27TH ST.
RR CROSSING

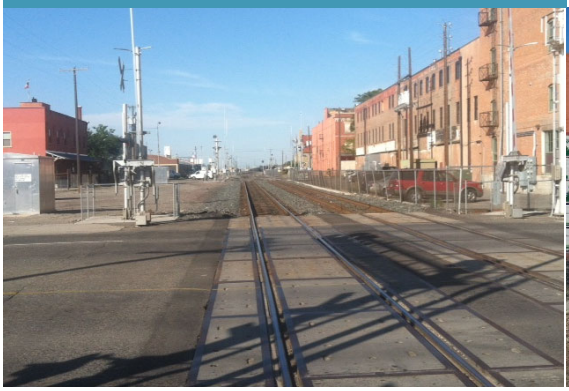
MONTANA
Department of Transportation

27th Street RR Crossing – Final Report

STPX 53-1(37)1

UPN 9354000

Billings, MT
March 2023



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1 Introduction

1.1 Area Overview

The city of Billings is the largest community in Montana with a current estimated population of 110,000. The railroad has always been a central feature in the City, since the City was founded in 1882. The rail activity in the City of Billings helps support three regional oil refineries, coal extraction in southeastern Montana, other mining and mineral extraction, agricultural concerns, and numerous other industries. As the City continues to grow, so does the traffic, both vehicular and rail traffic and pedestrian and bicycle activity.

The at-grade crossing at 27th Street is one of the busiest crossings for both trains and automobiles in Montana, causing traffic congestion and delays for automobiles, pedestrians, and bicyclists. With 27th Street being a part of Montana State Highway 3 and the National Highway System, it acts as the north-south arterial between Interstate 90 and the Billings Logan International Airport. It is also the main route used by emergency services, since the hospital facilities are on the north side of the railroad tracks.

Grade-separated crossings exist at Underpass Avenue (6th Street W), North 21st Street, and North 13th Street, however these routes require two to eight minutes of out of direction travel. The North 21st Street and North 13th Street crossings have low clearance making them unsuitable for some large vehicles.

1.2 Project Background

The project is a feasibility study to determine short and long-term solutions for the existing 27th Street at-grade railroad crossing located in the center of downtown Billings, MT. The current AADT at the train tracks is 14,830 vehicles with a projected AADT of 20,590 vehicles in 2040. The crossing consists of two main tracks with approximately 32 trains and six switching trains traveling through the crossing daily. Railroad activity at this urban crossing causes frequent traffic delays, impacting safety and emergency vehicle access. See Figure 1-1 for the project limits.

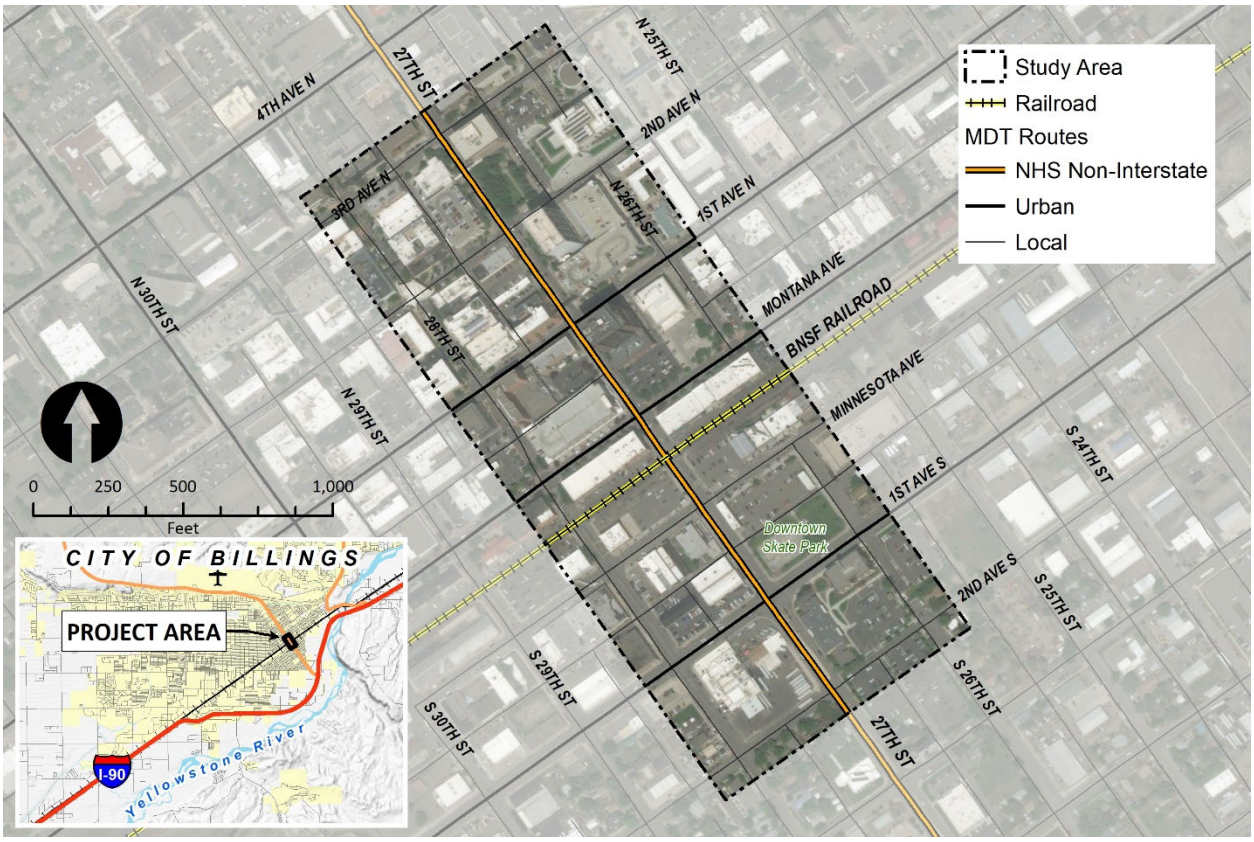


Figure 1-1. Project Limits

1.3 Crash History

MDT provided crash data along the 27th Street corridor between 4th Avenue North and 4th Avenue South from 2013 to 2017. A total of 231 crashes occurred on this corridor in this timeframe, including one incapacitating injury crash and one fatal crash. Of the reported crashes, 80 percent occurred at intersections and 20 percent of crashes occurred on segments between intersections. One crash was classified by MDT as related to the at-grade rail crossing.

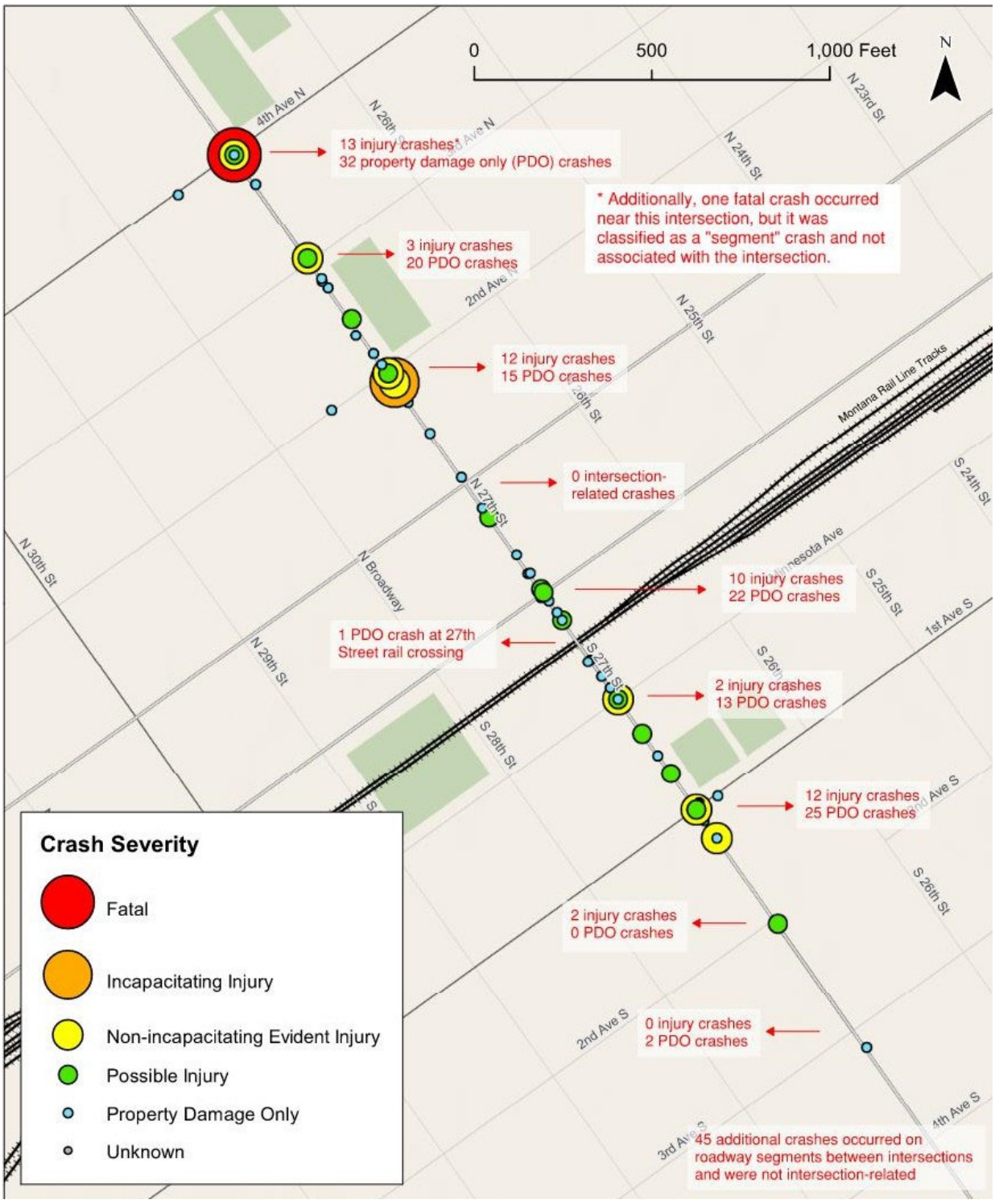


Figure 1-2. N 27th Street Crash History 2013-2017

1.4 Project Intent

The intent of this study is to expand on the previous studies and prepare a more detailed analysis of the crossing, potential impacts and improvements with the goal of providing practicable and fundable short-term and long-term improvement solutions for the 27th Street railroad crossing.

1.5 Project Breakdown

Tier 1

Tier 1 evaluated eight long-term and six short-term alternatives. No-build alternatives were also evaluated. Tier 1 was considered a fatal flaw analysis, recommending both long-term and short-term alternatives to be further analyzed during Tier 2.

Tier 2

Tier 2 further evaluated the alternatives moved forward from the Tier 1 analysis. Tier 2 recommended alternatives, both long-term and short-term, for further consideration.

Additional Short-Term Alternative Analysis

Through engagement with the City of Billings and other stakeholders, additional short-term alternatives were analyzed that would keep the existing railroad crossing at-grade.

1.6 Project Assumptions

The project does not account for future development along the 27th Street corridor, nor long-term planning for downtown Billings, MT. The long-term alternatives provide opportunity for the addition of future tracks by maintaining the minimum required vertical and horizontal clearance through the track envelope. Two future tracks are assumed for grade separated alternatives for the purposes of this study and were placed at minimum spacing per the UPRR-BNSF Guidelines for Railroad Grade Separation Projects. Coordination with the Local Railroad Representative will be required as potential solutions are implemented in the future.

2 Previous Studies

Beginning in the late 1950's, the 27th Street railroad crossing has been the subject of numerous studies and planning efforts. Previous studies examined various long-term alternatives including track adjustments, roadway overpass and underpass alternatives, and relocating the railroad out of the heart of downtown. Previous studies were reviewed by our team to evaluate recommendations and alternatives in this report. A brief summary of previous studies, including long-term alternatives, are provided in Figure 2-1 and in Table 2-1. Findings from previous studies have varied over the years, in part due to continued development of the City of Billings, as well as railroad infrastructure. One common theme across the various studies is the need for a solution at the 27th Street at-grade railroad crossing.

Previous Studies

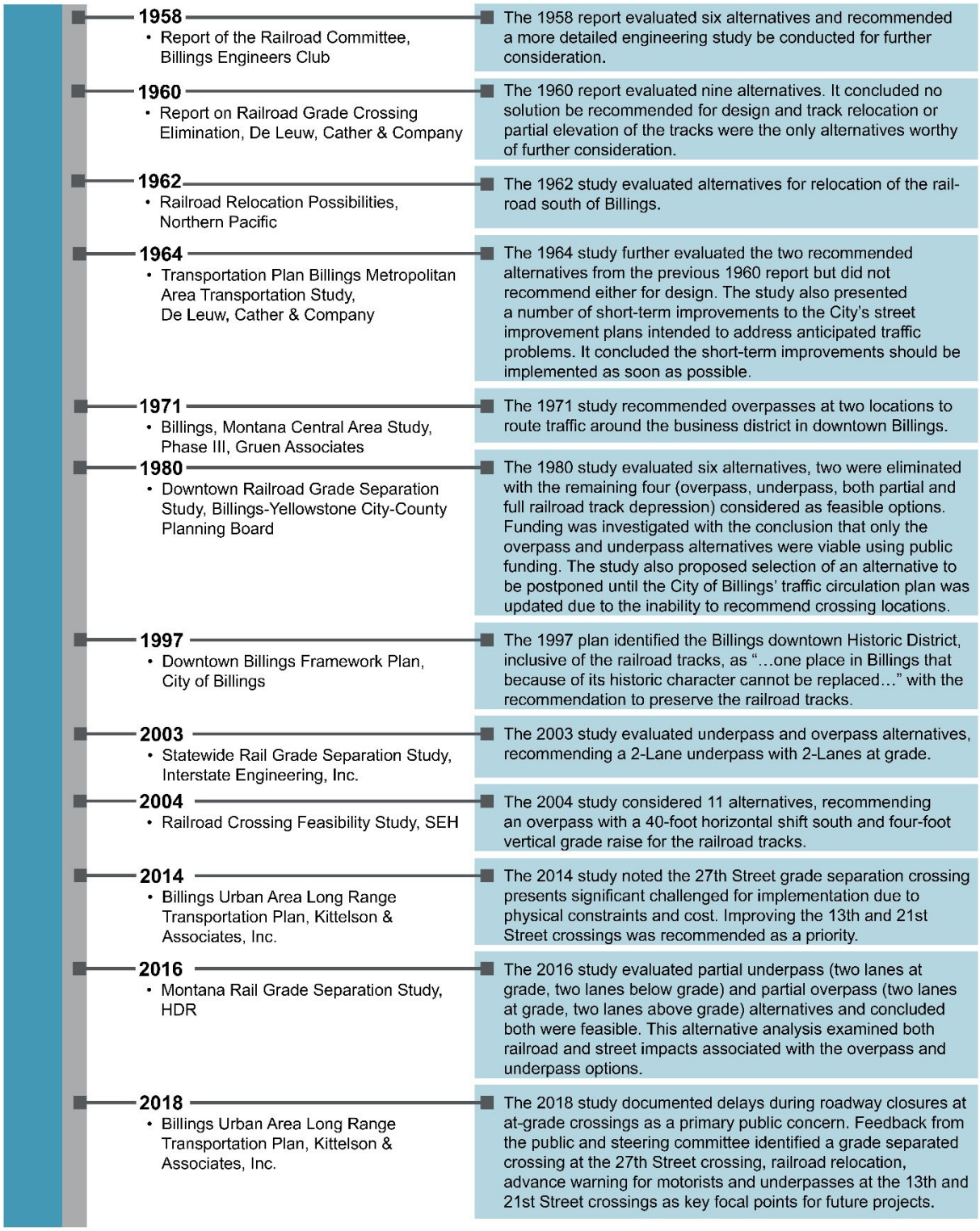


Figure 2-1. Previous Studies Timeline

Table 2-1. Previous Studies

Study Year	Alternative	Recommendation/Finding
1958	Do nothing	Additional detailed engineering study is required
	Raise one or more streets	
	Lower one or more streets	
	Raise railroad tracks	
	Lower railroad tracks	
	Relocate railroad tracks	
1960	Relocate railroad tracks parallel to Interstate 90	Feasible alternative
	Relocate railroad tracks along State Avenue	Not Recommended
	Raise railroad tracks (fully elevated)	Not Recommended
	Raise railroad tracks (partially elevated tracks/depressed underpass)	Feasible alternative
	Lower railroad tracks (fully depressed)	Not Recommended
	Lower railroad track (partially depressed tracks/elevated overpass)	Not Recommended
	Underpasses at 27th and 29th Streets	Not Recommended
	Overpasses at 27th and 29th Streets	Not Recommended
	Overpasses at 25th and 32nd Streets	Not Recommended
1962	Relocate the railroad tracks	Feasible alternative
1964	Relocate railroad tracks parallel to Interstate 90	Feasible alternative
	Raise railroad tracks (partially elevated)	Feasible alternative
1971	Overpasses at two locations	Feasible alternative
1980	Overpasses at 25th and 30th Streets	Feasible alternative
	Underpasses at 25th and 30th Streets	Feasible alternative
	Lower railroad tracks (fully depressed)	Not Recommended[1]
	Raise railroad tracks (fully elevated)	Not Recommended
	Lower railroad track (partially depressed tracks/elevated overpass)	Not Recommended[1]
	Raise railroad tracks (partially elevated tracks/depressed underpass)	Not Recommended
1997	N/A	Preserve railroad
2004	Do Nothing	Not Recommended
	Underpass at 27th Street	Not Recommended
	Underpass at 27th Street with railroad track adjustment	Feasible alternative
	Partial underpass at 27th Street (2 lanes above and below)	Not Recommended
	Raise railroad tracks (partially elevated tracks/depressed underpass)	Not Recommended
	Overpass at 27th Street	Not Recommended
	Lower railroad track (partially depressed tracks/elevated overpass)	Not Recommended
	Relocate railroad tracks (mainline) South of I-90	Not Recommended
	Relocate railroad tracks (mainline) North of I-90	Not Recommended
	Relocation of railroad switching operations	Not Recommended
	Relocate railroad tracks (mainline) North of Billings	Not Recommended
2014	N/A	27th Street challenges identified[2]
2016	Partial overpass at 27th Street (2 lanes above and below)	Feasible alternative
	Partial underpass at 27th Street (2 lanes above and below)	Feasible alternative
2018	N/A	27th Street discussed[3]

[1]Alternative was not recommended due to estimated cost and anticipated private funding required.

[2]Signficiant physical constraints and project costs were identified as challenges for the 27th Street grade crossing.

[3]Traffic delays during roadway closures at at-grade crossings identified as a primary public concern.

3 Design Standards

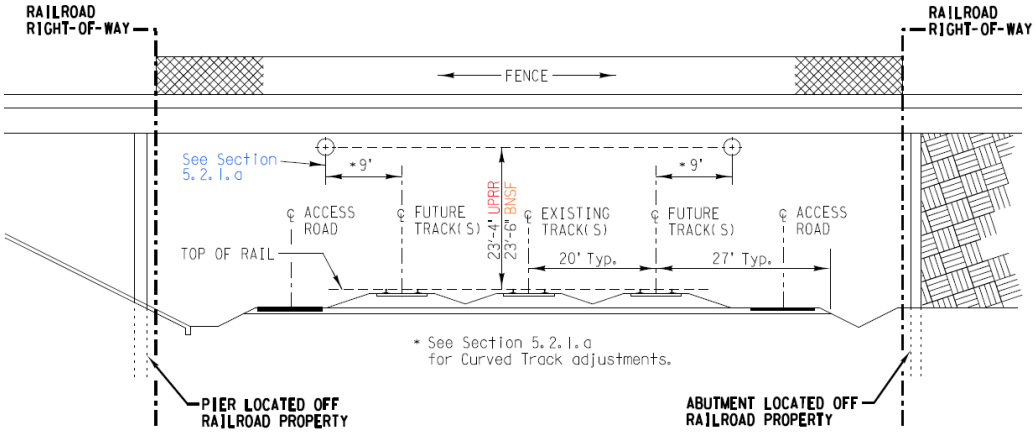
The alternatives for this study will be designed in accordance with current MDT geometric design criteria for an Urban Principal Arterial (NHS – Non Interstate) as shown in Table 3-1. Long-term alternatives will be developed using the BNSF/UPRR Guidelines for Railroad Grade Separation Projects and current AASHTO LRFD Bridge Design Specifications, 8th Edition. Some designs may require design exceptions due to the nature of the project location and the need to maintain business access and minimize the impacts throughout the corridor.

Table 3-1. MDT Design Criteria for Urban Principal Arterials

Urban Principal Arterials (NHS - Non Interstate)		
Roadway Elements	Travel Lane Width[1]	12 ft
	Minimum Roadway Width[2]	Curbed: 28 ft
	Shoulder Width	Curbed: 0 ft
	Cross Slope	2%
	Minimum Median Width	Raised[3]: 4 ft
	TWLTL Width[4]	12 ft
	Bicycle Lane Width[5]	4 ft
	Parking Lane Width[6]	10 ft[7]
Cut Section	Ditch Slope	4:01
Alignment Elements	Design Speed[8]	40 mph
	Stopping Sight Distance	305 ft
	Intersection Sight Distance	195 ft
	Minimum Radius	533 ft
	Superelevation Rate	e_{max} = 4.0%
	Maximum Grade	Level: 6%
	Minimum Vertical Clearance	17.0 ft[9]

[1] For multilane facilities, the interior lane width is 11 feet and the exterior lane width is 12 feet.
[2] The lane width does not include the gutter section.
[3] The raised median width needs to be added to the exclusive left-turn lane width.
[4] This is also applicable for an exclusive left-turn lane with a flush median.
[5] The bicycle lane width can include the shoulder width if there is no parking. A 5-foot width is recommended from the face of curb, guardrail or other roadside barriers. An increased lane width is recommended where the percentage of trucks or buses is high.
[6] Includes the width of the gutter section.
[7] 8 feet may be acceptable when the lane is not likely to become a traffic lane in the foreseeable future.
[8] The design speed should match the conditions and driver expectancy. The determination of the design speed should be based on consideration of roadside development, number and type of approaches, lane configuration and traffic control devices.
[9] The clearances apply to the arterial passing under a bridge. The minimum clearance includes a 6-inch additional allowance for future overlays.

Figure 3-1. Union Pacific Railroad – BNSF Railway Guidelines for Railroad Grade Separation Projects



4 Public Outreach

A comprehensive public involvement plan was implemented throughout the study. The public involvement plan included public meetings and individual stakeholder meetings organized to inform and solicit feedback from the public, as well as businesses and organizations within the project area. Feedback from the community was used to aid in the development of the evaluation criterion for the decision-making process. The goal was to provide transparency throughout the process and for the public outreach to objectively assist in the effort to identify practicable solutions.

4.1 Past Public Meetings

From November 2018 through December 2022, MDT hosted a series of in-person open house and online live public meetings, where the project team shared the study overview, process, and next steps with the public for the existing 27th Street at-grade railroad crossing. The project team also answered stakeholder questions and listened to their issues and concerns. In-person open house and online public meetings are listed in reverse order below.

In-Person Open House Public Meeting – December 12, 2022, 3:00-6:00 p.m.

Display boards used at the in-person open house public meeting updated stakeholders about the project study. Key project personnel were available to answer stakeholder questions and discuss the project. Project personnel collected and added stakeholder comments to the issues database.

Online Public Meeting – December 15, 2022, 11:30 a.m.

A PowerPoint presentation was given during the online live public meeting to update stakeholders about the project study. Key project personnel were available to answer stakeholder questions. Project personnel collected and added stakeholder comments to the issues database. Similar information was presented at both this meeting and the in-person open house meeting.

Two Online Live Public Meetings – December 1, 2020, 11:30 a.m. and 4:30 p.m.

Instead of an in-person open house public meeting, two online live meetings were held due to COVID-19 and concerns about public safety. MDT hosted both online meetings on December 1, 2020, at 11:30 a.m. and 4:30 p.m. Key project personnel shared the study overview and next steps.

In-Person Open House Public Meeting – April 29, 2019

An in-person open house public meeting was held April 29, 2019, to inform stakeholders and the public about project progress.

In-Person Open House Public Meeting – November 27, 2018

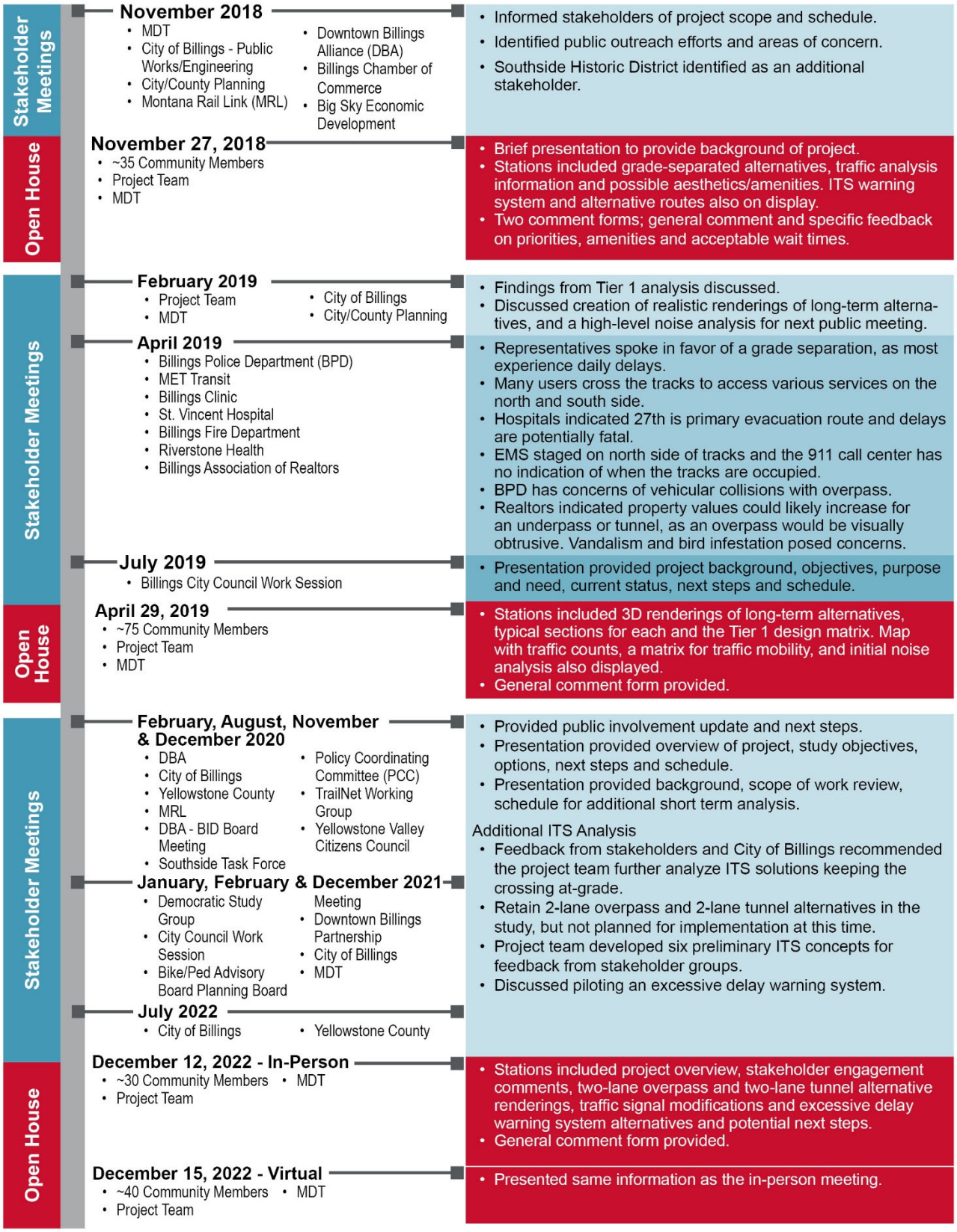
An in-person public meeting was held on November 27, 2018, to introduce the project team and project study.

Stakeholder Engagement

Throughout the study, the project team has continuously met with individuals and stakeholder groups, including the following, to provide study updates and gather feedback.

- Nearly 20 individual contacts with local business owners
- Big Sky Economic Development
- Bike Ped Advisory Board
- Bike Walk MT/ Montana PTA
- Billings Chamber of Commerce
- BNSF Railway
- City of Billings, multiple departments, including Parks, Planning, Public Works, PCC, School District, and Traffic
- Democratic Study Group
- Downtown Billings Alliance
- Downtown Billings Partnership
- Emergency response/ first responders
    - Billings Clinic
    - Billings and Lockwood Fire Departments
    - Billings Police Department
    - Montana Highway Patrol
    - Riverstone Health
    - Saint Vincent’s Healthcare
    - Yellowstone County Sheriff’s Department
- Montana Motor Carriers
- Montana Rail Link
- Southside Neighborhood Task Force
- TrailNet
- Yellowstone County, including Commissioners and Road and Bridge
- Yellowstone Valley Citizens Council

Figure 4-1. Public Outreach Timeline



4.2 Public Comment

The project website hosted by MDT contains project updates, links to exhibits from the public meeting, and a link to a comment page for the community to comment electronically, see 27th Street RR Crossing - Billings | Montana Department of Transportation (MDT) (mt.gov).

Throughout the project public and stakeholder concerns consistently included the following.

- Drainage issues, icy conditions on steep grades, and cost were mentioned as concerns about building an underpass.
- Potential visual obstruction and impact to property values from an overpass were consistently expressed concerns.
- Because of concerns emergency response concerns, several stakeholders asked if the study had reviewed construction of over/underpass in different locations, such as 30th Street or 31st Street.
- Downtown property and business owners expressed concerns that an overpass or underpass would become a shelter or draw for the unhoused population.
- Some commentors suggested relocation of the train tracks (horizontally or vertically). Make this a railway project, not a roadway project.
- Stakeholders also suggested signal improvements to clear traffic more efficiently after a train delay, improvements to the 21st Street Underpass, and various other concerns with the infrastructure across the city, not pertaining to this study.
- Stakeholders expressed appreciation that MDT included their concerns, issues, and suggestions in the study.

5 Community Considerations

5.1 Environmental Review

An environmental review of the study area was performed using records search of the Montana Natural Heritage Program (MTNHP) and a database search of the United States Fish and Wildlife Service (USFWS). The search identified multiple state Species of Concern within the study vicinity (three-mile radius), and threatened and endangered species are known to occur in Yellowstone County, Montana. However, due to the highly developed and disturbed nature of the study limits, no suitable habitat exists for any federally threatened, endangered, or candidate species listed in Yellowstone County or any state Species of Concern, with the exception of the Peregrine Falcon, which may use tall buildings and overhangs for nesting.

Additionally, no aquatic resources, including streams or wetlands, were identified within the study limits. Permits required for impacts to streams or wetlands from improvement alternatives carried forward from this study are not anticipated. Construction storm water permits may be required in accordance with the Montana Pollutant Discharge Elimination System (MPDES). One Hazardous Substances Release site, the South Downtown Solvent Plume, is located within/adjacent to the study limits.

Table 5-1 below shows the coordination necessary moving forward.

Table 5-1. Environmental Coordination

Agency	Action Item
Montana Department of Environmental Quality (DEQ)	A letter will be sent to DEQ regarding the South Downtown Solvent Plume and further communication may be necessary regarding other hazardous materials and contaminated soils in the area as alternatives are developed.
Montana Department of Natural Resources and Conservation (DNRC)	None; Mineral leases or mining activities are highly unlikely within and adjacent to the study limits.
Environmental Protection Agency (EPA)	None; Study limits are not on tribal lands and no federal super fund sites are found.
Montana Fish, Wildlife & Parks (FWP)	As alternatives are further developed, and a preferred alternative determined, communication with the FWP regarding potential effects to Peregrine Falcon may be required.
United States Army Corps of Engineers (USACE)	None; No wetlands, streams, or jurisdictional watercourses are located within the study limits that would require permitting under Section 404 of the Clean Water Act.
United States Fish & Wildlife Service (USFWS)	None; Whooping Crane and Red Knot are the only federally listed species for Yellowstone County and due to the highly developed nature of the study limits, no suitable habitat exists for these species, and they are not likely to reside within the study limits.
City of Billings	Any alternative carried forward from this study will need to comply with any applicable conditions set forth in the MS4 permit and additional coordination with the Parks and Recreation Department regarding Section 4(f) and Section 6(f) use may be required.
Yellowstone County	None; There are no county owned parks or recreation areas within or immediately adjacent to the study limits.
State Historic Preservation Office (SHPO)	As alternatives are further developed, and a preferred alternative determined, additional coordination and Section 106 consultation with SHPO may be required.

5.2 Biological Resources Review

Multiple alternatives are currently being considered under this study, and therefore a project and associated final construction limits have not been determined. Alternatives under consideration would have no effect on the federally-listed Whooping Crane or Red Knot, nor is this study located within core or general Sage Grouse habitat. No aquatic resources were identified within or directly adjacent to the study limits. One proposed alternative, the grade-separated overpass alternative, may have a greater impact on Peregrine Falcon, a state Species of Concern, if the raptor is nesting on adjacent buildings.

The Biological Resources Review took into account the general wildlife species listed below and found the proposed alternatives in the study likely have negligible impacts to the local wildlife due to the lack of suitable habitat within the study limits.

- Mammals – 22 species documented in the study vicinity
- Birds – 120 avian species documented in the study vicinity
- Reptiles and amphibians – nine species of reptiles and six species of amphibians documented in the study vicinity

One plant species of concern and 17 terrestrial species of concern may occur within the study vicinity, but none are found to be impacted by the alternatives due to the lack of suitable habitat. The overpass alternative would likely have a greater impact on species, such as the Peregrine Falcon, as the roadway would be elevated, likely having a greater effect on potential nesting sites on adjacent buildings.

Two aquatic species of concern exist within the study vicinity but would not be impacted by any of the alternatives in the study, as no aquatic habitat exists within or directly adjacent to the study limits.

One endangered species and one threatened species exist within Yellowstone County, Montana. The Whooping Crane is endangered but is highly unlikely to be affected by the alternatives due to the lack of migratory and foraging habitat within the study limits. The Red Knot is threatened but is unlikely to be affected by the alternatives due to the lack of suitable habitat within the study limits.

5.3 Socioeconomic Issues

According to the U.S. Census Bureau data, the percentage of people living below the poverty line is 21.3 percent in Tract 3 and 16.5 percent in Tract 4.02. These percentages are notably higher than the corresponding percentages for city of Billings (10.8 percent) and Yellowstone County (10.1 percent), and somewhat higher than the state of Montana (14.4 percent). Based on the census data provided, relative concentrations of minorities and residents below the poverty level are identified within the study vicinity, particularly south of the BNSF railroad tracks within Census Tract 3.

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* directs federal programs, policies, and activities do not have disproportionately high and adverse human health and environmental effects on minority and low-income populations. For all alternatives evaluated, potential impacts to low income and minority populations would need to be considered, as there are higher concentrations of these populations in the study limits and vicinity.

5.4 Neighborhood Continuity

The 27th Street corridor serves as a major route connecting Interstate 90 to downtown Billings, the hospital corridor, the Billings Logan International Airport, and continues MT 3 above the Billings Rimrocks to the west. In addition, local businesses rely on 27th Street for access. Alternatives evaluated would need to review proposed changes in traffic patterns and how access to businesses would be maintained if a grade-separated alternative is carried forward. Overall, providing a grade separation at the railroad crossing could positively benefit traffic operations, improve travel times, and increase vehicular and non-motorized safety.

The 27th Street corridor has long rows of single and multi-story buildings located on both sides of the roadway. Currently an at-grade railroad crossing with crossing arms and warning lights is found just north of Minnesota Avenue. Several landscape trees border both sides of 27th Street, with a pedestrian overpass crossing the roadway between 2nd Avenue North and 3rd Avenue North. Distant views of the Billings Rimrocks are found north and south of the study limits, however these views are primarily blocked by buildings.

Evaluation of alternatives will consider impacts to the visual character of the area. An overpass structure would likely have a greater impact on the visual character, compared to an underpass or tunnel structure. An elevated structure could alter existing views on the 27th Street roadway, and impact views from adjacent buildings, residences, and parks.

5.5 Historic Review and Section 4(f) Resources

Sections 4(f) of the U. S. Department of Transportation Act of 1966 protects publicly-owned parks, recreational areas, wildlife and waterfowl refuges, and public and private historic sites of local, state, and national significance. Federally-funded transportation projects cannot "use" Section 4(f) properties unless there are no feasible and prudent avoidance alternatives and all possible planning to minimize harm has occurred.

Several potential Section 4(f) resources were identified within the study limits. These include both park/recreation resources and historic sites. At the corner of 1st Avenue South and 27th Street is the Downtown Billings Skate Park. The park is owned by the city, open to the public, and includes a constructed skate park, public bathrooms, and picnic facilities. In addition, 14 historic buildings, one historic monument, and three historic districts were identified within the study limits as part of the July 2018 cultural resources database review and survey completed for the study. Eight buildings and three historic districts are documented as National Register of Historic Places (NRHP) listed or eligible for listing. Six buildings and the historic monument are unevaluated but could be NRHP eligible. NRHP listed and eligible sites are considered Section 4(f) resources. The unevaluated sites, if determined eligible at a later date, would also be considered Section 4(f) resources.

Table 5-2 shows the Section 4(f) Resources.

Table 5-2. Section 4(f) Resources

Eligibility	Property Name	Address	Section 4(f) Resource
NRHP Listed	Chamber of Commerce Building	303 North 27th Street	Yes
	L&L Building	2624 Minnesota Avenue	Yes
	Oliver Building	2702 Montana Avenue	Yes
	P.W. McAdow Store	2702 Minnesota Avenue and 8, 10, and 12 South 27th Street	Yes
	Glenn Apartments	14(16) South 27th Street	Yes

Table 5-2. Section 4(f) Resources

Eligibility	Property Name	Address	Section 4(f) Resource
	Safeway Grocery Store	18 South 27th Street	Yes
	Stone-Ordean-Wells Building/St. Vincent de Paul Thrift Store	2624 Montana Avenue	Undocumented, but within a Section 4(f) historic district
NRHP Eligible	Yellowstone County Courthouse	217 North 27th Street	Yes
Unevaluated	Securities Building/Walkers Grill	2700 First Avenue North	No
	Grand Hotel/Custer's Hotel/Jakes Grill	2701 First Avenue North	No
	Burger Dive	114 27th Street North	No
	Rockman Building	2702, 2708, 2710, 2712 Second Avenue North	No
	James T. Webb Monument	Corner of North 27th Street and Second Avenue South	No
	Billings City Hall	220 North 27th Street	No
	First Congregational Church	310 North 27th Street	No
NRHP Listed Historic Districts	Southside Historic District		Yes
	Billings Townsite Historic District		Yes
	Billings Old Town Historic District		Yes

Impacts to and use of potential Section 4(f) resources will need to be considered during the alternatives evaluation. These uses may include permanent or temporary encroachment into a Section 4(f) property. A grade-separated, overpass structure would likely have a greater visual impact than an underpass or tunnel structure, as an elevated structure, adjacent to historic buildings and recreational areas may negatively affect the aesthetic features or attributes of the resource.

5.6 Land and Water Conservation Fund Properties

Section 6(f) of the Land and Water Conservation Fund (LWCF) Act protects federal investments and the quality of resources purchased or improved by the LWCF. The Secretary of the Interior must approve any conversion of LWCF property to a use other than public, outdoor recreation. A review of Montana Cadastral and available aerials, maps, and city/county databases show one LWCF funded park within the study limits. The City of Billings Downtown Skate Park is located at the corner of 1st Avenue South and 27th Street. No other LWCF properties were identified within or adjacent to the study limits.

Evaluation of alternatives would need to consider proximity to the Downtown Skate Park. Additional coordination with FWP would be necessary if an alternative forwarded from this study affects the park.

6 Design Considerations

6.1 Drainage

A preliminary review of the storm water management was performed for each of the three build alternatives as well as the no-build alternative. Each alternative was evaluated for impacts to the existing storm drain system, general features of anticipated storm drain modifications, water quality considerations, and relative cost of needed improvements to the storm water system.

Regional surface drainage is generally west to east within the project area. Gutter flow in the cross streets to the west generally flows towards 27th Street and is collected at corner inlets on the west side of 27th Street. 27th Street itself has a crowned cross-section and sheet flows both east and west to curb inlets. Any gutter flow not being captured by inlets on the east side of 27th Street generally continues to flow east along the cross streets.

If existing drainage patterns are modified, a hydraulic and hydrologic report must be submitted to the railroad for review.

No-Build and Short-Term Alternatives

There would be no impacts to the existing storm drain system with the no-build and short-term alternatives. According to the MDT Billings District Maintenance department, there are no known storm drain system deficiencies at the time this report was written within the general study area along 27th Street from 1st Avenue South to 3rd Avenue North. If it is found the existing storm drain system is deficient, the no-build and short-term alternatives would not allow for correction of the system. There are currently no known storm water treatment facilities in the immediate project area and there would be no opportunity for improvements to the storm water quality with these alternatives.

2-Lane Overpass

IMPACTS TO EXISTING STORM DRAIN SYSTEM (PHYSICAL & OPERATIONS)

At the southern limits of the 2-Lane overpass alternative, approximately 360 linear feet of 10” storm drain main running longitudinally on 27th Street between Minnesota Avenue and 1st Avenue South with one curb inlet and lateral drains would be impacted. Depending on the size and depth of the overpass footings impacts to the 10” storm drain main running longitudinally on 27th Street between Montana Avenue and 1st Avenue North along with three curb inlets and laterals are likely. The bridge piers should be spaced to avoid impacts to the 24” storm drain main flowing east crossing 27th Street in the alley north of Montana Avenue.

The 2-Lane Overpass is not expected to change the general surface flow that exists today, since the primary improvements are along the centerline of 27th Street where a crowned roadway section currently exists.

GENERAL FEATURES OF ANTICIPATED STORM DRAIN MODIFICATIONS

Between Minnesota Avenue and 1st Avenue South, approximately 360 linear feet of new 18" storm drain main would be placed west of the south overpass ramp beneath the southbound at-grade travel lane replacing the impacted longitudinal storm drain main. Assuming overpass footing impacts will exist between Montana Avenue and 1st Avenue North, approximately 360 linear feet of new 18" storm drain main would be placed either west or east beneath the at-grade travel lanes to replace the longitudinal storm drain main.

Along the overpass, intermediate inlets would capture surface runoff, with vertical pipelines attached to the structure directing the storm water to the 27th Street median below. The median could provide some detention storage and would have inlet drains discharging into the relocated storm drain. If the overpass inlets are designed to thoroughly drain the deck, the overpass ramps are not anticipated to require intermediate inlets to meet spread criteria due to their short length and steepness. Some improvements of intersection curb inlets at 1st Avenue South and 2nd Avenue North should be anticipated to accommodate ramp runoff. Due to the increased drainage area at both of these intersections, there may be the need to incorporate detention/retention facilities underground to minimize impacts to the downstream systems.

WATER QUALITY CONSIDERATIONS

Vegetated median storage beneath the overpass structure could be considered to improve surface treatment of the storm water drainage off the overpass. In areas where new storm drain trunk mains would be replaced, mechanical treatment devices could be installed.

RELATIVE STORM WATER COST

At this level of analysis, the relative cost of the 2-Lane overpass is expected to be significantly lower than both the 2-Lane underpass and 2-Lane tunnel alternatives. This alternative does not require a pump station or inverted siphon. It has less potential to require upsizing of the existing storm drain collection system due to the rerouting storm water between trunk mains.

2-Lane Underpass

IMPACTS TO EXISTING STORM DRAIN SYSTEM (PHYSICAL & OPERATIONS)

The 2-Lane underpass alternative would displace approximately 1,100 linear feet of 10" storm drain main running longitudinally on 27th Street between 3rd Avenue North and 1st Avenue South. Roughly 17 curb inlets and laterals drain to these longitudinal mains. The underpass would conflict with a 24" storm drain main flowing east crossing 27th Street in the alley north of Montana Avenue.

The 2-Lane Underpass is not expected to change the general surface flow, other than all rainfall and snowmelt in the middle lanes of 27th Street would be captured within the underpass.

GENERAL FEATURES OF ANTICIPATED STORM DRAIN MODIFICATIONS

Approximately 1,100 linear feet of new 18” storm drain main would be relocated west of the underpass beneath the southbound at-grade travel lane to replace the displaced longitudinal storm drain main. This includes 380 linear feet between 2nd Avenue North and 3rd Avenue North, 360 linear feet between Montana Avenue and 1st Avenue North, and 360 linear feet between Minnesota Avenue and 1st Avenue South.

Within the underpass, intermediate inlets along the ramps and full-width trench drains at each of the two sag points would capture surface runoff. These inlets and trench drains would collect storm water in a new 18” storm drain main beneath the underpass with an estimated required length of 1,000 linear feet. This main would then be routed to a pump station which would lift all storm water captured in the underpass up to the existing collection system.

The underpass structure is assumed to be sealed from groundwater. In addition, all features of the underpass collection system must be designed to be watertight to prevent backflow of groundwater into the underpass or leakage into the pump station. Design considerations for the storm water system will include pipe materials and joint types meeting strict watertight criteria. Trench plugs will need to be used in all groundwater areas to prevent migration of fine-grained materials through the pipe bedding. If necessary, the pump station will be designed to handle allowable groundwater leakage volumes related to the underpass structure seal.

It is assumed that groundwater dewatering will be required for construction of the underpass structure. The pump station could be designed to function as a means to dewater the site during the construction, and then used after construction is completed. Any impacts resulting from lowering the groundwater have not been identified or considered, at this time.

The new pump station would likely consist of a 12-ft or larger diameter manhole acting as a wet well. The pump station would include three submersible pumps; electrical, control, and monitoring systems; maintenance access hatch; discharge piping and adjacent valve vault; and a force main pipeline. The location of the new pump station is undecided. There will be limited room directly adjacent to the underpass beneath the at-grade lane and sidewalk, therefore additional right-of-way or easement may be required. A location on the east side of 27th Street is preferable, as this is the downstream direction of the collection system. The pump station force main will discharge to an existing storm drain trunk main, most likely in either 1st Avenue South or the alley north of Montana Avenue, depending on the final pump station location. The capacity of the receiving pipeline will be verified and may need to be upgraded in size to accommodate additional flows. An alternative to lessen the impact on the downstream collection system is to limit the pump discharge rate, which would in turn require additional wet well storage. Consideration could also be given to discharging to both trunk mains. The preferred pump station design configuration and need for downstream collection system upgrades will be determined at the next study phase as necessary.

The 24” storm drain main crossing 27th Street in the alley north of Montana Avenue would be converted to an inverted siphon beneath the underpass so it could continue to function without requiring an extensive new gravity pipeline system to divert the flow

along an alternate route. A small diameter drain line into the pump station wet well would be incorporated into the siphon design.

WATER QUALITY CONSIDERATIONS

The underpass pump station could be preceded by a mechanical treatment device for grit and oil separation, which would provide water quality treatment for all storm water entering the underpass system. Storm water ponds or other surface treatment alternatives are not considered viable for this alternative due to space constraints.

RELATIVE STORM WATER COST

At this level of analysis, the relative cost is essentially identical to the 2-Lane tunnel alternative and therefore the 2-Lane tunnel and 2-Lane underpass alternatives are tied at the highest relative cost compared to the 2-Lane overpass alternative and no-build alternative.

2-Lane Tunnel

IMPACTS TO EXISTING STORM DRAIN SYSTEM (PHYSICAL & OPERATIONS)

The impacts to the existing storm drain system are essentially identical to the 2-Lane underpass alternative. It has been verified that the 24” storm drain main crossing 27th Street in the alley north of Montana Avenue is too deep, at eight feet to be perpetuated over the top of the tunnel which only provides four feet between the pavement and top of tunnel.

GENERAL FEATURES OF ANTICIPATED STORM DRAIN MODIFICATIONS

New storm drain system features for the 2-Lane tunnel are mostly identical to the 2-Lane underpass alternative, except for the at-grade drainage features between the railroad and 1st Avenue North, the extents of the tunnel. Along this stretch, the new 18” storm drain main would be relocated east of the underpass beneath the northbound at-grade travel lane to replace the 360 linear feet of displaced longitudinal 10” storm drain main. This main would collect runoff from curb inlets on both sides of 27th Street and could be routed over the top of the tunnel.

WATER QUALITY CONSIDERATIONS

The water quality considerations are essentially identical to the 2-Lane underpass alternative.

RELATIVE STORM WATER COST

At this level of analysis, the relative cost is essentially identical to the 2-Lane underpass alternative and therefore the 2-Lane tunnel and 2-Lane underpass alternatives are tied at the highest relative cost compared to the 2-Lane overpass alternative and no-build alternative.

6.2 Utility Conflicts

Water mains and services, sanitary mains and services, and storm drain mains and laterals are all present within the study limits. Utility conflicts are likely with any of the build alternatives.

Most of the public utilities crossing the corridor are gravity-fed, either requiring long runs of replacement/relocation or pump stations to lift the relocated sections back to existing utilities. Most of the communication utility is aerial, however, several runs of fiber and copper exist within the study limits. Several natural gas mains and service lines are located within the project limits. Maintenance of the Gas mains and service lines are a concern of the utility once a grade separation is constructed.

Utility relocations on railroad right-of-way will need to be coordinated with the railroad. No utility attachments are permitted on Underpass structures. Fiber optic lines must be placed underground within railroad right-of-way.

Further utility coordination will be necessary prior to finalizing design on a grade separated alternative.

Public Works utilities can be found using the City of Billings GIS system.

No-Build and Short-Term Alternatives

The no-build and short-term alternatives are anticipated to have no utility conflicts.

2-Lane Overpass

Pier placement is key when it comes to utility conflicts. The piers are currently spaced in a manner to allow for the most useable space possible underneath the bridge for traffic operations, sight distance, aesthetic and multi-modal opportunities. Utilities located within the pier foundation envelope will require relocation. Since the pier foundation footprint is much less than the underpass and tunnel alternatives, the required relocations are less with the overpass alternative. The risk associated with excavating in an urban area is much less as well. The potential of delays and scope/cost creep is also less with the overpass alternative when compared to the underpass and tunnel alternatives.

2-Lane Underpass

The underpass alternative along with the tunnel alternative have the greatest impact to utilities. Utilities running parallel to 27th Street could likely be relocated beneath the at-grade lanes, however further investigation to the potential location of those utilities will need to be completed. Utilities crossing 27th Street would need to be completely relocated with pump stations likely for the gravity-fed utilities. With the extensive utility relocates and depth of excavation, risk runs high with the underpass and tunnel alternatives. Undocumented or abandoned utilities could be present. Uncovering existing utilities could cause construction delays and scope/cost creep.

2-Lane Tunnel

The tunnel has the same impact to utilities as the underpass does. In the location of the enclosed tunnel limits, opportunity does exist for utilities to be placed between the

pavement section and the top of the tunnel, however, further investigation is required to understand the feasibility of utility placement on top of the tunnel.

6.3 Structural Analysis

Geotechnical

The surface and subsurface conditions were studied during a geotechnical investigation and used for the Tier 1 analysis. Groundwater depths were typically shown to vary from five feet to 20 feet below the existing roadway, depending on location and time of the year. Groundwater levels fluctuate considerably depending on the season.

A frost depth of 54” is recommended to footing foundations and the use of Type I or II Cement for footings.

Seismic

The seismic hazard was evaluated according to the 2017 AASHTO Bridge Design Specification, 8th Edition using the general procedures. The 27th Street corridor classifies as Site Class D and the Seismic Zone is 1 with a PGA of 0.042g. Based on a review of the available geologic mapping, it does not appear the project area is located near an active fault. Due to the low seismic activity in the area and groundwater depths of approximately five to 20 feet below the surface, liquefaction is unlikely at this site.

2-Lane Overpass

The proposed overpass structure option would likely have single shaft, hammerhead piers with abutments using retaining walls to support the embankment material for approximately 50 feet from the ends of the structure. Foundation options would include:

- Spread footings on improved subgrade
- Drilled shafts extending into shale bedrock
- Driven steel piles advanced into shale bedrock

Proposed superstructure options for the overpass would include welded steel plate girders and precast, prestressed concrete girders. Local fabricators and suppliers, located in Billings, MT, would be able to furnish these beam shapes.

2-Lane Underpass

Seventeen feet of vertical clearance between the structure supporting the railroad tracks and the roadway underpass will be provided. Further investigation is needed depending on the structure type, per UPRR/BNSF Grade Separation Guidelines. Current underpass design does not provide for any future railroad tracks to pass over the underpass.

The proposed underpass structure would consist of vertical retaining walls and a slab on grade to support the roadway surface. Proposed retaining wall types could include cast-in-place concrete cantilever retaining walls or MSE-type walls with a concrete panel or block-type face.

East-West crossings across the underpass would be maintained through the use of economical bridges for 1st Avenue South, Montana Avenue, 1st Avenue North and 3rd Avenue North.

2-Lane Tunnel

The 2-Lane tunnel alternative would be similar to the 2-Lane underpass alternative. The tunnel alternative allows one and a half blocks to have wider pedestrian facilities and a two-way left-turn lane and one travel lane in each direction on top of the tunnel.

7 Alternative Analysis

7.1 Tier 1 Results

The Tier 1 analysis evaluated eight long-term alternatives and six short-term alternatives, as summarized in Figure 7-1 and Figure 7-2.

Figure 7-1. Tier 1 Long-Term Alternative Results

Evaluation Criteria		Long Term Alternatives						
	No-Build	2 Lane Overpass	2 Lane Underpass	2 Lane Tunnel	4 Lane Overpass	4 Lane Underpass	Relocate RR	Grade Separate 27th (Minnesota to Montana Only)
Fatal Flaw Analysis								
Meets Current Design Standards	🟢	🟢	🟢	🟢	🟢	🟢	N/A	X
Meets Stakeholder Interest and Achieves Project Goals	🟡	🟡	🟡	🟡	🟡	🟡	🔴	🟡
Traffic Mobility and Route Connectivity	🟡	🟢	🟡	🟡	🔴	🔴	🟢	🟢
Multi-Modal Connectivity	🟡	🟢	🟢	🟢	🔴	🔴	🟢	🟢
Constructability	🟢	🟡	🟡	🟡	🟡	🔴	🔴	🟡
Property Impacts and Business Access	🟢	🟡	🟡	🟡	🔴	🔴	🔴	🟡
Railroad Operations Impacts	🟡	🟡	🟡	🟡	🟢	🟢	X	🟢
Capital Costs	🟢	🟡	🟡	🔴	🔴	🔴	🔴	🟡
Recommended for Tier II Analysis	✓	✓	✓	✓				

Figure 7-2. Tier 1 Short-Term Alternative Results

Evaluation Criteria		Short Term Alternatives				
	No-Build	28th St and 29th St Closure	Signal Modifications	ITS	28th St Closure	29th St Closure
Fatal Flaw Analysis						
Meets Stakeholder Interest and Achieves Project Goals	🟡	🟡	🟡	🟡	🔴	🟡
Traffic Mobility and Route Connectivity	🟡	🔴	🟡	🟢	🔴	🔴
Multi-Modal Connectivity	🟡	🔴	🟡	🟡	🔴	🔴
Property Impacts and Business Access	🟢	🟡	🟢	🟢	🟡	🟡
Railroad Operations Impacts	🟡	🟢	🟡	🟡	🟡	🟡
Capital Costs	🟢	🟡	🟡	🟡	🟡	🟡
Recommended for Tier II Analysis	✓	✓	✓	✓		

Based on the conclusion from the Tier 1 analysis, the 2-Lane Overpass, 2-Lane Underpass, 2-Lane Tunnel and No-build alternatives were the long-term solutions moved forward to be analyzed further in Tier 2. The short-term alternatives recommended to be analyzed further from Tier 1 to Tier 2 were the no-build, 28th and 29th Street closures, signal modifications, and an ITS system.

7.2 Long-Term Alternatives

The three grade separated alternatives analyzed for Tier 2 are shown in Table 7-1 below.

Table 7-1. Long-Term Alternative Analysis

Long - Term Alternatives									
Evaluation Criteria	Points	No-Build		2-Lane Overpass		2-Lane Underpass		2-Lane Tunnel	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Traffic Mobility and Route Connectivity	25	10	250	50	1250	30	750	30	750
Probable Opinion of Construction Cost	25	40	1000	30	750	15	375	5	125
Constructability	20	50	1000	30	600	10	200	10	200
Long-Term Risk	20	50	1000	25	500	10	200	5	100
Property Impacts and Business Access	15	60	900	0	0	30	450	30	450
Railroad Operations Impacts	15	10	150	50	750	30	450	30	450
Multi-Modal Connectivity	10	50	500	25	250	0	0	15	150
Aesthetic Opportunities	5	25	125	5	25	10	50	50	250
Noise Analysis	5	0	0	25	125	30	150	35	175
Total	140	295	4925	240	4250	165	2625	210	2650

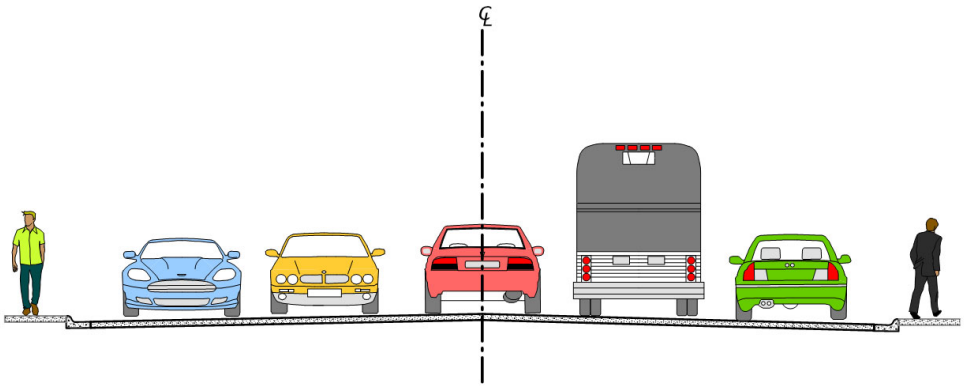
No-Build

27th Street currently meets MDT's design criteria for an Urban Principal Arterial (NHS – Non Interstate). The current roadway is a curbed facility with two 12-foot travel lanes, one in each direction, with turn-lanes developing near intersections. The cross slope is generally 2 percent throughout the study corridor. A raised median exists along 27th Street beginning at the interstate, continuing north and terminating at 1st Avenue South. Currently, no bike lanes or on-street parking exist along 27th Street. The existing horizontal alignment is tangent with a level vertical grade. All traffic and pedestrians are currently stopped by trains at the crossing and would be stopped with the no-build alternative.

The no-build alternative would maintain existing conditions and would not meet the project's objective of providing a free-flowing travel route at the railroad crossing. Using an average growth factor of 1.0 percent, the amount of traffic on 27th Street would increase by 5,760 AADT by 2040, which would result in additional delays for thru-traffic along this corridor. It is unknown if the railroad traffic will increase, decrease, or stay the same by 2040.

Figure 7-3 below shows the current typical section of 27th Street.

Figure 7-3. Current 27th Street Typical Section



2-Lane Overpass

The 2-Lane overpass alternative begins near the intersection of 27th Street and 3rd Avenue South and continues to approximately the intersection of 27th Street and 3rd Avenue North. Current design standards require a maximum vertical grade of six percent, a minimum of 17 feet vertical clearance for a roadway overpass, and 23.5 feet clearance for the railroad overpass.

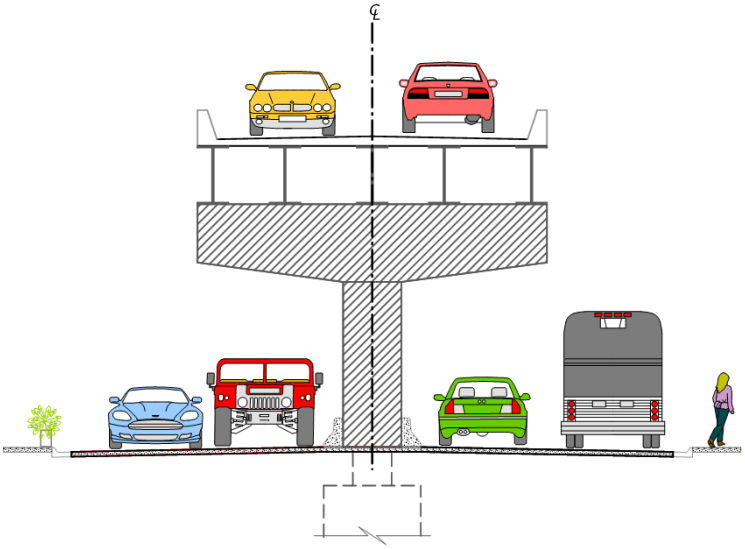
Two travel lanes, one in each direction, would remain at-grade to provide access to the businesses and maintain route connectivity along the 27th Street corridor. These two lanes would be stopped by a crossing train. Pedestrians would remain at-grade for the same reason, to maintain access to the businesses along 27th Street and would be stopped by a crossing train. Two travel lanes, one in each direction, would bridge over the railroad in a free-flowing condition. Traveling north on 27th Street, the driver would make the decision to take the overpass or remain at-grade just north of the 2nd Avenue South intersection. Once on the overpass the driver would by-pass, 1st Avenue South, Minnesota Avenue, Montana Avenue, 1st Avenue North and 2nd Avenue North. Traveling south on 27th Street, the driver would make the decision to take the overpass or remain at-grade just past 3rd Avenue N. The 2nd Avenue South intersection would be raised to meet the overpass and would require retaining walls on the front or back side of sidewalk to minimize impacts to surrounding properties through the transition.

Underneath the overpass left turn lanes, one in each direction, would be developed to allow turning movements onto 1st Avenue South, Minnesota Avenue, Montana Avenue, 1st Avenue North and businesses in between, where appropriate.

Although it does not eliminate the at-grade crossing, this alternative meets the project goals of providing a safe, free-flowing route at the railroad crossing while maintaining accessibility throughout the downtown area.

Figure 7-4 below shows the 2-Lane overpass typical section of 27th Street.

Figure 7-4. Overpass Typical Section



2-Lane Underpass

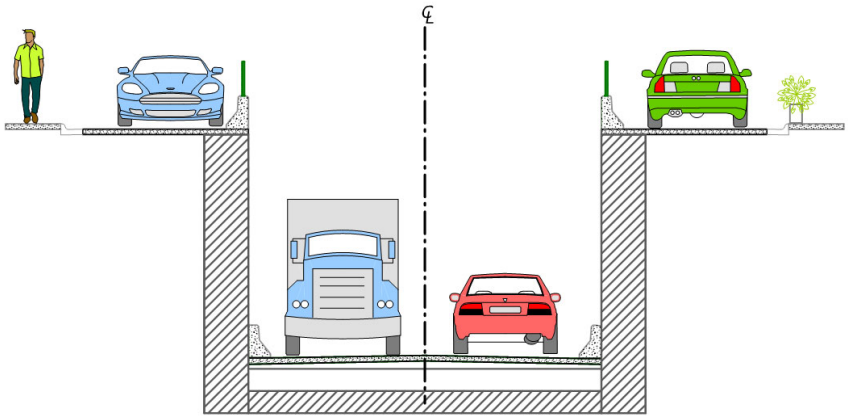
The 2-Lane underpass alternative would maintain a minimum of 17 feet vertical clearance throughout the underpass, and a vertical clearance of 17.5 feet under the railroad as required by the railroad. This alternative would begin near the intersection of 1st Avenue South and end between 2nd Avenue North and 3rd Avenue North along 27th Street. Maximum vertical grades of six percent were used in development of the vertical profile.

Similar to the overpass alternative, the underpass would have two travel lanes, one in each direction remaining at-grade to provide access to the businesses and maintain route connectivity along the 27th Street corridor. Pedestrians would also remain at-grade. Two travel lanes, one in each direction, would bridge underneath the railroad crossing in a free-flowing condition. The decision would be made to take the underpass or remain at-grade at the 1st Avenue South intersection and just south of the 3rd Avenue North intersection. All side streets and intersections would remain at-grade. Minnesota Avenue and 2nd Avenue North are currently proposed to be converted to right-in, right-out access only. Due to the low volumes of traffic on those roadways, a bridge is not warranted to maintain traffic over the underpass. The railroad would bridge over the underpass. The one way couplet, Montana Avenue and 1st Avenue North, would bridge over the underpass. No turn lanes would be provided for turning movements from 1st Avenue South to 3rd Avenue North.

Although it does not eliminate the at-grade crossing, this alternative meets the project goals of providing a safe, free-flowing route at the railroad crossing while maintaining accessibility throughout the downtown area.

Figure 7-5 below shows the 2-Lane underpass typical section of 27th Street.

Figure 7-5. Underpass Typical Section



2-Lane Tunnel

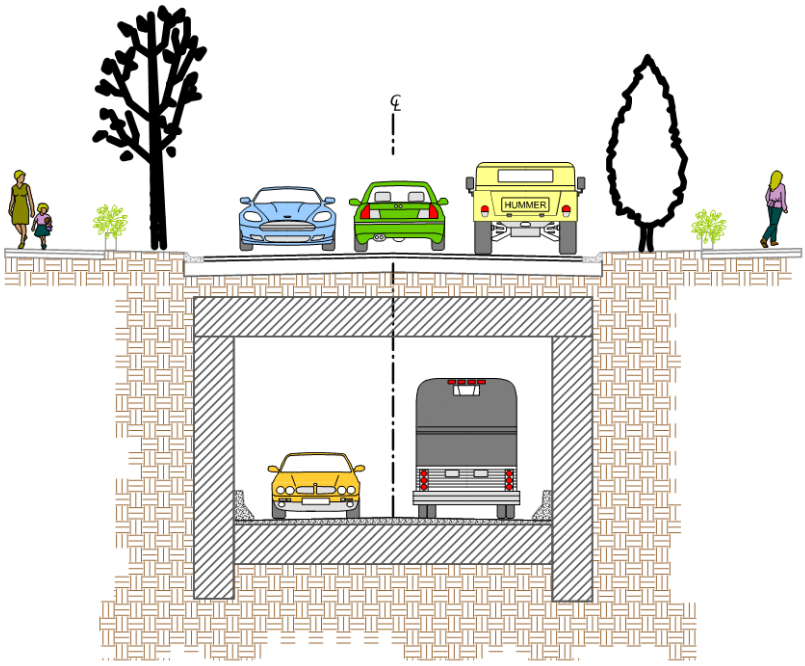
The tunnel alternative would be designed to the same standards as the underpass alternative, using maximum vertical grades of six percent and minimum vertical clearances of 17.5 feet and 17 feet for the railroad and roadways, respectively. The tunnel would begin around the train tracks and terminate just north of 1st Avenue North. The top of the tunnel would be traversable. On top of the tunnel, there would be two travel lanes, one in each direction and a two way left turn lane (TWLTL). Pedestrian facilities including bike lanes could be located on top of the tunnel.

The 2-Lane tunnel alternative submerges two lanes which bypass access to Minnesota Avenue, Montana Avenue, 1st Avenue North, and 2nd Avenue North, as well as any business access in between. The two at-grade lanes maintain access to businesses and amenities throughout the corridor.

Although it does not eliminate the at-grade crossing, this alternative meets the project goals of providing a safe, free-flowing route at the railroad crossing while maintaining accessibility throughout the downtown area.

Figure 7-6 below shows the 2-Lane tunnel typical section of 27th Street.

Figure 7-6. Tunnel Typical Section



7.2.2 Traffic Mobility and Route Connectivity

All build alternatives provide enhanced traffic mobility along 27th Street by introducing a free-flowing grade separation. However, all build alternatives close 2nd Avenue North through traffic across 27th Street, converting 2nd Avenue North to a right-in/right-out only access which modifies the existing route connectivity. Most traveling public may not be effected by the route loss; however, MET Transit would be required to change some of

their bus routes connecting to the Downtown Transfer center by way of 2nd Avenue North across 27th Street. Figure 7-9 and Figure 7-10 shows the current MET Transit routes.

Tier 1 included a high level look into rail operations, transit impacts, multi-modal connectivity and multi-modal facilities, intersection level of service (LOS) and volume-to-capacity ratio (V/C), and vehicle connectivity. While Tier 2 dove deeper by including queuing and safety analyses.

Figure 7-7 and Figure 7-8 shows the results from the Tier 1 and Tier 2 evaluation, respectively.

Figure 7-7. Tier 1 Traffic Evaluation Results

Good Neutral Poor

Alternative	Scenario	Rail Operations	Transit	Active Transportation		LOS & V/C	Vehicle Connectivity
				Connectivity	Facilities		
Short-Term	No-Build	Neutral	Neutral	Good	Neutral	Good	Neutral
	Close Broadway Railroad Crossing	Neutral	Neutral	Poor	Neutral	Neutral	Poor
	Close 29th Street Railroad Crossing	Good	Good	Poor	Neutral	Neutral	Poor
	Close Broadway and 29th Street Railroad Crossings	Good	Good	Poor	Neutral	Neutral	Poor
	ITS Solution	Neutral	Neutral	Good	Neutral	Good	Good
	Signal Modifications	Neutral	Neutral	Good	Neutral	Good	Neutral
Long-Term	No-Build	Neutral	Neutral	Good	Neutral	Good	Neutral
	2-Lane Over	Neutral	Good	Good	Neutral	Good	Good
	2-Lane Under	Neutral	Good	Neutral	Neutral	Neutral	Neutral
	2-Lane Tunnel	Neutral	Good	Neutral	Good	Neutral	Neutral
	4-Lane Over	Good	Poor	Poor	Neutral	Good	Poor
	4-Lane Under	Good	Poor	Poor	Neutral	Neutral	Poor
	Relocate Railroad	Poor	Good	Good	Neutral	Good	Good
	Grade Separate Minnesota to Montana	Good	Good	Good	Neutral	Good	Good

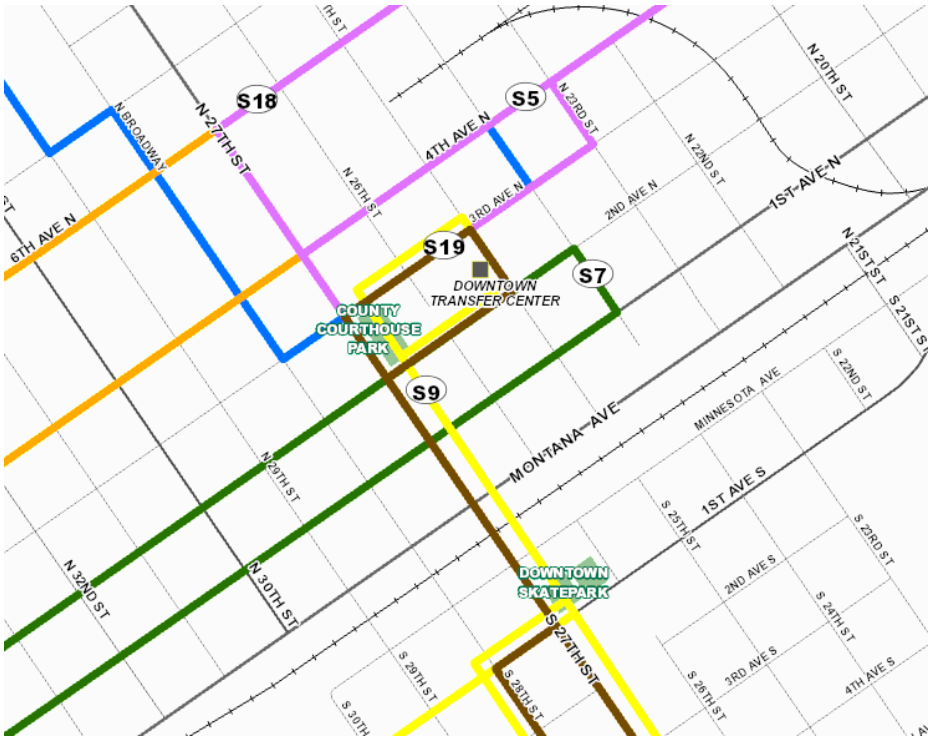
Figure 7-8. Tier 2 Traffic Evaluation Results

Good Neutral Poor

Alternative	Scenario	Queueing Analysis	Safety Analysis	Transit	Active Transportation		LOS & V/C	Vehicle Connectivity
					Connectivity	Facilities		
Short-Term	No-Build	Poor	Poor	Neutral	Good	Neutral	Good	Neutral
	Close Broadway and 29th Street Railroad Crossings	Poor	Neutral	Good	Poor	Neutral	Neutral	Poor
	ITS Solution	Neutral	Poor	Neutral	Good	Neutral	Good	Good
	Signal Modifications	Poor	Poor	Neutral	Good	Neutral	Good	Neutral
Long-Term	No-Build	Poor	Poor	Neutral	Good	Neutral	Good	Neutral
	2-Lane Overpass	Good	Neutral	Good	Good	Neutral	Good	Good
	2-Lane Underpass	Good	Good	Good	Neutral	Neutral	Neutral	Neutral
	2-Lane Tunnel	Good	Good	Good	Neutral	Good	Neutral	Neutral

Figure 7-9. MET Transit Weekday Routes

Figure 7-10. MET Transit Weekend Route



No-Build

With an expected growth of 1 percent, the at-grade crossing will only experience more delays without a grade separation. With the projected 2040 PM Peak traffic volumes, the no-build alternative queue lengths at the at-grade railroad crossing is approximately 850 feet and 1025 feet, for the northbound and southbound traffic, respectively. Compared to the build alternatives, the no-build experiences the longest queue lengths. None of the key intersections have a V/C ratio greater than 0.90 and/or LOS E or worse. Moderate restrictions and/or no improvement to rail crossing event connectivity is expected.

From a safety standpoint, the no-build alternative has a total of 118 conflict points across the 8 intersections examined during the Tier 2 analysis. The no-build has the most conflict points when compared to the build alternatives.

The no-build has no benefit to traffic mobility and no impact to existing routes.

2-Lane Overpass

This alternative maintains free-flowing traffic for one lane in each direction. While the crossing is occupied, heavy volumes would likely accumulate on the overpass as more drivers avoid waiting for the train to clear. Where the overpass provides minimum vertical clearance, all access will be sustained for the at-grade lanes. Where the overpass is transitioning to meet existing grade and minimum vertical clearance cannot be maintained, right-in, right-out access would be provided.

With the projected 2040 PM Peak traffic volumes, the 2-Lane Overpass alternative queue lengths at the at-grade railroad crossing is approximately 300 feet and 375 feet, for the northbound and southbound traffic, respectively. Compared to the underpass and tunnel alternative, the overpass experiences a slightly longer queue length in the southbound direction. None of the key intersections have a V/C ratio greater than 0.90 and/or LOS E or worse. Minimal restrictions and/or improved rail crossing event connectivity is expected.

The 2-Lane Overpass alternative has a total of 94 conflict points across the 8 intersections examined during the Tier 2 analysis. The overpass has more conflict points than the underpass or tunnel.

The overpass has some benefit to traffic mobility and one route impact.

2-Lane Underpass

The 2-Lane underpass alternative accommodates free-flowing traffic while a train occupies the railroad crossing. Two lanes would remain at-grade and traffic would be impacted until the corridor is cleared, while the other two lanes pass underneath the railroad. Through traffic would be eliminated on Minnesota Avenue and 2nd Avenue North, but would accommodate right-in, right-out accessibility.

With the projected 2040 PM Peak traffic volumes, the 2-Lane Underpass alternative queue lengths at the at-grade railroad crossing is approximately 300 feet and 300 feet, for both the northbound and southbound traffic. Compared to the overpass alternative, the underpass experiences a slightly shorter queue length in the southbound direction and experiences the same queue lengths as the tunnel alternative. One to five of the key intersections have a V/C ratio greater than 0.90 and/or LOS E or worse. Which means

most of the intersections in the vicinity of the tracks would fail in 2040. Moderate restrictions and/or no improvement to rail crossing event connectivity is expected.

The 2-Lane Underpass alternative has a total of 65 conflict points across the 8 intersections examined during the Tier 2 analysis. The underpass has less conflict points than the overpass and the same as the tunnel.

The underpass has some benefit to traffic mobility and two route impacts.

2-Lane Tunnel

The 2-Lane tunnel alternative provides the opportunity for free-flowing traffic while a train occupies the railroad crossing. Two lanes with a center turn lane would remain at-grade and traffic would be impacted until the corridor is cleared, while the other two lanes pass underneath the railroad. Montana Avenue and 1st Avenue North would function as they do currently. Right-in, right-out access would be implemented on 2nd Avenue North and Minnesota Avenue.

With the projected 2040 PM Peak traffic volumes, the 2-Lane Tunnel alternative queue lengths at the at-grade railroad crossing is approximately 300 feet and 300 feet, for both the northbound and southbound traffic. Compared to the overpass alternative, the tunnel experiences a slightly shorter queue length in the southbound direction and experiences the same queue lengths as the underpass alternative. One to five of the key intersections have a V/C ratio greater than 0.90 and/or LOS E or worse. Which means most of the intersections in the vicinity of the tracks would fail in 2040. Moderate restrictions and/or no improvement to rail crossing event connectivity is expected.

The 2-Lane Tunnel alternative has a total of 65 conflict points across the 8 intersections examined during the Tier 2 analysis. The tunnel has the same amount of conflict points as the underpass and less than the overpass.

The tunnel has some benefit to traffic mobility and two route impacts.

7.2.3 Opinion of Probable Construction Costs

The following opinion of probable construction costs were based on estimated construction costs in 2019.

No-Build

The no-build alternative has no cost associated.

2-Lane Overpass

Based on the preliminary level of design, the approximate probable opinion of cost is $37,800,000. The overpass alternative is the least costly.

2-Lane Underpass

Based on the preliminary level of design, the approximate probable opinion of cost is $75,600,000. The underpass alternative is costly.

2-Lane Tunnel

Based on the preliminary level of design, the approximate probable opinion of cost is $84,700,000. The tunnel alternative is the most costly.

7.2.4 Constructability

A grade separation through the heart of downtown Billings would cause disruption to normal traffic and pedestrian operations during construction. It is likely the construction of a grade separation would take two construction seasons, possibly more. Construction could be sequenced to allow traffic/pedestrians to access the 27th Street Corridor outside the construction season. It is recommended for all alternatives to close the 27th Street corridor to traffic during active construction for safety of both the construction crew and traveling public. If deemed necessary, one lane for emergency vehicles could be left open during construction. A temporary first responder's center could be staged on the south side of the tracks to help eliminate medical emergency delays during construction. MET Transit would need to evaluate their routes during construction. A pedestrian route would need to remain open on one side or the other throughout construction. The necessary measures to protect pedestrians from construction debris and activities would need to be implemented.

The existing routes surrounding the 27th Street corridor within the study limits would need to be improved in anticipation of additional traffic during construction of a grade separation. Pavement conditions, signing, and signal phasing would need to be evaluated to handle the traffic being displaced by closing 27th Street.

Investigation into the existing structure foundations should occur to identify any protective measures necessary to support existing structures during construction of any build alternative.

No-Build

There is no construction risk associated with the no-build alternative.

2-Lane Overpass

The overpass has the least risk during construction. Dewatering would be necessary for the placement of pier foundations. Utilities within the pier locations would need to be relocated. The railroad could operate as usual during the majority if the construction activities. Railroad operations would need to be considered when placing the girders over the tracks. A minimum temporary vertical clearance of 21'-6" must be maintained throughout construction.

2-Lane Underpass

The underpass and tunnel alternative have the greatest risk during construction. Constant dewatering during construction would be necessary. Extensive utility relocations would be essential. A shoofly would be crucial for the railroad to conduct normal operations during construction. Any temporary shoring systems impacting railroad operations and/or support the railroad embankment must be designed per the railroad guidelines for temporary shoring. Further investigation of the impacts to the existing building's foundations is necessary to understand the full implications of the construction of an underpass.

2-Lane Tunnel

The constructability of the tunnel would be the same as the underpass.

7.2.5 Long-Term Risk

As with any large infrastructure there will be additional maintenance associated with the build alternatives as well as potential safety risk. Standard maintenance of the roadway is required regardless of the alternative advanced. Typical maintenance items included, pavement markings, barrier upkeep/replacement, pavement work, etc. This section identifies the additional maintenance considerations for each alternative and potential long-term safety risk.

No-Build

No additional maintenance or introduction of potential safety risk is associated with the no-build alternative.

2-Lane Overpass

An overpass would not require a pump station and does not have the potential for flooding. Therefore, only some additional maintenance is required. Roadway drainage would be captured on the bridge and piped to the existing storm drain. With minimal change to the impervious surface, it is likely the capacity of the existing storm system is sufficient; however, further analysis should be conducted as design progresses. During construction dewatering may be necessary for the placement of the pier foundations.

Snow removal on the overpass could present a challenge since care would need to be given to the traveling public and pedestrians below the bridge. The overpass can accommodate some snow storage on the shoulders, but the majority of the snow would need to be plowed off the structure and placed elsewhere. Since there is a stop condition (signal control) on either end of the structure, deicing would need to take place on the structure to allow vehicles to slow down and/or stop at the bottom of the overpass. During inclement weather events, the overpass could be closed forcing all traffic to remain at-grade. Deicing measures would likely be necessary to help with traction on the six percent grade. Additional safety risk is associated with the overpass with the introduction of six percent grades, increasing the likelihood of sliding on ice.

2-Lane Underpass

Extensive additional maintenance is required with the underpass alternative. According to the geotechnical investigations conducted for this study, the water table fluctuates by season with an average depth between five and 20 feet below the surface. The excavation necessary to construct the underpass or tunnel alternatives would be approximately 27 feet below the ground surface. During construction, a pump would be necessary to dewater the site at all times. The final design would require a pump station for removal of storm water. Storm water would be pumped into the existing storm drain facilities. Consideration will need to be given to the capacity and service life of the existing storm drain infrastructure and outfall to ensure the underpass or tunnel can be drained efficiently. With 2 lanes remaining at-grade and functioning as they are today, the depressed lanes could be closed if necessary for pump maintenance or as a result of

flooding. A potential for moderate safety risk is present for the underpass alternative, due to the possible flooding that could occur in the depressed lanes. The underpass alternative remaining open reduces the risk slightly since someone trapped in flood waters could be rescued from above.

The underpass would accumulate snow, which would need to be removed. With the limited footprint available within the underpass, it does not allow for snow storage and snow would need to be removed and stored elsewhere. The at-grade lanes would be maintained in the same manner as they are today. Deicing measures would likely be necessary to help with traction on the six percent grade.

2-Lane Tunnel

The tunnel would accumulate snow similar to underpass at the entrance and exit. The fully enclosed portion of the tunnel would not accumulate snow. Deicing measures would be necessary for vehicles to gain traction on the six percent grade.

The additional maintenance is similar to the underpass alternative; however, the potential safety risk is slightly higher for the tunnel. A person trapped in flood waters inside the tunnel would be much harder to rescue.

7.2.6 Property Impacts and Business Access

No-Build

No property impacts or business access impacts are present with the no-build alternative.

2-Lane Overpass

Minor adjustments may be required, such as converting certain intersections to right-in, right-out only. The pedestrian overpass connecting the parking deck and condominiums just north of the 27th Street and 1st Avenue North intersection would be removed as part of this alternative. The transition of the overpass down to existing grade occurs through the 2nd Avenue South and 2nd Avenue North intersections. Consideration was given to keeping full access at 2nd Avenue North by raising the intersection to meet the overpass. Raising the intersection causes extensive property impacts the businesses along 2nd Avenue North, primarily on the west side of 27th Street. To minimize impacts to the surrounding properties, converting 2nd Avenue North to a right-in/right out access only keeps the sidewalks, outside lanes, and 2nd Avenue North at the same elevation it is today.

Since the overpass alternative completely removes the overhead skywalk, it was considered to have extensive property impacts.

2-Lane Underpass

Minor adjustments may be required, such as converting certain intersections to right-in, right-out only. The underpass will require a significantly sized pump station, which will require maintenance and accessibility and therefore careful consideration of its location is required. It will likely require right-of-way be purchased outside the project limits.

Since the underpass alternative converts some crossroads to right-in/right-out only, it was considered to have some business access impacts.

2-Lane Tunnel

Minor adjustments may be required, such as converting certain intersections to right-in, right-out only. Like the underpass, the tunnel will require a significantly sized pump station, which will require maintenance and accessibility and therefore careful consideration of its location is required. It will likely require right-of-way be purchased outside the project limits.

Since the tunnel alternative converts some crossroads to right-in/right-out only, it was considered to have some business access impacts.

7.2.7 Railroad Operations Impacts

Coordination with local representatives of the railroad should be conducted in the future to better understand the railroad operation requirements, to further identify constructability concerns and to develop design accommodations.

No-Build

The railroad operations will continue as they currently do with the no-build alternative. The no-build provides no impacts and no benefit to the railroad.

2-Lane Overpass

With the 2-Lane overpass alternative, the railroad operations would be maintained with two lanes crossing at-grade as opposed to the current 4-Lane crossing. This would reduce train/vehicular conflict at the crossing. Railroad operations would remain uninterrupted with exception of short periods of time during the construction of the bridge over the tracks.

An overpass has the least impact to Railroad operations during construction. The structure should be designed and constructed in a manner limiting interruption to railroad operations.

According to the Union Pacific Railroad – BNSF Railway Guidelines for Railroad Grade Separation Projects, any permanent obstructions need to be placed outside railroad right-of-way. The proposed overpass alternative from Tier 2 places the piers of the bridge on railroad right-of-way. The pier location was chosen to maintain a reasonable girder depth. As the span lengthens the girder depth increases, requiring the vertical grade to raise in order to maintain minimum vertical clearance requirements. Coordination with the railroad is required moving forward to determine if the pier placement is acceptable. The piers are placed to be in-line with the buildings on the north side of the tracks and as far as possible from the tracks on the south.

Submittal and review of design calculations is not required by the railroad for new overhead structures.

The overpass has minimal impacts and some benefit to the railroad, since only coordination will be required during construction and two lanes of traffic are removed from the at-grade crossing.

2-Lane Underpass

With the 2-Lane underpass alternative, the railroad operations would be maintained with two lanes crossing at-grade as opposed to the current Four-Lane crossing. This would reduce train/vehicular conflict at the crossing. To construct the undercrossing, both railroad tracks would need to be temporarily detoured onto a shoofly to maintain railroad operations during construction.

According to the Guidelines for Railroad Grade Separation Projects, underpass structures have the most interference with railroad operations during construction and should be avoided. Underpasses are discouraged by the railroad due to safety concerns, possible interruption to railroad operations, cost, and limitation of future replacement and maintenance.

All design calculations for the railroad structure, and supporting documents, must be provided to the railroad for review.

The current proposed underpass alternative does not include a railroad access road on the bridge structure. Coordination with the local railroad representative will be necessary moving forward to identify appropriate access road needs.

Since a shoofly will be required during and the railroad requiring review of the structural analysis of the railroad structure there are some impacts to the railroad. There is some benefit to the railroad since two lanes of traffic are removed from the at-grade crossing.

2-Lane Tunnel

With the 2-Lane tunnel alternative, the railroad operations would be maintained with two lanes crossing at-grade as opposed to the current Four-Lane crossing. This would reduce train/vehicular conflict at the crossing. To construct the tunnel structure, both railroad tracks would need to be temporarily detoured onto a shoofly to maintain railroad operations during construction.

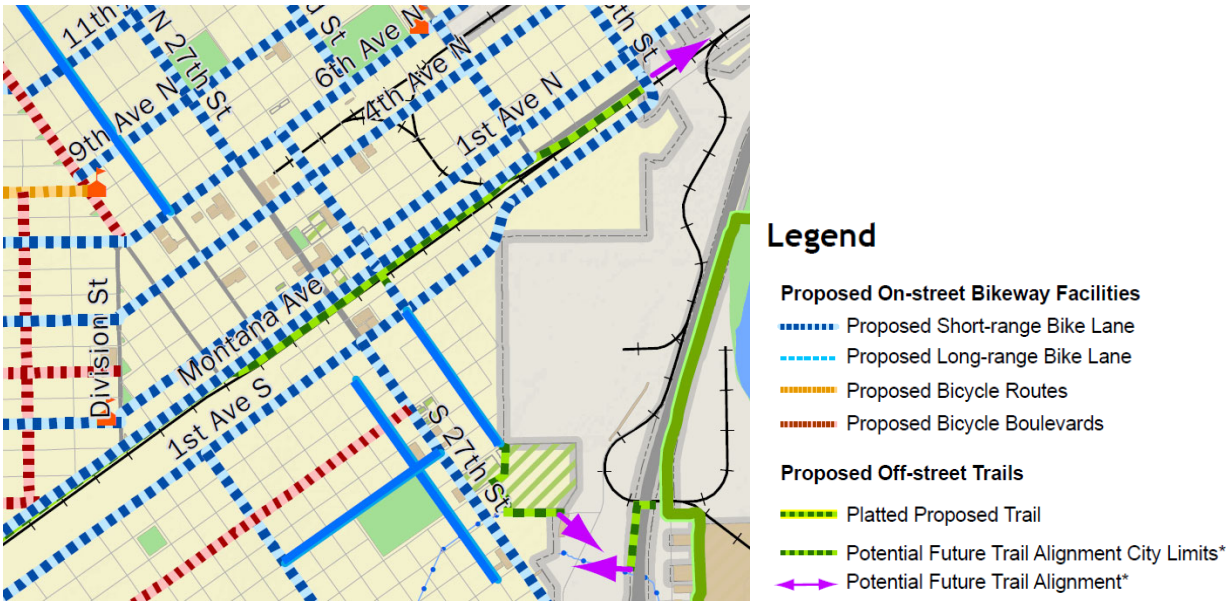
All design calculations, and supporting documents, must be provided for the tunnel structure to the railroad for review.

Since a shoofly will be required during and the railroad requiring review of the structural analysis of the railroad structure there are some impacts to the railroad. There is some benefit to the railroad since two lanes of traffic are removed from the at-grade crossing.

7.2.8 Multi-Modal Connectivity

All the build alternatives eliminate the multi-modal opportunities at 2nd Avenue North in the E-W direction. The Billings Area Bikeways and Trail Master Plan show a proposed short-range bike lane on 2nd Avenue North crossing 27th Street. As the alternatives currently stand, no pedestrian accessibility is proposed to cross 27th Street at 2nd Avenue North. Further consideration is required at this location to determine if a pedestrian overpass is warranted at this crossing.

Figure 7-11. Billings Area Bikeways and Trail Master Plan



No-Build

27th Street had at-grade sidewalks along both sides of the roadway. There are no bike lanes along the corridor. The no-build alternative does not accommodate multi-modal improvements. There are no impacts and no opportunity for multi-modal improvements.

2-Lane Overpass

The 2-Lane overpass alternative would affect pedestrian connectivity. Most corners would allow for N-S and E-W pedestrian crossings. The E-W crossing would likely be eliminated from the 2nd Avenue North intersection. Pedestrian through-traffic and access to businesses would be maintained while meeting ADA compliance. In order to maintain 11-foot lanes and acceptable shy distances to structural elements, a bike lane would not fit within the corridor.

Impacts to the Billings Area Bikeways and Trail Master Plan occur with this alternative. The impacts to the multi-modal facilities are considered minor since the master plan bike lane could route underneath the bridge. Some opportunity for improvement of the existing multi-modal facilities exists, since the footprint beneath the bridge could accommodate pedestrians.

2-Lane Underpass

The 2-Lane underpass alternative would affect pedestrian connectivity. All N-S pedestrian crossings would be maintained, while E-W crossings would likely be limited to 1st Avenue South, Montana Avenue, 1st Avenue North and 3rd Avenue. N. Pedestrian through-traffic and access to businesses would be maintained while meeting ADA compliance. In order to maintain 11-foot lanes and acceptable shy distances to structural elements, a bike lane would not fit within the corridor.

Impacts to the Billings Area Bikeways and Trail Master Plan occur with this alternative. The impacts to the existing multi-modal facilities is considered major with the underpass alternative since the existing sidewalks will be narrowed to accommodate the underpass. There is no opportunity to enhance the multi-modal facilities with this alternative.

2-Lane Tunnel

All sidewalks would remain at-grade, providing pedestrian access to all businesses along the corridor. There would be opportunity for multi-modal facilities to be located on top of the tunnel between Montana Avenue and 1st Avenue North. The 2-Lane tunnel alternative provides the most flexibility for multi-modal connectivity.

Impacts to the Billings Area Bikeways and Trail Master Plan occur with this alternative. The impacts to the existing multi-modal facilities is considered major with the tunnel alternative since the existing sidewalks will be narrowed to accommodate the underpass. However, some opportunity to enhance multi-modal facilities exists on top of the tunnel.

7.2.9 Aesthetic Opportunities

No-Build

There is no introduction of a visual obstruction, and there is no aesthetic enhancement opportunity.

2-Lane Overpass

Aesthetic alternatives for an urban overpass could include concrete form liners on the pier columns and back face of the concrete bridge rail. Form liners allow for design or patterns to be added to the concrete face during pouring. A concrete coating or integrating pigment could add color to the concrete portions of the structure. Using haunches in the steel girder profile would further enhance aesthetics of the overpass structure.

Fencing is required on the overpass along the railroad right-of-way. Opportunities for ornate fencing may exist, however prior approval from the railroad is required. All fencing must meet the fencing guidelines of the railroad.

Underneath the overpass, opportunities for raised planters, landscaping, and art exist; however, there is an introduction of a visual obstruction with the structure itself.

2-Lane Underpass

Concrete form liners could be used on the vertical retaining walls for the underpass and tunnel alternatives. A variety of form liners could be used including stacked-stone or a more abstract design. The addition of pigment into the concrete used for the walls could add color to the retaining walls. The aesthetics opportunities are considered limited with the underpass alternative, but there is no introduction of a visual obstruction.

2-Lane Tunnel

The tunnel alternative has the same aesthetic opportunities as the underpass for the vertical retaining walls. On top of the tunnel where wider pedestrian facilities are

proposed, landscaped boulevards, raised planters, benches, and art are a few examples of the potential aesthetic opportunities available. The aesthetics opportunities are considered extensive with the tunnel alternative, and there is no introduction of a visual obstruction.

7.2.10 Noise Analysis

A conceptual noise analysis was conducted along the 27th Street corridor for Tier 2. The conceptual noise analysis provided an initial estimate of existing and future traffic noise levels at noise-sensitive receptors. The receptors along 27th Street include a health clinic, offices, parks, apartments, loft residences, meeting rooms, hotel guest rooms, commercial spaces and restaurants. See Figure 7-12. Noise Receptor Locations below for noise receptor locations. Many of the receptor buildings are multi-level and the conceptual noise analysis considered multiple floors, but not all. The intent of the conceptual noise analysis was to estimate the noise levels at representative receptor locations (horizontal and vertical) along 27th Street, and compare the traffic noise levels of the long-term alternatives. The traffic noise levels of the No Build, 2-Lane Overpass, 2-Lane Underpass, and 2-Lane Tunnel alternatives were compared to determine if a design alternative would significantly increase or decrease the traffic noise levels at the noise-sensitive receptors adjacent to 27th Street at representative 1st to 20th Floor building locations.

Figure 7-12. Noise Receptor Locations

No-Build

An increase in traffic from 2018 to 2040 results in an increase in noise due to traffic along 27th Street. The anticipated noise levels would be considered “moderate” to “loud” and are typical for urban environments. People outside in this area may feel the need to raise their voices to be heard above the background noise. The decibels increase by 1 dBA.

2-Lane Overpass

With 2 lanes of traffic elevated, concrete jersey rail along the edges of the overpass, embankments at the north and south ends of the overpass, and a bridge between 1st Avenue South to 1st Avenue North, the anticipated noise levels decrease compared to the no-build alternative. Approximately half of the traffic would be elevated, while the

other traffic would remain at-grade. The concrete jersey rail shields some noise from the elevated lanes and the bridge partially shields some noise from the traffic below. The reduction in noise would typically be perceived as no difference to between a clearly noticeable and half as loud reduction. The decibels decrease by 5 dBA.

2-Lane Underpass

With 2 lanes of traffic depressed, the walls of the underpass partially shield the lower floors of buildings from the underpass noise. The reduction in the traffic at-grade and the shielding effect of the underpass lower the noise levels at most of the receptors compared to the No Build alternative. The reduction in noise would typically be perceived as no difference to between a clearly noticeable and half as loud reduction. The decibels decrease by 6 dBA.

2-Lane Tunnel

Similarly to the 2-Lane underpass, the 2-Lane tunnel alternative, depresses 2 lanes of traffic. The tunnel is fully enclosed for 1.5 blocks, further shielding the receptors from the traffic noise. With the reduction in traffic at-grade and the partial shielding in the transition areas and full shielding in the tunnel portion, this alternative provides the greatest reduction in noise as compared to the 2-Lane Underpass, 2-Lane Overpass and No-Build alternatives. The reduction in noise would typically be perceived as no difference to a clearly noticeable reduction. The decibels decrease by 7 dBA.

7.2.11 Long-Term Evaluation Criteria

Long-Term Evaluation Criteria		
Criteria	**Description/Purpose**	**Points**
Traffic Mobility and Route Connectivity	The identified concerns at the current at-grade crossing are the many delays due to the frequent train crossings and slow-to-move traffic once the train has cleared. The goal is to keep traffic flowing without hindering the accessibility of the downtown core. Traffic mobility and route connectivity play a significant role in the decision-making process.	25
Probable Opinion of Construction Cost	The cost to complete the project and the opportunity for the MPO to fund the project plays a significant role in the decision-making process so a practicable solution is implemented in a timely manner and benefits the community long term.	25

Constructability	A long-term grade separated alternative would require extensive foresight to alleviate potential setbacks during construction since the roadway would likely be closed to traffic during construction for at least 2 seasons. With the appropriate planning, phasing, and equipment all alternatives are constructible. However, the risk associated with construction differs considerable between the alternatives and plays a significant role in the decision-making process. High risk could jeopardize the safety of the public and contractors not to mention the potential inflation in cost.	20
Long-Term Risk	For the lifetime of the infrastructure additional maintenance is required for any of the build alternatives. The risk associated with the additional maintenance plays a significant role in the decision-making process in regards to public safety and potential inflation of cost.	20
Property Impacts and Business Access	27th Street is a major arterial, providing access to businesses, the airport, the interstate, and hospitals. Maintaining access to the arterial is vital. Minimizing impacts to the surrounding properties is one of the project goals. Therefore, impacts to existing properties and businesses play a significant role in the decision-making process.	15
Railroad Operations Impacts	The railroad is identified as the major stakeholder in the project. Careful consideration should be given to reduce impacts to the railroad property and operations. Impacts to railroad operations play a significant role in the decision-making process.	15
Multi-Modal Connectivity	Although multi-modal facilities are important, the urban constraints of the project do not allow for substantial multi-modal accommodations. However, care should be given to provide the best benefit for all modes of transportation and therefore plays a moderate role in the decision-making process.	10
Aesthetic Opportunities	The ability to beautify the downtown core is a benefit to the community, however it does not play a significant role in the decision-making process since steps can be taken for any build alternatives to beautify the downtown core.	5
Noise Analysis	Noise levels are a concern to the community in the downtown core. The increase or reduction in noise between each of the alternatives is not substantial and since the project is located in the heart of an urban environment, where noise is more likely, noise does not play a significant role in the decision-making process.	5
Total		140

7.2.12 Long-Term Scoring

Traffic Mobility and Route Connectivity	Score
No Benefit to Traffic/No Impact to Routes	10
Some Benefit to Traffic/One Route Impact	50
Some Benefit to Traffic/Two Route Impacts	30

Probable Opinion of Construction Cost	Score
No Cost	40
Least costly	30
Costly	15
Most costly	5

Constructability	Score
No Risk	50
Some Risk	30
Extensive Risk	10

Long-Term Risk	Score
No Safety Risk/No Additional Maintenance	50
Some Risk/Some Additional Maintenance	25
Moderate Risk/Extensive Additional Maintenance	10
Extensive Risk/Extensive Maintenance	5

Property Impacts and Business Access	Score
No Impacts	60
Extensive Impacts	0
Some Impacts	30

Railroad Operations Impacts	Score
No Impacts/No Benefit	10
Minimal Impacts/Some Benefit	50
Some Impacts/Some Benefit	30

Multi-Modal Connectivity	Score
No Impacts/No Opportunity	50
Minor Impacts/Some Opportunity	25
Major Impacts/No Opportunity	0
Major Impacts/Some Opportunity	15

Aesthetic Opportunities	Score
No Visual Obstruction/No Opportunity	25
Visual Obstruction/Some Opportunity	5
No Visual Obstruction/Limited Opportunity	10
No Visual Obstruction/Extensive Opportunity	50

Noise Analysis	Score
+1 dBA	0
-5 dBA	25
-6 dBA	30
-7 dBA	35

7.3 Short-Term Alternatives

Table 7-2 below summarizes the findings of the Tier 2 analysis for the Short-Term alternatives.

Table 7-2. Short-Term Alternative Analysis

Short-Term Alternatives									
Evaluation Criteria	Points	No-Build		28th and 29th Street Closures		Signal Modifications		ITS (Intelligent Transportation System)	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Meets Stakeholder Interest and Achieves Project Goals	35	0	0	90	3150	90	3150	90	3150
Probable Opinion of Construction Cost	30	40	1200	15	450	30	900	5	150
Traffic Mobility and Route Connectivity	25	40	1000	0	0	50	1250	50	1250
Property Impacts and Business Access	20	80	1600	10	200	80	1600	80	1600
Railroad Operations Impacts	20	10	200	80	1600	10	200	10	200
Multi-Modal Connectivity	10	30	300	0	0	60	600	30	300
Total	140	200	4300	195	5400	320	7700	265	6650

7.3.1 Meets Stakeholder Interest and Achieves Project Goals

No-Build

The no-build alternative does not meet the stakeholder interest nor does it achieve the project goal of finding a practicable solution for the at-grade crossing.

28th and 29th Street Closures

A closure of both the 28th and 29th Street crossings would benefit the railroad and public by eliminating the risk of train/vehicular conflict at both crossings. Operational benefits

could be realized by the railroad during switching activities, with some mobility benefits possible for traffic and pedestrians at the 27th Street crossing. This alternative, however, would result in an overall loss of route connectivity for vehicular traffic. This alternative meets some of the stakeholder interests by eliminating two at-grade crossings, bettering the railroad operations to help remove some of the delay at the 27th Street crossing. The closures could be incorporated into any of the short-term or long-term alternatives.

Further coordination with the railroad is required to better determine potential operational improvements attainable with this alternative.

Signal Modifications

The addition of a protected southbound left-turn phase at the 27th Street/Montana Avenue intersection was identified as desirable during the project to allow the southbound left-turn movement to be served while the at-grade crossing is occupied. Considerations in support of a projected left-turn included reduced delay for drivers, comparatively low implementation cost and additional separation between vehicles and pedestrians in the crosswalk on the east side of the intersection. MDT implemented a southbound left-turn phase at the intersection in May 2020 while the 27th Street RR Crossing study was on-going.

ITS (Intelligent Transportation System)

The ITS improvement would use variable message signs (VMS) to provide drivers advance notice of the arrival of trains at the at-grade crossing and the duration of the closure. This technology allows drivers to make better choices about when to use alternate routes. This solution helps maximize vehicle mobility and has no long-term impacts to rail operations. This alternative achieves some of the project goals by giving drivers and pedestrians alike the information they need choose if they want to take an alternate route while the crossing is occupied. Some traffic may be removed from the 27th Street at-grade crossing.

7.3.2 Opinion of Probable Construction Costs

The following opinion of probable construction costs were based on estimated construction costs in 2019.

No-Build

The no-build alternative has no cost associated.

28th and 29th Street Closures

The opinion of probable construction cost is $170,000 - $340,000 based on demolition and rehab of the crossings. The closures are costly, falling between the other short-term alternatives.

Signal Modifications

The opinion of probable construction cost is $100,000 - $250,000 depending on the extent of signal modifications. The signal modifications are the least costly of the short-term alternatives.

ITS (Intelligent Transportation System)

The opinion of probable construction cost is $250,000 - $500,000 depending on the extent of the ITS system. The ITS is the most costly of the short-term alternatives.

7.3.3 Traffic Mobility and Route Connectivity

No-Build

The no-build alternative does not affect traffic mobility or route connectivity. If a practicable and fundable solution is not identified, the no-build would notice additional delays as traffic volumes increase in time. With the no-build alternative there is no benefit to traffic mobility and no loss in route connectivity.

28th and 29th Street Closures

Closure of 28th and 29th Street would increase traffic on surrounding streets. Traffic would seek alternate routes for N-S travel, resulting in a loss of route connectivity for vehicular traffic.

During railroad switching operations, some activities in the vicinity of the 28th and 29th Street crossings could be modified to reduce the frequency in which the warning devices at the 27th Street crossing are activated, thereby improving traffic mobility and potentially decreasing wait times. For through train movements, wait times would likely increase at the 27th Street crossings due to increased vehicular traffic.

Further coordination with the railroad is required to better determine potential operational improvements attainable with this alternative.

The closures alone provide no benefit to traffic mobility and results in a loss of route connectivity.

Signal Modifications

The signal modifications would allow southbound left-turning vehicle traffic at the 27th Street/Montana Avenue intersection to operate more efficiently while the at-grade crossing is occupied. The signal modifications provide some benefit to traffic mobility by removing some of the traffic from the crossing and result in no loss of route connectivity.

ITS (Intelligent Transportation System)

The ITS improvement does not modify the existing route connectivity. The at-grade crossings will be closed to traffic with or without this improvement. However, an ITS solution would provide drivers information allowing them to make better choices about when to use alternate routes. With the ITS there is some benefit to traffic mobility by removing some traffic from the crossing and results in no loss of route connectivity.

7.3.4 Property Impacts and Business Access

No-Build

The no-build would not impact properties or business accesses.

28th and 29th Street Closures

No properties would be impacted by the closure of 28th and 29th Street. Business access, however, could be negatively impacted due to the loss of route connectivity.

Signal Modifications

No property impacts are anticipated with the signal modifications. Business located on Montana Avenue, east of 27th Street would be easier to access during rail crossings.

ITS (Intelligent Transportation System)

No property impacts are anticipated with the ITS improvement. The VMS used as part of this improvement are anticipated to be installed on existing City or State-owned rights-of-way. No business accesses are impacted with this alternative.

7.3.5 Railroad Operations Impacts

No-Build

The no-build alternative would not impact railroad operations and does not provide a benefit to the railroad.

28th and 29th Street Closures

Closure of the 28th and 29th Street crossings could allow some improvement for switching train activities in the vicinity of the current crossing locations without activating the warning devices at the 27th Street crossing. Safety benefits would be provided by lessening the risk of vehicle/train conflicts at two crossings. Further coordination with the railroad is required to better determine potential operational improvements attainable with this alternative. There are no negative impacts to the railroad operations and there is extensive benefit to the railroad operations.

Signal Modifications

No impacts to the railroad operations are anticipated. However, the signal improvement would allow southbound left-turning vehicle traffic at the 27th Street/Montana Avenue intersection to operate more efficiently during rail crossings. No benefit to the railroad operations exist with this alternative.

ITS (Intelligent Transportation System)

No long-term impacts to the railroad operations are anticipated. The ITS solution may require additional data from the railroad and require upgrades to track circuitry. These improvements would be relatively minor, and the railroad is well situated to make these

types of improvements without major disturbance to their operations. The ITS improvement would not provide benefit to the railroad operations.

7.3.6 Multi-Modal Connectivity

No-Build

The no-build alternative does not affect multi-modal connectivity. Currently there are no bike lanes on 27th Street and there are two at-grade sidewalks, one on either side of the road.

28th and 29th Street Closures

Closure of 28th and 29th Street would eliminate pedestrian crossing at these locations resulting in a loss of route connectivity. During railroad switching operations, however, multi-modal mobility could increase at the 27th Street crossing due to fewer warning device activations.

Signal Modifications

Signal modifications could accommodate phasing for pedestrian crossings, bettering multi-modal connectivity for those not stopped by the crossing train.

ITS (Intelligent Transportation System)

The ITS improvements could be used by pedestrians and bicycles in the same manner as drivers. However, given the slower travel speeds of pedestrians and bicycles, out-of-direction travel may be less desirable. There is no loss in multi-modal connectivity.

7.3.7 Short-Term Evaluation Criteria

Short-Term Evaluation Criteria		
Criteria	**Description/Purpose**	**Points**
Meets Stakeholder Interest and Achieves Project Goals	The stakeholder interests provide a solution without impacting the identified stakeholders in a negative manner. The project goal is to find a practicable and fundable solution to the at-grade railroad crossing. This plays a significant role in the decision-making process for the short-term solutions.	35
Probable Opinion of Construction Cost	The cost to complete the project and the opportunity for the MPO to fund the project plays a significant role in the decision-making process so a practicable solution is implemented in a timely manner and benefits the community long term.	30

Traffic Mobility and Route Connectivity	The identified concerns at the current at-grade crossing are the many delays due to frequent train crossings and slow to move traffic once the train has cleared. The goal is to keep traffic flowing without hindering the accessibility of the downtown core. First-responders vocalized the need for a free-flowing route. Traffic mobility and route connectivity play a significant role in the decision-making process.	25
Property Impacts and Business Access	Consideration for the impacts any alternative has on the surrounding properties and business accesses. Impacts to existing properties and businesses plays a role in the decision-making process.	20
Railroad Operations Impacts	The railroad is identified as one of the major stakeholders in the project. Careful consideration should be given to reduce impacts to the railroad property and operations. Impacts to railroad operations play a significant role in the decision-making process.	20
Multi-Modal Connectivity	Although multi-modal facilities are important, the urban constraints of the project do not allow for substantial multi-modal considerations and does not play a significant role in the decision-making process.	10
Total		140

7.3.8 Short-Term Scoring

Meets Stakeholder Interest and Achieves Project Goals	Score
Goals Not Met	0
Some Goals Met	90

Property Impacts and Business Access	Score
No Impacts	80
Some Impacts	10

Probable Opinion of Construction Cost	Score
No Cost	40
Least costly	30
Costly	15
Most costly	5

Railroad Operations Impacts	Score
No Impacts/No Benefit	10
No Impacts/Extensive Benefit	80

Traffic Mobility and Route Connectivity	Score
No Benefit to Traffic/No Loss in Connectivity	40
No Benefit to Traffic/Loss of Connectivity	0
Some Benefit to Traffic/No Loss in Connectivity	50

Multi-Modal Connectivity	Score
No Loss in Connectivity	30
Benefit to Connectivity	60
Loss in Connectivity	0

8 Intelligent Transportation System Concepts

Based on input received during public involvement and from the City of Billings, MDT elected to evaluate Intelligent Transportation System (ITS) concepts from the short-term alternatives in more detail. Other short-term alternatives are not recommended for further evaluation at this time.

8.1 Concepts for Evaluation

This section describes the preliminary ITS concepts. The preliminary concepts are presented in two categories:

- Traffic Signal Enhancements, which is a combination of activated signs, railroad preemption strategies, and signal timing strategies to facilitate non-railroad crossing movements during a crossing event and manage queue discharge after a crossing event.
- Excessive Delay Warning System (EDWS), which provides traveler information systems to bring awareness of railroad crossing events that may generate excessive delay. This will allow users to make informed decisions, which may include diverting to alternative routes.

8.1.1 Traffic Signal Enhancements

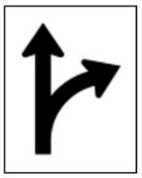
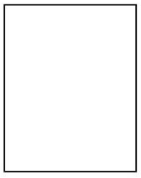
Restricted Right-Turn Blank-Out Sign

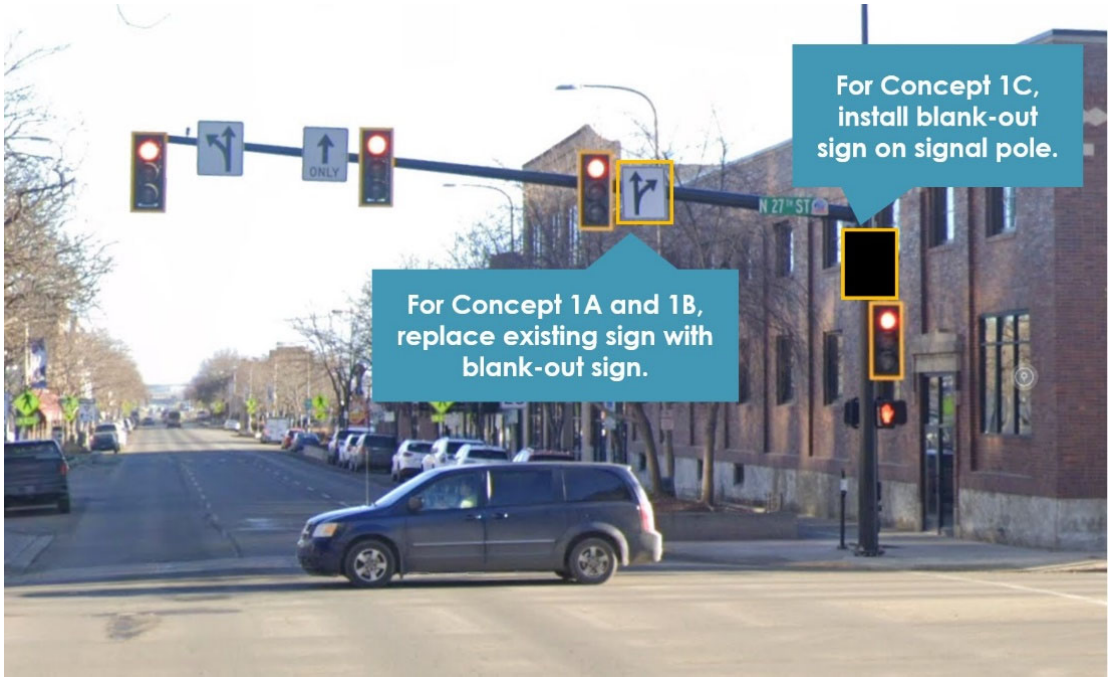
Montana Avenue has three eastbound travel lanes with the outside lanes being shared thru-left and thru-right turn lanes. The right-most eastbound travel lane at N 27th Street & Montana Avenue is currently a shared thru and right-turn lane. During railroad crossing events, right-turning vehicles are delayed and generate a queue on the right-most eastbound lane. There are approximately 90 vehicles per hour making the eastbound right-turn movement during the PM peak hour.

Signage at the N 27th Street & Montana Avenue could be modified to restrict eastbound right- turn movements during railroad crossing events. Blank-out signs could be configured to display either of the following messages:

- Concept 1A: Shared Thru-Right to Thru Only Sign – Under normal operations, the right-most travel lane will display a SHARED THRU-RIGHT LANE sign. During a railroad crossing event, the sign will display a THRU ONLY sign. A 2-channel blank- out sign is required for this concept. The blank-out sign would replace the existing SHARED THRU-RIGHT sign on the mast arm.
- Concept 1B: Shared Thru-Right to No Right-Turn Sign – Under normal operations, the right-most travel lane will display a SHARED THRU-RIGHT LANE sign. During a railroad crossing event, the sign will display a NO RIGHT TURN sign. A 2-channel blank-out sign is required for this concept. The blank-out sign would replace the existing SHARED THRU-RIGHT sign on the mast arm.
- Concept 1C: No Right-Turn Blank Out Sign – Under normal operations, sign will rest dark (no signage displayed). During a railroad crossing event, the sign will display a NO RIGHT TURN sign. Only 1 channel is required for this blank-out sign configuration. The blank-out sign would be installed on the signal pole.

Restricted right-turn blank-out sign concepts and example sign placement locations are presented in the figures below.

Concept	Description	Normal Operations	Excessive Delay Event Predicted
Concept 1A	Shared Thru-Right to Thru Only Sign (2-Channel Blank Out Sign)		
Concept 1B	Shared Thru-Right to No Right Turn Sign (2-Channel Blank Out Sign)		
Concept 1C	No Right-Turn (1-Channel Blank Out Sign)		



Concept 1C: No Right-Turn Blank Out Sign was selected as preferred given its simplicity.

The City of Billings is kicking off a one-way to two-way conversion project in downtown that includes analysis and evaluation of the Montana Ave. roadway cross-section at the 27th Street to the east. This improvement option should be coordinated with that project.

The restricted right-turn blank-out sign concept could also be applied at the nearby N 29th Street And N Broadway Intersections on Montana Avenue.

Further, success of the restricted right-turn blank-out sign concept could be enhanced through provision of additional wayfinding signage directing drivers eastbound on Montana Avenue to the existing railway undercrossings at S 21st Street (vertical clearance restricted) and N 13th Street.

Southbound Left-Turn Modifications

During a railroad crossing event, vehicles traveling southbound at N 27th Street & Montana Avenue will be delayed, forming a queue. The available striped queue storage for the southbound left- turn lane at N 27th Street & Montana Avenue is approximately 60 feet. If the southbound thru queues extend beyond approximately 100 feet, the standing thru queues will effectively block access to the southbound left-turn lane. The southbound left-turn movement operates with a protected-permissive left-turn phase. There are approximately 100 vehicles per hour making the southbound left-turn movement during the PM peak hour today.

The following concepts facilitate the southbound left-turn movement during a railroad crossing event:

- Concept 2A: Left-Turn Recall During Preemption – The railroad preemption strategy at N 27th Street & Montana Avenue is configured to service the southbound left-turn movement and north-south pedestrian crosswalk on demand (vehicle detected and/or pedestrian activates crosswalk) after initial rail preemption. There may be an opportunity to provide additional minimum recall during preemption to serve the southbound left-turn phase when left-turning vehicles aren't in position to be detected by the traffic signal. Under normal operations, the minimum recall is disabled.

  Today, the permissive southbound left-turn movement begins concurrent with the north-south pedestrian walk phase and the left-turn motor vehicle(s) is required to yield to pedestrians. If left-turn recall is implemented during pre-emption, consideration should be given to prohibiting the conflicting pedestrian walk phase from operating concurrently. This could be achieved through implementation of a protected only left-turn recall phase. In addition to considering implications for a person walking at the intersection, the potential for providing additional left-turn recall should also consider (and be coordinated with) the previously cited City of Billings downtown one-way to two-way conversion project.

- Concept 2B: Extend Southbound Left-Turn Lane – Vehicles trying to access the left-turn lane during a crossing event may temporarily travel against opposing traffic to bypass the standing southbound thru queues. The potential wrong-way travel issue could be mitigated by extending the southbound left-turn lane to 1st Avenue N to improve access to the southbound left-turn lane. At N 27th Street & 1st Avenue N, this concept will require the following:
  - Removal of the northbound left-turn lane and adjusting placement of signal heads on mast arm. There are approximately 60 vehicles per hour making the northbound left-turn movement during the PM peak hour.

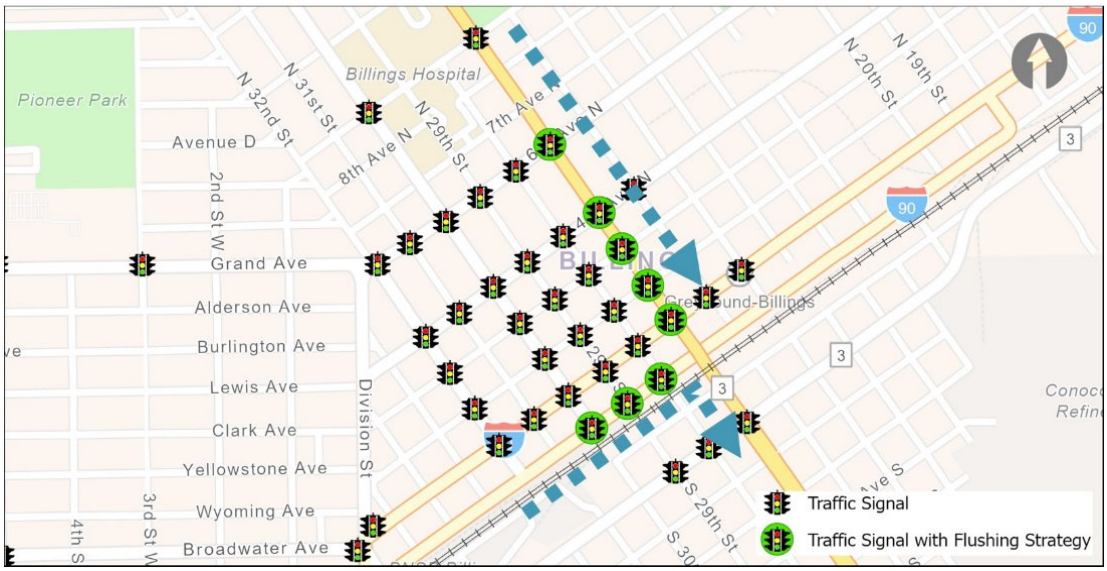
- Reconfiguring the northbound left-most thru lane as a shared left-thru lane.

Concept 2B was not advanced due to potential safety issues related to permitted left-turn movements from a shared thru-left lane, and the reduced capacity for the northbound left-turn movement.

Additional Pedestrian Function: Public feedback during the December 2022 project open house identified the desire for north-south pedestrian movements across Montana Avenue at N Broadway and N 29th Street similar to how the traffic signal at N 27th Street operates today during rail preemption events. In concept, the existing traffic signals could provide a pedestrian activated north-south crossing of Montana Avenue (pedestrian only phase) while the traffic signals are operating in preemption to afford persons walking the opportunity to cross. MDT staff confirmed that traffic signal timing programming at the recently upgraded traffic signals at both the N Broadway and N 29th Street intersections can be modified to facilitate the opportunity for persons walking to cross north-south at the signals while operating in preemption.

Queue Flushing Strategy

After a railroad crossing event, a surge in traffic volumes for movements crossing the railroad tracks occurs. Traffic signals under normal operations may not have sufficient bandwidth or progression strategy to serve the surge in traffic volumes. A post-railroad preemption queue flushing strategy could be employed to serve movements crossing the railroad tracks. Due to the relatively short block spacing and limited queue storage in the downtown area, the flushing strategy conceptually would prioritize progression for the southbound direction. Furthermore, N 27th Street & 1st Avenue S is not directly adjacent to the railroad crossing and does not currently operate with railroad preemption, making a northbound flushing strategy less effective. The figure below illustrates the key movements identified for a queue flushing strategy.



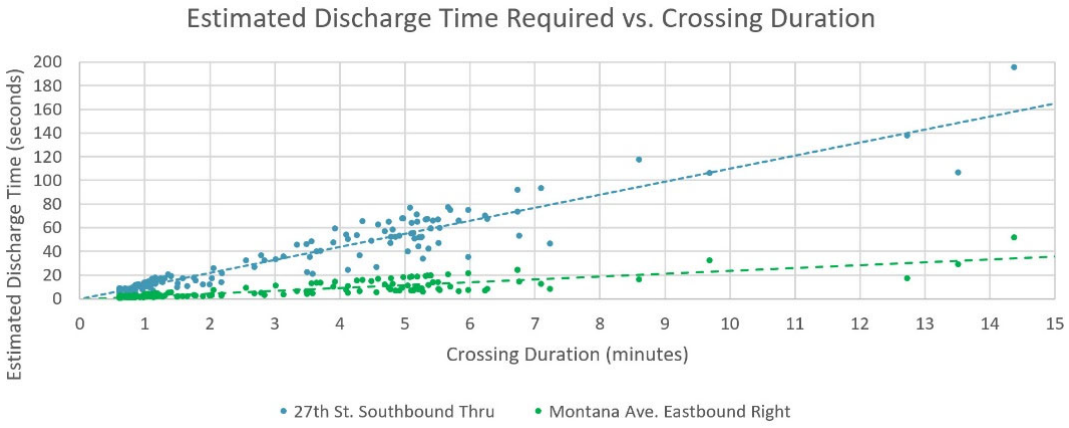
Railroad crossing events vary in duration and do not occur on a set schedule. As such, the intensity of the resulting traffic surge varies. For short duration crossing events or crossing events occurring outside peak periods, the existing signal timings may be able

to adequately serve the crossing movements. From 6:30 AM through 6:30 PM, N 27th Street & Montana Avenue serves a split of 33 seconds for the eastbound movement and 37 seconds for the southbound thru movement.

Based on a preliminary analysis of the existing signal timings, peak period railroad crossing data (provided by MRL for September 16 - October 16, 2018) and turning movement counts (collected on June 2018), a flushing strategy could in concept provide an operational benefit under the following conditions at N 27th Street & Montana Avenue:

- For the eastbound right-turn movement, crossing events greater than 7-minutes, which represents 5% of all crossing events.
- For the southbound thru movement, crossing events greater than 3-minutes, which represents 54% of all crossing events.

The figure below illustrates the estimated discharge time (or green time) required to serve the traffic surge associated with the southbound thru or eastbound right-turn movement at N 27th Street & Montana Avenue after a crossing event. The planning level analysis assumed a saturation flow rate of 1,800 vehicle/lane/hour and did not account for the potential rerouting decisions of blocked traffic.



The queue flushing strategy could be implemented using one or a combination of the following signal timing concepts:

- Concept 3A: Hold Green – When a flushing strategy is triggered, the traffic surge can be served by engaging a follow-up preemption strategy with an extended green time. At the conclusion of the follow-up preemption strategy, the traffic signal will transition back to its scheduled based time-of-day plan.
- Concept 3B: Increased Cycle Length – When a flushing strategy is triggered, the traffic surge can be served by using an increased cycle length. This allows the traffic signal to serve the surging demand across one or more cycles, and may better balance the mobility needs for all movements.
- Concept 3C: Negative Offset – When a flushing strategy is triggered, a special coordination plan may be used to start the green interval earlier at a downstream intersection to allow the downstream queue to dissipate before upstream vehicles arrive.

- Concept 3D: Variable Flushing Time Based on Preemption Duration – Because the flushing strategy is more effective with long duration crossing events, the duration of the crossing event could be used to conditionally trigger and alter the duration of the flushing event. This may require custom programming of logic into the traffic signal controllers.
- Concept 3E: Variable Flushing Time based on Detector – Because the flushing strategy is intended to serve the crossing delayed movements, the flushing strategy could be triggered and terminated based on detector status for the traffic signals along N 27th Street This may require custom programming of logic into the traffic signal controller.

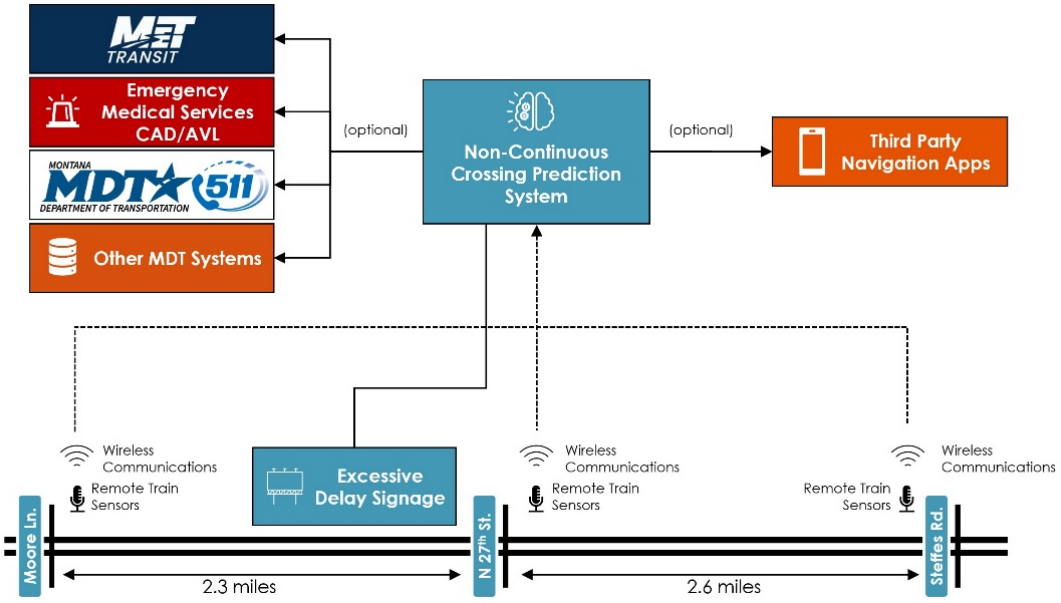
The queue flushing strategy would rely on the traffic signal's existing connection to MDT's TACTICS (central traffic signal system) to trigger the strategy. The queue flushing strategy may also require the traffic signal controllers to be upgraded to Siemens M60 controllers with Linux operating systems to take advantage of the peer-to-peer functionality.

Evaluation of the queue flushing strategies identified multiple implementation challenges. While the queue flushing strategies explored could reduce delay for southbound through traffic on the N 27th Street corridor, doing so would increase delay for east-west movements intersecting with the corridor (further, the east-west movements that would be delayed are higher in volume than the southbound traffic that would benefit). On the equipment side, while queue flushing is conceptually feasible, the City and MDT each use different control equipment that currently lacks compatibility necessary to communicate between traffic signal controllers in the downtown area. Additionally, the City's on-going one-way street to two-way street conversions in the downtown area will impact and complicate the queue flushing strategies and their potential benefits to southbound through traffic. For these reasons, no queue flushing strategy was advanced to implement.

8.1.2 Excessive Delay Warning System (EDWS)

The purpose of the EDWS is to inform the traveling public of excessive delays from an on-going or anticipated railroad crossing event. This information allows the traveling public to make an informed decision on whether to remain in queue, reroute their trip, or change their destinations.

The figure below illustrates the proposed system architecture for the EDWS.



Non-Continuous Crossing Prediction System

A continuous train crossing event occurs when a train travels through a crossing unimpeded at a consistent pace. A non-continuous train crossing occurs when a train travels through a crossing at a varying and inconsistent pace. The train may stop on the crossing or even reverse. Non-continuous crossings are typically prolonged events. An example of a non-continuous train crossing event is train switching. The heart of this concept is a system to predict non-continuous train crossing events that would generate excessive delays for the traveling public. In concept, this system would perform the following primary functions:

- Predict Non-Continuous Train Crossings – The system receives and processes sensor data on passing trains from the field in real-time. Using machine learning algorithms, the system would detect and classify sensor readings that match non- continuous train crossing events. The system's machine learning algorithm requires the system to be calibrated with train data specific to the 27th Street crossing location.
- Application Programming Interface (API) – The API is the primary means of by which the predictive system would interface with other systems and deliver a notification that an excessive delay event is expected. The API would directly interface with the traveler information system in the field. The API could also interface with other local systems such as MDT 511, Emergency Medical Services' Computer Aided Dispatch (CAD) system, or navigation applications (such as Waze).
- Reporting and Visualizations – Approved users would be able to access the system via a web- browser and retrieve historical data related to railroad crossing events. This data would be accessible as data visualizations.

Remote Train Sensors

To minimize impact to the railroad system, the EDWS would rely on remote sensors located outside the railroad right-of-way. These sensors detect the presence of the train and other supplementary data that could be used by the EDWS to better predict non-continuous train crossing events. These sensors would communicate with the non-continuous crossing prediction system via cellular technology. Sensor technologies used would depend on the vendor-specific requirements of the system's predictive technology.

These sensors would need to be deployed at several locations, including at upstream crossing locations to provide sufficient advance warning to the 27th Street Crossing. Subject to further system architecture design, sensors would likely be located at the following crossing locations:

- Moore Lane;
- 27th Street; and
- Steffes Road.

Excessive Delay Signage

Signage in advance of the 27th Street crossing would be the primary means of communicating excessive delay events to the traveling public. Placement of the signage systems will need to consider the following factors:

- Ability to make rerouting decisions – Placement of signage would need to be sufficiently in advance of the crossing so the traveling public would be able to make an informed decision on rerouting.
- Relevance to the traveling public – Signage placed too far from the crossing location may be less relevant to road users and risks informing only large numbers of non-crossing users.
- Existing railroad warning signs – There are existing advance railroad warning signs located on 27th Street at the following locations:
    - 230-feet north of 3rd Avenue S;
    - 140-feet south of 3rd Avenue N; and
    - 300-feet south of 6th Avenue N.

Adding new signage without consideration of the existing signs' design and location may contribute to sign clutter and diminish its effectiveness.

Mainline Signage

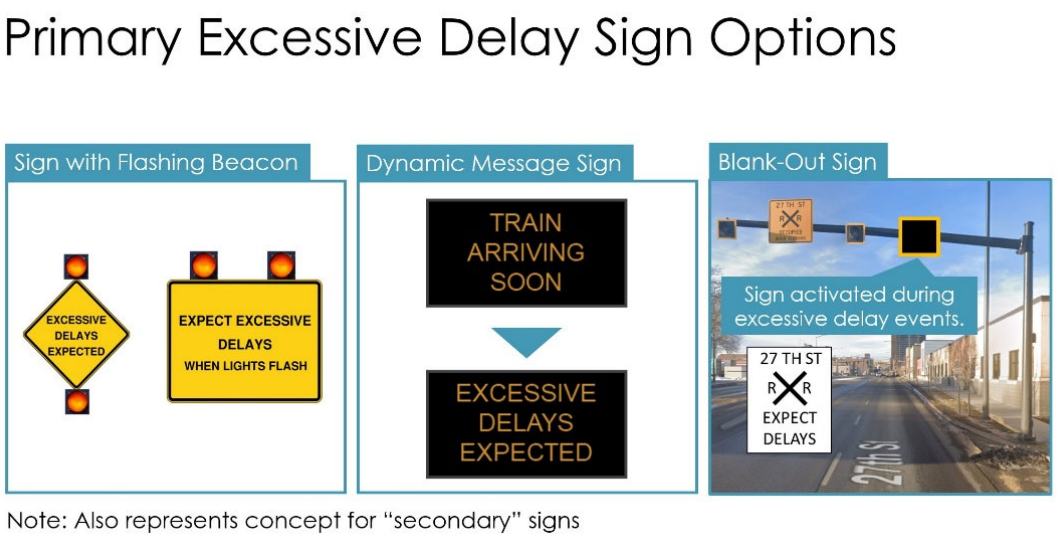
There are several options for the signage along 27th Street:

- Concept 4A: Sign with Flashing Beacons would be designed in accordance with the warning signs standards in Chapter 2C of the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD 2009 Edition). Flashing beacons would activate when an excessive delay event is detected.
- Concept 4B: Dynamic Message Signs (DMS) would be designed in accordance with the Changeable Message Signs standards in Chapter 2L of the MUTCD.

The DMS could display one or more alternative messages depending on the data received from the prediction system. DMS provides flexibility to MDT to change or provide additional messages.

- Concept 4C: Blank-out signs would be designed in accordance with Changeable Message Signs standards in Chapter 2L of the MUTCD. Under normal operation (no excessive delays predicted), the blank-out signs will appear blank. When an excessive delay event is predicted, the blank-out signs will be activated with a "27 TH ST CROSSING, EXPECT DELAYS" sign. Although blank-out signs do not provide as much messaging flexibility as DMS, blank-out signs are smaller and weigh less, making it more feasible to place on existing traffic signal mast arms without modification.

The figure below illustrates options for excessive delay warning signs along 27th Street.



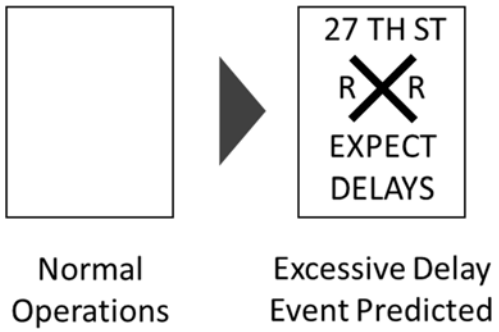
Potential locations for installing signage on 27th Street are as follows:

- For northbound traffic (south of the crossing), between 1st Avenue S and 4th Avenue S.
- For southbound traffic (north of the crossing), between 200 feet north of 1st Avenue N and 400 feet north of 4th Avenue N.

Side Street Signage

Vehicles traveling on the side streets entering 27th Street have the greatest opportunity to reroute to alternative crossing locations. Blank-out signs presented in Figure 10 could be mounted on existing signal mast arms or poles.

The figure below is a concept of an excessive delay blank-out sign.



Based on the Billings Travel Demand Model, the table below summarizes the locations with the highest proportion of vehicles entering the 27th Street crossing and are candidate locations for an excessive delay warning sign.

Intersection	Traffic	Potential Sign Placement
2nd Avenue N & N 27th Street	8% (1,035 vehicles) of all southbound crossings.	Between N 27th St. and N 28th St.
1st Avenue N & N 27th Street	11% (1,410 vehicles) of all southbound crossings.	Between N 27th St. and N 26th St.
Montana Avenue N & N 27th Street	34% (4,220 vehicles) of all southbound crossings.	Between N 27th St. and N 36th St.
1st Avenue S & N 27th Street	17% (1,550 vehicles) of all northbound crossings.	Between S 27th St. and S 26th St.

3rd Avenue N and 4th Avenue N each currently serve approximately 3% of all daily southbound crossing traffic arriving onto N 27th Street. Therefore, an excessive delay signage may not be effective at those locations.

Pedestrian/Bicycle Signage

For non-motorized users, understanding if a crossing event is an excessive delay event could inform travel decisions. Bicyclists may choose to take other existing connections across the railroad tracks such as at Underpass Avenue, 21st Street, or at 13th Street People walking may be more inclined to peruse the surrounding businesses while waiting for the excessive delay crossing event to conclude.

Pedestrian-Scale Dynamic Message Signs (Concept 5) may be placed at 27th Street, 28th Street and 29th Street crossings to help non-motorized users make informed travel decisions. Pedestrian-scale signage technologies vary in size, weight, power requirements, messaging flexibility and place-making characteristics. Some technologies are primarily designed to display transit information but could be repurposed to display information from the non-continuous crossing prediction system.

The figure below illustrates the range of options for pedestrian-scale signage systems.

Concept 5 was placed on hold. This concept could be revisited if the City moves forward with the 25th Street Pedestrian Bridge project depending on the outcomes of the Excessive Delay Warning System pilot.

8.1.3 Other Considerations

Pedestrian/Bicycle Safety at the Railroad Crossing

The 27th Street, 28th Street, and 29th Street crossings are currently equipped with pedestrian gates and detectible warning devices. Additional safety measures could be considered to enhance the pedestrian and bicycle safety at the crossings:

- Concept 6A: Directional Surfaces provide orientation to the correct pathways that cross the railroad tracks. They also help guide visually impaired pedestrians and avoid drop-offs or other edges not located at the designated pathway.
- Concept 6B: Gate Skirts are a secondary pedestrian gate bar, identical to the primary pedestrian gate bar. It helps to block additional area under the primary gate bar to restrict pedestrians from traveling under the primary gate.
- Concept 6C: Dynamic Envelope Markings signify the clearance area needed for a train and its cargo through the railroad crossing. The markings are highly visible and are based on MUTCD's "Do Not Block Intersection Markings" section.
- Concept 6D: Pedestrian Swing Gates must be pulled open by pedestrians to be able to cross the railroad tracks and pushed open to exit the right-of-way. This forces the pedestrians to pause before making the decision to cross.

The figure below shows the example deployments of the concept safety treatments.

The pedestrian/bicycle treatments identified in Concept 6 could be pursued in the future in coordination with BNSF Railway if a safety issue is identified. Pedestrian gates were implemented when the N 27th Street crossing was converted to a Quiet Zone.

8.2 ITS Concepts Evaluation

The following describes how the identified concepts were evaluated along with the evaluation factors. Each concept was rated “good”, “fair”, “poor”, or “not evaluated” based on the following factors:

- Mobility –Potential to reduce delays, manage queuing or alter travel patterns to reduce congestion within the vicinity of the 27th Street railroad crossing.
- Safety –Potential to raise users’ awareness of safety risks and potentially mitigate crashes.
- Clarity –Potential to communicate useful and meaningful information accurately and reliably to the traveling public.
- Ease of Implementation –Constructability and readiness for implementation.

The table below summarizes the evaluation results for each of the proposed concepts.

Concept	Description	Mobility	Safety	Clarity	Ease to Implement
TRAFFIC SIGNAL ENHANCEMENTS					
1A	Shared Thru-Right to Thru Only Sign	●	-	●	●
1B	Shared Thru-Right to No Right-Turn Sign	●	-	●	●
1C	No Right-Turn Blank Out Sign	●	-	●	●
2A	Left-Turn Recall During Preemption	●	-	●	●
2B	Extend Southbound Left-Turn Lane	●	●	●	●
3A	Hold Green	●	-	●	●
3B	Increased Cycle Length	●	-	●	●
3C	Negative Offset	●	-	●	●
3D	Variable Flushing Time Based on Preemption Duration	●	-	●	●
3E	Variable Flushing Time based on Detector	●	-	●	●
EXCESSIVE DELAY WARNING SYSTEM					
4A	Sign with Flashing Beacons	-	-	●	●
4B	Dynamic Message Signs (DMS)	-	-	●	●
4C	Blank-out signs	-	-	●	●
5	Pedestrian-Scale Dynamic Message Signs	-	-	●	●
OTHER CONSIDERATIONS					
6A	Directional Surfaces	-	●	-	●
6B	Gate Skirts	-	●	-	●
6C	Dynamic Envelope Markings	-	●	-	●
6D	Pedestrian Swing Gates	-	●	-	●

Legend

- ● Good
- ● Fair
- ● Poor
- \- Not evaluated based on this criteria

Of the traffic signal enhancements explored, Concepts 1C and 2A are recommended for future consideration. In addition, it is recommended that MDT modify the current traffic signal programming to provide a pedestrian activated north-south crossing of Montana Avenue at N Broadway and N 29th Street (pedestrian only phase) while the traffic signals are operating in preemption.

Evaluation of the queue flushing strategies (summarized as 3A-3E above) identified many challenges from an implementation perspective and no flushing strategy was advanced to implement at this time due to a lack of equitable signal progression strategy, currently incompatible traffic controller technology, and the added complexity of on-going two-way conversion projects.

A future pilot study is recommended to further assess the excessive delay warning system.

Pending the outcome of the excessive delay warning system pilot, Concept 5 could be revisited if the City advances the 25th Street Pedestrian Bridge project.

The pedestrian/bicycle treatments identified in Concept 6 could be pursued in the future in coordination with BNSF Railway if a safety issue is identified.

9 Conclusions

9.1 Long-Term Recommendations

Based on the evaluation criteria described in this report, the no-build, 2-lane overpass, and 2-lane tunnel alternatives are the recommended for further consideration. The no-build alternative is recommended in the event a practicable and fundable solution is not advanced. The no-build alternative does not address the at-grade safety concerns, but it does not negatively affect the traffic, route, or multi-modal mobility. The 2-lane overpass and 2-lane tunnel alternatives are recommended as they address the at-grade safety concerns and maintains connectivity throughout the downtown corridor while providing additional potential benefits to the downtown core.

Based on engagement from the City of Billings, stakeholders, and the general public, the long-term alternatives will be retained in this study, but will not be moved forward for a recommended alternative for implementation at this time.

9.2 ITS Concept Recommendations

Based on the evaluation criteria described in this report and engagement from City of Billings, stakeholders, and the general public, the following ITS concepts are recommended for future implementation.

Concept 1 – Restricted Right-Turn Blank-Out Sign

Concept 1C: No Right-Turn Blank Out Sign was preferred due to its simplicity. Sign locations for consideration include the eastbound approaches on Montana Avenue at N 29th Street, N Broadway, and N 27th Street. Success of the restricted right-turn blank out sign concept could be enhanced through provision of additional wayfinding signage directing drivers eastbound on Montana Avenue to the existing railway undercrossings at S 21st Street. (vertical clearance restricted) and N 13th Street.

Concept 2 – Southbound Left-Turn Modifications

Concept 2A: Left-turn Recall During Preemption was preferred. Evaluation of potential changes to adjust left-turn recall on N 27th Street at Montana Avenue to consider potential safety implications and be coordinated with the City of Billings one-way to two-way conversion and Montana Avenue (27th Street to 22nd Street) project.

Additional Pedestrian Function: Assess potential to provide a pedestrian activated north-south crossing of Montana Avenue at N Broadway and N 29th Street while the traffic signals are operating in railroad preemption to afford persons walking the opportunity to cross like how N 27th Street operates today.

Concept 4 – Excessive Delay Warning System

The recommendation to implement an excessive delay warning system includes a pilot project concept with a vendor to test the effectiveness of the excessive delay warning system and to help better understand design and implementation challenges for a permanent solution.

9.3 Next Steps

The following are recommendations for next steps for possible implementation.

- Conduct pilot study – Coordinate with a technology vendor to identify and deploy a pilot implementation of the excessive delay warning system. The implementation could rely on temporarily deployed equipment. The pilot study could be designed to test different messaging strategies, fine-tune algorithms, identify design or implementation challenges for a permanent system, and assess effectiveness in terms of resultant driver route choice/travel patterns.
- Include No Right-Turn Blank Out Signs – Include “No Right Turn” black out signs for the eastbound approaches on Montana Avenue at N 29th Street, N Broadway, and N 27th Street. The design will need to be coordinated with the City of Billings one-way to two-way conversion and Montana Avenue (27th Street to 22nd Street) project.
- Implement Left-Turn Recall During Preemption – Further evaluate potential benefits and implications of adjusting minimum recall for southbound left-turning movements at N 27th Street & Montana Avenue during a railroad preemption event. Monitor southbound left- turn operations. The effort will need to be coordinated with the City of Billings one-way to two-way conversion and Montana Avenue (27th Street to 22nd Street) project. Also provide a pedestrian activated north-south crossing of Montana Avenue at N Broadway and N 29th Street while the traffic signals are operating in railroad preemption to afford persons walking the opportunity to cross like how N 27th Street operates today.

Based on engagement from the City of Billings, stakeholders, and the general public, the long-term alternatives will be retained in this study, but will not be moved forward for a recommended alternative for implementation at this time.