

US 97 Parkway Plan Phase 2

Draft Technical Memorandum #8 – Murphy Road / Powers Road
Improvement Concepts

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Prepared for:



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INTRODUCTION

This memorandum focuses on the design option for the US 97/Powers Road and US 97/Murphy Road locations. The work in this memorandum builds off the analysis already performed in Technical Memorandum #7 by developing conceptual interchange/overcrossing designs at these locations, as well as providing additional sensitivity analysis related to the traffic interaction between them. This memorandum will assess the following concepts:

1. Powers Road Tight Diamond Interchange
2. Powers Road Overcrossing
3. Murphy Road Tight Diamond Interchange
4. Associated Frontage Road Connections

This memorandum will ultimately recommend a series of improvements related to the Powers Road and Murphy Road connections to US 97, backed by conceptual designs and cost estimates.

CONCEPTS

POWERS ROAD

Under future conditions, the existing Powers Road intersection will fail to provide sufficient capacity for the northbound and southbound movements on US 97. Two concepts were identified to address this issue: an interchange and an overcrossing.

Tight Diamond Interchange Concept

To mitigate the capacity issue at this location without complete closure of the intersection and restricting access to US 97, a compact “tight” diamond interchange could be constructed at the intersection. This interchange would allow for full access on and off US 97. This concept would also address some of the safety issues with the current at-grade intersection configuration. A conceptual configuration of such a tight diamond interchange is shown in Figure 1 and further described in the rest of this section.

Assumed Concept Elements

The design components are summarized as follows:

- **Alignment:** The proposed design for the new Powers Road interchange would bring Powers Road over existing US 97 as a tight diamond interchange. Consideration could be given to potentially skewing the interchange to reduce right-of-way (ROW) impacts in more detailed design, if ramp spacing permits.
- **Cross Section:** The assumed roadway for the Powers Road overcrossing was designed to be consistent with existing conditions and other existing overcrossings in Bend. This includes matching the existing three 12' lanes, 6' bike lanes in both directions, a 6" curb, and 6' sidewalk along Powers Road through the existing intersection. Additionally, the inclusion of 7' planters leading up to, but not across, the overcrossing on Powers Road will match what is shown on the recently improved Murphy Road overcrossing.



Figure 1: US 97/Powers Road Tight Diamond Interchange Concept





- **Structure:** The overcrossing ties down at about 380' at 6% downgrade on either side of the existing US 97 edge of roadway. The overcrossing at-grade landings are expected to avoid impacts to existing commercial driveways and access to neighborhoods on either end.
 - As shown in the May 2019 version of the Bend Urban Area Street System map, Powers Road across US 97 will be a minor arterial. Section 2-3 of the City of Bend Design Standards: Part II lists a maximum permissible grade of 6% along any arterials.
 - The ODOT Highway Design Manual (HDM, 2012) lists a 17'-4" vertical clearance standard for any roadway over High Routes.

According to the standards above and an assumed structure depth of 5', it was determined that the surface-to-surface height of 23' (rounded up) was required and used for the design height of the overcrossing.

- **Ramps:** The ramps for the interchange were designed per standards listed in Chapter 9 of the ODOT HDM. Grades ranged from 3%-5% down to existing US 97. With the Powers Road overcrossing designed first, the ramps connected at-grade to the new Powers Road elevations at their respective locations shown in Figure 1.

Ramps on the northeast and southwest corners will have little or no ROW impacts while the southeast and northwest corners have significant ROW acquisitions needed to fit. The southeast corner (northbound off-ramp) requires acquisition of at least one tax lot (181208CA01700 in Deschutes County Data Portal) which currently is listed as the Moose Lodge. The northwest corner (southbound off-ramp) requires the acquisition of potentially several properties (residential homes) to fit.

With the current Powers Road alignment, a skew was applied to the ramp connections of up to 15 degrees as allowed by the ODOT HDM to help reduce distance offset from the US 97 centerline along Powers Road and to reduce distance along US 97 needed to tie in. The existing right-in-right-out jug handles at Powers Road and US97 will be removed to accommodate these ramps. A curb radius of 55' was used for the ramp terminals on the overcrossing to accommodate larger vehicles.

- **Other Elements:** Retaining walls and sound walls are shown where needed with the assumptions of flat ground along the existing corridor and a maximum 1V:3H slope from shoulder to existing, 1V:6H where allowable.

Structural Design

US 97 is part of the State Highway Freight System and is designated as a "High Route" by the Oregon Department of Transportation. The vertical clearance requirement for US 97 is 17'-4".

The bridge design concept balances this vertical clearance requirement, US 97 existing corridor width, and Powers Road profile grade and sight distance requirements, with the structure's span length / depth requirements. This resulted in the structure design concept consisting of a two-span precast pre-stressed concrete girder bridge over US 97, with an overall length of 160' and a width of 66'-6".

Additionally, construction projects along the US 97 corridor have included a specific architectural theme for the bridges and retaining walls. This architectural theme is included in this bridge concept, including custom pre-stressed precast concrete exterior girders that provide a haunch soffit and arch-like effect,



inward sloping textured abutment walls with earth tone concrete stain, and 2-Tube metal bridge railing in matching earth tone color.

Although a detailed analysis has not been performed on whether sound walls and retaining walls are warranted, both are assumed and nominally accounted for in the cost estimate.

Key Constraints

To mitigate the capacity issue at this location without closing the intersection altogether and restricting access to US 97, a tight diamond interchange (250' – 400' spacing between ramps per ODOT Highway Design Manual) could be constructed at this intersection. This interchange would allow for full access on and off US 97. This concept would also address some of the safety issues with the current at-grade intersection configuration.

Without survey data, it is impossible to determine several design details; including where the overcrossing needs to tie-in on Powers Road, existing condition elevations and grades, and how high ramps will need to rise to match the overcrossing. This factors into ROW needs, quantities/costs, and could impact the design.

Further design would need to be done to determine whether the stopping sight distance of the design would work. Assuming a 40-mph design speed, a stopping sight distance of 305' would be needed with a vertical curve of about 520'. Currently, the overcrossing spans 900' between tie-ins as shown in the plan.

Right-of-Way

The ROW assumptions for the concept design were subject to the following constraints:

- Without survey data, ROW impacts are assumed based on Deschutes County Data Portal taxlot mapping comparisons to design.
- Additionally, without modelling the design it is difficult to say where any elevated facilities will tie-in to existing conditions.

Cost Estimate

The following assumptions were made as part of the cost estimating process:

- Without survey data, a flat surface was assumed. Therefore, embankment quantities for the ramps may not be accurate.
- Design engineering is not factored into cost estimate.
- ROW acquisition is not factored into cost estimate.
- Retaining wall(s) are assumed and nominally estimated
- The bridge unit price was developed from 2014 ODOT bid data for the Murphy Road interchange and includes the cost premium for the architectural themed elements. The 2015 prices were escalated by 3% per year for 2019 prices.

The total estimated cost of the interchange is **\$24,659,000**. The detailed breakdown of the cost estimate is included in Appendix A.

Overcrossing Concept

The Powers Road overcrossing concept would construct an overcrossing at the US 97/Powers Road intersection to maintain east-west connectivity, assuming the right-in-right-out (RIRO) intersections



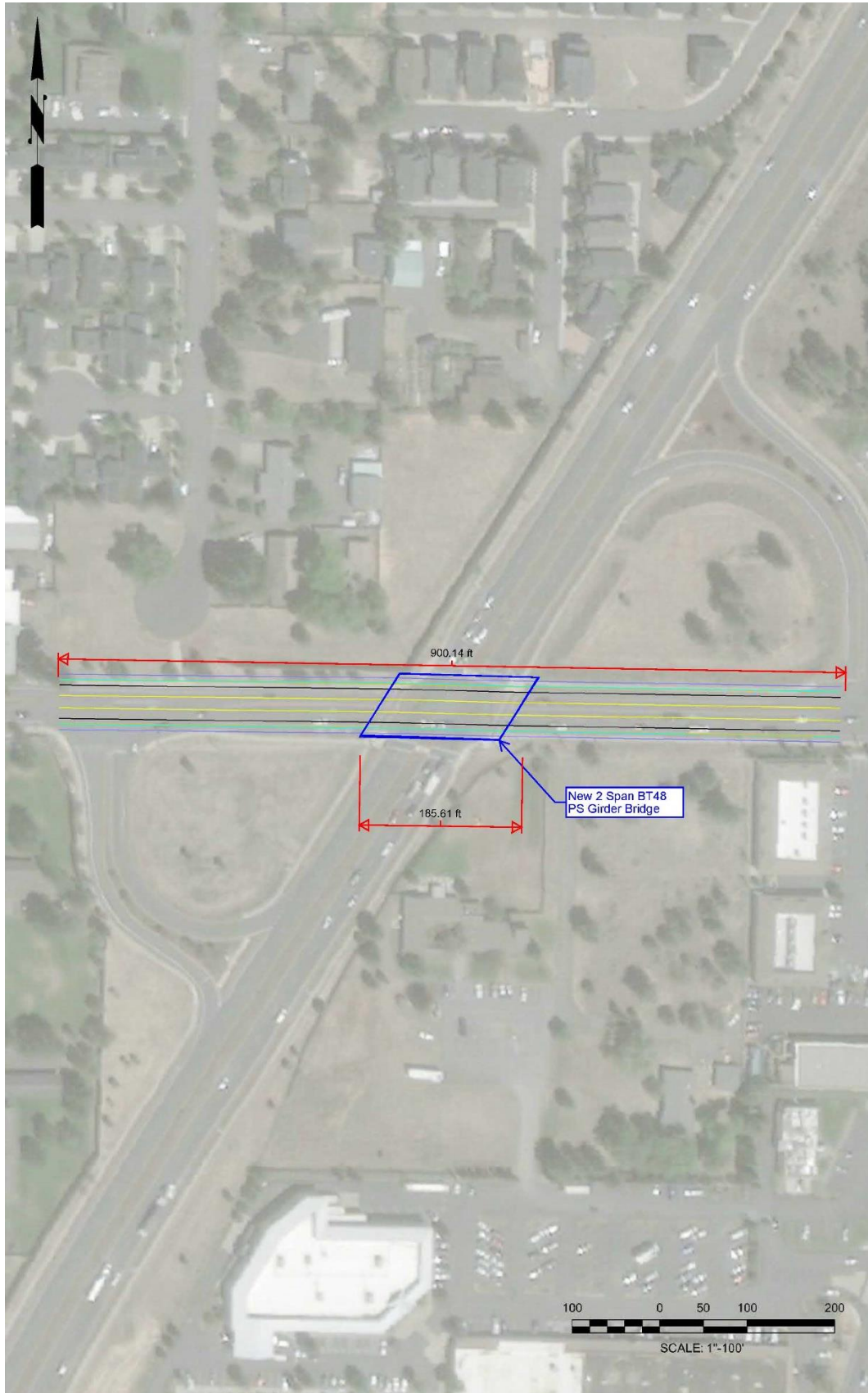
along the Parkway are closed. The grade separation would allow Parkway traffic to move freely at this location by removing the at-grade conflicts with Powers Road traffic. Furthermore, with fewer conflicts between movements, the risk of crashes is reduced.

Assumed Concept Elements

The design concept for the Powers Road Overcrossing is shown in Figure 2. The concept elements used for the design of the overcrossing are the same as those used for the Powers Road Tight Diamond Interchange.



Figure 2: Powers Road Overcrossing Concept





Structural Design

Assumed to be the same structural design as the tight diamond interchange overcrossing.

Key Constraints

Assumed to be that same as the key constraints for the tight diamond interchange overcrossing.

Right-of-Way

The ROW impacts of the overcrossing are negligible, as the structure could be built in existing ROW.

Cost Estimate

The cost estimate used the same assumptions as the overcrossing portion of the tight diamond interchange estimate. The estimated cost of the overcrossing is **\$8,034,000**.

MURPHY ROAD

The Murphy Road Crossing Plan includes the following planned facilities:

- Northbound Loop Ramp and Southbound Off-Ramp
- South Frontage Road

These facilities were included in all the Technical Memorandum #7 analysis as the assumed Future No-Build conditions. This memorandum explores a tight diamond interchange design at Murphy Road, which will be compared through traffic operations sensitivity testing against the Murphy Crossing ramps, along with additional assessment of frontage system concepts.

Murphy Crossing Plan Northbound Loop Ramp/Southbound Off-Ramp

The Murphy Crossing Plan¹ included a southbound off-ramp to frontage road and a northbound loop on-ramp from 3rd Street to US 97, as shown in Figure 3, which originated from the Murphy Crossing – Preferred Plan.

The northbound loop ramp would connect the south approach to the Murphy Road/3rd Street roundabout to US 97 northbound via a tight radius loop ramp through the current Les Schwab property. The design of this ramp is still at the conceptual level, but it would likely require design exceptions related to tight radii and may also require reconstruction of the Murphy Road overcrossing of US 97 to accommodate acceleration lanes. The cost of this concept was estimated to be \$5 million in 2009, which escalated to present day costs equates to **\$6,700,000**. It is important to note that this cost estimate does not account for the most recent design and construction of the current ramps and configuration of the Murphy Road overcrossing, which could potentially add significant cost.

The southbound off-ramp would tie into the south frontage road near Romaine Village Road. Note that this ramp design would not be functional without at least a frontage road connection between Romaine Village Road and Murphy Road. The cost of this concept was estimated to be \$2.4 million in 2009, which escalated to present day costs equates to **\$3,200,000**.

South Frontage Road

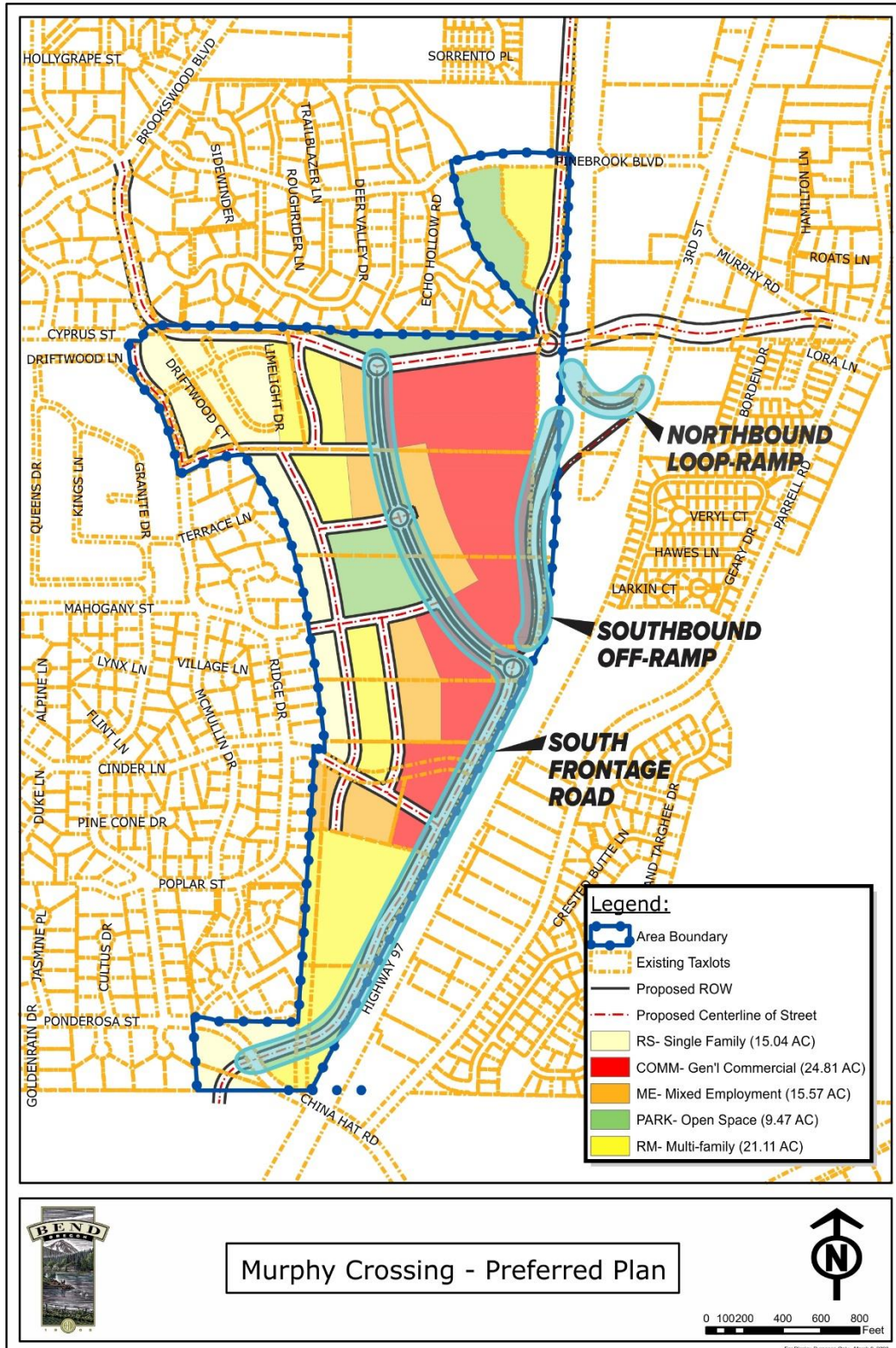
The south frontage road northern terminus would be located west of the north frontage road connection to Murphy Road and would extend south skirting existing development to connect to

¹ US 97: South Parkway Murphy Interchange Area Management Plan, David Evans and Associates, February 2007. October 26, 2019



Ponderosa Road. The conceptual layout for this project is shown Figure 3. The total estimated cost for the south frontage road is **\$10,600,000**, assuming a 2.9% escalation over the 2009 Murphy Crossing Plan cost estimate.

Figure 3: Murphy Cross Preferred Plan Concepts





North Frontage Road

To provide a parallel route to US 97 and provide circulation and access to current users of the Badger Road and Pinebrook Boulevard RIRO access locations west of the Parkway, a frontage road is planned to extend from Murphy Road to Powers Road (See Figure 4).

Figure 4: North Frontage Road Concept





This improvement would facilitate the closure of access to US 97 from Badger Road and Pinebrook Boulevard. Note that the Badger Road RIRO access would have to be closed to facilitate an interchange at Powers Road, and the Pinebrook RIRO access would have to be closed to accommodate a northbound on-ramp and southbound off-ramp at Murphy Road. Blakely Road would be incorporated into the frontage road as part of the connection between Badger Road and Powers Road. Where feasible, roundabouts may be incorporated into intersection design at later stages.

The frontage road is assumed to match the existing proposed typical sections for the 3rd Street bridge improvements including curb radii between 55' – 76', three 12' lanes, 6' bike lanes along both directions, 6' sidewalks, 6" curbs, and 7' planters (no planters on the bridge structure). The frontage road improvements are designed to City of Bend standards as a local street improvement.

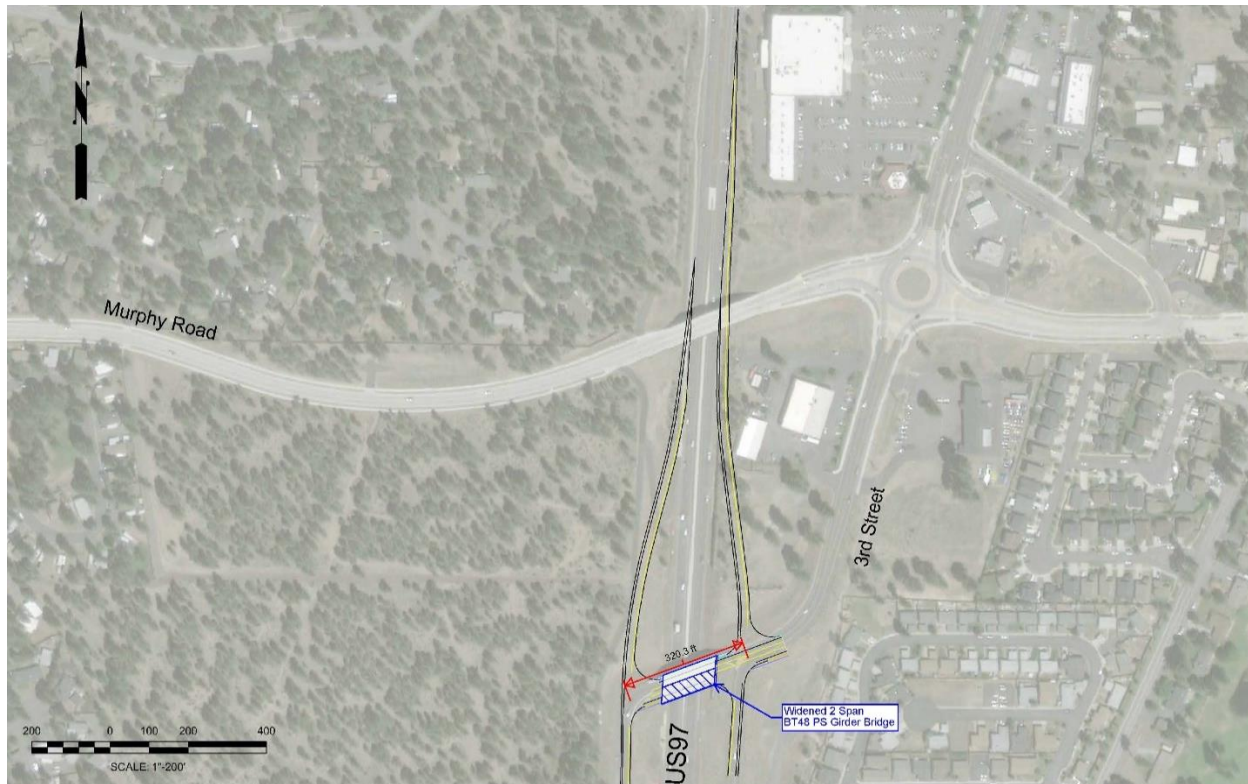
Significant ROW acquisition is needed for the frontage road system including multiple empty lots along US 97 to the west, New Hope Church, and potential impacts to the neighborhood at Blakely Road between Powers Road and Badger Road. The detailed cost breakdown for the North Frontage Road is included in Appendix A. The estimated total cost for the North Frontage Road is **\$15,154,000**.

Tight Diamond Concept

This improvement includes building two new ramps on the north side of the existing 3rd Street bridge located to the south of the Murphy Road overcrossing on US 97. The improvements would widen the existing bridge and create a full access diamond interchange, as shown in Figure 5.



Figure 5: Murphy Tight Diamond Concept



Assumed Concept Elements

The design components are summarized as follows:

- **Cross Section:** Typical sections for this bridge and new roadway between Murphy Road to the west of US 97 and to 3rd Street east of US 97 will match those along Murphy Road - 12' lanes, 6' bike lanes, 0.5' curb, 6' sidewalks, and 7' planter strips where shown. Three travel lanes will match those where the new bridge connects to the existing 3rd Street just south of Murphy Road, and Murphy Road just west of US 97. A connection from the ramps on the west side of the intersection to Murphy Road at a location west of the proposed north frontage road will be provided.
- **Structure:** To accommodate traffic heading eastbound across the bridge along with the two new ramps, the existing 3rd Street bridge will be widened to the south using an existing abutment on the east side of US 97 that is anticipated to accommodate the widening.
- **Ramps:** A southbound off-ramp and a northbound on-ramp will be added to the existing half interchange. These ramps are designed to ODOT HDM standards and tie into existing conditions on US 97 and 3rd Street. Both ramps are designed with 3% grades which are sufficient for the ramps to come up to grade with the overcrossing.
- **Other Elements:** Roundabouts at each of the ramp terminals have been considered but may not be feasible. Using similar design standards as the roundabouts located on Murphy Road just to the north, it may be difficult to incorporate these roundabouts into the current design and existing facilities.



Structural Design

The bridge design concept widens a recently constructed ODOT bridge (number 22019) over US 97.

This recent construction included extending the east abutment retaining wall to the south, in preparation for a future widening. Our design concept utilizes this accommodation and widens the existing bridge to the south.

When widening an existing bridge, a key consideration is for the widened portion of the bridge superstructure to have the same stiffness as the existing bridge. This enables the existing and widened portions to react uniformly to loading. Our design concept includes removing the existing bridge deck to the center of the exterior pre-stressed concrete girder and constructing a two-span pre-stressed precast concrete girder bridge widening with identical girder size and spacing of the existing bridge.

ODOT records note that the existing bridge provides 18'-0" of vertical clearance over US 97. US 97 is part of the State Highway Freight System² and is designated as a "High Route" by the Oregon Department of Transportation³. The US 97 vertical clearance requirement of 17'-4"⁴ is met by the existing bridge and the concept widening.

The concept design incorporates the same architectural theme for the bridge widening, including custom pre-stressed, precast concrete exterior girders with a soffit with haunches, inward sloping textured abutment walls with earth tone concrete stain, and 2-Tube metal bridge railing in matching earth tone color.

Although a detailed analysis has not been performed on whether sound walls and retaining walls are warranted, both are not assumed to be required and are not accounted for in the cost estimate.

Key Constraints

Constraints for the ramps included the Murphy Road overcrossing to the north and utilizing existing ramps on the south side of the 3rd Street bridge. As-built plans from the US 97/Murphy Rd: Brookwood-Parrell (Bend) Phase I project (provided by ODOT, 2014-2015) show room under the northbound side of the bridge to expand for a 16' lane and 6' shoulder along the existing right northbound lane under the bridge. Assuming this is accurate, there should be room to expand for a ramp, especially since the alignment of the ramp ties into US 97 south of the bridge.

The northbound on-ramp was designed to accommodate an acceleration lane widening the roadway while avoiding having to widen the Murphy Road overcrossing of US 97. Potential issues that came up during design were in ramp length (curves, spirals, entrance angle, acceleration length, and taper) and descending grade. We found that the length of the ramp to be the controlling factor and that, with a design fit to ODOT HDM, the grade could be flattened to more desirable conditions.

Typical roadway sections were designed to match those in other areas of Bend to maintain the same aesthetic.

Existing ramps at the 3rd Street bridge mean any new ramps would likely tie into 3rd Street at the same locations.

² Oregon Department of Transportation, Oregon Freight Plan, amended 2017; Chapter 4 Freight Systems

³ Oregon Department of Transportation, *Oregon Highway Design Manual, 2012*; Section 4.5.1

⁴ Oregon Department of Transportation, *Bridge Design Manual, May 2018*; Section 3.14.4



An abutment built previously during the Murphy Road improvements, means that widening the bridge to the south would be cheaper and require less work.

Right-of-Way

The ROW assumptions for the concept design were subject to the following constraints:

- Without survey data, ROW impacts are assumed based off Deschutes County Data Portal taxlot mapping comparisons to design.
- Additionally, without modelling the design, it is difficult to say where any elevated facilities will tie into existing conditions.

Cost Estimate

The following assumptions were made as part of the cost estimating process:

- Without survey data, a flat surface was assumed. Embankment quantities for the ramps may not be accurate.
- Design engineering is not factored into cost estimate.
- ROW acquisition is not factored into cost estimate.
- Retaining wall(s) are assumed and nominally estimated.
- The bridge unit price was developed from 2014 ODOT bid data for the Murphy Road and includes the cost premium for the architectural themed elements. The 2015 prices were escalated by 3% per year for 2019 prices.

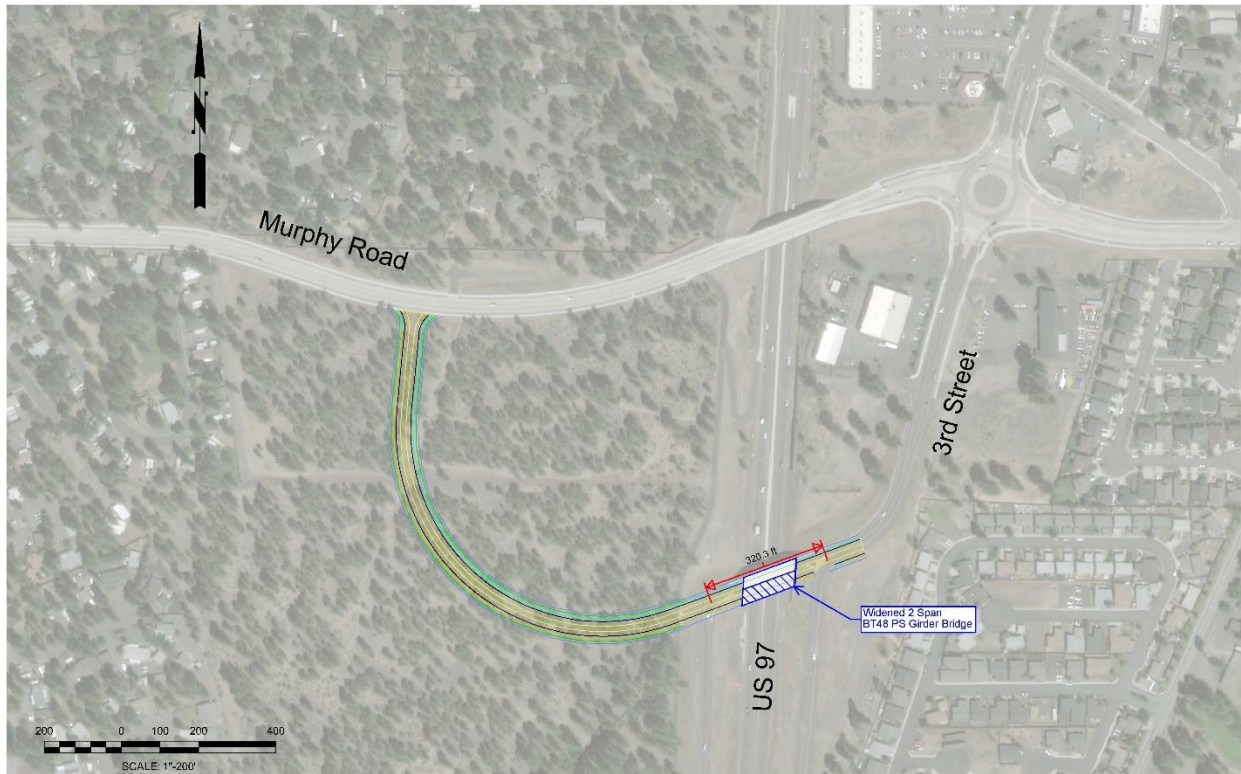
The total estimated construction cost of the tight diamond bridge and ramps is **\$11,853,000**.

West Loop Frontage Road

To connect the Tight Diamond interchange to Murphy Road, a frontage road concept was developed that connects the southbound ramp terminal to Murphy Road. This concept is shown in Figure 6 and would likely terminate at Murphy Road with a roundabout. Note also that this concept could be refined as a phase of the South Frontage Road concept from the Murphy Crossing Plan. The estimated cost for a frontage road connection between the southbound ramp terminal and Murphy Road is **\$10,907,000**. The detailed breakdown of the cost estimate is included in Appendix A.



Figure 6: West Loop Frontage Road Concept



EVALUATION METHODOLOGY

LEVEL 2 EVALUATION

In the Second Level of Alternative Evaluation Technical Memorandum, a more comprehensive assessment of potential benefits and trade-offs associated with the identified alternatives using a combination of qualitative and quantitative analysis and evaluation criteria was applied.⁵ The Level 2 evaluation and the findings will be described later in this memorandum. The results will be discussed with project stakeholders, leading to the identification of the best projects to be combined into a final, Preferred Alternative. More details on the Level 2 evaluation process can be found in Technical Memorandum #7 (TM #7).

While TM #7 included full Level 2 Evaluation of the Powers Road Overcrossing and Interchange concepts, the Murphy Road loop ramps and frontage system were assumed as a future No-Build conditions. Therefore, the Murphy concepts will be scored against the applicable Level 2 Evaluation Criteria in this memorandum.

POWERS-MURPHY SENSITIVITY TESTING

The Level 2 Evaluation captured the operational impacts of the two following Murphy-Powers interactions:

⁵ Second Level Alternatives Evaluation Technical Memorandum #7, DKS Associates, September 2019. October 26, 2019



1. Powers Road Overcrossing with Murphy Road loop ramps/frontage system (Project Bundle A)
2. Powers Road tight diamond with Murphy Road loop ramps/frontage system (Project Bundle B)

To better understand the operational impacts of the improvements at Powers Road and Murphy Road intersections and interchanges, the following three additional interactions were tested:

3. Powers Road overcrossing with Murphy Road diamond interchange
4. Powers Road diamond interchange with Murphy Road diamond interchange
5. Powers Road diamond interchange with the existing Murphy Road half-interchange

A full four-step Bend-Redmond model run was used to capture the interaction of the existing Murphy half-interchange with a Powers Road diamond interchange. The other two intersections were tested using traffic re-assignments in the Bend Redmond model from Project Bundle A and Project Bundle B. Traffic forecasts for 2040 30HV conditions were developed for the five interaction scenarios at the following study intersections:

- Brookwood Blvd and Powers Road
- Blakely Road and Powers Road
- US 97 Southbound Ramp terminal and Powers Road
- US 97 Northbound Ramp terminal and Powers Road
- 3rd Street at Powers Road
- Parrell Road and Powers Road
- 3rd Street and Badger Road
- 3rd Street and Pinebrook Blvd
- Brookwood Blvd and Murphy Road
- New Southbound Frontage Road and Murphy Road
- 3rd Street and Murphy Road
- Parrell Road and Murphy Road
- US 97 Southbound Ramps and New Murphy Interchange
- US 97 Northbound Ramps and New Murphy Interchange
- US 97 and China Hat Road
- Parrell Road and China Hat Road
- Murphy Road and Old Murphy Road
- Murphy Road and Parrell Road

The operations at these intersections were then compared across the five interaction scenarios to determine the synergy between the access conditions at Powers Road and Murphy Road. Some key assumptions to note:

- The Powers Road diamond interchange with the existing Murphy Road half-interchange scenario is the only scenario tested that includes the existing RIRO at Ponderosa/China Hat Road and does not include the China Hat Road Overcrossing.
- All scenarios that include the Murphy loop ramps and frontage system include both the north and south frontage roads.
- The Murphy Road tight diamond scenarios do not include the complete north and south frontage roads but do contain the “West Loop Frontage Road”, a frontage road connecting the



3rd Street overcrossing to Murphy Road west of US 97 that could eventually be incorporated into the south frontage road concept.

- All five scenarios include the assumption that the Badger Road and Pinebrook Boulevard RIRO access would be closed.

The results of the sensitivity testing were then used to update the Level 2 Evaluation results for the Powers Road concepts and provide a scoring basis for frontage road and the Murphy Road interchange concepts.

SENSITIVITY TESTING

The sensitivity testing of the interaction of the Powers interchange/overcrossing and the Murphy diamond/loop ramp and frontage options was conducted as described in the methodology section.

Intersection traffic operations were analyzed using Synchro 10 (signals and stop-controlled) and Vistro 5 (at roundabouts) software and the Highway Capacity Manual (HCM)⁶ methodologies (HCM 2010⁷ at unsignalized intersections, HCM 2000 at signalized intersections, HCM 6⁸ at roundabouts). The analysis was conducted at all relevant study intersections using the seasonally factored 30 HV traffic volumes for the year 2040. Performance measures used for this analysis include volume-to-capacity (V/C) ratio, seconds of control delay, level of service (LOS), and 95th Percentile Queue lengths.

Tables 1 summarizes the HCM results of this analysis for the five sensitivity test scenarios, comparing each intersection's performance against the adopted mobility target.⁹ Locations where a performance measure exceeds the mobility target are bolded for ease of reference. The intersection HCM results are included in the Appendix D, and the forecasted volumes are included in Appendix E.

⁶ *2000 Highway Capacity Manual*, Transportation Research Board, Washington, D.C., 2000.

⁷ *2010 Highway Capacity Manual*, Transportation Research Board, Washington, D.C., 2010.

⁸ *2016 Highway Capacity Manual*, Transportation Research Board, Washington, D.C., 2016.

⁹ Mobility targets for ODOT facilities obtained from the 1999 Oregon Highway Plan.



Table 1: Powers-Murphy Sensitivity Tests Operations Results

#	Intersection	Jurisdiction	Control ^D	Mobility Target	Performance *				
				V/C or Delay	Powers Overcrossing w/ Murphy Loop Ramps + Frontage	Powers Overcrossing w/ Murphy Tight Diamond	Powers Interchange w/ Murphy Loop Ramps + Frontage	Powers Interchange w/ Murphy Tight Diamond	Powers Interchange w/ Existing Murphy Configuration
1	Brookwood Blvd & Powers Rd	City	Roundabout	≤ 1.00	1.25	1.28	1.55	1.61	1.83
2	Blakely Rd & Powers Rd	City	TWSC	(≤ 50 s)	9.6/> 100	9.8/> 100	10.4/> 100	10.4/> 100	11/> 100
3	US 97 SB Ramp & Powers Rd	ODOT/City	Signalized	< 0.85	NA	NA	0.92	0.93	0.90
4	US 97 NB Ramp & Powers Rd	ODOT/City	Signalized	< 0.85	NA	NA	0.61	0.67	1.06
5	3 rd St & Powers Rd	City	Signalized	≤ 1.00	0.95	1.00	0.95	1.06	1.21
6	Parrell Rd & Powers Rd	City	TWSC	(≤ 50 s)	8.7/34.0	8.8/38.1	9.2/ 63.4	9.4/ 92.3	9/46.2
7	3 rd St & Badger Rd	City	Signalized	≤ 1.00	0.53	0.56	0.55	0.59	0.64
8	3 rd St & Pinebrook Blvd	City	TWSC	(≤ 50 s)	11.9/ 67.8	12.5/> 100	11.8/44.3	12.4/ 55.3	12.4/ 72.7
9	Brookwood Blvd & Murphy Rd	City	Roundabout	≤ 1.00	1.08	1.04	1.07	0.98	0.89
10	New SB Frontage Rd & Murphy Rd	City	Roundabout	≤ 1.00	0.69	0.50	0.62	0.44	N/A
11	3 rd St & Murphy Rd	City	Roundabout	≤ 1.00	1.30	1.14	1.28	1.11	1.16
12	Parrell Rd and Murphy Rd	City	Roundabout	≤ 1.00	0.98	1.27	1.01	1.16	1.28
13	US 97 SB Ramp & Murphy Rd	ODOT/City	Signalized	< 0.85	NA	0.95	NA	0.85	NA
14	US 97 NB Ramp & Murphy Rd	ODOT/City	Signalized	< 0.85	NA	0.79	NA	0.74	NA
15	US 97 & China Hat Rd	ODOT/ City	Free F/TWSC	NA	NA	NA	NA	NA	--/> 100
16	Parrell Rd & China Hat	City	TWSC	(≤ 50 s)	> 100 /> 100	> 100 /> 100	9.4/16.4	8.0/11.5	9.6/17.6
17	Murphy Rd & Old Murphy Rd	City	TWSC	(≤ 50 s)	10.0/> 100	10.0/ 70.9	10.1/> 100	10.0/> 100	9.1/> 100



* Overall intersection V/C ratio at signalized intersections, worst case approach V/C at roundabouts, and V/C ratio for Major Street/Minor Street at two-way stop controlled (ODOT and City jurisdiction). Control delay for Major Street/Minor Street for two-way stop-controlled intersections (City jurisdiction).
BOLD values indicate performance measures failing to meet adopted mobility targets.



Based on the results of the operations analysis from the sensitivity test, the following findings were made for each relevant concept:

Powers Overcrossing:

1. Shift significant demand south to the Murphy interchange.
2. Causes operations to degrade well over capacity at 3rd Street and Murphy Road in particular when combined with the loop ramps at Murphy, mainly due to the eastbound to northbound Murphy movement being routed through this intersection.
3. Shifts demand north to the southbound off-ramp at Reed Market Road
4. Creates a significant capacity issues at Murphy Road/Parrell Road when implemented without the north and south frontage roads.
5. If implemented as part of a Powers Road interchange phase, would need to have a full interchange already built at Murphy Road.

Powers Interchange:

1. Ramp terminals need exclusive left turn lanes (if signalized) by year 2040, even if Murphy Road is a full interchange.
2. If constructed prior to remaining ramps at Murphy Road, northbound ramp terminal and 3rd Street/Powers Road will either be over capacity or require mitigation within the next 10 years.
3. Powers Road/Brookwood Boulevard will likely need mitigation within the next 5-10 years if the Powers interchange is constructed.

Murphy Crossing Plan Ramps:

1. Has significant operational impact on Murphy Road/3rd Street roundabout, as all movements heading eastbound on Murphy Road to northbound on US 97 or coming from northbound on US 97 to the westbound on Murphy Road must go through this intersection.

Murphy Road Tight Diamond:

1. Relieves some of the demand from the Murphy Road/3rd Street roundabout, compared to the loop ramp design.
2. Provides more direct access to the SE quadrant of the interchange than the loop ramp option, if constructed with the frontage connection from the south ramp terminal to Murphy Road.
3. Would function even better with the full build out of north and south frontage roads, as these connections better connect future land uses to the appropriate sides of the interchange, rather than routing everything through Murphy/3rd Street roundabout.
4. Functions with signals at ramp terminals.

North Frontage Road:

1. Helps to relieve some of the demand on Brookwood Boulevard at both the Murphy Road and Powers Road roundabouts.
2. Relieves some of the demand from 3rd Street
3. Would increase the need for an intersection capacity enhancement at Powers Road/Blakely Road (likely this would need to be included as part of the frontage road concept).

South Frontage Road:



1. Helps to relieve some of the demand at the Brookwood Boulevard/Murphy Road Roundabout
2. Would likely need enhanced intersection treatment (a roundabout) with any new development in the Murphy Crossing Area.
3. Relieves demand on Parrell Road, limiting neighborhood cut-through conflicts.
4. Would significantly increase the effectiveness of a China Hat Road overcrossing at dispersing traffic from future development in the “Thumb” and “Elbow” (SE Area).

West Loop Frontage Road:

1. Relieves demand on the 3rd Street/Murphy Road roundabout, a key future bottleneck in the system.
2. Could serve and potentially be funded by future developments to the west of the Murphy interchange.
3. Could be combined as a phase of the South Frontage Road.

RESULTS

POWERS ROAD

The two concepts identified at Powers Road include grade separation and improvements to the existing interchange. These concepts were evaluated separately to identify their specific benefits and impacts against the future no build, per the methodology outlined in Introduction (Section 1.0) of Technical Memorandum #7. Evaluation results are displayed in Table 2 (more detailed scoring can be found in Appendix C).

Table 2: Evaluation Results for the Powers Road Alternatives

Goal	Evaluation Criteria (Level 2)	Evaluation Rating	
		Powers Rd. Projects	
		Overcrossing	Interchange
1	Reduction in crash frequency (all modes)	4	2
	Reduction in crash severity (all modes)	4	2
2	Travel Time Reliability measures on the Bend Parkway (planning time index)	2	2
	Percent through traffic on congested segments (modeled demand/capacity ratio ≥ 1.0) of the Bend Parkway	1	1
	Degree to which the alternative enhances travel for multiple modes (qualitative assessment)	1	1
3	Ability to meet ODOT v/c targets	-1	2
	Ability to meet Bend mobility standards (v/c ratios and LOS)	-2	0
4	Travel Time Reliability measures (planning time index) for specific routes during PM peak hour	-1	1
	Peak Hour VMT by street classification	-1	0



Goal	Evaluation Criteria (Level 2)	Evaluation Rating	
		Powers Rd. Projects	
		Overcrossing	Interchange
5	Number of bike and pedestrian crossing locations on the Bend Parkway with low Level of Traffic Stress (LTS 2 or lower)	2	1
	Miles of north-south bike and pedestrian facilities with low Level of Traffic Stress within 0.25 miles of the Bend Parkway	0	0
	Does the alternative allow for transportation demand management strategies?	0	0
6	Total PM peak hour vehicle delay (vehicle hours)	0	2
	Total PM peak hour vehicle miles traveled (regional measure)	-1	0
	Approximate degree of right of way impacts (order of magnitude costs)	0	-1
7	Total cost	1	-2
	Reduction in economic cost of delay and crashes	1	2
	Does alternative leverage existing planned projects and programs?	0	0
8	Can the alternative be separated into reasonably fundable and constructible phases?	0	0
	Does the alternative have local agency support?	0	1
Evaluation Total		10	14

Powers Road Overcrossing (\$8.0 million) – The key performance characteristics of this concept evaluated against the goals are summarized as follows:

Goal #1: Safety

- Decreases crashes by eliminating conflicts

Goal #2: Economic

- Significantly improves travel time reliability on the southern portion of the Parkway by reducing access south of Reed Market Road and removing queuing impacts caused by the existing Powers Road at-grade intersection

Goal #3: Mobility

- Eliminates the capacity constraints at the existing Powers Road and US 97 intersection
- Shifts significant volume north to the Reed Market Road interchange and south to the Murphy Road interchange, impacting traffic operations at key Parkway intersections (Reed Market Road interchange ramp terminals) and key local intersections (Reed Market Road and 3rd Street, Murphy Road and 3rd Street)

Goal #4: Accessibility



- Traffic demand shifted to Reed Market Road worsens travel times on a corridor flagged as already unreliable in the Bend TSP
- Increases traffic demand lower classification streets south of Reed Market
- Would likely increase or create neighborhood cut-through traffic issues, particularly in the Silver Lake Road area

Goal #5: Multimodal

- Provides a low-stress bicycle and pedestrian crossing of the Parkway

Goal #6: Environment

- Minor ROW impacts

Goal #7: Cost

- The negative impacts to vehicle delay at Murphy and Reed Market offset some of the benefits from safety improvements

Goal #8: Implementation

- The ongoing Bend TSP and MTP both identify an interchange at this location rather than an overcrossing

Based on overall performance scored against the project goals and having conflicts with other high performing projects (Powers Interchange), this concept is **Not Recommended for Implementation**. However, this concept could be considered as a near term phase to the Powers Road Diamond Interchange concept, but only if the Murphy Interchange provides full access.

Powers Road Diamond Interchange (\$24.7 million) – This option could include either traffic signals or roundabouts at the ramp terminals, likely dictated by right-of-way availability. The key performance characteristics of this concept evaluated against the goals are summarized as follows:

Goal #1: Safety

- Provides safety enhancement over existing at-grade configuration

Goal #2: Economic

- Manages queues within the interchange ramps, improving travel time reliability

Goal #3: Mobility

- Meets ODOT mobility targets at the ramp terminals
- Manages queues within the interchange ramps

Goal #5: Multimodal

- Provides low-stress bicycle and pedestrian access across the Parkway

Goal #6: Environment

- Has some ROW impacts

Goal #7: Cost Effective



- High cost concept

Goal #8: Implementation

- Could potentially be phased with an overcrossing first, ramps later
- Included on both the ongoing Bend TSP and MTP project lists

Based on overall performance scored against the project goals and having no conflicts with other high performing projects, this concept is **Recommended for Implementation**.

MURPHY ROAD

The preferred alternative build-out of the Murphy Road interchange was selected in the Murphy Crossing Plan, but the ultimate construction of the first two ramps (northbound off, southbound on) potentially precluded some key components of the remaining concept. A tight diamond concept was investigated and assessed for traffic impacts and feasibility against the Murphy Crossing preferred alternative to both understand the ultimate project at this location and the traffic triggers for proper construction phasing. In addition, several frontage road concepts were also tested and evaluated in this area. The evaluation results are presented Table 3.

Table 3: Evaluation Results for the Murphy Road and Frontage Road Concepts

Goal	Evaluation Criteria (Level 2)	Evaluation Rating				
		Murphy Interchange Projects		Frontage Road Projects		
		Northbound Loop Ramp and Southbound Off-Ramp*	Tight Diamond**	North Frontage Road	South Frontage Road	West Loop Frontage Road
1	Reduction in crash frequency (all modes)	0	2	2	2	2
	Reduction in crash severity (all modes)	0	2	2	2	2
2	Travel Time Reliability measures on the Bend Parkway (planning time index)	0	0	0	0	0
	Percent through traffic on congested segments (modeled demand/capacity ratio \geq 1.0) of the Bend Parkway	0	0	0	0	0
	Degree to which the alternative enhances travel for multiple modes (qualitative assessment)	0	2	2	0	0
3	Ability to meet ODOT v/c targets	1	2	0	0	2



Goal	Evaluation Criteria (Level 2)	Evaluation Rating				
		Murphy Interchange Projects		Frontage Road Projects		
		Northbound Loop Ramp and Southbound Off-Ramp*	Tight Diamond**	North Frontage Road	South Frontage Road	West Loop Frontage Road
	Ability to meet Bend mobility standards (v/c ratios and LOS)	1	1	2	2	1
4	Travel Time Reliability measures (planning time index) for specific routes during PM peak hour	0	0	0	0	0
	Peak Hour VMT by street classification	2	-1	1	1	0
5	Number of bike and pedestrian crossing locations on the Bend Parkway with low Level of Traffic Stress (LTS 2 or lower)	0	2	0	0	0
	Miles of north-south bike and pedestrian facilities with low Level of Traffic Stress within 0.25 miles of the Bend Parkway	0	0	2	0	0
	Does the alternative allow for transportation demand management strategies?	0	0	0	0	0
6	Total PM peak hour vehicle delay (vehicle hours)	0	1	1	1	1
	Total PM peak hour vehicle miles traveled (regional measure)	1	0	1	1	1
	Approximate degree of right of way impacts (order of magnitude costs)	-1	0	-2	-1	-1
7	Total cost	1	0	-1	0	0
	Reduction in economic cost of delay and crashes	1	2	1	1	1



Goal	Evaluation Criteria (Level 2)	Evaluation Rating				
		Murphy Interchange Projects		Frontage Road Projects		
		Northbound Loop Ramp and Southbound Off-Ramp*	Tight Diamond**	North Frontage Road	South Frontage Road	West Loop Frontage Road
	Does alternative leverage existing planned projects and programs?	2	2	2	2	2
8	Can the alternative be separated into reasonably fundable and constructible phases?	0	1	1	1	1
	Does the alternative have local agency support?	1	1	1	1	1
Evaluation Total		9	17	15	13	13

*Evaluation scores include interchange related benefits from the South Frontage Road

**Evaluation scores include interchange related benefits from the West Loop Frontage Road

Murphy Road Northbound Loop Ramp (\$6.7 million) and Southbound Off-Ramp (\$3.2 million) – This concept reflects the remaining ramps for the Murphy interchange per the Murphy Crossing Preferred Alternative. Note that the evaluation scores for this concept also include interchange related benefits from the South Frontage Road, which is required for the southbound off-ramp to function. The key performance characteristics of this concept evaluated against the goals are summarized as follows:

Goal #1: Safety

- Provides safety enhancement by providing a grade separated connection to the Parkway in place of the RIRO access at Pinebrook Boulevard and China Hat Road
- Potential safety issues related to tight radii of northbound on-ramp

Goal #3: Mobility

- Ramp terminals (free flow) meet ODOT v/c standards
- Degrades operations at the 3rd Street/Murphy Road intersection due to consolidated all on-ramp access to this single intersection
- Improves operations at Parrell Road/Murphy Road roundabout

Goal #4: Accessibility

- Provides better circulation and relieves some of the traffic demand from Brookwood Boulevard and Parrell Road (mainly due to the south frontage road)

Goal #6: Environment

- ROW impacts to built properties from the north loop ramp.

Goal #7: Cost Effective



- Interchange portion of the concept has relatively low cost (less than \$10 million) – this total does not include the cost of the South Frontage Road
- Leverage other planned projects, include the South Frontage Road and China Hat Overcrossing

Goal #8: Implementation

- Difficult to fully construct with Urban Renewal funding

The north loop ramp and southbound off-ramp concept for the Murphy interchange does not score well and conflicts with another high scoring option (the tight diamond) and is therefore **Not Recommended for Implementation**.

Murphy Road Tight Diamond Interchange (\$11.9 million) – The concept evaluated would include traffic signals at the ramp terminals. For evaluation purposes, this concept was combined with the West Loop Frontage Road concept, which provides a connection from the southbound ramp terminal to Murphy Road. The key performance characteristics of this concept evaluated against the goals are summarized as follows:

Goal #1: Safety

- Provides safety enhancement by providing a grade separated connection to the Parkway in place of the RIRO access at Pinebrook Boulevard and China Hat Road.

Goal #3: Mobility

- Meets ODOT mobility targets at southbound ramp terminal, could potentially also meet targets at the northbound ramp terminal with additional frontage connection improvements, or with a signal.

Goal #5: Multimodal

- Provides low-stress bicycle and pedestrian access across the Parkway

Goal #6: Environment

- Has some localized (Les Schwab) ROW impacts

Goal #7: Cost Effective

- Moderate cost concept

Goal #8: Implementation

- Could potentially be phased

Based on overall performance scored against the project goals and having no conflicts with other high performing projects, this concept is **Recommended for Implementation**.

North Frontage Road (\$15.2 million) – This concept creates a frontage road connection from Powers Road to Murphy Road, west of the Parkway. The concept includes improvements to Blakely Road from Powers Road to Pinebrook Road. The key performance characteristics of this concept evaluated against the goals are summarized as follows:



Goal #2: Accessibility

- Provides opportunity for low stress bike ped connection parallel to the Parkway

Goal #3: Mobility

- Improves operations at the Brookwood/Murphy, Powers/Parrell, and Brookwood/Powers intersections.

Goal #4: Accessibility

- Shifts some traffic of Brookwood Boulevard

Goal #5: Multimodal

- Provides opportunity for north-south low stress bike/ped route within 0.25 miles of the Parkway

Goal #6: Environment

- Delay reduction benefits, particularly at the Powers/Brookwood intersection
- Has some potential ROW impacts to built out properties

Goal #8: Implementation

- Could potentially be phased

Based on overall performance scored against the project goals and having no conflicts with other high performing projects, this concept is **Recommended for Implementation**.

South Frontage Road (\$10.6 million) – This concept creates a frontage road connection from Murphy Road to Ponderosa Road, west of the Parkway. The key performance characteristics of this concept evaluated against the goals are summarized as follows:

Goal #3: Mobility

- Improves operations at the Brookwood/Murphy and Murphy/Parrell intersections

Goal #4: Accessibility

- Shifts some traffic off of Parrell Road

Goal #6: Environment

- Delay reduction benefits, particularly at the Murphy/Parrell
- Has significant ROW impacts to currently undeveloped land

Goal #8: Implementation

- Could potentially be phased, possibly with the West Loop Frontage Road

Based on overall performance scored against the project goals and having no conflicts with other high performing projects, this concept is **Recommended for Implementation**.

West Loop Frontage Road (\$10.9 million) – This concept creates a frontage road connection from Murphy Road to the Murphy Interchange, west of the Parkway. The key performance characteristics of this concept evaluated against the goals are summarized as follows:



Goal #3: Mobility

- Improves operations at the 3rd Street/Murphy intersection

Goal #6: Environment

- Delay reduction benefits, particularly at the critical 3rd Street/Murphy intersection
- Has significant ROW impacts to currently undeveloped land

Goal #8: Implementation

- Could potentially be phased, possibly with the South Frontage Road and the Murphy Tight Diamond Interchange concepts

Based on overall performance scored against the project goals and having no conflicts with other high performing projects, this concept is **Recommended for Implementation**.

RECOMMENDATIONS

Based on the analysis and findings from the memorandum, the following implementation recommendations are made related to the Murphy Road and Powers Road interchanges:

1. The highest priority should be the Murphy interchange. The costs of the tight diamond concept make this improvement feasible, and this connection should help to relieve some of the existing operational issues at the Powers Road/US 97 intersection. Also, closure of the Badger Road and Pinebrook Boulevard RIRO access will only increase traffic at Powers Road/US 97 in absence of a full interchange at Murphy Road. This interchange is likely needed to serve both the Murphy Crossing Urban Renewal District and the SE Area, both of which are likely to develop in the short term. In addition, if the Powers Road interchange needs to be phased for funding purposes, the full access Murphy interchange is critical to serve short term demand while Powers Road access to the Parkway is limited.
2. The next highest priority should be the Power Interchange, as this location is already under heavy traffic demand. An overcrossing is not the ultimate solution at this location due to negative operational impacts both south at Murphy and north at Reed Market. However, an overcrossing could be implemented in the short term as an initial phase of a full interchange, provided the Murphy interchange is already full access. An interchange at Powers provides connection that could ultimately be used connected to a southern river crossing. The final interchange solution at Powers Road should include consideration of the travel demand impacts of a southern river crossing.
3. The north frontage road priority is predicated on the access and circulation strategy that will be implemented with the closure of the Badger Road and Pinebrook Boulevard RIRO access locations. This concept is recommended to be included with the Powers Road interchange at the latest, as that concept requires the closure of the Badger Road RIRO access.
4. The south frontage road is recommended to be implemented when the Murphy Crossing Urban Renewal District begins to develop, or when the “Thumb” develops, or when the China Hat overcrossing is constructed.



5. The west loop frontage road is recommended to be implemented as soon as possible after the construction of the Murphy tight diamond, preferably while the first commercial developments west of the interchange are under construction.