Concept Design and Comparison Report

For

160TH AND GREENWOOD / INNIS ARDEN INTERSECTION DESIGN

Contract No. 9250

November 1, 2019

Prepared By: KPFF Consulting Engineers

For

City of Shoreline

17500 Midvale Avenue North

Shoreline, WA 98133

(206) 801-2700

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Design Report

October 15, 2019

Prepared for:

City of Shoreline
17500 Midvale Avenue North
Shoreline, WA 98133
(206) 801-2700

Prepared by:

Nathan Anderson, PE
KPFF Consulting Engineers
1601 Fifth Avenue, Suite 1600
Seattle, WA 98101
(206) 622-5822

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1. Introduction

The City of Shoreline (City), in cooperation with the Shoreline Community College (SCC), plans to improve the existing intersection of Greenwood Avenue North / North 160th Street / Innis Arden Way in response to SCC's current and planned campus development. Based on an agreement between the City and SCC, intersection improvements need to be constructed by 2025. In the interim, SCC plans to construct frontage improvements until the full intersection improvements can be made.

The intent of this project is to study the effectiveness of a roundabout (RAB) option to handle future traffic demands, provide access for non-motorized users, estimate costs, and identify impacts to the project area. (See Figure 1-1 for project location map.)

The primary goals for the project are:

- Improve safety and mobility of the intersection for all modes.
- Identify a preferred alternative for the intersections of Greenwood Avenue North / North 160th Street / Northwest Innis Arden Way intersection control. Complete a 10% design for the preferred alternative. The design shall support the projected 2040 volumes shown in the SSC Transportation Technical Report.
- Complete outreach to the community and major stakeholders to inform the selection of a preferred concept.
- Develop detailed cost estimates for signalized and roundabout intersection options. The cost estimates should include all phases including design, right-of-way, and construction.

SCC conducted a transportation study and issued a Transportation Technical Report in October 2018. The report studied a signalized intersection option for Greenwood Avenue North / North 160th Street / Innis Arden Way, and additional improvements are required to support SCC campus development. Key findings from the report are included in this document and are compared to the analysis results of the roundabout option.

The following are the primary project stakeholders:

- The City of Shoreline
- Shoreline Community College
- Highland Terrace Neighborhood
- Shoreline Public Schools (SPS)
- Shoreline Fire Department
- King County Metro
- Community Renewal Area (CRA)

Figure 1-1: Project Location Map

2. Existing Conditions

The project area consists of an offset, stop-controlled intersection that connects the SCC, nearby residential areas, and the regional commercial area along State Route 99. Each leg of the intersection is a collector arterial and experiences significant queueing during morning and afternoon peaks. There are sidewalks and marked crosswalks on all legs. Bike lanes are planned for 160th as part of a future project. The area is heavily wooded with adjacent residential parcels on the east and south; to the west are undeveloped parcels owned by the SCC and Highland Terrace Elementary School (School).

3. Design Approach

KPFF engineers were tasked to develop up to three roundabout alternative concepts, perform analysis of these concepts, establish evaluation criteria, and work with City staff to select a preferred alternative. The preferred alternative then moved forward into a 10% design phase.

The following design criteria were used throughout the design process:

Table 3-1: Design Criteria and Constraints

Design Speed	35 miles per hour (mph) approach, 20 mph for RAB
Design Vehicle	60-foot articulated KC Metro bus
Classification	Collector arterial
Right-of-Way	Avoid right-of-way (ROW) acquisition from residential properties east and south of the intersection
Engineering Standards	Shoreline Engineering Development Manual (EDM)
Stormwater Manual	Shoreline EDM, 2019 Deptartment of Ecology Stormwater Management Manual for Western Washington (SMMWW)

4. Roundabout Alternative Analysis

KPFF worked with the City to develop two roundabout alternatives. A third option was explored but was ultimately determined not to be viable. The main constraints of the designs were avoiding right-of-way (ROW) takes from the residential parcels to the east and south and turning movements of 60-foot King County (KC) Metro buses. Both alternatives combined the two existing offset intersections into one roundabout. The traditional circular RAB shape was squeezed in the center to form a teardrop-style RAB in order to avoid ROW impacts. Evaluation criteria were established for scoring the alternatives. See Table 1 below for the Evaluation Matrix.

Turning movements were simulated for the design vehicle and were used to identify ideal locations for truck aprons. The 60-foot KC Metro bus will be able to fully navigate all movements of the roundabouts. In many cases, the back wheels will need to use the truck aprons, but will not encroach on the 6-inch vertical curb.

Roundabout Alternative Descriptions:

1. **Alternative A** maintains the existing eastbound and westbound lanes on Innis Arden. This allows the existing bus stop on eastbound Innis Arden to be maintained. This requires a larger overall footprint.
2. **Alternative B** combines the east- and westbound movement on Innis Arden into the current eastbound lanes. This will require a new bus pullout and shelter to be constructed on eastbound Innis Arden. The overall footprint of this option is smaller than Alternative A.

The scoring for each criteria used a scale from 1 to 5, where 1 is the least desirable outcome and 5 is the most desirable outcome.

Table 4-1 Evaluation Matrix

Criteria	Alternative A	Alternative B	Notes
Maintenance Cost	3	3	Alternative A has slightly more hardscape areas; however, it is our opinion that the difference is negligible when comparing long-term maintenance cost.
Construction Cost	3	4	Alternative A Construction Cost: $1.54 M Alternative B Construction Cost: $1.45 M See attached itemized cost estimates.
Safety	4	5	Alternative B has a shorter vehicular travel path through the RAB, and will allow less acceleration time before crossing the crosswalks.
Traffic Operations	3	3	Both alternatives will function similarly. No major queuing differences were identified.
Right-of-Way Impacts	2	1	Both alternatives avoid ROW impacts from the residential parcels to the east and south of the intersection. However, Alternative A will have a smaller impact on the School property.
Environmental Impact	2	2	Alternative A impacts six large trees on School district property, and Alternative B impacts five, but provides place-making and tree-planting opportunities on Innis Arden Way.
Utility Impacts	1	2	Both RAB alternatives impact the electrical undergrounding limits equally. Alternative B may allow Seattle City Light (SCL) to keep pole in center island.
Frontage Impacts	3	3	Both alternatives impact some of the frontage improvements within the intersection, but each leg of the RABs can tie into new frontages past the intersection.
Total	**21**	**23**	

The City identified **Alternative B** as the preferred roundabout alternative. The smaller travel paths for vehicles should reduce speeds at the crosswalks and produce safer pedestrian movements and shorter travel times. There is a cost savings with Alternative B due to the smaller footprint. In addition, it provides an opportunity to convert existing pavement on westbound Innis Arden to green space. (See Appendix A for a drawing of the preferred roundabout alternative.)

5. 10% Design of Preferred Roundabout Option

The team advanced the preferred roundabout alternative to a 10% design level. This work included the design elements listed below:

- Updates to sidewalk and crosswalk locations.
- Impacts to trees and utilities.
- Stormwater requirements.
- Estimate of construction costs. (See Appendix D.)
- Preparation of 10% design plans. (See Appendix C.)
- Traffic analysis with VISSIM modeling. (See Appendix E.)

The design work was completed with AutoCAD 2017 software and a survey basemap provided by SCC. Additionally, design files for the SCC's frontage improvements in the project area (constructed in 2019) were used to determine potential impacts to existing infrastructure.

Figure 5-1: Roundabout Option (see Appendix A for larger figure)

RIGHT-OF-WAY

The preliminary roundabout design avoids ROW acquisition from the residential parcel to the east and south of the intersection. However, Temporary Construction Easements (TCE) may be needed to construct the project.

ROW acquisition will be needed from the Shoreline School District for the parcel on the west side of the intersection. Our preliminary estimate is that **2,800 square feet** will needed.

UTILITY IMPACTS

The following utilities are located within the project area:

- Overhead power (Seattle City Light) along Greenwood Avenue North and North 160th Street with three poles in close vicinity to existing intersection.
- Gas lines (Puget Sound Energy) on North 160th Street, Greenwood Avenue North, and Northwest Innis Arden Way.
- Sanitary mains and service connections (Ronald Waste Water District) on North 160th Street and Greenwood Avenue North.
- Water mains and service connections (Seattle Public Utilities) on North 160th Street, Greenwood Avenue North, and Northwest Innis Arden Way.
- Storm drainage catch basins and a 12-inch trunkline that runs along the west side of Greenwood Avenue from south to north.

We are anticipating impacts to the overhead power poles at the northeast and southwest corners of the Greenwood Avenue North and North 160th Street intersection. The two poles (and one guy pole) will likely need to be relocated to construct the proposed sidewalk. There is also a pole located within the island of the proposed roundabout about that has both north-south and east-west connections. While there is no apparent conflict with its current location, further coordination with Seattle City Light (SCL) will be needed to confirm access requirements.

No major gas, water, or sanitary impacts are anticipated. Castings will need to be raised to grade and meter boxes may need to be adjusted.

STORM DRAINAGE

The project area consists of one Threshold Discharge Area (TDA), which is located in the Boeing Creek watershed. The proposed work includes constructing roadway pavement, curb and gutter, and sidewalk that will create new hard surfaces and replace some existing hard surfaces. The stormwater requirements for the project were determined using the 2019 Department of Ecology Stormwater Management Manual for Western Washington (SMMWW). Per the SMMWW Figure 1-3.2 flowchart (see Appendix E), Minimum Requirements (MR) 1-5 will apply to both new and replaced hard surfaces. The proposed design will create less than 5,000 square feet of new hard surfaces; therefore, Minimum Requirements 6-9 will not apply to any project surfaces. However, the city may choose to exceed the minimum requirements during final design. See Table 5-1 for a surface area summary and Appendix E for a Surface Area Figure.

Table 5-1: Surface Area Summary

New Hard Surface	4,010 square feet
Replaced Hard Surface	10,100 square feet
New Pollution-Generating Hard Surface	1,900 square feet
Existing Hard Surface	38,600 square feet

Note: Per SMMWW, asphalt overlay does not count as replaced impervious surface.

The new geometrics of the intersection will require additional catch basins and conveyance pipes to capture surface runoff on the upstream side of each curb ramp. These catch basins will be connected to the existing 12-inch trunkline that flows north on Greenwood Avenue North.

Minimum Requirement 5, is discussed in more detail below. Minimum Requirements 1-4 will need to be addressed during the Final Design.

Minimum Requirement 5 – On-Site Stormwater Management

Section 1-3.4.5 of the SMMWW provides a list of Best Management Practices (BMPs) for compliance with Minimum Requirement (MR) 5. BMP feasibility for this project:

- Dispersion is not a viable option for this site due to the narrow ROW corridor and built-up urban environment.
- Per City requirements, permeable pavement is not allowed within the ROW without a special exception from the Public Works Director.
- There are potential opportunities for bioretention in the open space adjacent to the multi-use path on Innis Arden Way, and within the roundabout island. A geotechnical investigation should be completed to determine if the native soils have the potential for infiltration.

TRANSIT

King County Metro operates routes 5, 330, 331, 345, and 355 through the project intersection. The roundabout has been designed to accommodate a 60-foot articulated Metro bus. Truck aprons will be needed to allow buses to navigate the roundabout without striking fixed objects or non-motorized users. There is currently a bus stop on the eastbound Innis Arden Way approach to the roundabout, and the current design does not include a bus pull-out. Future coordination will be needed to determine whether this bus stop will be relocated or if design modifications need to be made.

6. Signalized Option

The signalized option was developed as part of the SCC's intersection study in the Transportation Technical Report in October 2018 (Figure 6-1). A cost estimate was prepared for the signalized option; however, a multi-use path (10- to 12-foot width) was added to the east side of Greenwood Avenue and the north side of Innis Arden Way to match the path included in the roundabout option. Additional project elements and impacts are discussed below.

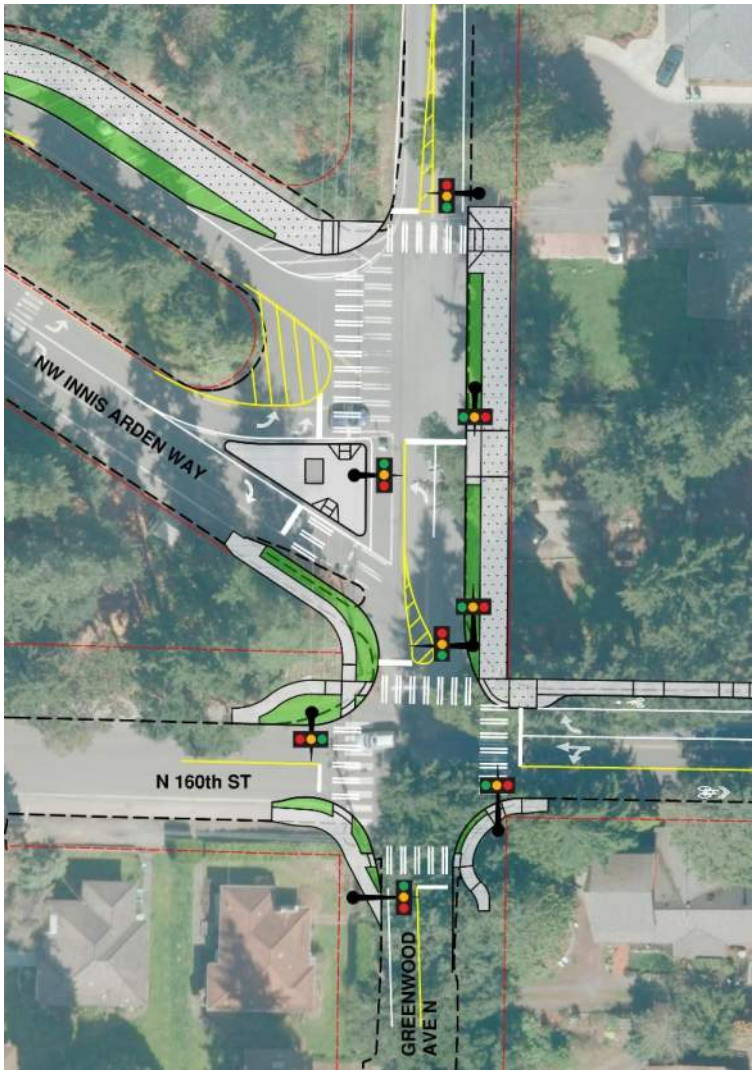


Figure 6-1: Signal Option (see Appendix B for larger figure)

RIGHT-OF-WAY

No ROW acquisitions are anticipated for construction of this option.

UTILITY IMPACTS

No major power, gas, water, or sanitary impacts are anticipated. Castings will need to be raised to grade and meter boxes may need to be adjusted.

STORM DRAINAGE

The stormwater requirements for the project were determined using the 2019 Department of Ecology Stormwater Management Manual for Western Washington (SMMWW). Per the SMMWW Figure 1-3.2 flowchart (see Appendix E), Minimum Requirements 1-5 will apply to both new and replaced hard surfaces. The new hard surfaces will be less than 5,000 square feet, and therefore Minimum Requirements 6-9 (including water quality treatment and flow control) do not apply to new or replaced surfaces. MR 1-5 will need to be addressed during the final design.

It is anticipated that new catch basins will be needed upstream of curb ramps and conveyance pipes will need to connect them to the existing 12-inch trunkline that flows north on Greenwood Avenue North.

TRANSIT

Existing King County bus operations and facilities are not expected to be impacted by this project.

7. Traffic Analysis

A traffic operations analysis was performed by Fehr & Peers and completed for the preferred roundabout alternative and the signal alternative for the project area. A memorandum summarizing the analysis and results can be found in Appendix F. The following intersections were studied:

- Greenwood Avenue / 160th Street
- Greenwood Avenue / Innis Arden Way
- Dayton Avenue / 160th Street

ANALYSIS RESULTS

Table 7-1: Existing (2018) Analysis Results By Intersection– Delay / LOS

Peak Hour	Intersection	Roundabout Alternative	Signal Alternative
AM	Greenwood Avenue / Innis Arden Way[2]	9 / A	16 / B
	Greenwood Avenue / 160th Street[2]		21 / C
	Dayton Avenue / 160th Street	12 / B	19 / B
MID	Greenwood Avenue / Innis Arden Way[2]	11 / B	16 / B
	Greenwood Avenue / 160th Street[2]		12 / B
	Dayton Avenue / 160th Street	10 / B	21 / C
PM	Greenwood Avenue / Innis Arden Way[2]	9 / A	12 / B
	Greenwood Avenue / 160th Street[2]		17 / B
	Dayton Avenue / 160th Street	11 / B	16 / B

1. Delay / LOS likely understated due to upstream metering.
2. Intersections analyzed as one intersection under Roundabout Alternative.

Table 7-2: Future (2040) Analysis Results By Intersection – Delay / LOS

Intersection	Peak Hour	Roundabout Alternative	Signal Alternative
AM	Greenwood Avenue / Innis Arden Way[2]	58 / F[3]	36 / D
	Greenwood Avenue / 160th Street[2]		81 / F
	Dayton Avenue / 160th Street	18 / B	18 / B
MID	Greenwood Avenue / Innis Arden Way[2]	27 / D	147 / F
	Greenwood Avenue / 160th Street[2]		36 / D1
	Dayton Avenue / 160th Street	12 / B	18 / B
PM	Greenwood Avenue / Innis Arden Way[2]	31 / D	51 / D1
	Greenwood Avenue / 160th Street[2]		136 / F
	Dayton Avenue / 160th Street	14 / B	16 / B

1. Delay / LOS likely understated due to upstream metering.
2. Intersections analyzed as one intersection under Roundabout Alternative.
3. The roundabout Alternative replaces two distinct intersections. Therefore, the delay is acceptable per City Standards.

Table 7-3: Existing (2018) Analysis Results By Combined Delay

Peak Hour	Intersection	Existing		Roundabout		Signal	
		Delay	LOS[1]	Delay	LOS[2]	Delay	LOS[1]
AM	Greenwood / 160 / Innis Arden	64	E	9	A	37	D
MID	Greenwood / 160 / Innis Arden	81	F	11	B	28	C
PM	Greenwood / 160 / Innis Arden	48	E	9	A	29	C

Table 7-4: Future (2040) Analysis Results By Combined Delay

Peak Hour	Intersection	Existing	Roundabout		Signal	
			Delay	LOS[2]	Delay	LOS[1]
AM	Greenwood / 160 / Innis Arden	N/A	58	F	117	F
MID	Greenwood / 160 / Innis Arden	N/A	27	D	183	F
PM	Greenwood / 160 / Innis Arden	N/A	31	D	187	F

1. LOS for Signals:
   - A ≤ 10 seconds
   - B ≤ 20 seconds
   - C ≤ 35 seconds
   - D ≤ 55 seconds
   - E ≤ 80 seconds
   - F > 80 seconds
2. RAB delay standard: delay > 35 seconds is an F rating.
3. City LOS standard is D or better in PM Peak.

TRAFFIC ANALYSIS SUMMARY

The operational analysis found that:

- The roundabout alternative resulted in equal or better operations across all scenarios analyzed.
- The roundabout experiences queues on Greenwood Avenue and Northeast 160th Street during the morning peak hour but does not affect any of the adjacent intersection.
- The signalized alternative breaks down due to queues created by the high number of vehicles turning left from Greenwood Avenue to Innis Arden Way.
- The roundabout alternative experiences level of service (LOS) F during the morning peak hour; however, it operates with less delay than the signalized alternative and combines two intersections.
- The roundabout alternative was found to operate with the least amount of delay and queuing.
- The signalized alternative does not meet the City's LOS requirements specified in SMC 20.60.140.

8. Summary of Costs

Preliminary cost estimates were prepared for the roundabout and signal options. These costs include construction, ROW acquisition, design, construction management, escalation, and other soft costs. A 30% design contingency and a 10% construction contingency have been added to the estimates. Unit costs were based on present-day WSDOT Unit Bid Analysis and recent bid tabulations. Detailed cost estimates can be found in Appendix D. The final project cost estimates are summarized in Table 8-1.

COST ASSUMPTIONS

- ROW costs are assumed to be $35 per square foot.
- For both options, the estimates include full replacement of the sidewalk on the east side of Greenwood Avenue and the north side of Innis Arden Way with a wider, concrete multi-use path.
- Storm drainage costs include catch basins at the upstream end of the crosswalk and conveyance pipes to connect to existing trunkline. A formal storm drainage design was not performed.
- SCL pole relocations were assumed to be $15k each. Coordination with SCL is needed.
- Landscaping for the roundabout was set at 5% of construction cost.
- Costs for illumination of the roundabout are shown as a lump sum. Below is an itemized list of illumination costs assumptions:
    - Pole: $7,000 x 7 ea. = $49,000
    - Luminaire Arm: $1,500 x 7 ea. = $10,500
    - Luminaire: $2,500 x 7 ea. = $17,500
    - Pole Foundation: $1,000 x 7 ea. = $7,000
    - Junction Box: $2,500 x 10 ea. = $25,000
        - Service Connection: $5,000 x 1 ls = $5,000
        - Conduit & Wiring (15%) = $17,000
        - Total = $131,000

- For the Signal Option, a 2” thick asphalt overlay was assumed for all existing pavement within the project limits. Full depth asphalt (6 inches) was used for trenching of new storm pipe and signal conduits.
    - Area HMA Overlay: 12,855 sf
    - Area of Full Depth Paving: 1,165 sf

Table 8-1: Summary of Total Project Costs

Summary of Total Project Costs		
	Roundabout	**Signalized**
Design and Administration	$233,000	$220,000
ROW	$78,000	$0
Construction	$1,886,300	$1,778,570
Total Project Costs	**$2,197,300**	**$1,998,570**

9. Conclusion

Alternative A was reviewed by the City and was determined to be the preferred roundabout alternative to move into the 10% design phase. Both the preferred roundabout alternatives and signal option were presented to the public at two Open House events in May and July 2019. The public was given an opportunity to review the options, ask questions, and provide comments.

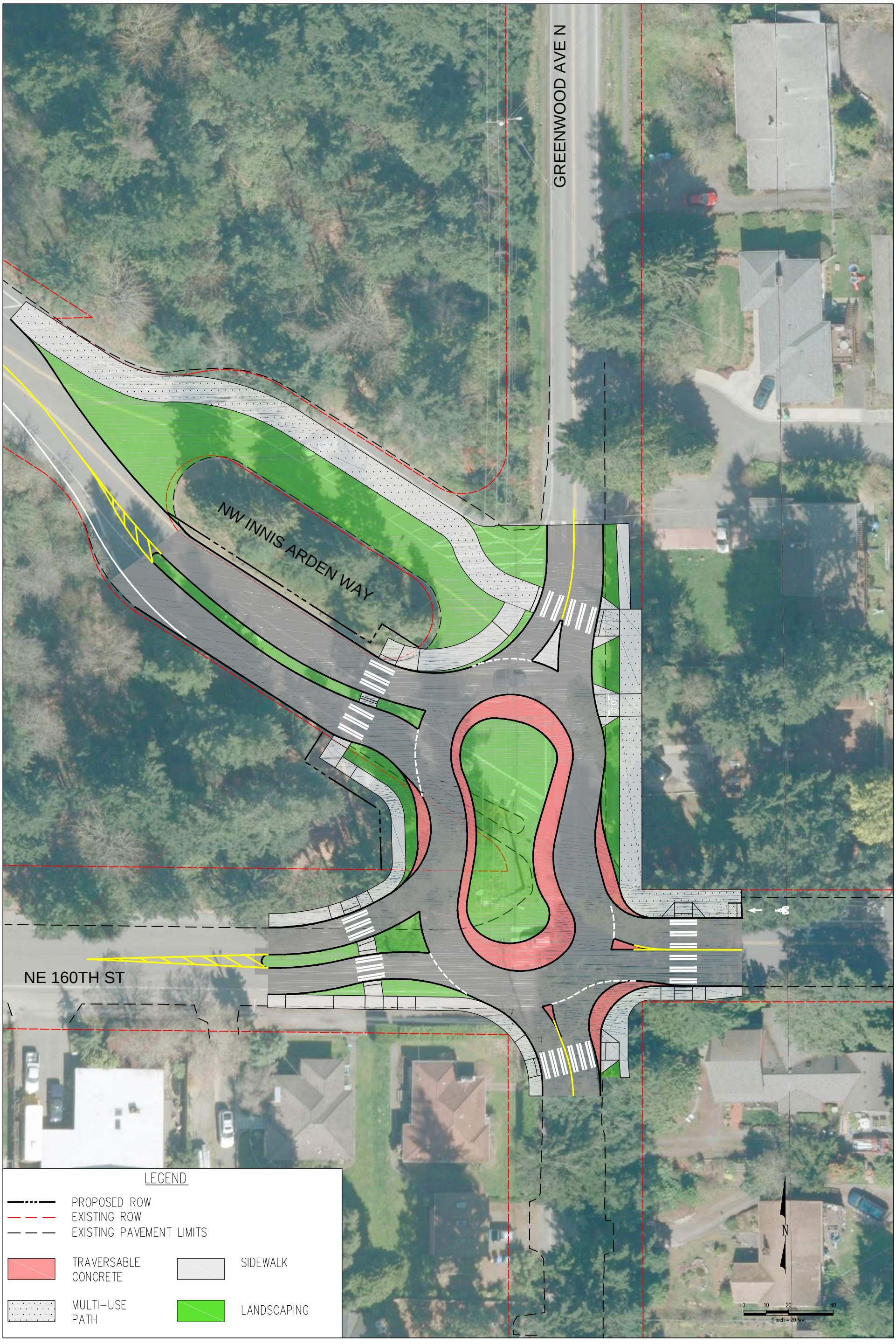
During the 10% design phase, we studied the engineering challenges, future traffic operational effects, and costs of constructing the preferred roundabout alternative. Additionally, the previously designed signal option was updated, costs were estimated, and a traffic analysis was performed. In the next phase of the project, either the signal or roundabout will be selected to move into final design.

Table 9-1: Evaluation Summary

Evaluation Criteria	Roundabout	Signalized
Total Project Costs	$2.20 Million	$2.00 Million
Right of Way Costs	Moderate	None
Maintenance Costs	Limited	Significant
Safety (all modes)	Significant Improvement	Improved
Traffic Flow	Moderate Improvement	Small Improvement
Environmental Impacts	Minimal	Moderate
Impacts to Current College Improvements	More Impact	Less Impact

Appendix A

Roundabout Option



CITY OF SHORELINE
Public Works Department
17544 Midvale Ave N
Shoreline, WA 98133
206-801-2700

N 160TH ST & GREENWOOD/INNIS ARDEN INTERSECTION IMPROVEMENTS

ROUNDABOUT ALTERNATIVE

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

Name: JeffreyF Date: Oct 15, 2019-02:55:42pm File: Z:\1900001-1900999\1900070 Shoreline Roundabout\CADD\Design\Alternatives Analysis\RD-ALTS_B1.dwg

Appendix B

Signal Option

GREENWOOD AVE N

NW INNIS ARDEN WAY

NE 160TH ST

LEGEND

EXISTING ROW

EXISTING PAVEMENT LIMITS

TRAVERSABLE CONCRETE

SIDEWALK

MULTI-USE PATH

LANDSCAPING

N

0 10 20 40

1 inch = 20 feet

CITY OF SHORELINE
Public Works Department
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206-801-2700

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SIGNAL ALTERNATIVE

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

Name: NAnderson Date: Aug 30, 2019-08:53:48am File: Z:\1900001-1900999\1900070 Shoreline Roundabout\CADD\Design\Alternatives Analysis\RD-ALTS_S.dwg

Appendix C

Roundabout 10% Design Plans

MATCHLINE: STA 38+05.00
SEE DWG RP02

MATCHLINE: STA 24+20.00
SEE DWG RP03

MATCHLINE: STA 25+60.00
SEE DWG RP03

NW INNIS ARDEN WAY

GREENWOOD AVE N

N 160TH ST

G 42+00

A 25+00

G 43+00

38+55

G 44+00

LEGEND:

- FULL DEPTH HMA: 6" HMA ON 2" CSBC
- 2" HMA OVERLAY
- CEMENT CONCRETE PAVEMENT TRUCK APRON: 6" PCCP ON 6"CSBC
- LANDSCAPE AREA
- CEMENT CONCRETE SIDEWALK: 4" PCCP ON 2" CSTC
- CEMENT CONCRETE PAVEMENT DRIVEWAY: 6" PCCP
- CEMENT CONCRETE TRAFFIC CURB AND GUTTER
- ROUNDABOUT CEMENT CONCRETE TRAFFIC CURB AND GUTTER
- ROW
- SD — STORM DRAIN
- CATCH BASIN W/GRATE
- CATCH BASIN W/SOLID COVER
- SOLAR POWERED RECTANGULAR RAPID FLASHING BEACON

CONSTRUCTION NOTES:

1. REMOVE TREE
2. RELOCATE POWER POLE
3. CONNECT TO EXISTING DRAINAGE STRUCTURE
4. CEMENT CONCRETE ROLLED CURB
5. CEMENT CONCRETE TRAFFIC CURB AND GUTTER
6. PERPENDICULAR CURB RAMP
7. PARALLEL CURB RAMP
8. POWER POLE TO REMAIN IN PLACE

N

0 5 10 20
1 inch = 10 feet

10% DESIGN - NOT FOR CONSTRUCTION

No	Date	Revision	By	Appr

CITY OF SHORELINE
Public Works Department
1744 Midvale Ave N
Shoreline, WA 98133
206-801-2700

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CHECKED BY NDA | APPROVED BY RJL
DATE: 3/1/19
J O B No. : 1900070

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

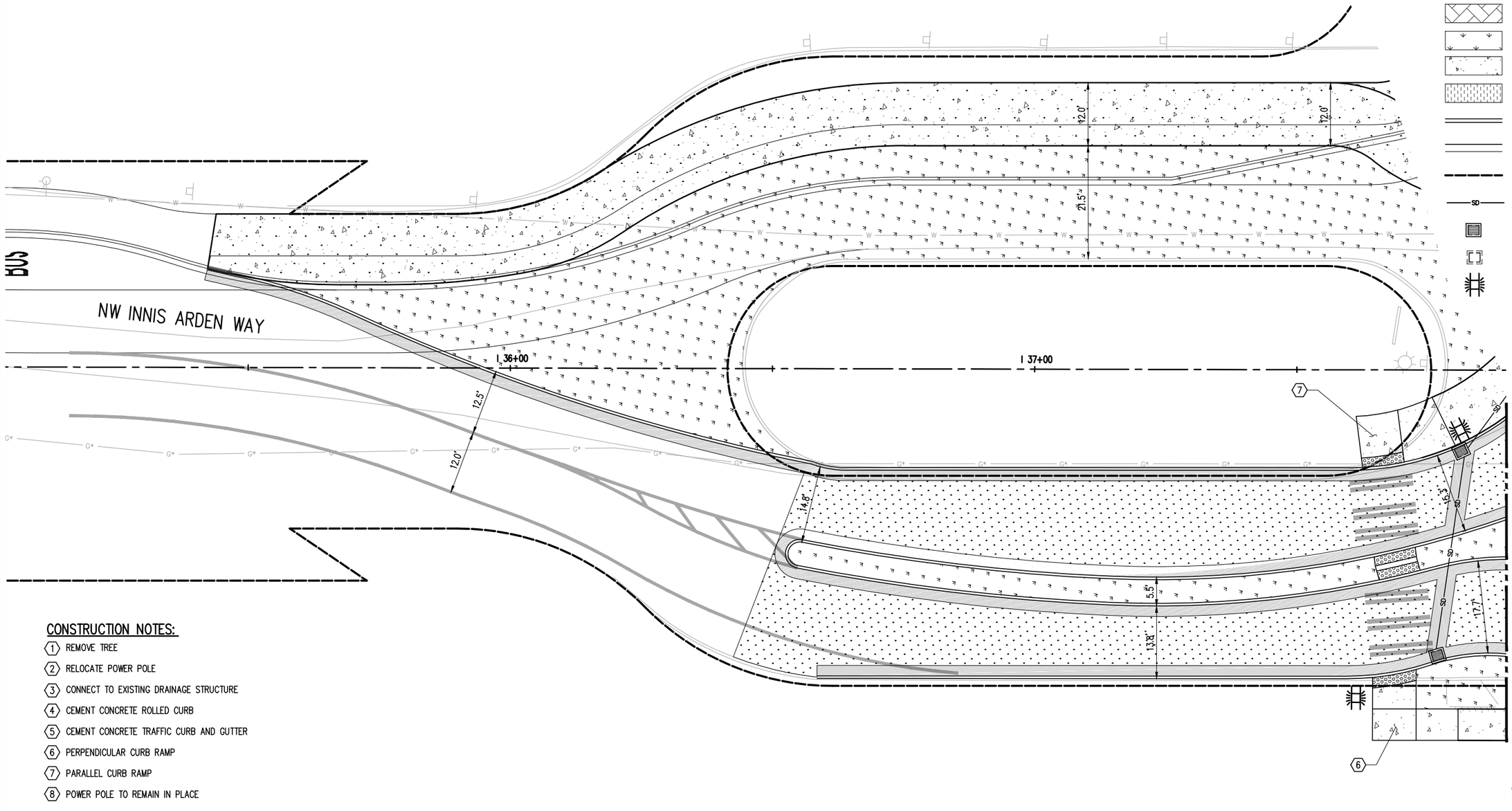
GREENWOOD 160TH/INNIS ARDEN INTERSECTION IMPROVEMENTS

ROUNDABOUT ALTERNATIVE

SHEET 1 OF 3

RP01

SCALE: 1" = 10'



LEGEND:

- FULL DEPTH HMA: 6" HMA ON 2" CSBC
- 2" HMA OVERLAY
- CEMENT CONCRETE PAVEMENT TRUCK APRON: 6" PCCP ON 6"CSBC
- LANDSCAPE AREA
- CEMENT CONCRETE SIDEWALK: 4" PCCP ON 2" CSTC
- CEMENT CONCRETE PAVEMENT DRIVEWAY: 6" PCCP
- CEMENT CONCRETE TRAFFIC CURB AND GUTTER
- ROUNDABOUT CEMENT CONCRETE TRAFFIC CURB AND GUTTER
- ROW
- SD — STORM DRAIN
- CATCH BASIN W/GRATE
- CATCH BASIN W/SOLID COVER
- SOLAR POWERED RECTANGULAR RAPID FLASHING BEACON

CONSTRUCTION NOTES:

1. REMOVE TREE
2. RELOCATE POWER POLE
3. CONNECT TO EXISTING DRAINAGE STRUCTURE
4. CEMENT CONCRETE ROLLED CURB
5. CEMENT CONCRETE TRAFFIC CURB AND GUTTER
6. PERPENDICULAR CURB RAMP
7. PARALLEL CURB RAMP
8. POWER POLE TO REMAIN IN PLACE

10% DESIGN - NOT FOR CONSTRUCTION

No	Date	Revision	By	Appr

CITY OF SHORELINE
Public Works Department
1744 Midvale Ave N
Shoreline, WA 98133
206-801-2700

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DATE: 3/1/19
J O B No. : 1900070

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

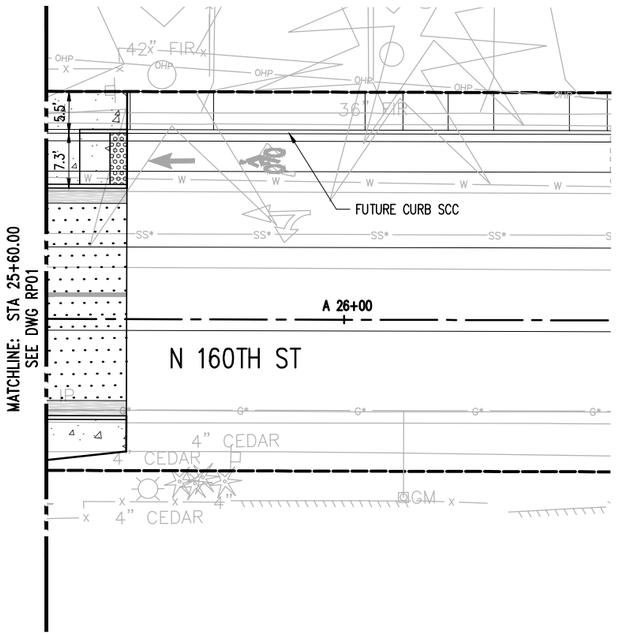
GREENWOOD 160TH/INNIS ARDEN INTERSECTION IMPROVEMENTS

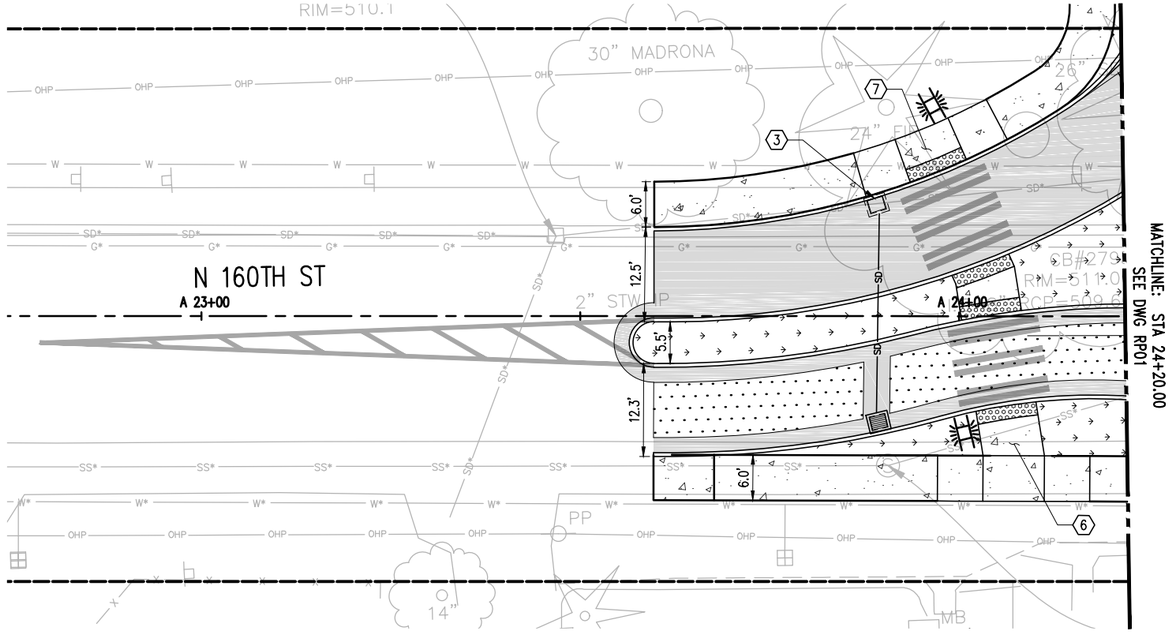
ROUNDABOUT ALTERNATIVE

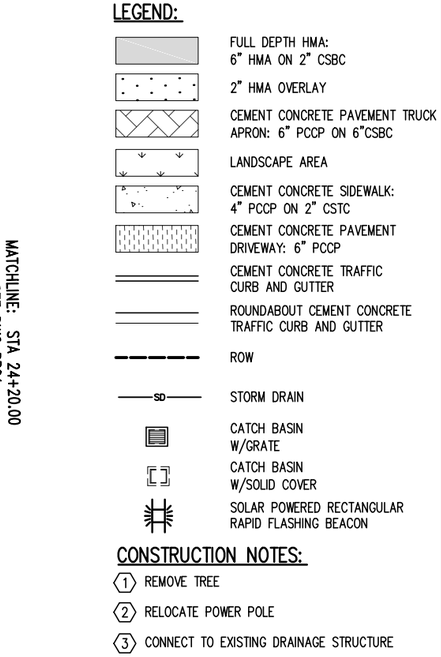
SHEET 2 OF 3

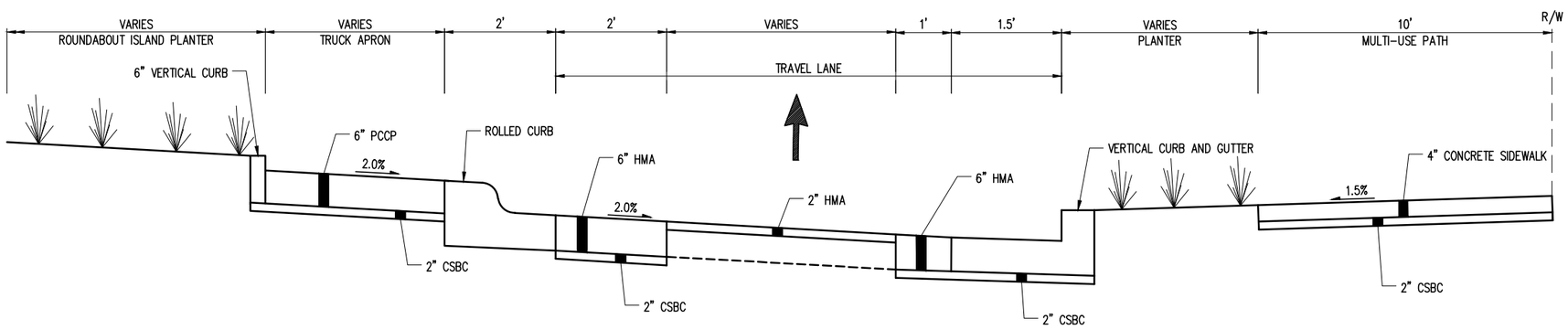
RP02

SCALE: 1" = 10'









A RP01 ROADWAY SECTION
SCALE: NTS

LEGEND:

- FULL DEPTH HMA: 6" HMA ON 2" CSBC
- 2" HMA OVERLAY
- CEMENT CONCRETE PAVEMENT TRUCK APRON: 6" PCCP ON 6"CSBC
- LANDSCAPE AREA
- CEMENT CONCRETE SIDEWALK: 4" PCCP ON 2" CSTC
- CEMENT CONCRETE PAVEMENT DRIVEWAY: 6" PCCP
- CEMENT CONCRETE TRAFFIC CURB AND GUTTER
- ROUNDABOUT CEMENT CONCRETE TRAFFIC CURB AND GUTTER
- ROW
- SD — STORM DRAIN
- CATCH BASIN W/GRATE
- CATCH BASIN W/SOLID COVER
- SOLAR POWERED RECTANGULAR RAPID FLASHING BEACON

CONSTRUCTION NOTES:

1. REMOVE TREE
2. RELOCATE POWER POLE
3. CONNECT TO EXISTING DRAINAGE STRUCTURE
4. CEMENT CONCRETE ROLLED CURB
5. CEMENT CONCRETE TRAFFIC CURB AND GUTTER
6. PERPENDICULAR CURB RAMP
7. PARALLEL CURB RAMP
8. POWER POLE TO REMAIN IN PLACE

N

0 5 10 20
1 inch = 10 feet

10% DESIGN - NOT FOR CONSTRUCTION

No	Date	Revision	By	Appr

CITY OF SHORELINE
Public Works Department
1744 Midvale Ave N
Shoreline, WA 98133
206-801-2700

DRAWN BY MRV | DESIGNED BY JMF
CHECKED BY NDA | APPROVED BY RJL
DATE: 3/1/19
J O B No. : 1900070

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

GREENWOOD 160TH/INNIS ARDEN INTERSECTION IMPROVEMENTS

ROUNDABOUT ALTERNATIVE

SHEET 3 OF 3

RP03

SCALE: 1" = 10'

Name: Jeffreyf Date: Oct 15, 2019-02:41:14pm File: C:\Temp\AcPublish_68228\1900070-RP.dwg

Appendix D

Cost Estimates

Client: City of Shoreline
Project: Greenwood/160th/Innis Arden Roundabout Study
Job #: 1900070
By: J. Fellows / N. Anderson
KPFF Consulting Engineers
Date: 11/1/2019

Engineer's Estimate of Probable Cost - Roundabout Alternative
10% Design

ITEM NO.	ITEM	QTY	UNIT	UNIT PRICE	TOTAL COST
	ROADWAY				
001	MOBILIZATION	1	LS	$80,000.00	$80,000.00
002	CONSTRUCTION SURVEYING	1	LS	$50,000.00	$50,000.00
003	SPCC PLAN	1	LS	$2,000.00	$2,000.00
004	SWPPP PREPARATION AND MAINTENANCE	1	LS	$5,000.00	$5,000.00
005	PROJECT TEMPORARY TRAFFIC CONTROL	1	LS	$100,000.00	$100,000.00
006	EROSION/WATER POLLUTION CONTROL	1	LS	$50,000.00	$50,000.00
007	ESC LEAD	120	DAY	$100.00	$12,000.00
008	CLEARING AND GRUBBING	1	LS	$5,000.00	$5,000.00
009	REMOVE TREE (10 IN. OR GREATER)	5	EA	$1,500.00	$7,500.00
010	REMOVAL OF STRUCTURE AND OBSTRUCTIONS	1	LS	$20,000.00	$20,000.00
011	ROADWAY EXCAVATION INCL. HAUL	1,030	CY	$40.00	$41,200.00
012	SAWCUTTING	2,000	LF	$4.00	$8,000.00
013	PLANING BITUMINOUS PAVEMENT	1,430	SY	$15.00	$21,450.00
014	CRUSHED SURFACING BASE COURSE	270	TN	$40.00	$10,800.00
015	CRUSHED SURFACING TOP COURSE	110	TN	$40.00	$4,400.00
016	HMA Cl. 1/2" PG 58H-22	450	TN	$150.00	$67,500.00
017	CEMENT CONC. TRAFFIC CURB AND GUTTER	1,330	LF	$50.00	$66,500.00
019	CEMENT CONC. MOUNTABLE CURB AND GUTTER	530	LF	$60.00	$31,800.00
020	CEMENT CONC. CURB RAMP, PERPENDICULAR	3	EA	$4,000.00	$12,000.00
021	CEMENT CONC. CURB RAMP, PARALLEL	11	EA	$4,000.00	$44,000.00
022	CEMENT CONC. SIDEWALK	800	SY	$75.00	$60,000.00
023	CEMENT CONC. PAVEMENT, TRUCK APRON	240	CY	$225.00	$54,000.00
024	CEMENT CONC. PAVEMENT, DRIVEWAY	30	CY	$200.00	$6,000.00
026	PERMANENT SIGNING AND CHANNELIZATION	1	LS	$15,000.00	$15,000.00
027	STRUCTURE EXCAVATION CLASS B INCL. HAUL	130	CY	$30.00	$3,900.00
028	SCHEDULE A STORM SEWER PIPE 12 IN. DIAM.	325	LF	$50.00	$16,250.00
029	ADJUST STRUCTURE TO GRADE	20	EA	$600.00	$12,000.00
030	CONNECTION TO DRAINAGE STRUCTURE	1	EA	$500.00	$500.00
031	GRAVEL BACKFILL FOR PIPEZONE BEDDING	50	TN	$50.00	$2,500.00
032	CATCH BASIN TYPE 1	14	EA	$2,000.00	$28,000.00
033	LANDSCAPING	1	LS	$50,000.00	$50,000.00
034	RELOCATE SCL POLE**	2	EA	$15,000.00	$30,000.00
035	ILLUMINATION	1	LS	$131,000.00	$131,000.00
	Construction Cost Subtotal				**$1,048,300.00**
	Contingency	30%			**$315,000.00**
	Construction Cost Total				**$1,363,300.00**
	Sales Tax			0.0%	**$0.00**
	Total Construction Cost				**$1,363,300.00**
	Design	15%			$205,000.00
	Construction Management	10%			$137,000.00
	Administration	2%			$28,000.00
	Construction Contingency	10%			$137,000.00
	ROW Acquisition	2,215	SF	$35.00	$78,000.00
	Cost Escalation (*Assumed Construction 2023)	3%			$249,000.00
	Total Project Cost				**$ 2,197,300.00**

* Construction will take place between 2021 and 2025

** Per franchise, SCL pays for pole relocations on City construction projects.

Client: City of Shoreline
Project: Greenwood/160th/Innis Arden Intersection Study
Job #: 1900070
By: J. Fellows / N. Anderson / C. Grgich
KPFF Consulting Engineers, Fehr & Peers
Date: 10/15/2019

Engineer's Estimate of Probable Cost - Signalized Alternative
10% Design

ITEM NO.	ITEM	QTY	UNIT	UNIT PRICE	TOTAL COST
	ROADWAY				
001	MOBILIZATION	1	LS	$70,000.00	$70,000.00
002	CONSTRUCTION SURVEYING	1	LS	$20,000.00	$20,000.00
003	SPCC PLAN	1	LS	$2,000.00	$2,000.00
004	SWPPP PREPARATION AND MAINTENANCE	1	LS	$5,000.00	$5,000.00
005	PROJECT TEMPORARY TRAFFIC CONTROL	1	LS	$50,000.00	$50,000.00
006	EROSION/WATER POLLUTION CONTROL	1	LS	$20,000.00	$20,000.00
007	ESC LEAD	60	DAY	$100.00	$6,000.00
008	CLEARING AND GRUBBING	1.00	LS	$5,000.00	$5,000.00
009	ROADWAY EXCAVATION INCL. HAUL	260	CY	$40.00	$10,400.00
010	SAWCUTTING	780	LF	$4.00	$3,120.00
011	CRUSHED SURFACING BASE COURSE	35	TN	$40.00	$1,400.00
012	CRUSHED SURFACING TOP COURSE	80	TN	$40.00	$3,200.00
013	HMA Cl. 1/2" PG 58H-22	220	TN	$150.00	$33,000.00
014	CEMENT CONC. CURB RAMP, PERPENDICULAR	4	EA	$4,000.00	$16,000.00
015	CEMENT CONC. CURB RAMP, PARALLEL	1	EA	$4,000.00	$4,000.00
016	CEMENT CONC. SIDEWALK	580	SY	$75.00	$43,500.00
017	CEMENT CONC. PAVEMENT, DRIVEWAY	35	CY	$100.00	$3,500.00
018	PERMANENT SIGNING AND STRIPING	1	LS	$15,000.00	$15,000.00
019	LANDSCAPING	1	LS	$25,000.00	$25,000.00
020	STRUCTURE EXCAVATION CLASS B INCL. HAUL	70	CY	$30.00	$2,100.00
021	SCHEDULE A STORM SEWER PIPE 12 IN. DIAM.	175	LF	$50.00	$8,750.00
022	ADJUST STRUCTURE TO GRADE	1	EA	$600.00	$600.00
023	CONNECTION TO DRAINAGE STRUCTURE	1	EA	$500.00	$500.00
024	GRAVEL BACKFILL FOR PIPEZONE BEDDING	30	TN	$50.00	$1,500.00
025	CATCH BASIN TYPE 1	6	EA	$2,000.00	$12,000.00
	SIGNAL				
029	JUNCTION BOX	15	EA	$1,500.00	$22,500.00
030	CONTROLLER CABINET	1	EA	$3,000.00	$3,000.00
031	CONTROLLER FOUNDATION	1	EA	$4,000.00	$4,000.00
032	NEMA TS2 CONTROLLER CABINET ASSEMBLY WITHOUT CONTROLLER	1	EA	$12,000.00	$12,000.00
033	NEMA TS2 CONTROLLER UNIT	1	EA	$5,000.00	$5,000.00
034	BATTERY BACKUP SYSTEM	1	EA	$5,000.00	$5,000.00
035	SERVICE CONNECTION	1	EA	$6,000.00	$6,000.00
036	SIGNAL POLE (30 FT ARM WITH LUMINAIRE)	5	EA	$10,000.00	$50,000.00
037	SIGNAL POLE FOUNDATION (30 FT ARM)	5	EA	$6,000.00	$30,000.00
038	SIGNAL POLE (20 FT ARM WITH LUMINAIRE)	2	EA	$7,500.00	$15,000.00
039	SIGNAL POLE FOUNDATION (20 FT ARM)	2	EA	$4,500.00	$9,000.00
040	TYPE 1 SIGNAL POLE	10	EA	$5,000.00	$50,000.00
041	TYPE 1 SIGNAL POLE FOUNDATION	10	EA	$4,000.00	$40,000.00
042	MASTARM GUIDE SIGNS	7	EA	$1,000.00	$7,000.00

Client: City of Shoreline
Project: Greenwood/160th/Innis Arden Intersection Study
Job #: 1900070
By: J. Fellows / N. Anderson / C. Grgich
KPFF Consulting Engineers, Fehr & Peers
Date: 10/15/2019

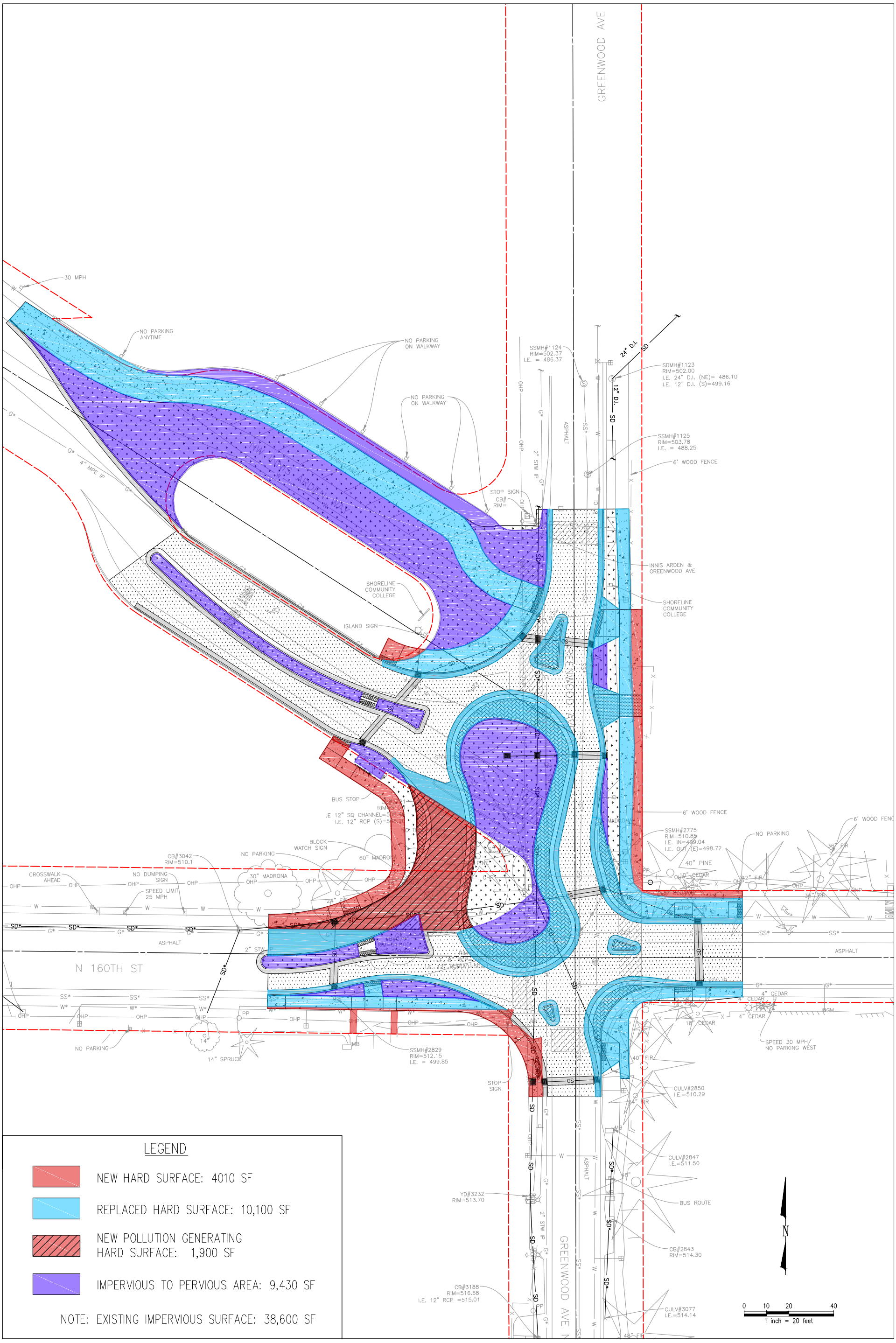
Engineer's Estimate of Probable Cost - Signalized Alternative
10% Design

ITEM NO.	ITEM	QTY	UNIT	UNIT PRICE	TOTAL COST
043	150W EQUIVALENT LED LUMINAIRE WITH 15 FT ARM	7	EA	$6,000.00	$42,000.00
044	PED SIGNAL HEAD	14	EA	$2,500.00	$35,000.00
045	PED PUSH BUTTON ASSEMBLY	14	EA	$2,500.00	$35,000.00
046	3-12 IN. SIGNAL HEAD	15	EA	$2,000.00	$30,000.00
047	5-12 IN. SIGNAL HEAD	1	EA	$2,500.00	$2,500.00
048	3-12 IN. SIGNAL BACKPLATE	15	EA	$1,000.00	$15,000.00
049	5-12 IN. SIGNAL BACKPLATE	1	EA	$1,000.00	$1,000.00
050	SIGNAL MOUNT HARDWARE	16	EA	$500.00	$8,000.00
051	DETECTION LOOP	35	EA	$1,000.00	$35,000.00
052	TRENCH & BACKFILL	1,000	LF	$75.00	$75,000.00
053	3 IN. PVC CONDUIT IN TRENCH	2,000	LF	$35.00	$70,000.00
054	SIGNAL WIRING	1	LS	$25,000.00	$25,000.00
	Construction Cost Subtotal				**$993,570.00**
	Contingency	30%			**$299,000.00**
	Construction Cost Total				**$1,292,570.00**
	Sales Tax			0.0%	**$0.00**
	Total Construction Cost				**$1,292,570.00**
	Design	15%			$194,000.00
	Construction Management	10%			$130,000.00
	Administration	2%			$26,000.00
	Construction Contingency	10%			$130,000.00
	ROW Acquisition	0	SF	$35.00	$0.00
	Cost Escalation (*Assumed Construction 2023)	3%			$226,000.00
	Total Project Cost				**$ 1,998,570.00**

* Construction will take place between 2021 and 2025

Appendix E

Storm Drainage Figures



LEGEND

- NEW HARD SURFACE: 4010 SF
- REPLACED HARD SURFACE: 10,100 SF
- NEW POLLUTION GENERATING HARD SURFACE: 1,900 SF
- IMPERVIOUS TO PERVIOUS AREA: 9,430 SF

NOTE: EXISTING IMPERVIOUS SURFACE: 38,600 SF

N 160TH ST & GREENWOOD/INNIS ARDEN INTERSECTION IMPROVEMENTS

SURFACE AREA FIGURE

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

Does the Project result in 2,000 square feet, or more, of new plus replaced hard surface area?
OR
Does the land disturbing activity total 7,000 square feet or greater?

Yes

Minimum Requirements #1 through #5 apply to the new and replaced hard surfaces and the land disturbed.

Next Question

Does the Project add 5,000 square feet or more of new hard surfaces?
OR
Convert ¾ acres or more of vegetation to lawn or landscaped areas?
OR
Convert 2.5 acres or more of native vegetation to pasture?

Yes

All Minimum Requirements apply to the new hard surfaces and the converted vegetation areas.

Next Question

Is this a road related project?

Yes

Does the Project add 5,000 square feet or more of new hard surfaces?

Yes

Do the new hard surfaces add 50% or more to the existing hard surfaces within the Site?

Yes

All Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas.

No

No additional requirements.

No

Is the total of new plus replaced hard surfaces 5,000 square feet or more,
AND
does the value of the proposed improvements - including interior improvements - exceed 50% of the assessed value (or replacement value) of the:

- existing Project Site improvements (for commercial or industrial projects) OR
- existing Site improvements (for all other projects)

Yes

No

No

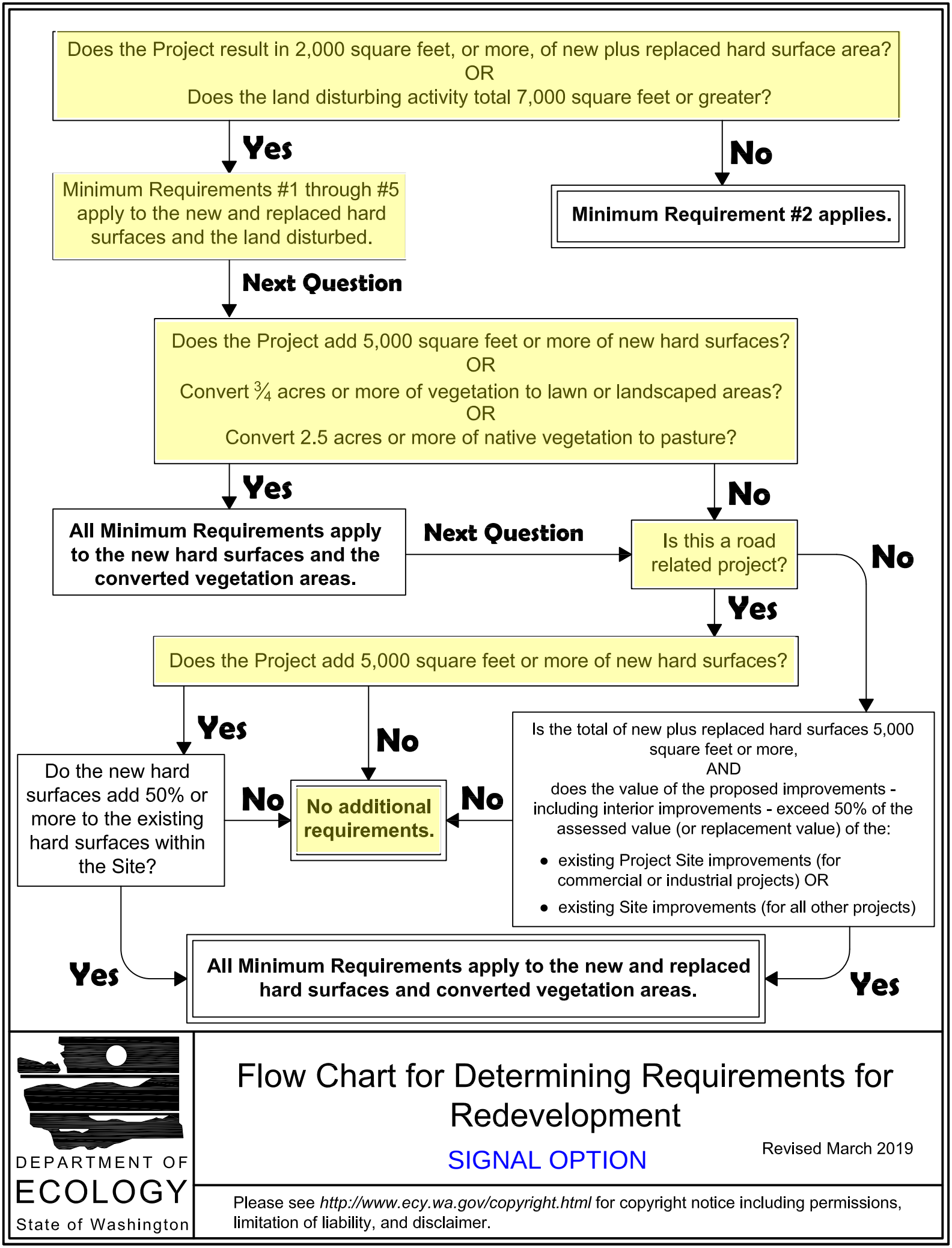
No

DEPARTMENT OF
ECOLOGY
State of Washington

Flow Chart for Determining Requirements for Redevelopment

ROUNDABOUT OPTION

Revised March 2019



Appendix F

Traffic Analysis

FEHR PEERS

Memorandum

Date: October 3, 2019

To: Nathan Anderson, KPFF

From: Chris Grgich, PE, PTOE
Kara Hall

Subject: Traffic Operations Alternatives Analysis for the 160th/Greenwood/Innis Arden Intersection

SE19-0663

Introduction

Traffic operations analysis has been completed for the preferred roundabout and signal alternative for the Greenwood Avenue/160th Street/ Innis Arden Road area (as shown in **Figure 1**) to the southeast of the Shoreline Community College Campus. Analysis was completed for AM, Mid-day and PM peak hours and assumed completion of the project identified in the *Shoreline Community College Master Plan*.

The three study intersections included in the analysis are:

- Greenwood Avenue / 160th Street
- Greenwood Avenue / Innis Arden Way
- Dayton Avenue / 160th Street

The three campus intersections providing access to Innis Arden Way were included in the simulation model in order to accurately represent traffic flow in the study area; however, no results were reported for those intersections.

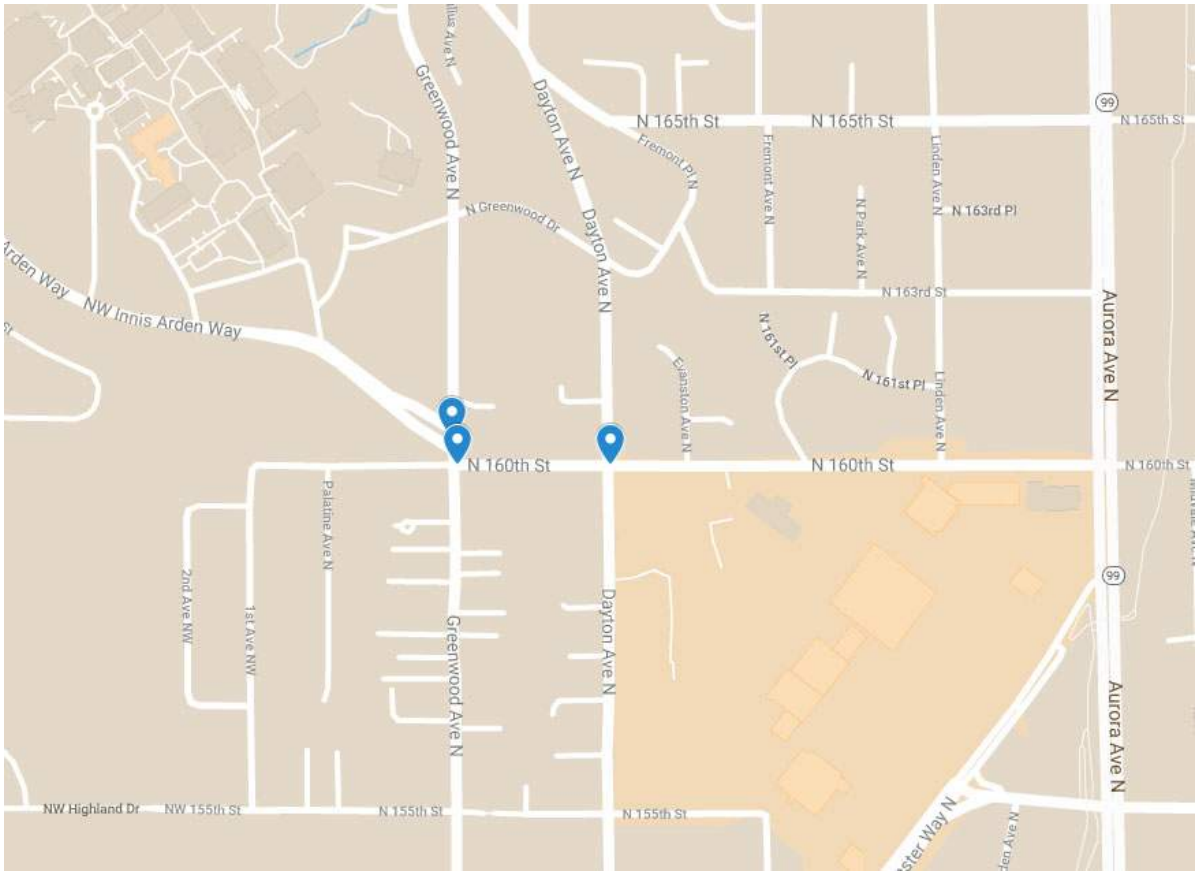


Figure 1. Study Intersections

Data Collection

Intersection turning movement volumes for Existing (2018) and Future (2040) with Project AM, Mid-day and PM peak hour conditions from the *Shoreline Community College Master Plan* were used as the basis for this analysis. These volumes are provided in the Appendix of this memo.

During the AM peak hour, trips traveling eastbound on 160th Street towards Shoreline Community College using Innis Arden Way by making a right-turn onto Greenwood Avenue and then a left-turn onto Innis Arden Way make up the heaviest movements at the study intersections.

During the Mid-day peak hour, while the movements above remain high, an increase in trips leaving Shoreline Community College also results in large amounts of traffic turning right onto Greenwood Avenue from Innis Arden Way and then making a left-turn onto 160th Street.

During the PM peak hour, the highest movement in the study area is northbound trips traveling along Greenwood Avenue.

Methodology

Each of the alternatives were analyzed using the traffic analysis software VISSIM. This software is a micro-simulation tool that allows the user to model intersection configurations and evaluate performance. VISSIM was selected for this study due to its ability to model unusual and complex configurations. For this evaluation, average delay and Level of Service (LOS) were used as the primary metrics to evaluate intersection performance. LOS is a term that describes the operating performance of an intersection or roadway. LOS is measured quantitatively and reported on a scale from A to F, with A representing the best performance and F the worst. **Table 1** provides a brief description of each LOS letter designation and an accompanying average delay per vehicle for both signalized and unsignalized intersections. The Highway Capacity Manual 2016 (HCM 2016) methodology was used in this study to remain consistent with "state of the practice" professional standards. This methodology has different quantitative evaluations for signalized and unsignalized intersections (roundabouts). For signalized intersections, the LOS is provided for the overall intersection (weighted average of all approach delays). For this study, the roundabout alternative was analyzed using unsignalized intersection thresholds for delay and LOS.

Table 1: Level of Service Descriptions

LOS	Description	Signalized Intersections Avg. Delay (sec/veh)[1]	Unsignalized Intersections Avg. Delay (sec/veh)[2]
A	Free Flow / Insignificant Delay	< 10.0	< 10.0
B	Extremely favorable progression. Individual users are virtually unaffected by others in the traffic stream.	> 10.0 to 20.0	> 10.0 to 15.0
C	Stable Operations / Minimum Delays	> 20.0 to 35.0	> 15.0 to 25.0
D	Good progression. The presence of other users in the traffic stream becomes noticeable.	> 35.0 to 55.0	> 25.0 to 35.0
E	Stable Operations / Acceptable Delays	> 55.0 to 80.0	> 35.0 to 50.0
F	Fair progression. The operation of individual users is affected by interactions with others in the traffic stream	> 80.0	> 50.0

1. Overall intersection LOS and average delay (seconds/vehicle) for all approaches.
2. Worst approach LOS and delay (seconds/vehicle) only.
3. Volume to capacity (v/c) rate, average values.

Source: Fehr & Peers descriptions, based on *2016 Highway Capacity Manual*.

Scenarios Analyzed

The proposed alternatives were evaluated under Existing (2018) and Future (2040) conditions. This section describes the two alternatives that were evaluated.

Roundabout Alternative

This alternative assumes that the Greenwood Avenue / Innis Arden Way / 160th Street intersections would be configured into a modified oval-about as shown on **Figure 2**.

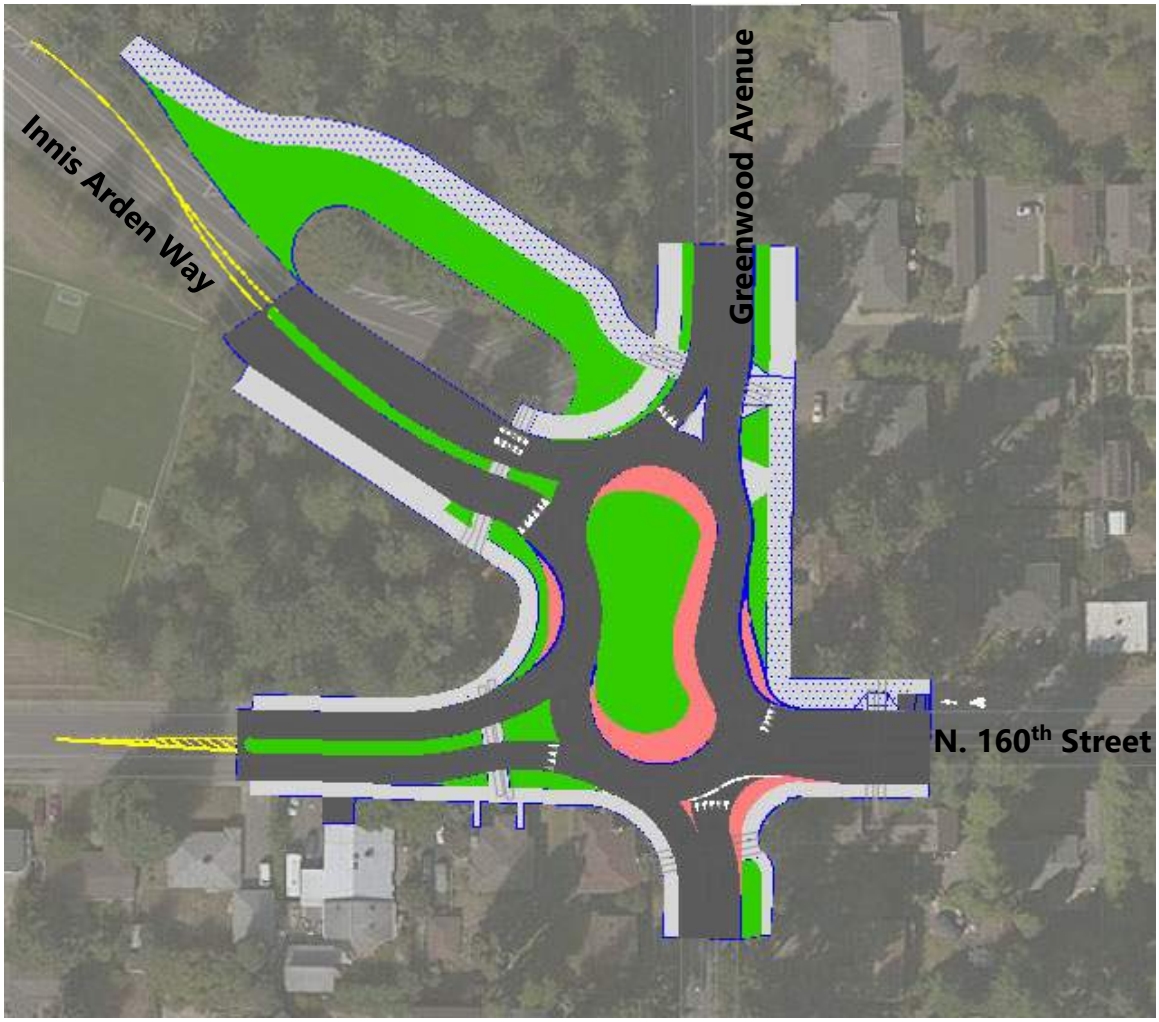


Figure 2. Roundabout Alternative

Signal Alternative

This alternative assumes that the Greenwood Avenue / Innis Arden Way and Greenwood Avenue / 160th Street intersections would be modified to include dedicated storage for vehicles turning left from Greenwood Avenue onto Innis Arden Way and signal control at both intersections. Due to close intersection spacing, it was assumed that all three study intersections would operate with signal coordination. The proposed signal alternative is shown on **Figure 3**.

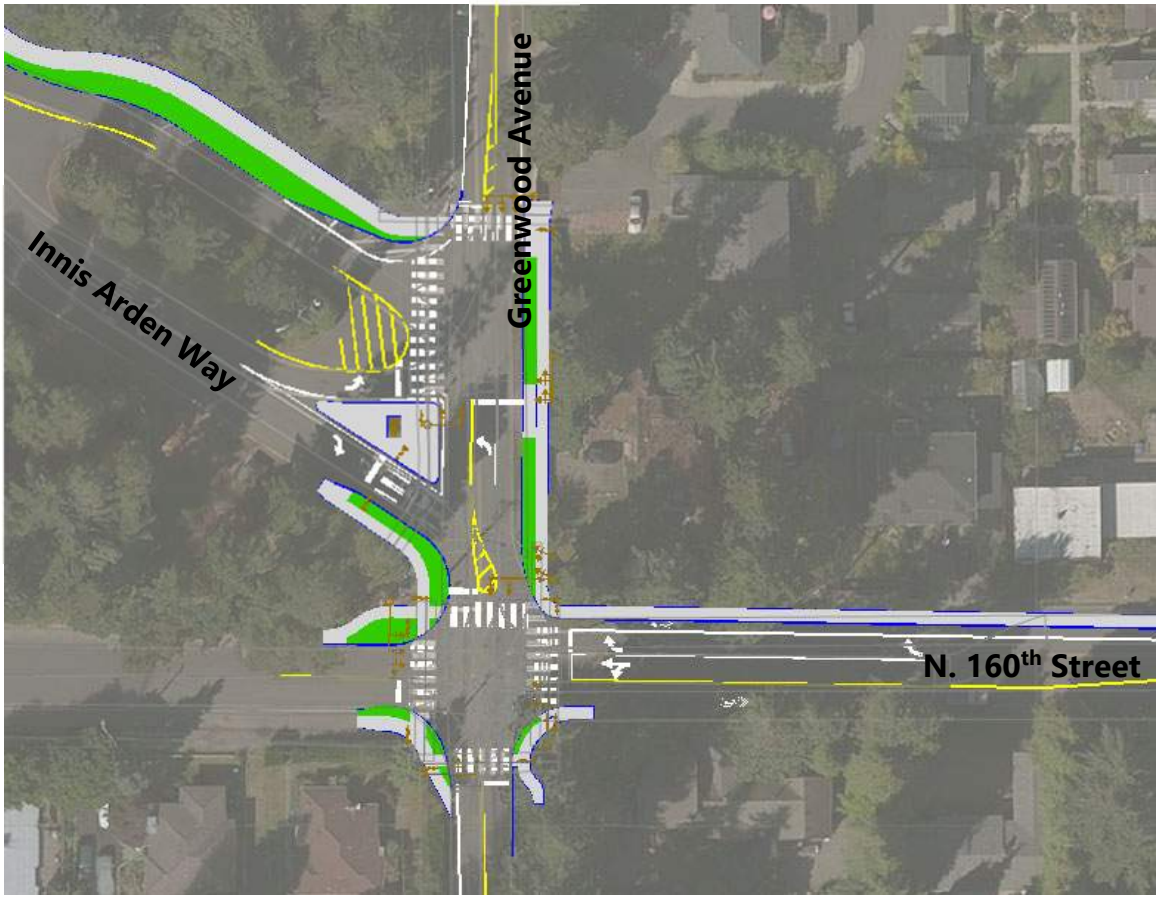


Figure 3. Signal Alternative

Analysis Results

The LOS results for both alternatives during the AM, Mid-day, and PM peak hours are summarized below. Operational results for Existing (2018) are shown in **Table 2** while **Table 3** summarizes the results for Future (2040) conditions.

Table 2: Existing (2018) Analysis Results – Delay / LOS

Peak Hour	Intersection	Roundabout Alternative	Signal Alternative
AM	Greenwood Avenue / Innis Arden Way[2]	9 / A	16 / B
	Greenwood Avenue / 160th Street[2]		21 / C
	Dayton Avenue / 160th Street	12 / B	19 / B
MID	Greenwood Avenue / Innis Arden Way[2]	11/B	16 / B
	Greenwood Avenue / 160th Street[2]		12 / B
	Dayton Avenue / 160th Street	10 / B	21 / C
PM	Greenwood Avenue / Innis Arden Way[2]	9/ A	12/ B
	Greenwood Avenue / 160th Street[2]		17 / B
	Dayton Avenue / 160th Street	11 / B	16 / B

1. Delay / LOS likely understated due to upstream metering
2. Intersections analyzed as one intersection under Roundabout Alternative.

Table 3: Future (2040) Analysis Results – Delay / LOS

Intersection	Peak Hour	Roundabout Alternative	Signal Alternative
AM	Greenwood Avenue / Innis Arden Way[2]	58 / F[3]	36 / D
	Greenwood Avenue / 160th Street[2]		81 / F
	Dayton Avenue / 160th Street	18 / B	18 / B
MID	Greenwood Avenue / Innis Arden Way[2]	27/D	147/ F
	Greenwood Avenue / 160th Street[2]		36 / D[1]
	Dayton Avenue / 160th Street	12 / B	18/ B
PM	Greenwood Avenue / Innis Arden Way[2]	31/D	51 / D[1]
	Greenwood Avenue / 160th Street[2]		136 / F
	Dayton Avenue / 160th Street	14 / B	16/ B

1. Delay / LOS likely understated due to upstream metering
2. Intersections analyzed as one intersection under Roundabout Alternative.
3. The Roundabout Alternative replaces two distinct intersections, therefore the delay is within an acceptable ranger per City Standards.

Roundabout Alternative

As shown in **Table 2** and **3**, the roundabout alternative operates with lower delay at the Innis Arden Way / Greenwood Avenue and Greenwood Avenue / 160th Street intersections when compared to the signalized alternative across all scenarios. While the roundabout would operate at LOS F during the AM peak hour, the delay experienced by the driver would be significantly lower than the signal alternative at where drivers would need to travel through two intersections, which would operate at LOS D and LOS F.

As shown on **Figure 4**, during the AM peak hour when volume traveling from 160th Street to Innis Arden Way is highest, queue spill-back occurs on Greenwood Avenue for vehicles attempting to enter the roundabout and on 160th Street. However, spillback does not reach the Dayton Avenue intersection on 160th Street.

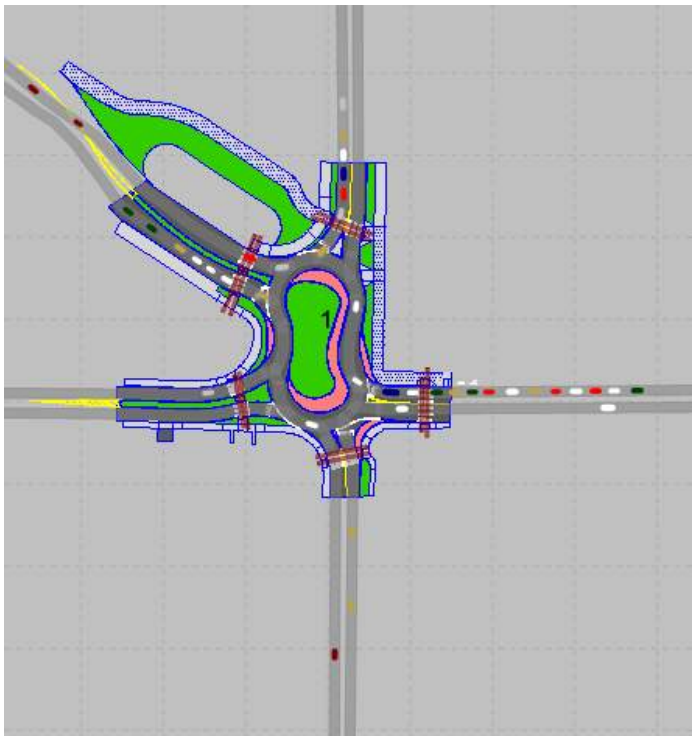


Figure 4. Roundabout Alternative Analysis

Signal Alternative

Operational analysis for the signal alternative resulted in less than acceptable operations across at one or more study intersections during all peak hours in 2040. During the AM and PM peak hours

the Greenwood Avenue and Innis Arden Way intersection operates at LOS D, while the 160th Street intersection operates at LOS F. During the Mid-day peak hour, the Greenwood Avenue and Innis Arden way intersection operates acceptably, while the 160th Street intersection operates at LOS F.

During the Mid-day peak hour queueing occurs on Innis Arden Way due to the high number of vehicles turning right onto Greenwood Avenue then attempting to make a left-turn at 160th Street. This limits the number of vehicles able to access the 160th Street intersection during the peak hour, resulting in understated delays for the Greenwood Avenue / 160th Street intersection, as noted in **Table 3**.

As shown on **Figure 5** below, operations for this alternative fail due to limited storage for vehicles turning left from Greenwood Avenue to Innis Arden Way and limited storage for vehicles turning right on Greenwood Avenue from Innis Arden way. Under 2040 conditions, the northbound-left volume exceeds 300 vehicles per hour during all time periods, and is as high as 695 vehicles per hour during the AM peak hour. This volume would normally warrant dual left-turn lanes. The 70 feet of available storage capacity fills almost immediately impacting all other approaches.

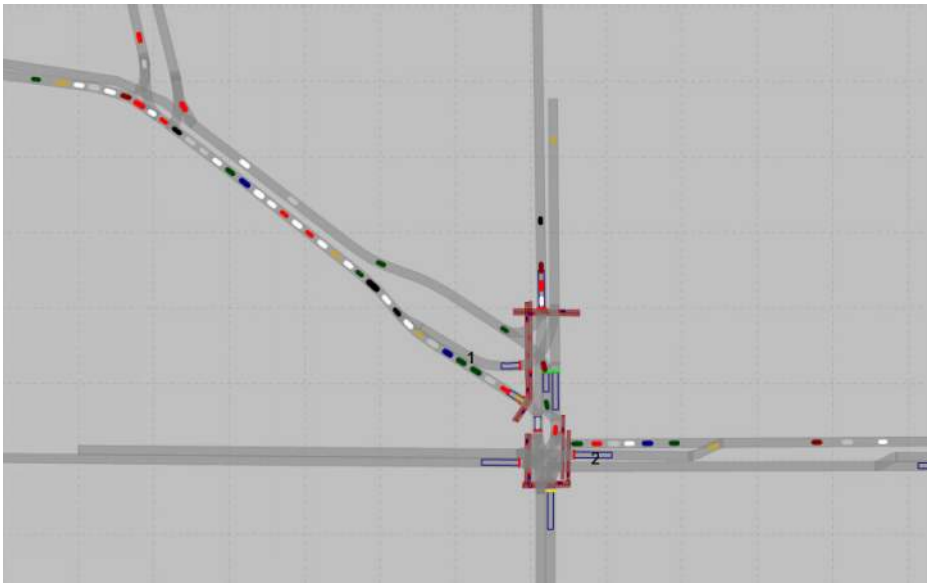


Figure 5. Signal Alternative Analysis

Conclusion

The operational analysis found that:

- the roundabout alternative resulted in equal or better operations across all scenarios analyzed;
- delay times for the roundabout alternative replaces delay experienced at the two intersections existing today;
- the roundabout experiences queues on Greenwood Avenue and NE 160th Street during the AM peak hour but does not affect any of the adjacent intersections;
- the signalized alternative breaks down due to queues created by the high number of vehicles turning left from Greenwood Avenue to Innis Arden Way; and
- the roundabout alternative experiences LOS F during AM peak hour, however, operates with less delay than the signalized alternative.

The roundabout alternative was found to operate with the least amount of delay and queuing.