



## MEMORANDUM

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**Date:** December 17, 2006 **Project #:** 8202.00

**To:** Barry Jonson, P.E., W&H Pacific

**From:** Sonia Hennum, P.E. & Dave Daly

**Project:** Neff Road Transportation Study

**Subject:** Neff Road Corridor Improvement Concepts

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Per direction from City of Bend staff, this memorandum summarizes the transportation assessment and preliminary design alternatives that were developed for the Neff Road corridor project. The project focuses on two locations along Neff Road, the first is frontage along Pilot Butte Middle School and the second is the Neff Road/Purcell Boulevard intersection.

### **PILOT BUTTE MIDDLE SCHOOL FRONTAGE**

This location was identified as a study location based on direction provided by City of Bend staff, and was originally limited in scope to develop four conceptual sketches of possible mitigation alternatives. At the July 12, 2006 meeting with City of Bend staff, four basic mitigation alternative concepts were developed to help improve the operations and safety at the school access points during peak travel times. The initial alternatives identified were:

- Single-lane roundabouts at both school access points;
- A single-lane roundabout at the primary access (Shepard Avenue) with additional widening at the secondary access;
- Widening of Neff Road and increased channelization to accommodate left turns into the school access points and pedestrian movements; and
- Construction of a separate westbound drop-off area on the north side of Neff Road.

Sketches of each preliminary concept were prepared to assess potential impacts and to aid further discussion.

### **Concept 1 - Single Lane Roundabouts**

Concept 1 shows the construction of single-lane roundabouts at both access locations. This concept's main operational and safety advantage is the restriction of left-turn maneuvers at each approach. Instead of left-turn maneuvers, vehicles travel through the roundabouts to make U-turns and right-turn movements. This configuration reduces the severity of crashes and helps maintain constant vehicular flow. As with typical roundabout operations, priority is given to the circulating vehicle, while vehicles entering the roundabout are yield controlled. In addition,

pedestrians are able to cross a single direction of traffic before arriving at a refuge island to finish crossing the road. The disadvantages of this concept are the potential significant right-of-way impacts, the additional widening necessary at the second access, and a high cost of construction. Figure 1 illustrates the preliminary sketch for concept 1.

### **Concept 2 - Single Lane Roundabout with Additional Widening**

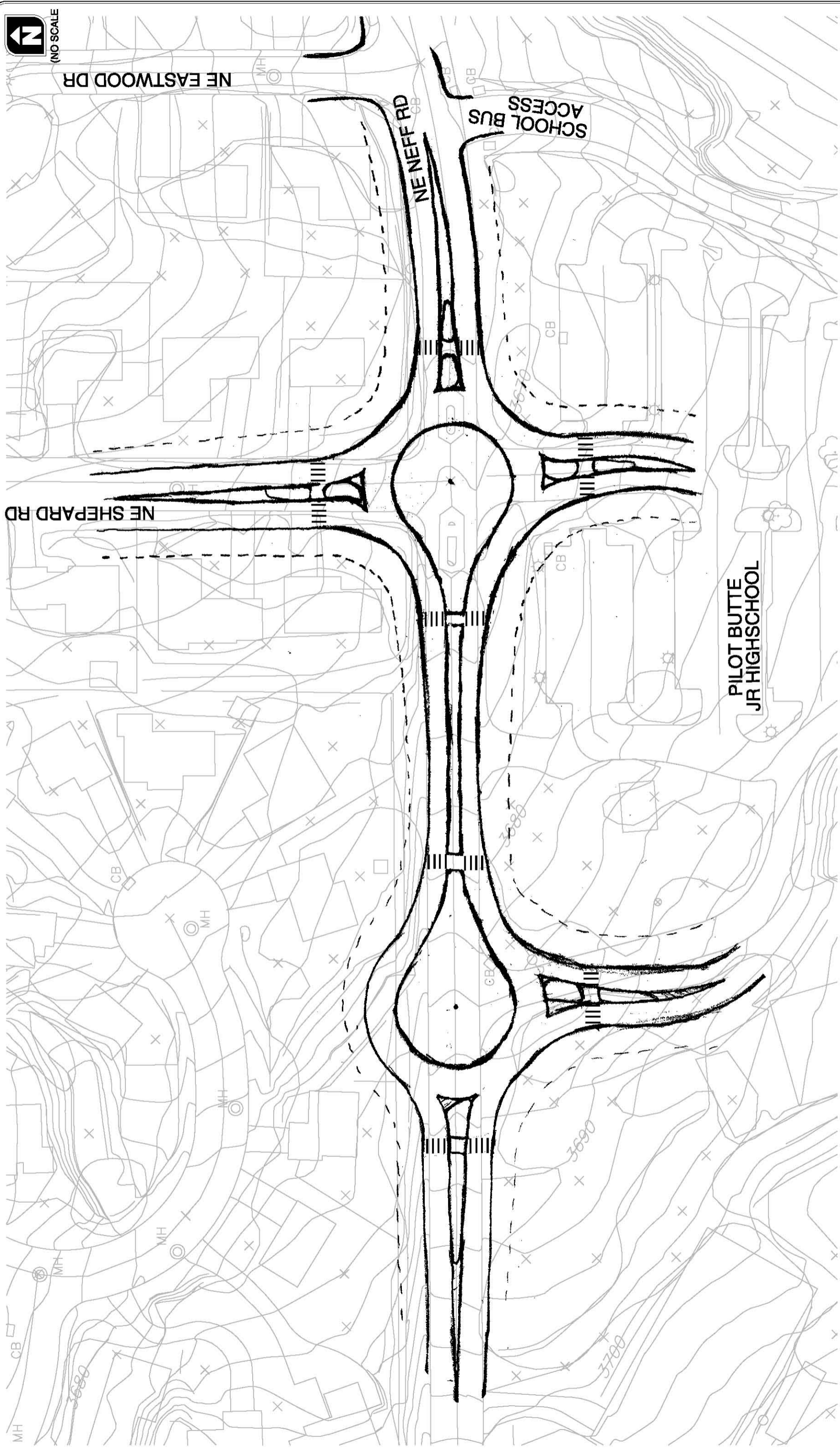
Concept 2 investigates the construction of a single-lane roundabout at the Shepard Road-Main School Access intersection, with additional widening improvements at the secondary access point. The secondary access would be restricted to ingress only access, allowing eastbound right-in and westbound left-in movements. The advantages to this concept include more direct access to the school at Shepard Road, meaning less out-of-direction travel for motorists. The roundabout helps to reduce conflicts at the Sheppard Road intersection, and pedestrians are able to cross one direction of traffic at a time due to the roundabout channelization. The disadvantages with this alternative are right-of-way impacts and relatively high cost of construction. Figure 2 shows the preliminary sketch for concept 2.

### **Concept 3 - Neff Road Widening and Channelization**

Concept 3 includes additional widening to Neff Road to accommodate eastbound and westbound left turn lanes at the Shepard Road-Main School Access intersection. The left turns would be channelized to accommodate a pedestrian crossing refuge area, allowing pedestrians to cross one direction of traffic at a time. Because of this channelization, however the northbound and southbound left turns at this intersection would be restricted. The secondary access point would be full access. The advantages to this concept are the limited right-of-way impacts and relatively low construction cost. The disadvantages include limited access to Sheppard Road and the school main access due to restricted left turns out of these approaches, and it is likely that the left turn out of the full secondary access point could experience high vehicle delay during peak times. Figure 3 shows the preliminary sketch for concept 3.

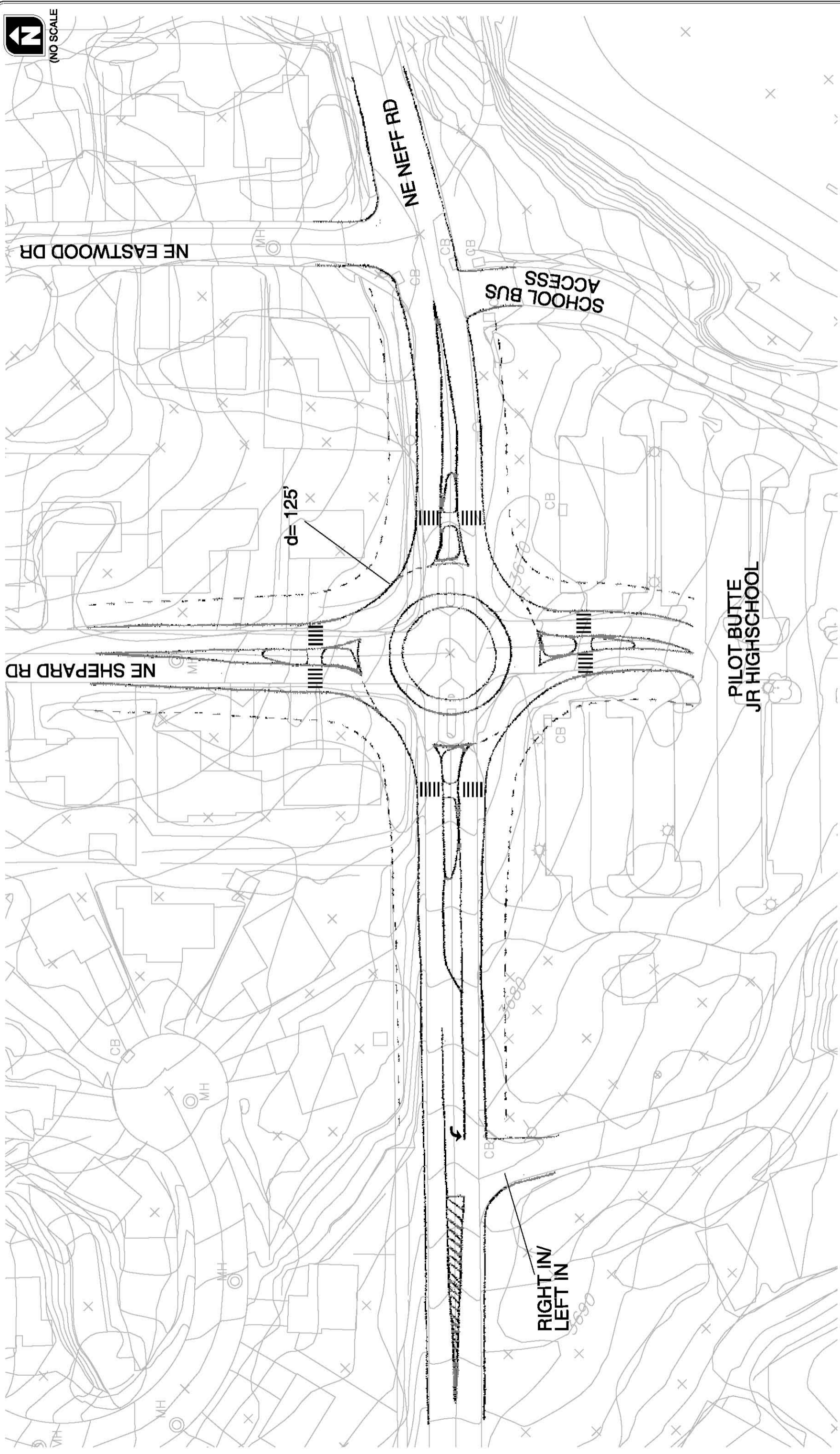
### **Concept 4 - Neff Road Drop-Off Area**

Concept 4 shows additional widening on Neff Road to accommodate a drop off area in the westbound direction. This would help to remove left turns into and out of the school access. The main access would remain as a full access, while the secondary access would be ingress only, accommodating the westbound left-in and the eastbound right-in. This alternative could potentially have lower costs when compared to the other concept ideas. Some disadvantages include the increased pedestrian crossing distance at the Shepard Road/Main Access intersection. There is a higher right-of-way impact for the school, as a majority of the widening would occur on the south side of Neff Road. In addition, further analysis would need to be completed to determine the appropriate storage length for the drop off area. Figure 4 illustrates the preliminary sketch for concept 4.



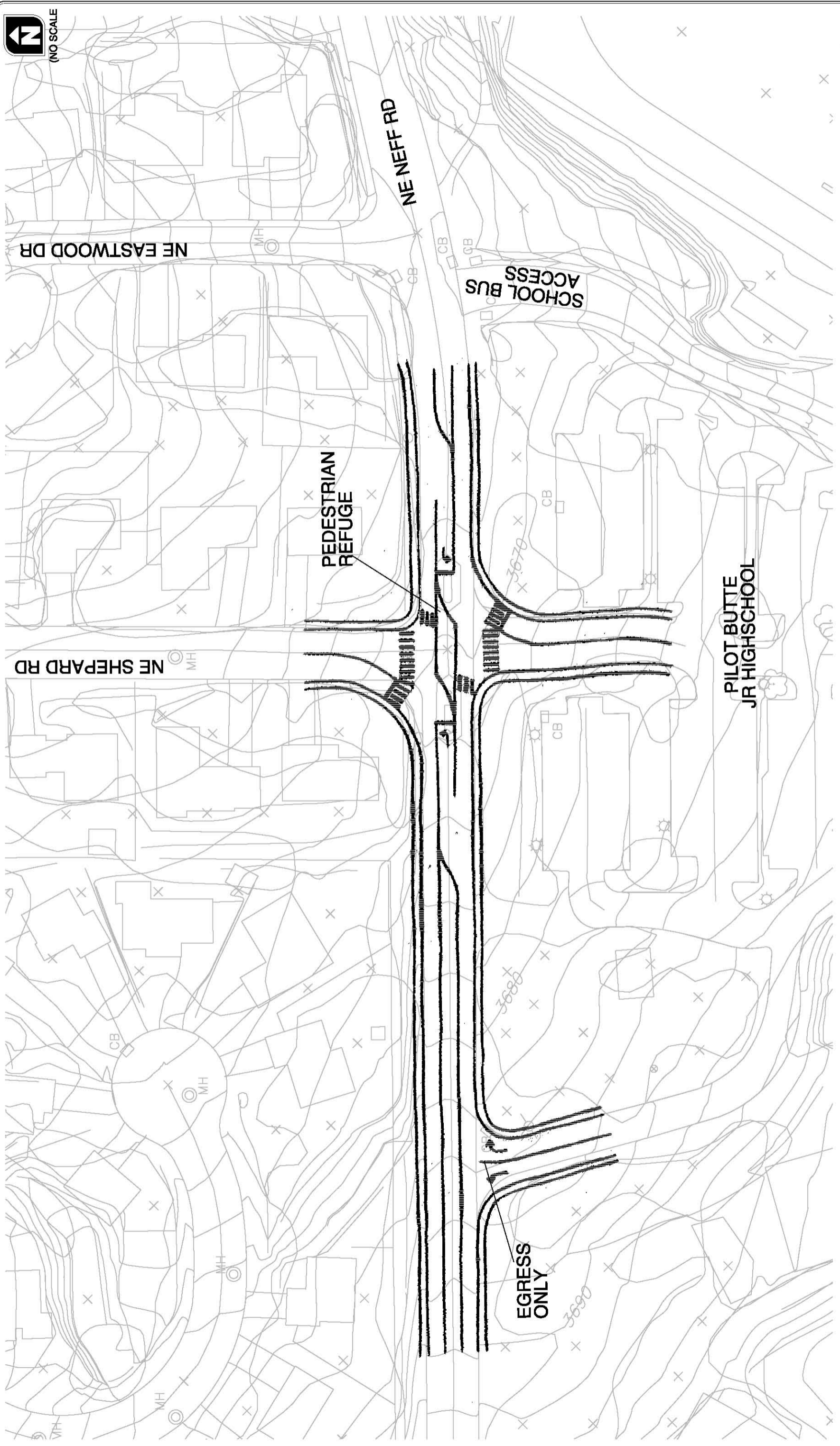
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DUAL ROUNDABOUT CONCEPT NUMBER 1  
BEND, OREGON  
FIGURE 1



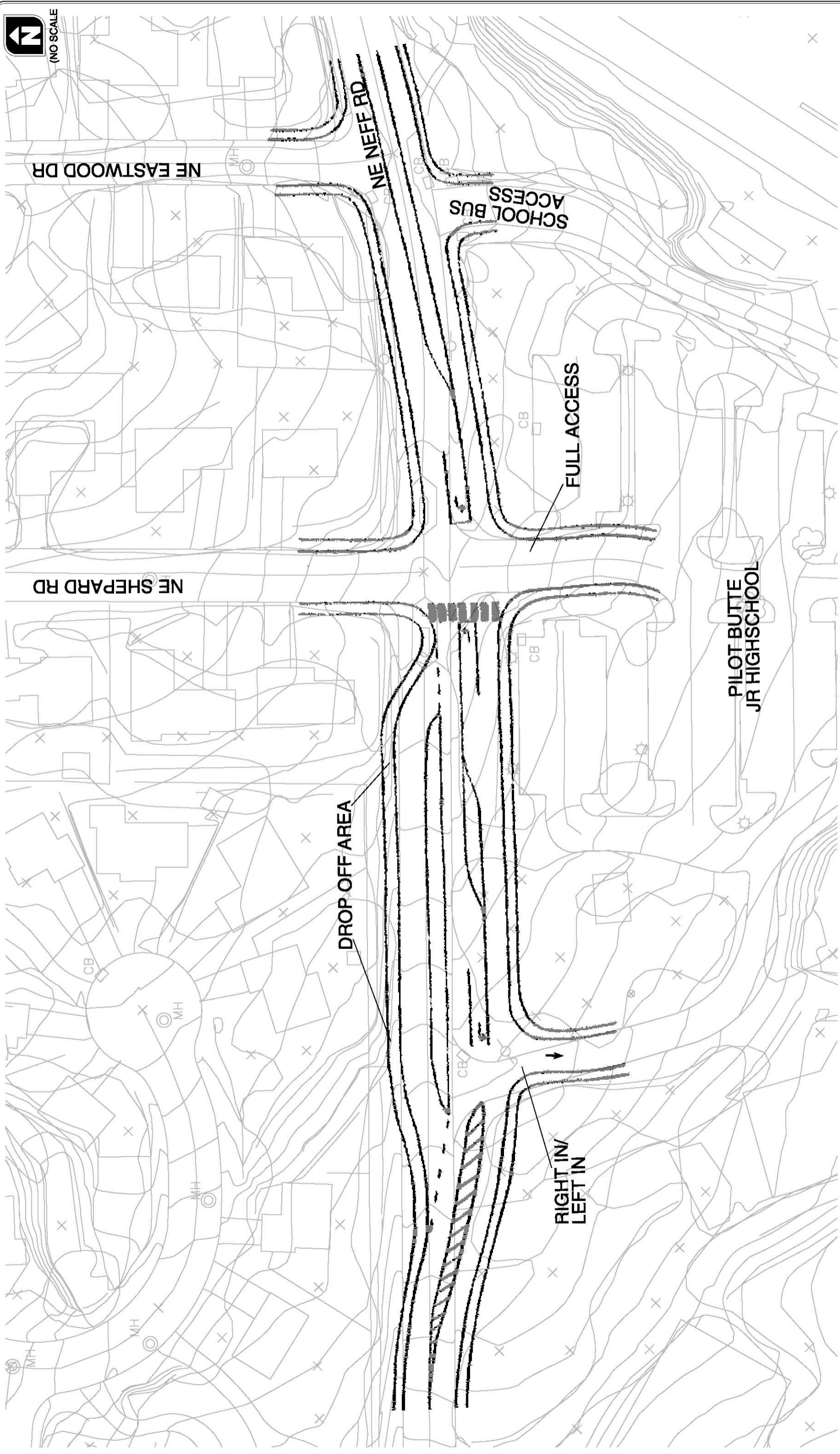
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FIGURE 2a  
ROUNDABOUT AND WIDENING CONCEPT NUMBER 2  
BEND, OREGON



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CHANNELIZATION WIDENING CONCEPT NUMBER 3  
BEND, OREGON  
FIGURE 3a



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DROP OFF AREA CONCEPT NUMBER 4  
BEND, OREGON  
FIGURE 4

## **REFINED SCHOOL FRONTAGE CONCEPTS**

Upon review of the first four preliminary concepts, two concepts were selected for further evaluation. The refined concepts are described in detail below.

### **Concept 2B – Smaller Single-Lane Roundabout with Additional Widening**

Under the refined version of concept 2, the roundabout diameter was reduced to 110-feet. This is as small as is reasonable at this particular location without compromising the operational or safety integrity of the intersection. Given the high volume demand along Neff and the activity at the school driveway, an urban mini-roundabout would essentially operate as a two-way stop controlled intersection for vehicles exiting the school or Shepard Road, thereby not providing any significant operational benefit. In addition, a mini-roundabout would not provide the distinct pedestrian crossings or paths that are needed at this location. Figure 5 illustrates the preliminary sketch for concept 2B.

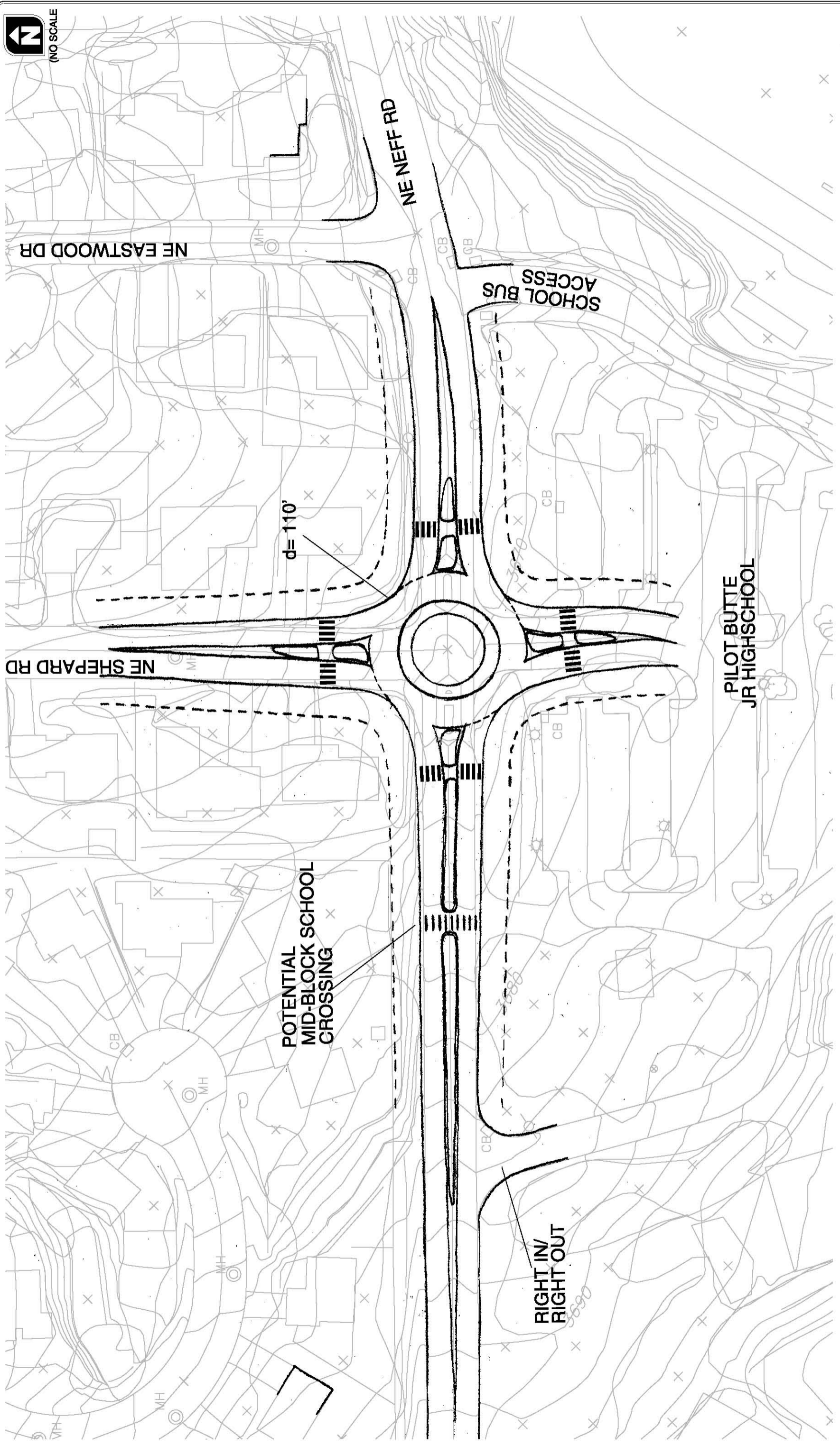
A potential mid-block pedestrian crossing has been shown between the two school access points. This would serve as the controlled school crossing with a crossing guard to relieve those pedestrian movements from the school's vehicular access intersections. A discussion regarding considerations associated with a mid-block crossing is provided below.

### **Concept 3C – Neff Road Widening and Turn Lanes at Sheppard Intersection**

This version of the concept has been updated to show full movements at the Shepard Road-Main School Access intersection. The intersection would be constructed with left-turn lanes on Neff Road. The intersection could be two-way stop controlled (i.e. stop signs on the Sheppard Road and Main Access approach) or potentially signalized in the future. Figure 6 shows the preliminary sketch for concept 3C.

The school Pilot Butte Middle School is currently generating about 435 trips in the AM peak hour (7:15 – 8:15 a.m.) and about 180 trips in the school afternoon peak hour (2:45 – 3:34 p.m.). These volumes do not meet MUTCD volume signal warrants at the Shepard intersection unless all of the right-turn movements are included in the analysis. Standard practice is to only include 50% of the right turn volume in the warrant analysis to account for right-turn on red maneuvers. In addition, the intersection will not meet the general pedestrian signal warrants (190 crossings in the peak hour or a minimum of 400 crossings over 4 hours). The location does meet the criteria for the School Crossing warrant. The benefits of signalizing the intersection could be evaluated under those requirements in context of the trade-offs to through vehicles along Neff Road.

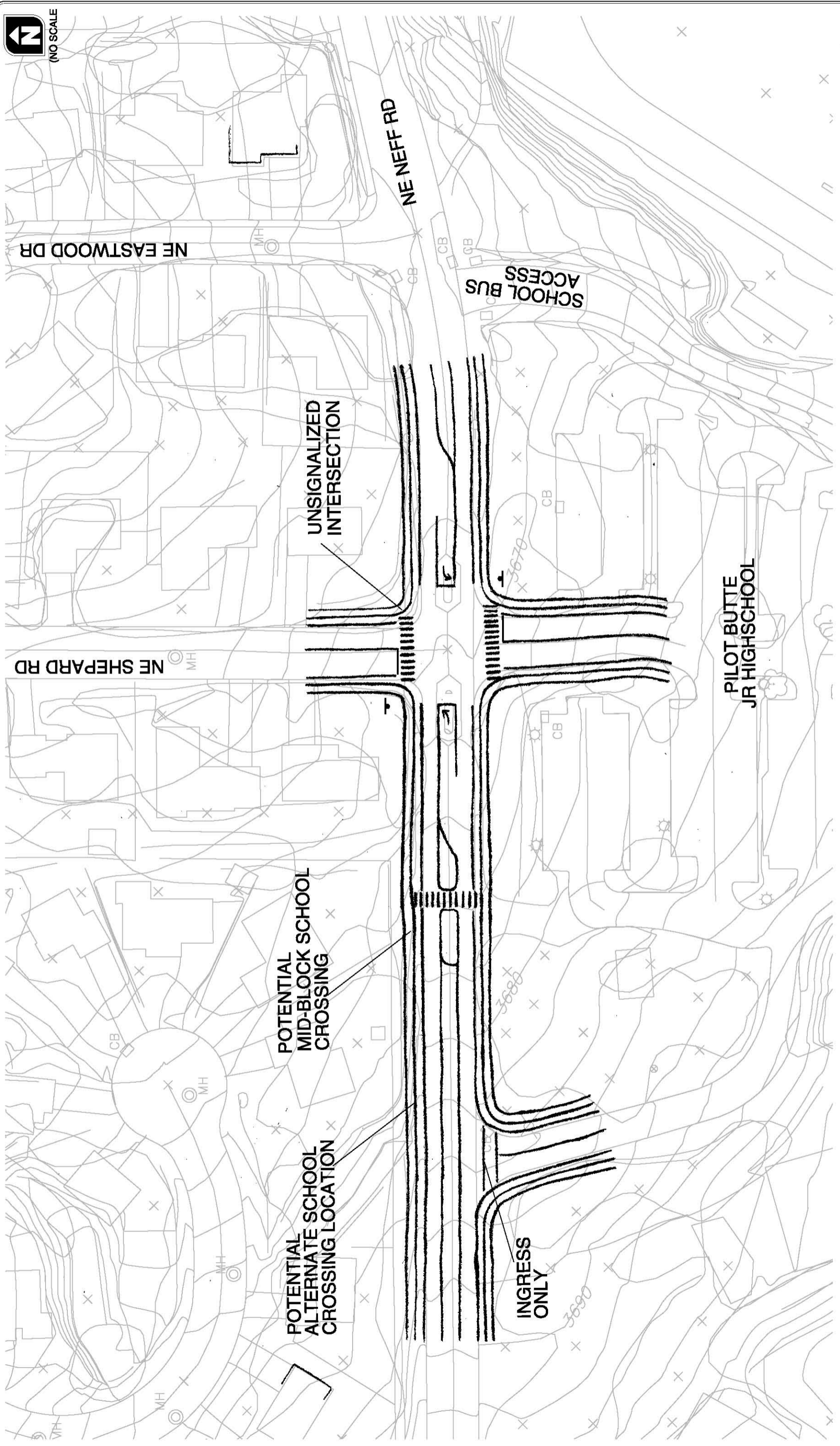
The sketch shows a mid-block crossing between the two school access points. This would only be a consideration if the Shepard Road intersection was not signalized. If the intersection is signalized, crossing pedestrians at the signal would be the desired strategy and no mid-block crossing would be recommended.



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FIGURE 2b  
ROUNDABOUT AND WIDENING CONCEPT NUMBER 2b  
BEND, OREGON





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FIGURE 3C  
MAIN ACCESS INTERSECTION (UNSIGNALIZED) CONCEPT NUMBER 3c  
BEND, OREGON

### **Mid-Block Pedestrian Crossing Considerations**

As previously discussed, there may be a benefit to vehicular operations for the school exit to take the guarded school pedestrian movements out of the Shepard Road intersection and relocate them to a mid-block location between the two school access points. Conversations with City of Bend Staff and school operators, the crossing of pedestrians at the Shepard Road intersection contributes to the difficulty drivers have in exiting the school driveway. In the final design phase the most appropriate location for the school crossing should be evaluated in further detail to determine the optimum balance between vehicular operations and pedestrian safety. Through this evaluation the special requirements and safety concerns associated with mid-block crossings should be considered:

- Is the crossing guard currently only responsible for crossing children across Neff or do they also protect crossing of the minor approaches (Shepard Road, school driveway) as well? If they are responsible for multiple crossings, moving the Neff crossing to mid-block would require children to cross those minor streets unprotected unless a second guard is provided.
- The crossing will have to operate safely during all hours of the day even when crossing guards are not present. Current research and literature generally tends towards crossings at intersections as more reliable and safer because of driver expectancy, recognition, and response. The MUTCD also generally discourages mid block crossings if they can be accommodated at an intersection location within a reasonable distance.
- Appropriate advanced warning (signing and striping), both for through vehicles on Neff Road and those turning out of the school driveway, will be very important. The MUTCD has an entire section related to school zone and crossing signing and striping.

## **NEFF ROAD/PURCELL BOULEVARD INTERSECTION**

A preliminary analysis of intersection safety and operations was conducted at the Neff Road/Purcell Boulevard intersection to determine potential mitigation measures for the intersection.

### **Intersection Safety**

The safety history at the Neff Road/Purcell Boulevard intersection does not exceed levels of crashes unexpected at a signalized intersection. Most of the crashes (particularly the rear end crashes) occurred in the year immediately after the temporary signal was introduced. This is expected in any situation where you introduce a new signal. The number of reported crashes has been significantly declining ever since. This is likely the result of more driver familiarity with the traffic control, but the declining number of reported crashes could also be attributable to new crash reporting procedures and thresholds for reporting requirements. Regardless, the intersection has been tagged by the City and there are improvements that could be made to reinforce safer driver behavior. There are two predominant crash trends occurring at the intersection:

- Eastbound and westbound left-turns from Neff Road to Purcell Boulevard conflicting with through vehicles on Neff
  - The signal phasing for these left-turns is currently protected-permitted. The crashes are occurring during the permitted phase when left-turn vehicles do not correctly judge gaps in the through traffic and attempt to make their turn without sufficient time. Changing the signal phasing to protected only will help to remove the decision needed from the drivers. This sometimes reduces the overall intersection capacity but the intersection should still operate acceptably (see operational details below).
- Rear end crashes in the eastbound direction approaching the signal down the hill
  - These were high initially after the signal introduction but have been steadily declining ever since. Sight distance does not appear to be an issue so it is likely that it just took a while for drivers to become familiar with the new signal and that speeds coming down the hill contribute to the occurrence. You will always have some rear end crashes approaching a traffic signal but there are a variety of treatments that could be used to improve driver awareness and manage speeds such as advanced signing, striping, and warning devices, and speed management treatments such as pavement markings, median treatments, and corridor landscaping.

Decreasing the grade along Neff Road will also serve to manage speeds approaching the signal. However, this will not be inexpensive (considering the near-term project budget constraints) and more detailed civil work will be required to determine how extensive the improvements would need to be.

Improved crossings and curb treatments should also be included as part of the intersection improvements to provide better conditions and increased visibility for pedestrians and bicyclists.

## **Traffic Operations**

In addition to safety, the intersection operations were investigated to determine potential future improvement options at the intersection. The operations analysis was conducted during the weekday a.m. and p.m. peak hours. Traffic volume data was collected in July 2006 for the existing conditions analysis. Under 2006 existing conditions the intersection currently meets the City of Bend signalized intersection operation standard (v/c less than 1.0 and delay less than 80 seconds) during both the a.m. and p.m. peak periods.

### Estimated Growth

To assess future traffic conditions a 3 percent annual growth rate was applied to existing traffic volumes to arrive at traffic volume forecasts for a year 2016 and year 2026 horizon year. The growth factor was based on a review of previous traffic studies conducted in the City of Bend as well as preliminary forecasts from the Bend Urban Area MPO travel demand model.

### Year 2016 Traffic Operations

In its current configuration (geometry and control), assuming the 3% annual growth factor, the intersection will have approximately a 5-year lifespan. By year 2016 conditions, the intersection is forecast to exceed acceptable operating standards during the p.m. peak hour operations. The intersection is forecast to still operate acceptably during the a.m. conditions. Mitigation for the p.m. peak hour condition includes widening Purcell Boulevard to accommodate separate left turn lanes in both the northbound and southbound directions. Additional modifications to the signal timing would be required.

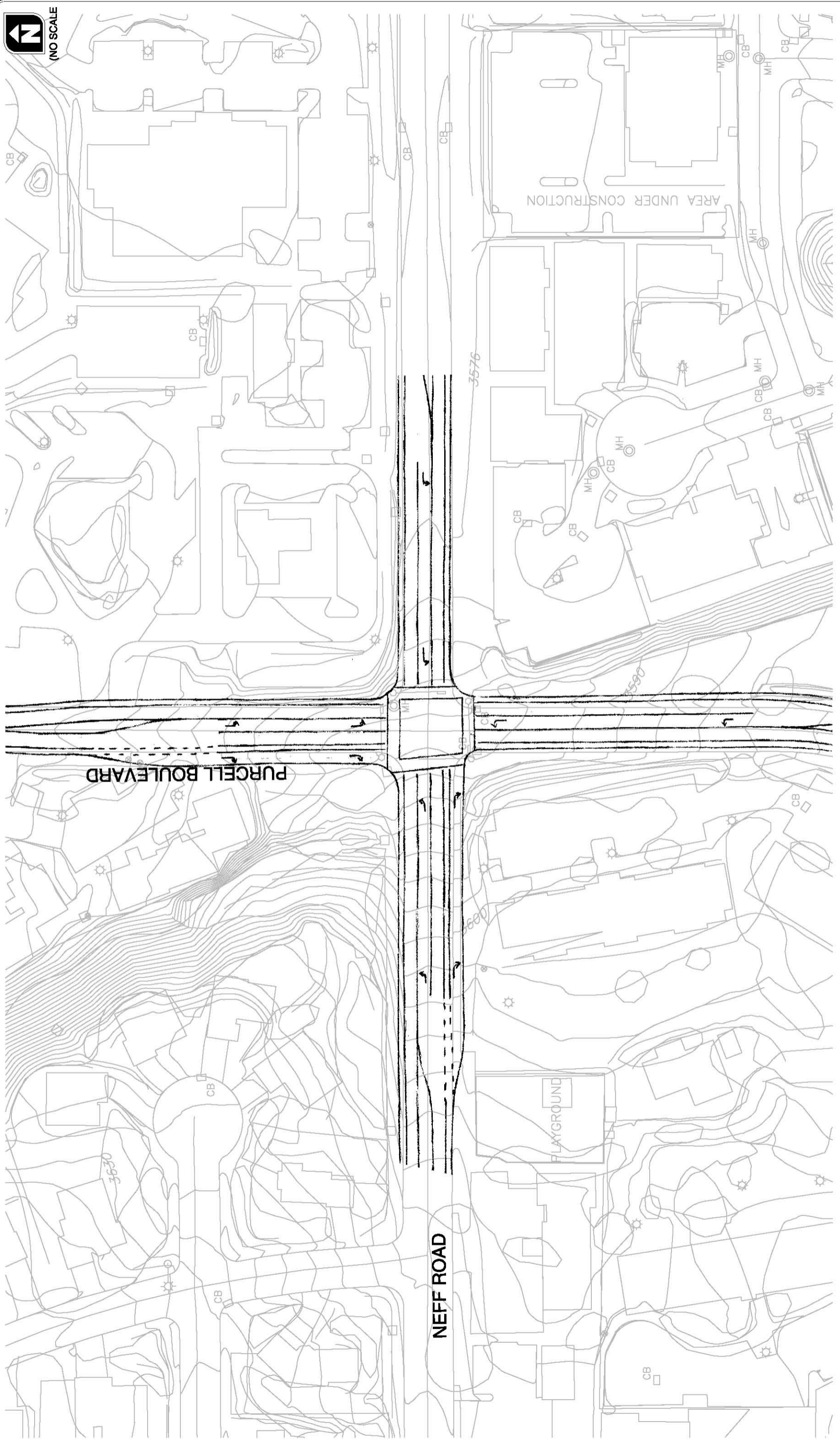
### Year 2026 Traffic Operations

By year 2026 conditions the intersection is forecast to exceed acceptable operating standards even with the construction of mitigations for the 2016 condition. Additional mitigation would include widening Neff Road to include separate left, through and right turn lanes on the eastbound and westbound approaches. In addition, the southbound approach of Purcell Blvd would require a separate left, through, right lane configuration as well. During the design phase, further analysis will be needed to ensure that adequate left turn vehicle storage is available on all four approaches, per City of Bend operations standards.

## **Mitigation Alternatives**

Two alternative mitigation concepts were developed and analyzed for the Neff Road/Purcell Boulevard intersection.

- Improved Signalized Intersection – Figure 7 illustrates the future intersection layout included forecast lane geometry and required storage bays. It is important to note that the geometry shown is only at the intersection, it is likely that additional widening would need to occur on Neff or Purcell to accommodate this geometry. With this configuration, the signal will operate at 0.96 volume-to-capacity over the 20 year horizon. This assumes exclusive protected-only phasing for all left-turn movements as discussed in the safety section above.

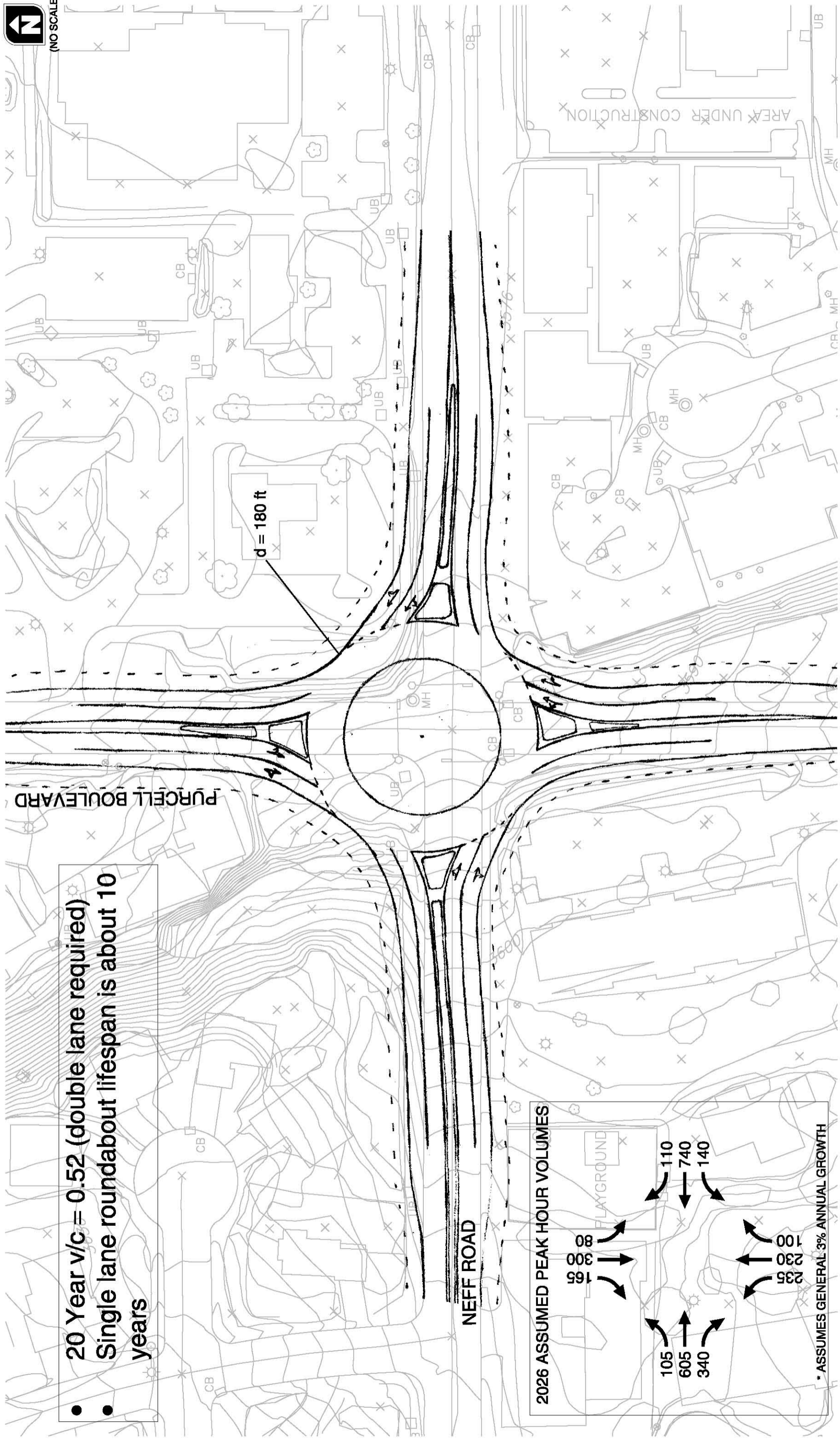


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NEFF ROAD/PURCELL BOULEVARD SIGNAL CONCEPT  
BEND, OREGON  
FIGURE 1

- Roundabout Intersection – Figure 8 illustrates a roundabout option for mitigation. Based on the operational analysis, a double-lane roundabout is required to accommodate the forecast travel demand. A single-lane roundabout would have approximately a 10-year lifespan at this location with the 3% annual growth rate that was assumed. The double lane roundabout's 20-year volume-to-capacity ratio is 0.52 for the critical approach.

In addition to the geometric mitigations discussed above, the Neff Road/Purcell Boulevard intersection requires additional mitigation to improve the intersection approach grades and sight distance. This mitigation presents significant construction challenges, as Neff Road serves as an emergency vehicle route to the St. Charles Medical Center, located east of the Neff Road/Purcell Boulevard intersection. Special consideration should be taken to evaluate construction methods for maintaining traffic operations at this intersection.



- 20 Year v/c = 0.52 (double lane required)
- Single lane roundabout lifespan is about 10 years

**2026 ASSUMED PEAK HOUR VOLUMES**

\* ASSUMES GENERAL 3% ANNUAL GROWTH

105, 605, 340, 110, 740, 140, 165, 130, 88, 235, 230, 100

NEFF ROAD/PURCELL BOULEVARD ROUNDABOUT CONCEPT  
BEND, OREGON

FIGURE 1

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## **PREFERRED IMPROVEMENT CONCEPTS**

Based on the preliminary design and benefits outlined above a preliminary preferred alternative for each study area emerged. The preferred options resulted based on considerations of right-of-way impacts, implementation costs, and the operations and safety benefits that result.

The preferred concepts are:

- **School Frontage: Concept 3C – Neff Road Widening and Turn Lanes at Shepard Intersection**
  - Widening of Neff Road to provide full movements at the Shepard Road-Main School Access intersection. The intersection would be constructed with left-turn lanes on Neff Road. The intersection could be two-way stop controlled (i.e. stop signs on the Shepard Road and Main Access approach) or potentially signalized in the future.
  - The school Pilot Butte Middle School is currently generating about 435 trips in the AM peak hour (7:15 – 8:15 a.m.) and about 180 trips in the school afternoon peak hour (2:45 – 3:34 p.m.). These volumes do not meet MUTCD volume signal warrants at the Shepard intersection. In addition, the intersection will not meet the general pedestrian signal warrants (190 crossings in the peak hour or a minimum of 400 crossings over 4 hours). The location does meet the criteria for the School Crossing warrant and the benefits of signalizing the intersection could be evaluated under those requirements in context of the trade offs to through vehicles along Neff Road.
  - The sketch shows a mid-block crossing between the two school access points. This would only be a consideration if the Shepard Road intersection was not signalized. If the intersection is signalized, crossing pedestrians at the signal would be the desired strategy and no mid-block crossing would be recommended. Even in the unsignalized configuration, careful consideration should be given before relocating the pedestrian crossing as described in the previous section of this memorandum.
- **Neff Road/Purcell Boulevard: Improved Signalized Intersection**
  - Figure 7 illustrates the future intersection layout including forecast lane geometry and required storage bays. It is important to note that the geometry shown is only at the intersection, it is likely that additional widening would need to occur on Neff or Purcell to accommodate this geometry. With this configuration, the signal will operate at 0.96 volume-to-capacity over the 20 year horizon. This assumes exclusive protected-only phasing for all left-turn movements as discussed in the safety section above.
  - Based on the need for a double-lane configuration with a roundabout, it appears that the signal is the better near-term alternative as turn lane improvements (and the right-of-way they require) could be more easily phased in over time.
  - A sensitivity analysis was conducted for the eastbound and southbound right-turn lanes shown in the concept. The need for the eastbound right-turn lane is triggered



under year 2020 conditions (15 years) and the southbound right-turn lane is not triggered until 2025 conditions. As such, as long as easements were obtained to ensure signal pole placement at the desired ultimate locations, the intersection could be constructed without these particular right-turns in the near-term until right-of-way could be obtained in the future. However, the eastbound right-turn lane may have other safety benefits, given the rear-end crash history on this approach, that may want to be considered during the design phase.

We trust this memorandum provides a summary of the analysis and assessment that has been completed as part of the preliminary design phase. If you have any questions please contact us at 1-866-900-2683.