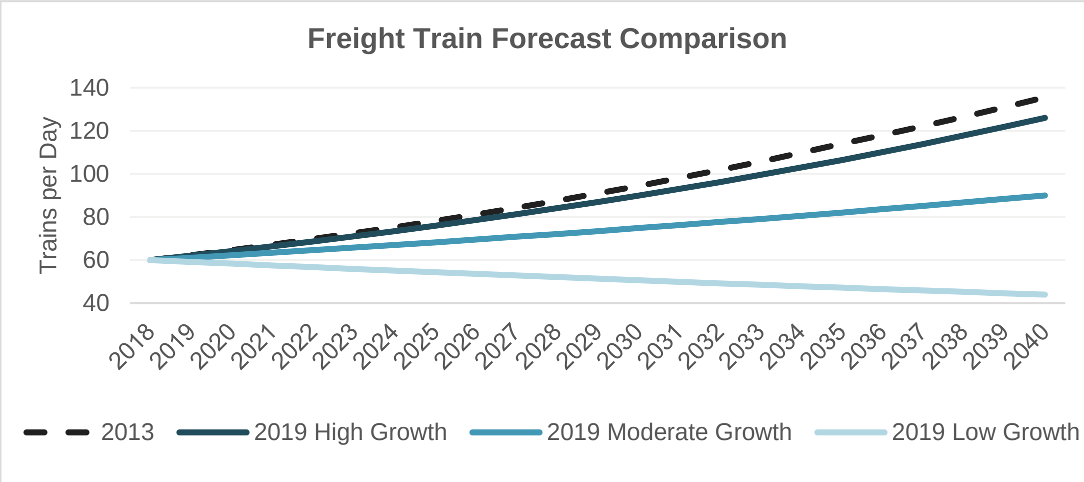
Table 34: Quantitative Assessment of Sensitivity, Summary (Discounted at 7%)

Original NPV (discounted at 7%)	Parameters	Change in Parameter Value	New NPV (discounted at 7%)	Change in NPV	New B/C Ratio
$21,573,509	Capital Expenditures	+25% Costs	$16,930,549	-21.5%	1.73
		-25% Costs	$26,216,469	21.5%	2.81
	AADT Growth Rate	+2% Growth	$32,716,628	51.7%	2.76
		-2% Growth	$14,468,389	-32.9%	1.78
	Freight Train Growth Rate	WSDOT Moderate Growth	$17,389,321	-19.4%	1.94
		WSDOT Low Growth	$11,504,418	-46.7%	1.62

As to be expected, lowering the growth rates for both traffic and freight train growth reduce the net present value of the projects. Traffic growth provides significant variation, with a 2% increase or decrease resulting in the net present value increasing by $11.1 million to decreasing by $7.1 million respectively.

Varying the growth scenario of the freight train forecasts, particularly the low growth scenario, significantly affects the BCR. As discussed in Section 4, it’s noted that the 2019 moderate growth scenario projects current train volumes of 60 trains per day are not reached until 2022 while the high growth scenario better reflects current freight train volumes which provides the basis for selecting the high growth scenario for the base analysis. Figure 2 compares the growth of current volumes (60 trains per day) using growth rates from the 2019 and 2013 state rail plans. Despite the negative growth rate assumed by the low growth scenario, the project BCR remains resilient with a BCR of 1.62.

Figure 2: Freight Train Forecast Comparison



Sources: 2013 Washington State Rail Plan, 2019 Washington State Rail System Plan

Decreasing or increasing capital costs by 25% results in the BCR ranging between 1.73 and 2.81. The sensitivity analysis indicates that the Pines Road Grade Separation project is robust across the changes, with the benefit cost ratio exceeding 1.62 in each of the cases examined, resulting in beneficial impacts to stakeholders and society.

10 Supplementary Data Tables

This section breaks down all benefits associated with the merit criteria outcomes (State of Good Repair, Economic Competitiveness, Quality of Life, Safety, and Environmental Sustainability) in annual form for the Pines Road Grade Separation project. Supplementary data tables are also provided for some specific benefit categories.

10.1 Annual Estimates of Total Project Benefits and Costs

Calendar Year	Project Year	Total Benefits ($2018)	Total Costs ($2018)	Undiscounted Net Benefits ($2018)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2017	1	$0	-$1,420,052	-$1,420,052	-$1,420,052	-$1,420,052
2018	2	$0	-$515,667	-$515,667	-$515,667	-$515,667
2019	3	$0	-$515,667	-$515,667	-$481,931	-$500,647
2020	4	$0	-$2,072,333	-$2,072,333	-$1,810,056	-$1,953,373
2021	5	$0	-$2,041,333	-$2,041,333	-$1,666,336	-$1,868,109
2022	6	$0	-$2,041,333	-$2,041,333	-$1,557,323	-$1,813,698
2023	7	$0	-$8,165,464	-$8,165,464	-$5,821,863	-$7,043,601
2024	8	$0	-$4,899,278	-$4,899,278	-$3,264,596	-$4,103,068
2025	9	$0	-$3,266,185	-$3,266,185	-$2,034,016	-$2,655,708
2026	10	$4,193,345	$0	$4,193,345	$2,440,565	$3,310,265
2027	11	$4,271,792	$0	$4,271,792	$2,323,572	$3,273,973
2028	12	$4,354,455	$0	$4,354,455	$2,213,584	$3,240,123
2029	13	$4,440,884	$0	$4,440,884	$2,109,832	$3,208,189
2030	14	$4,532,110	$0	$4,532,110	$2,012,311	$3,178,731
2031	15	$4,627,435	$0	$4,627,435	$1,920,221	$3,151,058
2032	16	$4,727,157	$0	$4,727,157	$1,833,273	$3,125,208
2033	17	$4,832,248	$0	$4,832,248	$1,751,429	$3,101,636
2034	18	$4,941,954	$0	$4,941,954	$1,674,011	$3,079,663
2035	19	$5,056,973	$0	$5,056,973	$1,600,908	$3,059,552
2036	20	$5,177,281	$0	$5,177,281	$1,531,771	$3,041,107
2037	21	$5,303,106	$0	$5,303,106	$1,466,353	$3,024,287
2038	22	$5,435,191	$0	$5,435,191	$1,404,557	$3,009,333
2039	23	$5,573,744	$0	$5,573,744	$1,346,132	$2,996,162
2040	24	$5,694,502	$0	$5,694,502	$1,285,324	$2,971,918
2041	25	$5,742,384	$0	$5,742,384	$1,211,338	$2,909,618
2042	26	$5,791,758	$0	$5,791,758	$1,141,825	$2,849,161
2043	27	$5,841,048	$0	$5,841,048	$1,076,208	$2,789,717
2044	28	$5,891,149	$0	$5,891,149	$1,014,429	$2,731,695
2045	29	$5,942,609	$0	$5,942,609	$956,346	$2,675,297
2046	30	$5,993,460	$0	$5,993,460	$901,430	$2,619,602
2047	31	$6,046,101	$0	$6,046,101	$849,857	$2,565,641
2048	32	$6,099,336	$0	$6,099,336	$801,252	$2,512,846
2049	33	$6,153,054	$0	$6,153,054	$755,429	$2,461,143
2050	34	$6,207,459	$0	$6,207,459	$712,251	$2,410,586
2051	35	$6,261,913	$0	$6,261,913	$671,494	$2,360,905
2052	36	$6,317,135	$0	$6,317,135	$633,099	$2,312,355
2053	37	$6,373,137	$0	$6,373,137	$596,927	$2,264,907

Calendar Year	Project Year	Total Benefits ($2018)	Total Costs ($2018)	Undiscounted Net Benefits ($2018)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2054	38	$6,429,929	$0	$6,429,929	$562,847	$2,218,534
2055	39	$16,462,449	$0	$16,462,449	$1,346,774	$5,514,640
Total		**$174,715,097**	**-$24,937,312**	**$149,777,785**	**$21,573,509**	**$66,093,930**

10.2 Annual Demand Projections

Calendar Year	Project Year	Total Annual Traffic at Pines Road Crossing	Total Annual Traffic at Trent Ave. Intersection	Annual Freight Trains at Pines Road Crossing	Annual Passenger Trains at Pines Road Crossing	Total Vehicle Hours of Delay - Passenger Vehicles	Total Vehicle Hours of Delay - Trucks	Total Vehicle Hours of Delay - Bus Driver and Passenger
2017	1	16,128	27,074	60.0	2.00	22,674	3,128	261
2018	2	16,363	27,374	60.0	2.00	23,005	3,173	264
2019	3	16,601	27,859	62.1	2.00	24,133	3,329	277
2020	4	16,843	28,352	64.2	2.00	25,318	3,492	291
2021	5	17,089	28,854	66.4	2.00	26,560	3,663	305
2022	6	17,338	29,365	68.7	2.00	27,864	3,843	320
2023	7	17,591	29,886	71.0	2.00	29,232	4,032	336
2024	8	17,847	30,415	73.5	2.00	30,667	4,230	352
2025	9	18,107	30,954	76.0	2.00	32,173	4,438	370
2026	10	18,371	31,502	78.6	2.00	33,754	4,656	388
2027	11	18,639	32,060	81.3	2.00	35,412	4,884	407
2028	12	18,910	32,628	84.1	2.00	37,152	5,124	427
2029	13	19,186	33,205	86.9	2.00	38,978	5,376	448
2030	14	19,465	33,794	89.9	2.00	40,894	5,641	470
2031	15	19,749	34,392	93.0	2.00	42,904	5,918	493
2032	16	20,037	35,001	96.2	2.00	45,014	6,209	517
2033	17	20,329	35,621	99.5	2.00	47,227	6,514	543
2034	18	20,625	36,252	102.9	2.00	49,550	6,835	570
2035	19	20,926	36,894	106.4	2.00	51,987	7,171	598
2036	20	21,231	37,548	110.1	2.00	54,545	7,523	627
2037	21	21,540	38,213	113.9	2.00	57,228	7,894	658
2038	22	21,854	38,889	117.8	2.00	60,044	8,282	690
2039	23	22,173	39,578	121.8	2.00	62,999	8,690	724
2040	24	22,496	40,279	125.0	2.00	65,577	9,045	754
2041	25	22,823	40,993	125.0	2.00	66,533	9,177	765
2042	26	23,156	41,719	125.0	2.00	67,503	9,311	776
2043	27	23,494	42,458	125.0	2.00	68,486	9,446	787
2044	28	23,836	43,210	125.0	2.00	69,484	9,584	799

Calendar Year	Project Year	Total Annual Traffic at Pines Road Crossing	Total Annual Traffic at Trent Ave. Intersection	Annual Freight Trains at Pines Road Crossing	Annual Passenger Trains at Pines Road Crossing	Total Vehicle Hours of Delay - Passenger Vehicles	Total Vehicle Hours of Delay - Trucks	Total Vehicle Hours of Delay - Bus Driver and Passenger
2045	29	24,183	43,975	125.0	2.00	70,497	9,724	810
2046	30	24,536	44,754	125.0	2.00	71,524	9,865	822
2047	31	24,893	45,546	125.0	2.00	72,567	10,009	834
2048	32	25,256	46,353	125.0	2.00	73,624	10,155	846
2049	33	25,624	47,174	125.0	2.00	74,697	10,303	859
2050	34	25,998	48,010	125.0	2.00	75,786	10,453	871
2051	35	26,376	48,860	125.0	2.00	76,890	10,606	884
2052	36	26,761	49,725	125.0	2.00	78,011	10,760	897
2053	37	27,151	50,606	125.0	2.00	79,148	10,917	910
2054	38	27,546	51,502	125.0	2.00	80,301	11,076	923
2055	39	27,948	52,414	125.0	2.00	81,471	11,237	936
Total		**839,019**	**1,493,287**	**3,984**	**78**	**2,071,417**	**285,713**	**23,809**

10.3 Safety Outcomes: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Fatalities Avoided	Injuries Avoided	PDO Avoided
2017	1	0.00	0.00	0.00
2018	2	0.00	0.00	0.00
2019	3	0.00	0.00	0.00
2020	4	0.00	0.00	0.00
2021	5	0.00	0.00	0.00
2022	6	0.00	0.00	0.00
2023	7	0.00	0.00	0.00
2024	8	0.00	0.00	0.00
2025	9	0.00	0.00	0.00
2026	10	0.24	1.75	11.63
2027	11	0.24	1.76	11.71
2028	12	0.24	1.77	11.79
2029	13	0.24	1.77	11.86
2030	14	0.24	1.78	11.94
2031	15	0.24	1.79	12.02
2032	16	0.24	1.80	12.10
2033	17	0.24	1.81	12.18

Calendar Year	Project Year	Fatalities Avoided	Injuries Avoided	PDO Avoided
2034	18	0.24	1.82	12.26
2035	19	0.24	1.82	12.35
2036	20	0.24	1.83	12.43
2037	21	0.24	1.84	12.51
2038	22	0.24	1.85	12.60
2039	23	0.24	1.86	12.68
2040	24	0.24	1.87	12.77
2041	25	0.24	1.88	12.85
2042	26	0.24	1.89	12.94
2043	27	0.24	1.89	13.03
2044	28	0.24	1.90	13.11
2045	29	0.24	1.91	13.20
2046	30	0.24	1.92	13.29
2047	31	0.24	1.93	13.39
2048	32	0.24	1.94	13.48
2049	33	0.24	1.95	13.57
2050	34	0.24	1.96	13.66
2051	35	0.24	1.97	13.76
2052	36	0.24	1.98	13.85
2053	37	0.24	1.99	13.95
2054	38	0.24	2.00	14.04
2055	39	0.24	2.01	14.14
Total		**7.24**	**56.2**	**385.1**

10.4 Safety Outcomes: Annual Benefit Estimates

Calendar Year	Project Year	Improved Safety and Avoided Accident Costs	Total Safety Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0
2018	2	$0	$0	$0	$0
2019	3	$0	$0	$0	$0
2020	4	$0	$0	$0	$0
2021	5	$0	$0	$0	$0
2022	6	$0	$0	$0	$0
2023	7	$0	$0	$0	$0

Calendar Year	Project Year	Improved Safety and Avoided Accident Costs	Total Safety Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2024	8	$0	$0	$0	$0
2025	9	$0	$0	$0	$0
2026	10	$2,660,577	$2,660,577	$1,548,480	$2,100,284
2027	11	$2,664,040	$2,664,040	$1,449,061	$2,041,765
2028	12	$2,667,533	$2,667,533	$1,356,038	$1,984,895
2029	13	$2,671,056	$2,671,056	$1,269,000	$1,929,628
2030	14	$2,674,610	$2,674,610	$1,187,559	$1,875,918
2031	15	$2,678,196	$2,678,196	$1,111,356	$1,823,721
2032	16	$2,681,812	$2,681,812	$1,040,053	$1,772,994
2033	17	$2,685,461	$2,685,461	$973,335	$1,723,695
2034	18	$2,689,141	$2,689,141	$910,905	$1,675,784
2035	19	$2,692,853	$2,692,853	$852,488	$1,629,221
2036	20	$2,696,598	$2,696,598	$797,826	$1,583,967
2037	21	$2,700,368	$2,700,368	$746,674	$1,539,982
2038	22	$2,704,172	$2,704,172	$698,809	$1,497,234
2039	23	$2,708,008	$2,708,008	$654,019	$1,455,688
2040	24	$2,711,878	$2,711,878	$612,107	$1,415,309
2041	25	$2,715,782	$2,715,782	$572,886	$1,376,065
2042	26	$2,719,721	$2,719,721	$536,184	$1,337,922
2043	27	$2,723,693	$2,723,693	$501,838	$1,300,851
2044	28	$2,727,701	$2,727,701	$469,698	$1,264,820
2045	29	$2,731,743	$2,731,743	$439,620	$1,229,801
2046	30	$2,735,821	$2,735,821	$411,474	$1,195,764
2047	31	$2,739,940	$2,739,940	$385,134	$1,162,683
2048	32	$2,744,094	$2,744,094	$360,484	$1,130,530
2049	33	$2,748,284	$2,748,284	$337,415	$1,099,278
2050	34	$2,752,511	$2,752,511	$315,826	$1,068,902
2051	35	$2,756,775	$2,756,775	$295,622	$1,039,377
2052	36	$2,761,077	$2,761,077	$276,713	$1,010,678
2053	37	$2,765,416	$2,765,416	$259,017	$982,783
2054	38	$2,769,793	$2,769,793	$242,455	$955,668
2055	39	$2,774,208	$2,774,208	$226,955	$929,312
Total		**$81,452,863**	**$81,452,863**	**$20,839,031**	**$43,134,520**

10.5 State of Good Repair: Annual Benefits Estimates

Calendar Year	Project Year	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings	Total State of Good Repair Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0	$0
2018	2	$0	$0	$0	$0	$0
2019	3	$0	$0	$0	$0	$0
2020	4	$0	$0	$0	$0	$0
2021	5	$0	$0	$0	$0	$0
2022	6	$0	$0	$0	$0	$0
2023	7	$0	$0	$0	$0	$0
2024	8	$0	$0	$0	$0	$0
2025	9	$0	$0	$0	$0	$0
2026	10	$0	$11,000	$11,000	$6,402	$8,684
2027	11	$0	$11,000	$11,000	$5,983	$8,431
2028	12	$0	$11,000	$11,000	$5,592	$8,185
2029	13	$0	$11,000	$11,000	$5,226	$7,947
2030	14	$0	$11,000	$11,000	$4,884	$7,715
2031	15	$0	$11,000	$11,000	$4,565	$7,490
2032	16	$0	$11,000	$11,000	$4,266	$7,272
2033	17	$0	$11,000	$11,000	$3,987	$7,060
2034	18	$0	$11,000	$11,000	$3,726	$6,855
2035	19	$0	$11,000	$11,000	$3,482	$6,655
2036	20	$0	$11,000	$11,000	$3,255	$6,461
2037	21	$0	$11,000	$11,000	$3,042	$6,273
2038	22	$0	$11,000	$11,000	$2,843	$6,090
2039	23	$0	$11,000	$11,000	$2,657	$5,913
2040	24	$0	$11,000	$11,000	$2,483	$5,741
2041	25	$0	$11,000	$11,000	$2,320	$5,574
2042	26	$0	$11,000	$11,000	$2,169	$5,411
2043	27	$0	$11,000	$11,000	$2,027	$5,254
2044	28	$0	$11,000	$11,000	$1,894	$5,101
2045	29	$0	$11,000	$11,000	$1,770	$4,952
2046	30	$0	$11,000	$11,000	$1,654	$4,808
2047	31	$0	$11,000	$11,000	$1,546	$4,668
2048	32	$0	$11,000	$11,000	$1,445	$4,532
2049	33	$0	$11,000	$11,000	$1,351	$4,400
2050	34	$0	$11,000	$11,000	$1,262	$4,272
2051	35	$0	$11,000	$11,000	$1,180	$4,147
2052	36	$0	$11,000	$11,000	$1,102	$4,026
2053	37	$0	$11,000	$11,000	$1,030	$3,909

Calendar Year	Project Year	Residual Value of Infrastructure Asset	Operations and Maintenance Cost Savings	Total State of Good Repair Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2054	38	$0	$11,000	$11,000	$963	$3,795
2055	39	$9,974,925	$11,000	$9,985,925	$816,937	$3,345,114
Total		**$9,974,925**	**$330,000**	**$10,304,925**	**$901,042**	**$3,516,736**

10.6 Economic Competitiveness: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Avoided Person Hours of Delay at Rail Crossings	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)
2017	1	0	0	0	0
2018	2	0	0	0	0
2019	3	0	0	0	0
2020	4	0	0	0	0
2021	5	0	0	0	0
2022	6	0	0	0	0
2023	7	0	0	0	0
2024	8	0	0	0	0
2025	9	0	0	0	0
2026	10	84,691	12,067	2,041	1,339
2027	11	88,852	12,660	2,141	1,404
2028	12	93,218	13,282	2,246	1,473
2029	13	97,799	13,935	2,357	1,546
2030	14	102,606	14,620	2,472	1,622
2031	15	107,651	15,338	2,594	1,701
2032	16	112,944	16,092	2,722	1,785
2033	17	118,497	16,884	2,855	1,873
2034	18	124,325	17,714	2,996	1,965
2035	19	130,441	18,585	3,143	2,062
2036	20	136,857	19,500	3,298	2,163
2037	21	143,591	20,459	3,460	2,269
2038	22	150,656	21,466	3,630	2,381
2039	23	158,070	22,522	3,809	2,498
2040	24	164,539	23,444	3,965	2,600
2041	25	166,937	23,786	4,023	2,638
2042	26	169,370	24,132	4,081	2,677
2043	27	171,838	24,484	4,141	2,716
2044	28	174,342	24,841	4,201	2,755
2045	29	176,883	25,203	4,262	2,796
2046	30	179,461	25,570	4,324	2,836
2047	31	182,076	25,943	4,387	2,878
2048	32	184,729	26,321	4,451	2,920
2049	33	187,421	26,704	4,516	2,962
2050	34	190,153	27,093	4,582	3,005
2051	35	192,924	27,488	4,649	3,049
2052	36	195,735	27,889	4,717	3,094

Calendar Year	Project Year	Avoided Person Hours of Delay at Rail Crossings	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)
2053	37	198,588	28,295	4,785	3,139
2054	38	201,482	28,708	4,855	3,184
2055	39	204,418	29,126	4,926	3,231
Total		**4,591,093**	**654,150**	**110,629**	**72,561**

10.7 Economic Competitiveness: Annual Benefit Estimates

Calendar Year	Project Year	Reduced Travel Time Costs	Reduced Vehicle Operating Costs	Total Economic Competitiveness Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0	$0
2018	2	$0	$0	$0	$0	$0
2019	3	$0	$0	$0	$0	$0
2020	4	$0	$0	$0	$0	$0
2021	5	$0	$0	$0	$0	$0
2022	6	$0	$0	$0	$0	$0
2023	7	$0	$0	$0	$0	$0
2024	8	$0	$0	$0	$0	$0
2025	9	$0	$0	$0	$0	$0
2026	10	$1,471,515	$48,966	$1,520,481	$884,934	$1,200,282
2027	11	$1,543,811	$51,605	$1,595,416	$867,801	$1,222,753
2028	12	$1,619,672	$54,864	$1,674,536	$851,249	$1,246,012
2029	13	$1,699,272	$58,117	$1,757,389	$834,923	$1,269,575
2030	14	$1,782,798	$62,208	$1,845,006	$819,205	$1,294,050
2031	15	$1,870,441	$65,945	$1,936,386	$803,532	$1,318,585
2032	16	$1,962,407	$69,704	$2,032,111	$788,088	$1,343,465
2033	17	$2,058,907	$74,242	$2,133,149	$773,151	$1,369,187
2034	18	$2,160,166	$78,579	$2,238,745	$758,340	$1,395,112
2035	19	$2,266,419	$83,176	$2,349,595	$743,822	$1,421,544
2036	20	$2,377,912	$88,127	$2,466,039	$729,612	$1,448,538
2037	21	$2,494,904	$93,065	$2,587,970	$715,595	$1,475,883
2038	22	$2,617,666	$98,457	$2,716,123	$701,898	$1,503,851
2039	23	$2,746,483	$104,223	$2,850,706	$688,483	$1,532,395
2040	24	$2,858,883	$108,606	$2,967,489	$669,801	$1,548,710
2041	25	$2,900,546	$110,901	$3,011,447	$635,255	$1,525,876
2042	26	$2,942,817	$114,048	$3,056,864	$602,650	$1,503,775

Calendar Year	Project Year	Reduced Travel Time Costs	Reduced Vehicle Operating Costs	Total Economic Competitiveness Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2043	27	$2,985,703	$116,459	$3,102,162	$571,571	$1,481,610
2044	28	$3,029,214	$119,021	$3,148,235	$542,112	$1,459,820
2045	29	$3,073,359	$122,273	$3,195,632	$514,274	$1,438,639
2046	30	$3,118,148	$124,237	$3,242,385	$487,662	$1,417,171
2047	31	$3,163,589	$127,298	$3,290,887	$462,576	$1,396,476
2048	32	$3,209,693	$130,253	$3,339,946	$438,759	$1,376,014
2049	33	$3,256,469	$132,984	$3,389,453	$416,133	$1,355,738
2050	34	$3,303,926	$135,683	$3,439,609	$394,665	$1,335,727
2051	35	$3,352,075	$137,660	$3,489,735	$374,221	$1,315,722
2052	36	$3,400,925	$139,666	$3,540,591	$354,836	$1,296,015
2053	37	$3,450,487	$141,702	$3,592,189	$336,455	$1,276,604
2054	38	$3,500,772	$143,767	$3,644,539	$319,026	$1,257,484
2055	39	$3,551,789	$145,862	$3,697,651	$302,501	$1,238,650
Total		**$79,770,770**	**$3,081,698**	**$82,852,468**	**$18,383,129**	**$41,265,263**

10.8 Environmental Sustainability: Pertinent Quantifiable Impacts (1 of 2)

Calendar Year	Project Year	Annual Emissions Avoided - CO_2 (tons)	Annual Emissions Avoided - NOx (tons)	Annual Emissions Avoided - VOC (tons)	Annual Emissions Avoided - PM (tons)	Annual Emissions Avoided - SO_2 (tons)
2017	1	0.0	0.000	0.000	0.000	0.000
2018	2	0.0	0.000	0.000	0.000	0.000
2019	3	0.0	0.000	0.000	0.000	0.000
2020	4	0.0	0.000	0.000	0.000	0.000
2021	5	0.0	0.000	0.000	0.000	0.000
2022	6	0.0	0.000	0.000	0.000	0.000
2023	7	0.0	0.000	0.000	0.000	0.000
2024	8	0.0	0.000	0.000	0.000	0.000
2025	9	0.0	0.000	0.000	0.000	0.000
2026	10	176.5	0.019	0.076	0.000	0.003
2027	11	182.2	0.019	0.079	0.000	0.003
2028	12	188.2	0.020	0.081	0.000	0.003
2029	13	194.3	0.020	0.084	0.000	0.004
2030	14	200.7	0.021	0.087	0.000	0.004
2031	15	205.7	0.026	0.107	0.001	0.004
2032	16	210.9	0.031	0.128	0.001	0.005

Calendar Year	Project Year	Annual Emissions Avoided - CO_2 (tons)	Annual Emissions Avoided - NOx (tons)	Annual Emissions Avoided - VOC (tons)	Annual Emissions Avoided - PM (tons)	Annual Emissions Avoided - SO_2 (tons)
2033	17	216.2	0.036	0.149	0.001	0.006
2034	18	221.7	0.042	0.172	0.001	0.007
2035	19	227.2	0.048	0.196	0.001	0.008
2036	20	233.0	0.049	0.201	0.001	0.008
2037	21	238.8	0.050	0.206	0.001	0.009
2038	22	244.9	0.052	0.212	0.001	0.009
2039	23	251.0	0.053	0.217	0.001	0.009
2040	24	255.3	0.054	0.221	0.001	0.009
2041	25	254.8	0.054	0.220	0.001	0.009
2042	26	254.3	0.054	0.220	0.001	0.009
2043	27	253.9	0.054	0.219	0.001	0.009
2044	28	253.4	0.053	0.219	0.001	0.009
2045	29	252.9	0.053	0.218	0.001	0.009
2046	30	252.4	0.053	0.218	0.001	0.009
2047	31	251.9	0.053	0.218	0.001	0.009
2048	32	251.4	0.053	0.217	0.001	0.009
2049	33	250.9	0.053	0.217	0.001	0.009
2050	34	250.5	0.053	0.216	0.001	0.009
2051	35	254.1	0.054	0.220	0.001	0.009
2052	36	257.8	0.054	0.223	0.001	0.009
2053	37	261.6	0.055	0.226	0.001	0.009
2054	38	265.4	0.056	0.229	0.001	0.010
2055	39	269.2	0.057	0.233	0.001	0.010
Total		**7,081**	**1.35**	**5.53**	**0.03**	**0.23**

10.9 Environmental Sustainability: Pertinent Quantifiable Impacts (2 of 2)

Calendar Year	Project Year	Avoided Vehicle-hours of Delay Time
2017	1	0
2018	2	0
2019	3	0
2020	4	0

Calendar Year	Project Year	Avoided Vehicle-hours of Delay Time
2021	5	0
2022	6	0
2023	7	0
2024	8	0
2025	9	0
2026	10	38,797
2027	11	40,704
2028	12	42,704
2029	13	44,802
2030	14	47,005
2031	15	49,315
2032	16	51,740
2033	17	54,284
2034	18	56,954
2035	19	59,756
2036	20	62,695
2037	21	65,780
2038	22	69,016
2039	23	72,413
2040	24	75,376
2041	25	76,475
2042	26	77,589
2043	27	78,720
2044	28	79,867
2045	29	81,031
2046	30	82,212
2047	31	83,410
2048	32	84,626
2049	33	85,859
2050	34	87,110
2051	35	88,380
2052	36	89,668
2053	37	90,974
2054	38	92,300
2055	39	93,645
Total		**2,103,208**

10.10 Environmental Sustainability: Annual Benefit Estimates

Calendar Year	Project Year	Avoided Emissions Costs	Total Environmental Sustainability Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2017	1	$0	$0	$0	$0
2018	2	$0	$0	$0	$0
2019	3	$0	$0	$0	$0
2020	4	$0	$0	$0	$0
2021	5	$0	$0	$0	$0
2022	6	$0	$0	$0	$0
2023	7	$0	$0	$0	$0
2024	8	$0	$0	$0	$0
2025	9	$0	$0	$0	$0
2026	10	$1,287	$1,287	$749	$1,016
2027	11	$1,336	$1,336	$727	$1,024
2028	12	$1,387	$1,387	$705	$1,032
2029	13	$1,439	$1,439	$684	$1,040
2030	14	$1,494	$1,494	$663	$1,048
2031	15	$1,852	$1,852	$769	$1,261
2032	16	$2,234	$2,234	$866	$1,477
2033	17	$2,638	$2,638	$956	$1,693
2034	18	$3,068	$3,068	$1,039	$1,912
2035	19	$3,524	$3,524	$1,116	$2,132
2036	20	$3,644	$3,644	$1,078	$2,140
2037	21	$3,768	$3,768	$1,042	$2,149
2038	22	$3,896	$3,896	$1,007	$2,157
2039	23	$4,029	$4,029	$973	$2,166
2040	24	$4,135	$4,135	$933	$2,158
2041	25	$4,154	$4,154	$876	$2,105
2042	26	$4,173	$4,173	$823	$2,053
2043	27	$4,193	$4,193	$773	$2,003
2044	28	$4,213	$4,213	$725	$1,953
2045	29	$4,233	$4,233	$681	$1,906
2046	30	$4,254	$4,254	$640	$1,859
2047	31	$4,274	$4,274	$601	$1,814

Calendar Year	Project Year	Avoided Emissions Costs	Total Environmental Sustainability Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2048	32	$4,296	$4,296	$564	$1,770
2049	33	$4,317	$4,317	$530	$1,727
2050	34	$4,339	$4,339	$498	$1,685
2051	35	$4,402	$4,402	$472	$1,660
2052	36	$4,467	$4,467	$448	$1,635
2053	37	$4,532	$4,532	$424	$1,611
2054	38	$4,598	$4,598	$402	$1,586
2055	39	$4,665	$4,665	$382	$1,563
Total		**$104,841**	**$104,841**	**$22,147**	**$51,334**

Appendix D

Pines Road/BNSF Grade Separation
Consolidated Traffic and Safety Analysis

FEHR PEERS

MEMORANDUM

Date: October 24, 2018

To: Erica Amsden, City of Spokane Valley

From: Chris Breiland, and Nathan Chan, Fehr & Peers

Subject: Pines Road/BNSF Grade Separation – Consolidated Traffic and Safety Analysis

SE17-0560

INTRODUCTION

As part of a larger effort to remove at-grade rail crossings in the Spokane region, Spokane Valley is working to grade separate the Pines Road/BNSF crossing and improve traffic and freight operations at the Pines Road/Trent Avenue intersection. In support of this project, Fehr & Peers prepared an existing conditions analysis, developed travel demand forecasts, traffic operations and safety analyses under year 2020 and 2040 conditions for multiple alternatives at the Pines Road / Trent Avenue intersection, as well as analysis under the scenario that closes the at-grade railroad crossing at University Road. This memo presents a summary of findings for four conceptual alternatives studied as part of the Pines Road/BNSF Grade Separation project.

Project Context

This project is part of a larger effort known as Bridging the Valley, which is a regional program to separate vehicle traffic from major train crossings between Spokane, WA and Athol, ID. Through these projects, Spokane Valley seeks to improve safety, provide reliable traffic and freight routes, and spur economic development and job creation.

The City of Spokane Valley is leading the effort to secure funding and study alternatives for the Pines Road/BNSF Grade Separation project, which is included in the City's 2018 Six-Year Transportation Improvement Program (TIP). The goals of this project include:

- Improving emergency vehicle access
- Improving safety and reduce delay caused by train/vehicle conflict
- Reducing noise from train horns at crossings
- Improving access to Trent Elementary and the neighborhood to the north of Trent Avenue

- Enhancing development capabilities of almost 230 acres of mixed-use commercial property

EXISTING CONDITIONS ANALYSIS

The existing conditions analysis includes an analysis of existing traffic operations and collision history in the area. Traffic analysis was performed for the following intersections:

1. Pines Road / Trent Avenue
2. University Road / Trent Avenue
3. Argonne Road / Trent Avenue
4. Argonne Road / Montgomery Avenue

Collision history was documented at the Pines Road/BNSF rail crossing and the Pines Road / Trent Avenue intersection.

Turning Movement Count Collection

Intersection turning movement counts were collected at the four study intersections mentioned previously during the AM (7-9 AM) and PM (4-6 PM) peak hours on Wednesday August 30, 2017.

BNSF Rail Operations

The Burlington Northern Santa Fe (BNSF) Railroad crosses Pines Road (SR 27) and University Road just south of Trent Avenue. The BNSF route is one of the company's main transcontinental lines between west coast ports and the interior of the country and hosts Amtrak's twice-daily Empire Builder between Chicago and Seattle/Portland. **Table 1** illustrates some basic operating characteristics for each of these at-grade crossings. Federal Railroad Administration (FRA) data indicates that the BNSF line hosts about 56 trains per day, mostly long-haul freight trains passing quickly through the area.

Historic collision data indicates that the grade crossings at University Road have operated safely over the last 40 years. However, a fatal vehicle collision occurred with a train at the Pines Road / BNSF crossing in 2001.

TABLE 1. OPERATING CHARACTERISTICS

Street Crossing	Average Trains per Day	Typical Train Frequency	Gates Down Average/Max (minutes)	Typical Train Speed	List of Collisions (1975-2016)
Pines Road	56	10-90 mins[1]	3/4.5 mins[1]	1 - 79 mph	2001 - fatality

Source: Federal Railroad Administration, 2017
1. Data was not collected at the BNSF and Pines Road railroad crossing. Results are from a similar study at the BNSF/Barker Road crossing prepared by Fehr & Peers in 2017.

Level of Service Standards

Level of service (LOS) is used to describe and evaluate traffic operations along major arterial corridors and intersections within a city. Levels range from LOS A to LOS F, which encompass a range of congestion types from uninterrupted traffic (LOS A) to highly-congested conditions (LOS F). The description and intersection delay thresholds of each LOS category are described in **Table 2.** These are based on the Highway Capacity Manual, which is the methodology used by Spokane Valley. The LOS for signalized intersections is measured by the average delay per vehicle entering the intersection from all approaches, while the LOS for unsignalized intersections is measured by the average delay per vehicle on the approach with the highest average delay.

TABLE 2. LEVEL OF SERVICE DESCRIPTION AND DELAY THRESHOLDS AT INTERSECTIONS

Level of Service	Description	Signalized Intersection Delay (seconds)	Unsignalized Intersection Delay (seconds)
A	Free-flowing conditions.	0-10	0-10
B	Stable operating conditions.	10-20	10-15
C	Stable operating conditions, but individual motorists are affected by the interaction with other motorists.	20-35	15-25
D	High density of motorists, but stable flow.	35-55	25-35
E	Near-capacity operations, with speeds reduced to a low but uniform speed.	55-80	35-50
F	Over-capacity conditions with long delays.	> 80	>50

Source: Highway Capacity Manual 2016, Transportation Research Board

The LOS standards for Spokane Valley defined in their Comprehensive Plan as follows:

- LOS D for major arterial corridors:
  - Argonne / Mullan between Trent Avenue and Appleway Boulevard.
  - Pines Road between Trent Avenue and 8th Avenue.
  - Evergreen Road between Indiana Avenue and 8th Avenue.
  - Sullivan Road between Wellesley Avenue and 8th Avenue.
  - Sprague Avenue / Appleway Boulevard between Fancher Road and Park Road.
- LOS D for signalized intersections not on major arterial corridors.
- LOS E for unsignalized intersections (LOS F is acceptable if the peak hour traffic signal warrant is not met).

WSDOT also uses LOS thresholds for State Highways and given that Trent Avenue is also State Route 290 (SR 290), intersections with Trent Avenue would need to operate at LOS D or better to meet WSDOT LOS standards for state routes in urban areas.

Existing Intersection Traffic Operations

Existing traffic conditions, including average vehicle delay and LOS, at the study area intersections are shown in **Table 3**. Detailed calculations are provided in **Attachment A**. These results were calculated with the following assumptions:

- Intersection peak hour factors (PHF) were consistent with 2017 counts
- Truck percentages consistent with 2017 counts (6% AM and 2% PM)
- Signal timing between AM and PM peak hours were consistent

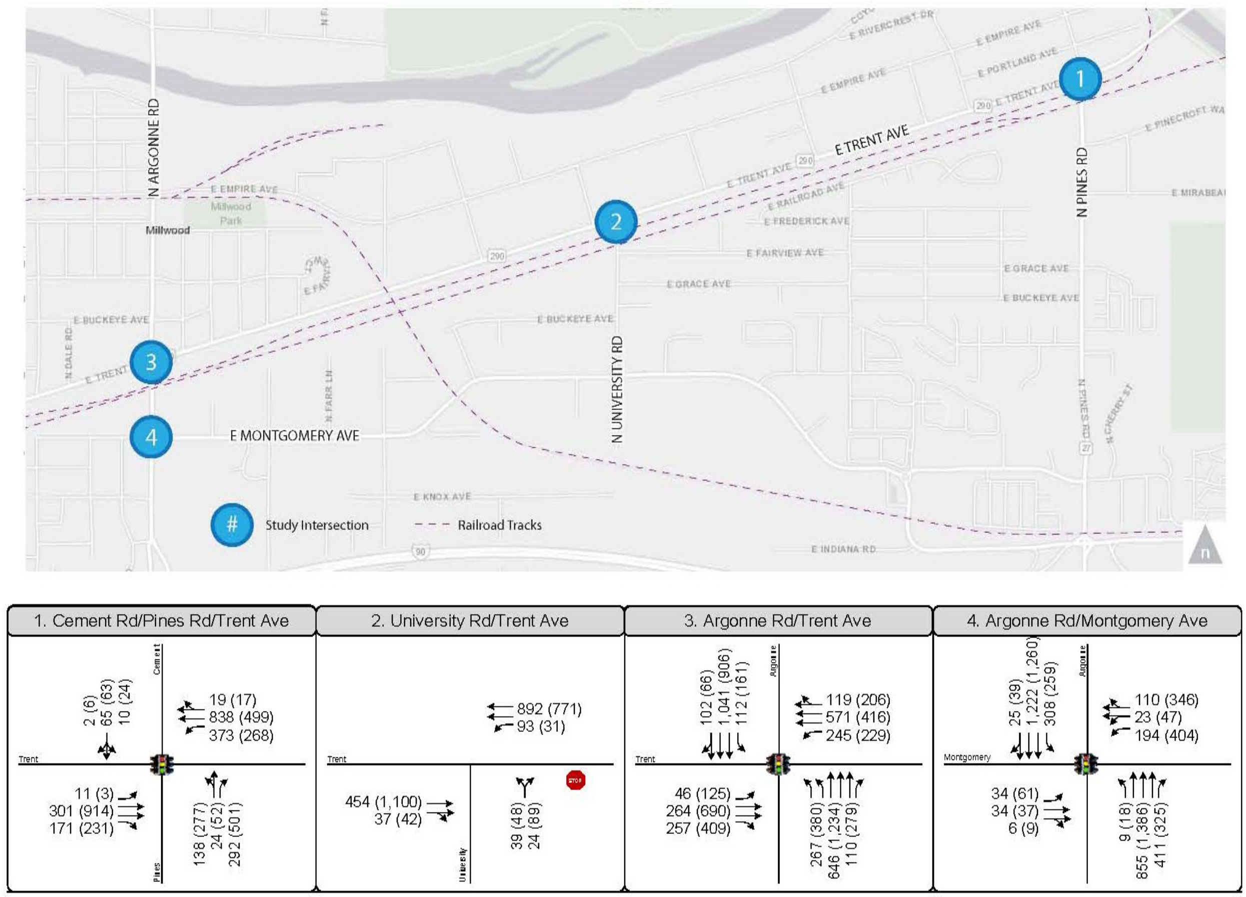
TABLE 3. 2017 EXISTING PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			Delay	LOS	Delay	LOS
1	Pines Road / Trent Avenue	Signal	26	C	47	D
2	University Road / Trent Avenue	TWSC / NB	17	C	29	D
3	Argonne Road / Trent Avenue	Signal	47	D	50	D
4	Argonne Road / Montgomery Avenue	Signal	33	C	39	D

Source: Fehr & Peers, 2017

Under existing conditions, all four intersections currently meet WSDOT and Spokane Valley LOS standards during the AM and PM peak hours. The existing lane configurations for each study intersection and peak hour turn movement counts are shown in **Figure 1.**

Figure 1. 2017 Existing Lane Configurations and AM (PM) Peak Hour Turning Movements



Pines Road / Trent Avenue Intersection Collision History

Vehicle collision history was analyzed over a five-year period from January 2012 to December 2016 at the Pines Road / Trent Avenue intersection. **Table 4** provides a summary of the collision history at the intersection by severity and whether the cause was related to the intersection. There were 59 collisions reported at or near the Pines Road / Trent Avenue intersection where 22 resulted in an injury while zero resulted in a fatality. 45 of the 59 collisions were found to be at the intersection or the cause was found to be related to the intersection. Of the 22 injury collisions, 18 were from collisions where the cause was related to the intersection.

TABLE 4. 2012-2016 COLLISION SUMMARY BY SEVERITY AT THE PINES ROAD / TRENT AVENUE INTERSECTION

Summary	All Collisions	Fatal Collisions	Injury Collisions	Intersection Related
5-year total	59	0	22	45
Average per year	11.8	0	4.4	9.0

Source: WSDOT, 2017

Table 5 provides a summary of crashes from 2012 to 2016 at the Pines Road / Trent Avenue intersection by crash type. Of the 59 total crashes over this period, about 46% resulted in a rear-end collision at the traffic light while about 31% were caused by an improper left-turn or failure to yield. While the remaining collisions had a variety of causes.

TABLE 5. 2012-2016 COLLISIONS BY TYPE AT THE PINES ROAD / TRENT AVENUE INTERSECTION

Severity	Total	Improper turn/failure to yield	Rear-end at traffic light	Railway Crossing Gate	Speeding	Pedestrian	Other
All crashes	59	18	27	3	2	1	8
Injury crashes	22	6	10	0	1	1	4

Source: WSDOT, 2017

Based on the analysis of recent collisions at this location, it is likely that a roundabout at this location would reduce the “improper left turn” and “rear-end at traffic light” collisions. The reduction in these types of collisions is based on a low-speed approach to the roundabouts, which make it easier to judge gaps in traffic and safely enter the traffic stream. The likelihood of injury crashes is also much lower at a roundabout. While roundabouts are generally shown to have lower injury/fatality collision rates, there can be more sideswipe and low-speed failure to yield collisions. Additionally, the grade separation would eliminate the issue of railway crossing gate collisions (although the railway grade crossing collisions are rare).

TRAVEL DEMAND FORECASTING

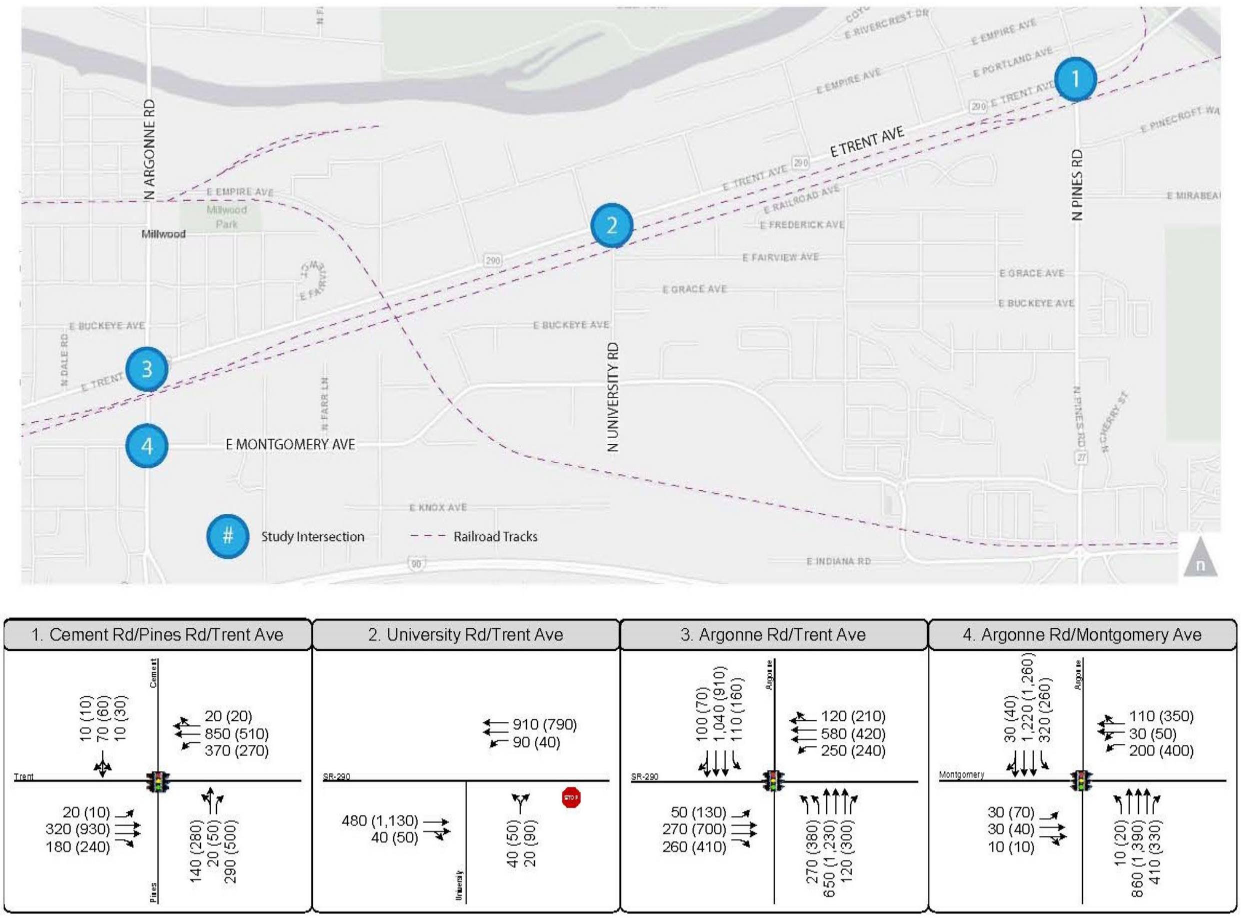
AM and PM traffic volumes at each of the study intersections were developed for 2020 and 2040 conditions.

2020 Forecasts

Volumes were forecast to year 2020 using an annual growth rate calculated using the 2017 counts and the 2040 forecasted volumes from the SRTC regional travel demand model (see next section). This growth rate was then then applied to the 2017 counts to develop the 2020 forecasts. The forecasting process for the

2040 volumes is explained in the following section. The 2020 forecasted volumes and intersection lane configurations are shown in **Figure 2.**

Figure 2. 2020 No Build Lane Configurations and AM (PM) Peak Hour Turning Movement Forecasts



2040 Forecasts

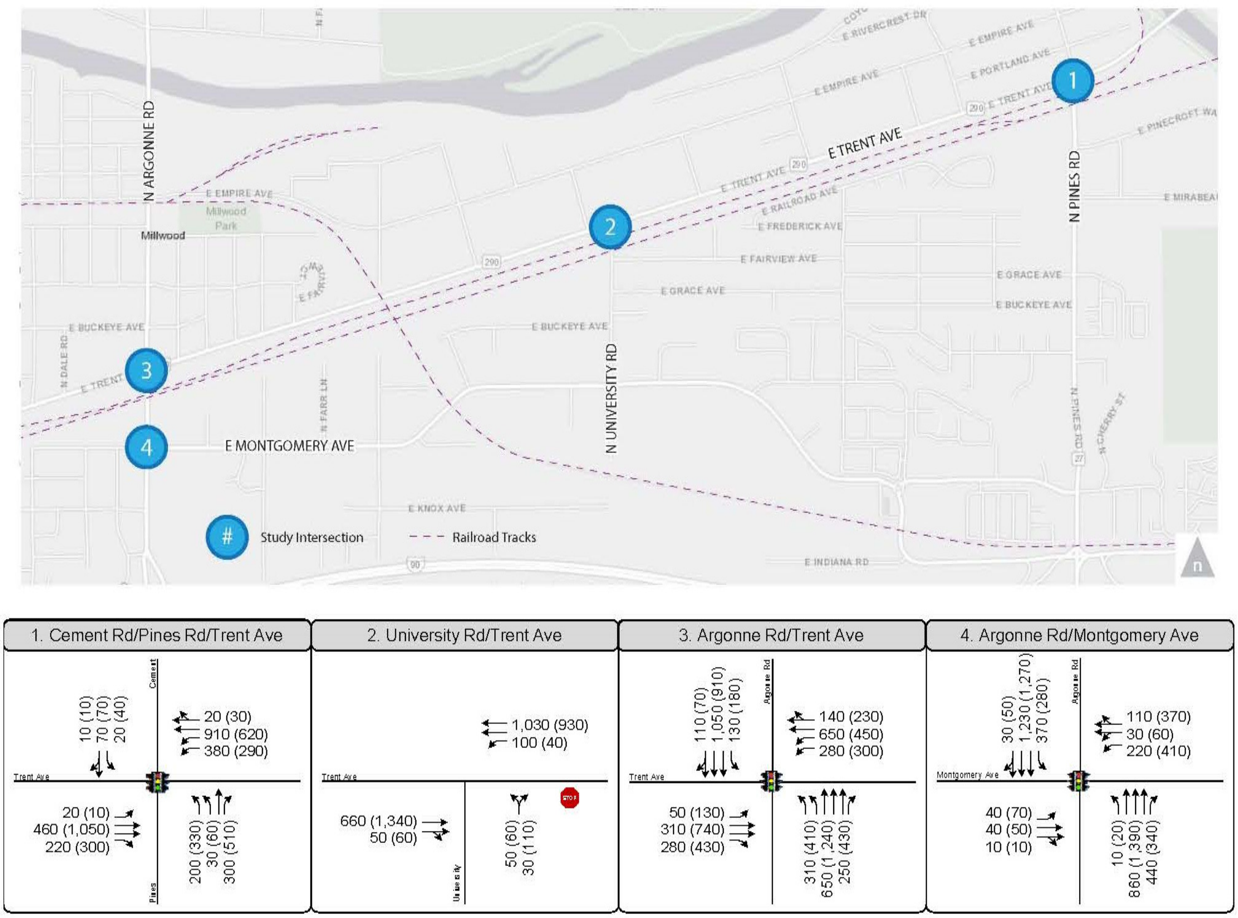
The 2040 AM and PM peak forecasts were forecasted using the SRTC regional travel demand model developed for the Horizon 2040 Regional Transportation Plan. This model was recently updated in December 2017 and it includes the regional growth forecast for Spokane Valley, Spokane County and all the surrounding jurisdictions. In addition to land use growth, there were several key transportation projects assumed in the SRTC 2040 model:

- The Barker Road/I-90 interchange would be reconfigured to a standard diamond interchange with two-lane roundabouts plus slip ramps for right-turn movements at both ramps (as reflected in I-90/Barker Rd the Interchange Justification Report)
- Barker Road between I-90 and Appleway Avenue would be widened to five lanes
- Bigelow Gulch Road would be widened to four lanes and connected to Sullivan Road

Instead of using the traffic forecasts directly from the 2040 travel demand model, 2040 AM and PM peak volumes were estimated using an industry standard approach known as the difference method. Under the difference method, the difference in traffic volumes between the 2015 and 2040 models were added to the observed counts at each of the study intersections to arrive at a 2040 forecast traffic volume. This method reduces model error by relying as much as possible on observed data rather than model output data.[1]

The 2040 forecasted volumes and lane configurations are shown in **Figure 3**.

Figure 3. 2040 No Build Lane Configurations and AM (PM) Peak Hour Intersection Turning Movement Forecasts



[1] The volume forecasts on Cement Rd show minimal growth despite increases in residential land use north of Trent Ave. The SRTC model loads these additional vehicle trips directly onto Trent Ave, bypassing Cement Rd, so these volumes do not appear in the intersection forecasts. Since the traffic volume on Cement Rd accounts for less than 5% of the total intersection volume, increasing the volume forecasts to include these additional trips would have a limited impact on the intersection operations and would not alter the conclusions of this analysis.

2020 AND 2040 ALTERNATIVES ANALYSIS

AM and PM peak hour vehicle delay and level of service (LOS) were analyzed for 2020 and 2040. There are four conceptual alternatives being studied for the Pines Road / BNSF Grade Separation Project. These four alternatives only affect the lane configuration and intersection control of the Pines Road / Trent Avenue intersection. So, the following intersections were analyzed in 2020 and 2040 under each alternative:

- No Build:
  - Pines Road / Trent Avenue
  - University Road / Trent Avenue
  - Argonne Road / Trent Avenue
  - Argonne Road / Montgomery Avenue
- Alternative 1:
  - Pines Road / Trent Avenue
- Alternative 1a (roundabout):
  - Pines Road / Trent Avenue
- Alternative 2:
  - Pines Road / Trent Avenue
- Alternative 2a (roundabout):
  - Pines Road / Trent Avenue

No Build Results

All four study intersections were analyzed under the No Build alternative which includes the following assumptions:

- 2020 intersection lane configurations and signal timings were consistent with the 2017 existing analysis
- 2040 analysis assumes consistency with the Spokane Valley Comprehensive Plan:
  - Improvements at the Pines Road / Trent Avenue intersection were assumed to be consistent with the Spokane Valley Comprehensive Plan which includes:
    - North/south split phasing changed to standard protected left turn phasing
    - Addition of a second westbound left turn pocket
    - Addition of a dedicated southbound left turn pocket
    - Reconfigured northbound approach with two left turn pockets, one through lane, and one right turn lane
  - Improvements at the Argonne Road / Trent Avenue intersection were assumed to be consistent with the Spokane Valley Comprehensive Plan which includes:
    - Restriping one westbound through lane as a dedicated left turn lane

Tables 6 and 7 show the intersection operation results for 2020 and 2040 under the No Build conditions respectively. Detailed Synchro results can be found in **Attachment B.**

TABLE 6. 2020 NO BUILD PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			Delay	LOS	Delay	LOS
1	Pines Road / Trent Avenue	Signal	28	C	50	D
2	University Road / Trent Avenue	TWSC / NB	18	C	32	D
3	Argonne Road / Trent Avenue	Signal	48	D	51	D
4	Argonne Road / Montgomery Avenue	Signal	33	C	40	D

Source: Fehr & Peers, 2018

TABLE 7. 2040 NO BUILD PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			Delay	LOS	Delay	LOS
1	Pines Road / Trent Avenue	Signal	23	C	28	C
2	University Road / Trent Avenue	TWSC / NB	24	C	**69**	**F**
3	Argonne Road / Trent Avenue	Signal	52	D	52	D
4	Argonne Road / Montgomery Avenue	Signal	37	D	43	D

Source: Fehr & Peers, 2018

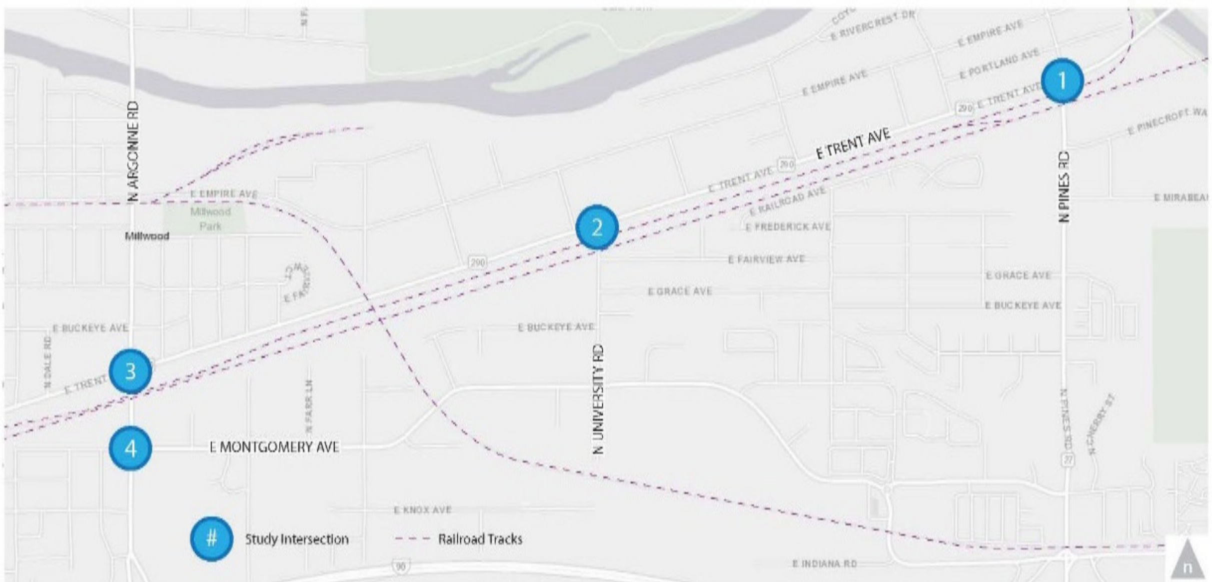
The analysis shows that under the No Build Condition, all intersections would operate at an acceptable LOS during the AM and PM peak hour in both 2020 and 2040 conditions, except for the University Road / Trent Avenue intersection. By 2040, the University Road / Trent Avenue intersection fails both the City's and WSDOT's standards during the PM peak hour.

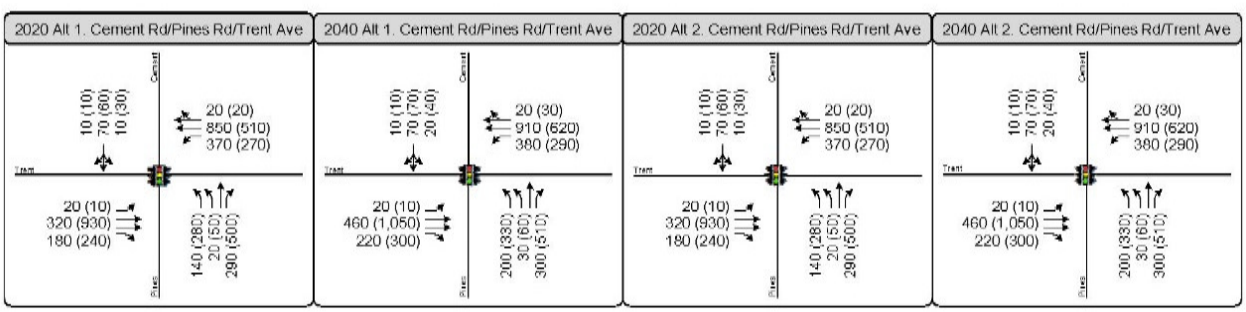
While intersection LOS standards are generally met under the No Build alternative, the delays and at-grade rail safety issues at the Pines Road / BNSF crossing are not addressed. Additionally, the queues caused by the Pines Road / Trent Avenue signal are expected to grow in the future as regional traffic volumes increase. The northbound queues at this intersection will extend back across the railroad tracks, increasing the potential for vehicle/train conflicts.

Grade Separation Alternative Results

The Pines Road / Trent Avenue intersection was evaluated under the following four BNSF grade separation alternatives. Note that a reconstruction of the Pines Road / Trent Avenue intersection is required for the grade separation to be able to depress the roadway under the railroad tracks. For roundabout alternatives (1a and 2a), forecasted traffic volumes in 2040 two eastbound and westbound lanes for the roundabouts. Conceptual drawings of the alternatives are provided in **Attachment C.** 2020 and 2040 lane configurations and turning movement forecasts are provided in **Figure 4.**

Figure 4. 2020 and 2040 Alternatives Lane Configuration and AM (PM) Peak Hour Turning Movement Forecasts





Alternative 1:

The analysis included the following additional assumptions not clearly shown in the conceptual drawings:

- There is one eastbound and westbound left-turn lane (same geometry as the No Build conditions)
- The eastbound right-turn has the same geometry as the No Build conditions
- The northbound movement has two left-turn lanes with one pocket of 150 feet and one trap lane
- The southbound approach is a single shared lane

Alternative 1a (roundabout):

This alternative was analyzed using the Sidra software (version 6.1) using the settings consistent with WSDOT's Sidra Policy Settings published in November 2015. The lane configurations were assumed to follow those in the conceptual drawings. In this case, the assumed speed on Pines Road approaching the intersection is 35 miles per hour and 25 miles per hour on Cement Road approaching the intersection. The circulating speed within the roundabout is assumed to be 15-20 miles per hour.

Alternative 2:

This analysis for this alternative includes the following assumptions in conjunction with the conceptual drawings:

- There is one eastbound left-turn lane with the same geometry as the No Build conditions
- The eastbound right-turn has the same geometry as the No Build Scenario
- There are two westbound left-turn pockets with a storage length of 175 feet
- The northbound movement has two left-turn lanes with one pocket of 150 feet and one trap lane
- The northbound movement also has one right-turn pocket of approximately 150 feet
- The southbound approach is a single shared lane

Alternative 2a (roundabout):

The lane configuration is the same as that of Alternative 1a; however, given the additional curvature of the northbound approach, the assumed speed on Pines Road approaching the intersection was decreased to 15 miles per hour.

Tables 8 and 9 show the operation analysis results for the Pines Road / Trent Avenue intersection under each alternative including the No Build for 2020 and 2040 respectively. Detailed operation results can be found in **Attachment D.**

TABLE 8. 2020 NO BUILD AND ALTERNATIVES PEAK HOUR INTERSECTION OPERATIONS

Pines Rd / Trent Ave	Control	AM Peak Hour	PM Peak Hour
		Delay / LOS	Delay / LOS
No Build	Signal	28 / C	47 / D
Alternative 1	Signal	27 / C	42 / D
Alternative 1a	Roundabout	8 / A	9 / A
Alternative 2	Signal	24 / C	32 / C
Alternative 2a	Roundabout	7 / A	7 / A

Source: Fehr & Peers, 2018

TABLE 9. 2040 NO BUILD AND ALTERNATIVES PEAK HOUR INTERSECTION OPERATIONS

Pines Rd / Trent Ave	Control	AM Peak Hour	PM Peak Hour
		Delay / LOS	Delay / LOS
No Build	Signal	23 / C	28 / C
Alternative 1	Signal	28 / C	41 / D
Alternative 1a	Roundabout	9 / A	9 / A
Alternative 2	Signal	26 / C	32 / C
Alternative 2a	Roundabout	8 / A	8 / A

Source: Fehr & Peers, 2018

In the 2020 and 2040 scenarios, both alternatives meet the City and WSDOT LOS standard. In both the AM and PM peak hour, Alternative 2 performs better than Alternative 1 in terms of delay and LOS. Similarly, the roundabout alternative (Alternative 2a) operates at an even better LOS than Alternative 2.

It is worth noting that while the intersection operations for Alternatives 2 and 2a might be slightly better than 1 and 1a, the sharp curve south of the Pines Road / Trent Avenue intersection is unusual for an arterial road and the lower speed required to negotiate this curve will negate much of the intersection operations improvements, particularly for the roundabout alternative. Additional discussion about the disadvantages of this sharp curve are included in the conclusions section.

These results show slightly more delay for Alternative 1 and 2 when compared with the No Build due to the difference in lane geometry at the southbound approach. In all Alternatives, the southbound approach consists of a shared right, through, and left movement whereas the No Build includes a separate left turn pocket. If the Alternatives included this separate left turn pocket, the operations are anticipated to be similar to the No Build alternative. For example, the Alternative 2 PM peak hour would improve to have a delay of 32 seconds with a LOS C.

In addition to improving the operations at the intersection, roundabouts also help manage queuing in the system. Alternative 1 experiences long queuing for vehicles traveling in the eastbound and westbound directions in the 2020 PM and 2040 PM peak hours. In the eastbound direction, queues are anticipated to spill back to the previous intersection and in the westbound direction queues are anticipated to spill back onto the bridge over the Spokane River. Alternative 2 experiences long queuing in the eastbound directions during the 2020 PM and 2040 PM peak hours and in the westbound direction in the 2040 AM and PM peak hours. In the 2040 PM peak hour, both Alternative 1 and 2 experience long queuing for vehicles traveling in the northbound direction where queues are expected to spill back to the bridge under railroad tracks.

2020 AND 2040 SAFETY ANALYSIS

A safety analysis was conducted to predict average intersection collision frequency in 2020 and 2040 at the Pines Road / Trent Avenue intersection under each Alternative along based on the Highway Safety Manual (HSM) predictive method. The following scenarios were analyzed:

- No Build scenario
- Alternative 1 with a signal
- Alternative 1 with a roundabout
- Alternative 2 with a signal
- Alternative 2 with a roundabout

Methodology

We used WSDOT's spreadsheet tool for urban and suburban arterials to automate the HSM Predictive analysis[2] (see http://www.wsdot.wa.gov/Design/Support.htm). The WSDOT disclaimer should be noted as it relates to the results when using this tool.[3] The tool, which is based on the HSM predictive method, includes several inputs to predict average annual crashes by type, including:

- Intersection control type (signal or stop)
- Number of legs on intersection

[2] Safety Analysis Guide. Washington State Department of Transportation, September 2017. Pg 16.

[3] Under 23 U.S. Code § 148 and 23 U.S. Code § 409, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

- Average Annual Daily Traffic entering intersection
- Presence of lighting
- Calibration factor
- Number of approaches with left-turn and right-turn lanes
- Left-turn signal phasing (permissive, protected or permissive/protected)
- Pedestrian crossing volume
- Lanes crossed by a pedestrian
- Collision history (not applicable to multiyear forecasts)
- Presence of red-light cameras
- Right-turn on red restrictions
- Number of bus stops within 1,000 feet of the intersection
- Schools within 1,000 feet of the intersection
- Alcohol sales establishments within 1,000 feet of the intersection

For the above inputs, many variables were assumed to be consistent under all 2020 and 2040 scenarios, including:

- Lighting would be present;
- The calibration factor was set to 1 (default);
- No red-light cameras would be present;
- Right-turn on red would be allowed (under scenarios that assume signals);
- No public transit bus stops would be within 1,000 feet of the intersection;
- The Trent Elementary school would be within 1,000 feet of the intersection;
- Two alcohol establishments would be within 1,000 feet of the intersection (Dos Amigos and Valley Bar and Grill)

Intersection Type

The spreadsheet tool includes a stop control and signal control option but does not include a roundabout option. Therefore, a signal was assumed for all intersections and predicted collisions for intersections with a roundabout were adjusted from the predictions with a signal based on research provided by WSDOT and other sources (see description below).

Reduction in Collisions from Roundabouts

WSDOT references studies by the Institute for Highway Safety and Federal Highway Administration that have shown that roundabouts are safer than signals.[4] Based on those studies as compared to other control types, roundabouts typically achieve:

- A 37 percent reduction in overall collisions

[4] https://www.wsdot.wa.gov/Safety/roundabouts/benefits.htm

- A 75 percent reduction in injury collisions
- A 90 percent reduction in fatality collisions
- A 40 percent reduction in pedestrian collisions

The reduction in collisions can be attributed to lower travel speeds (typically 15-20 mph) through the intersection, eliminating the temptation to "beat the light" (all drivers must slow down), and the one-way travel pattern which reduces the likelihood of T-bone and head-on collisions.

To be consistent with WSDOT data sources, the methodology used to predict collisions with a roundabout is based on a 75% reduction in injury collisions and 37% reduction in all collisions from what would be predicted with a signal.

Average Annual Daily Traffic Forecasts

Average annual daily traffic (AADT) was forecast for the year 2020 for each approach to each intersection by applying an annual growth rate to the most recent observed daily count. The annual growth rate was calculated from the most recent observed count and the 2040 forecasted AADT from the SRTC model. Traffic volumes in 2020 were assumed to be the same under both alternatives as well as the No Build Scenario. Under Alternative 2, the north leg would tie into E Portland Avenue instead of Cement Road. Given that these are both low volume streets that provide local access to the same general area, the volumes were assumed to be the same as Alternative 1 and the No Build Scenario.

Average annual daily traffic (AADT) was forecast for the year 2040 for each approach to the intersection using the SRTC travel demand model developed to support the Horizon 2040 plan. One model run was used for 2040 forecasts under both alternatives, including the No Build Scenario. To develop forecasts, the difference method was used whereby the growth in daily traffic for each segment between the 2015 model and 2040 model was added to the existing (most recent) observed daily traffic counts as reported by City of Spokane Valley[5]. This method reduces the likelihood of model error. The 2020 and 2040 AADT outcomes using the methodologies described here are summarized in **Table 10**.

[5] http://www.spokanevalley.org/Traffic (see "Most Recent ADT")

TABLE 10: 2020 AND 2040 AADT BY APPROACH FOR EACH ALTERNATIVE

Alternative	Intersection	EB	WB	NB	SB
2020 AADT					
No Build / Alternative 1 / Alternative 2	Pines Road / Trent Avenue	11,500	13,600	8,100	800
2040 AADT					
No Build / Alternative 1 / Alternative 2	Pines Road / Trent Avenue	13,500	15,200	8,400	840

Source: WSDOT, 2018

Lane Configurations

The number of turn lanes at each intersection under each alternative as well as the maximum number of lanes a pedestrian would have to cross was based on the conceptual drawings provided in **Attachment C** and were shown previously in **Figure 4**.

Under both alternatives and the No Build Scenario, right-turn only lanes are included in the eastbound and northbound approaches, as well as two northbound left-turn lanes and one eastbound left-turn lane. Under Alternative 1 there would be one westbound left-turn lane, while under Alternative 2 and the No Build Scenario there would be two westbound left-turn lanes. Under the No Build Scenario there would be a southbound left-turn pocket, which is not assumed in Alternative 1 and 2.

Left-Turn Signal Phasing

Under Alternative 1 and 2 all left-turns would have a protected signal phasing, except for the southbound left, which would be permissive. The southbound approach is a low-volume movement that primarily provides access to the adjacent businesses. Under the No Build Scenario all left-turns would have a protected signal phase.

Pedestrian Crossing Volumes

Two-hour pedestrian counts across all four legs of the existing Pines Road / Trent Avenue intersection were collected on a weekday in August 2017 in both the AM peak period (7 AM – 9 AM) and the PM peak period (4 PM – 6 PM). The combined total pedestrian crossings during these four hours was 22. Using calibration factors from the National Bicycle and Pedestrian Documentation Project (which estimates about 20% of daily pedestrian activity occurs during these four hours), it was estimated that there are about 110 daily pedestrian crossings at the Pines Road / Trent Avenue intersection.

A 2% annual growth rate was assumed for pedestrian volumes crossing the Pines Road/Trent Avenue intersection. Therefore, it was assumed that by 2020 there would be about 120 daily pedestrian crossings at this intersection.

Data from the SRTC travel demand model shows that within the three transportation analysis zones surrounding this intersection the number of households will grow by about 125% and the number of employees will grow by about 260% between 2015 and 2040. Based on these localized growth forecasts it was assumed that pedestrian volumes would increase by about 200% between now and 2040. Therefore, it was estimated that by 2040 there would be about 330 daily pedestrian crossings of the Pines Road / Trent Avenue intersection.

Safety Analysis Findings

Using the methodology described in the previous section, Table **11** shows the average predicted crashes per year by 2040 at the Pines Road / Cement Road / Trent Avenue intersection under Alternative 1, both with a signal and with a roundabout. The findings illustrate that the Pines Road intersection is predicted to have a higher average number of injury crashes per year with a signal than with a roundabout. The results would be predicted to be similarly higher if a signal as opposed to a roundabout were assumed under the other alternatives.

TABLE 11. PREDICTED AVERAGE COLLISIONS PER YEAR BY ALTERNATIVE AT PINES ROAD / TRENT AVENUE

Intersection	Intersection Control	Predicted average collisions per year	Fatal & injury collisions per year	PDO crashes per year
Year 2020				
Alternative 1	Signal	3.9	1.4	2.5
Alternative 1a	Roundabout	2.4	0.4	2.2
Alternative 2	Signal	3.9	1.4	2.5
Alternative 2a	Roundabout	2.4	0.4	2.2
No Build	Signal	3.3	1.2	2.1
Year 2040				
Alternative 1	Signal	4.5	1.6	2.9
Alternative 1a	Roundabout	2.8	0.4	2.5
Alternative 2	Signal	4.5	1.6	2.9
Alternative 2a	Roundabout	2.8	0.4	2.5
No Build	Signal	3.9	1.4	2.5

Source: Fehr & Peers, 2017

The No Build Scenario is predicted to have slightly fewer injury crashes per year (in both 2020 and 2040) than both Alternatives 1 and 2 with a signal. This finding is primarily because the No Build Scenario assumes a separate left-turn pocket with protected left-turn signal phasing for southbound movements, while Alternative 1 and 2 do not. However, the No Build scenario is predicted to have about one more fatal and injury crash per year on average (in both 2020 and 2040) than Alternatives 1 and 2 with a roundabout.

UNIVERSITY ROAD CLOSURE SCENARIO

When evaluating the grade separation of Pines Road at the BNSF mainline, Spokane Valley, SRTC, and BNSF have also considered the benefits and consequences of closing the University Road crossing of the tracks. As part of this study, Fehr & Peers analyzed the effects of closing the at-grade railroad crossing at University Road and examined rerouted travel demand as well as intersection operations at the remaining three study intersections for the 2020 and 2040 AM and PM peak hour.

Using the SRTC regional travel demand model, traffic volumes were rerouted from the University Road / Trent Avenue intersection to adjacent intersections based on model travel patterns. **Figures 5 and 6** present the trip distribution results of closing University Road. Approximately 200 vehicles were rerouted in the 2020 scenarios and approximately 300 were rerouted in the 2040 scenarios.

Figure 5. University Road Closure – Trip Distribution (In)

Figure 6. University Road Closure – Trip Distribution (Out)

Approximately 90% of trips turning onto Trent Avenue from University Road were assumed to travel either eastbound or westbound along Trent Avenue past the adjacent study intersections.

For vehicles heading in the eastbound direction, it is assumed that approximately 50% of those vehicles are expected to reroute to Pines Road via Montgomery Avenue. The remaining 50% are expected to use other residential streets to reach Pines Road.

The rerouted vehicles were assigned to the volume forecasts at the three remaining study intersections and the intersection operations were analyzed for the 2020 and 2040 scenarios. At the Argonne Road / Trent Avenue intersection in 2040, the westbound approach is only assumed to have two through lanes (as opposed to three in the 2020 scenario).

Figures 7 and 8 show the updated traffic volume forecasts for 2020 and 2040 after the University Road closure.

Figure 7. 2020 University Road Closure Lane Configuration and AM (PM) Peak Hour Turning Movement Forecasts

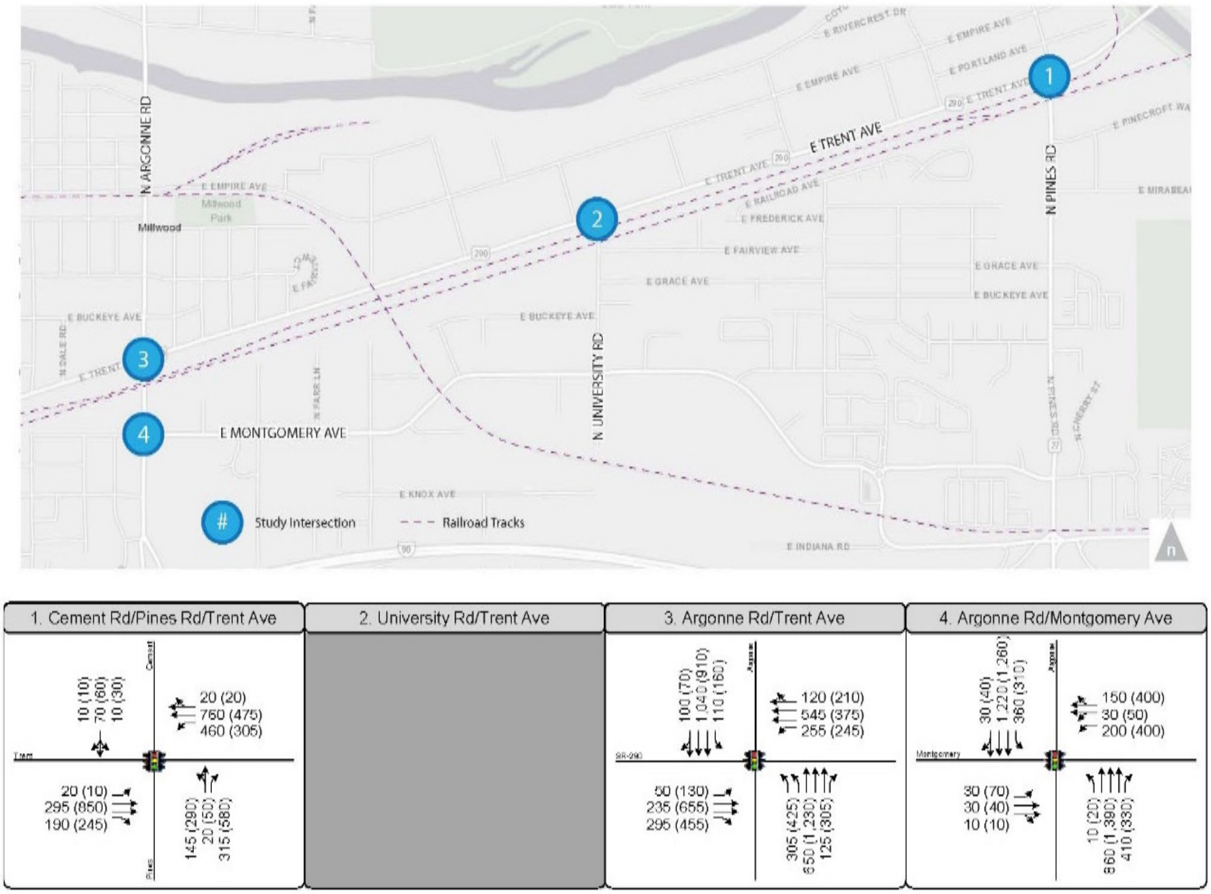
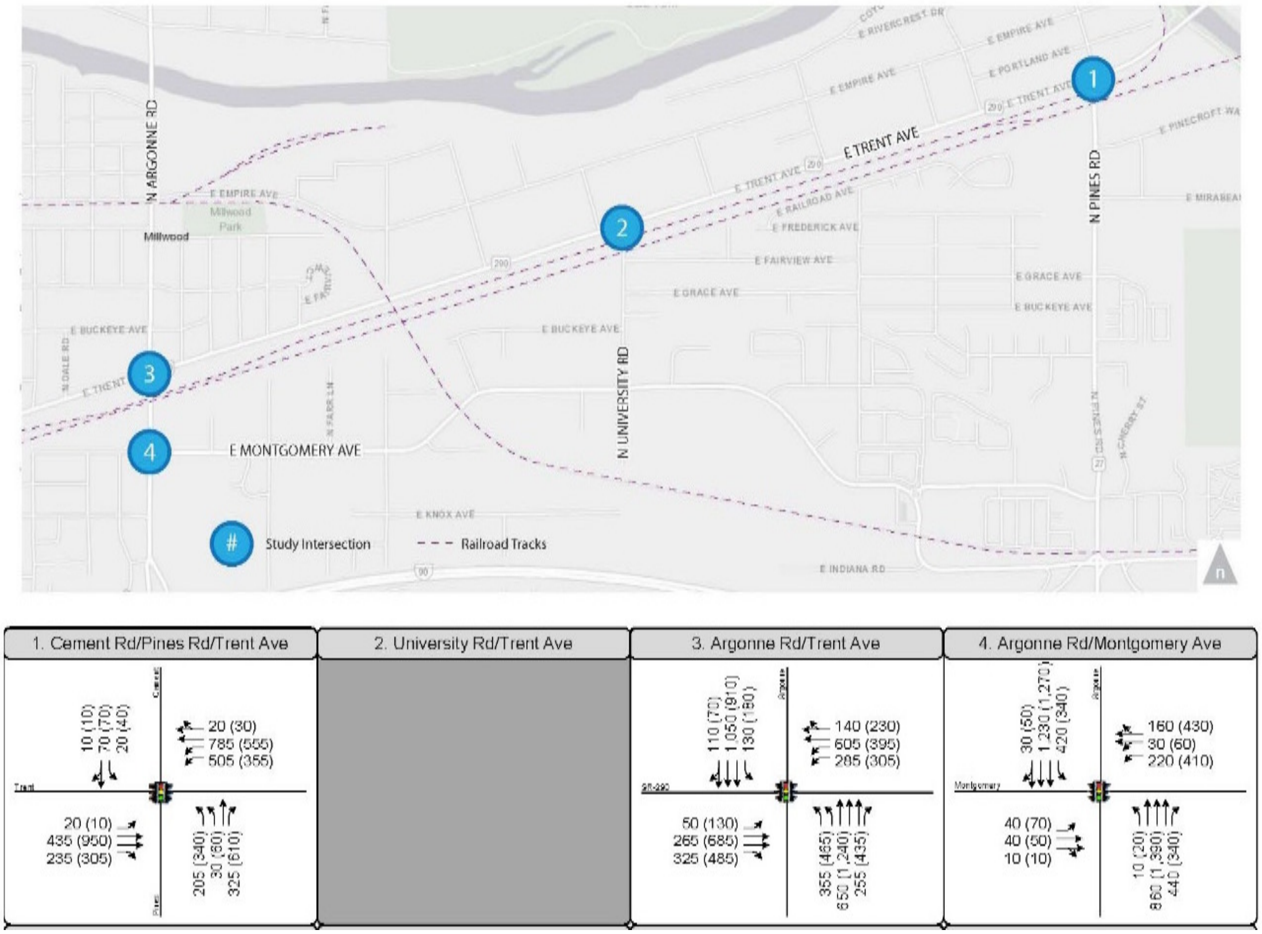


Figure 8. 2040 University Road Closure Lane Configuration and AM (PM) Peak Hour Turning Movement Forecasts



The delay and LOS results for the 2020 and 2040 University Road closure scenario are shown in **Tables 12 and 13** below and can also be found in **Attachment E**:

TABLE 12. 2020 NO BUILD AND UNIVERSITY CLOSURE PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			No Build Delay / LOS	Closure Delay / LOS	No Build Delay / LOS	Closure Delay / LOS
1	Pines Road / Trent Avenue	Signal	28 / C	33 / C	50 / D	53 / D
2	University Road / Trent Avenue	TWSC / NB	18 / C		32 / D	
3	Argonne Road / Trent Avenue	Signal	48 / D	48 / D	51 / D	51 / D
4	Argonne Road / Montgomery Avenue	Signal	33 / C	34 / C	40 / D	44 / D

Source: Fehr & Peers, 2017

TABLE 13. 2040 COMPREHENSIVE PLAN AND UNIVERSITY CLOSURE PEAK HOUR INTERSECTION OPERATIONS

ID	Intersection	Control / Approach	AM Peak Hour		PM Peak Hour	
			No Build Delay / LOS	Closure Delay / LOS	No Build Delay / LOS	Closure Delay / LOS
1	Pines Road / Trent Avenue	Signal	23 / C	24 / C	28 / C	31 / C
2	University Road / Trent Avenue	TWSC / NB	24 / C		**69 / F**	
3	Argonne Road / Trent Avenue	Signal	52 / D	52 / D	52 / D	52 / D
4	Argonne Road / Montgomery Avenue	Signal	37 / D	39 / D	43 / D	51 / D

Source: Fehr & Peers, 2017

In 2020 and 2040, all intersections meet the City and WSDOT LOS standards with the closure of the University Road / BNSF crossing. While the results indicate that the University Road / BNSF crossing could be closed without resulting in any LOS impacts, and would in fact eliminate the LOS F condition at University Road/Trent Avenue,[6] consideration must be given to the drivers that would need to reroute to find an alternative route to Trent Avenue. Unlike some other areas in Spokane Valley, the residential area around the University Road/BNSF crossing is not well connected to the surrounding street grid. The UPRR tracks

[6] There are other options available to improve the LOS at this intersection including widening to include separate left and right northbound turn lanes or restricting access to be right in/out only. Additional study would be required to determine the best course of action to improve LOS.

significantly limit access to the west and south and hilly terrain limits access to the west. It is worth noting that the University Road /BNSF crossing is one of the few quiet zone crossings in the Valley. Quiet zones have enhanced safety systems at the grade crossings, which allow trains to pass without blowing their whistles.

Given the factors described above, the fact that there has not been a train/vehicle collision at this crossing in more than 40 years, and the low current and forecasted volumes (Pines Road has nearly six times the PM peak hour volume as University Road), we recommend that the University Road/BNSF crossing be maintained.

SUMMARY OF FINDINGS

Based on the analysis of the different alternatives, each concept offers different advantages and disadvantages as they relate to mobility, traffic flow, delay and safety. Under Alternatives 1 and 2, traffic operations at the redesigned Pines Road / Trent Avenue intersection show similar traffic operations and safety results when comparing the two alternatives. Overall, the roundabout alternatives perform better than the signals with respect to LOS, queuing, and safety, although the traffic signal options would still meet LOS thresholds and perform similarly to many other signalized arterial intersections in Spokane Valley and around the state.

Alternatives 2 and 2a include an intersection geometry that consists of a sharp 90 degree turn in the northbound approach to enter the intersection. This configuration can cause potential issues with truck and freight operations entering the intersection from the south as trucks may be slow in navigating the sharp turn and oversize loads may track into adjacent lanes. This configuration also presents a potential safety issue given the sharp curve as drivers would enter the curve and have limited visibility of the rest of the intersection and of the vehicles queued at the intersection. These potential visibility issues could be addressed with signage/flashing beacons/variable message signs, but these elements add cost and complexity to the project and are unnecessary for Alternatives 1 and 1a. Overall, the configuration for Alternatives 2 and 2a is unusual, which may catch unfamiliar drivers off-guard.

Since all four Alternatives only affect the Pines Road / Trent Avenue intersection, no operational issues other than those shown under the No Build condition are expected for the other study intersections.

Given that the Pines Road / Trent Avenue intersection would have the capacity to serve increased demand due to the University Road closure, the Alternatives are also expected to operate similarly in 2020 and 2040 even if University Road was closed. However, given the limited connectivity to the neighborhood around the University Road / BNSF crossing, along with the relatively low volumes of traffic and existing safety enhancements at this crossing, we recommend that the University Road grade crossing remain open.

ATTACHMENT A: 2017 EXISTING CONDITIONS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	11	301	171	373	838	19	138	24	292	10	65	2
Future Volume (veh/h)	11	301	171	373	838	19	138	24	292	10	65	2
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1700	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	12	342	0	424	952	22	157	27	162	11	74	2
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	22	593	265	475	1495	35	206	35	214	14	94	3
Arrive On Green	0.01	0.19	0.00	0.31	0.49	0.49	0.16	0.16	0.16	0.07	0.07	0.07
Sat Flow, veh/h	1527	3047	1363	1527	3045	70	1312	226	1363	201	1350	36
Grp Volume(v), veh/h	12	342	0	424	476	498	184	0	162	87	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1591	1538	0	1363	1587	0	0
Q Serve(g_s), s	0.6	8.2	0.0	21.3	18.6	18.6	9.2	0.0	9.1	4.3	0.0	0.0
Cycle Q Clear(g_c), s	0.6	8.2	0.0	21.3	18.6	18.6	9.2	0.0	9.1	4.3	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.04	0.85		1.00	0.13		0.02
Lane Grp Cap(c), veh/h	22	593	265	475	748	781	241	0	214	111	0	0
V/C Ratio(X)	0.54	0.58	0.00	0.89	0.64	0.64	0.76	0.00	0.76	0.78	0.00	0.00
Avail Cap(c_a), veh/h	114	1176	526	1331	1802	1882	651	0	577	464	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	39.3	29.4	0.0	26.4	15.1	15.1	32.4	0.0	32.4	36.8	0.0	0.0
Incr Delay (d2), s/veh	18.6	0.9	0.0	6.0	0.9	0.9	5.0	0.0	5.4	11.4	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	3.5	0.0	9.7	8.0	8.3	4.2	0.0	3.7	2.2	0.0	0.0
LnGrp Delay(d),s/veh	57.9	30.2	0.0	32.4	16.0	16.0	37.4	0.0	37.8	48.1	0.0	0.0
LnGrp LOS	E	C		C	B	B	D		D	D		
Approach Vol, veh/h		354			1398			346			87	
Approach Delay, s/veh		31.2			21.0			37.6			48.1	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.2	45.4		17.6	31.0	21.6		10.1
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	2.6	20.6		11.2	23.3	10.2		6.3
Green Ext Time (p_c), s	0.0	6.1		1.4	1.7	5.4		0.2

Intersection Summary	
HCM 2010 Ctrl Delay	26.4
HCM 2010 LOS	C

Intersection	
Int Delay, s/veh	1.3

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	454	37	93	892	39	24
Future Vol, veh/h	454	37	93	892	39	24
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	91	91	91	91	91	91
Heavy Vehicles, %	6	6	6	6	6	6
Mvmt Flow	499	41	102	980	43	26

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	540	0	1214	270
Stage 1	-	-	-	-	519	-
Stage 2	-	-	-	-	695	-
Critical Hdwy	-	-	4.22	-	6.92	7.02
Critical Hdwy Stg 1	-	-	-	-	5.92	-
Critical Hdwy Stg 2	-	-	-	-	5.92	-
Follow-up Hdwy	-	-	2.26	-	3.56	3.36
Pot Cap-1 Maneuver	-	-	997	-	168	716
Stage 1	-	-	-	-	551	-
Stage 2	-	-	-	-	446	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	997	-	151	716
Mov Cap-2 Maneuver	-	-	-	-	278	-
Stage 1	-	-	-	-	551	-
Stage 2	-	-	-	-	400	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	17.3
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	362	-	-	997	-
HCM Lane V/C Ratio	0.191	-	-	0.103	-
HCM Control Delay (s)	17.3	-	-	9	-
HCM Lane LOS	C	-	-	A	-
HCM 95th %tile Q(veh)	0.7	-	-	0.3	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	46	264	257	245	571	119	267	646	110	112	1041	102
Future Volume (vph)	46	264	257	245	571	119	267	646	110	112	1041	102
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	1456	4077		2825	4185	1303	1456	4129	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	1456	4077		2825	4185	1303	1456	4129	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	50	287	279	266	621	129	290	702	120	122	1132	111
RTOR Reduction (vph)	0	0	67	0	21	0	0	0	39	0	7	0
Lane Group Flow (vph)	50	287	212	266	729	0	290	702	81	122	1236	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.0	15.8	37.3	28.4	36.2		21.5	68.1	96.5	16.7	58.3	
Effective Green, g (s)	10.5	18.3	44.8	30.9	38.7		25.5	70.1	101.5	18.7	60.3	
Actuated g/C Ratio	0.07	0.12	0.30	0.21	0.26		0.17	0.47	0.68	0.12	0.40	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	101	355	389	299	1051		480	1955	881	181	1659	
v/s Ratio Prot	0.03	c0.10	0.10	c0.18	0.18		c0.10	0.17	0.02	c0.08	c0.30	
v/s Ratio Perm			0.07						0.04			
v/c Ratio	0.50	0.81	0.55	0.89	0.69		0.60	0.36	0.09	0.67	0.74	
Uniform Delay, d1	67.2	64.1	44.1	57.9	50.3		57.6	25.6	8.4	62.7	38.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.90	0.20	0.19	1.00	1.00	
Incremental Delay, d2	3.8	12.7	1.6	25.8	2.0		1.5	0.4	0.0	9.5	1.9	
Delay (s)	71.0	76.8	45.6	83.7	52.3		111.0	5.5	1.7	72.2	40.1	
Level of Service	E	E	D	F	D		F	A	A	E	D	
Approach Delay (s)		62.2			60.5			32.6			43.0	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	47.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	72.8%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	34	34	6	194	23	110	9	855	411	308	1222	25
Future Volume (vph)	34	34	6	194	23	110	9	855	411	308	1222	25
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.98		1.00	0.92		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2845		1325	2528		1456	4185	1303	1456	4173	
Flt Permitted	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2845		1325	2528		1456	4185	1303	1456	4173	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	38	38	7	218	26	124	10	961	462	346	1373	28
RTOR Reduction (vph)	0	7	0	0	103	0	0	0	271	0	1	0
Lane Group Flow (vph)	38	38	0	126	139	0	10	961	191	346	1400	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.5	7.5		23.1	23.1		1.2	45.0	45.0	54.4	98.2	
Effective Green, g (s)	10.0	10.0		25.6	25.6		2.2	47.0	46.0	55.4	100.2	
Actuated g/C Ratio	0.07	0.07		0.17	0.17		0.01	0.31	0.31	0.37	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	97	189		226	431		21	1311	399	537	2787	
v/s Ratio Prot	c0.03	0.01		c0.10	0.06		0.01	c0.23		c0.24	0.34	
v/s Ratio Perm									0.15			
v/c Ratio	0.39	0.20		0.56	0.32		0.48	0.73	0.48	0.64	0.50	
Uniform Delay, d1	67.1	66.2		57.0	54.6		73.3	45.9	42.3	39.1	12.4	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.75	0.63	
Incremental Delay, d2	2.6	0.5		9.6	2.0		16.0	3.7	4.1	4.3	0.5	
Delay (s)	69.7	66.8		66.6	56.6		89.4	49.6	46.3	33.7	8.3	
Level of Service	E	E		E	E		F	D	D	C	A	
Approach Delay (s)		68.1			60.0			48.8			13.4	
Approach LOS		E			E			D			B	

Intersection Summary			
HCM 2000 Control Delay	33.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.6%	ICU Level of Service	B
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	3	914	231	268	499	17	277	52	501	24	63	6
Future Volume (veh/h)	3	914	231	268	499	17	277	52	501	24	63	6
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1700	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	3	933	0	273	509	17	283	53	256	24	64	6
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	6	1034	471	302	1592	53	314	59	330	30	80	8
Arrive On Green	0.00	0.33	0.00	0.19	0.52	0.52	0.23	0.23	0.23	0.07	0.07	0.07
Sat Flow, veh/h	1587	3106	1417	1587	3069	102	1347	252	1417	416	1108	104
Grp Volume(v), veh/h	3	933	0	273	257	269	336	0	256	94	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1618	1599	0	1417	1628	0	0
Q Serve(g_s), s	0.2	35.9	0.0	21.1	12.0	12.0	25.5	0.0	21.2	7.1	0.0	0.0
Cycle Q Clear(g_c), s	0.2	35.9	0.0	21.1	12.0	12.0	25.5	0.0	21.2	7.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.06	0.84		1.00	0.26		0.06
Lane Grp Cap(c), veh/h	6	1034	471	302	806	839	373	0	330	118	0	0
V/C Ratio(X)	0.48	0.90	0.00	0.91	0.32	0.32	0.90	0.00	0.78	0.80	0.00	0.00
Avail Cap(c_a), veh/h	431	1340	611	431	806	839	447	0	396	462	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	62.2	39.8	0.0	49.6	17.4	17.4	46.6	0.0	44.9	57.1	0.0	0.0
Incr Delay (d2), s/veh	47.1	7.3	0.0	17.3	0.2	0.2	19.0	0.0	7.8	11.5	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.2	16.3	0.0	10.7	5.2	5.4	13.3	0.0	9.0	3.6	0.0	0.0
LnGrp Delay(d),s/veh	109.3	47.1	0.0	66.8	17.6	17.6	65.6	0.0	52.7	68.6	0.0	0.0
LnGrp LOS	F	D		E	B	B	E		D	E		
Approach Vol, veh/h		936			799			592			94	
Approach Delay, s/veh		47.3			34.4			60.0			68.6	
Approach LOS		D			C			E			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	6.5	70.9		34.1	29.8	47.6		13.6
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.2	14.0		27.5	23.1	37.9		9.1
Green Ext Time (p_c), s	0.0	7.4		1.6	0.7	3.8		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	47.0
HCM 2010 LOS	D

Intersection	
Int Delay, s/veh	2.1

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	1100	42	31	771	48	89
Future Vol, veh/h	1100	42	31	771	48	89
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	1183	45	33	829	52	96

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1228	0	1686	614
Stage 1	-	-	-	-	1205	-
Stage 2	-	-	-	-	481	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	563	-	85	435
Stage 1	-	-	-	-	247	-
Stage 2	-	-	-	-	588	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	563	-	80	435
Mov Cap-2 Maneuver	-	-	-	-	186	-
Stage 1	-	-	-	-	247	-
Stage 2	-	-	-	-	554	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.5	28.6
HCM LOS			D

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	296	-	-	563	-
HCM Lane V/C Ratio	0.498	-	-	0.059	-
HCM Control Delay (s)	28.6	-	-	11.8	-
HCM Lane LOS	D	-	-	B	-
HCM 95th %tile Q(veh)	2.6	-	-	0.2	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰	↑↑↑↱		↰↰	↑↑↑	↱	↰	↑↑↑↱	
Traffic Volume (vph)	125	690	409	229	416	206	380	1234	279	161	906	66
Future Volume (vph)	125	690	409	229	416	206	380	1234	279	161	906	66
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	1513	4133		2936	4349	1354	1513	4305	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	1513	4133		2936	4349	1354	1513	4305	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	128	704	417	234	424	210	388	1259	285	164	924	67
RTOR Reduction (vph)	0	0	32	0	59	0	0	0	64	0	5	0
Lane Group Flow (vph)	128	704	385	234	575	0	388	1259	221	164	986	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	16.8	35.8	60.8	20.5	39.5		25.0	52.9	73.4	19.8	42.7	
Effective Green, g (s)	19.3	38.3	68.3	23.0	42.0		29.0	54.9	78.4	21.8	44.7	
Actuated g/C Ratio	0.13	0.26	0.46	0.15	0.28		0.19	0.37	0.52	0.15	0.30	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	194	772	616	231	1157		567	1591	707	219	1282	
v/s Ratio Prot	0.08	c0.23	0.12	c0.15	0.14		0.13	c0.29	0.05	c0.11	c0.23	
v/s Ratio Perm			0.16						0.12			
v/c Ratio	0.66	0.91	0.62	1.01	0.50		0.68	0.79	0.31	0.75	0.77	
Uniform Delay, d1	62.2	54.2	31.1	63.5	45.2		56.2	42.4	20.4	61.5	48.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.83	0.38	0.18	1.00	1.00	
Incremental Delay, d2	7.9	15.0	2.0	62.6	0.3		2.3	2.8	0.2	13.1	2.8	
Delay (s)	70.1	69.2	33.1	126.1	45.5		105.1	19.0	3.9	74.6	50.8	
Level of Service	E	E	C	F	D		F	B	A	E	D	
Approach Delay (s)		57.2			67.2			34.1			54.2	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	49.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	88.8%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2015 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱		↰	↰↑↱		↰	↑↑↑	↱	↰	↑↑↱	
Traffic Volume (vph)	61	37	9	404	47	346	18	1386	325	259	1260	39
Future Volume (vph)	61	37	9	404	47	346	18	1386	325	259	1260	39
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.90		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2940		1377	2578		1513	4349	1354	1513	4330	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2940		1377	2578		1513	4349	1354	1513	4330	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	62	38	9	412	48	353	18	1414	332	264	1286	40
RTOR Reduction (vph)	0	9	0	0	242	0	0	0	132	0	2	0
Lane Group Flow (vph)	62	38	0	284	287	0	18	1414	200	264	1324	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	156		385	721		40	1739	532	282	2424	
v/s Ratio Prot	c0.04	0.01		c0.21	0.11		0.01	c0.33		c0.17	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.78	0.25		0.74	0.40		0.45	0.81	0.38	0.94	0.55	
Uniform Delay, d1	70.1	68.1		49.0	43.8		71.9	40.0	32.4	60.1	20.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.81	0.67	
Incremental Delay, d2	36.4	0.8		11.9	1.6		7.9	4.3	2.0	30.1	0.6	
Delay (s)	106.5	68.9		60.9	45.4		79.8	44.3	34.4	78.8	14.6	
Level of Service	F	E		E	D		E	D	C	E	B	
Approach Delay (s)		90.3			50.8			42.8			25.2	
Approach LOS		F			D			D			C	

Intersection Summary			
HCM 2000 Control Delay	39.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	84.2%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

ATTACHMENT B: 2020 AND 2040 NO BUILD CONDITIONS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Future Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1700	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	364	0	420	966	23	159	23	160	11	80	11
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	38	607	271	469	1465	35	207	30	210	14	101	14
Arrive On Green	0.02	0.20	0.00	0.31	0.48	0.48	0.15	0.15	0.15	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	1527	3042	72	1342	194	1363	169	1228	169
Grp Volume(v), veh/h	23	364	0	420	484	505	182	0	160	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1591	1537	0	1363	1566	0	0
Q Serve(g_s), s	1.2	9.1	0.0	22.0	20.2	20.2	9.5	0.0	9.4	5.3	0.0	0.0
Cycle Q Clear(g_c), s	1.2	9.1	0.0	22.0	20.2	20.2	9.5	0.0	9.4	5.3	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	0.87		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	38	607	271	469	734	766	237	0	210	129	0	0
V/C Ratio(X)	0.61	0.60	0.00	0.90	0.66	0.66	0.77	0.00	0.76	0.79	0.00	0.00
Avail Cap(c_a), veh/h	110	1130	505	1279	1731	1808	625	0	554	440	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	40.4	30.4	0.0	27.7	16.5	16.5	33.9	0.0	33.9	37.6	0.0	0.0
Incr Delay (d2), s/veh	14.7	1.0	0.0	6.3	1.0	1.0	5.2	0.0	5.6	10.1	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.7	3.9	0.0	10.0	8.7	9.0	4.4	0.0	3.9	2.7	0.0	0.0
LnGrp Delay(d),s/veh	55.1	31.4	0.0	33.9	17.5	17.4	39.2	0.0	39.5	47.8	0.0	0.0
LnGrp LOS	E	C		C	B	B	D		D	D		
Approach Vol, veh/h		387			1409			342			102	
Approach Delay, s/veh		32.8			22.4			39.3			47.8	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.1	46.3		17.9	31.7	22.6		11.4
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.2	22.2		11.5	24.0	11.1		7.3
Green Ext Time (p_c), s	0.0	6.4		1.4	1.7	5.6		0.3

Intersection Summary			
HCM 2010 Ctrl Delay			27.9
HCM 2010 LOS			C

Intersection	
Int Delay, s/veh	1.2

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	480	40	90	910	40	20
Future Vol, veh/h	480	40	90	910	40	20
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	91	91	91	91	91	91
Heavy Vehicles, %	6	6	6	6	6	6
Mvmt Flow	527	44	99	1000	44	22

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	571	0	1247	286
Stage 1	-	-	-	-	549	-
Stage 2	-	-	-	-	698	-
Critical Hdwy	-	-	4.22	-	6.92	7.02
Critical Hdwy Stg 1	-	-	-	-	5.92	-
Critical Hdwy Stg 2	-	-	-	-	5.92	-
Follow-up Hdwy	-	-	2.26	-	3.56	3.36
Pot Cap-1 Maneuver	-	-	971	-	160	699
Stage 1	-	-	-	-	531	-
Stage 2	-	-	-	-	444	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	971	-	144	699
Mov Cap-2 Maneuver	-	-	-	-	272	-
Stage 1	-	-	-	-	531	-
Stage 2	-	-	-	-	399	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.8	18
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	342	-	-	971	-
HCM Lane V/C Ratio	0.193	-	-	0.102	-
HCM Control Delay (s)	18	-	-	9.1	-
HCM Lane LOS	C	-	-	A	-
HCM 95th %tile Q(veh)	0.7	-	-	0.3	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	270	260	250	580	120	270	650	120	110	1040	100
Future Volume (vph)	50	270	260	250	580	120	270	650	120	110	1040	100
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	1456	4078		2825	4185	1303	1456	4130	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	1456	4078		2825	4185	1303	1456	4130	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	293	283	272	630	130	293	707	130	120	1130	109
RTOR Reduction (vph)	0	0	66	0	21	0	0	0	42	0	7	0
Lane Group Flow (vph)	54	293	217	272	739	0	293	707	88	120	1232	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.0	16.1	37.9	28.0	36.1		21.8	68.0	96.0	16.9	58.1	
Effective Green, g (s)	10.5	18.6	45.4	30.5	38.6		25.8	70.0	101.0	18.9	60.1	
Actuated g/C Ratio	0.07	0.12	0.30	0.20	0.26		0.17	0.47	0.67	0.13	0.40	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	101	361	394	296	1049		485	1953	877	183	1654	
v/s Ratio Prot	0.04	c0.10	0.10	c0.19	0.18		c0.10	0.17	0.02	c0.08	c0.30	
v/s Ratio Perm			0.07						0.05			
v/c Ratio	0.53	0.81	0.55	0.92	0.70		0.60	0.36	0.10	0.66	0.75	
Uniform Delay, d1	67.4	64.0	43.8	58.5	50.5		57.4	25.7	8.6	62.5	38.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.89	0.19	0.17	1.00	1.00	
Incremental Delay, d2	5.4	13.0	1.7	31.6	2.2		1.6	0.4	0.0	8.2	1.9	
Delay (s)	72.7	77.0	45.4	90.1	52.7		109.8	5.4	1.5	70.6	40.3	
Level of Service	E	E	D	F	D		F	A	A	E	D	
Approach Delay (s)		62.4			62.6			32.0			43.0	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	47.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	73.4%	ICU Level of Service	D
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	30	10	200	30	110	10	860	410	320	1220	30
Future Volume (vph)	30	30	10	200	30	110	10	860	410	320	1220	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.96		1.00	0.93		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2806		1325	2536		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2806		1325	2536		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	34	34	11	225	34	124	11	966	461	360	1371	34
RTOR Reduction (vph)	0	10	0	0	102	0	0	0	268	0	2	0
Lane Group Flow (vph)	34	35	0	133	148	0	11	966	193	360	1403	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.1	7.1		23.9	23.9		1.2	46.0	46.0	53.0	97.8	
Effective Green, g (s)	9.6	9.6		26.4	26.4		2.2	48.0	47.0	54.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.32	0.31	0.36	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	93	179		233	446		21	1339	408	524	2774	
v/s Ratio Prot	c0.02	0.01		c0.10	0.06		0.01	c0.23		c0.25	0.34	
v/s Ratio Perm									0.15			
v/c Ratio	0.37	0.19		0.57	0.33		0.52	0.72	0.47	0.69	0.51	
Uniform Delay, d1	67.3	66.5		56.6	54.1		73.4	45.1	41.5	40.8	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.78	0.64	
Incremental Delay, d2	2.4	0.5		9.8	2.0		21.6	3.4	3.9	5.2	0.5	
Delay (s)	69.7	67.1		66.4	56.1		95.0	48.5	45.4	37.1	8.6	
Level of Service	E	E		E	E		F	D	D	D	A	
Approach Delay (s)		68.2			59.7			47.8			14.4	
Approach LOS		E			E			D			B	

Intersection Summary			
HCM 2000 Control Delay	33.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	64.8%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Future Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1700	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	949	0	276	520	20	286	51	255	31	61	10
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	18	1041	475	303	1570	60	314	56	328	38	75	12
Arrive On Green	0.01	0.34	0.00	0.19	0.51	0.51	0.23	0.23	0.23	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	1587	3052	117	1357	242	1417	491	965	158
Grp Volume(v), veh/h	10	949	0	276	264	276	337	0	255	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1615	1599	0	1417	1614	0	0
Q Serve(g_s), s	0.8	38.3	0.0	22.3	13.0	13.1	26.9	0.0	22.1	8.1	0.0	0.0
Cycle Q Clear(g_c), s	0.8	38.3	0.0	22.3	13.0	13.1	26.9	0.0	22.1	8.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.07	0.85		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	18	1041	475	303	799	831	370	0	328	126	0	0
V/C Ratio(X)	0.54	0.91	0.00	0.91	0.33	0.33	0.91	0.00	0.78	0.81	0.00	0.00
Avail Cap(c_a), veh/h	413	1282	585	413	799	831	428	0	379	438	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	64.3	41.6	0.0	51.8	18.6	18.6	49.0	0.0	47.1	59.3	0.0	0.0
Incr Delay (d2), s/veh	22.4	8.7	0.0	19.7	0.2	0.2	21.5	0.0	8.6	11.5	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.5	17.6	0.0	11.4	5.6	5.9	14.1	0.0	9.4	4.0	0.0	0.0
LnGrp Delay(d),s/veh	86.7	50.3	0.0	71.5	18.8	18.8	70.5	0.0	55.7	70.8	0.0	0.0
LnGrp LOS	F	D		E	B	B	E		E	E		
Approach Vol, veh/h		959			816			592			102	
Approach Delay, s/veh		50.7			36.6			64.1			70.8	
Approach LOS		D			D			E			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.5	73.3		35.3	31.0	49.9		14.7
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.8	15.1		28.9	24.3	40.3		10.1
Green Ext Time (p_c), s	0.0	7.6		1.4	0.7	3.6		0.3

Intersection Summary			
HCM 2010 Ctrl Delay			50.1
HCM 2010 LOS			D

Intersection	
Int Delay, s/veh	2.3

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	1130	50	40	790	50	90
Future Vol, veh/h	1130	50	40	790	50	90
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	1215	54	43	849	54	97

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1269	0	1753	634
Stage 1	-	-	-	-	1242	-
Stage 2	-	-	-	-	511	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	543	-	76	422
Stage 1	-	-	-	-	236	-
Stage 2	-	-	-	-	567	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	543	-	70	422
Mov Cap-2 Maneuver	-	-	-	-	175	-
Stage 1	-	-	-	-	236	-
Stage 2	-	-	-	-	522	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.6	31.7
HCM LOS			D

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	281	-	-	543	-
HCM Lane V/C Ratio	0.536	-	-	0.079	-
HCM Control Delay (s)	31.7	-	-	12.2	-
HCM Lane LOS	D	-	-	B	-
HCM 95th %tile Q(veh)	2.9	-	-	0.3	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	700	410	240	420	210	380	1230	300	160	910	70
Future Volume (vph)	130	700	410	240	420	210	380	1230	300	160	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	1513	4132		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	1513	4132		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	714	418	245	429	214	388	1255	306	163	929	71
RTOR Reduction (vph)	0	0	30	0	59	0	0	0	65	0	5	0
Lane Group Flow (vph)	133	714	388	245	584	0	388	1255	241	163	995	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.0	35.9	61.0	20.5	39.4		25.1	52.8	73.3	19.8	42.5	
Effective Green, g (s)	19.5	38.4	68.5	23.0	41.9		29.1	54.8	78.3	21.8	44.5	
Actuated g/C Ratio	0.13	0.26	0.46	0.15	0.28		0.19	0.37	0.52	0.15	0.30	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	196	774	618	231	1154		569	1588	706	219	1276	
v/s Ratio Prot	0.09	c0.24	0.13	c0.16	0.14		0.13	c0.29	0.05	c0.11	c0.23	
v/s Ratio Perm			0.16						0.13			
v/c Ratio	0.68	0.92	0.63	1.06	0.51		0.68	0.79	0.34	0.74	0.78	
Uniform Delay, d1	62.3	54.4	31.0	63.5	45.4		56.2	42.5	20.9	61.4	48.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.82	0.39	0.21	1.00	1.00	
Incremental Delay, d2	9.0	16.4	2.0	76.1	0.4		2.3	2.8	0.2	12.8	3.1	
Delay (s)	71.2	70.8	33.0	139.6	45.7		104.7	19.2	4.6	74.3	51.4	
Level of Service	E	E	C	F	D		F	B	A	E	D	
Approach Delay (s)		58.3			71.6			33.9			54.6	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	50.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2015 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	40	10	400	50	350	20	1390	330	260	1260	40
Future Volume (vph)	70	40	10	400	50	350	20	1390	330	260	1260	40
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.90		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2938		1377	2577		1513	4349	1354	1513	4329	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2938		1377	2577		1513	4349	1354	1513	4329	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	41	10	408	51	357	20	1418	337	265	1286	41
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	134	0	2	0
Lane Group Flow (vph)	71	42	0	286	279	0	20	1418	203	265	1325	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	156		385	721		40	1739	532	282	2424	
v/s Ratio Prot	c0.05	0.01		c0.21	0.11		0.01	c0.33		c0.18	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.27		0.74	0.39		0.50	0.82	0.38	0.94	0.55	
Uniform Delay, d1	70.6	68.2		49.1	43.6		72.0	40.1	32.5	60.2	20.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.81	0.68	
Incremental Delay, d2	63.6	0.9		12.2	1.6		9.5	4.3	2.1	29.8	0.6	
Delay (s)	134.1	69.1		61.3	45.2		81.5	44.4	34.5	78.8	14.8	
Level of Service	F	E		E	D		F	D	C	E	B	
Approach Delay (s)		106.9			50.8			43.0			25.4	
Approach LOS		F			D			D			C	

Intersection Summary			
HCM 2000 Control Delay	39.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	85.0%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Future Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1604	1604	1700
Adj Flow Rate, veh/h	23	523	0	432	1034	23	227	34	136	23	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	40	802	508	570	1310	29	325	328	541	40	137	19
Arrive On Green	0.03	0.26	0.00	0.19	0.43	0.43	0.11	0.20	0.20	0.03	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	2963	3048	68	2963	1604	1363	1527	1380	190
Grp Volume(v), veh/h	23	523	0	432	517	540	227	34	136	23	0	91
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1592	1482	1604	1363	1527	0	1570
Q Serve(g_s), s	1.0	10.5	0.0	9.4	20.1	20.1	5.1	1.2	4.6	1.0	0.0	3.8
Cycle Q Clear(g_c), s	1.0	10.5	0.0	9.4	20.1	20.1	5.1	1.2	4.6	1.0	0.0	3.8
Prop In Lane	1.00		1.00	1.00		0.04	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	40	802	508	570	655	684	325	328	541	40	0	156
V/C Ratio(X)	0.58	0.65	0.00	0.76	0.79	0.79	0.70	0.10	0.25	0.58	0.00	0.58
Avail Cap(c_a), veh/h	111	1023	607	1298	1079	1127	779	550	730	513	0	596
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	33.0	22.5	0.0	26.1	16.9	16.9	29.4	22.1	13.8	33.0	0.0	29.5
Incr Delay (d2), s/veh	12.8	1.0	0.0	2.1	2.2	2.1	2.7	0.1	0.2	12.8	0.0	3.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	4.5	0.0	4.0	8.7	9.1	2.2	0.5	1.7	0.6	0.0	1.8
LnGrp Delay(d),s/veh	45.8	23.4	0.0	28.2	19.0	18.9	32.1	22.3	14.1	45.8	0.0	33.0
LnGrp LOS	D	C		C	B	B	C	C	B	D		C
Approach Vol, veh/h		546			1489			397			114	
Approach Delay, s/veh		24.4			21.7			25.1			35.6	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	6.3	20.0	19.2	23.0	13.5	12.8	7.8	34.4
Change Period (Y+Rc), s	4.5	* 6	6.0	5.0	6.0	6.0	6.0	* 5
Max Green Setting (Gmax), s	23.0	* 24	30.0	23.0	18.0	26.0	5.0	* 49
Max Q Clear Time (g_c+I1), s	3.0	6.6	11.4	12.5	7.1	5.8	3.0	22.1
Green Ext Time (p_c), s	0.0	0.9	1.7	5.0	0.5	1.0	0.0	7.4

Intersection Summary	
HCM 2010 Ctrl Delay	23.4
HCM 2010 LOS	C

Notes
* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Intersection						
Int Delay, s/veh	1.5					

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	660	50	100	1030	50	30
Future Vol, veh/h	660	50	100	1030	50	30
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	91	91	91	91	91	91
Heavy Vehicles, %	6	6	6	6	6	6
Mvmt Flow	725	55	110	1132	55	33

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	780	0	1539	390
Stage 1	-	-	-	-	753	-
Stage 2	-	-	-	-	786	-
Critical Hdwy	-	-	4.22	-	6.92	7.02
Critical Hdwy Stg 1	-	-	-	-	5.92	-
Critical Hdwy Stg 2	-	-	-	-	5.92	-
Follow-up Hdwy	-	-	2.26	-	3.56	3.36
Pot Cap-1 Maneuver	-	-	807	-	102	597
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	399	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	807	-	88	597
Mov Cap-2 Maneuver	-	-	-	-	212	-
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	345	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	23.6
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	280	-	-	807	-
HCM Lane V/C Ratio	0.314	-	-	0.136	-
HCM Control Delay (s)	23.6	-	-	10.2	-
HCM Lane LOS	C	-	-	B	-
HCM 95th %tile Q(veh)	1.3	-	-	0.5	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	310	280	280	650	140	310	650	250	130	1050	110
Future Volume (vph)	50	310	280	280	650	140	310	650	250	130	1050	110
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	2825	2835		2825	4185	1303	1456	4125	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	2825	2835		2825	4185	1303	1456	4125	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	337	304	304	707	152	337	707	272	141	1141	120
RTOR Reduction (vph)	0	0	56	0	12	0	0	0	102	0	8	0
Lane Group Flow (vph)	54	337	248	304	847	0	337	707	170	141	1253	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.2	31.5	53.3	20.4	43.7		21.8	58.3	78.7	18.8	50.3	
Effective Green, g (s)	10.7	34.0	60.8	22.9	46.2		25.8	60.3	83.7	20.8	52.3	
Actuated g/C Ratio	0.07	0.23	0.41	0.15	0.31		0.17	0.40	0.56	0.14	0.35	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	103	660	528	431	873		485	1682	727	201	1438	
v/s Ratio Prot	0.04	0.12	0.08	c0.11	c0.30		c0.12	0.17	0.04	c0.10	c0.30	
v/s Ratio Perm			0.11						0.09			
v/c Ratio	0.52	0.51	0.47	0.71	0.97		0.69	0.42	0.23	0.70	0.87	
Uniform Delay, d1	67.2	50.7	32.7	60.3	51.2		58.4	32.3	16.9	61.6	45.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.56	0.46	1.17	1.00	1.00	
Incremental Delay, d2	4.7	0.7	0.7	5.2	23.4		3.2	0.6	0.1	10.5	6.1	
Delay (s)	71.9	51.4	33.4	65.5	74.6		94.4	15.3	19.9	72.2	51.8	
Level of Service	E	D	C	E	E		F	B	B	E	D	
Approach Delay (s)		45.1			72.2			36.5			53.8	
Approach LOS		D			E			D			D	

Intersection Summary			
HCM 2000 Control Delay	52.2	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	40	40	10	220	30	110	10	860	440	370	1230	30
Future Volume (vph)	40	40	10	220	30	110	10	860	440	370	1230	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.93		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2827		1325	2544		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.98		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2827		1325	2544		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	45	45	11	247	34	124	11	966	494	416	1382	34
RTOR Reduction (vph)	0	10	0	0	102	0	0	0	288	0	2	0
Lane Group Flow (vph)	45	46	0	138	165	0	11	966	206	416	1414	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.2	7.2		23.8	23.8		1.2	40.0	40.0	59.0	97.8	
Effective Green, g (s)	9.7	9.7		26.3	26.3		2.2	42.0	41.0	60.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.28	0.27	0.40	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	94	182		232	446		21	1171	356	582	2774	
v/s Ratio Prot	c0.03	0.02		c0.10	0.06		0.01	c0.23		c0.29	0.34	
v/s Ratio Perm									0.16			
v/c Ratio	0.48	0.25		0.59	0.37		0.52	0.82	0.58	0.71	0.51	
Uniform Delay, d1	67.7	66.7		56.9	54.5		73.4	50.6	47.1	37.8	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.69	0.80	
Incremental Delay, d2	3.8	0.7		10.8	2.3		21.6	6.7	6.7	5.1	0.5	
Delay (s)	71.5	67.4		67.7	56.9		95.0	57.2	53.8	31.1	10.6	
Level of Service	E	E		E	E		F	E	D	C	B	
Approach Delay (s)		69.2			60.6			56.4			15.2	
Approach LOS		E			E			E			B	

Intersection Summary			
HCM 2000 Control Delay	37.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.2%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Future Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1667	1667	1700
Adj Flow Rate, veh/h	10	1071	0	296	633	31	337	61	214	41	71	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	20	1304	779	388	1615	79	425	275	412	57	90	13
Arrive On Green	0.01	0.41	0.00	0.13	0.53	0.53	0.14	0.17	0.17	0.04	0.06	0.06
Sat Flow, veh/h	1587	3167	1417	3079	3073	150	3079	1667	1417	1587	1430	201
Grp Volume(v), veh/h	10	1071	0	296	326	338	337	61	214	41	0	81
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1540	1583	1640	1540	1667	1417	1587	0	1631
Q Serve(g_s), s	0.6	26.5	0.0	8.2	10.8	10.9	9.3	2.8	11.1	2.3	0.0	4.3
Cycle Q Clear(g_c), s	0.6	26.5	0.0	8.2	10.8	10.9	9.3	2.8	11.1	2.3	0.0	4.3
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	20	1304	779	388	832	862	425	275	412	57	0	103
V/C Ratio(X)	0.51	0.82	0.00	0.76	0.39	0.39	0.79	0.22	0.52	0.72	0.00	0.79
Avail Cap(c_a), veh/h	90	1725	967	769	1150	1192	734	435	549	90	0	130
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	43.2	23.0	0.0	37.2	12.5	12.5	36.7	31.9	26.1	42.0	0.0	40.7
Incr Delay (d2), s/veh	19.1	2.5	0.0	3.1	0.3	0.3	3.4	0.4	1.0	15.5	0.0	22.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	11.9	0.0	3.7	4.8	5.0	4.2	1.3	4.4	1.2	0.0	2.6
LnGrp Delay(d),s/veh	62.4	25.5	0.0	40.3	12.8	12.8	40.1	32.3	27.1	57.5	0.0	62.7
LnGrp LOS	E	C		D	B	B	D	C	C	E		E
Approach Vol, veh/h		1081			960			612			122	
Approach Delay, s/veh		25.9			21.3			34.8			60.9	
Approach LOS		C			C			C			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	9.2	19.5	17.1	42.3	18.2	10.5	7.1	52.3
Change Period (Y+Rc), s	6.0	5.0	6.0	* 6	6.0	5.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	23.0	22.0	* 48	21.0	7.0	5.0	64.0
Max Q Clear Time (g_c+I1), s	4.3	13.1	10.2	28.5	11.3	6.3	2.6	12.9
Green Ext Time (p_c), s	0.0	1.1	0.9	7.8	0.8	0.1	0.0	9.8

Intersection Summary	
HCM 2010 Ctrl Delay	27.8
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Intersection	
Int Delay, s/veh	4.8

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	1340	60	40	930	60	110
Future Vol, veh/h	1340	60	40	930	60	110
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	50	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	1441	65	43	1000	65	118

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	1505	0	2059	753
Stage 1	-	-	-	-	1473	-
Stage 2	-	-	-	-	586	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	441	-	~ 48	352
Stage 1	-	-	-	-	177	-
Stage 2	-	-	-	-	519	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	441	-	~ 43	352
Mov Cap-2 Maneuver	-	-	-	-	132	-
Stage 1	-	-	-	-	177	-
Stage 2	-	-	-	-	468	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.6	68.6
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	222	-	-	441	-
HCM Lane V/C Ratio	0.823	-	-	0.098	-
HCM Control Delay (s)	68.6	-	-	14	-
HCM Lane LOS	F	-	-	B	-
HCM 95th %tile Q(veh)	6.2	-	-	0.3	-

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

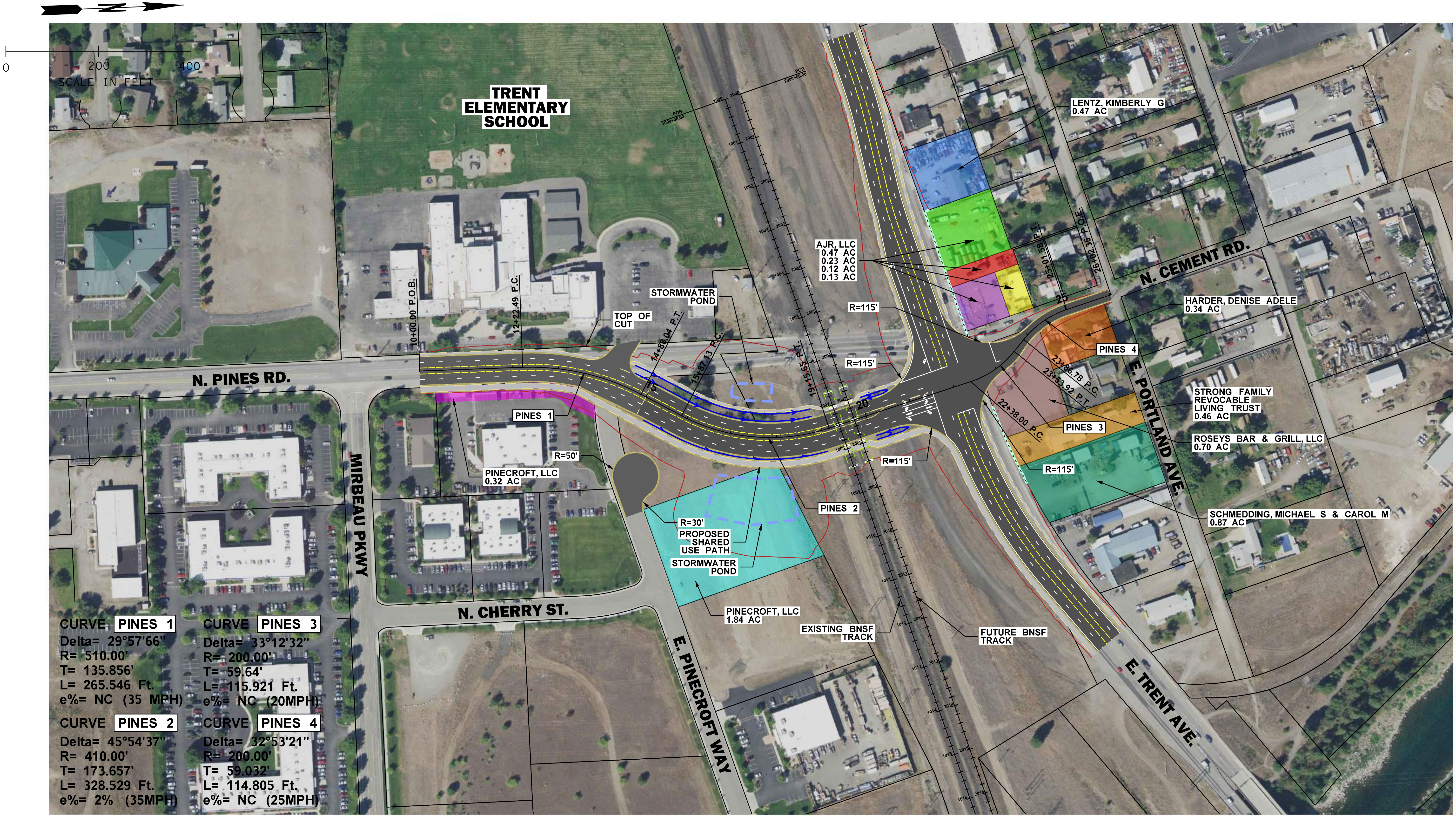
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	740	430	300	450	230	410	1240	430	180	910	70
Future Volume (vph)	130	740	430	300	450	230	410	1240	430	180	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	2936	2873		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	2936	2873		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	755	439	306	459	235	418	1265	439	184	929	71
RTOR Reduction (vph)	0	0	27	0	42	0	0	0	68	0	5	0
Lane Group Flow (vph)	133	755	412	306	652	0	418	1265	371	184	995	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.6	40.5	67.6	11.5	34.4		27.1	55.6	67.1	21.4	44.9	
Effective Green, g (s)	20.1	43.0	75.1	14.0	36.9		31.1	57.6	72.1	23.4	46.9	
Actuated g/C Ratio	0.13	0.29	0.50	0.09	0.25		0.21	0.38	0.48	0.16	0.31	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	202	867	677	274	706		608	1670	650	236	1345	
v/s Ratio Prot	c0.09	c0.25	0.13	c0.10	0.23		0.14	c0.29	0.05	c0.12	0.23	
v/s Ratio Perm			0.17						0.22			
v/c Ratio	0.66	0.87	0.61	1.12	0.92		0.69	0.76	0.57	0.78	0.74	
Uniform Delay, d1	61.7	50.9	26.9	68.0	55.2		55.0	40.1	27.9	60.8	46.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.59	0.40	0.27	1.00	1.00	
Incremental Delay, d2	7.5	9.5	1.6	89.5	17.7		2.4	2.4	0.9	15.0	2.2	
Delay (s)	69.2	60.4	28.4	157.5	72.8		89.6	18.6	8.3	75.8	48.3	
Level of Service	E	E	C	F	E		F	B	A	E	D	
Approach Delay (s)		50.7			98.7			30.5			52.5	
Approach LOS		D			F			C			D	

Intersection Summary			
HCM 2000 Control Delay	52.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	86.9%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	50	10	410	60	370	20	1390	340	280	1270	50
Future Volume (vph)	70	50	10	410	60	370	20	1390	340	280	1270	50
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.98		1.00	0.90		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2953		1377	2577		1513	4349	1354	1513	4325	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2953		1377	2577		1513	4349	1354	1513	4325	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	51	10	418	61	378	20	1418	347	286	1296	51
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	138	0	3	0
Lane Group Flow (vph)	71	52	0	301	305	0	20	1418	209	286	1344	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	157		385	721		40	1739	532	282	2422	
v/s Ratio Prot	c0.05	0.02		c0.22	0.12		0.01	c0.33		c0.19	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.33		0.78	0.42		0.50	0.82	0.39	1.01	0.56	
Uniform Delay, d1	70.6	68.4		49.8	44.1		72.0	40.1	32.7	61.0	21.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.91	0.87	
Incremental Delay, d2	63.6	1.2		14.6	1.8		9.5	4.3	2.2	46.2	0.6	
Delay (s)	134.1	69.6		64.4	45.9		81.5	44.4	34.8	101.7	18.9	
Level of Service	F	E		E	D		F	D	C	F	B	
Approach Delay (s)		104.3			52.4			43.0			33.4	
Approach LOS		F			D			D			C	

Intersection Summary			
HCM 2000 Control Delay	43.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	87.3%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecast			
c Critical Lane Group			

ATTACHMENT C: CONCEPTUAL DESIGNS



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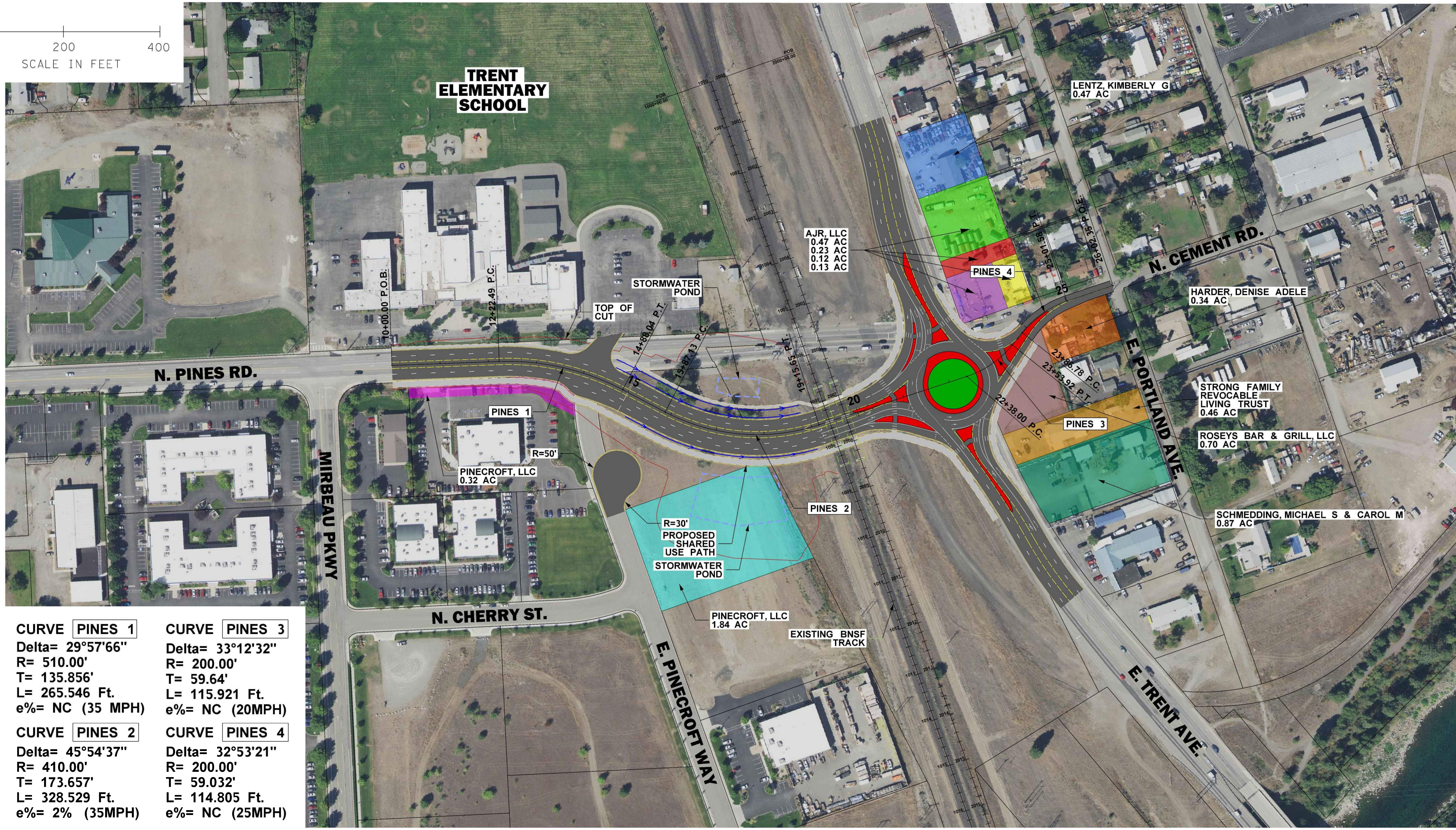
City of Spokane Valley

PINES & TRENT ALTERNATIVE 1

DAVID EVANS AND ASSOCIATES INC.

HDR



CURVE PINES 1	CURVE PINES 3
Delta= 29°57'66"	Delta= 33°12'32"
R= 510.00'	R= 200.00'
T= 135.856'	T= 59.64'
L= 265.546 Ft.	L= 115.921 Ft.
e%= NC (35 MPH)	e%= NC (20MPH)

CURVE PINES 2	CURVE PINES 4
Delta= 45°54'37"	Delta= 32°53'21"
R= 410.00'	R= 200.00'
T= 173.657'	T= 59.032'
L= 328.529 Ft.	L= 114.805 Ft.
e%= 2% (35MPH)	e%= NC (25MPH)

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City of Spokane Valley

PINES & TRENT ALTERNATIVE 1 - ROUNDABOUT

DAVID EVANS AND ASSOCIATES INC.

HDR

CURVE	PINES 1	PINES 2	PINES 3	PINES 4	PINES 5
Delta=	26°55'55"	13°35'13"	60°24'24"	108°48'07"	70°58'40"
R=	510.00'	510.00'	250.00'	110.00'	200.00'
T=	122.12'	60.75'	145.52'	153.65'	142.60'
L=	239.73 Ft.	120.94 Ft.	263.57 Ft.	208.88 Ft.	247.76 Ft.
e%=	NC (35 MPH)	NC (35MPH)	4.0% (30MPH)	NC (20MPH)	NC (25MPH)

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CITY OF Spokane Valley

PINES & TRENT ALTERNATIVE 2

DAVID EVANS AND ASSOCIATES INC.

HDR

CURVE PINES 1
Delta= 26°55'55"
R= 510.00'
T= 122.12'
L= 239.73 Ft.
e%= NC (35MPH)

CURVE PINES 2
Delta= 12°32'53"
R= 510.00'
T= 56.07'
L= 111.69 Ft.
e%= NC (35MPH)

CURVE PINES 3
Delta= 58°42'55"
R= 250.00'
T= 140.60'
L= 256.16 Ft.
e%= 4.0% (30MPH)

CURVE PINES 4
Delta= 109°55'45"
R= 110.00'
T= 156.89'
L= 211.05 Ft.
e%= NC (20MPH)

CURVE PINES 5
Delta= 109°55'45"
R= 200.00'
T= 142.60'
L= 247.76 Ft.
e%= NC (25MPH)

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CITY OF Spokane Valley

PINES & TRENT ALTERNATIVE 2 - ROUNDABOUT

DAVID EVANS AND ASSOCIATES INC.

HDR

FEHR & PEERS

ATTACHMENT D: 2020 AND 2040 ALTERNATIVES ANALYSIS

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	364	205	420	989	159	23	330	102
v/c Ratio	0.26	0.64	0.49	0.79	0.61	0.44	0.12	0.72	0.51
Control Delay	68.0	48.6	10.6	45.0	20.4	52.4	51.7	15.7	58.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	68.0	48.6	10.6	45.0	20.4	52.4	51.7	15.7	58.0
Queue Length 50th (ft)	15	115	0	241	248	50	14	0	61
Queue Length 95th (ft)	57	233	68	485	406	113	50	91	156
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	91	947	564	1070	2635	1008	547	682	372
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.25	0.38	0.36	0.39	0.38	0.16	0.04	0.48	0.27

Intersection Summary
Description: 2017 counts

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Future Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	364	0	420	966	23	159	23	160	11	80	11
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	38	608	272	469	1466	35	451	244	208	14	101	14
Arrive On Green	0.02	0.20	0.00	0.31	0.48	0.48	0.15	0.15	0.15	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	1527	3042	72	2963	1604	1363	169	1228	169
Grp Volume(v), veh/h	23	364	0	420	484	505	159	23	160	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1591	1482	1604	1363	1566	0	0
Q Serve(g_s), s	1.2	9.0	0.0	21.9	20.1	20.1	4.0	1.0	9.4	5.3	0.0	0.0
Cycle Q Clear(g_c), s	1.2	9.0	0.0	21.9	20.1	20.1	4.0	1.0	9.4	5.3	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	1.00		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	38	608	272	469	734	767	451	244	208	129	0	0
V/C Ratio(X)	0.61	0.60	0.00	0.89	0.66	0.66	0.35	0.09	0.77	0.79	0.00	0.00
Avail Cap(c_a), veh/h	110	1135	508	1284	1739	1816	1210	655	557	442	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	40.2	30.3	0.0	27.5	16.4	16.4	31.6	30.3	33.9	37.5	0.0	0.0
Incr Delay (d2), s/veh	14.7	0.9	0.0	6.2	1.0	1.0	0.5	0.2	6.0	10.1	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.7	3.9	0.0	10.0	8.5	8.9	1.7	0.5	3.9	2.7	0.0	0.0
LnGrp Delay(d),s/veh	54.9	31.2	0.0	33.8	17.4	17.3	32.1	30.5	39.8	47.6	0.0	0.0
LnGrp LOS	D	C		C	B	B	C	C	D	D		
Approach Vol, veh/h		387			1409			342			102	
Approach Delay, s/veh		32.6			22.3			35.6			47.6	
Approach LOS		C			C			D			D	
Timer	1	2	3	4	5	6	7	8				
Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	8.1	46.1		17.7	31.6	22.6		11.4				
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5				
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5				
Max Q Clear Time (g_c+I1), s	3.2	22.1		11.4	23.9	11.0		7.3				
Green Ext Time (p_c), s	0.0	6.4		1.3	1.7	5.6		0.3				
Intersection Summary												
HCM 2010 Ctrl Delay			27.2									
HCM 2010 LOS			C									

MOVEMENT SUMMARY

Site: Pines / Trent AM - Alt1a

Pines / Trent
2020 AM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	152	3.0	0.072	9.0	LOS A	0.3	7.5	0.39	0.65	33.7
8	T1	22	3.0	0.072	4.5	LOS A	0.3	7.5	0.38	0.63	27.2
18	R2	315	3.0	0.238	4.7	LOS A	1.1	28.4	0.42	0.59	35.0
Approach		489	3.0	0.238	6.1	LOS A	1.1	28.4	0.41	0.61	34.1
East: Trent Ave											
1	L2	420	3.0	0.596	11.9	LOS B	4.0	101.4	0.50	0.69	34.9
6	T1	966	3.0	0.596	7.5	LOS A	4.0	102.0	0.49	0.63	39.6
16	R2	23	3.0	0.596	7.2	LOS A	4.0	102.0	0.49	0.61	29.8
Approach		1409	3.0	0.596	8.8	LOS A	4.0	102.0	0.49	0.65	37.9
North: Cement Rd											
7	L2	11	3.0	0.187	10.2	LOS B	0.8	19.4	0.71	0.78	29.1
4	T1	76	3.0	0.187	6.1	LOS A	0.8	19.4	0.71	0.78	27.0
14	R2	11	3.0	0.187	6.5	LOS A	0.8	19.4	0.71	0.78	28.7
Approach		98	3.0	0.187	6.6	LOS A	0.8	19.4	0.71	0.78	27.4
West: Trent Ave											
5	L2	22	3.0	0.184	13.4	LOS B	1.1	27.1	0.62	0.71	30.5
2	T1	348	3.0	0.184	8.8	LOS A	1.1	28.9	0.61	0.69	39.3
12	R2	196	3.0	0.120	5.7	LOS A	0.0	0.0	0.00	0.58	41.4
Approach		565	3.0	0.184	7.9	LOS A	1.1	28.9	0.40	0.65	39.6
All Vehicles		2561	3.0	0.596	8.0	LOS A	4.0	102.0	0.46	0.65	36.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	364	205	420	989	159	23	330	102
v/c Ratio	0.21	0.54	0.44	0.61	0.67	0.39	0.11	0.70	0.46
Control Delay	51.6	33.7	8.0	35.6	21.3	40.3	39.6	13.7	44.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	51.6	33.7	8.0	35.6	21.3	40.3	39.6	13.7	44.7
Queue Length 50th (ft)	11	87	0	94	171	38	10	0	46
Queue Length 95th (ft)	46	168	54	199	383	89	40	82	125
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	175		150		150	
Base Capacity (vph)	113	1179	653	2472	2898	1247	677	766	460
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.20	0.31	0.31	0.17	0.34	0.13	0.03	0.43	0.22

Intersection Summary
Description: 2017 counts

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Future Volume (veh/h)	20	320	180	370	850	20	140	20	290	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	364	0	420	966	23	159	23	160	11	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	40	724	324	571	1229	29	478	259	220	14	102	14
Arrive On Green	0.03	0.24	0.00	0.19	0.40	0.40	0.16	0.16	0.16	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	2963	3042	72	2963	1604	1363	169	1228	169
Grp Volume(v), veh/h	23	364	0	420	484	505	159	23	160	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1591	1482	1604	1363	1566	0	0
Q Serve(g_s), s	1.0	6.8	0.0	8.8	18.3	18.3	3.1	0.8	7.4	4.2	0.0	0.0
Cycle Q Clear(g_c), s	1.0	6.8	0.0	8.8	18.3	18.3	3.1	0.8	7.4	4.2	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	1.00		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	40	724	324	571	616	643	478	259	220	130	0	0
V/C Ratio(X)	0.58	0.50	0.00	0.74	0.79	0.79	0.33	0.09	0.73	0.78	0.00	0.00
Avail Cap(c_a), veh/h	139	1429	639	3137	2189	2286	1524	825	701	556	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	31.8	21.8	0.0	25.1	17.2	17.2	24.6	23.6	26.3	29.7	0.0	0.0
Incr Delay (d2), s/veh	12.6	0.5	0.0	1.9	2.3	2.2	0.4	0.1	4.5	9.7	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	2.9	0.0	3.8	8.0	8.4	1.3	0.4	3.1	2.2	0.0	0.0
LnGrp Delay(d),s/veh	44.4	22.4	0.0	27.0	19.5	19.4	25.0	23.7	30.9	39.4	0.0	0.0
LnGrp LOS	D	C		C	B	B	C	C	C	D		
Approach Vol, veh/h		387			1409			342			102	
Approach Delay, s/veh		23.7			21.7			27.7			39.4	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.7	32.7		15.7	18.7	21.7		10.0
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.0	20.3		9.4	10.8	8.8		6.2
Green Ext Time (p_c), s	0.0	6.4		1.3	1.9	5.7		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	23.7
HCM 2010 LOS	C

MOVEMENT SUMMARY

Site: Pines / Trent - Alt2a

Pines / Trent
2020 AM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	152	3.0	0.072	1.9	LOS A	0.3	7.5	0.39	0.33	21.4
8	T1	22	3.0	0.072	0.7	LOS A	0.3	7.5	0.38	0.29	18.5
18	R2	315	3.0	0.238	0.8	LOS A	1.1	28.4	0.42	0.20	21.6
Approach		489	3.0	0.238	1.1	LOS A	1.1	28.4	0.41	0.25	21.4
East: Trent Ave											
1	L2	420	3.0	0.596	11.9	LOS B	4.0	101.4	0.50	0.69	34.9
6	T1	966	3.0	0.596	7.5	LOS A	4.0	102.0	0.49	0.63	39.6
16	R2	23	3.0	0.596	7.2	LOS A	4.0	102.0	0.49	0.61	29.8
Approach		1409	3.0	0.596	8.8	LOS A	4.0	102.0	0.49	0.65	37.9
North: Cement Rd											
7	L2	11	3.0	0.187	10.2	LOS B	0.8	19.4	0.71	0.78	29.1
4	T1	76	3.0	0.187	6.1	LOS A	0.8	19.4	0.71	0.78	27.0
14	R2	11	3.0	0.187	6.5	LOS A	0.8	19.4	0.71	0.78	28.7
Approach		98	3.0	0.187	6.6	LOS A	0.8	19.4	0.71	0.78	27.4
West: Trent Ave											
5	L2	22	3.0	0.184	13.4	LOS B	1.1	27.1	0.62	0.71	30.5
2	T1	348	3.0	0.184	8.8	LOS A	1.1	28.9	0.61	0.69	39.3
12	R2	196	3.0	0.120	5.7	LOS A	0.0	0.0	0.00	0.58	41.4
Approach		565	3.0	0.184	7.9	LOS A	1.1	28.9	0.40	0.65	39.6
All Vehicles		2561	3.0	0.596	7.1	LOS A	4.0	102.0	0.46	0.58	32.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	949	245	276	540	286	51	510	102
v/c Ratio	0.14	0.80	0.38	0.80	0.28	0.65	0.21	0.80	0.62
Control Delay	74.3	46.3	14.3	71.7	14.4	64.9	57.1	14.6	77.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	74.3	46.3	14.3	71.7	14.4	64.9	57.1	14.6	77.3
Queue Length 50th (ft)	9	414	52	239	102	132	43	0	90
Queue Length 95th (ft)	33	#631	147	#432	225	191	88	127	165
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	386	1202	646	386	1936	771	418	737	414
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.79	0.38	0.72	0.28	0.37	0.12	0.69	0.25

Intersection Summary

Description: 2017 counts

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Future Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	949	0	276	520	20	286	51	255	31	61	10
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	19	1057	482	306	1592	61	638	345	294	39	76	13
Arrive On Green	0.01	0.34	0.00	0.19	0.52	0.52	0.21	0.21	0.21	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	1587	3052	117	3079	1667	1417	491	965	158
Grp Volume(v), veh/h	10	949	0	276	264	276	286	51	255	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1615	1540	1667	1417	1614	0	0
Q Serve(g_s), s	0.7	34.6	0.0	20.3	11.7	11.7	9.7	3.0	20.8	7.4	0.0	0.0
Cycle Q Clear(g_c), s	0.7	34.6	0.0	20.3	11.7	11.7	9.7	3.0	20.8	7.4	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.07	1.00		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	19	1057	482	306	811	842	638	345	294	128	0	0
V/C Ratio(X)	0.53	0.90	0.00	0.90	0.33	0.33	0.45	0.15	0.87	0.80	0.00	0.00
Avail Cap(c_a), veh/h	453	1406	641	453	811	842	904	489	416	480	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	58.6	37.4	0.0	47.0	16.4	16.5	41.3	38.7	45.7	54.0	0.0	0.0
Incr Delay (d2), s/veh	21.4	6.4	0.0	15.4	0.2	0.2	0.5	0.2	13.1	10.8	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	15.7	0.0	10.2	5.0	5.3	4.2	1.4	9.2	3.7	0.0	0.0
LnGrp Delay(d),s/veh	80.0	43.8	0.0	62.5	16.7	16.7	41.8	38.9	58.8	64.8	0.0	0.0
LnGrp LOS	F	D		E	B	B	D	D	E	E		
Approach Vol, veh/h		959			816			592			102	
Approach Delay, s/veh		44.1			32.2			48.9			64.8	
Approach LOS		D			C			D			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.4	68.2		29.7	29.0	46.6		13.9
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.7	13.7		22.8	22.3	36.6		9.4
Green Ext Time (p_c), s	0.0	7.6		2.0	0.8	4.0		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	42.2
HCM 2010 LOS	D

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt1a

Pines / Trent
2020 PM
Roundabout

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
Movement Performance - Vehicles											
South: Pines Rd											
3	L2	304	3.0	0.209	10.4	LOS B	1.0	26.4	0.66	0.82	33.1
8	T1	54	3.0	0.209	5.6	LOS A	1.0	26.4	0.66	0.78	26.9
18	R2	543	3.0	0.549	7.1	LOS A	3.7	93.9	0.78	0.94	34.2
Approach		902	3.0	0.549	8.1	LOS A	3.7	93.9	0.73	0.89	33.3
East: Trent Ave											
1	L2	307	3.0	0.437	12.3	LOS B	2.3	59.3	0.55	0.76	22.6
6	T1	580	3.0	0.437	7.8	LOS A	2.4	60.2	0.54	0.67	39.5
16	R2	23	3.0	0.437	7.5	LOS A	2.4	60.2	0.54	0.64	29.7
Approach		909	3.0	0.437	9.3	LOS A	2.4	60.2	0.54	0.70	31.2
North: Cement Rd											
7	L2	33	3.0	0.174	9.1	LOS A	0.7	17.3	0.64	0.81	28.7
4	T1	65	3.0	0.174	7.1	LOS A	0.7	17.3	0.64	0.81	17.8
14	R2	11	3.0	0.174	5.4	LOS A	0.7	17.3	0.64	0.81	28.4
Approach		109	3.0	0.174	7.5	LOS A	0.7	17.3	0.64	0.81	21.0
West: Trent Ave											
5	L2	11	3.0	0.469	13.4	LOS B	3.3	83.3	0.68	0.74	30.5
2	T1	1011	3.0	0.469	8.8	LOS A	3.4	88.1	0.67	0.72	39.2
12	R2	261	3.0	0.160	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1283	3.0	0.469	8.3	LOS A	3.4	88.1	0.53	0.69	39.4
All Vehicles		3203	3.0	0.549	8.5	LOS A	3.7	93.9	0.60	0.75	34.1

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	949	245	276	540	286	51	510	102
v/c Ratio	0.12	0.73	0.36	0.65	0.30	0.60	0.20	0.79	0.57
Control Delay	65.7	35.8	11.7	59.5	15.2	55.3	49.6	13.7	65.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	65.7	35.8	11.7	59.5	15.2	55.3	49.6	13.7	65.8
Queue Length 50th (ft)	8	318	40	107	97	110	36	0	75
Queue Length 95th (ft)	30	534	132	178	220	176	82	122	154
Internal Link Dist (ft)		5246			2649		2504		831
Turn Bay Length (ft)	220		260	285		150		150	
Base Capacity (vph)	445	1387	721	863	1822	889	482	772	477
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.68	0.34	0.32	0.30	0.32	0.11	0.66	0.21

Intersection Summary
Description: 2017 counts

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Future Volume (veh/h)	10	930	240	270	510	20	280	50	500	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	949	0	276	520	20	286	51	255	31	61	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	19	1145	522	364	1449	56	661	358	304	40	78	13
Arrive On Green	0.01	0.37	0.00	0.12	0.47	0.47	0.21	0.21	0.21	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	3079	3052	117	3079	1667	1417	491	965	158
Grp Volume(v), veh/h	10	949	0	276	264	276	286	51	255	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1540	1554	1615	1540	1667	1417	1614	0	0
Q Serve(g_s), s	0.6	27.4	0.0	8.6	10.6	10.7	7.9	2.4	17.0	6.1	0.0	0.0
Cycle Q Clear(g_c), s	0.6	27.4	0.0	8.6	10.6	10.7	7.9	2.4	17.0	6.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.07	1.00		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	19	1145	522	364	738	767	661	358	304	130	0	0
V/C Ratio(X)	0.52	0.83	0.00	0.76	0.36	0.36	0.43	0.14	0.84	0.78	0.00	0.00
Avail Cap(c_a), veh/h	547	1699	775	1061	850	884	1092	591	502	581	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	48.5	28.3	0.0	42.1	16.4	16.4	33.6	31.4	37.1	44.5	0.0	0.0
Incr Delay (d2), s/veh	19.9	2.3	0.0	3.2	0.3	0.3	0.4	0.2	6.4	9.8	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	12.1	0.0	3.8	4.6	4.8	3.4	1.2	7.2	3.1	0.0	0.0
LnGrp Delay(d),s/veh	68.4	30.6	0.0	45.4	16.7	16.7	34.0	31.6	43.6	54.4	0.0	0.0
LnGrp LOS	E	C		D	B	B	C	C	D	D		
Approach Vol, veh/h		959			816			592			102	
Approach Delay, s/veh		31.0			26.4			37.9			54.4	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.2	52.9		26.2	17.7	42.4		12.5
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.6	12.7		19.0	10.6	29.4		8.1
Green Ext Time (p_c), s	0.0	7.6		2.2	1.1	7.0		0.4

Intersection Summary	
HCM 2010 Ctrl Delay	32.1
HCM 2010 LOS	C

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt2a

Pines / Trent
2020 PM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	304	3.0	0.209	3.3	LOS A	1.0	26.4	0.66	0.60	21.2
8	T1	54	3.0	0.209	1.9	LOS A	1.0	26.4	0.66	0.51	18.3
18	R2	543	3.0	0.549	3.2	LOS A	3.7	93.9	0.78	0.89	21.3
Approach		902	3.0	0.549	3.2	LOS A	3.7	93.9	0.73	0.77	21.1
East: Trent Ave											
1	L2	307	3.0	0.437	12.3	LOS B	2.3	59.3	0.55	0.76	22.6
6	T1	580	3.0	0.437	7.8	LOS A	2.4	60.2	0.54	0.67	39.5
16	R2	23	3.0	0.437	7.5	LOS A	2.4	60.2	0.54	0.64	29.7
Approach		909	3.0	0.437	9.3	LOS A	2.4	60.2	0.54	0.70	31.2
North: Cement Rd											
7	L2	33	3.0	0.174	9.1	LOS A	0.7	17.3	0.64	0.81	28.7
4	T1	65	3.0	0.174	7.1	LOS A	0.7	17.3	0.64	0.81	17.8
14	R2	11	3.0	0.174	5.4	LOS A	0.7	17.3	0.64	0.81	28.4
Approach		109	3.0	0.174	7.5	LOS A	0.7	17.3	0.64	0.81	21.0
West: Trent Ave											
5	L2	11	3.0	0.469	13.4	LOS B	3.3	83.3	0.68	0.74	30.5
2	T1	1011	3.0	0.469	8.8	LOS A	3.4	88.1	0.67	0.72	39.2
12	R2	261	3.0	0.160	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1283	3.0	0.469	8.3	LOS A	3.4	88.1	0.53	0.69	39.4
All Vehicles		3203	3.0	0.549	7.1	LOS A	3.7	93.9	0.60	0.72	29.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	523	250	432	1057	227	34	341	114
v/c Ratio	0.28	0.80	0.36	0.85	0.63	0.58	0.16	0.42	0.62
Control Delay	70.0	54.7	4.8	53.0	21.2	55.8	51.1	2.6	66.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	70.0	54.7	4.8	53.0	21.2	55.8	51.1	2.6	66.8
Queue Length 50th (ft)	17	197	0	299	297	85	24	0	81
Queue Length 95th (ft)	51	303	49	483	426	138	59	24	161
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	84	810	775	685	2022	624	338	925	246
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.27	0.65	0.32	0.63	0.52	0.36	0.10	0.37	0.46

Intersection Summary
Description: 2040 forecast

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Future Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	523	0	432	1034	23	227	34	136	23	80	11
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	37	733	478	476	1609	36	326	177	575	30	105	14
Arrive On Green	0.02	0.24	0.00	0.31	0.53	0.53	0.11	0.11	0.11	0.10	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	1527	3048	68	2963	1604	1363	315	1096	151
Grp Volume(v), veh/h	23	523	0	432	517	540	227	34	136	114	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1592	1482	1604	1363	1561	0	0
Q Serve(g_s), s	1.4	14.3	0.0	24.7	22.0	22.0	6.7	1.8	5.8	6.5	0.0	0.0
Cycle Q Clear(g_c), s	1.4	14.3	0.0	24.7	22.0	22.0	6.7	1.8	5.8	6.5	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.04	1.00		1.00	0.20		0.10
Lane Grp Cap(c), veh/h	37	733	478	476	804	840	326	177	575	149	0	0
V/C Ratio(X)	0.62	0.71	0.00	0.91	0.64	0.64	0.70	0.19	0.24	0.76	0.00	0.00
Avail Cap(c_a), veh/h	101	973	585	824	1216	1271	750	406	770	292	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	43.9	31.6	0.0	30.0	15.3	15.3	38.9	36.7	16.9	40.1	0.0	0.0
Incr Delay (d2), s/veh	15.8	1.7	0.0	7.9	0.9	0.8	2.7	0.5	0.2	7.8	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.7	6.2	0.0	11.4	9.4	9.8	2.9	0.8	2.2	3.1	0.0	0.0
LnGrp Delay(d),s/veh	59.7	33.3	0.0	37.9	16.2	16.2	41.6	37.3	17.1	47.9	0.0	0.0
LnGrp LOS	E	C		D	B	B	D	D	B	D		
Approach Vol, veh/h		546			1489			397			114	
Approach Delay, s/veh		34.4			22.5			32.8			47.9	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		15.0	34.3	26.8		14.7	8.2	52.9
Change Period (Y+Rc), s		5.0	6.0	5.0		6.0	6.0	* 5
Max Green Setting (Gmax), s		23.0	49.0	29.0		17.0	6.0	* 73
Max Q Clear Time (g_c+I1), s		8.7	26.7	16.3		8.5	3.4	24.0
Green Ext Time (p_c), s		1.3	1.7	5.5		0.2	0.0	8.0

Intersection Summary	
HCM 2010 Ctrl Delay	27.8
HCM 2010 LOS	C

Notes
* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent AM - Alt1

Pines / Trent
2040 AM
Roundabout

Movement Performance - Vehicles												
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	217	3.0	0.113	9.4	LOS A	0.5	12.4	0.47	0.70	33.5
8	T1	33	3.0	0.113	4.8	LOS A	0.5	12.4	0.47	0.67	27.1
18	R2	326	3.0	0.265	5.1	LOS A	1.3	32.3	0.51	0.63	34.8
Approach		576	3.0	0.265	6.7	LOS A	1.3	32.3	0.49	0.66	33.7
East: Trent Ave											
1	L2	432	3.0	0.664	13.1	LOS B	5.3	136.9	0.62	0.78	22.5
6	T1	1034	3.0	0.664	8.6	LOS A	5.3	136.9	0.61	0.73	39.1
16	R2	23	3.0	0.664	8.2	LOS A	5.3	136.7	0.61	0.71	29.6
Approach		1489	3.0	0.664	9.9	LOS A	5.3	136.9	0.61	0.74	32.1
North: Cement Rd											
7	L2	22	3.0	0.235	10.9	LOS B	1.0	25.7	0.75	0.86	28.2
4	T1	76	3.0	0.235	8.9	LOS A	1.0	25.7	0.75	0.86	17.6
14	R2	11	3.0	0.235	7.2	LOS A	1.0	25.7	0.75	0.86	27.8
Approach		109	3.0	0.235	9.1	LOS A	1.0	25.7	0.75	0.86	19.8
West: Trent Ave											
5	L2	22	3.0	0.270	13.7	LOS B	1.7	42.7	0.68	0.75	30.4
2	T1	500	3.0	0.270	9.1	LOS A	1.8	45.9	0.67	0.72	39.1
12	R2	239	3.0	0.147	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		761	3.0	0.270	8.3	LOS A	1.8	45.9	0.46	0.69	39.3
All Vehicles		2934	3.0	0.664	8.8	LOS A	5.3	136.9	0.55	0.72	33.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	23	523	250	432	1057	227	34	341	114
v/c Ratio	0.24	0.75	0.33	0.76	0.76	0.48	0.13	0.50	0.52
Control Delay	47.6	37.3	3.1	43.8	26.2	35.0	31.7	3.9	41.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	47.6	37.3	3.1	43.8	26.2	35.0	31.7	3.9	41.6
Queue Length 50th (ft)	11	123	0	103	189	53	15	0	50
Queue Length 95th (ft)	40	218	35	#233	#496	94	42	25	114
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	175		150		150	
Base Capacity (vph)	97	894	903	565	1388	867	470	687	343
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.24	0.59	0.28	0.76	0.76	0.26	0.07	0.50	0.33

Intersection Summary

Description: 2040 forecast

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Future Volume (veh/h)	20	460	220	380	910	20	200	30	300	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	523	0	432	1034	23	227	34	136	23	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	40	790	526	534	1259	28	376	204	418	33	114	16
Arrive On Green	0.03	0.26	0.00	0.18	0.41	0.41	0.13	0.13	0.13	0.10	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	2963	3048	68	2963	1604	1363	315	1096	151
Grp Volume(v), veh/h	23	523	0	432	517	540	227	34	136	114	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1592	1482	1604	1363	1561	0	0
Q Serve(g_s), s	1.0	10.2	0.0	9.3	20.1	20.1	4.8	1.3	5.1	4.7	0.0	0.0
Cycle Q Clear(g_c), s	1.0	10.2	0.0	9.3	20.1	20.1	4.8	1.3	5.1	4.7	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.04	1.00		1.00	0.20		0.10
Lane Grp Cap(c), veh/h	40	790	526	534	630	658	376	204	418	163	0	0
V/C Ratio(X)	0.58	0.66	0.00	0.81	0.82	0.82	0.60	0.17	0.32	0.70	0.00	0.00
Avail Cap(c_a), veh/h	114	1050	643	666	765	799	1022	553	715	398	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	32.1	22.1	0.0	26.3	17.4	17.4	27.5	26.0	17.8	28.9	0.0	0.0
Incr Delay (d2), s/veh	12.6	1.0	0.0	6.0	6.0	5.8	1.6	0.4	0.4	5.4	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	4.4	0.0	4.2	9.4	9.8	2.1	0.6	2.0	2.3	0.0	0.0
LnGrp Delay(d),s/veh	44.8	23.1	0.0	32.3	23.4	23.2	29.1	26.4	18.2	34.3	0.0	0.0
LnGrp LOS	D	C		C	C	C	C	C	B	C		
Approach Vol, veh/h		546			1489			397			114	
Approach Delay, s/veh		24.0			25.9			25.1			34.3	
Approach LOS		C			C			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		13.5	18.0	22.3		13.0	7.7	32.6
Change Period (Y+Rc), s		5.0	6.0	5.0		6.0	6.0	* 5
Max Green Setting (Gmax), s		23.0	15.0	23.0		17.0	5.0	* 34
Max Q Clear Time (g_c+I1), s		7.1	11.3	12.2		6.7	3.0	22.1
Green Ext Time (p_c), s		1.3	0.7	5.0		0.2	0.0	5.2

Intersection Summary	
HCM 2010 Ctrl Delay	25.7
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent AM - Alt2

Pines / Trent
2040 AM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	217	3.0	0.113	2.2	LOS A	0.5	12.4	0.47	0.40	21.4
8	T1	33	3.0	0.113	1.0	LOS A	0.5	12.4	0.47	0.35	18.4
18	R2	326	3.0	0.265	1.1	LOS A	1.3	32.3	0.51	0.28	21.6
Approach		576	3.0	0.265	1.5	LOS A	1.3	32.3	0.49	0.33	21.3
East: Trent Ave											
1	L2	432	3.0	0.664	13.1	LOS B	5.3	136.9	0.62	0.78	22.5
6	T1	1034	3.0	0.664	8.6	LOS A	5.3	136.9	0.61	0.73	39.1
16	R2	23	3.0	0.664	8.2	LOS A	5.3	136.7	0.61	0.71	29.6
Approach		1489	3.0	0.664	9.9	LOS A	5.3	136.9	0.61	0.74	32.1
North: Cement Rd											
7	L2	22	3.0	0.235	10.9	LOS B	1.0	25.7	0.75	0.86	28.2
4	T1	76	3.0	0.235	8.9	LOS A	1.0	25.7	0.75	0.86	17.6
14	R2	11	3.0	0.235	7.2	LOS A	1.0	25.7	0.75	0.86	27.8
Approach		109	3.0	0.235	9.1	LOS A	1.0	25.7	0.75	0.86	19.8
West: Trent Ave											
5	L2	22	3.0	0.270	13.7	LOS B	1.7	42.7	0.68	0.75	30.4
2	T1	500	3.0	0.270	9.1	LOS A	1.8	45.9	0.67	0.72	39.1
12	R2	239	3.0	0.147	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		761	3.0	0.270	8.3	LOS A	1.8	45.9	0.46	0.69	39.3
All Vehicles		2934	3.0	0.664	7.8	LOS A	5.3	136.9	0.55	0.65	29.8

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	1071	306	296	664	337	61	520	122
v/c Ratio	0.17	0.94	0.33	0.88	0.35	0.73	0.24	0.77	0.65
Control Delay	72.3	56.9	2.8	77.2	15.7	64.1	53.4	19.3	71.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	72.3	56.9	2.8	77.2	15.7	64.1	53.4	19.3	71.7
Queue Length 50th (ft)	9	478	0	247	139	145	47	129	101
Queue Length 95th (ft)	30	#710	46	#447	257	209	96	224	173
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	285		150		1000	
Base Capacity (vph)	60	1143	959	364	1881	578	313	693	282
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.94	0.32	0.81	0.35	0.58	0.19	0.75	0.43

Intersection Summary

Description: 2040 forecasts

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Future Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	1071	0	296	633	31	337	61	214	41	71	10
Adj No. of Lanes	1	2	1	1	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	19	1180	735	324	1735	85	451	244	497	50	86	12
Arrive On Green	0.01	0.37	0.00	0.20	0.56	0.56	0.15	0.15	0.15	0.09	0.09	0.09
Sat Flow, veh/h	1587	3167	1417	1587	3073	150	3079	1667	1417	543	941	132
Grp Volume(v), veh/h	10	1071	0	296	326	338	337	61	214	122	0	0
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1587	1583	1640	1540	1667	1417	1616	0	0
Q Serve(g_s), s	0.7	38.1	0.0	21.7	13.4	13.4	12.5	3.9	13.7	8.8	0.0	0.0
Cycle Q Clear(g_c), s	0.7	38.1	0.0	21.7	13.4	13.4	12.5	3.9	13.7	8.8	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	0.34		0.08
Lane Grp Cap(c), veh/h	19	1180	735	324	894	926	451	244	497	148	0	0
V/C Ratio(X)	0.53	0.91	0.00	0.91	0.36	0.37	0.75	0.25	0.43	0.82	0.00	0.00
Avail Cap(c_a), veh/h	67	1252	768	401	946	980	635	344	581	306	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	58.4	35.4	0.0	46.3	14.2	14.2	48.6	44.9	29.5	53.0	0.0	0.0
Incr Delay (d2), s/veh	21.4	9.5	0.0	22.2	0.2	0.2	3.0	0.5	0.6	10.7	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	18.2	0.0	11.5	5.9	6.1	5.5	1.8	5.4	4.4	0.0	0.0
LnGrp Delay(d),s/veh	79.8	44.8	0.0	68.4	14.4	14.4	51.6	45.5	30.1	63.8	0.0	0.0
LnGrp LOS	E	D		E	B	B	D	D	C	E		
Approach Vol, veh/h		1081			960			612			122	
Approach Delay, s/veh		45.2			31.1			43.5			63.7	
Approach LOS		D			C			D			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		22.4	30.3	50.3		15.9	7.4	73.1
Change Period (Y+Rc), s		5.0	6.0	* 6		5.0	6.0	6.0
Max Green Setting (Gmax), s		24.5	30.0	* 47		22.5	5.0	71.0
Max Q Clear Time (g_c+I1), s		15.7	23.7	40.1		10.8	2.7	15.4
Green Ext Time (p_c), s		1.7	0.6	4.2		0.3	0.0	9.8

Intersection Summary	
HCM 2010 Ctrl Delay	40.7
HCM 2010 LOS	D

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt1

Pines / Trent
2040 PM
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	359	3.0	0.275	10.8	LOS B	1.5	37.6	0.73	0.85	33.0
8	T1	65	3.0	0.275	6.0	LOS A	1.5	37.6	0.74	0.81	26.8
18	R2	554	3.0	0.617	8.1	LOS A	4.5	116.3	0.85	1.00	33.7
Approach		978	3.0	0.617	8.9	LOS A	4.5	116.3	0.80	0.94	32.9
East: Trent Ave											
1	L2	330	3.0	0.538	13.2	LOS B	3.4	87.7	0.64	0.83	22.5
6	T1	705	3.0	0.538	8.6	LOS A	3.5	88.6	0.63	0.75	39.1
16	R2	34	3.0	0.538	8.2	LOS A	3.5	88.6	0.63	0.72	29.5
Approach		1068	3.0	0.538	10.0	LOS B	3.5	88.6	0.63	0.78	31.5
North: Cement Rd											
7	L2	43	3.0	0.236	9.8	LOS A	1.0	24.9	0.70	0.84	28.4
4	T1	76	3.0	0.236	7.8	LOS A	1.0	24.9	0.70	0.84	17.7
14	R2	11	3.0	0.236	6.1	LOS A	1.0	24.9	0.70	0.84	28.1
Approach		130	3.0	0.236	8.3	LOS A	1.0	24.9	0.70	0.84	21.0
West: Trent Ave											
5	L2	11	3.0	0.552	14.7	LOS B	4.6	118.8	0.76	0.82	30.3
2	T1	1141	3.0	0.552	9.9	LOS A	4.8	121.9	0.75	0.79	38.9
12	R2	326	3.0	0.201	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1478	3.0	0.552	9.1	LOS A	4.8	121.9	0.59	0.75	39.2
All Vehicles		3655	3.0	0.617	9.3	LOS A	4.8	121.9	0.66	0.81	33.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	NBR	SBT
Lane Group Flow (vph)	10	1071	306	296	664	337	61	520	122
v/c Ratio	0.14	0.88	0.32	0.71	0.38	0.68	0.23	0.84	0.61
Control Delay	59.0	42.0	2.2	56.8	16.7	51.2	43.3	22.2	58.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	59.0	42.0	2.2	56.8	16.7	51.2	43.3	22.2	58.4
Queue Length 50th (ft)	7	371	0	104	127	117	38	95	81
Queue Length 95th (ft)	27	#591	38	#169	252	175	82	#194	150
Internal Link Dist (ft)		5151			2649		2154		831
Turn Bay Length (ft)	220		260	175		150		150	
Base Capacity (vph)	73	1230	1028	454	1731	668	362	633	339
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.14	0.87	0.30	0.65	0.38	0.50	0.17	0.82	0.36

Intersection Summary

Description: 2040 forecasts

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰↰	↑↱		↰↰	↑	↱		✣	
Traffic Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Future Volume (veh/h)	10	1050	300	290	620	30	330	60	510	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	1071	0	296	633	31	337	61	214	41	71	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	19	1234	788	370	1529	75	512	277	405	51	89	12
Arrive On Green	0.01	0.39	0.00	0.12	0.50	0.50	0.17	0.17	0.17	0.09	0.09	0.09
Sat Flow, veh/h	1587	3167	1417	3079	3073	150	3079	1667	1417	543	941	132
Grp Volume(v), veh/h	10	1071	0	296	326	338	337	61	214	122	0	0
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1540	1583	1640	1540	1667	1417	1616	0	0
Q Serve(g_s), s	0.6	29.9	0.0	9.0	12.5	12.5	9.8	3.0	12.2	7.1	0.0	0.0
Cycle Q Clear(g_c), s	0.6	29.9	0.0	9.0	12.5	12.5	9.8	3.0	12.2	7.1	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.09	1.00		1.00	0.34		0.08
Lane Grp Cap(c), veh/h	19	1234	788	370	788	816	512	277	405	152	0	0
V/C Ratio(X)	0.52	0.87	0.00	0.80	0.41	0.41	0.66	0.22	0.53	0.80	0.00	0.00
Avail Cap(c_a), veh/h	83	1389	857	514	860	891	756	409	518	380	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	47.0	26.9	0.0	41.0	15.2	15.2	37.4	34.6	28.7	42.5	0.0	0.0
Incr Delay (d2), s/veh	19.7	5.6	0.0	6.1	0.3	0.3	1.5	0.4	1.1	9.3	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	13.9	0.0	4.1	5.5	5.7	4.3	1.4	4.8	3.5	0.0	0.0
LnGrp Delay(d),s/veh	66.7	32.6	0.0	47.1	15.6	15.6	38.8	35.0	29.8	51.8	0.0	0.0
LnGrp LOS	E	C		D	B	B	D	C	C	D		
Approach Vol, veh/h		1081			960			612			122	
Approach Delay, s/veh		32.9			25.3			35.3			51.8	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		20.9	17.5	43.3		14.0	7.2	53.7
Change Period (Y+Rc), s		5.0	6.0	* 6		5.0	6.0	6.0
Max Green Setting (Gmax), s		23.5	16.0	* 42		22.5	5.0	52.0
Max Q Clear Time (g_c+I1), s		14.2	11.0	31.9		9.1	2.6	14.5
Green Ext Time (p_c), s		1.8	0.5	5.5		0.3	0.0	9.4

Intersection Summary		
HCM 2010 Ctrl Delay		31.6
HCM 2010 LOS		C

Notes
* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

MOVEMENT SUMMARY

Site: Pines / Trent PM - Alt2

Pines / Trent
2040 PM
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Pines Rd											
3	L2	359	3.0	0.275	3.7	LOS A	1.5	37.6	0.73	0.67	21.1
8	T1	65	3.0	0.275	2.2	LOS A	1.5	37.6	0.74	0.57	18.3
18	R2	554	3.0	0.617	4.1	LOS A	4.5	116.3	0.85	1.01	21.1
Approach		978	3.0	0.617	3.8	LOS A	4.5	116.3	0.80	0.86	20.9
East: Trent Ave											
1	L2	330	3.0	0.538	13.2	LOS B	3.4	87.7	0.64	0.83	22.5
6	T1	705	3.0	0.538	8.6	LOS A	3.5	88.6	0.63	0.75	39.1
16	R2	34	3.0	0.538	8.2	LOS A	3.5	88.6	0.63	0.72	29.5
Approach		1068	3.0	0.538	10.0	LOS B	3.5	88.6	0.63	0.78	31.5
North: Cement Rd											
7	L2	43	3.0	0.236	9.8	LOS A	1.0	24.9	0.70	0.84	28.4
4	T1	76	3.0	0.236	7.8	LOS A	1.0	24.9	0.70	0.84	17.7
14	R2	11	3.0	0.236	6.1	LOS A	1.0	24.9	0.70	0.84	28.1
Approach		130	3.0	0.236	8.3	LOS A	1.0	24.9	0.70	0.84	21.0
West: Trent Ave											
5	L2	11	3.0	0.552	14.7	LOS B	4.6	118.8	0.76	0.82	30.3
2	T1	1141	3.0	0.552	9.9	LOS A	4.8	121.9	0.75	0.79	38.9
12	R2	326	3.0	0.201	6.2	LOS A	0.0	0.0	0.00	0.60	40.7
Approach		1478	3.0	0.552	9.1	LOS A	4.8	121.9	0.59	0.75	39.2
All Vehicles		3655	3.0	0.617	7.9	LOS A	4.8	121.9	0.66	0.79	29.3

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

ATTACHMENT E: 2020 AND 2040 UNIVERSITY ROAD CLOSURE ANALYSIS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	20	295	190	460	760	20	145	20	315	10	70	10
Future Volume (veh/h)	20	295	190	460	760	20	145	20	315	10	70	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1700	1604	1604	1700	1604	1700
Adj Flow Rate, veh/h	23	335	0	523	864	23	165	23	188	11	80	11
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	36	517	231	565	1564	42	226	31	228	14	100	14
Arrive On Green	0.02	0.17	0.00	0.37	0.52	0.52	0.17	0.17	0.17	0.08	0.08	0.08
Sat Flow, veh/h	1527	3047	1363	1527	3032	81	1348	188	1363	169	1228	169
Grp Volume(v), veh/h	23	335	0	523	434	453	188	0	188	102	0	0
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1527	1524	1590	1536	0	1363	1566	0	0
Q Serve(g_s), s	1.5	10.4	0.0	33.3	19.6	19.6	11.8	0.0	13.5	6.5	0.0	0.0
Cycle Q Clear(g_c), s	1.5	10.4	0.0	33.3	19.6	19.6	11.8	0.0	13.5	6.5	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.05	0.88		1.00	0.11		0.11
Lane Grp Cap(c), veh/h	36	517	231	565	786	820	257	0	228	128	0	0
V/C Ratio(X)	0.64	0.65	0.00	0.93	0.55	0.55	0.73	0.00	0.82	0.80	0.00	0.00
Avail Cap(c_a), veh/h	90	931	417	1054	1427	1488	515	0	457	363	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	49.1	39.3	0.0	30.6	16.6	16.6	40.1	0.0	40.8	45.8	0.0	0.0
Incr Delay (d2), s/veh	17.4	1.4	0.0	7.1	0.6	0.6	4.0	0.0	7.3	10.9	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.8	4.5	0.0	15.1	8.3	8.7	5.3	0.0	5.6	3.2	0.0	0.0
LnGrp Delay(d),s/veh	66.5	40.7	0.0	37.7	17.2	17.2	44.1	0.0	48.1	56.6	0.0	0.0
LnGrp LOS	E	D		D	B	B	D		D	E		
Approach Vol, veh/h		358			1410			376			102	
Approach Delay, s/veh		42.3			24.8			46.1			56.6	
Approach LOS		D			C			D			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	8.4	58.3		22.0	43.5	23.2		12.8
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	6.0	95.0		34.0	70.0	31.0		23.5
Max Q Clear Time (g_c+I1), s	3.5	21.6		15.5	35.3	12.4		8.5
Green Ext Time (p_c), s	0.0	5.5		1.5	2.2	4.8		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	32.6
HCM 2010 LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	235	295	255	545	120	305	650	125	110	1040	100
Future Volume (vph)	50	235	295	255	545	120	305	650	125	110	1040	100
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	1456	4072		2825	4185	1303	1456	4130	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	1456	4072		2825	4185	1303	1456	4130	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	255	321	277	592	130	332	707	136	120	1130	109
RTOR Reduction (vph)	0	0	65	0	23	0	0	0	44	0	7	0
Lane Group Flow (vph)	54	255	256	277	699	0	332	707	92	120	1232	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.0	15.5	39.1	28.3	35.8		23.6	68.3	96.6	16.9	56.6	
Effective Green, g (s)	10.5	18.0	46.6	30.8	38.3		27.6	70.3	101.6	18.9	58.6	
Actuated g/C Ratio	0.07	0.12	0.31	0.21	0.26		0.18	0.47	0.68	0.13	0.39	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	101	349	404	298	1039		519	1961	882	183	1613	
v/s Ratio Prot	0.04	0.09	c0.12	c0.19	c0.17		c0.12	0.17	0.02	0.08	c0.30	
v/s Ratio Perm			0.08						0.05			
v/c Ratio	0.53	0.73	0.63	0.93	0.67		0.64	0.36	0.10	0.66	0.76	
Uniform Delay, d1	67.4	63.7	44.4	58.5	50.2		56.6	25.5	8.4	62.5	39.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.83	0.23	0.21	1.00	1.00	
Incremental Delay, d2	5.4	7.7	3.2	33.7	1.7		1.9	0.4	0.0	8.2	2.2	
Delay (s)	72.7	71.3	47.6	92.2	51.9		105.4	6.2	1.8	70.6	41.9	
Level of Service	E	E	D	F	D		F	A	A	E	D	
Approach Delay (s)		59.3			63.1			33.7			44.4	
Approach LOS		E			E			C			D	

Intersection Summary			
HCM 2000 Control Delay	48.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	74.5%	ICU Level of Service	D
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	30	10	200	30	150	10	860	410	360	1220	30
Future Volume (vph)	30	30	10	200	30	150	10	860	410	360	1220	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.96		1.00	0.91		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2806		1325	2503		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2806		1325	2503		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	34	34	11	225	34	169	11	966	461	404	1371	34
RTOR Reduction (vph)	0	10	0	0	139	0	0	0	268	0	2	0
Lane Group Flow (vph)	34	35	0	148	141	0	11	966	193	404	1403	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.1	7.1		23.9	23.9		1.2	46.0	46.0	53.0	97.8	
Effective Green, g (s)	9.6	9.6		26.4	26.4		2.2	48.0	47.0	54.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.32	0.31	0.36	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	93	179		233	440		21	1339	408	524	2774	
v/s Ratio Prot	c0.02	0.01		c0.11	0.06		0.01	c0.23		c0.28	0.34	
v/s Ratio Perm									0.15			
v/c Ratio	0.37	0.19		0.64	0.32		0.52	0.72	0.47	0.77	0.51	
Uniform Delay, d1	67.3	66.5		57.3	54.0		73.4	45.1	41.5	42.5	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.78	0.65	
Incremental Delay, d2	2.4	0.5		12.5	1.9		21.6	3.4	3.9	7.5	0.5	
Delay (s)	69.7	67.1		69.8	55.9		95.0	48.5	45.4	40.8	8.6	
Level of Service	E	E		E	E		F	D	D	D	A	
Approach Delay (s)		68.2			60.7			47.8			15.8	
Approach LOS		E			E			D			B	

Intersection Summary			
HCM 2000 Control Delay	34.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	10	850	245	305	475	20	290	50	580	30	60	10
Future Volume (veh/h)	10	850	245	305	475	20	290	50	580	30	60	10
Number	1	6	16	5	2	12	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1635	1667	1667	1636	1700	1700	1667	1667	1700	1667	1700
Adj Flow Rate, veh/h	10	867	0	311	485	20	296	51	286	31	61	10
Adj No. of Lanes	1	2	1	1	2	0	0	1	1	0	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	4	2	2	4	4	2	2	2	2	2	2
Cap, veh/h	18	961	438	337	1551	64	323	56	336	38	75	12
Arrive On Green	0.01	0.31	0.00	0.21	0.51	0.51	0.24	0.24	0.24	0.08	0.08	0.08
Sat Flow, veh/h	1587	3106	1417	1587	3043	125	1364	235	1417	491	965	158
Grp Volume(v), veh/h	10	867	0	311	247	258	347	0	286	102	0	0
Grp Sat Flow(s),veh/h/ln	1587	1553	1417	1587	1554	1614	1598	0	1417	1614	0	0
Q Serve(g_s), s	0.8	35.2	0.0	25.3	12.2	12.3	27.8	0.0	25.4	8.2	0.0	0.0
Cycle Q Clear(g_c), s	0.8	35.2	0.0	25.3	12.2	12.3	27.8	0.0	25.4	8.2	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.08	0.85		1.00	0.30		0.10
Lane Grp Cap(c), veh/h	18	961	438	337	792	823	379	0	336	126	0	0
V/C Ratio(X)	0.54	0.90	0.00	0.92	0.31	0.31	0.92	0.00	0.85	0.81	0.00	0.00
Avail Cap(c_a), veh/h	410	1274	581	410	792	823	425	0	377	435	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	64.7	43.5	0.0	50.8	18.8	18.8	48.9	0.0	48.0	59.7	0.0	0.0
Incr Delay (d2), s/veh	22.4	7.4	0.0	23.8	0.2	0.2	22.9	0.0	15.5	11.5	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.5	16.0	0.0	13.3	5.3	5.5	14.7	0.0	11.4	4.1	0.0	0.0
LnGrp Delay(d),s/veh	87.1	50.9	0.0	74.7	19.0	19.0	71.8	0.0	63.5	71.3	0.0	0.0
LnGrp LOS	F	D		E	B	B	E		E	E		
Approach Vol, veh/h		877			816			633			102	
Approach Delay, s/veh		51.3			40.2			68.1			71.3	
Approach LOS		D			D			E			E	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	7.5	73.1		36.2	33.9	46.7		14.8
Change Period (Y+Rc), s	6.0	6.0		5.0	6.0	6.0		4.5
Max Green Setting (Gmax), s	34.0	54.0		35.0	34.0	54.0		35.5
Max Q Clear Time (g_c+I1), s	2.8	14.3		29.8	27.3	37.2		10.2
Green Ext Time (p_c), s	0.0	6.7		1.4	0.6	3.5		0.3

Intersection Summary	
HCM 2010 Ctrl Delay	52.8
HCM 2010 LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	655	455	245	375	210	425	1230	305	160	910	70
Future Volume (vph)	130	655	455	245	375	210	425	1230	305	160	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.91		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	1513	4115		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	1513	4115		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	668	464	250	383	214	434	1255	311	163	929	71
RTOR Reduction (vph)	0	0	29	0	67	0	0	0	66	0	5	0
Lane Group Flow (vph)	133	668	435	250	530	0	434	1255	245	163	995	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.0	35.1	62.3	20.5	38.6		27.2	53.6	74.1	19.8	41.2	
Effective Green, g (s)	19.5	37.6	69.8	23.0	41.1		31.2	55.6	79.1	21.8	43.2	
Actuated g/C Ratio	0.13	0.25	0.47	0.15	0.27		0.21	0.37	0.53	0.15	0.29	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	196	758	630	231	1127		610	1612	714	219	1239	
v/s Ratio Prot	0.09	c0.22	0.15	c0.17	0.13		0.15	c0.29	0.05	c0.11	c0.23	
v/s Ratio Perm			0.17						0.13			
v/c Ratio	0.68	0.88	0.69	1.08	0.47		0.71	0.78	0.34	0.74	0.80	
Uniform Delay, d1	62.3	54.1	31.6	63.5	45.4		55.2	41.8	20.5	61.4	49.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.83	0.40	0.26	1.00	1.00	
Incremental Delay, d2	9.0	11.7	3.2	82.8	0.3		2.6	2.6	0.2	12.8	3.9	
Delay (s)	71.2	65.7	34.7	146.3	45.7		103.7	19.4	5.4	74.3	53.3	
Level of Service	E	E	C	F	D		F	B	A	E	D	
Approach Delay (s)		54.9			75.4			35.5			56.3	
Approach LOS		D			E			D			E	

Intersection Summary			
HCM 2000 Control Delay	51.2	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	88.5%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2015 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	40	10	400	50	400	20	1390	330	310	1260	40
Future Volume (vph)	70	40	10	400	50	400	20	1390	330	310	1260	40
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.89		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2938		1377	2560		1513	4349	1354	1513	4329	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2938		1377	2560		1513	4349	1354	1513	4329	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	41	10	408	51	408	20	1418	337	316	1286	41
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	134	0	2	0
Lane Group Flow (vph)	71	42	0	306	310	0	20	1418	203	316	1325	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	156		385	716		40	1739	532	282	2424	
v/s Ratio Prot	c0.05	0.01		c0.22	0.12		0.01	c0.33		c0.21	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.27		0.79	0.43		0.50	0.82	0.38	1.12	0.55	
Uniform Delay, d1	70.6	68.2		50.0	44.2		72.0	40.1	32.5	61.0	20.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.82	0.69	
Incremental Delay, d2	63.6	0.9		15.5	1.9		9.5	4.3	2.1	78.4	0.5	
Delay (s)	134.1	69.1		65.5	46.1		81.5	44.4	34.5	128.7	15.0	
Level of Service	F	E		E	D		F	D	C	F	B	
Approach Delay (s)		106.9			53.0			43.0			36.9	
Approach LOS		F			D			D			D	

Intersection Summary			
HCM 2000 Control Delay	44.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	89.5%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2017 counts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰↰	↑↱		↰↰	↑	↱	↰	↱	
Traffic Volume (veh/h)	20	435	235	505	785	20	205	30	325	20	70	10
Future Volume (veh/h)	20	435	235	505	785	20	205	30	325	20	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1604	1604	1604	1604	1604	1700	1604	1604	1604	1604	1604	1700
Adj Flow Rate, veh/h	23	494	0	574	892	23	233	34	164	23	80	11
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Percent Heavy Veh, %	6	6	6	6	6	6	6	6	6	6	6	6
Cap, veh/h	39	716	470	714	1367	35	326	326	605	39	136	19
Arrive On Green	0.03	0.24	0.00	0.24	0.45	0.45	0.11	0.20	0.20	0.03	0.10	0.10
Sat Flow, veh/h	1527	3047	1363	2963	3035	78	2963	1604	1363	1527	1380	190
Grp Volume(v), veh/h	23	494	0	574	448	467	233	34	164	23	0	91
Grp Sat Flow(s),veh/h/ln	1527	1524	1363	1482	1524	1590	1482	1604	1363	1527	0	1570
Q Serve(g_s), s	1.1	10.8	0.0	13.3	16.7	16.7	5.5	1.3	5.5	1.1	0.0	4.0
Cycle Q Clear(g_c), s	1.1	10.8	0.0	13.3	16.7	16.7	5.5	1.3	5.5	1.1	0.0	4.0
Prop In Lane	1.00		1.00	1.00		0.05	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	39	716	470	714	686	716	326	326	605	39	0	154
V/C Ratio(X)	0.59	0.69	0.00	0.80	0.65	0.65	0.71	0.10	0.27	0.59	0.00	0.59
Avail Cap(c_a), veh/h	105	962	581	1221	1015	1059	732	518	768	482	0	561
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	35.1	25.4	0.0	26.0	15.6	15.6	31.3	23.6	12.8	35.1	0.0	31.4
Incr Delay (d2), s/veh	13.4	1.3	0.0	2.2	1.1	1.0	2.9	0.1	0.2	13.4	0.0	3.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	4.7	0.0	5.6	7.2	7.5	2.4	0.6	2.1	0.6	0.0	1.9
LnGrp Delay(d),s/veh	48.5	26.7	0.0	28.2	16.6	16.6	34.2	23.7	13.0	48.5	0.0	35.0
LnGrp LOS	D	C		C	B	B	C	C	B	D		C
Approach Vol, veh/h		517			1489			431			114	
Approach Delay, s/veh		27.7			21.1			25.3			37.7	
Approach LOS		C			C			C			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	6.4	20.8	23.5	22.1	14.0	13.2	7.9	37.8
Change Period (Y+Rc), s	4.5	* 6	6.0	5.0	6.0	6.0	6.0	* 5
Max Green Setting (Gmax), s	23.0	* 24	30.0	23.0	18.0	26.0	5.0	* 49
Max Q Clear Time (g_c+I1), s	3.1	7.5	15.3	12.8	7.5	6.0	3.1	18.7
Green Ext Time (p_c), s	0.0	1.0	2.3	4.3	0.6	1.1	0.0	6.4

Intersection Summary	
HCM 2010 Ctrl Delay	23.9
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	265	325	285	605	140	355	650	255	130	1050	110
Future Volume (vph)	50	265	325	285	605	140	355	650	255	130	1050	110
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.97		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2913	1303	2825	2831		2825	4185	1303	1456	4125	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2913	1303	2825	2831		2825	4185	1303	1456	4125	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	288	353	310	658	152	386	707	277	141	1141	120
RTOR Reduction (vph)	0	0	56	0	13	0	0	0	109	0	8	0
Lane Group Flow (vph)	54	288	297	310	797	0	386	707	168	141	1253	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	8.2	28.8	53.3	20.6	41.2		24.5	60.8	81.4	18.8	50.1	
Effective Green, g (s)	10.7	31.3	60.8	23.1	43.7		28.5	62.8	86.4	20.8	52.1	
Actuated g/C Ratio	0.07	0.21	0.41	0.15	0.29		0.19	0.42	0.58	0.14	0.35	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	103	607	528	435	824		536	1752	750	201	1432	
v/s Ratio Prot	0.04	0.10	c0.11	c0.11	c0.28		c0.14	0.17	0.03	0.10	c0.30	
v/s Ratio Perm			0.12						0.09			
v/c Ratio	0.52	0.47	0.56	0.71	0.97		0.72	0.40	0.22	0.70	0.88	
Uniform Delay, d1	67.2	52.1	34.3	60.3	52.4		57.0	30.5	15.5	61.6	45.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.37	0.48	1.39	1.00	1.00	
Incremental Delay, d2	4.7	0.6	1.4	5.5	23.3		3.5	0.5	0.1	10.5	6.3	
Delay (s)	71.9	52.7	35.7	65.8	75.7		81.9	15.1	21.7	72.2	52.2	
Level of Service	E	D	D	E	E		F	B	C	E	D	
Approach Delay (s)		45.6			72.9			35.3			54.2	
Approach LOS		D			E			D			D	

Intersection Summary			
HCM 2000 Control Delay	51.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	84.9%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	40	40	10	220	30	160	10	860	440	420	1230	30
Future Volume (vph)	40	40	10	220	30	160	10	860	440	420	1230	30
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.97		1.00	0.91		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1456	2827		1325	2503		1456	4185	1303	1456	4170	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1456	2827		1325	2503		1456	4185	1303	1456	4170	
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Adj. Flow (vph)	45	45	11	247	34	180	11	966	494	472	1382	34
RTOR Reduction (vph)	0	10	0	0	148	0	0	0	288	0	2	0
Lane Group Flow (vph)	45	46	0	161	152	0	11	966	206	472	1414	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	7.2	7.2		23.8	23.8		1.2	40.0	40.0	59.0	97.8	
Effective Green, g (s)	9.7	9.7		26.3	26.3		2.2	42.0	41.0	60.0	99.8	
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.01	0.28	0.27	0.40	0.67	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	94	182		232	438		21	1171	356	582	2774	
v/s Ratio Prot	c0.03	0.02		c0.12	0.06		0.01	c0.23		c0.32	0.34	
v/s Ratio Perm									0.16			
v/c Ratio	0.48	0.25		0.69	0.35		0.52	0.82	0.58	0.81	0.51	
Uniform Delay, d1	67.7	66.7		58.1	54.3		73.4	50.6	47.1	40.0	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.73	0.81	
Incremental Delay, d2	3.8	0.7		15.8	2.2		21.6	6.7	6.7	8.2	0.5	
Delay (s)	71.5	67.4		73.9	56.5		95.0	57.2	53.8	37.2	10.8	
Level of Service	E	E		E	E		F	E	D	D	B	
Approach Delay (s)		69.2			62.5			56.4			17.4	
Approach LOS		E			E			E			B	

Intersection Summary			
HCM 2000 Control Delay	38.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	72.9%	ICU Level of Service	C
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰↰	↑↱		↰↰	↑	↱	↰	↱	
Traffic Volume (veh/h)	10	950	305	355	555	30	340	60	610	40	70	10
Future Volume (veh/h)	10	950	305	355	555	30	340	60	610	40	70	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1667	1667	1667	1667	1667	1700	1667	1667	1667	1667	1667	1700
Adj Flow Rate, veh/h	10	969	0	362	566	31	347	61	316	41	71	10
Adj No. of Lanes	1	2	1	2	2	0	2	1	1	1	1	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	19	1171	720	448	1535	84	427	352	505	55	153	22
Arrive On Green	0.01	0.37	0.00	0.15	0.50	0.50	0.14	0.21	0.21	0.03	0.11	0.11
Sat Flow, veh/h	1587	3167	1417	3079	3054	167	3079	1667	1417	1587	1430	201
Grp Volume(v), veh/h	10	969	0	362	293	304	347	61	316	41	0	81
Grp Sat Flow(s),veh/h/ln	1587	1583	1417	1540	1583	1637	1540	1667	1417	1587	0	1631
Q Serve(g_s), s	0.6	26.7	0.0	11.0	10.9	10.9	10.5	2.9	17.8	2.5	0.0	4.5
Cycle Q Clear(g_c), s	0.6	26.7	0.0	11.0	10.9	10.9	10.5	2.9	17.8	2.5	0.0	4.5
Prop In Lane	1.00		1.00	1.00		0.10	1.00		1.00	1.00		0.12
Lane Grp Cap(c), veh/h	19	1171	720	448	796	823	427	352	505	55	0	175
V/C Ratio(X)	0.52	0.83	0.00	0.81	0.37	0.37	0.81	0.17	0.63	0.75	0.00	0.46
Avail Cap(c_a), veh/h	83	1580	903	704	1053	1089	672	399	545	83	0	175
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	47.2	27.5	0.0	39.8	14.6	14.6	40.2	31.1	25.6	46.0	0.0	40.3
Incr Delay (d2), s/veh	19.7	2.8	0.0	3.9	0.3	0.3	4.2	0.2	2.0	18.0	0.0	1.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	12.2	0.0	4.9	4.8	5.0	4.7	1.3	7.2	1.4	0.0	2.1
LnGrp Delay(d),s/veh	66.9	30.3	0.0	43.7	14.9	14.9	44.5	31.3	27.6	64.0	0.0	42.2
LnGrp LOS	E	C		D	B	B	D	C	C	E		D
Approach Vol, veh/h		979			959			724			122	
Approach Delay, s/veh		30.7			25.7			36.0			49.6	
Approach LOS		C			C			D			D	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	9.3	25.3	20.0	41.6	19.3	15.3	7.2	54.4
Change Period (Y+Rc), s	6.0	5.0	6.0	* 6	6.0	5.0	6.0	6.0
Max Green Setting (Gmax), s	5.0	23.0	22.0	* 48	21.0	7.0	5.0	64.0
Max Q Clear Time (g_c+I1), s	4.5	19.8	13.0	28.7	12.5	6.5	2.6	12.9
Green Ext Time (p_c), s	0.0	0.6	1.0	6.8	0.8	0.1	0.0	8.3

Intersection Summary	
HCM 2010 Ctrl Delay	31.2
HCM 2010 LOS	C

Notes

* HCM 2010 computational engine requires equal clearance times for the phases crossing the barrier.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	130	685	485	305	395	230	465	1240	435	180	910	70
Future Volume (vph)	130	685	485	305	395	230	465	1240	435	180	910	70
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0	2.5	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95		0.97	0.91	1.00	1.00	0.91	
Frt	1.00	1.00	0.85	1.00	0.94		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	3027	1354	2936	2860		2936	4349	1354	1513	4303	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	3027	1354	2936	2860		2936	4349	1354	1513	4303	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	699	495	311	403	235	474	1265	444	184	929	71
RTOR Reduction (vph)	0	0	27	0	55	0	0	0	69	0	6	0
Lane Group Flow (vph)	133	699	468	311	583	0	474	1265	375	184	994	0
Turn Type	Prot	NA	pm+ov	Prot	NA		Prot	NA	pm+ov	Prot	NA	
Protected Phases	1	6	7 9	5	2		7 9	4	5	3	8	
Permitted Phases			6						4			
Actuated Green, G (s)	17.6	38.3	67.9	11.5	32.2		29.6	57.8	69.3	21.4	44.6	
Effective Green, g (s)	20.1	40.8	75.4	14.0	34.7		33.6	59.8	74.3	23.4	46.6	
Actuated g/C Ratio	0.13	0.27	0.50	0.09	0.23		0.22	0.40	0.50	0.16	0.31	
Clearance Time (s)	5.5	5.5		5.5	5.5			5.0	5.5	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	202	823	680	274	661		657	1733	670	236	1336	
v/s Ratio Prot	c0.09	c0.23	0.16	c0.11	0.20		0.16	c0.29	0.05	c0.12	0.23	
v/s Ratio Perm			0.19						0.22			
v/c Ratio	0.66	0.85	0.69	1.14	0.88		0.72	0.73	0.56	0.78	0.74	
Uniform Delay, d1	61.7	51.7	28.4	68.0	55.7		53.9	38.3	26.4	60.8	46.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.52	0.42	0.31	1.00	1.00	
Incremental Delay, d2	7.5	8.2	2.9	95.8	13.1		2.8	2.0	0.8	15.0	2.3	
Delay (s)	69.2	59.9	31.3	163.8	68.8		85.0	18.2	8.9	75.8	48.7	
Level of Service	E	E	C	F	E		F	B	A	E	D	
Approach Delay (s)		50.1			99.9			30.8			52.9	
Approach LOS		D			F			C			D	

Intersection Summary			
HCM 2000 Control Delay	51.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.84		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	85.3%	ICU Level of Service	E
Analysis Period (min)	15		
Description: 2040 forecasts			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	70	50	10	410	60	430	20	1390	340	340	1270	50
Future Volume (vph)	70	50	10	410	60	430	20	1390	340	340	1270	50
Ideal Flow (vphpl)	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625	1625
Total Lost time (s)	3.0	3.0		3.0	3.0		3.0	3.0	4.0	3.0	3.0	
Lane Util. Factor	1.00	0.95		0.91	0.91		1.00	0.91	1.00	1.00	0.91	
Frt	1.00	0.98		1.00	0.89		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1513	2953		1377	2559		1513	4349	1354	1513	4325	
Flt Permitted	0.95	1.00		0.95	0.99		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1513	2953		1377	2559		1513	4349	1354	1513	4325	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	71	51	10	418	61	439	20	1418	347	347	1296	51
RTOR Reduction (vph)	0	9	0	0	251	0	0	0	138	0	3	0
Lane Group Flow (vph)	71	52	0	322	345	0	20	1418	209	347	1344	0
Turn Type	Split	NA		Split	NA		Prot	NA	Perm	Prot	NA	
Protected Phases	7	7		8	8		1	6		5	2	
Permitted Phases									6			
Actuated Green, G (s)	5.5	5.5		39.5	39.5		3.0	58.0	58.0	27.0	82.0	
Effective Green, g (s)	8.0	8.0		42.0	42.0		4.0	60.0	59.0	28.0	84.0	
Actuated g/C Ratio	0.05	0.05		0.28	0.28		0.03	0.40	0.39	0.19	0.56	
Clearance Time (s)	5.5	5.5		5.5	5.5		4.0	5.0	5.0	4.0	5.0	
Vehicle Extension (s)	3.0	3.0		4.0	4.0		3.0	4.0	4.0	3.0	4.0	
Lane Grp Cap (vph)	80	157		385	716		40	1739	532	282	2422	
v/s Ratio Prot	c0.05	0.02		c0.23	0.13		0.01	c0.33		c0.23	0.31	
v/s Ratio Perm									0.15			
v/c Ratio	0.89	0.33		0.84	0.48		0.50	0.82	0.39	1.23	0.56	
Uniform Delay, d1	70.6	68.4		50.8	44.9		72.0	40.1	32.7	61.0	21.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	0.93	0.89	
Incremental Delay, d2	63.6	1.2		19.0	2.3		9.5	4.3	2.2	121.2	0.6	
Delay (s)	134.1	69.6		69.8	47.2		81.5	44.4	34.8	177.6	19.2	
Level of Service	F	E		E	D		F	D	C	F	B	
Approach Delay (s)		104.3			55.1			43.0			51.7	
Approach LOS		F			E			D			D	

Intersection Summary			
HCM 2000 Control Delay	50.5	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	92.7%	ICU Level of Service	F
Analysis Period (min)	15		
Description: 2040 forecast			
c Critical Lane Group			

Appendix E

Secured Funding Letters

SRTC SPOKANE REGIONAL TRANSPORTATION COUNCIL
421 W. RIVERSIDE AVE. SUITE 500 • SPOKANE WA 99201 • 509.343.6370 • WWW.SRTC.ORG

December 20, 2018

2018 STBG Funding Award - $1,890,000 for ROW

The Honorable Rod Higgins
City of Spokane Valley
11707 E Sprague Ave
Spokane Valley WA 99206

Project: Pines Grade Separation – Right of Way Phase
Award Amount: $1,890,000
Program: Urban Surface Transportation Block Grant (STBG)

Dear Mayor Higgins;

Congratulations! On November 8, 2018, the Spokane Regional Transportation Council (SRTC) Board of Directors selected City of Spokane Valley's Pines Grade Separation-Right of Way Phase project for funding as part of the 2018 SRTC Call for Projects. Thank you for you and your staffs' hard work.

SRTC is excited to offer City of Spokane Valley a partial funding award of $1,890,000 from the Urban STBG program.

This project will be included in the 2019-2022 SRTC Transportation Improvement Program (TIP) amendment for Board consideration at the January 18, 2019 Board meeting. Once the TIP Amendment is approved, it will be included in the State Transportation Improvement Program (STIP.) After the funding is programmed into the STIP, you may seek obligation of the federal funds through WSDOT Local Programs consistent with the funding policies outlined in the most current SRTC TIP Guidebook.

Attached is an Acceptance of Funding Agreement outlining conditions of the award that must be signed by an official having authority. **Please the attached agreement no later than January 16, 2018**. Again, congratulations and we look forward to working with the City of Spokane Valley. If you have any questions, please do not hesitate to contact me at (509) 343-6370 or at sminshall@srtc.org.

Sincerely,

Sabrina C Minshall

Sabrina C. Minshall, AICP
Executive Director, Spokane Regional Transportation Council

cc: Arne Woodard, Council Member, City of Spokane Valley
Adam Jackson, City of Spokane Valley
Keith Martin, WSDOT-Eastern Region Local Programs

SRTC SPOKANE REGIONAL TRANSPORTATION COUNCIL
421 W. RIVERSIDE AVE. SUITE 500 • SPOKANE WA 99201 • 509.343.6370 • WWW.SRTC.ORG

2018 STBG Funding Award - $1,890,000 for ROW

Agency: City of Spokane Valley
Address: 11707 E Sprague Ave, Spokane Valley, WA 99206
Project: Pines Grade Separation – Right of Way Phase
Award Amount: $1,890,000
Partial Award: Yes
Program: Urban Surface Transportation Block Grant
Elected Official Contact: Mayor Rod Higgins
SRTC Board Member(s) Council Member Arne Woodard
Staff Member: Adam Jackson

Conditions of Award:

- All programming is subject to the SRTC TIP Guidebook. The TIP Guidebook is updated yearly.
- Eligible activities and conditions are subject to all federal, state, and laws, regulations, and Board guidance
- The project must be delivered in its entirety per the description in the original application unless scope or other changes are approved in writing by SRTC.
- If a partial award, the applicant is responsible for securing all additional funds on the project in addition to local match. If the award is a full award, the applicant is responsible for securing all required match.
- Availability of local funds must be demonstrated for the year the project is programmed.
- If a project receives a partial funding award, and is unable to secure additional, non-local funds for the project prior to delivery, programming may be delayed upon request with approval of the SRTC Board, and agencies can re-submit under a subsequent call for projects; additional funding is not guaranteed.
- Any change of use of SRTC funds for phases (PE, ROW, CN), or geographical segments of a project must be approved in writing and in advance of changes so administrative modifications or amendments can be made. This applies to changes necessitated by reasons such as but not limited to the securing of additional fund sources, costs savings or increases, or design modifications.

Agreed to and Approved:

Mark Calhoun

~~Mayor Rod Higgins~~ Mark Calhoun
City of Spokane Valley City Manager

1/11/2019
Date

Sabrina C. Minshall

Sabrina C. Minshall, AICP, Executive Director
Spokane Regional Transportation Council

12-20-18
Date

SPOKANE REGIONAL TRANSPORTATION COUNCIL
421 W. RIVERSIDE AVE. SUITE 500 • SPOKANE WA 99201 • 509.343.6370 • WWW.SRTC.ORG

February 13, 2020 2020 STBG Funding Award - 1,905,000 for ROW

The Honorable Ben Wick
City of Spokane Valley
10210 E Sprague Ave
Spokane Valley WA 99206

Project: Pines Grade Separation RW
Award Amount: $1,905,~~100~~ 000 AJ
Program(s): Urban Surface Transportation Block Grant (STBG)

Dear Mayor Wick;

Congratulations! On February 13, 2020, the Spokane Regional Transportation Council (SRTC) Board of Directors selected City of Spokane Valley's Pine Grade Separation RW project for funding as part of the SRTC contingency funding process. This project previously received funding in the 2018 SRTC Call for Projects and was awarded partial funding of $1,890,000. This supplemental funding completes the award request for this project.

SRTC is excited to offer City of Spokane Valley an award of $1,905,~~100~~ 000 AJ from the Urban STBG program.

This project will be included in the 2020-2023 SRTC Transportation Improvement Program (TIP) amendment for Board consideration at the April 9, 2020 Board meeting. Please submit your project record into Secure Access Washington (SAW) by March 6, 2020. Once the TIP Amendment is approved, it will be included in the State Transportation Improvement Program (STIP.) After the funding is programmed into the STIP, you may seek obligation of the federal funds through WSDOT Local Programs consistent with the funding policies outlined in the most current SRTC TIP Guidebook.

Attached is an Acceptance of Funding Agreement outlining conditions of the award that must be signed by an official having authority. **Please sign and return the attached agreement no later than February 29, 2020**. Again, congratulations and we look forward to working with the City of Spokane. If you have any questions, please do not hesitate to contact me at (509) 343-6370 or at sminshall@srtc.org.

Sincerely,

Sabrina C. Minshall

Sabrina C. Minshall, AICP
Executive Director, Spokane Regional Transportation Council

cc: Gloria Mantz, City of Spokane Valley
Adam Jackson, City of Spokane Valley
Keith Martin, WSDOT-Eastern Region Local Programs

SRTC SPOKANE REGIONAL TRANSPORTATION COUNCIL

421 W. RIVERSIDE AVE. SUITE 500 - SPOKANE WA 99201 - 509.343.6370 - WWW.SRTC.ORG

2020 STBG Funding Award - 1,905,000 for ROW

Agency: City of Spokane Valley
Address: 10210 E Sprague Ave
Project: Pines Grade Separation RW
Award Amount: $1,905,~~100~~ 000 AJ
Partial Award: No
Program(s): Urban Surface Transportation Block Grant (STBG)
Elected Official Contact: Mayor Ben Wick
SRTC Board Member(s): Mayor Ben Wick
Staff Member: Gloria Mantz

Conditions of Award:

- All programming is subject to the SRTC TIP Guidebook. The TIP Guidebook is updated yearly.
- Eligible activities and conditions are subject to all federal and state laws and regulations, and SRTC Board guidance.
- The project must be delivered in its entirety per the description in the original application unless scope or other changes are approved in writing by SRTC.
- If a partial award, the applicant is responsible for securing all additional funds on the project in addition to local match. If the award is a full award, the applicant is responsible for securing all required match.
- Availability of local funds must be demonstrated for the year the project is programmed.
- If a project receives a partial funding award, and is unable to secure additional, non-local funds for the project prior to delivery, programming may be delayed upon request with approval of the SRTC Board, and agencies can re-submit under a subsequent call for projects; additional funding is not guaranteed.
- HIP funding must be obligated no later than September 30, 2022.
- Any change of use of SRTC funds for phases (PE, ROW, CN), or geographical segments of a project must be approved in writing and in advance of changes so administrative modifications or amendments can be made. This applies to changes necessitated by reasons such as, but not limited to, the securing of additional fund sources, costs savings or increases, or design modifications.

Agreed to and Approved:

Mark Calhoun

~~Mayor Ben Wick~~ MARK CALHOUN
City of Spokane Valley CITY MANAGER

2/23/2020
Date

Sabrina C. Minshall

Sabrina C. Minshall, AICP, Executive Director
Spokane Regional Transportation Council

2-19-2020
Date

2019 CRISI award email - $1,246,500 for PE/NEPA - no formal FRA documents have been issued to date.

Adam Jackson

From: Kniss, Valarie (FRA) <Valarie.Kniss@dot.gov>
Sent: Thursday, June 13, 2019 7:53 AM
To: Mark Calhoun; Adam Jackson
Cc: Maldonado, Leonardo (FRA)
Subject: Pines Road/BNSF Grade Separation Project (FY18 CRISI) - Notification of Award

Importance: High

Hello,

Congratulations on your recent award for the **Pines Road/BNSF Grade Separation** (Project), under the Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program.

Federal Railroad Administration Announces More Than $326 Million in Grants to Support Railroad Infrastructure (June 12, 2019): https://railroads.dot.gov/newsroom/federal-railroad-administration-announces-more-326-million-grants-support-railroad

The Federal Railroad Administration's Office of Railroad Policy and Development (RPD) is responsible for overseeing this Project. More information on the Office is available here: https://www.fra.dot.gov/Page/P0031

Please find our contact information below:

- **FRA Regional Manager** (Primary Point of Contact)
  - Valarie Kniss
  - 202.493.0616
  - valarie.kniss@dot.gov
- **FRA Grant Manager**
  - Leo Maldonado
  - 202-493-6369
  - leonardo.maldonado@dot.gov

Next Steps

- **Point of Contact:** Please provide contact information (name, email, phone number) for the primary point of contact/project manager for this Project.
- **Project Kickoff Meeting:** A kickoff meeting will be scheduled to review the grant obligation process. I will send a follow-up email identifying potential dates for your selection.
- **Statement of Work Review / Development:** Please send me the Statement of Work that was included in your Application as a Word document so that FRA can begin preparing the SOW for obligation.

We are looking forward to getting started on this exciting project! Please let me know if you have any questions.

Best,
Valarie

Valarie Kniss
Northwest Regional Manager

Office of Program Delivery (RPD-15)
Federal Railroad Administration
O: 202.493.0616 | C: 202.430.9643
valarie.kniss@dot.gov

2019 CRISI award email - $1,246,500 for PE/NEPA - no formal FRA documents have been issued to date.

FMSIB Funding: 2000 Award, currently in deferred status.

FMSIB Priority Ranking: D

Current Estimated Cost (09/15/04)

Total Project Cost: $ 11,719

Dollars (in thousands)

FMSIB Share: $ 3,360

Project: **SR 27 Pines Rd BNSF Grade Crossing**

Location: Spokane Co

Lead Agency: WSDOT - Eastern

Geog. Area: EW

Scope: The project is located on SR 27 (Pines Rd) immediately south of SR 290 in Spokane County. The project will separate the railroad and roadway grades by constructing a railroad bridge over SR 27 and lowering the SR 27 grade. The project is designed to reduce truck and train delays by means of a railroad grade separation on a Spokane Valley arterial. This crossing is an intergral part of Spokane's Bridging the Valley Tranportation Study which identifies this location as a high priority grade separtion project.

Original Approved Amount

Freight Mobility	**$3,360**	**30%**
Partnership	$7,840	70%
TOTAL Project Cost	$11,200	100%

Partnerships:

	Anticipated	Committed	Dollars
WSDOT Funds**	X		7,714
BNSF	X		645
Partnership Total			8,359

	Total	PE	RW	CN
FMSIB	*3,360*			*3,360*
WSDOT Funds**	*7,714*	*1,000*	*1,075*	*5,639*
	-			
BNSF	*645*		*215*	*430*
	-			
Need	*11,719*	*1,000*	*1,290*	*9,429*
Total	**11,719**	**1,000**	**1,290**	**9,429**
Tentative timeframe	Ad-2008 CN start-2008	Complete 8/08	Complete 6/08	Complete 10/09

Cash Flow Needs:

Dollars (in thousands)		Prior	03 - 05	05 - 07	07 - 09	09 - 11	11 - 13	TOTAL
P.E. Phase	Total			448	552			1,000
	Freight Mobility							0
R.W. Phase	Total			353	937			1,290
	Freight Mobility							0
CN. Phase	Total				7,259	2,170		9,429
	Freight Mobility				1,680	1,680		3,360

Freight Mobility TOTAL	**$3,360**	**29%**
Partnership TOTAL	$8,359	71%
TOTAL Project Cost	$11,719	100%

** WSDOT funding for this freight mobility project is dependent on future new revenue to be authorized by the State Legislature. The project start date can be adjusted to coincide with funding.

FMSIB Funding: 2000 Award, currently in deferred status.

STATE OF WASHINGTON

FREIGHT MOBILITY STRATEGIC INVESTMENT BOARD

1063 Capitol Way, Rm. 201 • PO Box 40965 • Olympia, WA 98504-0965 • (360) 586-9695 • FAX (360) 586-9700

November 27, 2000

Mr. Harold White
WSDOT Eastern Region
2714 N. Mayfair Street
Spokane, WA 99207

Dear Mr. White,

The Freight Mobility Board thanks you for submitting a project for consideration during the 2000 call for projects. The scoring has been completed and the project selection committee made a recommendation to the full FMSIB.

The Board adopted the 10 highest scoring new projects to be added to the existing list of 33 freight mobility projects. These projects will become projects 34-43. These projects will retain their status even after a future call adds additional projects.

An additional 9 projects were added to make a total of 19 new freight mobility projects.

The FMSIB share of these projects is shown in the revised request column and total $132.8 M. or 32.7 % of total project costs.

Some projects that were not on a strategic freight corridor were evaluated as to whether they represented an emerging corridor. Two projects were accepted as emerging and five were not accepted as meeting the threshold criteria.

Two projects were studies, and the board determined that at this time, studies would not be considered since our resources were so limited.

One project was deemed to not have incremental value to freight movement, and appeared to return freight capacity to what existed before passenger rail service, thus mitigating the impact of passenger rail. The board did not believe this was the role of the Freight Mobility program.

FMSIB Funding: 2000 Award, currently in deferred status.

If your project was one of the top 19, congratulations, I look forward to working with you as we build the improvements in your area.

If your project was not one of the 19 selected, we want to thank you again for submitting your project for the board's consideration. We hope that in the future we will have a chance to approve a corridor or chokepoint project in your area. Corridors, and multiple partners, especially private sector financial commitments, score well in our process when considering a future submission. I would be happy to work with you if you have a project developing that is beneficial to freight movement.

Thank you again for your interest in our Freight Mobility Program.

Cordially,

Karen Schmidt

Karen Schmidt
Executive Director

Enc. – Project Selection Recommendation list

FMSIB Funding: 2000 Award, currently in deferred status.

If this relates to the Burlington Northern Pines Road Bridging the Valley separation that includes a FMSIB $3.36 million match of the approx $26 million estimate, we do not have funding in our current program, or for the next few years, for construction. If it is FMSIB's intent to move this money to another project, may I suggest the Havana or Park Road structures that are also within your program.

From: Gehring, Marsha
Sent: Wednesday, October 17, 2007 4:13 PM
To: Lenzi, Jerry C
Subject: Pines Road Project
Importance: High

I would like to set up a meeting **on October 29** to discuss the status of the Pines Road FMSIB project. I am interested in a status report on the progress of the project and the current funding plan. Please coordinate a time that would work for you with Marsha in my office (360) 586-9695 and I will leave it to you to decide who on your staff should be part of the meeting.

Thanks,

Karen

Karen Schmidt
Executive Director

1063 Capitol Way, Room 201
P.O.Box 40965
Olympia, WA 98504-0965
360 586-9695