Design and Construction of a Roundabout Corridor – Shiloh Road Corridor Case Study in Billings, MT

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Abstract: The proposed Shiloh Road Corridor Project (see right) is an approximately $45 million (all direct costs) project located in Billings, Montana administered by the Montana Department of Transportation. The project included completing a comprehensive Environmental Assessment (EA) which evaluated 4.5 miles of the mostly rural two-lane arterial for various street and intersection improvements to accommodate future development and the multimodal needs of the facility through its 20-year design life.

The Federal Highway Administration issued a Finding of No Significant Impacts (FONSI) for the preferred alternative in May 2007. The preferred alternative selected, and as documented in the FONSI, included an unprecedented (in United States) eight multilane roundabouts in series. In addition, the project included widening the facility to a 4-lane divided urban street facility with continuous bicycle and pedestrian facilities, significant landscaping, constructing a pedestrian underpass, significant hydraulics challenges, development and implementation of a stringent access control resolution and successful completion of right-of-way negotiations with approximately 135 property owners without requiring the use of eminent domain.

This project contained significant hurdles, including accelerated project delivery schedules, right-of-way, complex design elements, and shortfalls in project funding. The project was funded partially using American Recovery and Reinvestment Act funding and was constructed largely in 2009, with completion anticipated in late 2010.

Introduction

The Shiloh Road Corridor project is located along the western city limits of Billings, MT in Yellowstone County. The Big Sky Economic Development Authority calculated that approximately $750,000,000 (Billings Gazette; June 29, 2006) of pending development would result from the reconstruction of Shiloh Road. The facility is multi-jurisdictional with MDT, City of Billings and Yellowstone County all having partial ownership and/or maintenance responsibilities. Shiloh Road has many major and minor intersections along its length, with the sidestreets varying in functional classifications from Principal Arterials to local streets.

This paper will discuss the process this project went through, the challenges it faced, current status, and ultimately the outcome of designing and constructing a corridor of roundabouts.

Purpose and Need

The purpose of the project was to improve the mobility and safety of Shiloh Road corridor by increasing roadway capacity and providing bicycle, pedestrian, and transit improvements. The facilities were designed to provide adequate service through the year 2027.

The project is needed to improve safety by addressing specific safety issues and roadway and intersection deficiencies in the corridor. In addition, the project is needed to address mobility issues related to roadway capacity, transportation system linkages, alternative modes accommodations, and address long-term community planning goals.

Overview

The Shiloh Road Corridor Project was initiated in 2001 as a three-phase project. Phase I consisted of completing an Environmental Assessment (EA) in accordance with state and federal requirements. During Phase I numerous design alternatives were evaluated and their associated environmental, cultural and other impacts documented. Ultimately, through an extensive screening process a preferred alternative was selected. Phase II included the design and preparation of construction documents. Phase III was the Right-of-Way (R/W) phase, whereby all necessary R/W was secured, and this phase normally follows Phase II. Phases II and III were combined with this project, which presented unique challenges to the design team and MDT personnel, who had to work closely together to ensure good communication was maintained between the designers and MDT R/W personnel. The project required

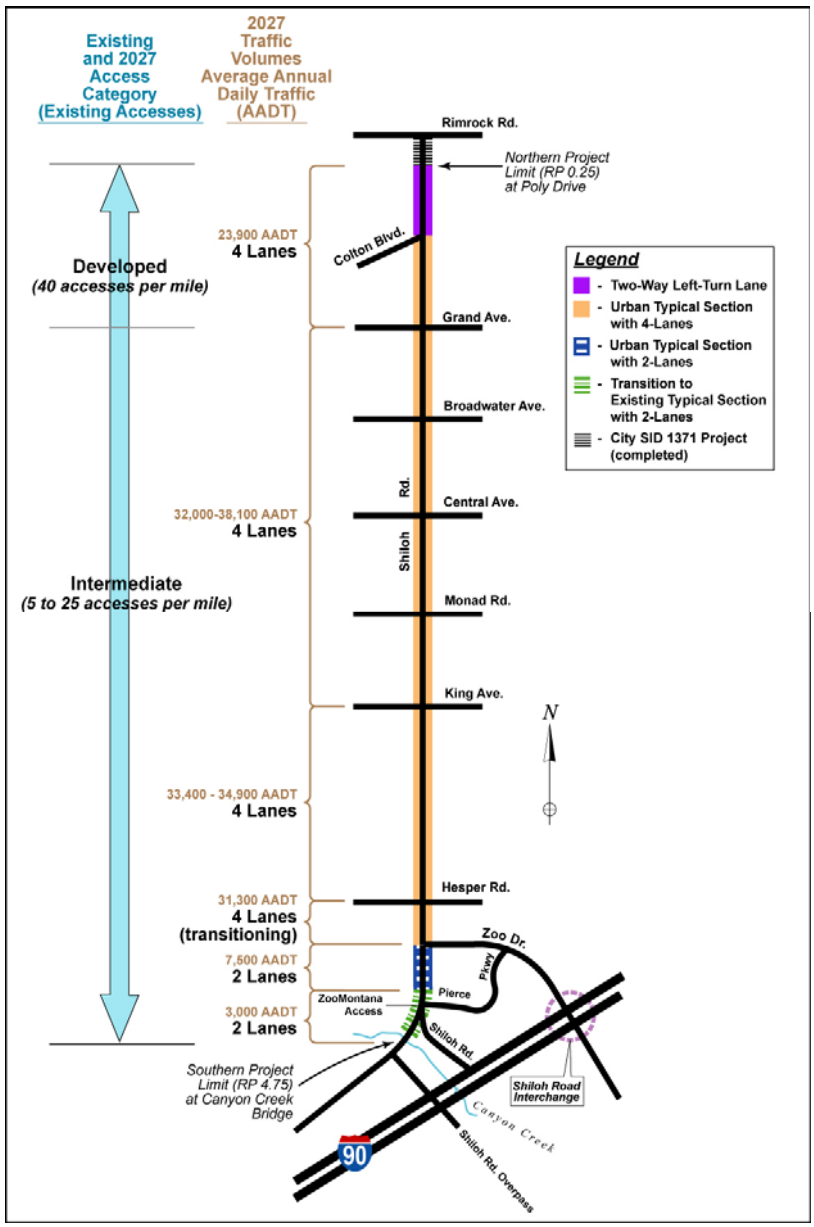

Figure 1

significant new R/W, easements and construction permits. Existing utilities were relocated, including, among many others, a 12-inch high pressure natural gas line and overhead transmission and distribution power. Significant interaction with the City of Billings and private utility companies was required.

Shiloh Road abuts approximately 135 properties along the project length, and is subject to significant traffic loading and traffic projections indicate Average Annual Daily Traffic (AADT) volumes will approach 40,000 vehicles per day (two-way combined traffic flow) on Shiloh Road by the year 2027, and sidestreet AADT volumes could exceed 15,000 vehicles per day. The existing street facility was essentially void of pedestrian facilities; the project will provide continuous facilities on both sides along its length to compliment the City's Heritage Trail Plan.

Environmental Process

The EA (http://www.mdt.mt.gov/pubinvolve/docs/eis_ea/ea_shiloh.pdf) evaluated 4.5 miles of the mostly rural two-lane arterial for various street and intersection improvements to accommodate future development and the multimodal needs of the facility through its 20-year design life. The EA commenced in 2002 and The Federal Highway Administration issued a Finding of No Significant Impacts (FONSI) (http://www.mdt.mt.gov/pubinvolve/docs/eis_ea/fonsi_shiloh.pdf) for the preferred alternative in May 2007. The environmental process was very extensive for this project, particularly due to the large number of alternatives that were evaluated for both the roadway and the intersections, and the reader is encouraged to review the EA and FONSI using the links provided above to better comprehend the project.

Numerous roadway and intersection alternatives were evaluated throughout the development of the EA, including evaluating up to twelve signalized intersections or twelve roundabouts; a combination of roundabouts and signals was also evaluated. In the end, only eight intersections were carried forward for roundabout construction and none for signalization.

Screening of alternatives – based on numerous criteria, alternatives were carefully screened in order to ultimately propose a preferred alternative for the EA.

The "preferred alternative" that came out of the environmental process and which proceeded into final design included eight multi-lane roundabouts capable of providing sufficient capacity through the year 2027, and provide additional reserve capacity. The roundabout corridor, as compared to it's signalized alternatives that were evaluated, required less R/W, was more cost effective, provided significant aesthetic enhancement opportunities, complimented the access control regime for the corridor, and created less environmental impacts overall.

Public Involvement

The project involved extensive public involvement. Stakeholder buy-in was an enormous challenge, involving many educational meetings to inform the public and agencies, and solicit feedback about this controversial design, particularly the use of roundabouts, throughout the design phase. As a direct result of this wide-ranging public outreach process, rights-of-way were successfully negotiated by MDT with every landowner without the use of eminent domain.

During the environmental document phase of the project, significant interaction and cooperation was required to get the project preferred alternative defined and refined in order to complete the EA and obtain the FONSI. The City of Billings, Yellowstone County, MDT, FHWA, and the consultant team worked closely together to obtain a unified front, meet community goals and planning objectives, and involve the public and community at-large to develop and obtain informed consent. Particularly challenging was obtaining informed consent to move forward with roundabouts as the preferred full access treatment at the major intersections. A mock-roundabout demonstration (right) was performed and found to be particularly effective in obtaining informed consent from the local elected officials, emergency services, cooperating agencies, and the community at-large.

In total, the project includes eight multi-lane roundabouts capable of providing sufficient capacity through the year 2027 with noticeable reserve capacity at most intersections. The roundabout corridor, as compared to it's signalized alternative required less R/W, was more cost effective, provided significant aesthetic enhancement opportunities, complimented the access control regime for the corridor, and created less environmental impacts overall (outlined in EA).

The Design

The Shiloh Road reconstruction project is largely responsible for the advent of consideration of roundabouts as a mitigation alternative across the state of Montana. The three phases of the project combined will include reconstruction of Shiloh Road to a four-lane divided urban street approximately 4.5 miles in length, with 8 multi-lane roundabouts in a series, continuous sidewalk and 10-ft separated multiuse path for pedestrians and cyclists, rigid access control, a pedestrian underpass, roadway lighting, a pedestrian actuated crossing using a rapid flashing beacons, raised median, numerous irrigation structures and crossings, drainage culverts, extensive landscaping and irrigation systems, the Montana's first noise barrier wall, and many other unique features.

Capacity – The Shiloh Road project was designed to accommodate traffic flows through the year 2027. A summary of Average Annual Daily Traffic (AADT) volumes are provided in Table 1 below. The intersection form selected to accommodate these traffic loads at the larger intersections was roundabouts. All of the roundabouts are multilane design. Signalized intersections were evaluated also. Overall travel time was calculated to be less using the corridor of roundabouts vs. traffic signals.

Table 1: Average Annual Daily Traffic (AADT) on Shiloh Road

Road Segment	2002 AADT	2007 AADT	2027 AADT
Canyon Creek Bridge – Zoo Dr.	4,020	4,170	7,490
Zoo Dr. – Hesper Rd.	11,420	10,730	31,325
Hesper Rd. – JTL access	9,010	8,410	33,185
JTL access – Montana Sapphire Dr.	9,010	8,075	33,590
Montana Sapphire Dr. – King Ave.	9,010	8,075	34,940
King Ave. – Monad Rd.	9,185	10,090	34,320
Monad Rd. – Central Ave.	10,375	11,925	38.095
Central Ave. – Howard St.	11,760	13,115	34,220
Howard St. – Broadwater Ave.	11,760	12,805	33,980
Broadwater Ave. – Yegen access	11,640	12,960	31,995
Yegen access – Grand Ave.	11,640	12,395	33,155
Grand Ave. – Poly Dr.	9,670	10,860	21,530
Poly Dr. – Rimrock Rd.	8,300	9,130	18,800

Source: Preliminary Traffic Report, Sanderson Stewart. (July 2005)

Roundabouts - prevailed as the preferred alternative, due to their many safety benefits, reduced environmental impacts, less right-of-way was required, overall project costs were less, and they met numerous objectives identified in area plans. All of the roundabouts are multilane roundabouts, which were determined necessary in order to provide sufficient capacity through the design year. They vary in footprint, geometry, and capacity. One roundabout was designed so that it could be readily expanded to a three-lane roundabout in the future.

Pedestrian Facilities – The project incorporates a 10-foot multiuse path on one side of the road and a 5-foot sidewalk on the other side along nearly the entire project (approximately 1200’ of Shiloh Road excluded since there was no substantiated reason to provide). The entire project was designed to meet ADA requirements, and one pedestrian underpass (discussed later) was provided, as well as one at-grade, mid-block pedestrian crossing in addition to the facilities at all the intersections.

Lighting – due to the presence of raised median along its length, continuous lighting is provided with the project. Roundabout lighting was provided with emphasis on lighting potential points of impact, as well as accenting crosswalks.

R/W – Given the funding constraints of this project, significant efforts were undertaken to minimize R/W acquisition, without sacrificing safety and mobility of all users, and such that private and public utilities had sufficient space and adequate access provisions for maintaining their utilities. Existing R/W varied significantly from 60 feet to over 100 feet; proposed R/W width generally varied from 100 feet to 160 feet to accommodate the proposed improvements and provide for utility relocation.

Access Control – The Shiloh Road project employed a strict access control regime. Two access control regimes are present in the corridor; MDT's "intermediate" and "developed" classifications (see Figure 1) were employed. The "intermediate" classification limited access as follows: full access on ½ mile spacing using roundabouts, ¾ access (no left onto Shiloh Road) on ¼ mile spacing, and right-in/right-out access on 1/8 mile spacing. Existing accesses were often combined or eliminated to better fit this scheme. In the "developed" area, full access was limited to a lesser degree, as existing access spacing and associated development was too dense to employ such restrictions. A two-way-left-turn lane was utilized through a portion of this area, and raised median to limit full access or ¾ accesses at public streets only, was utilized. The use of roundabouts at the full-access locations allowed for safe and legal u-turns and facilitated the access control regime that was desired.

Drainage – Significant waterways parallel and intersect Shiloh Road, including Hogan's Slough (right), where an existing bridge was replaced with a dual-cell 8'x8' box culvert to accommodate the anticipated flows during large storm events. Bypass flow requirements existed during construction in order to provide for and perpetuate continuous ambient stream flows, and provide for potential storm event surges.

Landscaping – early in the project process and in City/County Planning documents, Shiloh Road was identified as a "Gateway" corridor to Billings. With that, there came various objectives in addition to those that might be normally associated with an urban reconstruction project. The project needed to provide "unique" design elements, aesthetic, yet fitting the environment within which they fall. Landscaping provided was a design feature that could achieve these goals. An extensive effort was undertaken to determine the design, as well as the level of landscaping the project could incorporate. A landscaping regime was achieved that provided uniformity, fit the environment, was cost effective, had provisions for the safety of maintenance workers, and was acceptable to the City of Billings (assumed maintenance responsibility). Landscaping features consist of tree clusters, shrubs, bunch grasses, mulch, dry land grass, and irrigated turf grass in general. Roundabouts received a higher level of landscaping due to the desire to create focal points, provide visual cues to motorists of the upcoming intersection, provide way-finding cues to the visually impaired along sidewalks and path, and create a calm and soothing traffic control feature. Landscaping along the mainline was extensive, but intermittent; pods of landscaping were designed, to provide the sense of continuous landscaping to the motorists who parallel it,

while providing concrete-paved portions of median to reduce maintenance and for maintenance vehicles to occupy. Landscaping in the roundabouts and raised median utilize drip-irrigation. In the boulevard area behind the roadside curbs, turf grass (irrigated) is present, as well as intermittent shrubbery and trees. Beyond the sidewalk and multiuse path, dry land grass will be the predominant landscaping, along with intermittent trees.

Other Unique Design Elements

1. Simultaneous side-by-side car and truck accommodations – the roundabouts were designed so that a WB-20LM (WB-67) could pass through the roundabout side-by-side on entry and throughout the roundabout. Shiloh Road and the connecting sidestreet are anticipated to be high truck use facilities with in-excess of 1000 heavy vehicles per day anticipated on Shiloh Road by the design year. Large throat widths at roundabouts have a dramatic effect on the various design elements of the roundabout, and require a larger roundabout, more entry deflection, and provisions for truck-trailer off-tracking. This significant challenge was overcome.
2. The Shiloh Drain - a large agricultural drainage ditch that parallels Shiloh Road beginning at the Broadwater Ave Roundabout and extends the entire length of this Phase of the project. The ditch is 10 to 11.5 ft deep (top of embankment to invert of ditch) and approximately 40 to 50 ft wide (top of embankment to top of embankment) with steep side slopes of up to 1:1 (horizontal distance to vertical distance ratio). The drain is the receptor of the project's stormwater collection system, as well as the primary irrigation wastewater receptor from numerous farming operations along Shiloh Road. The drain is very close to Shiloh Road and guardrail was utilized to minimize errant vehicle encounters with the drain. Roundabouts were constructed over portions of the drain, thereby requiring the installation of large diameter culvert and box culvert.

Construction

Late in the design process the project was split (to encourage competitive bidding) into three segments due to right-of-way disputes and funding constraints. The southern segment, *Canyon Creek North*, extended from Canyon Creek bridge to just south of Hesper Road. The middle project, the *Shiloh Road Corridor*, extended from the BBWA Canal bridge to just north of Central Avenue. The final segment, *Poly Drive South*, extended from just north of Central Avenue to Poly Drive. The Poly Drive South project was awarded in March 2009. The Canyon Creek North was awarded in May 2009. The Shiloh Road Corridor project was awarded in October 2009. All three phases will be completed in 2010 based on their current schedules.

Some of the construction components, particularly irrigation features were especially time-sensitive, as irrigation season begins in mid-April. Special provisions were written very carefully to ensure proper coordination between the Contractor and farmers was maintained and specific timelines were met.

Particularly challenging with construction is maintaining traffic flows throughout the corridor. In general, temporary closures were allowed for the intersections to build up subgrade and gravel courses, install storm drain facilities, construct the truck apron and curbing, and install other features as time allowed. Due to the temporary nature of the allowable closures, the contractors had to be fairly ingenious in their construction phasing. One intersection does not allow a full-closure of the intersection, and requires alternating closures due to needs of adjacent businesses and lack of parallel detour routes. Along the mainline of Shiloh Road and the major intersecting sidestreets, the two-way traffic flow was generally required to be maintained during construction. Local business, residential, and pedestrian access were required at all times.

Grand Avenue roundabout (west approach)

The following section highlights some of the key design features and challenges that occurred during the construction of the Poly Drive South Project, which is the segment of the Shiloh Road project that is substantially completed at the time this paper was prepared.

Poly Drive South Project

Unique Project Elements

1. Grand Avenue Roundabout – this multilane (two lanes on entry and exit, with two circulatory lanes) roundabout provides reserve capacity through the design year, and was designed around significant obstacles, including:
   - Overhead power transmission facilities exist in three of the four quadrants. Large steel towers support the powerlines. The design did not require relocation of the steel towers, although protective barrier rail was used to protect it.
   - Two gas station/convenience stores exist in two of the intersection quadrants, and R/W was therefore significantly constrained. The design did not physically impact the businesses adversely and minimal R/W was required. Retaining wall was required in one quadrant.
   - Farm irrigation facilities exist in two of the intersection quadrants, including a large division structure. Construction of the roundabout occurred during active irrigation, and proved very challenging for the contractor. The design team, the contractor and the farmer worked together through the challenges with little impact to any farm operations.
   - Significant underground utilities are present at this intersection. Relocations were kept to a minimum, although an air-relief water vault required relocation, and numerous vertical adjustments of manholes and water valves were required.
   - Traffic control was very complicated. The design team developed a sequence of operations and traffic control regime that minimized total closure of the roundabout, and minimized disruption to the neighborhood and community at-large.

2. Broadwater Ave Roundabout – this roundabout was designed to accommodate large surges of traffic flow, due to the presence of a large church in the southwest quadrant of the intersection which can release 500-1000 vehicles per service, most of which will utilize the roundabout. To minimize impacts to the property, retaining wall was utilized. In the end, impacts to the facility were kept to a minimum with only minor parking

impacts. Irrigation facilities exist in two quadrants of the intersection and constrained the design.

3. Pedestrian Tunnel –a 24’ x 10’ x 110’ CONSPAN pedestrian tunnel was installed. This tunnel was not part of the original design, and resulted during R/W negotiations whereby a landowner desired to incorporate the pedestrian tunnel to provide a grade-separated east-west connection between the project’s 10-ft multiuse path and the sidewalk located on the opposite side of the road. The road grade was elevated approximately six additional feet from the Final design grades to fit the tunnel, its drainage system, and all appurtenances. A 24-inch water main was a constraint in the tunnel vertical alignment, and the tunnel forced the project storm drain to be installed deeper to fit underneath it. Vertical and horizontal transitions were required for the multiuse path and sidewalk. In addition, farm irrigation facilities exist on both sides of Shiloh Road and design provisions to prevent flooding of the tunnel were required. The tunnel is lit from within, and on its ends. The landowner paid for the majority of the tunnel construction, which was installed in the summer of 2009.

4. Rectangular Rapid Flash Beacon – after the Poly Drive South project was bid, a local elementary school and Billings School District No. 2 requested some form of enhanced crossing north of the project limits to provide a safe crossing for school-age children across the busy Shiloh Road. MDT and FHWA agreed to the request. The design team came up with a solution for the mid-block crossing. The solution includes raised median with a pedestrian refuge area, and pedestrian actuated rapid-flash LED beacons that alert motorists that the pedestrian crossing is in-use, or that a pedestrian desires safe passage across the roadway. Using this technology required MDT to work with FHWA, since these had not received final approval for use. The crossing will be installed in 2010.

5. Noise barrier wall – due to projected noise impacts to numerous townhomes, the design team designed a noise barrier wall that would blend in with the surroundings, meet noise mitigation requirements from FHWA, and meet specific objectives and requirements from the City. The noise barrier wall is approximately 10-ft tall to achieve the desired noise abatement. The lower 6-ft of the wall was constructed using a stacked-stone pattern prefabricated wall panel with a sandstone color that closely replicates the Billings Rimrocks formation, which is a natural stone backdrop to Billings and Shiloh Road approximately ½ mile north of the project. The top 4-ft of the noise barrier wall was constructed using a tinted transparent acrylic material, capable of withstanding impact from debris. Both portions of the wall have anti-graffiti design features to assist with maintenance if graffiti is applied to their surfaces.

6. Farm Irrigation – since some of the adjacent properties still practice active farming, irrigation supply and waste ditch design, headgate structures, division boxes, and other features were required throughout the project corridor.

Two of the three project phases received partial funding using American Recovery and Reinvestment Act (ARRA) funding.

Poly Drive South Segment
Total Length = 1.68 Miles
Reach: Central Ave. to Poly Dr.
Roundabouts at Broadwater Ave. & Grand Ave.
Awarded March 23, 2009
Engineer's Estimate = $8,113,132.05
Awarded Amount = $7,718,155.42
Actual Cost/Mile = $4,594,140.13/Mile

Canyon Creek North Segment
Total Length = 1.85 Miles
Reach: Canyon Creek Bridge to King Avenue
Roundabouts at Zoo Dr, Hesper Rd, Knife River, and King Ave.
Awarded May 19, 2009
Engineer's Estimate = $9,582,573.37
Awarded Amount = $8,478,131.62
Actual Cost/Mile = $4,582,773.85/Mile

Shiloh Road Corridor Segment
Total Length = 0.98 Miles
Reach: King Ave. to Central Ave.
Roundabouts at Monad Rd. & Central Ave.
Awarded October 6, 2009
Engineer's Estimate = $5,816,616.69
Awarded Amount = $5,199,668.16
Actual Cost/Mile = $5,095,674.80/Mile

All three projects were bid and let on the scheduled letting dates and came in under engineer's estimate, saving tax payer dollars.

Project Recognition

Sanderson Stewart is the proud recipient of the **ITE Intermountain Section *Outstanding Transportation Engineering Project of 2009*** for the Shiloh Road Corridor project.

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