

Final Feasibility Report

SP 8707-95 - TH 67

Slope Stability Repairs and Reconstruction

*TH 67, Granite Falls to Echo, near Upper Sioux Agency
State Park*

February 18, 2021



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1 Introduction

Minnesota Department of Transportation (MnDOT) is conducting a study to develop a variety of options to address the slope stability issues near Upper Sioux Agency State Park and to determine the preferred alternative to maintain the connectivity of Trunk Highway (TH) 67 between Granite Falls and Echo, Minnesota. This report documents the study process, feasibility, risk assessment, and recommendations for TH 67 near Upper Sioux Agency State Park. TH 67 is a minor arterial between Granite Falls and Echo and provides a critical connection for local farms and residences as well as for the Upper Sioux Community and the State Park. TH 67 is a two-lane rural highway and predominantly has a 50-mile-per-hour posted speed. The average daily traffic on TH 67 is 465 vehicles per day (2017 data). Figure 1 shows a vicinity map of the project area.

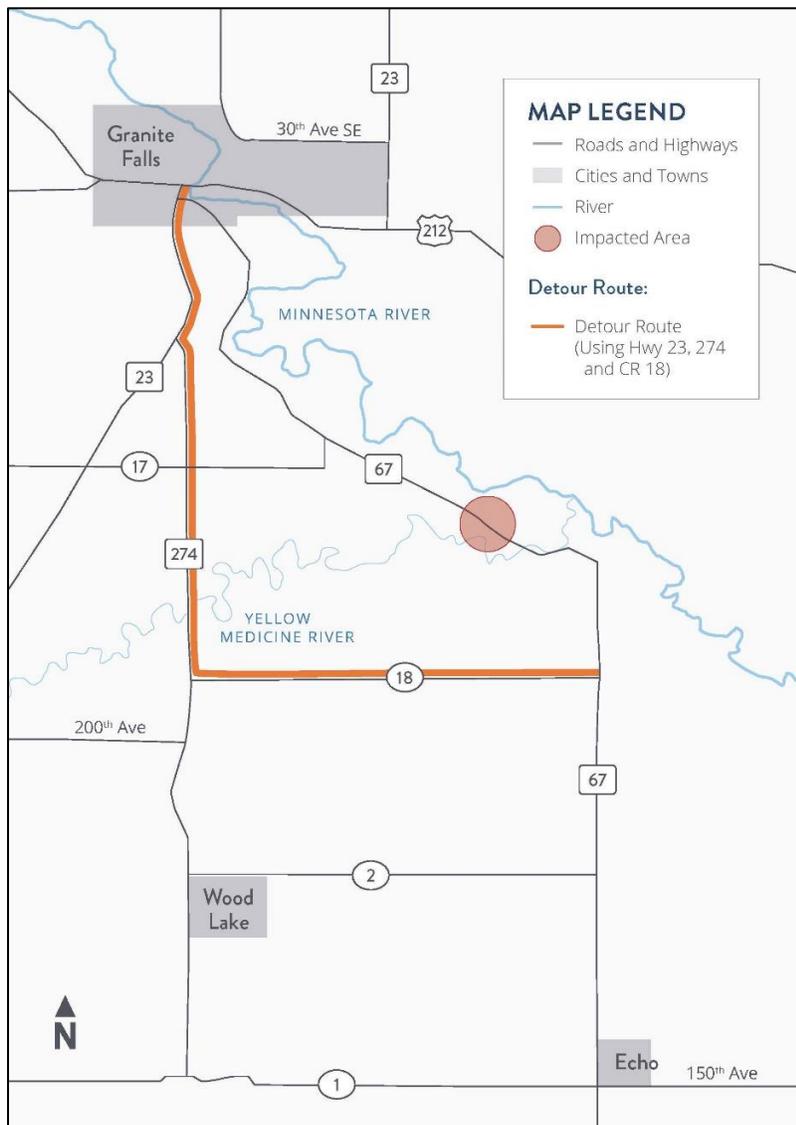


Figure 1. Vicinity Map

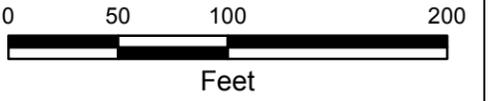
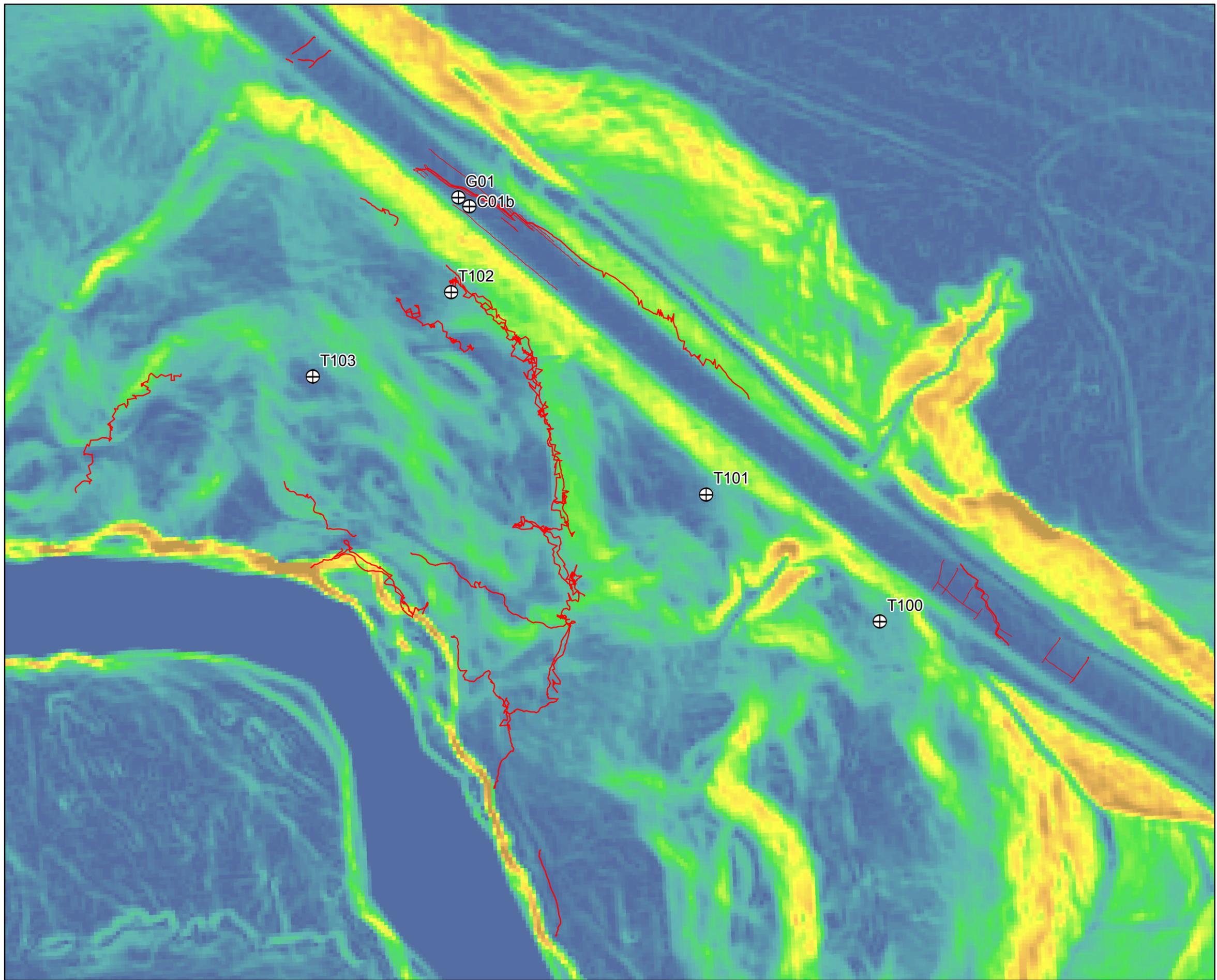
In April 2019, a portion of TH 67 near Upper Sioux Agency State Park was closed to traffic because of pavement distress as a result of embankment soil movement. This portion of the highway is constructed adjacent to the Minnesota River and crosses the Yellow Medicine River. The geomorphology of this region suggests that this hillside has previously experienced instability. Erosion along the Yellow Medicine River, along with fluctuations in the groundwater table, is believed to have initiated the landslide, which has led to embankment movement, pavement distress, and the subsequent closure of the road. Figures 2 and 3 show the impact of the landslide on the roadway surface. These photos are from May 2019, and the displacement has only increased over the past year. The embankment movement spans approximately 0.25-mile length of roadway. As a result of the road closure, traffic has been detoured to a route that includes TH 274 and Yellow Medicine County State Aid Highway (CSAH) 18 (see Figure 1).



Figure 2. TH 67 Pavement Distress, Looking West

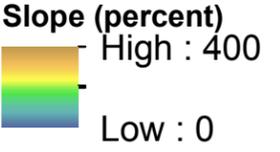
Figure 3. TH 67 Pavement Distress, Looking East

To obtain information about the rate of landslide movement and the possible location of the sliding surface, MnDOT Foundations Unit drilled four borings and installed Shape Accel Arrays, also known as slope inclinometers, in each borehole to monitor the movement. Figure 4 shows the boring locations. In addition, vibrating wire piezometers were installed along the hillside to record the water table. The data is being collected and hosted by Barr Engineering. Early indications of the monitoring showed that there was movement at a depth of 30 feet in the first boring location (approximately 50 feet below the surface of the roadway). Additional monitoring has revealed a secondary movement approximately 85 feet below the roadway surface, which is near the surface elevation of the river. Figure 5 shows a cross section of TH 67 through the landslide.



LEGEND

- ⊕ Geotech Borings
- Distress Lines (Field Observed)



Notes:
Slope elevation derived from MnTOPO LiDAR data. MnTOPO reports LiDAR data was collected on 11/7/2010 as part of MN River Basin collection project.

Coordinate System:
NAD 1983 HARN Adj MN Yellow Medicine Feet

Site Overview
Slope Instability
TH67 Granite Falls
SP8707-95 Project ID: T8A722

Version Date: 2018/06/11	Figure: 4
Created by: MJH	Checked by: AJE



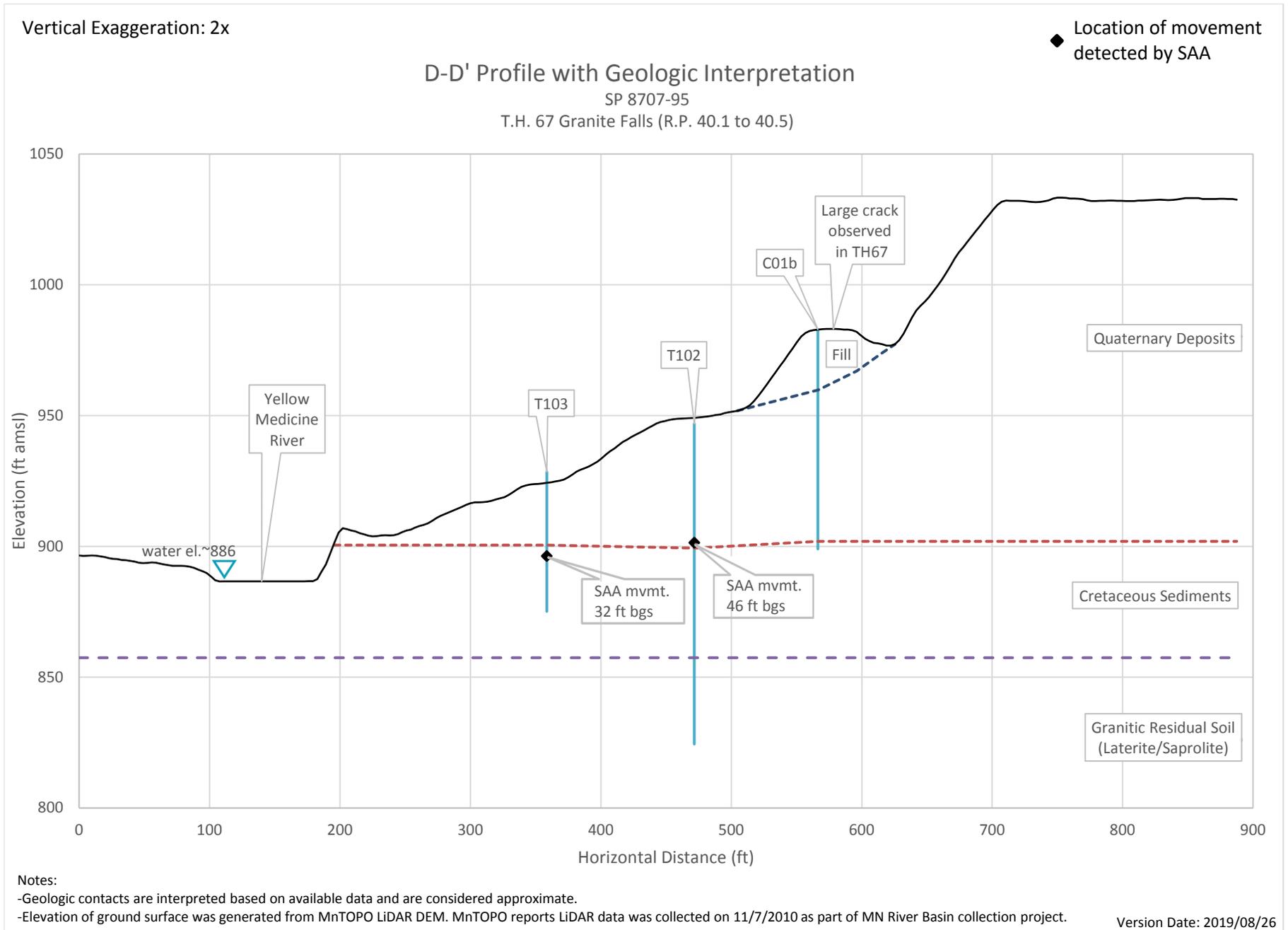


Figure 5 - Cross section through landslide area

2 Background

The current alignment of TH 67 was constructed in the mid-1930s. This construction included Bridge 5295 (now Bridge 87011) over the Yellow Medicine River. Before the 1930s, the previous alignment of TH 67 went through the area that is now Upper Sioux Agency State Park, which was not established until 1963, that is outside of the landslide area. Some of the internal park roadways and horse trails are parts of the old highway.

Prior to the March 2019 landslide, MnDOT had observed two washout areas. Both were localized areas behind guardrail caused by drainage runoff from the roadway surface, as shown in Figure 6. Several of the drainage culverts through the roadway embankment in the vicinity of the landslide area have eroded such that the pipe ends protrude from the slope, as shown in Figure 7.

In addition, there has been movement of the east abutment of Bridge 87011 over the Yellow Medicine River. This movement is due to a separate landslide pushing on the abutment from the southeast. The east abutment has moved approximately 5 to 8 inches over the last 30 years, and the rate of movement has increased in more recent years. MnDOT has made temporary modifications to the expansion joint between the bridge deck and abutment to keep the bridge operational. However, the expansion joint has closed as of the summer of 2020, so the movement is creating pressure on the bridge deck.



Figure 6. Washout Area at the Guardrail



Figure 7. Erosion at the Culvert End

The landslide near Upper Sioux Agency State Park occurred gradually in late March 2019. The Yellow Medicine River water elevation was high because of heavy winter snow melt and a spring rainfall that was greater than normal. The roadway was closed on April 4, 2019, because the cracking in the pavement grew too hazardous for traffic. The route has been detoured since the closure, with traffic routed to TH 274 and CSAH 18.

Upper Sioux Agency State Park is the main adjacent landowner to the project area. The park has two entrances. The main entrance is on top of the bluff, west of the landslide, while the second entrance is to the camping area along the river, east of the landslide. The road closure has severed the connection of these two entrances to the park, and there is no existing vehicular connection within the park that is available to the public. A second landowner is located south of the highway and adjacent to the Yellow Medicine River. This property does not have a residence on it and is primarily used for agriculture purposes, depending the how wet the year is and the ability to farm the land. The landowner also uses the property for recreational purposes.

3 Assessment Goals

TH 67 serves an important role in the transportation system in southwestern Minnesota. Minnesota State Statute 161.114 describes TH 67 as follows:

Route No. 67. Beginning at a point on Route No. 14 southerly of Echo and thence extending in a northerly and westerly direction to a point on Route No. 17 at or near Granite Falls, affording Echo, Granite Falls and intervening and adjacent communities a reasonable means of communication, each with the other and other places with the state.

As noted in the State Statute, TH 67 serves as a connection between Echo and Granite Falls. The purpose of this study is to develop a variety of options to address the slope stability issues near Upper Sioux Agency State Park and to determine the preferred alternative to maintain the connectivity of TH 67.

Each of the alternatives was developed to a concept level of design, and cost estimates were prepared. Any potential project is currently unfunded, so MnDOT District 8 will need to move funding around in their current budget, receive special emergency funding from the MnDOT Central Office, or get funding designated through the Minnesota State Legislature. The goal of this study is to evaluate the proposed alternatives to determine a cost-effective solution that will re-establish the route.

4 Proposed Alternatives

The alternatives under consideration can be categorized into two general types:

- Category 1, Reroute – Move the highway out of the existing corridor to avoid the landslide area, re-designating the TH 67 route using other existing roadways

- Category 2, Reconstruct – Reconstruct the highway in place or near the existing alignment, but use geotechnical solutions, such as micropiles, to stabilize the slope and mitigate against future landslides.

Several alternatives were developed from each category. The reroute and reconstruct alternatives carried forward for detailed evaluation in this feasibility report are discussed in Section 4.1 and Section 4.2, respectively. The alternatives dropped from further consideration are discussed in Section 4.3.

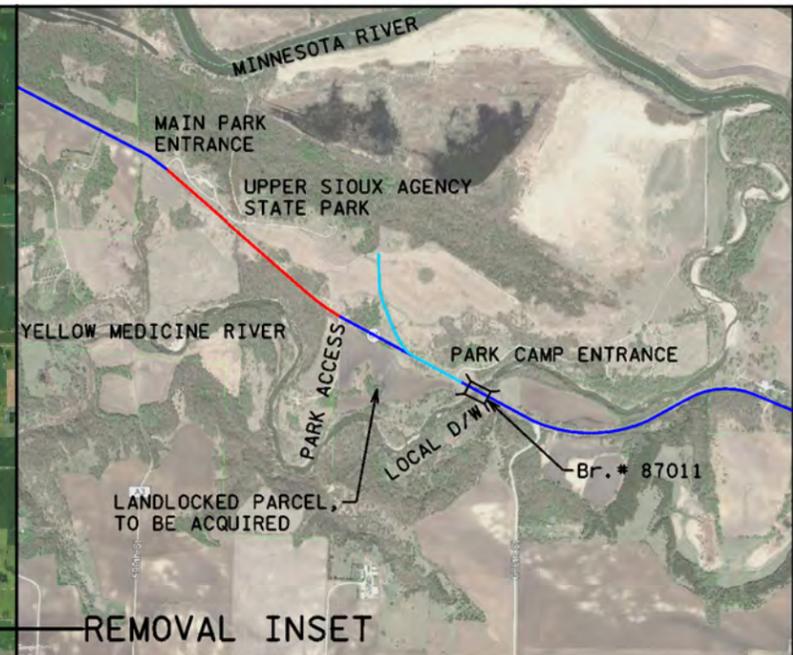
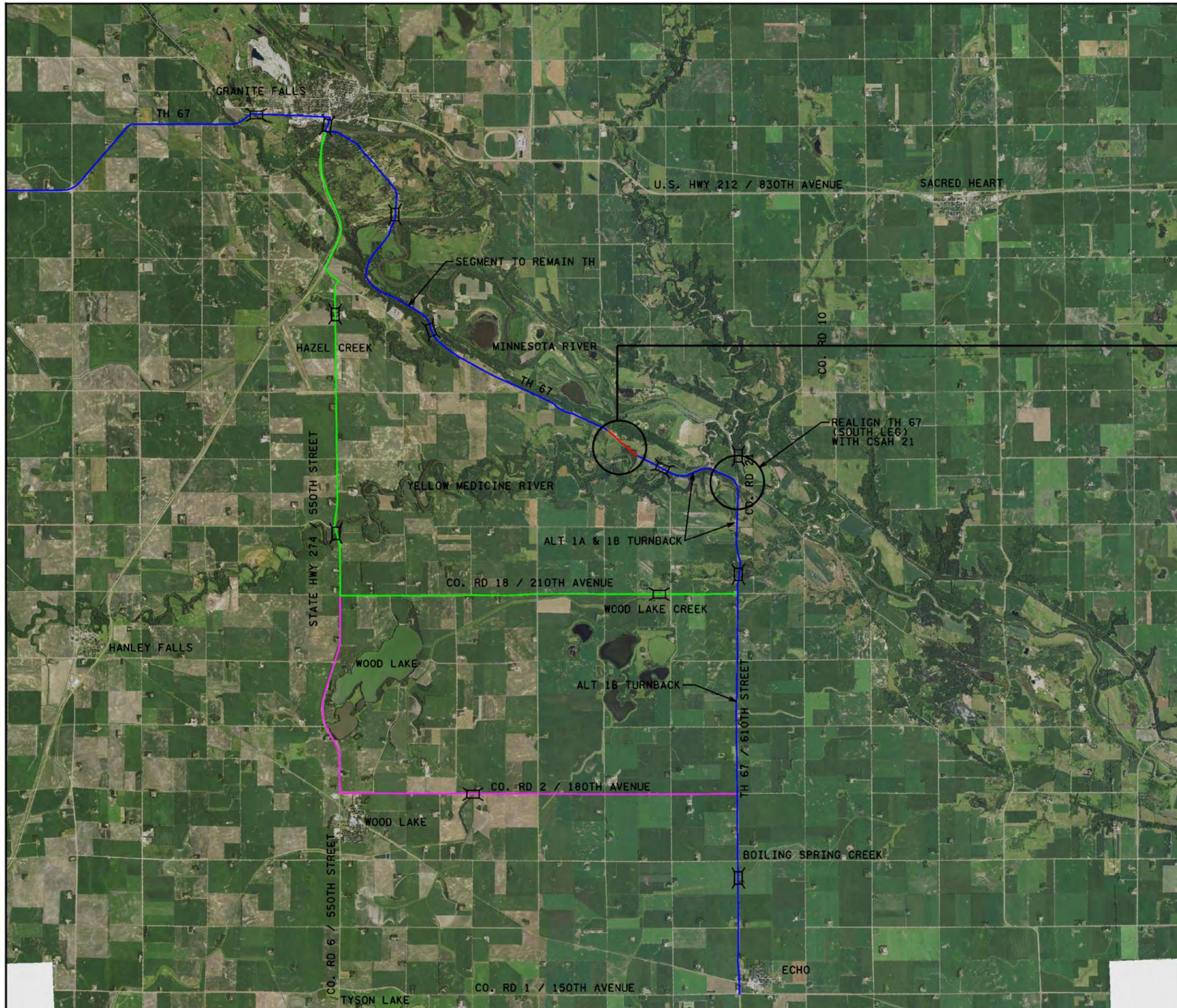
4.1 Reroute Alternatives

Alternative 1: Alternative 1 would reroute TH 67 outside of the existing corridor. Under Alternative 1, existing roadway options would serve as a re-designation of TH 67 and would still be consistent with the State Statute governing the endpoints of this portion of TH 67. Assuming a common starting point of Granite Falls and a common end point of Echo, the base length along the existing TH 67 alignment is 18.6 miles and typically takes 22 minutes of travel time. Two options for rerouting TH 67 are as follows:

- Alternative 1A: TH 67 would remain on TH 23 south of Granite Falls and then would turn east onto TH 274. The route would turn east on CSAH 18 (210th Avenue), directing travelers back to existing TH 67, and then would continue south on TH 67 to Echo. Alternative 1A is currently being used as the detour route while TH 67 is closed near Upper Sioux Agency State Park.
- Alternative 1B: TH 67 would remain on TH 23 south of Granite Falls and then would turn east onto TH 274. The route would turn east on Yellow Medicine CSAH 2 (180th Avenue), directing travelers back to existing TH 67, and then would continue south on TH 67 to Echo.

Alternatives 1A and 1B are shown in Figure 8.

Under either Alternative 1A or 1B, sections of existing TH 67 that would not be part of the new alignment would need to be re-designated as a new Trunk Highway or turned back to a local governing unit. For this analysis, it is assumed that the section of TH 67 from TH 23 to the Upper Sioux Agency State Park main entrance (north of the road closure) would remain a Trunk Highway. It is also assumed that TH 67 from the Yellow Medicine River to the new intersection of the proposed TH 67 (south of the road closure) would be turned back to a local agency. It is also assumed that the remaining segment of TH 274, south of the TH 67 re-route, would also be turned back to a local agency.



LEGEND	
	BOX CULVERT / BRIDGE
	TH67 PAVEMENT REMOVAL
	EXISTING TH67 ROUTE
	ALTERNATE 1A
	ALTERNATE 1B
	POSSIBLE STATE PARK CONNECTION



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NOT TO SCALE



FIGURE 8 - ALTERNATIVE 1A & 1B
 S.P.8707-95 TH 67 SLOPE STABILTY REPAIRS AND RECONSTRUCTION



Common elements in both Alternatives 1A and 1B include removing the pavement and aggregate base of the 0.6-mile section of TH 67 in the landslide area, between the main entrance to Upper Sioux Agency State Park and the park driveway access to a park building. This would reduce loading on the slope in the area. It is assumed that an internal park roadway would be built to connect the main park area on top of the bluff to the campground located along the river. Alternatives 1A and 1B assume that no riverbank protection is included as part of this alternative. Other state or federal agencies may decide to protect the riverbank at this location, but it would not be needed for transportation purposes. Bridge 87011 over the Yellow Medicine River would be removed to eliminate continued maintenance or replacement of the bridge. With no bridge, the landowner south of the existing highway would be landlocked, and either that parcel would be purchased or access would be provided via an easement through the State Park or a private driveway.

There are various sections of roadway that combine to make up the existing TH 67 alignment, as well as the two rerouted alignments in Alternatives 1A and 1B. Table A1 is included in Appendix A to describe these roadway segments.

Table 1 provides a summary of the travel distance and travel times for Alternatives 1A and 1B. It also sums the lengths of roadway that would be removed, re-designated as new Trunk Highways, and absorbed into the MnDOT system, as well as the net change in mileage to the MnDOT system. A more detailed table, Table A2, can be found in Appendix A

Table 1. Alternative 1 Summary

TH 67 Specific Impacts	Existing Road	Alternative 1A	Alternative 1B
Granite Falls to Echo travel distance per alternative (miles)	18.6	20.6	20.7
Travel time per alternative (minutes)	22	24	24

TH System Impacts	Existing Road	Alternative 1A	Alternative 1B
Net Change in TH System (miles)	0.0	-1.5	-1.4

County System Impacts	Existing Road	Alternative 1A	Alternative 1B
Net Change in CSAH System (miles)	0.0	-0.7	-0.8
Net Change in CR System (miles)	0.0	1.2	1.2

The following initial construction costs are assumed to be necessary to re-designate either CSAH 18 or CSAH 2 as Trunk Highway: signing, striping, rumble strips, guardrail placement at bridges, and minor culvert maintenance. The pavement is in good to fair condition and is not in

need of resurfacing. In addition, the traffic volumes at the intersections on either route do not warrant turn lanes or bypass lanes.

Under either Alternative 1A or Alternative 1B, there would be a reduction in long term maintenance for MnDOT because of the reduced lane miles of roadway and number of structures (bridges or box culverts). There would be a slight net increase for the County in long term maintenance due to added lane miles of roadway.

It is assumed for cost estimating purposes that the existing intersection on TH 67 at Yellow Medicine CSAH 21 would be realigned. TH 67 has a large curve from the south to the west that would no longer be necessary due to the roadway terminating at the Yellow Medicine River. Realigning the roadway to align with CSAH 21, and Renville CSAH 10 north of the Minnesota River, to the north would provide a better connection to TH 212 to the north and would better serve the transportation needs with the proposed highway network changes.

Under Alternatives 1A and 1B, there will be sections of existing TH 67 and TH 274 that will be turned back to the other agencies. Sections that are turned back to the County and re-designated as CSAH roadways need to be brought up to State Aid standards including replacement of Structure Number 6216. Structure Number 6216 is currently a 146-foot long, double 10-foot by 10-foot box culvert at Wood Lake Creek, approximately 0.3 miles north of CSAH 18.

4.2 Reconstruct Alternatives

Reconstruct alternatives for this project have to address three separate and distinct issues. Not only do they need to address the roadway connection, but they need to address the root cause of the landslide movement, which is erosion at the toe of the slope due to the Yellow Medicine River. Lastly, reconstruct alternatives need to address the on-going landslide issues at bridge 87011. Roadway alternatives are discussed in Section 4.2.1, riverbank protection strategies are discussed in Section 4.2.2, and bridge alternatives are discussed in Section 4.4.3.

4.2.1 Roadway Alternatives

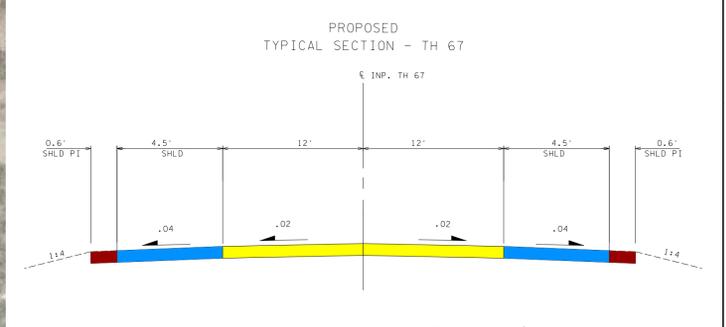
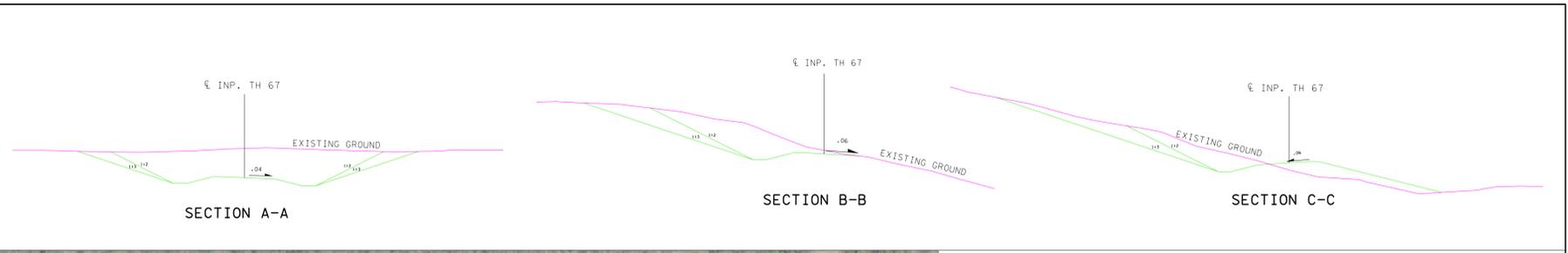
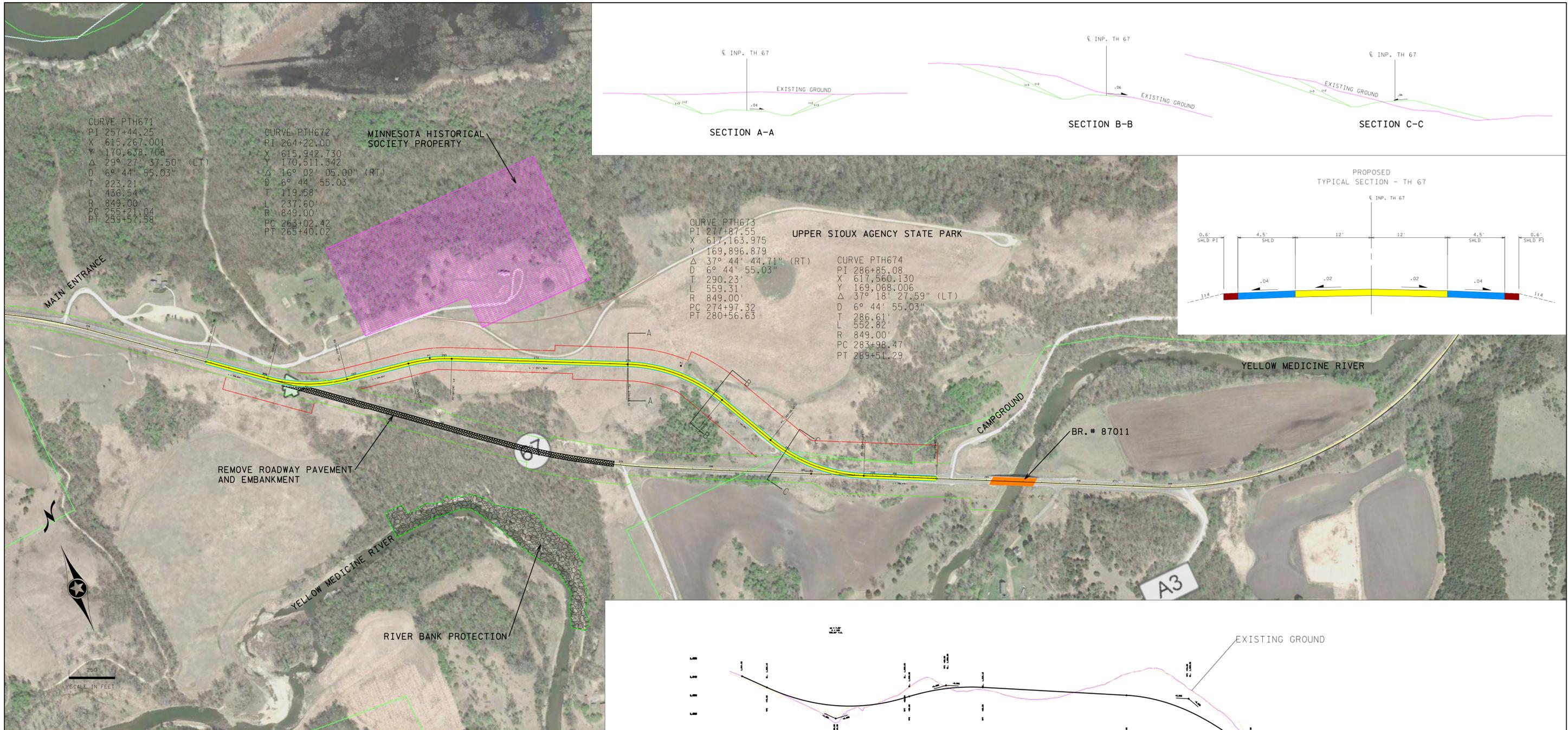
Alternative 2: Alternative 2 would reconstruct TH 67 near the existing corridor. Under Alternative 2, the highway would be realigned through Upper Sioux Agency State Park to remain above the bluff and, therefore, avoid the landslide area. The connection back to existing TH 67 would follow an existing horse trail that previously served as the old highway alignment along the side of the bluff. The proposed roadway grade of this section along the bluff would be approximately 8.5 percent, which exceeds the maximum design grade for this type of highway, requiring a design exception. Current design standards are greater than those from the pre-1930s, so this section would need to be carefully designed to avoid adding fill in the landslide area. The necessary widening would likely cut into the face of the bluff. The existing highway pavement and aggregate base in Alternative 2 would be removed to reduce the load on the failing slope. The risk of the Yellow Medicine River continuing to erode the toe of the slope still remains; even with this alternative moving the roadway outside of the current landslide area, future larger landslides could still occur. To mitigate this risk, Alternative 2 assumes that the

river would be armored in some fashion. This alternative also assumes that Bridge 87011 would be replaced with a new, longer bridge, and the new design would mitigate the current landslide issues at the bridge location. Alternative 2 is shown in Figure 9.

Alternative 3: Alternative 3 would maintain the current roadway alignment by constructing over the landslide. Because Alternative 3 involves stabilizing the landslide, it also includes the larger issue of controlling the Yellow Medicine River's influence on the slope, which requires protection of the riverbank.

Alternative 3 would reconstruct TH 67 in place after ground improvement techniques to pin the roadway embankment to a stable layer below. MnDOT contracted with Itasca Consulting Group to analyze the existing slope and develop possible options to pin the slope.

The preferred geotechnical solution included a system of A-shaped micropiles. The micropiles would be 90 feet in length (depth), have a diameter of approximately 1 foot, and be spaced horizontally every 6 feet. The overall length of the micropile system would be around 1,000 feet. A large 7-foot-tall by 8-foot-wide concrete grade beam would be poured in place. The micropiles would extend through the disturbed soils into an existing stiffer layer of materials. In addition to using the micropiles and the grade beam, the roadway section is expected to be built with lightweight fill to reduce the loading on the slope. With this alternative, it is assumed that riverbank protection would be included to further stabilize the slope. This alternative also assumes that Bridge 87011 would be replaced with a new, longer bridge, and the new design would mitigate the current landslide issues at the bridge location. Alternative 3 is shown in Figure 10, and a copy of the Itasca report, titled "TH 67 FLAC3D Analyses Results" can be found in Appendix A.



LEGEND

	PAVED ROADWAY (NEW CONSTRUCTION)
	PAVED SHOULDERS
	BRIDGE
	PROPOSED MNDOT RIGHT OF WAY
	STATE PARK CONNECTION
	EXISTING MNDOT RIGHT OF WAY
	EXISTING STATE PARK RIGHT OF WAY

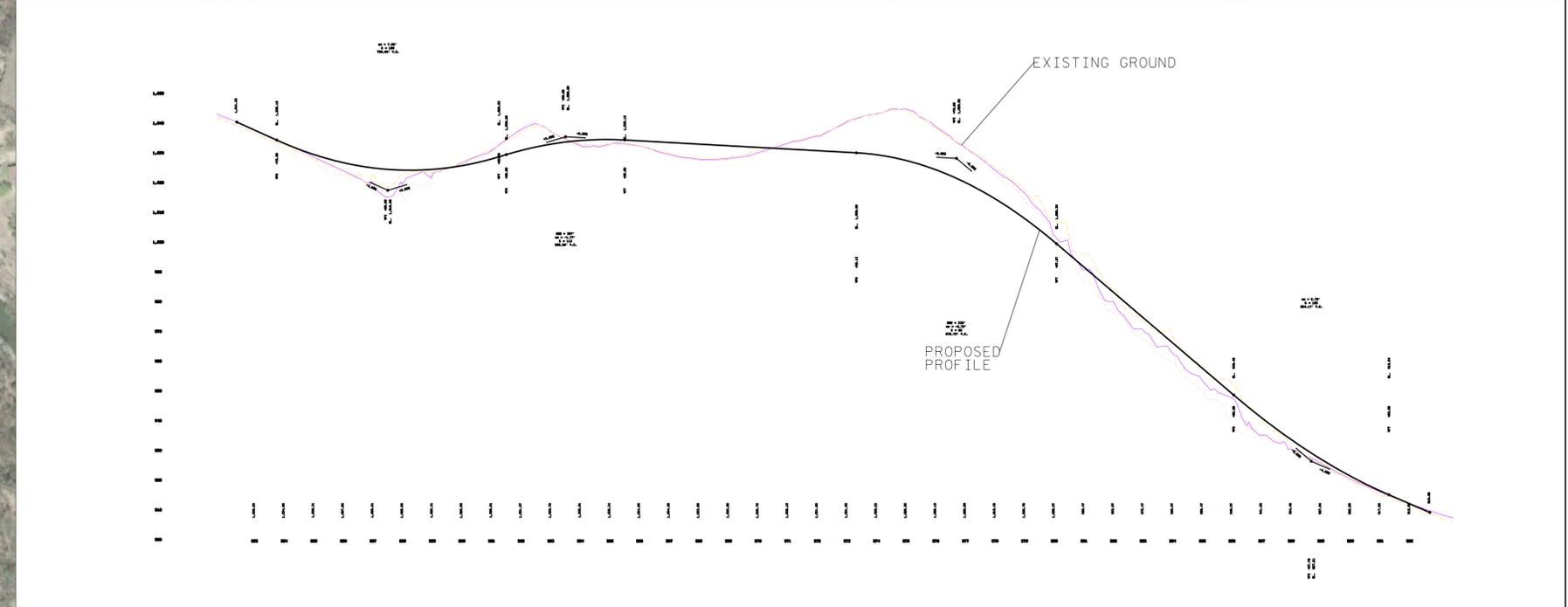


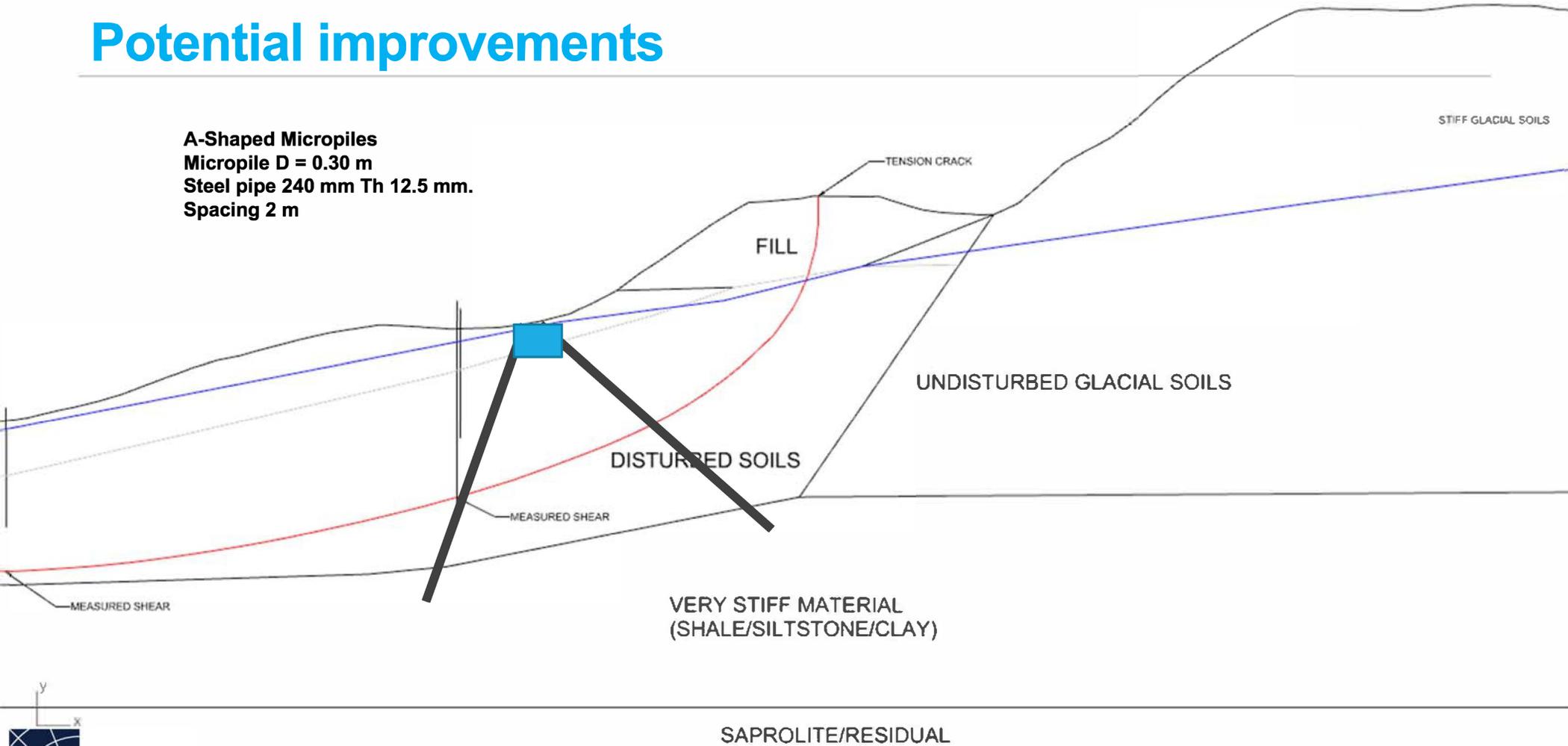
FIGURE 9 - ALTERNATIVE 2
 S.P.8707-95 TH 67 SLOPE STABILTY REPAIRS AND RECONSTRUCTION

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Potential improvements

A-Shaped Micropiles
Micropile D = 0.30 m
Steel pipe 240 mm Th 12.5 mm.
Spacing 2 m



SAPROLITE/RESIDUAL

GEOMECHANICS • HYDROGEOLOGY • MICROSEISMICS • MINING • CIVIL • ENERGY

Figure 10 - Alternative 3



4.2.2 Riverbank Protection Strategies

Several options were considered for protection of the riverbank, including the following:

- Option A: Protective Wall Along the Toe of the Slope (Riverbank) – A protective wall would be constructed along the toe of the slope to shield against further erosion and future landslides. Given the volume of material uphill of the wall, the design assumes 55-foot-deep shafts for a poured-in-place concrete pile with a 7-foot horizontal shaft spacing for a length spanning 811 feet along the riverbank. This option would be the most costly to construct but would provide the highest factor of safety to protect the slope against future landslides. Additional costs for clearing and grubbing, and a temporary access road for construction equipment and trucks are included.
- Option B: Rip Rap with Buried Toe – Rip rap would armor the riverbank and would be buried to the maximum scour depth of the river, as shown in Figure 11. Scour depths of the Yellow Medicine River are currently unknown, but for the purposes of this report, the depth was estimated to be 20 feet. At that depth, there would be substantial impacts on the river to install the buried toe. The maximum size of rip rap needed for this option is greater than the MnDOT specifications for Class 5 rip rap. Additional costs for clearing and grubbing, and a temporary access road for construction equipment and trucks are included.
- Option C: Rip Rap with Launchable Toe – Rip rap would armor the riverbank and would be thickened at the toe of the embankment slope, as shown in Figure 12. As the riverbed scours, the additional rip rap would fall down the slope to armor the newly exposed surface. The maximum size of rip rap needed for this option is greater than the MnDOT specifications for Class 5 rip rap. Additional costs for clearing and grubbing, and a temporary access road for construction equipment and trucks are included.
- Option D: Bendway Weirs – A series of weirs would be added to the outside of the river channel where the river velocity is the greatest, as shown in Figures 13 and 14. The weirs would slow down the water and would reduce the likelihood of erosion at the toe of the slope. The maximum size of rip rap needed for this option is greater than the MnDOT specifications for Class 5 rip rap. Additional costs for clearing and grubbing, and a temporary access road for construction equipment and trucks are included.

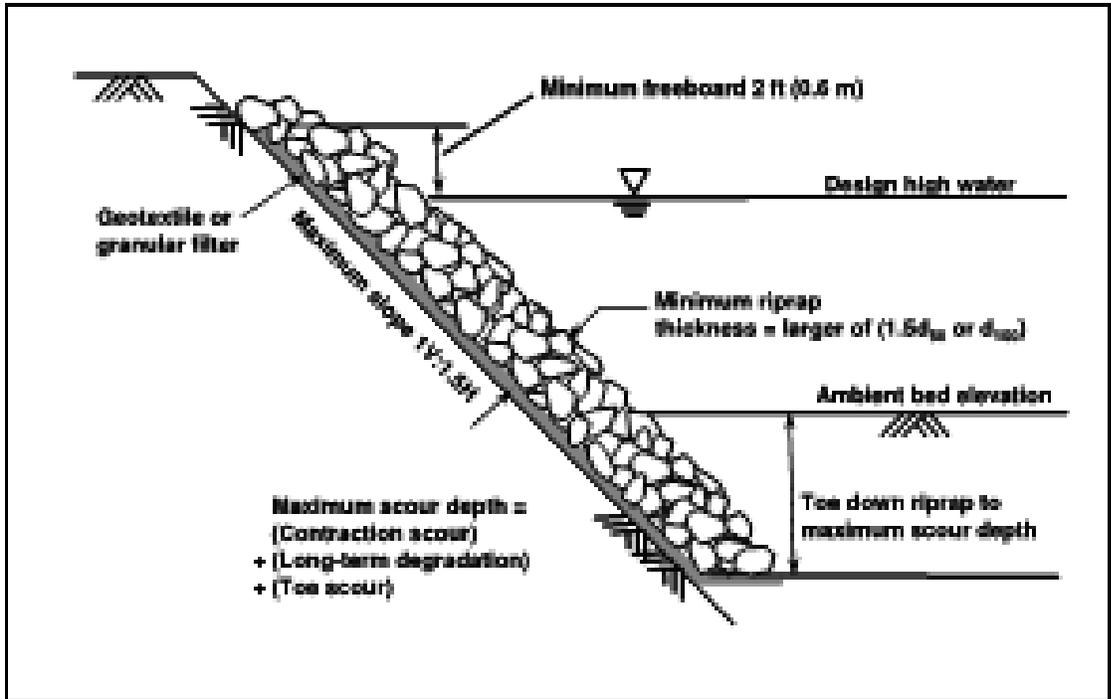


Figure 11. Rip Rap Revetment with Buried Toe

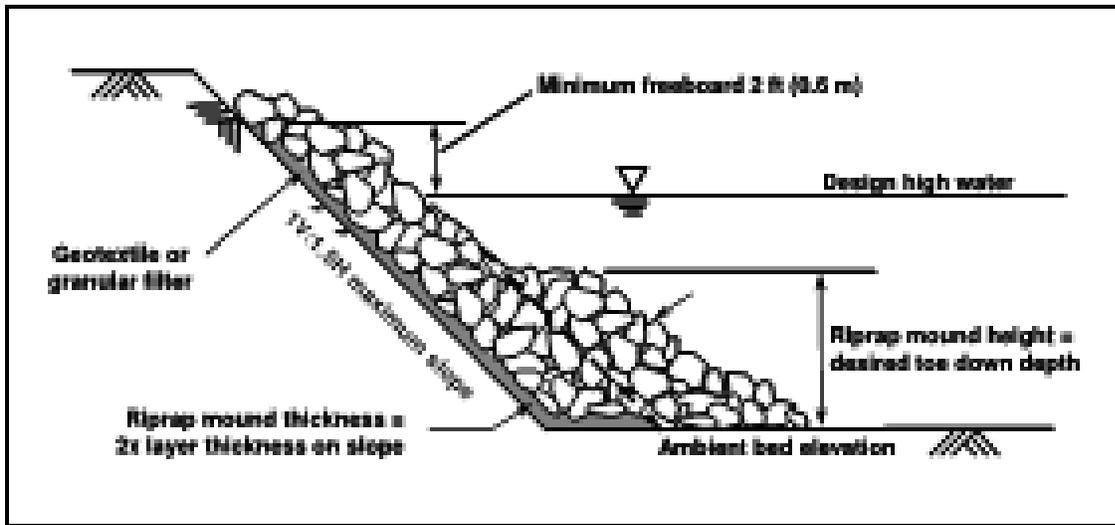


Figure 12. Rip Rap Revetment with Launchable Toe

- Option E: Bioengineered Solutions – Bioengineered solutions would include using items such as large woody material and brush mattress for erosion control. Similar to the rip rap options (Options B, C, and D), the bank would be covered with stumps, downed trees, and other brush materials to act as protection for the riverbank. This option is typically used for smaller streams where the velocity is not as great as it is in the Yellow Medicine River. The option was reviewed and deemed not appropriate for this location. The solution was not further investigated.

Cost estimates presented are preliminary based on the information available at the time of the study. Following review of the options previously noted, Options A and E were dismissed from further consideration. Option A is too costly, and Option E was deemed not viable due to the velocity of the river current. To proceed with Options B through D, a detailed survey of the river bottom would be required to understand the river characteristics. A detailed hydraulic analysis, complete with two-dimensional models, would be needed to confirm results and assumptions. Each option offers a different level of protection, which should be considered when evaluating stabilization options near the roadway. In each of these options, there are likely substantial environmental impacts associated with the construction of the riverbank protection strategy in addition to accessing the site.

4.2.3 Yellow Medicine River Bridge Strategies

Bridge 87011 has also been an on-going maintenance issue for MnDOT. As noted earlier, there is a second smaller slide that is pushing on the east abutment. In the reconstruct alternatives, this bridge at the Yellow Medicine River needs to be addressed to maintain the connection between Granite Falls and Echo. MnDOT contracted with Itasca Consulting Group to analyze the existing slope and develop possible options to pin the slope. They developed a similar a-frame micropile system with a grade beam to address the slide issue and alleviate the movement on the abutment. This solution would require a specialty contractor and extensive monitoring. In addition, the bridge superstructure would be removed to permit the construction to occur. This solution was determined to be overly complicated and not cost effective. As a result, a new, longer bridge that would span the slide area is a more desirable solution. This cost has been assumed on all reconstruction alternatives. A copy of the Itasca report, titled “TH 67 Br 87011 FLAC3D Back Analysis” can be found in Appendix B.

4.3 Alternatives Dropped from Further Consideration

The alternatives discussed in this section were dropped from further consideration because they were determined to be too costly or did not provide a high enough factor of safety, or both.

Category 1, Reroute: In addition to Alternatives 1A and 1B, two other reroute alternatives were considered. While both alternatives would satisfy the base requirements of the State Statute, they were determined to be less desirable than Alternatives 1A and 1B.

Beginning in Granite Falls, the first reroute alternative dropped from further consideration would stay on TH 212 instead of turning south on TH 23 to cross the Minnesota River. It would follow TH 212 roughly 7.5 miles east and then would turn south on Renville CSAH 10. This county

road crosses the Minnesota River and becomes Yellow Medicine CSAH 21. It intersects with existing TH 67 a little less than 2 miles east of the landslide area. This alignment would add the fewest new miles to the MnDOT system, but it would not offer as much roadway to turn back to a local agency. Therefore, it would add the most net new miles to the MnDOT system. The alternative would also add a substantial river bridge (over the Minnesota River). This alternative had the highest annual maintenance cost of all the reroute options. Finally, it is the lengthiest of the reroute options at 21.6 miles long between Granite Falls and Echo, or 3 miles longer than the existing route.

The second reroute alternative dropped from further consideration is similar to Alternatives 1A and 1B. On this route, TH 67 would remain on TH 23 south of from Granite Falls and then would turn east onto TH 274. The route would continue south on TH 274 into Wood Lake, Minnesota. TH 274 terminates in Wood Lake, but the roadway continues south as Yellow Medicine CSAH 6. The route would continue on CSAH 6 to Yellow Medicine CSAH 1 (150th Avenue) and then would turn east to follow CSAH 1 into Echo. Overall, this alignment was a similar length to Alternatives 1A and 1B; and it provides the greatest opportunity to turn back portions of TH 67 to a local agency leading to potential reduced system maintenance costs. However, it added the most miles to the MnDOT system of all of the reroute alternatives and therefore was the most costly of the reroute alternatives considered.

Category 2, Reconstruct: In addition to Alternatives 2 and 3, two other reconstruct alternatives were considered. The first reconstruct alternative dropped from further consideration included a land bridge across the landslide area. The bridge would be approximately 840 feet long. Deep foundations using drilled shafts approximately 85 feet deep were estimated to accommodate the earth pressure load from a potential future landslide. The drilled shafts would extend through the slip planes to bedrock. The volume of earth in the landslide area is substantial, and distribution of load to the shafts would need to be determined. Because of the horizontal landslide movement, the foundations would need to be oversized to resist the lateral load, as well as possibly a design to allow movement of soil around the foundation as the landslide movement continues, if this soil movement allowance is possible. The existing roadway embankment would be removed below the beams to reduce the load on the slope, eliminate soil pressure on the bridge superstructure, and re-establish drainage patterns. Through the analysis, it was determined that riverbank protection would benefit the design and long-term maintenance of the bridge. However, riverbank protection does not mitigate the landslide movement and does not eliminate the risk of lateral bridge movement.

The second reconstruct alternative dropped from further consideration was reconstructing the roadway embankment of TH 67 in place using lightweight fill to reduce the load of the roadway on the slope, combined with riverbank protection to reinforce the conditions at the base of the landslide. MnDOT's Foundations Unit evaluated the use of lightweight fill as a replacement for soil in the road embankment to reduce load on the landslide as a mitigation measure to reduce future landslide movement. A series of figures were developed from the analysis to illustrate the site conditions.

A limit equilibrium model was run on the pre-landslide conditions and on a scenario where the entire 20-foot roadway embankment was replaced with lightweight fill. The limit equilibrium model analyzes the slope stability and provides a factor of safety given certain site conditions. MnDOT's analysis showed a slight increase in the factor of safety of only 0.12 and an overall factor of safety just shy of 1.2, which is not acceptable per American Association of State Highway Transportation Officials requirements.

A finite element model was also run to provide strain and displacement data. Finite element models are more complex than the limit equilibrium model and provided greater insight into the kinematics of the slope. What this analysis showed was that a lightweight fill roadway embankment has a negative effect on the slope above the roadway. The analysis showed that there is greater strain, or a destabilization, in these soils due to a loss of counterbalance of the roadway embankment with the reduced weight of the lightweight fill. Therefore, the lightweight fill option would require additional mitigation to the upper slope as well.

MnDOT Foundations Unit concluded that the lightweight fill option is not feasible given the low factor of safety and the additional work and cost required to stabilize the upper slope.

5 Evaluation Process and Criteria

For evaluating the alternatives, a process was developed to establish the positives and negatives of each alternative as well as to conduct a risk assessment to review potential impacts. Figure 15 summarizes the main components of the evaluation process.

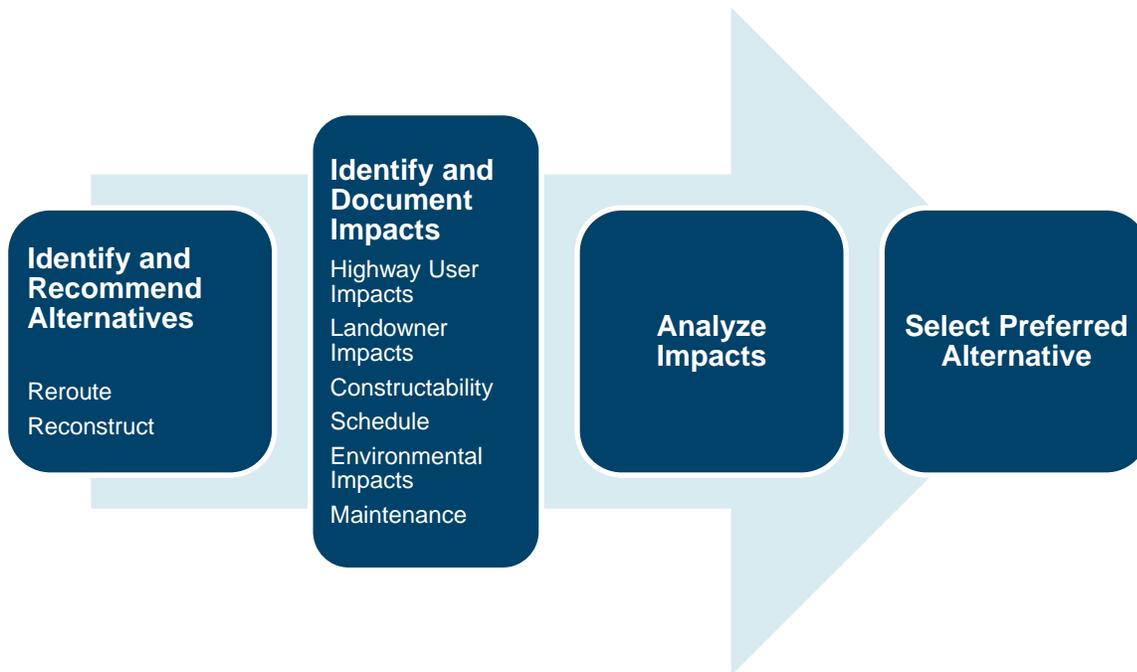


Figure 15. Feasibility Study Process

The evaluation criteria for these TH 67 alternatives are largely based on typical value engineering criteria, such as highway operations, local road operations, and impacts on construction, schedule, the environment, and maintenance. To identify and document impacts of the alternatives presented in Section 4, the following types of impacts were considered:

- Highway User Impacts – Determine impacts on the traveling public, including travel time, route distance, and grade changes.
- Initial Cost – Cost is important given that funding has not been secured for this project and its need will compete with other projects across Minnesota.
- Environmental Impacts – Determine impacts on various expected environmental issues, including cultural resources, historic properties, Section 6(f), and areas of biodiversity.
- Landowner Impacts – Assess how adjacent landowners would be impacted in regard to access and right-of-way.
- Maintenance – Any new construction will have differing long-term maintenance consequences compared to maintenance activities prior to the landslide. Maintenance impacts will be reviewed in relation to both the roadway and bridge.
- Constructability – Identify special or unusual design and construction activities that may require a specialty contractor and have a higher associated risk.

For each criterion developed, an evaluation objective was identified, as was a measure for comparison purposes. The evaluation criteria include both quantitative and qualitative measures. Table 2 summarizes the evaluation criteria. Each alternative was screened based on these criteria to inform the feasibility and risk assessment, discussed in Section 6.



Table 2. Evaluation Criteria

Evaluation Criterion	Evaluation Criterion	Evaluation Objective	Measures for Comparison
Highway User Impacts	Travel time	Increase or decrease from existing	<ul style="list-style-type: none"> Travel time (min)
Highway User Impacts	Route distance	Increase or decrease from existing	<ul style="list-style-type: none"> Distance (miles)
Highway User Impacts	Grade changes	Increase or decrease from existing	<ul style="list-style-type: none"> Roadway grades (%)
Initial Cost	Total Project Cost Estimate	Construction Cost, right-of-way, and engineering	<ul style="list-style-type: none"> Cost (\$)
Environmental Impacts	Cultural resources	Identify Locations of impact	<ul style="list-style-type: none"> Risk of impact
Environmental Impacts	Historic properties	Identify Locations of impact	<ul style="list-style-type: none"> Risk of impact
Environmental Impacts	Section 6(f)	Identify Locations of impact	<ul style="list-style-type: none"> Risk of impact
Environmental Impacts	Areas of biodiversity	Identify Locations of impact	<ul style="list-style-type: none"> Risk of impact
Landowner Impacts	Access	Access impacts	<ul style="list-style-type: none"> Mitigation to maintain access
Landowner Impacts	Right of Way	Locations for permanent and temporary right-of-way acquisition	<ul style="list-style-type: none"> Risk of right-of-way impact (acres)
Maintenance	State Maintenance	Increase or decrease from existing	<ul style="list-style-type: none"> Roadway length (miles)
Maintenance	State Maintenance	Increase or decrease from existing	<ul style="list-style-type: none"> Bridge area (SF)
Maintenance	Yellow Medicine County Maintenance	Increase or decrease from existing	<ul style="list-style-type: none"> Roadway length (miles)
Maintenance	Yellow Medicine County Maintenance	Increase or decrease from existing	<ul style="list-style-type: none"> Area (SF)
Constructability	Construction Schedule	Constructability Review	<ul style="list-style-type: none"> Year of construction completion
Constructability	Construction Complexity	Constructability Review	<ul style="list-style-type: none"> Comparison to standard methods

6 Feasibility and Risk Assessment

The feasibility and risk assessment of TH 67 is based on evaluating each alternative with respect to the evaluation criteria in comparison to the existing alignment prior to the landslide and subsequent closure of the roadway. The summary of the feasibility and risk assessment is presented in Table 3. A more detailed table can be found in Appendix A. Environmental concerns are shown in Figure 16.



Table 3. Evaluation Matrix

Criterion	Alternative 1A (Reroute on CSAH 18)	Alternative 1B (Reroute on CSAH 2)	Alternative 2 (Reconstruct through State Park)	Alternative 3 (Reconstruct in Place)
Highway User Impacts	<ul style="list-style-type: none"> • 2 minutes of additional travel time 	<ul style="list-style-type: none"> • 2 minutes of additional travel time 	<ul style="list-style-type: none"> • No change 	<ul style="list-style-type: none"> • No change
Initial Cost	<ul style="list-style-type: none"> • \$12.1M-\$14.3M 	<ul style="list-style-type: none"> • \$12.1M-\$14.3M 	<ul style="list-style-type: none"> • \$22.7M-\$30.2M 	<ul style="list-style-type: none"> • \$37.9M-\$46.5M
Environmental Impacts	<ul style="list-style-type: none"> • Low probability of environmental impacts 	<ul style="list-style-type: none"> • Low probability of environmental impacts 	<ul style="list-style-type: none"> • High probability of cultural resource and Section 6(f) impacts 	<ul style="list-style-type: none"> • High probability of cultural resource and Section 6(f) impacts
Landowner Impacts	<ul style="list-style-type: none"> • Access impacts to State Park and local residents 	<ul style="list-style-type: none"> • Access impacts to State Park and local residents 	<ul style="list-style-type: none"> • Right-of-way acquisition from DNR (State Park) 	<ul style="list-style-type: none"> • Right-of-way acquisition from DNR (State Park)
Maintenance	<ul style="list-style-type: none"> • Net decrease to State annual maintenance cost • Net increase to County and DNR annual maintenance cost 	<ul style="list-style-type: none"> • Net decrease to State annual maintenance cost • Net increase to County and DNR annual maintenance cost 	<ul style="list-style-type: none"> • Slight increase to State annual maintenance cost • No change to County annual maintenance cost 	<ul style="list-style-type: none"> • No change to State or County annual maintenance cost
Constructability	<ul style="list-style-type: none"> • Standard construction methods 	<ul style="list-style-type: none"> • Standard construction methods 	<ul style="list-style-type: none"> • Significant risk of delay in schedule due to project complexity 	<ul style="list-style-type: none"> • Significant risk of delay in schedule due to project complexity

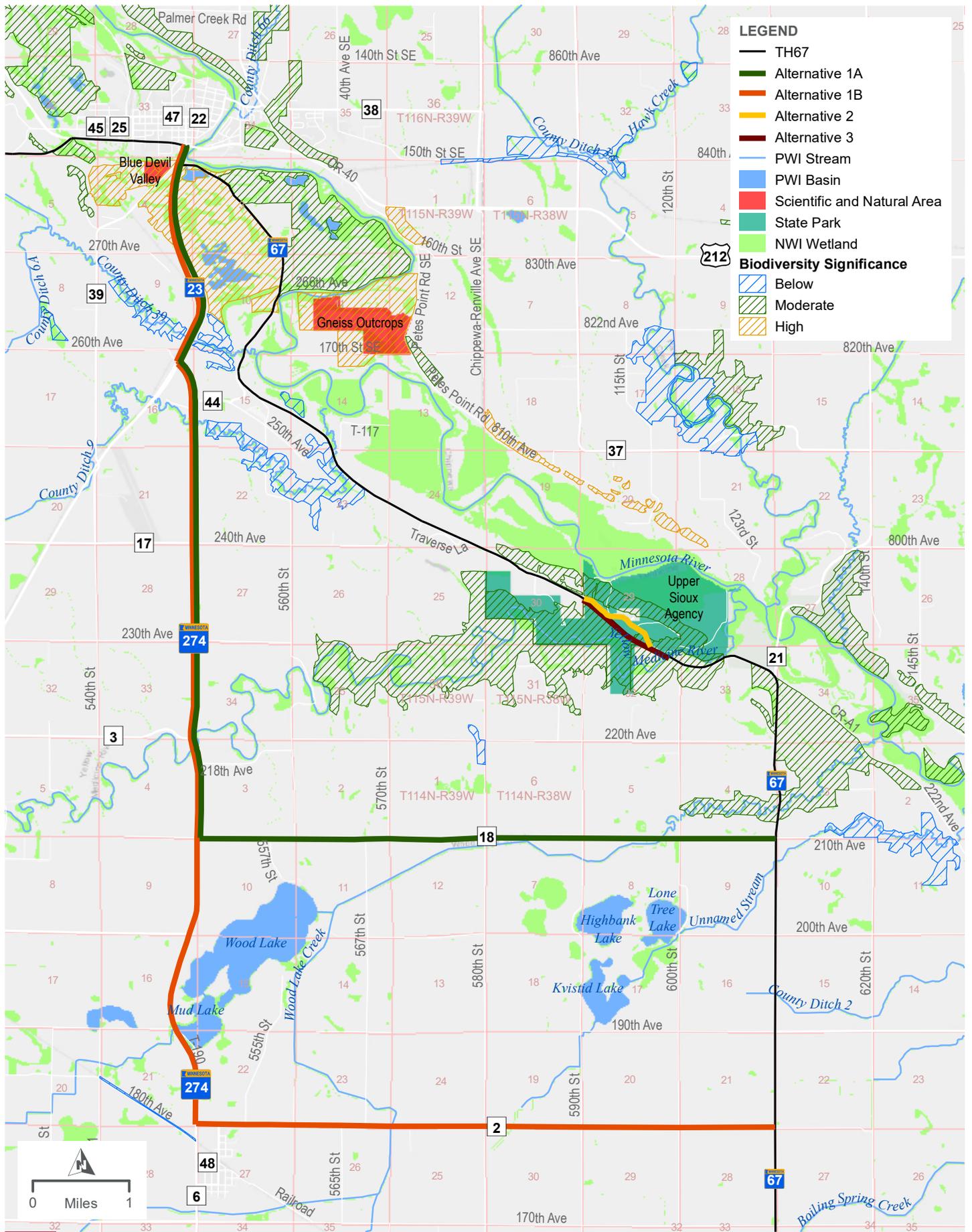


FIGURE 16 - PROPOSED PROJECT ALTERNATIVES AND ENVIRONMENTAL ISSUES



7 Stakeholder and Public Input

In addition to, but separate from, the evaluation process, stakeholder input was sought through a detailed public and agency involvement process. Because several key stakeholders will be influenced in different ways by the selection of a preferred roadway alternative, there has been a concerted effort to engage these stakeholders and gather their input. The input has been solicited not to develop the roadway alternatives but rather to understand the impacts of the proposed roadway alternatives on the stakeholders and to determine the level of support for any or all of the alternatives.

7.1 Stakeholder Input

The following is a listing of the stakeholders whose input was sought through the engagement process.

- Upper Sioux Community Leadership and Tribal Historic Preservation Officer (THPO)
- Minnesota DNR/Upper Sioux Agency State Park
- Yellow Medicine County
- Renville County
- City of Echo
- City of Granite Falls
- City of Wood Lake
- Local Emergency Responders
- School District and Bussing Companies
- Upper Minnesota Valley Regional Development Commission

Upper Sioux Community Leadership and Tribal Historic Preservation Officer expressed concerns regarding Alternatives 2 and 3 due to the high probability of cultural resource impacts. The City of Wood Lake has expressed preference for Alternative 1B due to being routed adjacent to Wood Lake.

7.2 Public Input

Below is a summary of the public engagement activities performed.

Mailed letter to approximately 250 impacted landowners between TH 67, TH 274, and CSAH 2. The letter contained project details, timelines, and potential solutions, and provided an opportunity to communicate directly with the project manager. This resulted in 26 direct conversations between interested stakeholders and the project manager.

- Meetings with landowners, farm owners and managers, area residents, and Yellow Medicine County Commissioners
- Common themes included access to State Park, scenery/scenic byway, property impacts, access to Wood Lake, traffic, visibility/sightlines, and drainage.

- In general, residents closest to the State Park and the Yellow Medicine River bridge were concerned about losing existing TH 67 connection

A virtual open house was held July 27th through August 9th, 2020 containing project details, timelines and potential solutions, with an opportunity to provide feedback. The virtual open house was advertised via post cards, newspaper ads, social media, and the project website.

- 947 visitors, some multiple visits
- 12 minutes average time spent on the web page
- 26 comments via the virtual open house and the project website
- Survey question, which reroute option can you support. 59 responses, 38 for Alternative 1A, 17 for Alternative 1B, and 4 for either.
- Reasons for selecting Alternative 1A: shortest connection back to existing TH 67, does not travel near Wood Lake, does travel by Historic Wood Lake Battlefield, Timm County Park, and Rock Valley Church, less highway turned back to local government
- Reasons for selecting Alternative 1B: Does travel near Wood Lake, better visibility/sight lines, wider road, more State highway turned back to local government.

8 Summary

Further analysis of the evaluation criteria for the four alternatives and a final recommended preferred alternative are provided in the following paragraphs.

Highway user impact

TH 67 serves 465 vehicles per day, the traffic volumes on this section are among the lowest five percent of Trunk Highways in District 8. The feasibility and risk assessment performed in section 6 indicates that there is a minor two-minute increase in travel time for most highway users for Alternatives 1A and 1B. It is acknowledged that there is potential for approximately 15-minute increase in travel time for landowners located within a couple miles of the road closure to get from one side of the Yellow Medicine River to the other. From a highway system standpoint, all alternatives are relatively equal.

Total Project Cost

Expected total project costs are as follows:

Alternative 1A	range \$12.1M to \$14.3M
Alternative 1B	range \$12.1M to \$14.3M
Alternative 2	range \$22.7M to \$30.2M
Alternative 3	range \$37.9M to \$46.5M

Initial costs are significantly greater for Alternatives 2 and 3, primarily because they not only include cost to reconstruct TH 67 but also stabilize the riverbank and replace the existing bridge over the Yellow Medicine River. Alternatives 1A and 1B are preferred for initial cost.

Environmental impacts

Alternatives 2 and 3 both have high probabilities of disturbing cultural and/or historical resources. Likewise, both these alternatives have a high probability of incurring Section 6(f) impacts to the State Park. Both alternatives also have impacts to naturally wooded areas of Moderate Biodiversity significance. In comparison, Alternatives 1A and 1B have little to no environmental impacts as they use existing roadways. As a result, Alternatives 1A and 1B are preferred from an environmental standpoint.

Landowner Impacts

Under both Alternatives 1A and 1B, there are impacts to access for the State Park. Under either of these alternatives, an internal State Park Road to connect the main entrance of the Park on top of the bluff to the State Park Campground is needed to address the access. There is also a private parcel of property that becomes landlocked. There is also additional R/W and construction needed at the existing TH 67 and CSAH 21 intersection to realign the intersection.

Under Alternative 2, over 13 acres of property is needed from the park for the realigned TH 67 through the Park, although there is the opportunity to offset that by vacating the R/W of the existing highway. Under both Alternatives 2 and 3, there is a need for temporary easements on over 15 additional acres to construct the improvements along the river and/or to construct the geotechnical improvements to stabilize the roadway. In both Alternatives, there would be extensive tree clearing required for the necessary temporary roadways and permanent construction.

The R/W cost is a relative minor cost to the overall project. On its own merit, landowner impacts are neutral across all alternatives.

Maintenance

Maintenance is an annual cost that agencies must account for to keep their highway and bridges serviceable to the traveling public. Alternatives 2 and 3 are similar in length to the existing TH 67 route. Alternative 2 is slightly longer and would add a steep grade of 8.5% so a minor cost add would be expected, while Alternative 3 would be expected to be the same as today.

Alternative 1A and 1B both offer similar costs. Alternative 1A reduces 1.5 miles from the Trunk Highway System in District 8, increases 0.5 miles to the County Highway System, and increases 0.6 miles to the DNR. It does add bridge 87054 on CSAH 18 to the State inventory but also eliminates the bridge 87011 over the Yellow Medicine River from the

system and turns back bridge 6216 (the double 10' by 10' box culvert) to the County. Still there is an expected reduction in annual maintenance costs for Alternative 1A.

For Alternative 1B, there is a reduction of 1.4 miles to the Trunk Highway system in District 8, increases 0.4 miles to the County Highway System, and increases 0.6 miles to the DNR. It does add bridge 87554 on CSAH 18 to the State inventory but also eliminates the bridge 87011 over the Yellow Medicine River from the system and turns back bridge 6216 (the double 10' by 10' box culvert) to the County. So there is also an expected reduction in annual maintenance costs for Alternative 1B.

Table 4 Maintenance Summary

	Alternative 1A Roadway (miles)	Alternative Roadway 1A Bridge (each)	Alternative 1B Roadway (miles)	Alternative 1B Bridge (each)	Alternative 2 Roadway (miles)	Alternative 3 Roadway (miles)
State	-1.5	+ 87054 - 87011 - 6216	-1.4	+ 87554 - 87011 - 6216	N/C	N/C
County	0.5	- 87054 +6216	+ 0.4	- 87554 +6216	N/C	N/C
DNR	0.6	N/C	+ 0.6	N/C	N/C	N/C

In regards to Maintenance, removal of the Yellow Medicine River bridge eliminates a major annual maintenance cost. Alternative 1A or 1B is the preferred alternative.

Constructability

Alternatives 2 and 3 are much more complex than Alternatives 1A and 1B. Both include a River Bridge replacement and riverbank protection in addition to the roadway reconstruction. Alternative 3 also adds a costly and specialized design and construction of a geotechnical system to stabilize the roadway. Alternatives 1A and 1B are both simpler construction projects and take place on roadways that are already in place. Alternatives 1A and 1B are preferred in regards to constructability.

Alternatives 2 and 3 are not recommended for further consideration due to significant environmental concerns and high cost.

8.1 Recommendation

Alternative 1A and 1B have similar impacts based on the criteria above; additional evaluation criteria are needed to further analyze the recommended route. The additional criteria used for evaluation are the engineering properties of the route: roadway geometrics, bridge condition, pavement condition, and culvert conditions.



Roadway geometrics

Both CSAH 2 and CSAH 18 are rural roadways with 12' lanes and 5' gravel shoulders. Per as-built plans, both roadways have 1:4 side slopes and similar clear zones. Roadway geometrics is neutral to either alternative.

Intersection Sight Distance

Both Alternative 1A and 1B introduce new turning movements at TH 274 and TH 67 for through travel on TH 67. Intersection sight distance is an important factor given the expected increase in traffic volumes at these intersections. At CSAH 18 on TH 67, there is a steep grade and a crest vertical curve to the north of the intersection that can limit the sight distance for traffic on CSAH 18. At CSAH 2 on TH 67, the grades are much flatter allowing greater sight distances. As a result, Alternative 2 is preferred for the better sight distance at the intersections.

Bridge Condition

Bridge 87504 on Alternative 1A is a precast channel span with timber abutments and piling, constructed in 1966. The bridge width is 30', which is narrower than the roadway. This structure type has a limited remaining service life and needs replacement if on the Trunk Highway system. Bridge 87554 on Alternative 1B is a prestressed concrete beam bridge, constructed in 2001. The bridge width is 36' and matches the roadway width. Alternative 1B is preferred due to bridge geometrics and condition.

Pavement condition

The following table describes the dates and ranges of the previous County resurfacing projects.

Table 5 Pavement Condition Summary

Roadway	Construction Date	From	To	Pavement Section
Alternative 1A (CSAH 18)	2001 (SAP 087-618-018)	TH 274	TH 67	Bit. Wear Course - 1.5" Bit. Non-Wear Course – 6" Aggregate Base – 5.5"
Alternative 1B (CSAH 2)	2011 (SAP 087-602-021)	TH 274	567th Street	Bit. Wear Course - 1.5" Bit. Non-Wear Course – 5" Aggregate Base – 3.5"
Alternative 1B (CSAH 2)	2001 (SAP 087-602-018)	567th Street	580th Street	Bit. Wear Course - 1.5" Bit. Non-Wear Course – 6" Aggregate Base – 5.5"
Alternative 1B (CSAH 2)	2018 (SAP 087-602-026)	580th Street	TH 67	Bit. Wear Course - 1.5" Bit. Non-Wear Course – 2" Mill – 1.5"

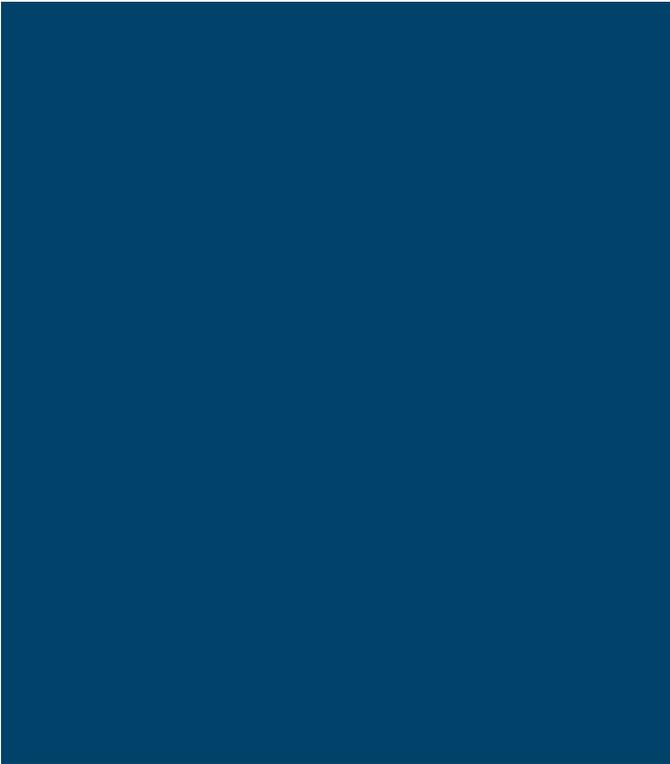
Alternative 1B is preferred due to better pavement condition compared to Alternative 1A.

Culvert conditions

A hydraulic review and preliminary recommendation was completed on Alternative 1A and 1B. Alternative 1A needs approximately six culvert liners, and culvert cleaning. Alternative 1B needs approximately two culvert liners, and no culvert cleaning. Alternative 1B is preferred due to better condition of existing culverts.

Final Recommendation

Considering all these additional criteria, Alternative 1B, rerouting TH 67 onto TH 23, TH 274, and CSAH 2, is the recommended alternative to re-establish TH 67 between Granite Falls and Echo.



Appendix A

TH 67 Background Information





Table A1 describes the various sections of roadway that combine to make up the existing TH 67 alignment, as well as the two rerouted alignments in Alternatives 1A and 1B. Values in the table in bold type represent proposed Truck Highway 67 miles in each alternative. Values that are underlined represent the sections that are proposed to be turned back to the County or the State Park, and negative values in italics represent segments that would be removed.

Table A2 provides the travel distance and travel times for Alternatives 1A and 1B. It also sums the lengths of roadway that would be removed, re-designated as new Trunk Highways, and absorbed into the MnDOT system, as well as the net change in mileage to the MnDOT system.

Table A1. Alternative 1 Roadway Section Summary

Roadway	From	To	Classification	Existing Road	Alternative 1A	Alternative 1B
TH 212	TH 67	TH 23	Major Arterial	1.2	1.2	1.2
TH 23	TH 212	TH 67	Major Arterial	0.2	0.2	0.2
TH 67	TH 23	Park Ent (LT)	Minor Arterial	7.3	7.3	7.3
TH 67	Park Ent (LT)	Access (RT)	Minor Arterial	0.6	-0.6	-0.6
TH 67	Access (RT)	Camp Ent (LT)	Minor Arterial	0.3	<u>0.3</u>	<u>0.3</u>
TH 67	Camp Ent (LT)	Access (RT)	Minor Arterial	0.1	-0.1	-0.1
TH 67	Access (RT)	CSAH 21	Minor Arterial	1.2	<u>1.2</u>	<u>1.2</u>
TH 67	CSAH 21	CSAH 18	Minor Arterial	1.7	<u>1.7</u>	<u>1.7</u>
TH 67	CSAH 18	CSAH 2	Minor Arterial	3.0	3.0	<u>3.0</u>
TH 67	CSAH 2	CSAH 1	Minor Arterial	3.0	3.0	3.0
TH 23	TH 67	TH 274	Major Arterial	2.2	2.2	2.2
TH 274	TH 23	CSAH 18	Major Collector	5.0	5.0	5.0
TH 274	CSAH 18	CSAH 2	Major Collector	3.1	3.1	3.1
TH 274	CSAH 2	2 nd Avenue	Major Collector	0.5	0.5	0.5
CSAH 18	TH 274	TH 67	Minor Collector	6.0	6.0	6.0
CSAH 2	TH 274	TH 67	Minor Collector	6.0	6.0	6.0

Note: All of the County State Aid Highways are in Yellow Medicine County.



Table A2. Alternative 1 Summary

TH 67 Specific Impacts	Existing Road	Alternative 1A	Alternative 1B
A.) Granite Falls to Echo travel distance per alternative (miles)	18.6	20.6	20.7
B.) Travel time per alternative (minutes)	22	24	24

TH System Impacts	Existing Road	Alternative 1A	Alternative 1B
C.) Existing TH System (TH 212+TH 23+TH 274+TH 67) (miles)	29.4		
D.) Proposed TH System (29.4 miles + E – F – G- H) (miles)	0.0	27.9	28.0
E.) Proposed CSAH re-designated as TH (miles)	0.0	6.0	6.0
F.) Proposed TH turnback to County (miles)	0.0	6.5	6.4
G.) Proposed TH turnback to State Park (miles)	0.0	0.3	0.3
H.) Removed TH at State Park (miles)	0.0	0.7	0.7
I.) Net Change in TH System (D-29.4 miles) (miles)	0.0	-1.5	-1.4

County System Impacts	Existing Road	Alternative 1A	Alternative 1B
J.) Proposed CSAH System (CSAH 18 + CSAH 2) (miles)	12.0		
K.) Proposed County System (12.0 miles – L + M + N) (miles)		12.5	12.4
L.) Proposed CSAH re-designated as TH (miles)		6.0	6.0
M.) Proposed TH turnback to County (CSAH designation) (miles)		5.3	5.2
N.) Proposed TH turnback to County (CR designation) (miles)		1.2	1.2
O.) Net Change in CSAH System (L + M – 12.0 Miles) (miles)	0.0	-0.7	-0.8
P.) Net Change in CR System (miles)	0.0	1.2	1.2



Table A3. Evaluation Matrix

Criterion	Alternative 1A (Reroute on CSAH 18)	Alternative 1B (Reroute on CSAH 2)	Alternative 2 (Reconstruct through State Park)	Alternative 3 (Reconstruct in place)
Highway User Impacts	<ul style="list-style-type: none"> • 2 minutes of additional travel time • 2-mile increase in trip distance • Flatter grades 	<ul style="list-style-type: none"> • 2 minutes of additional travel time • 2-mile increase in trip distance • Flatter grades 	<ul style="list-style-type: none"> • Similar travel time • Similar trip distance • Max. grade increase to 8.5% 	<ul style="list-style-type: none"> • Same travel time as existing • Same trip distance as existing • Same grades as existing
Initial Cost	<ul style="list-style-type: none"> • \$12.1M-\$14.3M 	<ul style="list-style-type: none"> • \$12.1M-\$14.3M 	<ul style="list-style-type: none"> • \$22.7M-\$30.2M 	<ul style="list-style-type: none"> • \$37.9M-\$46.5M
Environmental Impacts	<ul style="list-style-type: none"> • Low probability of cultural resource impacts • Low probability historic properties • No Section 6(f) required for park impacts • Impacts to areas of Low biodiversity significance 	<ul style="list-style-type: none"> • Low probability of cultural resource impacts • Low probability historic properties • No Section 6(f) required for park impacts • Impacts to areas of Low biodiversity significance 	<ul style="list-style-type: none"> • High probability of cultural resource impacts (burial mounds and artifacts) • Low probability of historic properties • High probability that Section 6(f) would be required for park impacts • Impacts to areas of Moderate biodiversity significance 	<ul style="list-style-type: none"> • High probability of cultural resource impacts (burial mounds and artifacts) • Low probability historic properties • High probability that Section 6(f) would be required for park impacts • Impacts to areas of Moderate biodiversity significance
Landowner Impacts	<ul style="list-style-type: none"> • Access impacts to State Park • Access impacts to local residents • Potential right-of-way acquisition due to landlocked parcel (37.5 acres) 	<ul style="list-style-type: none"> • Access impacts to State Park • Access impacts to local residents • Potential right-of-way acquisition due to landlocked parcel (37.5 acres) 	<ul style="list-style-type: none"> • No change to access • Right-of-way acquisition from DNR (State Park) (approx. 13 acres of permanent and 15 acres of temporary easement) 	<ul style="list-style-type: none"> • No change to access • Right-of-way acquisition from DNR (State Park) (approx. 17 acres of temporary easement)



Criterion	Alternative 1A (Reroute on CSAH 18)	Alternative 1B (Reroute on CSAH 2)	Alternative 2 (Reconstruct through State Park)	Alternative 3 (Reconstruct in place)
Maintenance (State)	<ul style="list-style-type: none"> • Net loss of 1.5 miles to Trunk Highway (TH) system • Add Bridge 87504 (stream bridge - 2,800 SF) • Remove Bridge 6216 (146' – 10' x 10' twin Box Culverts) • Removal of Bridge 87011 (Yellow Medicine River Bridge - 10,600 SF) • Net decrease in annual maintenance 	<ul style="list-style-type: none"> • Net loss of 1.4 miles to TH system • Add Bridge 87554 (stream bridge - 3,700 SF) • Remove Bridge 6216 (146' – 10' x 10' twin Box Culverts) • Removal of Bridge 87011 (10,600 SF) • Net decrease in annual maintenance 	<ul style="list-style-type: none"> • Grade increase from 5% to 8.5% • Slightly longer roadway • Slight increase in annual maintenance 	<ul style="list-style-type: none"> • No change in annual maintenance
Maintenance (Yellow Medicine County)	<ul style="list-style-type: none"> • Net loss of 0.7 miles to County State Aid Highway (CSAH) system • Net gain of 1.2 miles to County Road (CR) System • Remove Bridge 87504 (Stream bridge – 2,800 SF) • Add bridge 6216 (146' – 10' x 10' twin Box Culverts) • Net increase in maintenance 	<ul style="list-style-type: none"> • Net loss of 0.8 miles to County State Aid Highway (CSAH) system • Net gain of 1.2 miles to County Road (CR) System • Remove Bridge 87554 (Stream bridge – 3,700 SF) • Add bridge 6216 (146' – 10' x 10' twin Box Culverts) • Net increase in maintenance 	<ul style="list-style-type: none"> • No change in annual maintenance 	<ul style="list-style-type: none"> • No change in annual maintenance



Criterion	Alternative 1A (Reroute on CSAH 18)	Alternative 1B (Reroute on CSAH 2)	Alternative 2 (Reconstruct through State Park)	Alternative 3 (Reconstruct in place)
Constructability	<ul style="list-style-type: none"> Remove TH 67 surfacing Remove Bridge 87011 CSAH 18 improvements for TH designation Construct 0.3 miles of internal State Park road Realign TH 67/CSAH 21 intersection TH 67 turnback improvements to meet State Aid Standards (to be completed by County) Route is currently available to highway users CSAH 18 improvements expected in 2022 Construction of internal State Park road must be complete before bridge removal 	<ul style="list-style-type: none"> Remove TH 67 surfacing Remove Bridge 87011 CSAH 2 improvements for TH designation Construct 0.3 miles internal State Park road Realign TH 67/CSAH 21 intersection TH 67 turnback improvements to meet State Aid Standards (to be completed by County) Route is currently available to highway users CSAH 2 improvements expected in 2022 Construction of internal State Park road must be complete before bridge removal 	<ul style="list-style-type: none"> 0.6 miles of grading and paving new highway through State Park Replace Bridge 87011 Stabilize riverbank Remove TH 67 surfacing Construction expected in 2023 Significant risk of delay in schedule due to project complexity 	<ul style="list-style-type: none"> Specialty contractor required for design and construction Replace 0.25 miles of TH 67 Use lightweight fill for roadway embankment Construct 1,000 feet of micropiles Replace Bridge 87011 Stabilize riverbank Replace TH 67 surfacing Construction expected in 2023 Significant risk of delay in schedule due to project complexity

Appendix B

TH 67 FLAC3D Analysis Results

Appendix C

TH 67 Br 87011 FLAC3D Back Analysis