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ENGINEERING REVIEW OF FREIGHT REROUTE WITHIN
DRAFT ENVIRONMENTAL IMPACT STATEMENT

Review of the proposed plan to reroute the daily freight rail traffic of the TC&W Railroad would be described as detrimental at best to freight operations. The new ruling grade for all freight would dramatically affect the operations, maintenance and capital plans for this railroad. Comments related to these three items are detailed below:

Background:

In a perfect world, all railway alignments would be tangent (straight) and flat. This would provide for the most economical operations and the least amount of maintenance. A freight train is most commonly comprised of power and cars. The power may be one or more locomotives located generally at the front of the train. The cars are then located in a line behind the power. As a train moves up and down a hill, it could be visualized as pulling on a chain. As the chain is pulled up a hill everything follows very nicely in a straight line. If the chain gets pulled over a hill, the downhill portion of the chain tries to bunch up behind the leading link and doesn't want to stay in a straight line (buff – downhill forces; draft – uphill forces). As the chain is pulled around in a curve, the trailing links in the chain try to form a straight line. The chain analogy creates a good visualization for the forces acting on a train.

The proposed connecting route for the TC&W Railroad would require both loaded and empty trains to negotiate a series of steep grades and sharp reversing curves. The current proposed design for a connecting route from the Bass Lake Spur to the MNS Spur includes grades of 0.86% and 1.5% grades leading up to and through an 8 degree curve. The high point of the grade is well into the curve. Thus west bound traffic would have to pull up a grade of 1.5% while turning through an 8 degree curve while the trailing cars would be negotiating a reversing set of curves behind.

In the BNSF Design Guidelines, Revision May 2011, under the heading of Vertical Curves states "For secondary main tracks (speed < 50 MPH), the rate of change should not be more than 0.10 feet per station in sags, and not more than 0.20 feet per station on summits." Considering the curve proposed between the Bass Lake Spur and the MNS Spur, there is a 0.86% east bound grade and a 1.5% west bound grade with the summit being at about Station 141+82. The length of the vertical curve is 400 feet or 4 stations. Thus the rate of change per station can be calculated as $(0.86 + 1.50) / 4 = 0.59$ feet per station. This is greater than 0.20 feet per station by almost 3 times.

AREMA (American Railway Engineering and Maintenance-of-Way Association) provides an equivalent grade by adding 0.04% of grade for every degree of curve. Therefore the compensated grade for the proposed route is $1.5\% + 0.04 * 8 = 1.82\%$. Now the 8 degree curve is reduced to an equivalent grade of 1.82% on tangent (straight) track. This creates a new "Ruling Grade" for any freight operation. A ruling grade is the maximum grade for which the railroad must allocate power (locomotives) to pull a load.

AREMA also specifies that the tractive effort (the force required by the locomotive) increases by 20 pounds/ton per percent of grade. Since the maximum existing grade is 0.45% the increase in grade becomes $1.82\% - 0.45\% = 1.37\%$ and increases the tractive effort required by 137 tons on a full (10,000 ton) train, requiring at least one additional locomotive and the likelihood of distributed power. Distributed power is the ability of placing locomotives at both the front and the rear of the train. Distributed power requires a mechanism that will balance the force between the front and rear locomotives such that they will work together to move the loads.

The 2003 AREMA "Practical Guide to Railway Engineering" points out many hazards associated with extreme curvature, reverse curvature and undulating grade. This publication summarizes as follows:

"... reversing curves should be avoided at all costs. With reverse curves, there are two dynamic components acting on a single car or rail vehicle causing a yawing effect, which is of concern. . . . The net effect is a couple about the center of the car. This compares to a car on a single curve where the forces at either end of the car are acting in the same direction and thus counter-acting one another. This couple effect greatly increases the likelihood of the train buckling and thus a derailment."

Once onto the MNS Spur, there are two reversing curves with grades as high as 1.5% and compensated grades as high as 1.72%. For an east bound loaded grain train of 110 cars, the train would be 7045 feet with three locomotives; the train would extend through the first three curves from the Bass Lake Spur to the MNS. When the curve radius and grade is severe, the potential for accidents is increased. This is not desirable in an urban area and certainly less than desirable from a railroad's standpoint.

It is difficult for many people to visualize how long a train can be. If a 7000 foot loaded grain train were east bound and the back of the train was positioned at the beginning of the curve where the Bass Lake Spur turns north to the MNS Spur, the front of the train would be positioned just north of the 29th Street crossing. Within this length, the train would be trailing through three horizontal reverse curves and six vertical curves. The dynamics of the train will be very difficult for the crew to control and the potential for derailment is very high.

Maintenance:

Curves, especially sharp curves, are a maintenance problem for all railroads. Rail life is severely impacted on any curve over two degrees and the useful life is shortened based on tonnage and speed. Excessive effective grade (over 1% compensated) will cause an increase of wheel burns to the rail, which will lead to an increase in web/head fracture or broken rail. The low rail is flattened particularly when the rail is traversed at slow speeds and underbalance imposes more car weight over the low rail. The high rail is abraded as the truck attacks the high rail as it is steered around the curve. AREMA indicates that wheel tread will generally guide the rail vehicle on curves up to three degrees before flange/rail contact begins to regularly occur (thus significant curve wear of rail head begins).

The proposed connecting route from the BNSF Wayzata Subdivision over the MNS Spur to the Bass Lake Spur will contain four horizontal curves that exceed 1% compensated grades. Within this route, there are 5,102 feet of curves that exceed 1% compensated grades. Depending on the tonnage, replacement of the rails and ties due to the curve will need to be frequent. Replacement of the rail for these curves would cost between \$150,000 and \$200,000 in today's dollars. Also, there are two switches in this proposed mainline at grades of 1.5% and very near the point of horizontal curve. These switch positions are certainly not desirable as they create likely points for derailment given their relative position in the horizontal and vertical alignments.

Super-elevation (inside rail is lower than the outside rail) is required to keep cars balanced and the speed of the train will create a centrifugal force that will try to keep the cars on a straight line. By introducing super-elevation, the force on the track is more balanced between the rails. However in sharp curves, the amount of super-elevation required to counteract the centrifugal force becomes more substantial. Without any super-elevation, the speed on the curve would be limited to 23 MPH.

To maintain this super-elevation is very costly. Failure to do so creates a hazardous condition where cars could overturn on the outside of the curve. Additionally, having a sharp curve on a bridge introduces safety issues related to public and railroad safety. Because of the safety concern, the FRA (Federal Railroad Administration) requirements for surface and alignment in a curve are much more stringent. For reference see FRA 213.55 and FRA 213.63. It is likely that the track within the curves would require surfacing at least 3 to 4 times per year at a current cost of around \$10,400 per time.

Operations:

Train Speed will be impacted primarily by the 8 degree horizontal curve although all of the curves in this proposed alignment will affect train speed. Without super-elevation in the curves, the train speed is limited to 23 MPH. Uphill trains will operate slower. If higher downhill speed is desired, super-elevation must be added to be compliant with FRA 213.57 which will result in rail flattening as referenced above.

Additional running time will be required for each train as they travel up the hills and around the horizontal curves. The result of the MNS Spur connection may be that heavier trains will need to double the entire MNS Spur (only half of the train will be hauled up the hill at a time), resulting in the need for a long siding at each side of the MNS Spur to accommodate the doubling movement. With increased power required for each train, there would likely be a need to purchase additional locomotives to run with each train. It is also very likely that distributed power would be required on each loaded train to avoid excessive force on drawbars. By our calculations, pulling a full train (10,000 tons) on the proposed alignment and grade, without distributed power would be possible with five locomotives but the coupler capacity would be exceeded by about 33% thus causing damage to cars.

A typical freight operation would organize cars in the train for efficient operation at the stations. For example, Station A might get 5 loaded fertilizer cars and 5 empty grain cars, Station B might get 3 loaded box cars and 4 loaded gondolas. The railroad would line these cars up in the train so that cars for Station A are at the rear of the train, next would be cars for Station B and so on. If empty cars are

interspersed with the loaded cars (ie: empty grain cars returning with loaded fertilizer cars) as is typically the case with freight movements, there is a concern that the loaded cars would pull the empty cars off the track on the inside of the curve. This is called a "straight lining the curve" derailment. To avoid this condition, the railroad would need to change their operations to group all the loads together behind the locomotive and all the empties following. Rearranging the cars in this fashion would require additional time, labor and fuel at every station to set out loads and empties. Additionally, it is possible that additional yard track would be required at the stations to maneuver the cars.

Capital Plans:

The additional locomotive power and the ability to distribute power would require a capital investment on the part of the Railroads. The proposed plan will require the Railroad to invest in new locomotives and maintenance equipment for surfacing the curves along with the additional cost of fuel. These costs will be incurred in perpetuity causing an increase in operating costs and a decrease in profitability. In addition, if the track changes the operations of the Railroad, additional siding tracks may be required to allow the railroad to manipulate the cars at each Station. The cost of track for freight is currently about \$165 per track foot plus the cost of switches. Thus if a station needed to have an additional 20 cars of track to set off cars at the station, the cost could be over \$300,000 per station.

Conclusion:

The proposed plan for the Bass Lake/MNS Spurs places sharp curves, reversing curves and steep grades in a mainline freight railroad. All guiding specifications and design guidelines have been violated by this proposed plan. Placing an 8 degree curve on a bridge with a steep grade on either side, introduces enough of a safety concern in itself to dismiss the current proposed plan.

This plan would draw criticism from any railroad wherever it is presented and should not be considered. With the information above, even if cost were not an issue, the safety concerns would certainly be enough to bring the designers back to the drawing board. Having an elevated grade in a curve has safety implications for the railroad workers, and the general public. Finding a solution that will satisfy these conditions should be a priority before anything else. Addressing the original set of criteria would require that no additional restrictions be imposed on the freight railroad. This plan imposes restrictions that are unreasonable for the operating railroad.

Respectfully,

Carey Bretsch, PE
Principal